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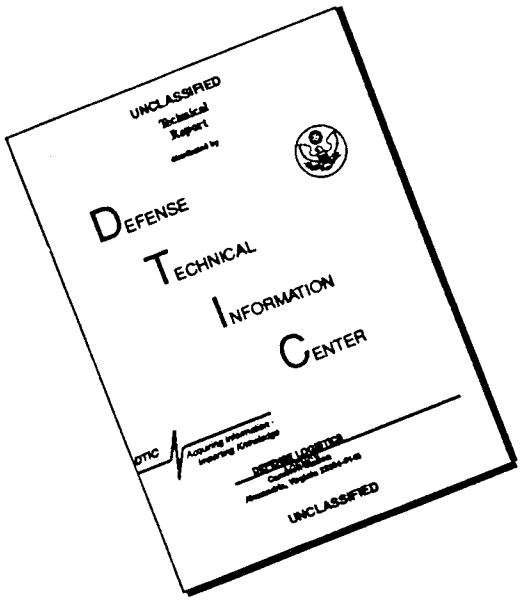

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FOREWORD

This volume contains summary descriptions of the unclassified portions of the Navy's basic and applied research program. The descriptions are necessarily brief because of the large amount of scientific research involved and because of the unclassified nature of the report. The volume contains summaries of work being performed by the Bureau of Naval Weapons, the Bureau of Ships, the Bureau of Medicine and Surgery, the Bureau of Yards and Docks, the Bureau of Naval Personnel, and the Office of Naval Research. It is hoped that the publication of the Navy Research Task Summary will assist university, industrial and non-profit agencies to coordinate their programs in terms of the Navy's ongoing research program.

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F001 TARGET SURVEILLANCE

F001-04 Photographic Surveillance

Photographic Processing Equipment, WF001-04-003. U. S. Naval Photographic Center; Activity #314; Evaluation Department.

The objective of this task is to support Navy photographic systems both airborne and shipborne through the development of shipboard and shorebased photo processing equipment. An additional objective is to increase the speed and quality of photo sensitive materials.

F002 NAVIGATION

F002-01 Systems Analysis, Studies, and Tests

Atmospheric Transmission Investigations, SF002-01-6105. U. S. Naval Research Laboratory; P01-0001/RDT&EN 61.2411; J. E. Gibson.

A considerable amount of useable data has been obtained from investigations conducted under this program. The attenuation of 8.5 millimeter waves from the sun and moon that results from passage through the earth's atmosphere has been measured over all seasons of the year, for all times of day, at latitudes varying from 15°N to 60°N. This investigation included the effects of precipitation. Radio emission from several discrete galactic and extra-galactic sources have been detected and measured at wave lengths of 1.87 and 3 cm. Experiments also have been carried out which show that flux density of the moon (averaged over the disc) at S-band is increased by approximately 10 per cent when the moon is illuminated by a transmitter.

F002-06 Electromagnetic Navigation

Avigation Research, RF 002-06-4200. U. S. Naval Research Laboratory; R04-04; C. V. Parker, P. A. Crafton, H. M. Suski.

This is a theoretical investigation of the general problem of the avoidance of collision between naval aircraft on three-dimensional curvilinear flight trajectories.

F002-09 Aircraft Landing Aids

Shorebased and Shipboard Aircraft Landing Aids, WF-002-09-002. C. E. Egeler, REQ. 19-61-5383, RSSH-32, BuWeps; Oxford Corporation, PR 4810-033-1, RSSH-32, BuWeps; National Bureau of Standards, REQ. 19-61-8012, RSSH-32, BuWeps; Naval Air Engineering Facility (SI), Philadelphia, Pa., Allot. 200, CO, NAEF(SI), Philadelphia.

This task covers the design, development, test, and evaluation of shipboard and shorebased visual landing aids including carrier deck lighting, optical landing systems, and seadrome and runway lighting.

A limited study of night lighting for CVA/CVS carriers was conducted. Applied research and "state of the art" improvement was conducted under contract with the National Bureau of Standards.

F003 ENVIRONMENTAL SURVEILLANCE

F003-02 Meteorological Charting and Mapping

Aerodynamical Measurements, RF 003-02-4250. U. S. Naval Research Laboratory; A03-01; R. M. Schecter.

This task is concerned with a study of the characteristics of aircraft aerological probes under velocity conditions and with the development of improved and more accurate aerological probes and sensors for use in basic aerological research with high speed aircraft.

Atmospheric Dynamics, RF 003-02-4251. U. S. Naval Research Laboratory, Washington 25, D. C.; A03-09; H. J. Mastenbrook, R. E. Ruskin, J. E. Dinger.

This task was established to make measurements and to analyze data to determine correlations between dynamical and physical atmospheric parameters such as turbulence, horizontal and vertical accelerations and velocities, horizontal temperature gradients, vertical and horizontal humidity gradients, water-vapor content, liquid-water content, vertical lapse rates, wind shear, absorption of solar radiation, and the meteorological situations as evidenced by fair weather, frontal activity, thunderstorm activity, low and high pressure areas, jet streams, clouds, and precipitation.

Integrated Surface Weather Observing System, WF-003-02-001. Avion Division, ACF Industries; Now-60-0434-C; Mr. Wesley Burt.

To provide increased quantities of more accurate, representative and timely data for machine analysis, weather forecasting and direct operational applications. This involves the development of automatic sensing and observing equipment as well as data reduction and computational devices.

Continue development of equipment to provide, by electronic means, for the sensing of meteorological parameters and presentation of the resulting data as true values. The equipment is to provide for local displays and message coding for teletype, radio or facsimile transmission.

Several experimental automatic weather stations have been developed and tested. A mechanical automatic weather station of preliminary design is in regular use. A prototype shipboard unit is under development. An automatic observing, encoding and transmitting system for shore use has been developed and evaluated. Equipment for the computation of runway visual range and approach light contact height is under development.

Radar Weather Detection, WF-003-02-002. Stanford Research Institute, NOas 59-6170-C, Myron G. H. Ligda; University of Miami, NOas 59-6217-C, Homer W. Hiser; University of Miami, NOas 60-6026-C, Homer W. Hiser; University of Maimi, NOw 61-0246-D, Homer W. Hiser.

To develop new and improved equipment and techniques for the application of radar to meteorological use. This includes identification, analysis and tracking of storms and meteorological phenomena, and methods of presentation and display of radar meteorological information.

Continue development of circuit elements and the investigation of weather phenomena to improve the capabilities of weather radar equipment and

evaluation techniques. This will include research studies as well as actual fabrication of circuit elements and special devices for radar use.

Environmental Measuring Equipment, WF 003-02/004. U. S. Naval Research Laboratory, Washington, D. C., Proj. Order 1-0014, Dr. J. E. Dinger; National Bureau of Standards, Washington, D. C., Interdepartmental Gov't Orders 19-61-8030-WEPS, 19-61-8031-WEPS, Mr. P. D. Lowell, Mr. Wm. Hakkarinen, Mr. Arnold Wexler.

Investigate and develop improved airborne and surface meteorological sensors, equipment and measuring techniques to meet fleet requirements for more rapid, accurate and extensive meteorological information.

Improved sensors to provide measurements of temperature, pressure, humidity, ozone, air density, concentration of particulate matter, wind velocity, turbulence, icing-areas and icing level height, index of refraction and atmospheric electricity are being studied, developed and tested.

A family of automatic weather stations for surface observations has been developed; boat-type, portable arctic type, moored buoy, floating buoy, and air droppable (grasshopper). A sonic anemometer (AN/GMQ-15) has been developed and is being tested. A specially sensitive dewpoint radiosonde has been developed.

F003-04 Oceanographic-Hydrographic Charting

Beach Trafficability Survey, Y-F003-04-001. Waterways Experiment Station; Appn. 17x1319 2514 RDT&E Bur. Control No. 25/10696; S. J. Knight.

The objective is to determine the trafficability of various types of beaches found throughout the world. The task will include the determination of the characteristics of beach soils, the origination of a beach soil classification series and the developement of trafficability measurement units. Modern warfare methods indicate that amphibious operations will continue to increase in rate of importance and be widely dispersed. Such dispersion requires the maximum use of all types of beaches not heretofore considered for such operations and creates a need for more detailed beach information. Because of the mutual interest of the Army and the Navy in trafficability it was decided to join the separate research efforts of BuDocks and the Corps of Engineers into a single fully integrated program. The program, as established, called for the location of areas, primarily beaches, possessing characteristics suitable for the study of the variables involved in trafficability measurements, the performance of the required vehicle mobility tests at these sites and laboratory investigations for the development of instruments for trafficability predictions.

F003-06 Meteorological Prediction

Environmental Analysis and Forecasting Techniques, WF 003-06-001. U. S. Navy Weather Research Facility, Norfolk, Virginia, Allotment 170, Officer in Charge; U. S. Fleet Numerical Weather Facility, Monterey, California, Allotment 228, Officer in Charge.

Investigate the results of recently acquired basic research information in meteorology and develop improved weather forecasting techniques for use by fleet meteorologists. Devise new environmental prediction methods for the major parameters which affect the operational use of all naval weapons, making maximum use of Electronic Data Processing systems.

Investigations and studies are being made of new techniques for surface and upper-air forecasting, sea condition analysis and prediction, jet stream prediction, pressure-height prediction, and the detection and forecasting of severe storms, such as hurricanes and typhoons. Numerical weather prediction methods are being devised and tested in connection with particular application to naval weather problems.

F005 COMMAND CONTROL

F005-01 Systems Analyses, Studies, and Tests

Study of Naval Combat Information Requirements, RF 005-01-4302. U. S. Naval Research Laboratory, Washington 25, D. C.; Y03-17; D. F. Wilson.

Experiments are being conducted wherein naval officers play tactical air defense games under controlled conditions of (usually) incomplete but progressively increasing information. The objective is to obtain scientific data on the logical organization of the decision process and to evaluate the effects of the tactical environment per se, certain personality characteristics of decision-makers, and the kind, amount, and presentation sequences of combat information on the threat evaluations and weapons assignment decisions of command-level officers and their senior delegates. A detailed digital computer model has been developed for describing, in terms of enemy bomber or own ship losses and on the basis of tactical parameters alone, the consequences of implementing various interceptor assignment schemes in the defense of a force. The model is now being extended to include guided missile defenses. This model is to be used in the future as a primary standard against which to compare officers' decisions in the games with the "real" military values of alternative courses of action, thus permitting a more meaningful quantification of the experimental program.

Optimum ASW System for PC(H), SF005-01-2106. Loral Electronics Corporation; 208-LR-11; Mr. B. J. Baron.

Study to Determine the optimum ASW system for PC(H)

(a) Obtain information from cognizant naval activities
(b) Determine requirements for ASW system for PC(H)
(c) Determine optimum ASW system for PC(H), operating in various modes, employing those techniques and equipments, the state of the art will permit in 1962 and 1965.

This work is necessary to fully understand the hydrofoil ASW problem and to improve the PC(H) ASW system, known to be deficient, in the future. Conducted at no cost to the government.

F006 COMMUNICATIONS

F006-03 Antennas and Radiating Systems

Vertical Radiator (Antenna) (U), Y-F006-03-001. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 10601; P. J. Rush.

The objective is to determine the practicability of constructing vertical radiators (antennas) of heights in the range of 3000 feet and above. There is a continuing requirement for improvement in the Naval Communication system for transmission of radio signals in the LF and VLF ranges. One of the methods for accomplishing this is the utilization of vertical radiators (antennas) of heights greater than currently available.

A conceptual study of unconventional methods for providing a vertical radiator of large heights was initiated in FY 1961. Phase I studies will cover antennas in the range of 3000 feet height; Phase II will consider heights in the range up to 3 miles, Concepts will be investigated as to feasibility with regard to practicability of construction, and economic factors involved. The Phase I study is currently underway and will be completed in June 1961. Desirability of further efforts in this field will be contingent on the results of this study.

F006-05 Visual, Optical and Infrared Communications

Modify Lens for AN/SAT-2 (U), SF006-05-7015. U. S. Naval Weapons Plant; Dr. S. G. Hall.

Modified optical assemblies are needed to increase the useful radiation output from the beacons which are part of Infrared Transmitting Set AN/SAT-2 and to eliminate a safety hazard. Several instances have been reported in which glass globes have shattered endangering personnel.

A preliminary design for a Fresnel lens of high temperature plastic has been prepared. The final design has been incorporated in a field change for all AN/SAT-2 beacons. The project is now complete.

Development of Infrared Filter for Signal Beacon (U), SF006-05-7017. Material Laboratory (NML), New York Naval Shipyard; Proj. No. 6201; S. Breitman.

This task is to install an infrared filter in a developmental daylight signalling beacon and evaluate for night time signalling. Two plastic windows and four glass Fresnel cylinders were coated with infrared filter material at the Portsmouth Naval Shipyard. It is planned to install the filters in beacons for evaluation at sea as soon as the present test schedules permit.

F007 DATA PROCESSING

F007-03 Analog Computers

Ship Design Automatic Computer, BUSAC 7 (U), SF007-03-2075. David Taylor Model Basin; Allot. 50169; J. H. Kenney, Code 236.

This task is part of a broad investigation for research and automation of ship design. It includes investigation and development of computing systems for automatic solution of combined ship design calculations. Phase I includes development of a computing system for combined hydrostatic calculations (curves of form, intact and damage stability, longitudinal strength). Phase II includes development for combined electrical-electronic calculations and machinery plant calculations. Phase III includes closed-loop digital to analog systems.

An efficient, highly reliable system suitable for direct use by the Naval Architects has been developed, permitting analog input of ship geometry. Pushbutton selection of internally wired programs and various inputs has been provided, permitting fast changes in programs.

Wave Resistance Simulation BUSAC 8 (U), SF007-03-2096. David Taylor Model Basin; Allot. 50169; C. W. Hoffman, Code 236.

In order to determine ship speedpower relations for new hull designs it is necessary to determine the wave making resistance of the proposed hulls. Present method is by model testing, which is expensive and time consuming and does not permit optimizing ship hull designs. Two dimensional simple models have been simulated giving excellent results.

Antenna Pattern Simulation BUSAC 9 (U), SF007-03-2097. David Taylor Model Basin; Allot. 50169; C. W. Hoffman, Code 236.

In order to determine types and locations of antennas aboard ship, it is necessary to determine the antenna radiation patterns. Present method is by model testing which is expensive and time consuming and does not permit optimizing antenna system designs. A simple antenna system radiation pattern has been simulated using analog computer techniques. Investigate and develop techniques and systems for simulating antenna radiation patterns by electrical-electronic means. Models of systems will be developed as necessary to determine system feasibility.

F007-04 Improved Converters

Data Conversion and Processing Techniques (U), SF007-04-7320. U. S. Navy Electronics Laboratory; Problem N4-9.

The purpose of this project is to establish a high order of technical capability in the fields of data conversion and processing by: (1) determining and developing techniques and circuits to obtain technical performance data in order to furnish consultation services to BUSHIPS and information suitable for preparation of equipment specifications for procurement purposes; (2) investigating techniques in terms of increased efficiency, rapid access, increased storage, maximum reliability, and environmental suitability. This includes work on magnetic circuitry, tapetron circuitry, ADCON and DACON equipment, semiconductor diodes and transistor devices.

High Speed D-A Converter (U), SF 007-04-7327. U. S. Navy Electronics Laboratory; Problem N4-9.

This project covers the design and development of a dual purpose high speed digital to analog converter which will provide for conversion of digital voltage information in both incremental and whole number form. Converter will be capable of accepting pulses at rates up to 6 megacycles and incrementally

converting these pulses by means of an up-down counter to analog voltage. At predetermined times, the counter will be cleared and digital whole number information from digital computer sources will be dumped into the counter for conversion to analog voltages. This solid state device will be applicable for supplying analog information to display equipment.

F007-05 Input-Output Devices

Integrated Flight Information (U), RF 007-05-0001. Douglas Aircraft Company, El Segundo, California; Nonr-1076(00) NR 228-001; H. L. Wolbers.

This task includes that portion of the Research Phase of the Army-Navy Instrumentation Program (ANIP) which is devoted to continuing research aimed at attaining an ultimate capability for the production of components for efficient and economical flight instrumentation and control systems for fixed wing aircraft.

F008 WEAPONS AND ORDNANCE

F008-01 Systems Analyses, Studies and Tests

Design Engineering, WF 008-01-015. Naval Weapons Plant; WO; George Neuman.

To develop processes and techniques and handbooks to aid designers in the area of parts and components to accomplish required performance and reliability. Reduce costs for test and evaluation of contractors submissions.

Analyze parts failure studies. Determine degree currently used testing methods are valid. Prepare handbooks which will include application data, evaluated and preferred components, and latest techniques and state-of-the-art. Establish feasibility of using commercial test laboratories in lieu of establishing qualified products list and testing of same.

Ordnance Ship Systems Compatibility, WF 008-01-017. Naval Air Engineering Facility (SI), Philadelphia, Pennsylvania; BuWeps - RSWI-3.

To develop through study and research imrpoved ship/airborne ordnance compatibility criteria for all aspects of airborne ordnance weapon system (less guided Missiles).

The size, weight and safety criteria of airborne ordnance dictate a continuing need for investigation of existing shipboard stowage and handling techniques and possible development of new criteria in order to meet individual ordnance requirements and specified OpNav delivery and aircraft loading rates. Ordnance design as well as shipboard environment are to be reviewed and studied in order to effect possible improvements in this area.

F008-03 Guidance

Shipboard Guidance Components, WF 008-03-002. Babcock Electronic Corporation, NEL, San Diego, California; Contract (New)(022) Allot. ( ); Hal Voeth, H. Bryan.

Design, develop and improve command guidance equipment for shipboard, fixed station, shore and aeronautical use. Design and develop supporting test equipment. Development objectives to meet shipboard requirements established by Ships Characteristics Board is of prime consideration in support of shipboard missile weapons systems. Develop new family of control equipment for operation in "C" band CNO recommended frequencies. OP Requirement SR-10701 applies.

New developments by industry and government activities will be required to meet shipboard standards. By utilizing the facilities of a BuShips Naval Testing Laboratory (NEL) and consulting services, fully qualified equipment for shipboard, fixed station, shore and aeronautical use will be realized in support of operational requirements established by Ships Characteristics Board and the Chief of Naval Operations.

F008-04 Fire Control

Digital Methods, RF 008-04-4501. U. S. Naval Research Laboratory, Washington, D. C.; R05-10, W. B. Poland.

The purpose of this task is to conduct studies of digital data processing systems, components, and circuits for Navy applications. Both circuit developments and studies for system design are being carried out under the project. Consultative services on digital methods are provided. Present work is mainly concerned with the transmission of digital data through noisy media.

Computer Mk 22 Developments, RF 008-04-4504. U. S. Naval Research Laboratory, Washington, D. C.; R05-13; C. H. Chrisman.

The Computer Mk 22 is an automatic digital relay computer used for automatic reduction of data in the operational evaluation of weapons systems. Addition of new components has increased the machine capacity; circuit modifications permit the simultaneous punching of output tapes and printing of output copy. Improved tape punches and readers have further reduced tape preparation time and provided for better verification of output tapes.

F008-09 Ballistics

Weapon Ordnance Ballistics, WF 008-09-001. NWL, Dahlgren, Allotment - 003, C. H. Wingo, Code KBB-1; NOTS, China Lake, Allotment - 004, E. F. Winkel, Code 4065; NOL, White Oak, Allotment - 005, F. J. DeMeritte, Code AE.

To conduct research in the Exploratory Development Area of Weapons and Ordnance, Ballistics, F008-09, established by OPNAVINST 3910.3 of 30 March 1959. In this area, supporting research is required to maintain or advance the knowledge sufficiently in aerodynamics, ballistics, and test and computing techniques to permit needed advances in weapon and ordnance design and performance, the adequate prediction of weapon dynamics, and preparation of reliable ballistic tables for increased speeds and altitudes of operation; also to support the ballistic aspects of weapon control design and

operation and the solution of weapon-aircraft compatibility problems involving weapon trajectory effects.

Wind-tunnels, aeroballistic ranges, and full-scale free-flight ranges are utilized to obtain aeroballistic data to support advances in ordnance design and improvement of aeroballistic theories and computing techniques. Data available from development and evaluation tests are used in developing analytical methods of predicting ballistics. Most of the work is accomplished by in-house efforts at the Naval Weapons Laboratory (NWL), the Naval Ordnance Test Station (NOTS), and the Naval Ordnance Laboratory (NOL). Work in these areas being conducted by other activities and contractors is monitored and the results utilized where applicable. Ballistic information is obtained whenever feasible in connection with other tests such as weapon compatibility and aircraft demonstrations.

F008-10 Weapon Effects

Analysis of Blast and Wave Effects on Waterfront Structures (U), Y-F008-10-005. NCEL; J. T. O'Brien.

The objective is to obtain data to improve the design of new piers and predict the likely behavior of various existing pier types subjected to dynamic loading by air blast and water waves from nuclear explosions.

Presently available information of air blast and water loading on waterfront structures is considered inadequate. Knowledge on water wave induced forces on a horizontal plate, e.g., a pier deck, is especially meager. Extensive studies are needed to determine the effects of such loadings.

Blast Resistance of Structural Shapes (U), Y-F008-10-102. NCEL; Appn. 17x1319 2504 RDT&E Bur. Control No. 10601; J. R. Allgood.

The objective is to provide precise information on the dynamic response of structures and structural elements. After testing structural elements and models in the blast simulator, the data will be compiled, analyzed, and interpreted to: verify or disprove existing theories; form the basis for assumptions of new theories, and serve as the basis for recommendation to be offered the designed.

Dynamic Load Testing of Prestressed Concrete Beams (U), Y-F008-10-102A. NCEL; (formerly reported under Y-F008-10-102); J. R. Allgood.

The objective is to determine how prestressed flexural members should be designed, how to gain the greatest resistance to blast loading, where they should be used, and the best way to destroy structures composed of such members.

Blast Resistance of Structural Connections (U), Y-F008-10-103. NCEL; Appn. 17x1319 2504 RDT&E Bur. Control No. 10601; H. R. Allgood, W. A. Shaw.

The objective is to obtain by means of blast simulator tests precise information on the dynamic response of structural connections to air blast loading. A series of connection specimens have been designed for loading in the blast simulator. Some connections and the auxiliary equipment necessary for testing have been fabricated.

The connection program consists of the dynamic testing of 23 welded portal frame knees, 15 beam-to-column connections, 3 column anchorages and 12 static tests. This pilot program is expected to indicate the resistance of connections subjected to blast loading as compared with the static load capacity. Also, some idea will be obtained on which type of connections are best suited for resisting dynamic loading and how the various connections might be modified to improve their capacity. Strain, acceleration, load, and reaction will be recorded and efforts will be made to determine the occurrence of local bukling. The series of 23 portal frame connections have been tested. The beam-column connections are being tested on a "fill-in" basis. These tests are scheduled for completion in June 1962. The report is tentatively scheduled for completion by March 1963.

Three Dimensional Blast Simulator (U), Y-F008-10-104. NCEL; J. R. Allgood.

The objective is to design, develop, fabricate and evaluate a 3-dimensional blast simulator which can simulate the pressure-time characteristics of a nuclear explosion over an area of at least 25-ft by 50-ft of a free field. An area source of high explosives and propellent will be used to generate shock waves up to 500 psi overpressures.

In the field of protective construction information on ground motion, soil-structure interaction, energy coupling and partition, and response of structures, elements and soils when subjected to transient loads is incomplete. This information can be obtained by testing above and below ground full-scale structures, structural elements and equipment in a 3-dimensional blast simulator.

Model Studies of Large Vented Openings (U), Y-F008-10-106. BRL/AFSWC.

The objective is to determine the optimum configuration of generator and equipment pits to afford the necessary protection to the generators and equipment against blast loading.

During recent full scale tests of personnel shelters, generator sets were exposed in generator pits to determine their resistance to air blast when the effects of dynamic (drag) pressures were eliminated. The potential advantages to be gained by placing the generators outside the protected area are considerable provided survival under these conditions can be assured. This assurance is necessary because proper operation of the generators after exposure to transient overpressures is essential for the survival of the occupants and continuation of the operational function of the shelter.

Model Studies of Soil Structure Interaction, Y-F008-10-108. NCEL; Appn. 17x1319 2514 RDT&E, Bur. Control No. 10601. J. R. Allgood, C. R. White.

The objective is to gain information which would serve as guidelines in the designs for "hardening" of sites and for the establishment of suitable theoretical techniques for the design of underground shelters. Approximately 30 tests will be required to study the effects of the following parameters: (1) flexibility of structure, (2) configuration of structure (including foundation), (3) ratio of structures span to depth of cover, and (4) soil environment of structure.

Dynamic Shear Studies on R/C Beams (U), Y-F008-10-110. NCEL; J. R. Allgood, W. A. Shaw.

The objective is to determine the shear resistance of reinforced concrete beams.

There are insufficient test data available on shear strength of reinforced concrete beams subjected to blast-type loads. The knowledge derived from the tests will permit safe and economical design of reinforced concrete beams, floor slabs, and wall panels.

Since there is no well defined testing procedure available, it is estimated at present that about twenty reinforced concrete beams will need to be tested. The parameters to be varied are the M/V ratio, the size of web reinforcement, the percent of tensile reinforcement, and the ultimate compressive strength of the concrete. The principle data to be recorded are: reaction and diagonal tension strain in concrete.

Blast Closure Valve Tests (U), Y-F008-10-111. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 10601; J. R. Allgood, E. N. Hellberg.

The objective is to determine the air flow and pressure drop characteristics, weatherability aspects, operational reliability of the triggering mechanism and blast resistance of existing and newly developed valves having merit.

Personnel protective shelters must be adequately protected from the overpressure of a nuclear detonation. To prevent interior structural damage and protect shelter inhabitants from overpressures entering the ventilation system, a fast-acting closure device at intake and exhaust duct openings of a ventilating system is required. In order to select the proper device for a particular shelter, it is necessary to know the air flow characteristics and the maximum dynamic overpressure resistance of the devices.

Basic Dynamic Properties of Various Structural Materials (U), Y-F008-10-401. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 10601; J. R. Allgood, W. A. Shaw.

The objective is to determine the dynamic properties of basic structural materials for which such data is lacking.

The design of structures to resist dynamic loads imposed by air blast and ground shock is often ultra conservative and other basic properties of many construction materials are unknown. Some experimental data has been obtained regarding the increased yield point of various grades of reinforcing steel subjected to high rates of strain. Better definition of this behavior is desired. Similarly, the dynamic properties of aluminum, plastics and other structural materials should be determined to aid the engineers in designing adequate but economical blast resistant structures.

Fundamental Behavior of Soils Under Time-Dependent Loads (U), Y-F008-10-402. NCEL, Appn. 17x1319 2504 RDT&E Bur. Control No. 10601, C. R. White; Rensselaer Polytechnic Institute, NBy-32195.

The objective is to establish the principles required for the evaluation of the effects of the interaction of foundation soils and structures subjected to transient foundation loading, particularly in regard to the design of underground shelters.

A beam and column device has been prepared for receiving a dynamic load in the blast simulator and transmitting it to a plate on soil in the pit below the simulator. A series of plate bearing tests has been completed on a dry cohesionless soil and the initial results indicate that the increase in bearing capacity of soil for dynamic loads is small. A specially instrumented triaxial compression cell was prepared for studying the effects of rapidly applied, high magnitude loads on the shearing strength of soils. A dry, cohesionless, silty sand was used for the tests. The pneumatic rapid load machine designed by MIT was used for loading. Stresses up to 100 psi were developed in the soil specimens. Rise times were on the order to 0.05 seconds.

The first series of dynamic triaxial shear tests has been completed. Cohesive soils will be studied later.

F008-11 Safety

Power Sources for Actuated Devices, WF 008-11-001. NOL, White Oak, Allotment - 017, B. White (Code WE); NOP, Macon, Allotment - 018, Allotment - 020, Allotment - 024, J. L. Pertsch (Pd270); NWL, Dahlgren, Allotment - 019, Allotment - 021, Allotment - 022, R. I. Rossbacher (Code WC); NOTS, China Lake, Allotment - 023, J. Sherman (Code 4543).

Supporting Research, Development, Product Engineering, Pilot Production, Qualification, Documentation and Malfunction investigation of Navy power cartridges in "across-the-board" applications including pilot escape systems, missile components, stores delivery and various miscellaneous items of weapon systems.

Research - Material research is planned on a continuing basis to keep up with extended environmental exposure and use requirements. New applications of explosive energy are defined and feasibility established.

Development - Development of cartridges and ballistic components is tailored to specific requirement for end applications with particular attention to adapting devices to use standard cartridges or to developing new cartridges of foreseeably broad application.

Evaluation - Product engineering, pilot production, qualification and documentation are intended to support service availability of readily produced ordnance of highest quality and widest possible use. Malfunctions are promptly and thoroughly investigated with respect to possible design, production or servicing inadequacies.

F008-18 Armament Handling Equipment

Handling Equipment and Techniques, WF 008-18-004. NOMHL, NAD, Earle, New Jersey, RSWI-81, K. E. Nyboe; NADC, Johnsville, Pennsylvania, RSWI-82, J. Mayhew; NATC, Patuxent River, Maryland, RSWI-82, J. Mayhew; NASWF, Albuquerque, New Mexico, RSWI-82, J. Mayhew; Contractor - Unknown, RSWI-8, G. Geyer.

A continuing requirement exists for the design, development and evaluation of new and/or improved weapons handling equipment to assure economical, reliable, rapid and safe handling of weapons throughout their logistical flow from manufacturer, through

the inland and coastal depots, and to the ultimate user. New concepts of handling equipment and techniques must be developed to maintain a level of proficiency which could be expected with our new aircraft and new shipboard launching systems. Standardization of handling equipment and techniques is of paramount importance. The long range objective is to develop an integrated weapons handling program to attain the maximum rate of weapons handling possible.

F008-21 Weapons Components and Equipment

General Usage Components and Parts, WF 008-21-001. Applied Physics Laboratory, Howard Co.; NOL, White Oaks; Contractors not determined.

Research, development and test for parts and components having general usage in naval weapons systems. These parts and components are electrical, electronic, mechanical and hydraulic which provide advantages in weapon systems design as to performance, cost, weight, size, reliability.

Exploit solid state and other advanced technologies to provide the objective advantages.

Precision Instrument Components (U), WF 008-21-002. Naval Avionics Facility, WO, Dale Taque; Naval Ammunition Depot, Crane, WO, Vernon Yeager; Contractors - not yet selected: Bendix, Ketay, Kearfott, Minneapolis-Honeywell, and others.

Develop precision instrument components for weapons control systems; develop new and improved precision rotating components for data transmission and computation; ally new concepts, processes and materials; measure failure rates and assign reliability figures to precision rotating components. Procure advanced commercial components; test and evaluate to ascertain commercial state of the art to supplement Navy development.

Review Naval Weapons systems programs and ascertain needs to fulfill other Navy requirements for precision instrument components. Review present and projected applications for possible incorporation of advanced commercial components. Redesign components as necessary to meet Navy requirements.

F009 GUIDED MISSILES

F009-01 Systems Analyses, Studies and Tests

Simulators/Components GM System Evaluation (U), WF 009-01-002. Naval Air Development Center, Allot. (048), H. G. Tremblay; Reeves Instrument Corporation, NOw 60-0339c (047), Dr. L. Bauer.

To provide facilities for performing essential investigations of weapon system parameters, including the solution of problems relating to the design of weapon control systems.

The Bureau of Naval Weapons cannot economically provide funds for the installation of simulation facilities at each of the contractor's plants where such facilities are required for performance of the contract. The Aeronautical Computer Laboratory, NADC, Johnsville, and Project CYCLONE, Reeves Instrument Corporation are centrally supported to provide computation facilities more economically.

These facilities have been engaged in the solution of problems as they are assigned, in the review of computing techniques, development of new techniques, and the mechanization of these techniques in the form of hardware to keep the facilities up to date.

Air Launched Weapon Systems Investigations, WF 009-01-009. NOTS, China Lake, California, Allotment; NADC, Johnsville, Pennsylvania, Allotment; NOL, Corona, Allotment; NMAC, Pt. Mugu, California, Allotment.

To conduct investigations, studies and exploratory research leading to providing the Fleet with the most advanced air launched weapons.

Conduct investigations, studies and exploratory research by selected BuWeps field activities in the areas of: (1) Air to Surface Tactical Strike Weapons; (2) Air to surface Nuclear Strike Weapons; (3) Anti-Air Warfare Weapons; and (4) General Support of New Missile Program Studies. This work will consist of two phases of effort, namely: (1) study and analysis, which consists of the support of qualified research groups in the appropriate areas and the necessary paper studies, and (2) Experimental Verification, which consists of building and testing of experimental hardware to prove out the more promising concepts evolving from the study and analysis phase.

F009-05 Launching

Missile Launcher Components and Techniques, WF 009-05-001. Ford Instrument Company, NOw-60-0160-C, Mr. V. Ordorica; Northern Ordnance, Inc., NOw-60-0017-C, Mr. G. A. Kane; Northern Ordnance, Inc., NOrd-19127, Mr. H. Randolph; Franklin Institute, New Sub-Task, Mr. R. Hollinger.

Research and experimental development of new concepts, methods and devices pertaining to power drives and automatic control systems for Guided Missile Launching Systems, for the purpose of increasing effectiveness, reliability, safety, ease of maintenance, uniformity and economy.

Theoretical study and analysis, laboratory models and bread-board tests, development of experimental models for shipboard tests and evaluations. This task is continuous and includes a variety of individual applied research and evaluation sub-tasks which are handled through contracts or task assignments to suitable industrial or Government research activities under RMLG-14 supervision.

F009-07 Structures

Missile Structural Dynamics, WF 009-07-001. Applied Physics Laboratory; NOrd 7386 (027); Dr. William Avery.

To support BuWeps plans for missile programs by insuring that missile and target engineering design and analysis techniques are available in order to optimize both new versions of established weapon systems and advanced weapon systems.

Theoretical and experimental investigations will be conducted on aeroelasticity and flutter problems under transient heating for new versions of existing missiles and targets. Design criteria for

structures for Mach 5 to 10 missiles will be developed. Studies directed to optimizing overall missile design will be undertaken. Data obtained will be promulgated as general and specific design specfications.

Missile Structures Materials, WF 009-07-002. Colorado School of Mines, NOrd 16136 (028), Gordon Poole; Georgia Institute of Technology, NOrd 17175 (030), Jessie Walton; Naval Ordnance Laboratory, Corona, Allot (031), Charles Haber; General Electric Company, NOW-60-04650 (032), William Sutton.

To support BuWeps long range plans for missile programs by insuring, through supporting research, that high temperature (1500°F to 4000°F) missile structural materials will be available to translate Mach 5 to 10 missile designs into hardware.

Supporting Research will be conducted on refractory metals such as molybdenum for use as airframe and structural components at temperatures (1600°F and above) where steels cannot be used. Ceramics for use as leading edges and diffuser components for use at 3500°F in air will be developed. Very high strength whiskers (2,000,000 PSI) will be used to reinforce high temperature metals such as molybdenum to produce composite materials that at high temperatures (2000°F) will have attractive strength-weight ratios. Plastics (non-organic polymers) that can be used for electronic application at temperatures over 1000°F will be developed.

F009-10 Ballistics

Missile Aerodynamics, WF 009-10-001. Naval Ordnance Laboratory, White Oak, Allot (034), Dr. I. Korobkin; Naval Ordnance Test Station, Allot (039), Mr. L. Doig; Applied Physics Laboratory, NOrd 7386, Dr. L. Cronvich.

To support BuWeps long range plans for future generation missile programs by insuring, through supporting research, that aerodynamic techniques are developed for flight in speed ranges from Mach 2 to 10.

Supporting research will be conducted on aerodynamic shapes to determine answers to foreseen problems of missiles which will be initiated in the one to five year future. Theoretical investigations will utilize, to a large extent, high speed computers. Experimental techniques which will be utilized include wind tunnels, ballistic ranges and free-flight testing. New facilities and techniques will be explored and developed.

F009-12 Safety

Weapon System Safety, WF 009-12-001. Naval Weapons Laboratory, Dahlgren, Virginia; Allot (001); Mr. H. Overman.

To conduct research and development to disclose unsafe conditions and provide design criteria and standards to minimize occurrence in future engineering design.

Conduct research and development relative to the safety aspects of Surface Weapons Systems and Air Launch Weapons System. Perform analytical analysis of weapon systems logistics and operational events for safety considerations. Conduct research and development and tests, studies, investigations, relative weapon hazards and unsafe conditions affecting personnel and material. Provide technical information on matters of safety to Bureau agencies. Establish standards for safety of personnel and material.

F009-20 Guided Missile Electrical Equipment

Power Generation and Distribution (U), WF 009-20-001. Naval Research Laboratory, 27-566, RAAE-53; NADC (AEEL), 27-202, RAAE-52/53; NBS, 27-881, RAAE-52; Industry, Various, RAAE-52/53.

To develop electric power generating, conversion, distribution and control systems required to meet the needs of missile application. Particular emphasis to be placed on reliability, storage and life.

F011 OTHER NAVAL DEFENSE APPLICATIONS

F011-05 ABC Defense

Radiac Support Investigation (U), SF 011-05-6003. Naval Radiological Defense Laboratory, Al. 178/RDT&EN 61.2411, Mr. K. Sinclair; Naval Research Laboratory, P.O. 1-0001/RDT&EN 61.2411, Mr. J. Hoover; Naval Material Laboratory, Al.171/RDT&EN 61.2411, Mr. J. McGreevy.

The purpose of this Task is to investigate the various areas within the radiac program, independent but in support of other Tasks; to provide information for the development of new radiac equipments to meet the rapidly increasing requirements; and to improve present equipments to more fully meet existing requirements.

Laboratory-Field Equipment for Radioactive Assay (U), SF 011-05-6005. Naval Material Laboratory, Al 171/RDT&EN 61.2411, Mr. J. McGreevy; Naval Material Laboratory, Al 171/RDT&EN 61.2411, Mr. J. McGreevy; Naval Material Laboratory, Al 171/RDT&EN 61.2411, Mr. J. McGreevy; Naval Material Laboratory, Al 171/RDT&EN 61.2411, Mr. J. McGreevy; Commercial, unassigned.

The purpose of this task is to investigate and develop equipment and procedures for determining the degree of radioactivity of various types of samples normally requiring laboratory type facilities and techniques to accomplish the measurement.

Radiac Component Test Equipment (U), SF 011-05-6006. Material Laboratory, Al 171/RDT&EN 61.2411, Mr. McGreevy; Material Laboratory, Al 171/RDT&EN 61.2411, Mr. Adelman; Electronics Products Company, NObsr-77555, Dr. F. Brandt; Commercial, Unassigned.

To investigate and determine valid testing techniques for new radiac and photo-multiplier tubes used in radiac equipment. One developmental model of a portable radiac tube tester and photomultiplier tube tester have been constructed by the Laboratory. Four service test models of the radiac tube tester based on the developmental model have been purchased, one model of which is undergoing tests at Material Laboratory. It is planned that four service test models of a photomultiplier tube tester will be procured for service test evaluation.

Portable Radiac Survey Equipment (U), SF 011-05-6007. Naval Research Laboratory, P. O. 1-0001-RDT&EN 61.2411, Dr. Freidman; Naval Radiological Defense Laboratory, Al.178/RDT&EN 61.2411, Mr. K. Sinclair; Naval Radiological Defense Laboratory, Al.178/RDT&EN 61.2411, Mr. K. Sinclair; Naval Radiological Defense Laboratory, Al.178/RDT&EN 61.2411, Mr. K. Sinclair; Naval Radiological Defense Laboratory, Al.178/RDT&EN 61.2411, Mr. K. Sinclair; Tracerlab, Incorporated, NObsr-75947, Mr. P. Street; Anton Electronic Labs, Inc., NObsr-72625, Mr. E. Willie; American Machine and Foundry Company, NObsr-77552, Mr. T. Calio; Naval Material Laboratory, Al.171/RDT&EN 61.2411, Mr. A. Clark; Commercial, unassigned.

The purpose of this task is to develop new and improved portable Radiac Survey to meet Naval requirements such as:

Alpha, Beta, Gamma Survey Equipment - Wide range investigation of instrumentation needed to detect, identify, and evaluate atomic radiation.

Neutron Survey Meter - Technical assistance provided to Bureau of Ships contractor in use of Van de Graaff accelerator to provide calibration points for neutron detector.

Wide Range Survey Equipment (Formerly B5 Problem 4, low range beta - gamma survey equipment). Equipment to consist of small, basic, high range gamma radiacmeter (NRDL RGI-20) using recycling ionization chamber, with auxiliary probes to cover low range and other functions. Model of RGI-20 completed. Preliminary design of beta skin-dose probe completed; development of low range probe begun under B5 Problem 1. Future - Complete development, evaluate against other approaches to high range, low range, and wide range problems.

Radiac Tubes (U), SF 011-05-9427. Naval Material Laboratory, Prob. 1103-1-19.82, Mr. R. Decker; Naval Material Laboratory, Prob. 1103-1-19.83, Mr. R. Decker; Naval Material Laboratory, Prob. 1103-1-19.84, Mr. R. Decker; Naval Material Laboratory, Prob. 1103-1-19.85, Mr. R. Decker; Naval Material Laboratory, Prob. 1103-1-19.86, Mr. R. Decker; Naval Research Laboratory, Prob. S-1515, Dr. Clark; Naval Research Laboratory, Prob. S-1696, Dr. Chubb; University of Maryland, NObsr-77522, Dr. R. Morgan; Anton Electronic Laboratories, Inc., NObsr-77600, Mr. M. Youdin; Anton Electronic Laboratories, Inc., NObsr-77623, Mr. M. Youdin.

The purpose of this Task is to investigate, develop, and evaluate new and improved radiation detection tubes.

Development of Radiac Parts (U), SF 011-05-9630. No Contractor, laboratory, or investigator.

This project covers the development of components specifically intended for application in radiac equipments, where the small size, low current and high voltage are the prime consideration.

Thermal and Radiological Damage Control, SF 011-05-1725. NAVRADLDEFLAB; 50178/RDT&E 61.2411; P. H. LaRiviere.

The purpose of this Task is to conduct research applicable to the establishment of a doctrine for radiological defense at sea, and to develop methods, procedures, equipment and materials for the implementation of such doctrine.

Development Tests at Sea, SF-011-05-1727. NAVRADLDEFLAB; 50178/RDT&E 61.2411; M. M. Bigger.

This Task provides development and evaluation tests at sea of methods, procedures, systems, equipment and materials for Fleet radiological defense.

Modification of Free Fields by Ships (U), SF 011-05-0501. U. S. Naval Radiological Defense Laboratory, San Francisco 24, California; 50178 RDT&EN 61.2411 MIPR DASA 529-61; H. R. Rinnert, B. W. Shumway, J. P. Hurley, E. Tochilin, N. E. Scofield, H. A. Howe.

To determine the modifying influence exerted by ships on free-field effects of nuclear weapons in protecting against gamma and neutron radiation, and effects of radioactive contamination.

Develop AW Techniques and Instrumentation (U), SF 011-05-0503. U. S. Naval Radiological Defense Laboratory, San Francisco 24, California; 50178 RDT&EN 61.2411 MIPR 529-61; H. R. Wasson, H. A. Zagorites, E. J. Wesley, A. Redmond, N. E. Ballou.

To develop techniques and instrumentation required for the prosecution of research in nuclear weapons effects.

Operational and biological data were reviewed to determine the directional and energy response requirements for high range radiacs and the means by which compliance should be determined. In addition, a number of in-service Radiac Sets were obtained and tested for their present and potential radiation measuring capabilities.

A highly-efficient plastic-lined ultrafilter was developed.

Roof Washdown Systems (U), Y-F011-05-201. NCEL, NRDL; Appn. 17x1319 2514 RDT&E Bur. Control No. 70601; E. N. Hellberg.

The objective is to develop design criteria for roof washdown systems for radiological decontamination and to determine the performance characteristics and effectiveness of typical systems on roofs of various slopes and materials.

Cold Weather Decontamination (U), Y-F011-05-202. NCEL, NRDL, Nuclear Defense Laboratory, Engineering Research and Development Laboratories, Cook Electric Company; Appn. 17x1319 2514 RDT&E Bur. Control Nos. 70601 and 25/70696; J. Maloney (NDL).

The objective is to develop suitable AW decontamination materials, techniques and equipment for use in cold weather with the temperature down to -10°F.

An existing plan of recovery has been established for land target complexes (Radiological Recovery of Fixed Military Installations, TP-PL-13). The problems of operation of the principles of TP-PL-13 under adverse weather conditions (winter conditions) were not analyzed in this publication. It is necessary to determine the effects of cold weather upon the operation of the basic recovery plan, in order to outline major problem areas most likely to be encountered, and to point out areas where experimental work is necessary for augmenting existing decontamination information.

Limited cold weather decontamination tests were conducted in March and April 1960 at Fort Greely and Point Barrow, Alaska. During these trials, the

roof washdown system, fire hosing and a street sweeper were tested and evaluated. These results were incorporated in the interim cold weather supplement to TP-PL-13 (draft completed).

Tests are being conducted in the NCEL cold chamber on the roof washdown system and equipment decontamination to fill the gaps where information is lacking.

Radiological Decontamination Sweeper (U), Y-F011-05-203. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 70601; W. R. Nehlson.

The objective is to develop and/or evaluate a motorized pavement sweeper capable of picking up and retaining fallout material until suitable disposal can be made.

Presently, no equipment is available with the capability of sweeping, retaining and protecting the operator in radioactive operations in paved areas. The Cole-Vac airfield vacuum sweeper was investigated and found to be unsuitable for this type of sweeping. Investigations by NRDL showed that the Tennant Model 100 street sweeper had several of the necessary features and had possibilities of being modified to accomplish the specified work. The Air Force is accomplishing this work. Continued appraisals of Air Force progress in this development will be made. In view of the Air Force development and a re-appraisal of Navy requirements, no development will be undertaken and a report summarizing operational requirements, technical information, adaptabilities of available sweepers, and appraisal of the Air Force sweeper will be made for such future need or action as the Navy may determine.

Radiological Consulting Services (U), Y-F011-05-205. NRDL; BuDocks Program Officer.

The objective is to receive from the NRDL consulting services, as required, on problems relating to radiological decontamination, radiation shielding and shelter habitability.

The NRDL has provided technical services during FY 1961 to the NCEL on matters pertaining to cold weather decontamination and roof washdown systems.

Fire Protection of Naval Shore Installations in Atomic Warfare (U), Y-F011-05-330. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 70601; E. N. Hellberg.

The objective is to develop feasible fire prevention criteria and techniques to minimize the hazard of and to control fires resulting from enemy attack.

Shelter Habitability Experimentation (U), Y-F011-05-331. U. S. Naval Research Laboratory, NMRI; Appn. 17x1319 2514 RDT&E Bur. Control Nos. 25/70696/701 and 70610; D. E. Ramskill.

The objective is to conduct experiments in a shelter with human subjects to determine CO_2 and temperature levels and other environmental factors, including psychological and physical effects on these personnel who are confined in a shelter for a certain period of time.

Such information is urgently needed for sound evaluation of our shelter schemes. Accordingly, BuDocks is sponsoring a program to obtain experimental data on shelter habitability. The Naval Medical Research Institute will give medical support to NRL, who will supervise these experiments in a Navy ammunition storage magazine modified for use as a personnel shelter. CO, CO_2 and temperature levels would be measured as well as other environmental factors. Psychological and physiological effects on human subjects confined in the shelter would be observed and recorded.

A contract is expected to be let during this quarter to erect the underground personnel test shelter at the U. S. Naval Medical Center, Bethesda, Maryland and is scheduled for completion by 1 August 1961.

Water Seals for Dynamic Loaded Buried Concrete Structures (U), Y-F011-05-332. NCEL; investigators not assigned.

The objective is to develop a satisfactory method for water sealing a buried reinforced concrete structure which may be subjected to a transient overpressure loading.

Current publications in the field of "Protective Shelter Construction" recommend that wherever possible the foundations for protective structures should be designed to allow punching shear action of the structure through the surrounding soil. Thus, differential displacements between the foundation footings and the floor slab are permitted. To prevent inundation, the structure must have effective seals.

It is planned to determine the dynamic elongation characteristics of commercially available waterseal materials by incorporating the currently accepted methods for waterproofing concrete structures into the design of concrete model structures which would be subjected to transient loadings in the blast simulator. If the currently available waterseal materials do not satisfactorily withstand the transient loading tests, development of appropriate waterseal materials will be initiated.

Fenestral Sprinkler System, Y-F011-05-334. NCEL; J. C. King.

The objective is to develop feasible fire prevention criteria and techniques to minimize the hazard of and to control fires resulting from enemy attack.

Susceptibility of Naval Installations to Sustained Fires Resulting from Nuclear Weapons (U), Y-F011-05-335. Factory Mutual Research Corporation, Norwood, Massachusetts; Appn. 17x1319 2514 RDT&E Bur. Control No. 25/70696; J. B. Smith.

The objective is to determine whether, outside the area of significant blast damage, there does exist a problem relative to ignition and sustained burning due to primary thermal radiation. Also, if a problem does exist, make recommendations to effectively reduce the susceptibility of Naval installations to sustained burning. Further, to develop suggestions as to specific avenues for future studies toward the solution of these problems.

A number of related studies have been conducted with different objectives in mind. To date, no definitive information has been developed to indicate that ignition of structural fires by thermal radiation is in fact a major problem outside the area of significant blast damage. A contract was awarded to the Factory Mutual Research Corporation

to make this operations research type study which will present some of the information in terms of probability of primary initiation and sustained burning.

Protective Construction Against Thermal Radiation (U), Y-F011-05-336. NCEL.

The objectives are to improve the understanding of ignition of construction materials from both high temperature (nuclear weapons) and low temperature (conflagration) thermal energy; to develop surface treatments which inhibit ignition and fire spread; and to classify conventional materials for their resistance capabilities.

Ground Motion Effects on Underground Structure Contents (U), Y-F011-05-401A. NCEL; investigator not assigned.

The objective is to determine the effects of ground motion on personnel and equipment, and to determine possible methods to reduce these effects.

The basic work done to date consists of measurements of ground motion during nuclear weapons effects tests, and theoretical studies regarding the problem. Much of this work is summarized in BuDocks Technical Study 27 which includes a bibliography of pertinent information.

Shielding Manual, Y-F011-05-402. NCEL; Appn. 17x1319 2504 RDT&E Bur. Control No. 10601; Lt(JG) L. K. Donovan.

The objective is to develop mathematical formulae, graphs, and tables based upon available scientific data on nuclear shielding for inclusion in a shielding manual on nuclear defense construction. The end product desired is a Shielding Manual for Nuclear Defense Construction.

It is understood that both OCDM and AFSWC are compiling data which would go into such a manual and this work must be investigated before further action can be taken in this area. Upon completion of this coordination an appropriate technical manual will be written.

Test of German Shelter Components (U), Y-F011-05-403. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 70601; E. N. Hellberg.

The objective is to test and evaluate shelter equipment developed and recommended by ARTOS Machinery Co., a German firm, for use in protective shelters.

As a result of recent full-scale tests and information provided by ARTOS Machinery Co., it was evident that certain German shelter components have merit and should be further evaluated for possible use in our shelter systems. Of particular interest is their sand filter which appears to have some value for filtering air and has the characteristics of resisting air blast from a nuclear weapon and thermal effects of a fire storm or near-conflagration.

F012 AIRCRAFT AND AIRCRAFT SUPPORT

F012-01 Systems Analyses, Studies and Tests

Viscous Flows (U), RF 012-01-0002. Mississippi State University, Starkville, Mississippi, Aerophysics Department; Nonr 978(01), NR 212-006; J. Cornish.

A theoretical and experimental study in viscous aerodynamics aimed at drag reduction, increased lift, propulsion improvement and stability augmentation especially at low speeds. This is a continuation of the investigation of the potential of combining a high lift and low drag suction boundary layer control system through the medium of two experimental research vehicles.

It has become apparent that the results obtained in the investigation of suction boundary layer control are sufficiently understood to warrant actual, practical application to a research vehicle specifically designed to embody the principles thus far delineated.

Shrouded Propellers (U), RF 012-01-0003. University of Wichita, Wichita, Kansas, Department of Engineering Research; Nonr 201(01), NR 212-007; V. O. Hoehne.

This task is an extension of the research program on shrouded propellers being conducted at the University of Wichita. The completion of the experimental program consists of mass flow and velocity surveys, tip clearance runs on a model with a 0.4 hub and fuselage interference runs. Analysis of these experimental runs and the formulation of selection procedures and application studies from the great mass of data collected throughout the program are being made.

Circulation Control and Flow Visualization (U), RF 012-01-0004. Princeton University, Princeton, N. J., Aeronautical Engineering Department, Subsonic Aerodynamics Laboratory, Forrestal Research Center; Nonr 1858(14), NR 212-011; D. C. Hazen.

This task is a theoretical and experimental research program of determining the aerodynamic factors involved in the dynamic response of aircraft in low speed flight. A substantial part of the work performed is in systematizing and critically evaluating available technical information together with theoretical and experimental data produced under the task in the field of subsonic aerodynamics. A most demanding aspect of this work is the requirement to fully understand the physical situation or basic problem in order to intelligently apply a satisfactory mathematical treatment.

"Vertodyne" VTOL Aircraft (U), RF 012-01-0008. Vertol Aircraft Corporation, Morton, Pennsylvania; Nonr 2364(00), NR 212-051; W. Z. Stepniewski.

The feasibility of utilizing ducted fans submerged in wings to achieve VTOL aircraft characteristics was investigated.

Theory for both hovering and forward flight was developed in order to facilitate a correlation of data and the prediction of performance. Wing-submerged ducted fan data from all available sources were used in the correlation. A significant advance in understanding of wing submerged and ducted fans has been made by this unified correlation which permits performance prediction for similar models.

Two-Place Inflatoplane (U), RF 012-01-0009. Goodyear Aircraft Corporation, Akron, Ohio; Nonr 1860(00), NR 212-065; T. Blair.

The purpose of this program was to design, construct, and flight test a light weight, two-place aircraft of pneumatic material, capable of being collapsed into a small package that would accommodate a light weight container suitable for airdrop delivery.

Feasibility of design and construction of a two-place inflatoplane as an extension to the one-place research aircraft has been proven. Numerous successful test flights were performed by the contractor.

Tilting Wing/Propeller VTOL Research Vehicle (U), RF 012-01-0010. Vertol Aircraft Corporation, Morton, Pennsylvania; Nonr 2136(00), NR 212-067; W. Z. Stepniewski.

The objective of this task is to design, fabricate, and flight test a research vehicle, employing the tilt-wing principle to achieve VTOL capabilities.

Deflected Slipstream VTOL Research Vehicle (U), RF 012-01-0011. Ryan Aeronautical Company, San Diego, California; Nonr 2139(00), NR 212-068; F. Landgraf.

The original task was to design, fabricate, and flight test a piloted full scale research vehicle employing propeller slipstream deflection principle to achieve direct ascent capabilities and in flight conversion to forward flight configuration. The task was later changed to add full scale wind tunnel testing prior to actual flight testing of the vehicle. Following an accident, involving the test vehicle on 13 February 1959, the contract was again amended to include rebuilding and reconditioning of this test vehicle.

Aircraft Design Information (U), RF 012-01-0014. Smithsonian Institution, Washington, D. C.; Nonr 1354(05), NR 212-080; L. Carmichael.

Advisory services as provided to the Naval Applications Group on long range plans for the aeronautical research program. Expert assistance also is provided for short periods of time to conduct special intensive studies on pertinent subjects.

Propeller Slipstream Analysis (U), RF 012-01-0015. Vehicle Research Corporation, Pasadena, California; Nonr 2388(00), NR 212-087; S. Rethorst.

This investigation is obtaining extensive ranges of analytical data on total lift and its spanwise distribution for wings extending through propeller slipstreams, including solid boundary effects. This work has treated airfoils at high angles of attack such as are encountered in tilt wing and deflected slipstream V/STOL vehicles. The current program extends this treatment to account for flow separations from the wing surface exterior to the slipstream. Solutions are obtained by electronic computations employing the modified Rethorst-Wu lifting surface theory for nonuniform flow. Results are expressed as parametric charts of lift characteristics over a range of flow conditions beyond the scope of existing analyses.

One-Place Inflatoplane (U), RF 012-01-0016. Goodyear Aircraft Corporation, Akron, Ohio; Nonr 2368(00), NR 212-088; B. Bain.

The original task specified that the Goodyear Aircraft Corporation would develop ten one-place inflatoplanes, constructed of pneumatic material, with inflation and deflation characteristics and capable of being air-drop delivered. During the course of development it became evident that numerous modifications and improvements were required to provide the Services with a safe and practical air vehicle. Such work is presently being conducted to incorporate these recommended improvements.

A Theoretical Study of Ground Effect Machines (U), RF 012-01-0017. Aerophysics Company, Washington, D. C.; Nonr 2747(00), NR 212-089; G. D. Boehler.

Analytical investigations are being performed of the flow fields about certain types of aerodynamic devices operating in close proximity to the ground or water. Of primary interest is the annular jet type ground effect machine (GEM), but work on analysis has begun of the flow field and resulting aerodynamic forces on a conventional wing operating in ground effect. Efforts on the annular nozzle are concentrated in the forward flight regime, because the hovering case is fairly well understood.

Investigation of Induced Velocity of a Lifting Rotor (U), RF 012-01-0018. Georgia Institute of Technology, Atlanta, Georgia, Aeronautical Engineering Department, Georgia Tech Research Institute; Nonr 991(05), NR 212-091; W. Castles, Jr.

This task is a theoretical investigation of the distribution of air-loads along helicopter rotor blades. Usable theory and procedure for calculating vortex strength coefficients and obtaining corresponding induced velocity distributions are being developed. Included are the effects of induced power required for a lifting rotor on performance. An attempt is being made to correlate the theoretically computed data with air-loads and stresses obtained from existing experimental data.

Airship Boundary Layer Control (U), RF 012-01-0019. Mississippi State University, Starkville, Mississippi, Aerophysics Department; Nonr 978(02), NR 212-094; J. Cornish, III.

This program involves basic research in the fundamentals of airflow behavior on present fleet airships and studies on how these airships may be improved by the application of geometric modifications and/or the concept of suction to control the boundary layer.

Intermittent Jet Mixing (U), RF 012-01-0021. Hiller Aircraft Corporation, Palo Alto, California; Nonr 3082(00), NR 212-099; R. M. Lockwood.

This program is an attempt to establish the basic mechanisms involved in the transfer of momentum and energy to an ambient fluid from an intermittent jet. The work involves development and use of satisfactory test equipment and techniques to reveal the nature of intermittent jet efflux in the presence of a concentric duct surrounding the exhaust stream as well as developing a mathematical, semi-empirical model to be employed in analyzing this unsteady mixing process. It is anticipated the current efforts will provide improved shapes of lightweight thrust augmentors and will be able to

determine the limits of variation away from pulse-jet wave forms which will still exhibit satisfactory performance gains over steady flow ejectors.

Investigation of Rotor Blade Stall Flutter in Forward Flight (U), RF 012-01-0022. Massachusetts Institute of Technology, Cambridge, Massachusetts, Aeronautical Engineering Department; Nonr 1841(58), NR 212-100; R. H. Miller.

This task critically examined the factors which limit the maximum permissible angle of attack on a retreating helicopter rotor blade. An experimental investigation was conducted on the stall flutter of such rotor blades in forward flight.

Stall flutter was found to occur in all forward flight cases involving appreciable blade stall, and consisted almost entirely of blade motion in the torsional mode. The results of the study indicated that more information is required regarding the torsional aerodynamic damping of stalled rotating blades.

Investigation of Airloads Acting on a Lifting Rotor (U), RF 012-01-0023. Vertol Aircraft Corporation, Morton, Pennsylvania; Nonr 2811(00), NR 212-101; R. G. Loewy.

This task was part of a program to theoretically and empirically determine the distribution of airloads acting on helicopter rotor blades in various flight conditions. This particular study examined the requirements and problems associated with the measurement of unsteady air pressures on model rotor blades in wind tunnels.

Airloads Pressure Transducer Research (U), RF 012-01-0024. Bell Helicopter Corporation, Fort Worth, Texas; Nonr 2877(00), NR 212-102; R. Lynn.

This task is part of a program of exploration into means of determining accurately the flow field through lifting rotors. This portion is investigating new and novel methods and materials for devising a pressure transducer of unique properties and simple nature. Such a transducer could be used as a research tool directly on the blades of rotary-winged aircraft or in other applications calling for high frequency response pressure units.

Ducted Fan Flow Study (U), RF 012-01-0025. Therm Incorporated, Ithaca, New York; Nonr 2859(00), NR 212-103; A. Ritter.

This task is directed toward both theoretical studies and experimental correlations to secure a detailed understanding of the overall flow field within and adjacent to a ducted fan. Effects of various geometric parameters and their interactions are being investigated by variation of these parameters in their mathematical representations as well as in experimental test models.

Annular Ejector Tests (U), RF 012-01-0026. Hiller Aircraft Corporation, Palo Alto, California; Nonr 2840(00), NR 212-104; M. F. Gates.

An investigation of the thrust augmentation of a full-scale annular ejector. Having demonstrated the potential gains in augmentation of the annular configuration, and having verified their gains by preliminary experiments with a full scale test rig employing turbojet engine exhaust, it is now necessary to extend the work in order to establish optimum ground effect configuration. In addition, the effect of refinements to the full scale test rig is being evaluated to reflect the finding of small scale tests.

Two-Dimensional Jet Mixing (U), RF 012-01-0028. Fairchild Engine and Airplane Corporation, Hagerstown, Maryland; Nonr 2858(00), NR 212-106; H. B. Helmbold.

This task is an investigation of the basic phenomenon of turbulent momentum and energy transfer from a bounded jet to an adjacent free stream. Variations in gross velocity profiles throughout the mixing region are introduced by restrictions resulting from the presence of the surface and pressure gradients in the flow direction. This program is obtaining experimental evidence of velocities and turbulence parameters for two specific flow situations: the mixing jet bounded by a plane solid surface under constant pressure in the parallel stream and a similar plane, bounded jet passing a region of negative pressure. The initial phase of the work consists of controlled-turbulence wind tunnel modification, instrumentation, and calibration as well as initial tests of the constant pressure configurations. Supporting analytical studies attempting to describe the mixing process by correlation of turbulence parameters and mean flow conditions are conducted concurrently.

Carrier Flight Operation Study (U), RF 012-01-0029. Dunlap and Associates Incorporated, Stanford, Connecticut; Nonr 2869(00), NR 212-107; H. E. Blank, Jr.

This study has provided recommendations for planning toward improvement in operational effectiveness and safety on aircraft carriers with primary emphasis on the human factors involved. Limits of the study were restricted to flight operations.

Co-Axial Jet-Air Mixing (U), RF 012-01-0030. Convair, Division of General Dynamics Corporation, San Diego, California; Nonr 2854(00), NR 212-108; J. Shue.

In order to establish a valid basis for the design of mechanisms involving co-axial jet mixing, the contractor is attempting to develop a practical theory of turbulent mixing by means of realistic mathematical models with appropriate experimental verification and support. This theory would eventually allow a quantitative prediction of the velocity, temperature, and pressure profiles involved in the mixing process, including the effects of boundary conditions and axial pressure gradients.

Ring-wing Research (U), RF 012-01-0031. Grumman Aircraft Engineering Corporation, Bethpage, Long Island, New York; Nonr 2922(00), NR 212-109; R. A. Scheuing.

The step into the supersonic regime for the investigation of ring-wing shapes is a natural extension of the subsonic work. This contractor has developed a simple theoretical method for calculating supersonic lifting characteristics for the ring-wing and has verified his results experimentally for a few cases.

Internal Flow Study of Ground Effect Machines

(U), RF 012-01-0032. Vehicle Research Corporation, Pasadena, California; Nonr 3058(00), NR 212-110; S. Rethorst.

This investigation consists of theoretical and experimental analyses of internal flows in ground effect machines (GEMs). The theoretical analysis considers the momentum flux through and the losses sustained in a systematic and generalized family of inlets, diffusers, turning vanes, connecting passages and nozzles. Experimental techniques are used to explore problem areas, to yield data on aspects of the problem not amenable to analytical treatment, and to confirm the theoretical results through quantitative force measurements. The analysis includes both plenum and annular jet type vehicles.

The Matching of Propulsion Systems to the Ground Effect Machine (U), RF 012-01-0033. AiResearch Manufacturing Company of Arizona, Phoenix, Arizona; Nonr 3024(00), NR 212-111; L. W. Norman.

This work involves a parametric study of the matching of propulsion systems to the ground effect machine and its mission. All parameters which affect the power plant/GEM matching process are taken into consideration in the analysis. When vehicle weight, size, planform, endurance, hovering height, and velocity are varied over a wide range, the necessary installed horsepower is computed for the optimum propulsion system. Methods for optimizing the propulsion system for any GEM mission will be presented.

Steady-Flow Ejector Investigation (U), RF 012-01-0034. Lockheed Aircraft Corporation, Georgia Division, Marietta, Georgia; Nonr 3067(00), NR 212-112; J. F. Sutton.

This task is directed toward providing information which will improve the reliability of predicting thrust augmentation for ejector application to aircraft and ground effect machines. The program is both analytical and experimental with emphasis on tests to be made using a new test rig of great flexibility.

Investigation of Special Ground Effect Machine Configuration (U), RF 012-01-0035. Hiller Aircraft Corporation, Palo Alto, California; Nonr 3023(00), NR 212-114; M. F. Gates.

This investigation resulted in the evaluation of two special ground effect machine configurations which have excellent potential for economical high speed forward flight. Both theoretical and experimental studies have been included in the program to determine the performance, and stability and control characteristics of these GEM configurations in hovering and in forward flight.

Consideration is being given to extending this task to permit a more complete evaluation of the potential of the configurations under consideration.

Ground Effect Machine Structures (U), RF 012-01-0036. Ryan Aeronautical Company, Lindbergh Field, San Diego, California; Nonr 3068(00), NR 212-115; D. L. Marlin.

It is the purpose of this task to study the structural problems of ground effect machines, and to derive preliminary structural design criteria which may be used to define the probable weight and cost of basic structure to be employed in a large family of GEMs. It is thought, for example, that GEMs for some possible applications will use aircraft materials and construction techniques, while others will be structurally more akin to surface vehicles.

The first report has been a general one, covering the full span of structural activities from the development of the mission description to the calculation of structural weights. The investigation has included a "first look" at the structural requirements of ground effect machines in various categories from the small, high performance reconnaissance carrier to the large ocean-going transport.

Wind Tunnel Tests of Ground Effect Machine Models (U), RF 012-01-0037. University of Wichita, Wichita, Kansas, Engineering Research Department; Nonr 201(03), NR 212-116; C. A. Foltz.

This task involves tunnel tests which will produce a large amount of force data on a total of 24 geometric configurations of annular jet type ground effect machine models, plus a great many points of pressure data on ground plane, base plates and upper model surfaces.

Ground Effect Machine Morphology Study (U), RF 012-01-0038. Bell Aircraft Corporation, Buffalo, New York; Nonr 3074(00), NR 212-113; H. Mankuta.

This study compared the potential performance of ground effect machines as determined from existing data and concurrent research with the desirable accomplishment of a number of possible military missions. Areas of operation in which the principle of Ground Effect Machine may prove particularly useful for performing such missions have been analyzed in an attempt to delineate the detailed design problems which must be solved to adapt the Ground Effect Machine to practical use. Initial information was collected from other research investigators and from potential military users of such machines. This information, with continuing modifications based on new research results, will be used to form study matrices of mission requirements and significant vehicle parameters. Integration of these matrices will then present a preliminary representation of the optimum configuration for performance of the specified mission.

Swept Wing Characteristics (U), RF 012-01-0039. Vidya, Incorporated, Palo Alto, California; Nonr 3103(00), NR 212-117; A. H. Sacks.

This combined experimental and theoretical task is intended to study the separated flow phenomena encountered on highly swept or delta wings and slender body configurations at large angles of attack. The study began with a literature survey to establish a physically realistic and mathematically consistent model to be employed in the analysis. The purpose of this analysis is to calculate the positions and strengths of the separation vortices over the wing or body surface and thereby determine the pressure distributions, forces, and moments on the surface. An associated experimental study in a small deep-water tank will provide a check for the vortex calculations and will indicate

the form of the landing vortex patterns for other high-speed planforms.

Development of Methods for Predicting V/STOL Aircraft Characteristics (U), RF 012-01-0040. Vehicle Research Corporation, Pasadena, California; Nonr 3099(00), NR 212-118; S. Rethorst.

An investigation to analyze and develop mathematical procedures including curves, tables, ratios, and/or nomographs by which the efficiency, performance, weight and power characteristics of VTOL/STOL aircraft configurations can be predicted from the basic design parameters of the aircraft under consideration.

Analysis of GEM Operation over Water (U), RF 012-01-0041. Pneumodynamics Corporation, A subsidiary of Cleveland Pneumatic Industries, Incorporated, Bethesda, Maryland; Nonr 3179(00), NR 212-119; R. D. McVey.

An investigation is being conducted of the physical processes which govern the general over-water stability and control characteristics of Ground Effect Machines, directed toward the development of criteria which will provide general design guidance with respect to stability and control. In particular, the investigation includes the general problem of stability, including response to a generalized forcing function, and the effect on the vehicle of annular jet interaction with a deformable surface.

GEM Stability and Control (U), RF 012-01-0042. AiResearch Manufacturing Company of Arizona, Phoenix, Arizona; Nonr 3173(00), NR 212-120; L. W. Norman.

This work involves an analytical study to determine the effect of various GEM design and operating parameters on the response characteristics of the vehicle. Included in the study is an investigation of gyroscopic effects with regard to system damping. Test work has been initiated to obtain damping coefficient data for various parameters. System characteristics during vibration in the vertical mode and about the center of gravity are being measured.

Combined Spanwise Boundary Layer Control (U), RF 012-01-0043. Ryan Aeronautical Company, San Diego, California; Nonr 3174(00), NR 212-121; F. G. Wagner.

This combined experimental-analytical task is intended to obtain quantitative data on combined suction and blowing high lift BLC systems distributed spanwise on a wing planform. Systematic testing of a series of two-dimensional airfoil sections is being performed in an instrumented smoke tunnel, and results correlated with available or extended applicable theory. Optimum configurations will be chosen and employed in a three-dimensional semi-span model to be extensively investigated in a large scale wind tunnel. The information obtained will be directed toward the prediction of optimum characteristics of such a combined BLC system in sufficiently general form for application to a wide variety of aircraft planforms.

Behavior and Loading of GEM's in Waves (U), RF 012-01-0044. Netherlands Ship Model Basin, Wageningen, Netherlands; N 62558-2570, NR 212-122; G. Vossers.

It is the purpose of this task to obtain and evaluate experimental measurements of the stresses on two ground effect machine models while ditching in still water and in various wave conditions. Vertical and longitudinal accelerations are being measured. One of these models is also being tested, floating in waves at zero speed. Wave heights in all tests will be chosen in such a way that wave dimensions up to sea state 5 will be simulated.

GEM Propulsive Screen (U), RF 012-01-0045. Vehicle Research Corporation, Pasadena, California; Nonr 3207(00), NR 212-123; S. Rethorst.

This investigation consists of an analytical study of a diffuser shaped ground effect machine. The GEM model is being formulated in parametric terms and both the sustaining and propulsive forces calculated. The parameters are to include the diffuser configuration of the plenum chamber, the width and mass flow of the jet, the inward and rearward angle of disposition of this jet as a function of forward speed, and the machine performance attained thereby as a function of power required. Experimental and model techniques are being employed to explore problem areas, to yield data on aspects of the problem not amenable to analytical treatment, and to confirm the theoretical results.

Skyhook-Aerotriever Techniques (U), RF 012-01-0046. The Robert Fulton Company, Newtown, Connecticut; Nonr 3218(00), NR 212-124; R. E. Fulton, Jr.

The contractor is providing consultation services and equipment and is conducting experiments to test and demonstrate the feasibility for tactical use of in-flight pick-up and retrieval equipment such as the Fulton Aerotriever. Under an earlier task, the Aerotriever was developed and successfully demonstrated as an entirely new concept in air/sea rescue technique.

Rotating Cylinder Flap (U), RF 012-01-0047. Stanford University, Stanford, California, Department of Mechanical Engineering; Nonr 225(54), NR 212-127; F. R. Arnold.

This task is an attempt to determine the characteristics of a high-lift trailing edge device consisting of a rotating cylinder with spanwise axis interposed between a fixed airfoil and a deflected flap. Such a device would act as an economical and mechanically practical means of achieving the large angular changes in the direction of air flow, such as might be required in deflected slipstream or direct-lift VTOL and STOL aircraft. The program consists of a theoretical investigation of the potential performance of the rotating cylinder flap and experimental tests to determine the predicted aerodynamic characteristics and power requirements of a rotating cylinder flap applied to airfoil section models of VTOL and STOL configurations.

Investigation of Three-Dimensional Boundary Layer Separation (U), RF 012-01-0048. Bureau Technique Zborowski, Brunoy, France; N62558-2526, NR 212-128; E. A. Eichelbrenner.

This task involves an analytical and empirical investigation of the three-dimensional boundary

layer and the separated region at both the leading and trailing edges of an annular wing. Attempts are being made to develop a mathematical model, with supporting wind tunnel tests, of the significant portions of the flow fields about rather general annular wings at various angles of attack. A limiting case of this analysis is the two-dimensional infinite wing. Since the primary area of interest in this study is the three-dimensional boundary layer, preliminary tests and analysis are being performed with ellipsoids of both circular and elliptical cross section.

F012-03 Propulsion

Test and Evaluation - Aircraft Engines (U), WF 012-03-010. NATTS; In House Work.

This is a continuing task under which research, test, evaluation and development of large gas turbine engines and component systems are assigned to NATTS in support of the overall Naval aircraft power plant program. In general, the work consists of studies, evaluations, calibrations, qualification tests and investigations of large gas turbine engines and components.

Test and Evaluation - Aircraft Engines (U), WF 012-03-010. NAMC (AEL); In House Work.

This is a continuous task under which research, test, evaluation and development of reciprocating and small gas turbine engines and accessories, bench test of all engine accessories, test evaluation of propellers, fuel and lubricant research are assigned to AEL in support of the overall Naval aircraft power plant program. During Fiscal Year 1960, AEL completed work on 51 assigned projects and submitted 172 technical reports. Approximately 70% of the laboratory's effort was directed towards gas turbine applications while 30% was directed towards reciprocating engine applications. The work consists of: studies, evaluations, calibrations, qualification tests and investigations of small turbojet engines, turboprop, turboshaft and reciprocating engines, engine components, auxiliary power plants, engine accessories, propellers, fuels, lubricants and contaminants.

F012-05 Aircraft Support Equipment

Aircraft Fire Fighting Research and Equipment, WF 012-05-004. U. S. Naval Research Laboratory, Washington, D. C.; 566; Mr. D. F. Dreesen.

This project includes the study and investigations of all methods, materials and equipment which show maximum efficiency in the extinguishment of fires in and around aircraft on the ground. The design, development and test of new types of fire fighting materials and equipments.

Various formulations of foam concentrates are being produced to aid in the speed of control of crashed fuel fires. New domestic materials for quelling magnesium fires are being studied and evaluated.

Extensive development in the field of dry chemical extinguishing agents have been made and reported. Successful field results have been obtained with compatible dry chemical and potassium bicarbonate type powder. A powder for universal fire extinguishing requirements is being developed and evaluated. Engineering design parameters have been laid down by Naval Research Lab experimentation program, this work is continuing with useful naval air activity equipment implementation.

Continued surveillance of new methods and materials for combatting aircraft fires.

F012-06 Launching and Retrieving

Aircraft Carrier Catapult Development, WF 012-06-004. E. W. Bliss Company, NOw 60-0102-c, RSSH-21, BuWeps; Reaction Motors Division, Thiokol Chemical Corporation, NOas 60-6100-c, RSSH-21, BuWeps; Naval Air Engineering Facility (SI), Philadelphia, Pennsylvania, Allot. 200, CO, NAEF(SI), Philadelphia; Naval Air Test Facility (SI), Lakehurst, New Jersey, Allot. 204, CO, NATF(SI), Lakehurst.

This task covers the design, development, test and evaluation of aircraft carrier catapult equipment, systems, and/or components including automatic aircraft positioning and bridle arrester systems.

Aircraft Carrier Arresting Gear Development, WF 012-06-005. Douglas Aircraft Company, PR 4810-010-1, RSSH-22, BuWeps; Republic Steel Company, PR 4420-070-1, RSSH-22, BuWeps; E. W. Bliss Company, PR 4810-036-1, RSSH-22, BuWeps; Naval Air Engineering Facility (SI), Philadelphia, Pennsylvania, Allot. 200, CO, NAEF(SI), Philadelphia; Naval Air Test Facility (SI), Lakehurst, New Jersey, Allot. 204, CO, NATF(SI), Lakehurst.

This task covers the design, development, test, and evaluation of aircraft carrier arresting gear equipment, systems, and/or components.

Development of Landing Mat for Short Airfield for Tactical Support (SATS), WF 012-06-007. Naval Air Engineering Facility (SI), Philadelphia, Pennsylvania; Allot. 200; CO, NAEF(SI), Philadelphia.

This program covers the design, development, test, and evaluation of landing mat and associated support equipment for short airfield tactical support equipment for use by Marine expeditionary forces.

Aircraft Launching and Recovery Accessories Development, WF 012-06-008. Naval Air Engineering Facility (SI), Philadelphia, Pennsylvania, Allot. 200, CO, NAEF(SI), Philadelphia; Naval Air Test Facility (SI), Lakehurst, New Jersey, Allot. 204, CO, NATF(SI), Lakehurst.

This task covers the design, development, test, and evaluation of new configurations, materials, and fabrication techniques for the production of aircraft launching and recovery accessories and includes government effort to evaluate the suitability of contractor-developed accessories for aircraft launching and recovery.

Design, engineering, and statistical efforts are performed by the Naval Air Engineering Facility (SI), NAMC, Philadelphia. Dynamic and operational test of aircraft launching and recovery accessories is conducted by the Naval Air Test Facility (SI), Lakehurst, New Jersey.

Shipboard Compatibility of Aviation Systems, WF 012-06-009. Naval Air Engineering Facility (SI), Philadelphia, Pennsylvania; Allot. 200; CO, NAEF (SI), Philadelphia.

This task covers the design and engineering effort required to insure the shipboard compatibility of aviation support systems, including fueling, servicing, handling, repair and operational support. It includes studies of the effects of shop layouts, personnel areas, command spaces, and servicing facilities within the hull configurations of aviation ships. It also includes engineering services, equipment mock-up, and field studies as required. Major effort is currently applied to "Dash" support, crash handling, and electronic servicing requirements. This task is performed by the Naval Air Engineering Facility (SI), NAMC, Philadelphia, under the direction of the Bureau of Naval Weapons.

F012-11 Electrical Equipment

Electric Power Generation, Distribution and Lighting (U), WF 012-11-001. National Bureau of Standards, 45-881, RAAE-53; Naval Research Laboratory, 45-566, RAAE-52/53; NAMC (ACEL), 45-200, RAAE-53; NADC (AEEL), 45-202, RAAE-52/53; NATC (WST), 45-201, RAAE-52/53/54; Industry, various, RAAE-52/53.

To develop aircraft electric power generating, converting, distribution and lighting systems required to meet the needs of future and service aircraft. Particular emphasis to be placed on high reliability, maintenance-free systems.

F012-12 Integrated Instrumentation and Displays

Integrated Flight Information (U), RF 012-12-0001. Douglas Aircraft Company, El Segundo, California; Nonr 1076(00), NR 213-010; H. L. Wolbers.

This task and Project RF 007-05 are closely coordinated. Together they comprise the fixed wing aircraft portion of the Research Phase of the Army-Navy Instrumentation Program (ANIP). The work includes human factors studies to optimize displays and controls, the examination of systems requirements, determination of the proper division of effort between the pilot and the automatic portion of the system, the specification of areas of research for advanced components, and experimental determination of the utility of advanced displays and controls.

Helicopter Instrumentation, RF 012-12-0002. Bell Helicopter Company, Fort Worth, Texas; Nonr 1670(00), NR 213-014; O. Q. Niehaus.

This task and Project NR 228-000 are closely coordinated. Together they comprise the helicopter/VTOL portion of the Research Phase of the Army-Navy Instrumentation Program (ANIP). The work includes human factors studies to optimize displays and controls, the examination of systems requirements, determination of the proper division of effort between the pilot and the automatic portion of the system, the specification of areas of research for advanced components, and experimental determination of the utility of advanced displays and controls.

Transparent Phosphors (U), RF 012-12-0003. Libby Owens Ford Glass Company, Brackenridge, Pennsylvania; Nonr 2552(00), NR 213-017; J. Ogle, Jr.

The contractor is studying the feasibility of using interference filters in combination with transparent phosphors. The phosphors will be deposited by evaporation under a high vacuum and baked at a high temperature.

Man-Machine Information Center (U), RF 012-12-0005. Documentation, Incorporated, Washington, D. C.; Nonr 2718(00), NR 213-023; E. Miller.

The contractor porvides an information and analysis service in the area of man-machine systems for aircraft, submarines, and surface ships. The service is designed to meet the needs of project engineers responsible for research tasks in the ANIP, SUBIC, and SURIC programs. The service applies the contractor's Uniterm indexing method, automated to include machine storage and retrieval.

F012-14 Aircraft Hydraulic and Mechanical Components

Hydraulic, Pneumatic, and Mechanical Components, WF 012-14-001. Various contractors, various, RAAE-3; Office of Naval Research, 48-567, RAAE-34; Naval Air Material Center, 48-200, RAAE-3; Naval Avionics Facility, Indianapolis, 48-311, RAAE-34.

The development and evaluation of improved concepts of system design and improved equipments in the hydraulic, pneumatic and mechanical component areas as required to support aircraft development. Test and evaluation of equipment and components developed by Industry to determine their suitability for use in production aircraft.

Contract with Industry and initiate projects at Government activities for the development and test of improved systems and equipment. Provide design disclosure resulting from these developments to airframe and equipment manufacturers; and establish appropriate specifications to implement the results in production aircraft. Test Industry-developed components proposed for use on production aircraft to determine compliance with established specifications and suitability for release.

F013 SHIPS AND SUBMARINES

F013-01 Systems Analyses, Studies and Tests

Thermoelectric Air Conditioning and Refrigeration (U), SF 013-01-1900. Westinghouse Electric Corporation, NObs-77095, J. D. Meess; Carrier Corporation, NObs-77112, G. D. Hudelson; RCA, NObs-77123, J. R. Andersen; Whirlpool Corporation, NObs-77128; R. L. Eichhorn; York Corporation, NObs-78356; U. S. Naval Engineering Exp. St., Whirlpool Corporation, NObs-84050, R. L. Eichhorn.

Westinghouse, NObs-77095 - A 1 ton capacity chilled water-sea water air conditioning unit has been completed. Tests being conducted to determine the suitability of the design for submarine use.

Carrier, NObs-77112 - Work completed. Shows

present state of art makes T/E air conditioning feasible and practicable on submarines. Basic T/E modules built and tested confirming studies and also leading to a compact and efficient design for an air-water cooling coil.

RCA, NObs-77123 - A 1 ton capacity chilled water-sea water air conditioning unit completing. Tests being conducted to determine suitability of the design for submarine use. Model tests have proved satisfactory efficiency.

Whirlpool, NObs-77128 - Work completed. Shows T/E refrig. practicable for submarine frozen and chilled stores. Basic T/E modules built and tested prove results of the study and lead way to suitable design of shipboard system. NObs-84050 - Just beginning to build actual submarine system for test and evaluation.

York Corporation, NObs-78356 - Work completed, consisting of studies of improved food stowage methods for future design, making full use of advantages of T/E.

Electrostatic and Electromagnetic Pumps and Propulsion (U), SF 013-01-1901. Research-Cottrell; NObs-77164; M. Robinson.

The theory of "electrostatic wind" principle has been further developed and applied to model blowers. There are basic limiting factors which limit the practical application of the principle. The principle one is spark-over, which limits the voltage which can be applied.

Development of new principles is being carried out under F-01306-05. When feasibility has been established, development into practical devices will be attempted under this task.

F013-03 Hull Structural Mechanics

Transverse Strength of Ships Hull Framing (U), SF 013-03-1966. David Taylor Model Basin; 50169; Dr. R. Bart.

Establish a design procedure for the analysis of the transverse framing in hull structures. Present methods treat a frame as an isolated ring. This ring analysis, by its very nature, must be programmed for automatic machine calculation. In addition, the mechanism of isolating a ring makes the analysis overconservative and results in too much dead structural weight. Major effort in this task is to monitor British efforts in this field and use their test data and results to develop an IBM704 type solution to transverse frame analysis. Additional model tests will probably be necessary in FY 1963 to verify the computer program. Full scale measurements will also be made under docking block loads where loads are applied directly to the frames and also remote from the frames.

Strength of Plate Panels in Compression (U), SF 013-03-1968. David Taylor Model Basin; 50169; Mr. L. A. Becker.

The present design curves for panels in compression have not been verified for HY-80 and STS steels and are incomplete for the aluminum alloys. Little work has been done on complete stiffened panels and design methods for them are meager. Stiffened panels of HTS material only have been tested.

The buckling and ultimate strengths of welded and non-welded 6061-T6 aluminum have been determined. Each plate was simply supported on all four edges and loaded in edge compression. Ultimate strengths of non-welded plates were 2 to 15% less, depending on b/t ratio, than those obtained by present Bureau design procedures. Ultimate strengths of welded plates were 0 to 30% less depending upon location of welds.

Panels of 5000 series aluminum alloy, HY-80 steel and higher yield steel plates as well as stiffened panels still remain to be tested.

Stress Concentrations in Plates and Shapes with Internal Discontinuities (U), SF 013-03-1970. David Taylor Model Basin; 50169; Mr. J. S. Brock.

It is necessary to establish a method for analyzing the effect of openings (discontinuities) in loaded plates and to develop a design procedure for minimizing the effect of these openings. Analytical solutions have been obtained for stresses around unreinforced square and rectangular holes with rounded corners for all "in-plane" loadings. A solution has also been obtained for stresses around two adjacent holes in a tension field. These results have been verified experimentally.

Steel plates with square holes with varying sizes of rounded corners have been tested at Webb Institute; experimental stresses agreed very well with the theoretical stresses.

A report will be written on analytical studies on reinforced square openings. In addition, experimental work must be done to verify the analyses. Analytical and experimental work on other common hole shapes and reinforcements will also be done.

Stress Concentrations Due to Discontinuities in Tanker Longitudinals (U), SF 013-03-1971. David Taylor Model Basin; 50169; Mr. J. S. Brock.

Stress concentrations in the vicinity of stress raisers were determined in a photoelastic model of the longitudinal connection of a Navy oiler. The stress concentrations due to hard spots of the longitudinal connection were not excessive and were less than those at the drain hole. A second model designed to simulate the type of oiler longitudinal which failed in service was tested to determine the feasibility of using photoelastic techniques to determine the ultimate strength of full-scale structures. The results of this investigation indicate that scaled photoelastic models of structures may be used on design problems to indicate relative merits of various designs. Also shown was the acceptability of the joint detail. Further studies in stress concentrations will be made under Task 1970.

Investigation of Keel Block Loads (U), SF 013-03-1972. David Taylor Model Basin; 50169; Mr. J. S. Brock.

A knowledge of the keel-block loads during drydocking is important in the design of docking members of ships, particularly where stern overhang is large. Keel-block loads have been measured on five aircraft carriers and a destroyer. A simple method of predicting keel-block loads has been developed. On USS FORRESTAL (CVA 59), the maximum stresses did not occur at the aftmost block, and the difference in temperature between night and day had an

appreciable effect on the distribution of loads. The same differences may occur if the drydock is supported by piling rather than by solid rock. To determine this difference, USS BENNINGTON (CVA 20) was docked on hard blocks in a drydock built on solid rock. The report of the BENNINGTON tests will be completed and published. The method used for calculating the docking loads will then be evaluated for appropriate changes.

Wave Forces and Strains in Ships at Sea (U), SF 013-03-1973. David Taylor Model Basin; 50169; Dr. N. H. Jasper.

Statistical distribution patterns have been established for wave heights and for motions and hull girder bending moments for specific hull forms. Methods for predicting characteristic and extreme values of motion have been developed and in part verified by test. It has been shown, from sea tests on the USS ESSEX and by theory, that forces incident to bow flare immersion may produce severe "whipping" stresses in a limber hull. A method has been developed and coded for an IBM 704 which will give the response of a ship to any variation of force in time and longitudinal location with allowance for the time-varying vitural mass coefficients. Verification of theoretical studies must still be accomplished before a design procedure is evolved. It is planned to conduct further detailed studies on model scale, starting with a hydroelastic model of the ESSEX. Further, an analog computer "model" of the ESSEX will be "run" through various seas at various speeds to determine dynamic hull bending moments.

Ultimate Strength of Welded Structures (U), SF 013-03-1974. Lehigh University, Department of Civil Engineering; Nonr 610(03); principal investigator varies.

Analytical and experimental work on welded steel structures and their components in order to verify the theory of limit design and to develop design methods applicable to surface ship structures. Work is supported about equally by BuShips and private bodies (American Institute of Steel Construction, American Iron and Steel Institute, Column Research Council, Welding Research Council and Lehigh University). Results to date have proved the validity of using the full plastic reserve strength of steel for setting factors of safety in framed structures. Still to be proven is the applicability of ultimate strength to plates and shells as found in Navy ships. Tests and analysis of stiffened plates are now underway.

First test results show that ultimate strength of plating under axial loading is not significantly affected by the presence of normal loads of the magnitude found in ordinary surface ship design. A gross panel, consisting of stiffeners and plating, is affected by the presence of normal loads. Response is like that of a beam-column. Tests are continuing.

Shock Resistance of Shipboard Foundations (U), SF 013-03-1975. N. M. Newmark, Consulting Engineer; NObs 72432; N. M. Newmark.

Study various types of equipment foundations used aboard ship with respect to parameters concerning shock resistance and develop simplified methods for foundation design. Of particular importance is the design of submarine equipment foundations to resist near-miss shocks. At the same time minimum weight and construction costs must be considered.

The contractor surveyed equipment weights and sizes, reviewed existing shock design criteria and has developed improved design methods. Experience from related projects has been brought to bear on the problem. These include work on blast and earthquake loadings at the University of Illinois, studies of foundations by Bishop Engineering Company, shock design studies at the Naval Research Laboratory, and results of full scale underwater explosion tests, reported by David Taylor Model Basin and others.

Strength of Plate Panels in Shear (U), SF 013-03-1976. Lessells and Associates, Incorporated; NObs 72290; Mr. F. C. Bailey.

Test and evaluate metallic panels loaded in simple shear to determine the elastic buckling and ultimate load carrying capacity of plated structures. Tests on unstiffened panels have been completed and reported. A theory which predicts plate centerline stresses for plates with two parallel clamped edges has been evaluated. Shear stresses as much as 20% higher than nominal stresses have been measured. This difference is explainable and the theory appears sound. Specimens subdivided by elastic boundaries (stiffeners) are being prepared for tests. The stiffened panel will be closer to actual hull construction practice and should lead to realistic design criteria.

Intermediate Scale Model Tests (U), SF 013-03-1977. University of California, Department of Naval Architecture; NObs 77109; Professor H. A. Schade.

Use intermediate scale (about 1/10 size) models to investigate and correlate with theory the influence of structural details on the overall structural design of ships' hulls.

One of the major deficiencies in experimental hull stress analysis is the inability, due to cost, of conducting full scale hull bending tests. With the exception of some full scale tests in 1945 and earlier, only small scale model tests have been made for overall hull bending problems. These models limit the use of any fine structural details which may, in an actual situation, govern the hull design. To alleviate this difficulty, a program of intermediate scale model testing will be pursued. By using approximately 1/10 scale models, most significant details can be accounted for and included in the tests. Construction of the large basic hull model and its test jig has begun. The first tests will concern the deckhouse and the main hull girder interaction with particular attention being paid to the connection details. Tests should begin in the summer of 1961.

Socketed Joints for Rudder Stocks to Rudder Hubs (U), SF 013-03-1978. David Taylor Model Basin; 50169; Mr. L. A. Becker.

Develop design criteria for tapered stock-to-yoke and stock-to-hub connections by means of model tests.

Background: Previous designs of control-surface assemblies incorporated a ratio of length of taper

to stock diameter of two. Recent designs used a length-diameter ratio as low as one. The length of stock taper required for optimum design and the minimum acceptable length-diameter ratio is to be determined experimentally. No rational basis for designing these socketed fits is available.

A model has been built and loaded in pure bending with variations in stock penetration, yoke thickness, and relief. Testing has been completed for penetrations of one diameter and one-half diameter. Preliminary results indicate that the one-diameter penetration has definite design possibilities, while bearing stresses are very high with the one-half diameter penetrations.

Plate Panels Under Normal Loads (U), SF 013-03-2001. Southwest Research Institute, Department of Structural Research; NObs 78725; Thein Wah.

This project will provide the experimental effort to verify the theories of Clarkson and Young of the United Kingdom and Wah of the U. S. on the plastic design of plates under normal loads. These tests will aim at verifying or modifying assumptions on effects of membrane tensions in the middle plane of the plate and loading into the plastic range, unloading and then reloading. The output of the program will be design curves for the ultimate strength of ship plating. The test specimens have been made and the test jig is being fabricated. Tests should begin in the Spring of 1961. About 48 plates will be tested. Plate material will be MS, HTS and HY-80. Aluminum plates may be added to the program.

Welded Aluminum Columns (U), SF 013-03-2002. Material Laboratory, New York Naval Shipyard; 50171; principal investigator varies.

This task has been established to answer problems in structural design of welded aluminum columns. Specifically, an experimental program was needed to determine the effect of weld joints on the buckling and ultimate strengths of various aluminum alloys columns. The heat affected weld zone has the effect of making a non-homogeneous column. In addition, normal construction practice produces column eccentricities which affect column response. The effect of column straightening will also be studied. Some tests have been run but test jig difficulties and material problems have delayed further significant tests.

Minimum Weight Analysis Techniques for Ship Structures (U), SF 013-03-2008. David Taylor Model Basin, contract not assigned; Private Industry, contract not assigned.

The efficient design of a hull structure for a prescribed external loading and geometric configuration depends upon the stress level to which the components are designed. For structures designed for compression and shear loads, greatest efficiency can be achieved if the design stress level of the plate-stiffening system can properly approach the yield strength of the material used.

Due to buckling considerations which generally prevail for shear and compressive loads, it is necessary to employ some stiffening arrangement to properly support the plating. Since the plating performs contouring and sealing functions in addition to load transmission, the relative distribution of structure between the plating and stiffening systems as well as the geometric arrangement of the stiffening system can be varied to achieve minimum weight designs for prescribed loading indices. It is noted that the loading index combines the external loading and geometric features in a convenient form for minimum weight investigations.

F013-08 Auxiliary Machinery and Equipment

Photosynthetic Gas Exchangers (U), RF 013-08-0003. General Dynamics Corporation, Electric Boat Division, Groton, Connecticut; Nonr 2753(00), NR 266-007; A. Bialecki.

This study of photosynthetic gas exchangers is based on a requirement for providing a self-contained closed cycle air revitalization system for submarines. It combines the elimination of carbon dioxide with the production of oxygen through the use of algae cultures. Investigation is being conducted to determine the characteristics and requirements of steady-state, continuous culture systems and to obtain data for calculating the parameters for a full-scale shipboard unit. A test unit equal to the respiratory requirements (O^2 and CO^2) of one man is used. Light energy is supplied by tubular, high-intensity tungsten lamps. Highly turbulent, dense cultures will effect light-dark illumination of the culture for maximum utilization of visible light.

Oxygen-Carrying Membranes (U), RF 013-08-0004. Polytechnic Institute of Brooklyn, Brooklyn, New York; Nonr 839(27), NR 266-008; H. P. Gregor.

This task comprises fundamental research on the oxygen-carrying properties of polyelectrolyte-metal chelate complexes. These complexes are studied in solution form and in the form of insolubilized films or membranes. Studies include evaluations of the thermodynamic equilibria for oxygen uptake as well as rate studies. The objective of these studies is the preparation of synthetic systems, one of which would act to catalyze the reaction between carbon dioxide and water, and the other would act as a carrier for oxygen. A study of oxygen-carrying membranes is of fundamental importance as an analogue of biological oxidation-reduction and gill systems; it may lead also to processes for the practical extraction of dissolved oxygen from sea water for use in underwater craft, and for specific decontamination and control systems in space capsules.

F013-10 Shock Resistance

Shock Strength of Materials SF 013-10-1791. U. S. Naval Research Laboratory; PO-1-0001; I. Vigness and H. Forkois.

The objective of this task is to determine and evaluate the factors which influence the resistance of materials to shock loadings.

During the past year studies were made to determine the influence of bolt hole chamfering on the dynamic shear strength of bolted joints. The Class HI shock machine was used to dynamically load the test joints and the relationship between chamfer size and bolt size was investigated. Analysis of data is not yet complete; however, preliminary

results show some shear strength benefit from chamfered joints. A final report will be published in the near future.

Shock Mitigation of Equipment, SF 013-10-1795. American Machine and Foundry, Greenwich, Connecticut; NObs 78963; A. Burns.

The purpose of this task is, using information developed by other related phases of this project, to develop methods and procedures for the proper selection and design of shock mounts for shipboard installations.

Work under this contract is approximately 50 percent complete. A design guide will be prepared, covering the dynamic fundamentals of shock isolation, introduction to isolator selection procedures, determination of required isolator characteristics and the design/selection of isolation hardware.

The "Shock Mount Design Guide for Shipboard Equipment" should be ready for distribution by July 1961.

Guide for Shipboard Installations, SF 013-10-1796. Puget Sound Naval Shipyard; Allotment 50251.

It is the purpose of this task to investigate and evaluate the various methods employed in fastening the miscellaneous shipboard items for which no guides exist and to develop procedures which will retain these items in place under shock loadings.

Shock Tests of Miscellaneous Equipment and Systems, SF 013-10-1802. Norfolk Naval Shipyard (Underwater Explosions Research Division); Allotments 50288, 10362, 16471, 18458; Mr. R. E. Oliver.

A floating shock test platform has been developed for shock testing shipboard equipment weighing up to approximately 30,000 pounds. This facility has been utilized to test a Caterpillar diesel engine, and MSS angle-driven propulsion unit, a 750 kw turbine-generator and a 500 kw turbine-generator. These tests have indicated the usefulness of this facility for testing large units and a procedure for test is being written into MIL-S-901, the shock testing specification.

Future plans include test of an auxiliary propulsion unit for submarines as well as other large items as they become available.

Development of Shock Measuring Instruments, SF 013-10-1803. David Taylor Model Basin, Allotment 50169, Mr. K. T. Cornelius; Norfolk Naval Shipyard (Underwater Explosions Research Division), Allotment 50288, Mr. J. F. Shepherd; Naval Research Laboratory, PO-1-0001, Dr. I. Vigness.

The measurement of shipboard shock motions and forces and the responses of equipment requires special instrumentation which, in general, is not commercially available. Instruments must be developed and improved which will allow such measurements. Also, equipment must be developed and improved for recording and analyzing these measurements.

Future plans include development of improved velocity meters, accelerometers, deflection gages and semi-automatic data reduction equipment and readout facilities for magnetic tape recordings.

Shock Characteristics of Shock Testing Machines, SF 013-10-1804. U. S. Naval Research Laboratory, PO-1-0001; Dr. I. Vigness, H. M. Forkois.

The basic objective of this task is to determine the shock characteristics of the Navy HI shock machines specified in MIL SPEC MIL-S-901 and to establish performance standards for these machines. The data thus far obtained on these machines has proven difficult to correlate with the available information on shipboard shock, and more difficult to apply in the design of shock resistant equipment. Modifications to the machines, if feasible, to more closely simulate shipboard conditions will be recommended.

A secondary objective is the development of shock and vibration specifications based on laboratory testing of electronic equipment which is transported by wheeled vehicles.

A rough road simulator machine for wheeled vehicles has been constructed under Task 1808 of Project SF 013-10-03 and has been shipped to the Naval Research Laboratory for installation. Upon completion of installation, the machine will be evaluated for operational features and design improvements. Suitable instrumentation for statistical analysis of input motions transmitted by the machine to equipment installed in a truck or trailer, and the responses of equipment to these motions will be provided. Specifications based on these analyses will be developed.

Overload Study of Medium Weight Machine, SF 013-10-1805. U. S. Naval Engineering Experiment Station; Mr. Vallile.

The objective of this task was to investigate the characteristics of the shock motion of the Class HI shock testing machine for the medium weight equipment for loads exceeding those qualified in MIL-S-901 and ranging from 5000-9000 pounds.

Tests have been completed on obtaining shock measurements on the medium weight machine for loads up to 9000 pounds. This load is 4500 pounds greater than that presently specified as the limit for this machine.

Preliminary results submitted indicate that for the 9000 pound load the peak velocity change is approximately half of the value for a 4500 pound load. A final report is under preparation.

Calibrate and Test Shock Devices, SF 013-10-1806. David W. Taylor Model Basin; Allotment 169; W. E. Carr.

Various types of shock testing machines have been used by DATMOBAS to test and calibrate shock testing instruments. The need exists for developing a high-intensity shock testing machine which will simulate more closely shipboard shock.

A study of the possibilities of electro magnetic generators as a source of shock indicated that a machine of this type with large capacity is feasible. The shock signature on the Class HI light weight shock machine has been measured with velocity meters and reed gages. A report on the characteristics of the light weight shock machine will be prepared. An investigation to determine the possibility of altering the signature of the light weight shock machine by means of adapter mounts to simulate more closely shipboard shock motions will be conducted.

Investigate Capabilities of Hyge Accelerators, SF 013-10-1807. Convair, Incorporated, (Dynapak Division); NObs 72454; Mr. M. Kam.

A heavy weight shock machine would be a highly desirable item in the Bureau of Ships shock testing program. At present only equipment up to 4500 pounds is capable of HI shock testing. Equipment exceeding 4500 pounds has to be accepted on basis of design calculations or full scale testing. It is desired that some standard and economical test be established to accept equipment (weighing 2 to 20 tons) for shipboard use.

Power Generators, Incorporated, submitted a heavy weight shock machine report under NObs 68311 utilizing a different technique. However, this approach was considered limited and quite expensive.

With the advent of the "HYGE" accelerators, a relatively unknown device, it was thought applicable to the heavy weight shock machine problem. Dynapak (Division of Convair) was awarded a contract to conduct a feasibility study and produce drawings depicting a working design. The feasibility study together with preliminary drawings have been completed and submitted to the Bureau of Ships.

Rough Road Simulator; Construction, SF 013-10-1808. Twenty-First Century Electronics, Incorporated, Riverside, California; NObs 75699; Mr. E. Kronst.

Twenty-First Century Electronics, Incorporated, has completed the construction of the rough road simulator. It has been shipped to U. S. Naval Research Laboratory for installation. It is estimated that the simulator will be ready for evaluation by April 1961. An investigation to determine the performance of the machine is being conducted under Task 1804 of Project SF 013-10.

Shock Tube Design (U), SF 013-10-1809. Sandberg and Serrell Corporation; NOnr 2966(00)(X); Sandberg and Serrell Corporation.

Contractor, Sandberg and Serrell, has completed an investigation for developing a device which could simulate the pressure-time characteristics produced by nuclear weapon burst. Model tests that were completed have indicated that the concept in which this device was based on could be made workable in spite of the numerous engineering problems remaining to be solved. However, the emergence of the conical shock tube (see subproject SF 013-04-05, task 1771) has resulted in a discontinuation of the Sandberg and Serrell study until such a time when the full potentialities of the conical shock tube have been explored.

Modifying Class HI Shock Machines, SF 013-10-1810. U. S. Naval Engineering Experiment Station; Allotment 101; H. Rekate, R. Heise.

The specifications (MIL-S-901) for the Navy High Intensity Shock Machine for Medium Weight equipment defines the maximum test load as 4500 lbs. It allows 1100 lbs. of supporting structure; a total load on the anvil table of 5600 lbs. In the past and at present many heavy items of naval equipment have been installed aboard ship without prior knowledge of their shock resistance. In most cases, this resulted from the fact that the items were considered too heavy for testing on available shock machines. The input to the anvil table cannot be increased since the height of hammer drop is limited to six feet. The use of aluminum channels could increase the limit of equipment weight to about 5500 pounds instead of the present 4500 pound limit without decreasing the shock input severity. Before considering the substitution of aluminum channels, the response behavior of these channels had to be investigated.

The investigation has shown that aluminum alloy channels respond satisfactorily for the aforementioned shock conditions, and that they may be substituted for steel channels as specified. Stress analysis techniques were instrumental in obtaining the required information. A final report is under publication.

Construct Heavy Weight Shock Machine, SF 013-10-1811. Contractor unassigned.

The objective of this task is to construct a shock testing machine capable of testing equipment and systems weighing up to 20 tons.

Existing shock testing machines are limited in their capacity to testing equipment weighing up to 2-1/4 tons. A large number of vital shipboard items are beyond this weight range and cannot be shock tested. These items include radar systems, guided missile installations and nuclear propulsion items. Full scale shock tests of limited severity against operating ships have demonstrated the vulnerability of certain systems to the relatively minor shock loadings. Since shock tests of severe intensity against operating ships to fully evaluate shipboard equipment are not practical, shock testing of these heavy items on a laboratory simulator is the only practical solution for ruggedizing the shipboard equipment.

Preliminary plans for a HY-GE type heavy weight machine have been developed by Convair Incorporated, Dynapak Division and Powers Generators, Incorporated. Future plans will consist of analyzing the two approaches to the problem, to determine which design is the cheapest and most practical.

Improvement HI Shock Machine, SF 013-10-1812. Cook Electric Company, Forest Park, Illinois, NObs 84132; New England Trawler, Incorporated, Chelsea, Massachusetts, NObs 78712.

The Bureau of Ships plans for both the lightweight and medium weight shock machines are outdated and need to be revised. Specification, material and minor design changes are needed to bring the plans up to date. Two contracts have been let for revising the drawings. The plans for the lightweight machine have been completed. Approximately 85 percent of the plans for the medium weight machine have been revised and completion of all drawings is expected during the month of May 1961.

Floating Shock Simulator, SF 013-10-1813. David W. Taylor Model Basin, Allotment 169, W. E. Carr; Norfolk Naval Shipyard (Underwater Explosions Research Division), Allotment 288, Dr. H. Schauer.

Until recently the Bureau of Ships has had only three methods of shock testing individual pieces of equipment: (1) the shock testing machines, (2) operational ships, and (3) partial full scale test vehicles with equipment installed. Method (1) is

limited to equipment weighing less than 4500 pounds; Method (2) is very costly and is of limited severity and availability; while Method (3) is also high in cost. Therefore, a study to determine the feasibility of employing a floating platform for shock testing of heavy shipboard equipment was conducted. As a result of the study a floating platform was constructed. It was designed to shock test equipment weighing up to 30,000 pounds.

Motions of the platform were measured during the shock tests of a Caterpillar diesel engine, a right angle propulsion unit and two turbo-generators. Tests have also been conducted with a 7500 pound weight on the platform and against the platform alone. Velocity prediction curves have been constructed from data obtained. The suitability of utilizing the platform for shock testing shipboard equipment is presently being evaluated. Modifications, if necessary, to increase adequacy of simulation and to extend utility of platform will be made. Future plans consist of studying the performance of the modifications.

F013-11 Noise and Vibration Control

Internal Damping Materials (U), RF 013-11-0002, Department of Commerce, National Bureau of Standards, Washington, D. C.; NAonr 12-59, NR 264-019; S. Edelman.

The objective of this task was to measure the elastic properties of solids which have significant structural strength as well as significant internal acoustic damping. One of the items under the task was to study various types of suitable materials available and to analyze and measure them to determine the acoustic characteristics. Measurements were also made to determine the ranges of stiffness, rigidity, and internal damping of various materials which have appreciable internal damping capacities. Studies and experiments were also made to determine the feasibility of the use of combinations of high damping capacities materials when laminated or otherwise bonded.

Investigation of Dynamic Mechanical Properties of Materials (U), RF 013-11-0003. Chesapeake Instrument Corporation, Shadyside, Maryland; Nonr 2678(00), NR 264-020; J. W. Fitzgerald.

Conclusions based on the work under this contract may be summarized as follows: (1) completion of a program of dynamic mechanical measurements of materials currently in common use and those suitable for use in applications to noise and vibration control, (2) selection and measurement of materials which appear to have been ignored by previous investigations and which appear to give promise of having desirable dynamic mechanical properties, and (3) preparation and synthesis of improved materials or combinations of materials for dynamic mechanical and acoustic measurements.

F014 BOATS AND AMPHIBIOUS VEHICLES

F014-02 Hull

LCA Model Tests (U), SF 014-02-2058. DTMB - Hydromechanics Laboratory; E. P. Clement, G. Stunz.

A preliminary design for this craft was developed by a Navy contractor. The Bureau doubted the veracity of the contractor's speed-power estimates.

Model Tests (U), SF 014-02-2062. DTMB - Hydromechanics Laboratory, 525-026, E. Clement, DTMB Code 525; Davidson Laboratory, Mr. Allan Murray.

This task covers miscellaneous model tests for EHP and trim for feasibility studies and preliminary designs arising during the current FY for which no previous task has been established.

Resistance in smooth water has been determined for a variety of small craft designs. During FY '61 tests of 4 models of an LCSR were initiated. Carried over from last year were tests for a planing catamaran-resistance was found to be higher than that of good conventional planing boat designs.

Amphibious Craft Model Tests (U), SF 014-02-2063. DATMOBAS - Hydromechanics Laboratory; E. Clement, DATMOBAS Code 525.

The design of high speed wheeled amphibians is a new area and requires development of novel hull forms to meet the unusual characteristics required for the dual land and water use.

Patrol Boat Model Tests (U), SF 014-02-2064. DATMOBAS - Hydromechanics Laboratory; E. Clement, DATMOBAS Code 525.

Development of seaworthy high speed small craft for use as patrol craft types is seriously limited by the lack of comparative rough water test data. The smooth water resistance characteristics have been thoroughly investigated and it is now planned to extend this work to cover seaworthiness characteristics.

Air Cushion LCVP - Pilot Model (U), SF 014-02-2065. Anti-Friction Hull Company; P.R. No. 440-19832; Mr. Preist, Anti-Friction Hull Company, Mr. R. G. Henry, BuShips, Code 449.

The use of air cushion vehicles offers possibilities of increasing the speed of landing craft 2 or 3 fold without reducing the cargo capacity. Air cushion support also offers a substantial breakthrough in the resistance of wheeled amphibians.

Round Bottom Hull Test Series (U), SF 014-02-2055. DTMB - Hydromechanics Laboratory, 525-025, A. Aquino, DTMB Code 525; Davidson Laboratory, NObs 78349, Mr. Allan Murray, Davidson Laboratory.

Although the resistance characteristics of round bottom displacement forms are well established, there is very little systematic data for heavy displacements. A good comparative study has been made for low to medium loadings. This series will extend the existing data to cover the heavy loadings associated with most naval designs.

Bottom Pressure Tests (U), SF 014-02-2053. DTMB - Hydromechanics Laboratory; J. Foster, DTMB Code 587.

The determination of bottom scantlings for planning craft is presently based upon experience rather than theory. Calculations are now based upon limited case studies. There is no established design criteria for estimating loading on a planning boat bottom.

F014-03 Propulsion

Torsionmeter for Boats (U), SF 014-03-2051. DTMB; W. Risteen, DTMB Code 235.

Determination of torque on small craft propeller shaft is a useful method of determining power output and proper propeller size. A small portable meter for use on trials has long been needed.

Boat Propeller Tests (U), SF 014-03-2052. DTMB - Hydromechanics Laboratory; Peck, DTMB Code 526.

There are no propeller selection charts based upon the small commercial propellers used on small craft.

F015 LOGISTICS

F015-01 Systems Analyses, Studies and Tests

Structures in Deep Ocean (U), Y-F015-01-001. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 10601; J. T. Obrien and D. F. Griffin.

The objective is to develop systems and techniques to provide the capability for construction in deep ocean areas. Technological development in the world today indicates that much of the Naval Warfare of the future will occur at deep ocean depths. Concurrently there is a need for additional knowledges of methods for construction of installations in deep oceans.

Technical problems which have been identified to date and which will be important in the development of ocean bottom systems include the following: undisturbed samples of the bottom; installation and anchorage of foundations; current forces and other oceanographic data to design structures at depth; scouring problems, behavior of materials; moorings; positioning of objects; operation of motors and other equipment.

Literature surveys have been conducted in the various fields of interest and work of other agencies has been reviewed. A small high pressure unit for use in testing of materials has been procured and will be utilized in preliminary materials tests. A synoptic outline of a Manual for Construction in Deep Ocean areas has been prepared.

Work will be continued on the various investigations outlined above and a submersible unit for exposing material specimens on the ocean bottom will be developed and utilized.

F015-03 Packaging and Handling

Preservation and Packaging, WF 015-03-001. NOL, White Oak, Maryland, RSWI77/001/212-1/, H. F. McClellan; NUOS, Newport, Rhode Island, RSWI77/002/219-1/, T. Lemieux; Contractor--Unknown, RSWI77/003/ICG-1/, N. A. Junker; NOMHL, NAD, Earle, New Jersey, RSWI77/004/324-1/, J. Kelley; NOMHL, NAD, Earle, New Jersey, RSWI77/005/324-1/, J. Kelley; NCTO, Newport, Rhode Island, RSWI77/006/325-1/, H. Dorkin; Contractor--Unknown, RSWI77/007/ICG-1/, N. A. Junker; NOMHL, NAD, Earle, New Jersey, RSWI77/008/324-1/, J. Kelley; Contractor--Unknown, RSWI77/009/ICG-1/, N. A. Junker; Contractor--Unknown, RSWI77/010/ICG-5/, N. A. Junker.

Provide continuing applied research and development to improve capabilities in LOGISTICS including techniques, equipment, and services associated with all phases of preservation, packaging, palletizing, carloading, barge loading, and issue of weapons and weapon components. This includes analyses, study, design, construction and test of experimental equipment, evaluation, and documentation.

F015-05 Fuel and Ammunition Handling and Storage

Fuel Storage Tank Linings (U), Y-F015-05-001. U. S. Naval Research Laboratory; Appn. 17x1319 2514 RDT&E Bur. Control No. 25/70696/701; Dr. A. L. Alexander.

The objective is to develop methods and materials for lining and coating existing and new concrete and steel tanks for the storage of petroleum fuels. The preponderance of the work has been aimed at linings for concrete tanks, but now is shifting to the development of better linings for steel tanks--particularly coatings which create no toxic or combustion hazards during application. Also, emphasis is being placed upon those materials capable of sealing presently existing leaks of minor proportions.

Work is continuing on the evaluation of organic and inorganic coating systems. A system utilizing polyurethane primer and cover coatings is being tested and appears very promising.

Fuel Oil Additives (U), Y-F015-05-203. Contractor not determined; no contract.

The objective is to determine the most convenient and economical means to reduce, eliminate or neutralize the detrimental effects of the products of combustion caused by the presence of sulphur, sodium and vanadium in the fuel oil.

The Bureau has contracted for the development of a fuel oil test kit for use in power plants to determine the amounts of deleterious elements in residual fuel oils. Following the development of this kit, means for nullifying the harmful constituents should be prescribed to the field.

It is expected that the work will be accomplished by a qualified contractor. The first step will be to conduct a literative and field survey to determine which chemicals or methods appear to be most effective, economical and convenient for use by the Bureau. The next step is to test and evaluate the most promising chemicals, and depending on the results of the survey, other methods. The Bureau will make arrangements to award a contract in FY 61 after it is established that the fuel oil test kit is a convenient and effective tool.

Ship-to-Shore Bulk Fuel Delivery (Buoyant), Y-F015-05-301. NCEL, Appn. 17x1319 2514 RDT&E, Bur. Control No. 70601, J. J. Traffalis; Western Gear Corporation, NBy-3199.

The objective is to develop a buoyant fueling hose system for the ship-to-shore transfer of fuel. The system to be acceptable should be: simple in design; capable of rapid installation; easy to maintain and repair; permit high delivery rate of fuel over long distances; and, provide a minimum of obstruction to small boat traffic.

Ship-to-Shore Bulk Fuel Delivery Method (Bottom-

Laid) (U), Y-F015-05-302. NCEL; Appn. 17x1319 2514 RDT&E, Bur. Control No. 70601; J. J. Traffalis.

The objective is to develop a pipe line system capable of rapid installation on the sea bottom during amphibious operations. Under this task it is expected to investigate various types of pipe and methods of installing on the sea bottom in order to provide a replacement and/or alternate method to the buoyant hose method. The bottom laying system indicates a number of advantages over floating hose system with respect to detection and vulnerability.

Booster Station for Ship-to-Shore Bulk Fuel Delivery (U), Y-F015-05-303. NCEL; Appn. 17x1319 2514 RDT&E Bur. Control No. 70601; J. J. Traffalis.

The objective is to develop a floating booster station for use in conjunction with the buoyant and bottom laid fuel systems in order to extend the range of fuel delivery beyond the current 5,000 ft. capability. This requirement was generated due to the fact that under certain hydrographic conditions it may be necessary for the tanker to moor further than 5,000 feet from shore and therefore require a floating booster station to meet required fuel delivery rates. In order to provide a suitable unit at the earliest possible date a diesel driven pump unit is being investigated. Also in order to obtain the lightest practicable unit investigation of a gas turbine driven unit is also being studied.

600 GPM Ship-to-Shore Bulk Fuel Delivery Method, Y-F015-05-304. NCEL, Appn. 17x1319 2514 RDT&E Bur. Control No. 70601, J. J. Traffalis; Western Gear Corporation, NBy-3199.

The objective is to develop a hose and/or pipe line system with a delivery capacity of 600 GPM capable of rapid installation in the early phases of an amphibious operation. This system presents the possibility of eliminating booster stations where less than 600 GPM is required.

The greater utilization of aircraft in amphibious operations has considerably increased the demand for fuel thereby necessitating a higher rate of transfer for meeting requirements. As the first phase of this task, it is expected to develop a 6" system based on the principles of the present 4" bottom laid system. This system has been designed and equipment purchased for evaluation purposes.

Two installations of 2,000 ft. of 6" pipe have been made at Port Hueneme, California. The average rate of launching 90 Ft. Strings was 1,000 ft/hr. Maximum tensions of 27,000 lbs. were required to overcome friction on the sea bottom and 18,000 lbs. were necessary to maintain movement of the 2,000 ft. of pipe. In order to improve the speed of installation procurement has been initiated of quick connect type couplings and a power make-up device. These devices have been received and evaluation is currently underway.

F015-07 Crash, Firefighting and Decontamination

Shipboard Fire Extinguishment Studies (U), RF 015-07-4650. U. S. Naval Research Laboratory, Washington 25, D. C.; C08-14; R. L. Tuve.

This task is designed to study, evaluate, and originate new and improved equipment, materials, and methods for the prevention and extinguishment of fires and the protection of personnel aboard surface and subsurface vessels. Present objectives of superior aircraft carrier hangar and flight deck fire fighting equipment are receiving the greatest attention.

Propellant Fire Hazards (U), SF 015-07-3345. Material Laboratory (946); 70/171; H. Lacks.

This task is for development, tests, and evaluations of fire extinguishing agents for solid propellants used in shipboard missiles. Although this task does not include development of the means of introduction of extinguishing agents inside missiles, current developments in missile quench nozzles must be considered in the selection of candidate extinguishing agents.

Characteristic of shipboard solid propellant missiles is the presence of highly flammable and hazardous solid propellants, igniters, compressed gases, hydraulic fluids, warheads, and other materials. The fact that the quantities of such materials now being handled on board ship are increasing at a rapid rate as more missile systems are installed intensifies the hazard present.

The missile booster quench nozzle, developed by the Bureau of Ships for missile ready service magazines, is an automatic, mechanically actuated valve which injects water into accidentally ignited boosters. The nozzle is sensitive to and functions rapidly in the exhaust environment of missile boosters. Present shipboard installations do not provide a sufficiently high anticipated percentage of extinguishment or suppression.

Shipboard Fire Protection and Fire Fighting Equipments - Development (U), SF 015-07-3346. Material Laboratory, NAVSHIPYD, NYK (Code 946); 70/171; H. Lacks.

The program covers the study and development of fire protection and fire fighting equipment used aboard ship.

It is noteworthy that the fire protection and fire fighting problems aboard ship have changed radically with the introduction of atomic missiles and rockets propelled by liquid and solid propellants, which are not only flammable, but detonable, corrosive and toxic as well. The new hazards involved require the introduction of new fire fighting techniques and new equipment, as well as development and improvement of currently used equipment.

The Laboratory has taken the lead in developing a new type of foam nozzle, that unlike the currently used shipboard nozzle, provides variable range of foam streams with the same high quality foam generated for all ranges of throw. The Laboratory has also developed the first hydraulically-operated fire fighting monitor for shipboard use (mounting the new foam nozzle); it can be operated remotely or can be set to operate automatically to protect a given area; special note should be made that the monitor is actuated hydraulically by the fire fighting stream going to the nozzle. In addition, the Laboratory has worked on: piercing applicators for protection of airplanes (and the vessels) carrying atomic weapons; on the development of foam heads and foam sprinkler systems for shipboard uses; inline proportioners for use with foam generating devices; dry powder extinguishers.

Fuels, Oxidizers, and Propellants, Effectiveness of Fire Extinguishing and Fire Prevention, SF 015-07-3347. Material Laboratory, NAVSHIPYD, New York; 70/171; H. Lacks.

The objective of this task is to determine effectiveness of fire prevention and fire fighting techniques, equipment, and agents for extinguishment of fires involving aircraft, guided missile, and rocket motor fuels, oxidizers, and propellants.

With the introduction of liquid and solid propellants aboard ships and stations of the Naval establishment, radically new problems in safety, fire protection and fire fighting have arisen. The new materials are not only flammable, but detonable, toxic and corrosive as well.

Fire prevention and fire fighting techniques and extinguishing agents for fires involving oxidizer-fuel mixtures including LOX, H202, IRFNA, ZIP, MAE, AV gas and JP-5 have been studied. A new field station has been constructed for conducting this work. New techniques, model fire tests and instrumentation have been developed for this program. Determination has been made of the conditions under which serious detonations would occur, when using all the conventional extinguishing agents. Determination has been made that certain combinations of fuels and oxidizers cannot be used or handled safely aboard ship; other combinations have been found that can be employed with the minimum of risks involved.

Explosive and Toxic Vapor Detection (U), SF 015-07-3348. Material Laboratory, NAVSHIPYD, New York, (972); 70/171; E. C. Haas.

Investigation to provide data for improvement and use of detection and alarming devices and indicators for explosive and toxicological protection in missile or aircraft fuels and oxidizer spaces aboard naval ships.

Operational requirements for handling and storing liquid fuels and oxidizers aboard ships for use in missiles and high-speed aircraft have created the necessity for new or improved detection and surveillance devices. The requirement is for devices particularly applicable to Mixed Amine Fuel blends, RFNA, and the halogen compounds for detection and indication of explosivity and toxicity. Detection devices required for the fuels and oxidizers specified either do not exist, or do not presently meet the required ranges of toxicity or explosivity to provide acceptable protection to personnel or shipboard handling or stowage areas.

Foam Fire Extinguishment (U), SF 015-07-3355. Material Laboratory (946); 70/171; H. Lacks.

This work involves determination of the effectiveness of water spray and foam discharging from selected discharge devices in control and extinguishment of flammable liquid fires. Also, determinations of foam discharged from deck monitors in control and extinguishment of fires in areas equipped with overhead water sprinkler equipment operated simultaneously with the foam discharging monitors.

The results of this work will be applied to ship design and installations for fire protection. Foam-water sprinkling systems are now being specified for new construction hangar spaces as one example of the accomplishments of this work. Data obtained indicates that foam-sprinkler systems are capable of extinguishing class B fires in spaces whereas the data shows that water sprinklers will not extinguish class B fires.

Fire Protection and Fire Fighting Systems - Development (U), SF 015-07-3956. MATIAB Fire Extinguishment and Safety Equipment, Naval Weapons Laboratory, Dhalgren, Virginia; Code 946, H. Lacks, Section Head, M. Lambert, Unit Head, D. George.

The work covers the development of fixed systems used aboard ship for fire protection and fire fighting.

The new hazards resulting from the introduction of new types of naval weapons necessitates the development of new and improved fire protection systems aboardship for coping with these hazards.

Shipboard Fire Extinguishment Studies (U), SF 015-07-3350. U. S. Naval Research Laboratory (6220); 70/171; R. L. Tuve.

This task is designed to study, evaluate, and originate new and improved equipment, materials, and methods for the prevention and extinguishment of fires and the protection of personnel aboard surface and subsurface vessels. This project will produce data for issuing design specifications for shipboard foam sprinkling extinguishment, to determine relevance of design specifications for present foam extinguishment, and to develop new and improved foam techniques and materials. This data is necessary for the development of essential foam protection for carrier hangars and guided missile areas to provide required shipboard protection for new fuels and oxidizers being used and under development. Basically essential to maintain and increase ship survival potential.

Ultrasonic Flame Suppression (U), SF 015-07-3351. U. S. Naval Research Laboratory (5326B); 70/171; W. W. Balwanz, J. M. Headrick.

The objective is to determine in laboratory research the feasibility of flame suppression with ultrasonic sound, or attain sufficient attenuation of a fuel vapor or gas to secondarily suppress the flame. In a particular case, an appreciable extension of the time base of the burning would permit removal of the heat released over a longer period of time per unit quantity of fuel involved.

(a) The hypergolic nature of many rocket propellants, and aircraft fuel systems, can produce rapid disintegration and destruction of missiles, magazines, and ships. Rapid protection means are required.

(b) Laboratory and industry have commenced using ultrasonic sound to: disperse smoke particles and water vapor; cause cellular disruption; industrial cleaning and degreasing; industrial welding of metals; industrial foaming of liquids; industrial strength scanning of nuclear reactor tubing.

(c) The Naval Research Laboratory will conduct research and investigation to determine whether further work is justified. This task will investigate feasibility of ultrasonic sound to suppress flame or attenuate fuels or oxidizers in vapor or gas. Development of a feasibility will provide a potentially new method to protect magazines and fuel systems on naval ships.

Mechanism of Ignition and Extinguishment (U), SF 015-07-3352. National Bureau of Standards, Department of Commerce; 70/171; A. F. Robertson.

The current activities of the Navy in the development of self propelled missiles have led to the introduction of a variety of new fuels and oxidizing agents with their associated fire hazard problems. This project was initiated to assist in meeting the demand for solutions to these problems. The objective of the investigation is to obtain information on the mechanisms of ignition and extinguishment, with special attention being directed to fires involving propellant materials.

Liquid Propellants Vapor Explosion Research (U), SF 015-07-3353. BuMines, Interior Department; NAonr-48-59; M. G. Zabetakis.

This task will establish fire hazards to Naval Ships and provide data for the development of fire prevention and fire fighting equipment and materials that will materially improve the efficiency of naval ships by increasing ships survival potential and probability of mission accomplishment.

F015-12 Utilities and Services

Saline Water Conversion Plants for Shore Establishments (U), Y-F015-12-102. NCEL; no contract; J. S. Williams.

The objective is to conduct a technical study of the practicability and economics of utilizing saline water conversion plants as a source of potable water at Navy Shore Establishments located in arid and semi-arid regions. It is the intent of this task to collect, review and analyze technical data on various processes presently used commercially and those still in the research stage, to determine the most practical and economical type of plant for conversion of saline water at Navy Shore Establishments.

Mobile Gas Turbine Generators (U), Y-F015-12-103. Contractor not determined; no contract.

In general, the Bureau's experience record indicates a need for large, mobile, generating plants. Savings can be realized by avoiding high demand charges during outages and by peak shaving. These units would also be available for mobilization requirements.

Plastic Covers for Potable Water Reservoirs (U), Y-F015-12-104. NCEL; no contract; J. S. Williams.

The objective of this task is to develop a cover of plastic to protect potable water open storage tanks from contamination and reduce loss of water by evaporation.

Mobile Boiler Plant (U), Y-F015-12-301. Contractor not determined; no contract.

The objective is to develop, fabricate, and evaluate a prototype mobile boiler plant for use as a Navy reserve component.

The Navy has a continuous peacetime need for temporary steaming capacity for use at different locations as a mobile auxiliary or supplementary boiler while repairing or replacing existing boilers or for temporary steam needs for testing or other extraordinary requirements.

N-P for Remote Areas (U), Y-F015-12-402. NCEL, ERDL, Combustion Engineers, Martin Company, Alco Products, Incorporated; Appn. 17x1319 2514 RDT&E Bur. Control No. 25/70696.

The objective is to study the application of nuclear power for remote areas, including polar regions and develop, where necessary, nuclear power plants to fulfill the Navy's requirements for shore based nuclear power.

The RDT&E requirements of four specific areas are included in these studies. They are:

(a) McMurdo Sound, Antarctica - A 1500 KWE, PWR, skid-mounted plant is now under contract. The complete plant will be made up of 20-30 modules which can be moved into position and installed during the 3-month construction season. This plant will replace the existing diesel plant, and will provide for base load growth, and will allow electrification of presently installed oil galley and heating facilities. An in-house study has determined the economic feasibility of the nuclear plant.

(b) Byrd and Pole Stations, Antarctica - A 1000 KWE plant will be required at each of these stations. This plant will be made up of approximately 20 air-transportable modules. This plant will replace the existing diesel plant, and will provide for base load growth, and will allow electrification of presently installed oil galley and heating facilities. An in-house study has determined the economic feasibility of the nuclear plant.

(c) Barge-Mounted 10 and 20 MWC Plants - Barge mounted plants previously studied under NY 700 001-1 and NY 700 001-2 will be re-evaluated taking advantage of the latest advances in Boiling Water Reactor and Organic Moderated Reactor technology. A 20 MWC barge (or ship) mounted plant for the Atlantic Area will be studied.

(d) Based on recent developments in AEC sponsored programs, studies will be initiated in the following areas:

Adaptation of the ML-1 (gas-cooled reactor, closed cycle turbine) to meet Navy needs.

Feasibility of early use by the Navy of the SNAP type reactor plants (liquid metal cooled reactor).

Reactor power plant automation.

The Bureau will continue to maintain close contact with the AEC, Division of Reactor Development (Army Reactors) in all of the above-mentioned areas.

Nuclear Power Conventional Equipment Development (U), Y-F015-12-403. NCEL, ERDL, Combustion Engineering, Martin Company, Alco Products, Incorporated.

The objective of this task is to assist in the development of non-nuclear components of nuclear power plants presently being considered for use by the Navy.

Work under this task will include final design and some testing work associated with the non-nuclear components of a 1000 KWE nuclear power plant for Byrd and Pole Stations.

The Bureau will continue to maintain close contact with the AEC, DRD (Army Reactors) regarding all work under this task.

Environmental Survey - Antarctica (U), Y-F015-

12-404. U. S. Public Health Service; Appn. 17x1319 2514 RDT&E Bur. Control No. 25/70696.

National Science Foundation letter to SECDEF of 29 July 1960, stated the requirements with respect to reactor released radioactivity in Antarctica. In addition, the letter requested the DOD to undertake the necessary environmental survey work to ensure compliance with the stated requirements.

This task was initiated to determine the background radiation levels of the lithosphere, biosphere, and hydrosphere prior to operation of the McMurdo reactor (PM-3A), and to monitor the immediate power plant environment during plant operation.

It is planned to extend this environmental survey program in FY 1962 to include Byrd and Pole Stations. Some work is required in the development of automatic sampling equipment.

Radioisotopic Heat Source (U), Y-F015-12-405. Bureau; Appn. 17x1319 2514 RDT&E Bur. Control No. 25/70696.

It is the objective of this task to determine the feasibility of utilizing the heat of radioactive decay for space heating. It is planned to implement this program in the third quarter of FY 1961. The radioisotopic space heaters would have an output capacity in the neighborhood of 50,000 to 300,000 BTU/hr, and could be used for quarters heating in remote areas.

Special Duty Refrigeration Appliances (U), Y-F015-12-501. Contractor not determined; no contract.

The objective is to establish design features of cooling and refrigerating appliances especially constructed for use in highly corrosive tropical and subtropical areas and to determine the economical feasibility of replacing the presently used conventional units with the special duty units.

Refrigerators, freezers, water coolers, etc., located in tropical and subtropical locations have short service lives and require constant maintenance. Warm, humid air adjacent to the cool casing causes condensate to form in metal joints and creases which results in severe corrosion of these areas. Once the casing is pierced by corrosion, or if the casing was not originally air tight, high humidity air will enter the panels and cause deterioration of the thermal insulation. Wetting and possible collapse of the insulation reduces the outside temperature of the casing and the process is accelerated. Reduction of the termal resistance of the insulated panels also causes the compressor and electric motor to operate for longer periods, frequently resulting in premature failures.

Frost Free Refrigerators (U), Y-F015-12-901. Contractor not determined; no contract.

The objective is to investigate the application of frost-free refrigeration to Navy type reefers to determine if present units can be converted to frost-free operation, the cost of the conversion and an estimate of savings from non-spoilage, man-hours of labor saved because of the absence of frost and ice in the freezer or refrigerator and the nutrition improvement of food quality because of advanced refrigeration design.

Present Navy reefers are of the defrost type in which frost and ice form within the unit and must be periodically defrosted. This operation often permits spoilage of meats and foods or reduces the nutrition value of foods.

The investigation will include an intensive survey of manufacturers now building frost-free refrigerators to determine the results of commercial experience with this principle and to establish cost and adaptability factors should the results appear advantageous, a current type reefer will be converted to frost-free operation or a new one incorporating this principle will be procured and evaluated.

F015-14 Clothing and Protection of Personnel

Aerosol Filters (U), RF 015-14-4701. U. S. Naval Research Laboratory, Washington 25, D. C.; C08-10; J. A. Young.

This task consists of an investigation of aerosol filter materials and their characteristics with the ultimate goal of developing improved aerosol filters. Studies of such variables as fiber composition, size, electrical charge and surface treatment and aerosol size, shape, density and composition are in progress.

Adsorbents (U), RF 015-14-4702. U. S. Naval Research Laboratory, Washington 25, D. C.; C08-25; J. K. Thompson.

This task consists of a basic investigation of the structure of active carbons and their surface chemical properties. It includes a study of the reaction of the carbon surface at low temperature (below 150°C) with oxygen and other gases which may form surface complexes. Paramagnetic resonance absorption methods are used to study the presence of paramagnetic centers in the carbons and their possible relations to surface reactions. This study is expected to lead to a better understanding of the mechanism of surface oxidation and adsorption by active carbons.

Principles of Atmosphere Control in Spacecraft (U), RF 015-14-4703. U. S. Naval Research Laboratory, Washington 25, D. C.; C08-34; W. L. Anderson.

The similarity of the respective atmospheric problems of the uniquely sealed spaces in submarines and spacecraft demands a comprehensive attack on the control of spacecraft atmospheres utilizing and extending the knowledge gained in the submarine habitability program.

Improvement in Design and Materials of Life Saving Equipment and Accessories, SF 015-14-3391. Material Laboratory, New York Naval Shipyard; Allot. 171/70; John Mellon.

The all-theater type of ship operations now employed requires continued development of survival, rescue and detection aids to insure that items and materials such as signalling devices, canned drinking water, pumps, desalting kits, reflective tape, ring buoys, boat launchers and the like, offered for survival, detection and rescue use are current with latest technology of reduced weight and cube and offer maximum assistance to abandon ship personnel.

Life Preservers, SF 015-14-3392. Material

Laboratory, New York Naval Shipyard; Allot. 171/70; John Mellon.

Development of better life preservers is required; (1) in connection with more stringent problems of survival, escape and protection of personnel engaged in underwater operations and those assigned topside duty; (2) to meet new and future demands of the services and (3) to take advantage of technological improvements that will lead to distinct advantages of performance, service life and economy.

Improvement in Design of Life Saving Craft, SF 015-14-3393. Material Laboratory, New York Naval Shipyard; Allot. 171/70; John Mellon.

Development of better inflatable life saving craft and operating gear is required in connection with more stringent problems of survival of personnel adrift at sea created by the all-theatre type of operations now employed. Objective is to (1) provide new and improved end items for the survival, detection and rescue of surface and sub-surface personnel at sea; (2) to meet new and future demands of the services and (3) to take advantage of technological improvements that will lead to distinct advantages of performance, service life and economy.

F016 PERSONNEL ADMINISTRATION

F016-01 Systems Analyses, Studies and Tests

Study of Naval Personnel Systems, PF 016-01-001. American Institute for Research, PF 016-001C (Nonr 2872(00)); Richard L. Krumm

Many studies have been made of different components of the Naval personnel system during the past ten years. These studies have considered only limited aspects of the interaction of components and sub-systems. There have been, for instance, studies of the occupational classification structure, career ladders, selection standards, billet structures, training, distribution and other segments of the total system. However, there has been no systematic approach to analyse the interaction among these segments or the effect of changes in one segment on the other segments and the whole. It may be presumed, therefore, that certain decisions which are taken in certain areas will affect the stability of other areas, and advantages of the course of action adopted will be outweighed by adverse, but unanticipated results in other areas. The purpose of this task, therefore, is to provide for an exploratory study of the personnel system and its components to obtain a description of the system and its present procedures and practices, develop a system model, and formulate requirements and/or characteristics which provide the means of constructing criteria for evaluating the satisfactoriness of current sub-system and component design to support naval personnel administration and management. It will then be determined if further research efforts will be directed to the system as a whole or, alternatively, to improvement in other project areas of the Personnel Administration area (F016).

Development of Officer Personnel Systems, PF 016-01-002, NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department); PF 016-01-002W; Jack Pugh.

This research provides for the development and improvement of officer career structures and classification coding systems for determining, identifying, and classifying, and accounting for all regular and reserve officer manpower requirements and resources. The main objective is to keep Navy officer classification systems and coding structures in consonance with technological advances and changing operational requirements so that personnel plans, policies, and procedures concerned with career development, selection, promotion, training, distribution, assignment, accounting, reporting, and processing of officer manpower data will be in tune with the current needs of the naval establishment and will be capable of utilizing the fullest potentials of electronic data processing.

Research is directed towards two major areas:
(1) The development, improvement, and validation of occupational classification systems and structures for identifying, classifying and accounting for both billet and personnel qualifications requirements, and
(2) Investigations into utilization, improvement, integration and/or amalgamation of current systems and structures to increase their effectiveness in personnel management and administration.

Development of Enlisted Personnel Systems, PF 016-01-003. NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department), PF 016-01-003W, Mr. J. Hackett; NAVPERSRSCHFLDACTYSDIEGO (Personnel Systems Research Department), PF 016-01-003S, Mr. R. May.

As a result of research findings in this area during the period 1957-1961, the Chief of Naval Personnel has formulated and defined new concepts, principles, and objectives regarding the naval enlisted occupational classification systems. The Permanent Board for Review of the Enlisted Rating Structure is currently applying the new concepts and principles in its review of existing ratings to determine if they are structured in accordance with the expressed objectives. The purpose of this task now is to provide the Chief of Naval Personnel with the necessary research support to enable the Bureau of Naval Personnel to make sound applications of the concepts and principles to specific problem areas which result from changing technology or procedures.

F016-02 Qualitative/Quantitative Requirements

Methods and Techniques for Determining Navy-wide Qualitative Requirements, PF 016-02-001. NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department); PF 016-02-001W; J. J. Hackett.

The Navy qualitative manpower requirements are changing rapidly as the Navy is affected by various international, technological, and socio-economic developments. International relations and changes in the relative strengths of the members of the family of nations have imposed unprecedented peacetime operational commitments which require a Navy much larger and more ready than has previously been required short of mobilization. This situation is also effective with respect to the size of

other services. Accordingly, the total demands of the services for manpower are relatively much greater in proportion to the population resources than has previously been experienced in a "time of peace".

A second major influence on the qualitative manpower requirement of the Navy is technological progress in naval warfare. Virtually all major combatant characteristics of naval ships and aircraft have become significantly more complex in maintenance and in many cases operation is more complex. Armament, power plants, intelligence, and communications "hardware" have become increasingly complex; the end is not in sight and it can only be expected that qualitative requirements for naval personnel will necessarily reflect the increasing sophistications of the material until design and engineering of the latter display a different trend.

Development of Officer Qualification Standards, PF 016-02-002. NAVPERSRSCHFLDACTYSDIEGO (Personnel Systems Research Department), PF 016-02-002S, Russell May; NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department), PF 016-02-002W, Joseph Hackett.

This research provides for the development of billet and personnel qualifications, standards and requirements for identifying, classifying, describing, and correlating naval officer manpower resources and requirements. The main objective is to determine qualitative/quantitative standards for officer career planning, management, and development which will be in tune with the Navy's changing tasks and missions in an advancing technological and scientific environment. Research is directed towards 2 major areas: (1) the development, improvement, and validation of technical and professional standards and requirements for all peacetime and wartime officer billets, and (2) the development, improvement, and validation of standards and requirements for developing, evaluating, and improving officer knowledges and abilities capable of satisfying the billet requirements established under area (1).

Development of Enlisted Qualification Standards, PF 016-02-003. NAVPERSRSCHFLDACTYSDIEGO (Personnel Systems Research Department), PF 016-02-003S, R. V. May; NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department), PF 016-02-003W, J. J. Hackett.

This research provides for the development of qualifications standards for naval enlisted billets, careers and special categories. It includes research in physical, mental, training, experiential, and skill and knowledge requirements of the various kinds of naval enlisted duties. The development of improved methods and techniques of estimating future kinds and numbers of enlisted personnel requirements is a primary objective of this task, inasmuch as ongoing and probable future material development promises to aggravate the current requirements for enlisted personnel of high mental capacity and demonstrated ability.

Areas of research include: needed improvements in qualifications analysis methodology; classification entities and structures; specifications for selection, training, assignment and advancement; and similar areas.

Development of Qualitative Standards for Critical Ratings, P-F016-02-004. NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department); P-F016-02-004W; J. J. Hackett.

Current technological developments in naval warfare are affecting the character of virtually all naval enlisted occupations. The rapid evolution of weapons and equipments, and the emerging concept of systems, imposes increasingly rapid changes on the qualitative requirements of naval enlisted occupations. Increasing complexity of the material demands enlisted personnel of high mental capacity, and broader qualifications, than was true formerly. However, the proliferation of complex systems, with distinctive features as well as common characteristics, requires an increasing number of different kinds of specific occupational qualifications.

The most prominent area of changing requirements is, of course, that of weapons. However, other areas such as communications and operations are also changing in respect to material characteristics and display dynamic personnel requirements. This task is intended to provide for research into the changing personnel qualitative requirements and the development of improved standards for selection, promotion, career development, and utilization of enlisted personnel in such critical occupations as Sonarman, Radioman, and Guided Missileman. Of equal interest with the development of such occupational standards, is the problem of developing improved methods and techniques for the determination and expression of the standards.

F016-03 Reporting, Data Processing and Accounting

Electronic Data Processing Research, P-F016-03-001. NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department); P-F016-03-001W; Jack Pugh.

This research provides for analysis, evaluation, synthesis, improvement, and coordination of existing manpower information systems, and for the development of new classification and accounting systems and structures capable of utilizing the full potentials of electronic data processing (EDP) equipment and procedures in effecting improvements in naval personnel management and administration. Research and development will be directed towards five main areas: (1) new methods and techniques for improving and updating manpower records and accounts, (2) comprehensive common language coding structures for recording and comparing officer, enlisted, and civilian manpower requirements and resources, (3) occupational classification coding structures amenable to Electronic Data Processing, (4) integrated manpower classification and coding systems capable of reflecting the latest technological and operational advances and requirements, and (5) the application of Electronic Data Processing to research and development processes and procedures.

F016-05 Selection, Classification, Distribution, and Assignment

Improved Aptitude and Personality Tests (U),

PF 016-05-004. USNAVPERSRSCHFLDACTYWASHDC, PF 016-05-004-W1, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 016-05-004-W2, A. S. Glickman; USNAVPERSRSCHFLDACTYSDIEGO, PF 016-05-004-S3, L. V. Gordon.

This task is designed to improve existing selection and assignment procedures and includes the following sub-tasks: development of motivation tests to supplement the Basic Test Battery, development of biographical information blanks to improve officer assignment, development of a new classification to replace the current enlisted classification procedure, development of a new form of the Literacy Test to replace the present one in recruit classification, a critical review of current officer classification testing and procedures, and the development of new mechanical test items for use in various operational tests.

F016-07 Motivation/Morale

Studies in Career Motivation (U), PF 016-07-001. USNAVPERSRSCHFLDACTYWASHDC, PF 016-07-001-W1; A. S. Glickman; USNAVPERSRSCHFLDACTYSDIEGO, PF 016-07-001-S1, L. V. Gordon.

This task includes studies of factors which determine the retention of enlisted and officer personnel. The principal study is a four-year follow-up of a large sample of first-term enlisted personnel to determine how men's knowledge, expectations, attitudes, beliefs, and plans develop and change during the course of their first enlistment and the relationships of these factors on their ultimate decision to reenlist in or separate from the Navy. The basic design involves repeated assessment of varying sub-samples of the larger group (N=8,855). Related studies include direct personnel surveys and the validation of the officer career motivation test.

The Effects of Organizational Change (U), PF 016-07-003. USNAVPERSRSCHFLDACTYWASHDC; PF 016-07-003-W3; A. S. Glickman.

The purpose of this task is to investigate on a case study basis how any abolishment of officer specialist billets or warrant officer grades are accepted by the officers involved. Among the areas studied will be the attitudes developed towards the changes by personnel involved, the conditions under which the changes are accepted, and how the actual changes are implemented. The study will also concentrate on developing methodological tools for further studies of change.

Two areas of immediate concern can be distinguished:

a. What is the impact of change upon individuals occupying positions to be changed? Does identification with the Navy remain at the same level or does the change result in increased job dissatisfaction as well as concomitant poorer relationships with peers and superiors?

b. In what ways do individual reactions to these changes facilitate or retard them? It is certainly conceivable that adverse views of the change will impede successful transition.

Studies in Naval Leadership (U), PF 016-07-004. USNAVPERSRSCHFLDACTYWASHDC, PF 016-07-004-W1, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 016-07-004-W2, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 016-07-004-W3, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 016-07-004-W4, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 016-07-004-W5, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 016-07-004-W6, A. S. Glickman; American Institute for Research, Nonr 2838(00), C. Hahn.

To evaluate the current practices, procedures and techniques associated with the Navy Leadership program, research has been initiated in a number of problem areas associated with this effort. 1) Comparison of leadership concepts found among officers of different ranks. 2) Extent and kinds of changes in Petty Officer Leadership attitudes effected by leadership training. 3) Development of end-of-course leadership achievement tests. 4) Effectiveness of current leadership teaching methods. 5) Development of standards for selection of enlisted leadership instructors. 6) Effectiveness of the leadership training set forth in the curricula under various officer candidate training programs. 7) Development of Petty Officer Leadership assessment and training procedures.

F016-08 Organizational Analyses

Staffing Guides for Units Ashore and Afloat, PF 016-08-001. NAVPERSRSCHFLDACTYSDIEGO (Personnel Systems Research Department), PF 016-08-001.1S, PF 016-08-001.2S, PF 016-08-001.6S, Mr. R. V. May; NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department), PF 016-08-001.3W, PF 016-08-001.4W, PF 016-08-001.5W, Mr. J. H. Hackett.

This research is performed to provide techniques for determining the numbers and kinds of military personnel required (Afloat/Ashore) to insure optimum utilization of available military personnel.

Current research is directed toward the development of staffing guides for critical ratings such as ET's, FT's, GS's and other ratings requiring electronics and related training; staffing techniques to provide guidelines in developing true manpower requirements for AGMR class ships; staffing standards for gross military manpower allocation.

Techniques for Improving Naval Command Organization, PF 016-08-002. NAVPERSRSCHFLDACTYWASHDC (Personnel Systems Research Department), PF 016-08-002W, Mr. J. H. Hackett; NAVPERSRSCHFLDACTYSDIEGO (Personnel Systems Research Department), PF 016-08-002S, Mr. R. V. May.

This research is performed in support of General Order No. 21 and other manpower utilization requirements in order to provide naval personnel (officer and enlisted) with modern management appraisal techniques in order to achieve effective utilization of available naval personnel and to maintain Navy organization at the highest degree of effectiveness.

Current research is directed toward the development of new techniques to analyze naval occupations to yield comprehensive information for use in the development of training programs, officer and billet classification structures, aptitude tests, and other Naval personnel administration programs, and

new techniques in work simplification and organizational planning in order that effective utilization of naval manpower may be achieved and that naval organizations may be maintained at the highest degree of effectiveness.

F017 TRAINING

F017-01 Systems Analyses, Studies, and Tests

Personnel Research on Electronics Training Requirements, PF 017-01-001. U. S. Naval Personnel Research Field Activity, Washington, D. C., contract not applicable, principal investigator not yet determined; U. S. Naval Personnel Research Field Activity, San Diego; Contract Research as Necessary.

Research will be conducted to predict the total maintenance requirements of new systems planned through FY 1970. A consolidated personnel training requirements plan will be prepared by fiscal years. It will be directed towards providing specific indications of future personnel and training needs in terms of rates and ratings. A preliminary study of the projected requirements of 42 major new systems in the area of electronics maintenance has already been completed and used for planning purposes. It is intended to up-date these figures on a quarterly basis and extend research to other critical ratings and areas as required. Research has also been initiated into Post Graduate and officer personnel requirements of new weapons and support systems.

Multi-System Personnel Research Requirements, PF 017-01-002. U. S. Naval Personnel Research Field Activity, Washington, D. C., contract not applicable, principal investigator not yet determined; U. S. Naval Personnel Research Field Activity, San Diego; Contract Research as Necessary.

Research will provide realistic predictions in terms of utilization by operating units such as ship types and the effect of combining systems rather than a piecemeal individual approach by weapon and support systems without appreciation of cumulative requirements. Research will provide for analysis of specific combinations of requirements such as for a given ship type (FBM New Construction Tender); for use of several weapons systems (DLG Weapons Department); for overall future Navy-wide personnel requirements and for better techniques and procedures for projecting needs associated with new developments.

F017-02 Determination of Training Requirements

Personnel and Training Component Research, PF 017-02-001. U. S. Naval Personnel Research Field Activity, Washington, D. C., contract not applicable, principal investigator not yet determined; U. S. Naval Personnel Research Field Activity, San Diego; Contract Research as Necessary.

Research will keep abreast of improvements designed to advance future technical capability in such areas as satellite defense, nuclear weapons, etc. These are non-system type developments that if successful may be directly introduced into fleet use. It is imperative that personnel research be conducted to gain the lead time to support or contribute to the availability of manpower with appropriate skills and knowledges. This work is primarily concerned with the Bureau of Naval Weapons exploratory research development areas.

Personnel and Training Component Research, PF 017-02-002. U. S. Naval Personnel Research Field Activity, Washington, D. C., contract not applicable, principal investigator not yet determined; Y U. S. Naval Personnel Research FieldkActivity, San Diego; Contract Research as Necessary.

Research will keep abreast of progress being made in the field of equipment design, equipment reliability, equipment simplification, and human engineering having inherent personnel and training implications. Other areas involve advanced data processing techniques, research on digital and analog computers relating specifically to such systems as NTDS, OpConCenter and various missiles. This research is primarily concerned with the Bureau of Ships exploratory research development areas.

F017-03 Training Curricula

Development and Evaluation of School Curricula (U), PF 017-03-001. USNAVPERSRSCHFLDACTYSDIEGO, PF 017-03-001-S1, Earl Jones; USNAVPERSRSCHFLDACTYSDIEGO, PF 017-03-001-S2, Earl Jones; USNAVPERSRSCHFLDACTYSDIEGO, PF 017-03-001-S3, Earl Jones; USNAVPERSRSCHFLDACTYSDIEGO, PF 017-99-001-S1, Earl Jones; USNAVPERSRSCHFLDACTYSDIEGO, PF 017-99-001-S2, Earl Jones; USNAVPERSRSCHFLDACTYSDIEGO, PF 017-99-001-S3, Earl Jones; USNAVPERSRSCHFLDACTYSDIEGO, PF 017-99-003-S1, Earl Jones; USNAVPERSRSCHFLDACTYWASHDC, PF 017-99-001-W1, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 017-99-001-W2, A. S. Glickman; USNAVPERSRSCHFLDACTYWASHDC, PF 017-99-001-W3, A. S. Glickman.

The purpose of this task is to conduct experimental and developmental studies in support of the Training Division of the Bureau of Naval Personnel with a view toward evaluating the effectiveness of existing, planned, or alternative training procedures in meeting the objectives of training.

F017-05 Training Device Components and Training Aids

Altitude Training Rapid Decompression Chamber (9A12), RF 017-05-7001. Guardite Company, Wheeling, Illinois; N61339-469; R. Usher.

This device is an altitude chamber consisting of a main chamber with 250,000 foot simulation capability with the necessary auxiliary chambers. Rapid decompression capabilities will be a feature of this device.

Shorebased ASW Teaching Aids and MK 45, 46, 47, EX 10 and MK 37 Torpedoes, RF 017-05-7154. Contractor to be determined in 1962; Foster.

To design, develop and procure training devices which shall visually demonstrate clearly and simply, the physical characteristics as to shape and size and of the relative location of internal components of the MK 45, 47, 37 Torpedoes and the EX 10 Torpedoes. The devices shall be 3 dimensional

scaled models which will assemble and disassemble along the normal parting lines and the internal components shall be relative in size, shape and location.

Trainer System, Target Classification Sonar Operator (Laglines), RF 017-05-7155. ITT Laboratories, Incorporated, Nutley, New Jersey; N61339-171; G. Kushner.

This project is for the development of the lag line (modules) for Device X14E1, Sonar Operator's Target Classification Trainer (Shipboard Recorder) to make it compatible for recordings of tapes from and playback into the AN/SQS-23 Sonar.

Equipment Development for Psychological Research in Carrier Landing Tnr Device Design (9U108), RF 017-05-7144. Reflectone Corporation, Stamford, Connecticut; Nonr 1960; N. Gordon.

Development of a device suitable for research by the Human Engineering Department on the effectiveness of a pictorial landing display in teaching carrier landings. Research device being reoriented from carrier landing to include landbased display for the simulation and evaluation by the Human Engineering Department.

Tnr, ASROC Launcher Exer Sim Equip, RF 017-05-7146. Minneapolis Honeywell Company; Duarte, California, N61339-671; Battista (31).

A device to provide training for enlisted personnel in the maintenance and trouble shooting of ASROC launching equipment. These requirements still exist and have been incorporated into Task No. RF 017-04-7100.

Radar and Visual Shadow Depth Eval Tech., RF 017-05-7143. Westgate Laboratory Incorporated, Yellow Springs, Ohio; N61339-556; H. Barkan.

To evolve a fully automatic method which will provide an accurate compact means for arriving at solutions to training problems, involving, how to train in avoidance of detection of aircraft by enemy radar or visual lookout, and how to plan for maximum coverage by own radar or visual lookout of flying targets.

Task completed.

Indoctrination Tnr Equipment EOD School and Special Weapons School, RF 017-05-7112. Contractor to be determined during FY 61; Romano.

Development of a series of take-apart models, charts, training aids of various nuclear missiles to be used in demonstrations and lectures at Explosive Ordnance Disposal School. Primary use is for indoctrination of students in the nuclear weapons field. Included in this task are:

British Bromb Fuze #38, #860
USAN MK230 Hydrostatic Tail Fuze
British #73, MK-2 Pistol (Bomb)
Terrier BW-1, Arm-Safe Device
Hawk XM32E2 Arm Safe Device
LaCrosse Base Detonating Fuze
Bull Pup MK 310 Fuze
Closed Loop Hydraulic System
NiKi M30A1 Safe Arm Device
Honest John XM-50 Warhead Section
Little John XM-51
M103-1A Bomb Fuze

Experimental Model, Head Set Control of Wide-angle TV, RF 017-05-7072. Farrand Optical Company, Incorporated, New York, New York; N61339-799; O. F. Schaper.

To investigate the presentation of a TV picture (approximately 90°), which represents a sector of the 360° environment. A remotely located TV camera will be served to an observer's head so that the picture frame coincides at all times with the observer's viewing direction. Upon completion of the investigation, a demonstration model will be designed and constructed. This will provide for a visual presentation of "Real World" environment which can be built as an attachment to any synthetic trainer.

Experimental Model, Internal Space Crew Simulator, RF 017-05-7003. American Machine and Foundry Company, Chicago, Illinois; N61339-786; M. Shaul.

A study of the requirements for research, the solutions of research problems associated with simulation of an internal environmental closed ecological system, and the design and development of an experimental model of a simulator for space crews.

Transparencies, Missile ASROC (X3G38), RF 017-05-7161. Cushing and Nevell, New York, New York; N61339-246; L. Perkins.

Development of 25 ozalid 8" x 10" transparencies depicting, for orientation purposes, the fire control equipment, launches, rocket propulsion element, depth bomb, homing torpedo, performance characteristics, tactical use, and general system layout for the ASROC Weapon.

Transparencies have been delivered and task is considered complete.

Training Aid, Ballistic Missile, Functional Panel, Polaris Navigation Sys, RF 017-05-7159. Reflectone Corporation, Stamford, Connecticut; N61339-679; I. Friedland.

Development of a POLARIS Navigational System Functional Panel with supporting transparencies and Instructor's Guide which will depict the circuitry of component input and output values as resolved within a typical FBM navigational system. Device has been delivered and task is considered complete.

Training Aid, G/M Take-Apart Demonstrator ASROC (X3G57/56), RF 017-05-7163. Anchor Manufacturing Company, New York, New York; N61339-717; A. Moskowitz.

Development of a take-apart model for the ASROC missile, illustrating the relative size, shape, normal parting lines and major internal components of the missile. The demonstrator is panelized with a cross-section cutaway view of the missile with internal major components that are dummied and removable.

Device has been delivered and task is considered complete.

Indoc Tng Equipment for ASW Mines (U), RF 017-05-7167. Contractor to be determined in 1962.

Since new systems are continually being developed for mine and anti-mine warfare, it is necessary to conduct a continuing program for developing models and other training aids to provide indoctrination

and other types of training for these new systems.
This task has been deferred from FY 61 to FY 62.

Underwater Sound Reference Recording Library (30IG1), RF 017-05-7169. NAVTRADEVCEN; On-Station; J. Rosta.
To collect and catalog representative underwater sounds which may be useful in the design and operation of underwater sound simulators and trainers.

Aircraft Recognition Model Photography (16B5), RF 017-05-7170. NAVTRADEVCEN; On-Station; F. Romano.
To prepare photographs and slides for use in the aircraft recognition manual and for recognition briefing of air auto-aircraft crews.
Device has been delivered and task is considered complete.

New Radar Modules for Terrier, Tarter, Talos Shipboard Systems, RF 017-05-7173. Belock Instrument Corporation, College Point, New York; N61339-803; J. Maone.
To provide radar simulation modules for device X19A Series. Determination of the specific modules to be studied and/or fabricated is dependent upon resolution by CNO of the basic Navy approach to further radar procurement. Indications are that the modules will be either for AN/SPS 30 Series or AN/SPS 34 Series radars.

Droplet Coalescence Demonstrator (X11B88), RF 017-05-7175. NAVTRADEVCEN, On-Station, F. Romano.
Development of a device to demonstrate to students of aerology phenomenon of formation of fog, smog, rain, snow and ice. The device is to control atmosphere in a glass jar providing variation in temperature, pressure, humidity and suspended particles. Changes in temperatures may be obtained by use of electric filaments and dry ice.

Engineering Services for Dev 21B23A Aboard USS Canberra (CAG-2), RF 017-05-7180. Norfolk Navy Shipyard, Portsmouth, Virginia; PWR 5-60; R. Gordon.
To provide engineering services and modifications to correct deficiencies in device.

Target Simulation Equipment Weapon System Talos Equipped Cruiser (19A1), RF 017-05-7181. Belock Instrument Corporation, College Point, New York; N61339-200; V. Maone.
The simulation system developed by this task will be installed aboard a combatant ship and will be classified as a "strip ship" device of reasonable size and weight. Maximum use of operational equipment rather than the duplication of an operational function by a simulator, will be made. The system will provide all or any part of the radar search, fire control and missile control, ECM, sonar, course speed and DRT, synthetic signals.

Tng Aid, ALPHA Field Survey Meter (X11F5), RF 017-05-7183. Tracerlab, Waltham, Massachusetts; N61339-865; J. Wicks.
Develop a device to simulate the RAS-10 operational equipment in appearance and operation. Since it is not feasible to use alpha emitting material for training, a part of this device shall consist of a simulant for the alpha emitting material. This simulant should be soluble (preferably in water), invisible in solution and non-toxic.

Trn, Radiological Warfare Decont. Controlled Exer X11F3, RF 017-05-7184. NAVTRADEVCEN, 1065-2, J. Jacquis; U. S. Radiological Defense Laboratory, PW R 4-60.
Develop a short half-life isotope handling aparatus including a mixing chanber, contaminant disseminating equipment and radsafe isotope handling equipment. The preparation of a manuscript for a safety manual on the handling of this apparatus and contaminant material is an integral part of this development.

Biological and Chemical Warfare Defense Transp. 11Q10, RF 017-05-7185. Fenga and Donderi, New York, New york; N61339-245; R. A. Fornari.
Chemical Warfare Defense Transparency set consists of graphic coverage of chemical warfare agents, gas detection materials and elements of protection. The Biological set consists of transparencies in the following areas: anti-personnel; epidemiology; delivery; detection and identification; sampling procedures; protective measures and decontamination.

Modification to Increase the Number of Air Targets in Devices RS12, RS14, RF 017-05-7186. FADTC, Dam Neck, Virginia; On-Station; R. Kramer.
Air target modification of Devices RS12 and 14 so as to provide more effective team training for fleet air defense personnel in the procedures necessary to counter high density air raids.

Passive ECM Search Information Simulator for Device RS14, RF 017-05-7187. NAVTRADEVCEN REG OFC, San Diego, California; On-Station; K. Stabenau.
Provision of a synchro transmitter and receiving station will now enable an instructor to conveniently relay to trainees, information concerning such passive ECM parameters as Pulse Width, Pulse Repetition Frequency, etc.

Study Card Set, G/M TERRIER Test Equipment (X3G69), RF 017-05-7188. Renner, Incorporated, New York, New York; N61339-794; I. Friedland.
This device will consist of approximately 40 troubleshooting problem sheets, schematic diagrams and pictorial diagrams. The device will exercise the trainees ability to theoretically diagnose the malfunctions indicated on the problem sheet by analyzing the indications and resistances presented by the study card set.
The work under this task was transferred to RF 017-05-7210.

Monopulse Radar Simulation Equipment, Phase II (21B34A), RF 017-05-7190. Daystrom Instrument, Archbald, Pennsylvania, N61339-293, M. Solenick; Renner, Incorporated, Philadelphia, Pennsylvania, N61339-298.
Development of a finished device that meets shipboard specification to be installed on board a TERRIER G/M Ship (CAG II). To be used to activate the AN/SPQ-5 guidance radars and associated with Device 21B33a (CAG Cruiser G/M Shipboard GFCS Trainer) to that extent.

Radar Sim Sys for USS Canberra, RF 017-05-7192. Norfolk Navy Ship Yard, Portsmouth, Virginia; PWR 5-60; R. Gordon.

Engineering services to correct deficiencies in device and replace servos and other components to reduce heat and improve stability of the radar simulation system aboard the USS Canberra.

Simulator, Monopulse Radar for Radar Set, AN/SPQ-5A (21B34A) Mod., RF 017-05-7191. Belock Instrument Company, College Point, New York, N61339-668 (completed), W. Gannon; Norfolk Naval Shipyard, On-Station.

Development and delivery of simulation equipment for the purpose of training weapons control personnel in the operation of radar set AN/SPQ-5 on TERRIER G/M carrying-ship USS Canberra (CAG-2) has been completed. The remaining effort consists of installing delay lines in the device.

Indoc Tng Aids for Weapon Directory Sys MK 5, 6, 7, RF 017-05-7200. Contractor to be determined during FY 61; F. Fornari.

Provide training aids, such as study card sets and transparencies to be used for indoctrination training in weapon direction equipment for the MK 3, 4, 5, 6, 7.

Electronic Warfare Recognition Program (5F3), RF 017-05-7197. Depicto Films, Corporations, New York, New York; N61339-871; J. Rosta.

This device will consist of a series of 35mm slides and accompanying magnetic tapes depicting the various electronic signals, both visual and aural. Device 11B32, Sound Slide Projector, shall be used in conjunction with the presentation of the program. The Master Slide Tape Lesson Sets will be developed in the following major categories of Soviet Electronic equipment: (1) Airborne, Radars; (2) Air Defense Systems; (3) ASW Problems; (4) Shipborne Radar.

This task also supports Air Warfare requirements.

Indoctrination Training Aids, TALOS, TERRIER, TARTAR, RF 017-05-7210. Renner Incorporated, New York, N61339-794, I. Friedland; Data Design Laboratory, Ontario, California, N61339-813, I. Friedland; Data Design Laboratory, Ontario, California, N61339-866, J. Carolan; Data Design Laboratory, Ontario, California, N61339-892, H. Amistadi; Scientific Engineering Company, New York City, N61339-881, J. Cherubini; Scientific Engineering Company, New York City, N61339-907, C. Gehrlein; Scientific Engineering Company, New York, City, N61339-882, J. Cherubini.

This task consists of a series of training aids to be used in the indoctrination training for the TALOS, TERRIER and TARTAR Missiles:

Study Card Sets for:
- G/M Terrier Test Equip (DSM-54(V) Type B)
- G/M Terrier Test Equip (SPM-9)
- G/M Talos, Test Equip (A N/DSM-18)
- Fuze Test Set MK 344, Mod 0.
- G/M Test Equip DSM-18B
- G/M Test Equip CM/122 DSM
- G/M Tartar Test Equip AN/DSM-60 and AN/DSM-55
- G/M AN/SKH-1 Data Recorder
- G/M Terrier AN/UKR-10 Data Receiver
- AN/USQ-11, Miss Distance Indicator

Models for:
- G/M Terrier BT-3
- G/M Talos 6C-1
- G/M MK-7 Talos Launcher Sys
- G/M MK 11-0 Tartar Launching Sys
- G/M MK 12 Talos Launcher Sys

Animated Transparencies for:
- Terrier, Phase Comparison
- Terrier, Roll Stabilization Sys
- Terrier, Summation Network

G/M Radar Operator Charts Transparencies MK 74, 75, 77, RF 017-05-7205. Contractor to be determined in FY 61; A. Moskowitz.

To develop training aids and devices for the Mark 74, 75, 77 Fire Control System.

Transparencies for:
- G/M FCS MK 74: Doppler, Flase Range;
- G/M FCS:MK 77/Comp MKIII, MK77/SPG 49, MK 77/Comp MKIII MODI, MK 77 RADAR OPER;
- G/M Radar: AN/SPG 55 A&B, AN/SPM-1;
- G/M FCS ADV WPN SYS

Charts for:
- G/M FCS: MK 77/COMP MKIII, MK 77 RADAR OPER

Trainer ECM Field 15E1 Types I and II and III (X, L, S Bands), RF 017-05-7221. Litton Industries of Maryland, Incorporated; N61339-747; F. Christie.

Development of devices which will be part of a generalized ECM trainer, field, leaving, is feasible as possible, universal application to modern operational ECM systems being utilized by the Navy. Device will provide training in interpretation of the signals received by and displayed on ECM receivers, direction finders and pulse analyzers; to develop skills required to operate those equipments; and, to teach the procedures and team coordination.

Dynamic Test Program for WST, RF 017-05-7220. Cornell Aeronautical Laboratory, Buffalo, New York; N61339-318; M. Fischer.

This task consisted of four phases:

a. Synthesis and test procedures in WST Assembly.
b. Test criteria in WST acceptance.
c. Instrumentation study to test WSTs.
d. Equipment design (Blackbox input/output for test).

Overall task is considered complete and satisfactory reports have been received.

Photo Mission Trainer, RF 017-05-7225. Curtiss Wright Electronics Division, Carlstadt, New Jersey; N61339-706; R. Entwhistle.

Development of a simulator that will assist qualified instructors in teaching photo pilots and photo navigators, in the aerial phase of PH (B) School, the use of an aerial photographic viewfinder in a classroom, prior to flight.

JULIE Capability for S2F-1 WST (2F28A), RF 017-05-7224. Stavod Engineering Corporation, Plainfield, New Jersey; N61339-727; J. Merrigan.

This task consists of adding the Julie and ASH capability to Device 2F28, S2F-1 WST, two units of which are presently in the Fleet. The purpose is to up-date existing Devices 2F28, Trainer, Weapon System to the final Julie configuration of the S2F

aircraft.

Trainer, ECM Type IV and V (15E1), RF 017-05-7228. Aircraft Armaments, Incorporated, Cockeysville, Maryland; N61339-897; F. Christie.

This device will consist of a "live" radiating antenna, transmitter and control unit. When complementing the type I ("X" Band), type II ("S" Band), type III ("L" Band), type IV ("K" Band), type V ("P" Band), will provide training in those bands for ECM operators in the detection, location, and analysis of the aural and visual signals generated by the devices and received and displayed on the operational ECM equipment. This device will be fleet or shore based.

Radar Scope Interpretation Trainer, RF 017-05-7226. Goodyear Aircraft Corporation, Akron, Ohio; N61339-730; E. Kelley.

To develop a classroom demonstrator which will show AN/APG-51A "B" scope search and attack presentations with accompanying target position in range, azimuth and elevation. The device shall also show, in model form, the accompanying special relationships of the friendly and bogey aircraft and shall be large enough so that presentations and displays are adequate.

DECM Modification to A3D-1 OFT (2F29), RF 017-05-7233. NAVTRADEVCEN; On-Station; A. S. Wolff.

Development of two units of the DECM panels and controls for the A3D-1 OFT.

Simulator, Radar Signal, IFF Mk 10 (SIF) (15H3), RF 017-05-7231. General Applied Science Laboratories, Hempstead, New York; N61339-682; G. Holmes.

Modification of Device 15H3 (MK 10 IFF) to provide a Selective identification feature. This permits identification of selected targets, both surface and air, from among a number of such targets within a formation.

Device has been delivered and task is considered complete.

A/C Carrier Landing System Kit for 2H19 Visual Landing System Attachment, RF 017-05-7235. NAVTRADEVCEN; On-Station Order 1344; G. Huether.

A subtask consisting of a feasibility study in the simulation of a jet aircraft landing approach sequence from the time of "breakout" to a successful landing aboard the carrier utilizing aural and optical aids.

The other subtask to implement conclusions of the study into a modification kit which will be compatible with Device 2H19 and a current type OFT/WST Trainer.

AN/ASB-1A Radar Bomb Scoring Trainer Improvement Program (15Z5), RF 017-05-7234. Fairchild Astrionautics Division, Wyandanch, New York; N61339-587; J. Barth.

To provide increased realism to the AN/ASB-1A Radar Bomb Scoring Trainer through the incorporation of several engineering improvements and modification to Device 15Z5.

Maintain Simulator to Current Aircraft Configuration (WV2-OFT) (2F58), RF 017-05-7237. Curtiss Wright, Carlstadt, New Jersey; N61339-839; J. Barry.

Development of modification kits for all device 2F58, WV-2 OFT's as follows: (a) revise the pilot's and co-pilot's flight instrument power system to provide an independent emergency power supply; (b) stabilize the caging mechanism of the type MB-1 Gyro Horizon.

F3D WST Modification to the APG-51 (2F12/15V5), RF 017-05-7236. NAVSUPDEP, Mechanicsburg, Pennsylvania; On-Station; J. Merrigan.

This modification will incorporate the APG-51 radar. This device will provide training to students of the advanced flight training command in AI radar operation, radar intercepts.

Target, ASW Submarine MOD. To Increase Sonic Capability and Propulsion Characteristics, RF 017-05-7241. Clevite Ordnance, Cleveland, Ohio; N61339-75; R. Dickman.

Development of a device to be used by air, surface and subsurface fleet units, to provide sonar and "JULIE" operator training in ASW techniques of location, tracking and destruction of submarines.

It will be designed to supplement the use of actual submarines.

R6D-1 Hydraulic Modification Kit (2F43), RF 017-05-7238. Curtiss Wright Corporation, Carlstadt, New Jersey; N61339-660; B. Mele.

This task consists of a modification kit for the Device 2F43, R6D-1 OFT to modernize the existing trainer hydraulic system. Thus the training value of the R6D-1 OFT will be enhanced by keeping the trainer current with the present R6D-1 aircraft system configuration.

T/A Torque Convertor (X11H22), RF 017-05-7253. Lester Assoc., Incorporated, Hastings-on-Hudson, New York; N61339-699; E. Hall.

An operable model of a torque convertor with the interior visible.

Trainer, Airborne Sonar Target Generator Modification (15R6C), RF 017-05-7242. Waldorf Instrument Co., Huntington, New York; N61339-269; G. Kushner.

This device will couple synthetic sonar signals with the course and depth signals from Device 15R6, Dummy Sonar Housing. It will provide these signals directly to the operational receivers.

T/A Steering Differential (X11H24), RF 017-05-7255. S. H. Hunter, Incorporated, Syosset, New York; N61339-693; E. Hall.

An operable model of the steering differential used in the CD 850 Cross Drive Transmission.

T/A Pinion Gear (X11H23), RF 017-05-7254. Ben Lorenz, New York, New York; N61339-729; E. Hall.

An animated transparency of a gear train of three gear members, a pinion gear with a movable carrier, operating between two rack type gears.

Helicopter Flight Research Tool - Television Application (6TV1B), RF 017-05-7260.

To study 3 dimensional television for possible application to training techniques, specifically the problem of non-programmed visual displays in connections with 2FH3. Most of the intended work

has been accomplished. Any additional effort will be reported under RF 017-05-7276.

T/A Compound Planetary Gear (X11H25), RF 017-05-7256. S. H. Hunter, Incorporated, Syosset, New York; N61339-693; E. Hall.

An operable mockup of a compound planetary year train Allison-GM Model XT-90 Cross Drive Transmission.

Development, Application and Limitations of the Point Light Source Technique (2FH4), RF 017-05-7262. The De Florez Company, Incorporated, New York, New York; Nonr 1628(00); J. Achlich.

To extend the versatility of the point-source technique and thereby increase its usefulness in the solution of training problems. This is being done by presenting all available information as to the state of the art, and by establishing the point-source equipment to solve numerous specific visual display training problems.

Visual Aerial Reconnaissance Training, RF 017-05-7261. Viewlex, Incorporated, Long Island City, New York; N61339-391; N. Barkan.

Development of a projector which will be applicable to the following classes of problems within the U. S. Naval Training Device Center: training in the techniques of visual contact flying, aerial spotting, visual aerial search and aerial photographic reconnaissance.

Universal Digital Analog-Digital Shaft Converter, RF 017-05-7264. Massachusetts Institute of Technology; N61339-301; A. Weinrach.

Development of a device capable of directly converting a digital signal to an analog shaft position and vice versa. A universal device of this type will be applicable to a digital computer which required numerous analog inputs and outputs such as the digital OFT.

Digital Integration and Resolution (24DR1), RF 017-05-7263. Gruen Applied Science Laboratories, Incorporated, Hempstead, New York; N61339-128; A. Weinrach.

Development of a digital computer to be used for the generation of absolute and relative motion and position of ships and aircraft. This task is for the construction of necessary hardware to demonstrate the adequacy of the proposed system techniques.

Digital OFT Design Study 24F3, RF 017-05-7266. University of Pennsylvania, Philadelphia, Pennsylvania; N61339-272; M. Fisher.

Investigate feasibility of actuating more than one simulated aircraft cockpit from a digital computer utilizing a fixed program magnetic drum memory. Study includes development of the logical design, the selection and test of applicable circuits, and the preparation of a program for the nonvariable aircraft parameters and instructions for the iterative computation cycle.

Simulation Survey and Ready Reference Sys, RF 017-05-7265. C-E-I-R, Incorporated, Arlington, Virginia; N61339-130.

Devise a system for the recovery of technical data for adoption into the Ready Reference System from task to office files. Incorporate into an existing ready reference data system. Technical data which is not readily accessible or in the library system.

Experimental Model, Shipboard Fire Control Radar Trainer Tech (24JH1), RF 017-05-7268. Technitrol Engineering Company, Halesite, Long Island, New York; N61339-374; J. Hickey.

Development of a model Radar Equipment MK 25 MOD 3 Simulator to be interconnected between a polar position generator and an operational F/C radar system so as to provide training for F/C personnel in air target detection, acquisition and tracking. An experimental model to test the design resulting from this study will be developed. This system will provide variations in range, bearing and elevation of one or more targets and one or more Search and Fire Control Simulators. Varying target speed by varying tape speed shall be attempted. The results will be a new compact model of a fire control simulator and polar position generator to be used as a guide in the production of future small, light weight shipboard trainers. An experimental model of the target generator has been completed and satisfactorily tested.

During FY 61 a breadboard model of a programmed polar position generator, using magnetic tape recording equipment and techniques, which will provide variations in ranges bearing and elevation.

UDOFTT Transistorization Study, RF 017-05-7267. Sylvania Electronic Systems, Needham, Massachusetts; N61339-596; M. Fischer.

Investigate applicable digital computer circuits and logical techniques to transistorize, miniaturize and standardize the Universal Digital Operational Flight Trainer System.

Exploratory Model, Solid State Image Intensification, RF 017-05-7270. Westinghouse Electric Corporation, Garden City, New York; N61339-562; H. Barkan.

To develop a solid state device for application to Visual Systems. In the past, visual problems, which could be solved only by complex and costly opto-mechanical systems, hindered development in certain areas of interest. The development of the electro-luminescent principle, and its application to these areas, will make possible more flexible and less costly solution.

Development, Application and Study of the Point Light Source Techniques, RF 017-05-7269. The De Florez Company, Incorporated, Englewood Cliff, New Jersey; Nonr 1628(00); G. Puller.

Development of a Basic Motion Device for moving transparencies in the demonstration of the application of Point Light Source Technique and provides a visual display for various training tasks.

Aero Dynamic Computer Study for OFT's (2FS11), RF 017-05-7273. Massachusetts Institute of Technology; N61339-594; W. Herzog.

This task is for the fabrication of a research model of a combined analog digital computer for simulation of aircraft, and to study the miniaturization techniques for this computation.

Techniques to Military Tng Problems, RF 017-05-7272. Servo Corporation of America, New Hyde Park, New York; N61339-759; G. Huether.

An investigation and experimental apparatus for demonstrating the characteristics and use of infrared radiation and detecting techniques as applicable to military training problems.

Exploratory Model, Wide Angle TV Projection, RF 017-05-7276. General Precision Laboratory, Incorporated, Pleasantville, New York; N61339-695; G. Heuther.

This task which is a part of the development of a wide screen nonprogrammed training display, will develop a wide angle image pickup and projection system by the use of several closed loop television systems joined together to form a single wide angle visual presentation. Phase I developed the pickup system; Phase II will develop the target system.

Exploratory Model, Water Condition Sim., RF 017-05-7275. International Tel and Tel. Laboratories, Nutley, New Jersey; N61339-712; S. Rubin.

This task consists of a study and breadboard construction of a device which will simulate range and frequency attenuation effects of sound on water under a variety of conditions. Some of the variables to be considered are bathythermal conditions, bottom depth, bottom material, sea state and surface temperature. This simulator should provide more realistic effects than simple range of the day limitation and may be indispensable to the simulation of the operation of long-range sonars.

Exploratory MOD. Propulsion System for Terrain Operations, RF 017-05-7280. Daystrom Instrument Company, Archbald, Pennsylvania; N61339-616; A. Linder.

To provide for the study of techniques to adapt the automatic Ship Model Propulsion System (Device 16L1) to operations over a 3-D contoured surface (terrain models). This will expand the basic system to encompass simulated military operations on land as well as on sea areas, thus permitting remote control of many independently maneuvering land as well as sea vehicles.

Initial Hit Switch for Target Use, Standardization of, RF 017-05-7279. NAVTRADEVCEN; On-Station; B. Howe.

To improve the performance and reliability of existing target device operation and scoring by improvements in hit switches, scoring circuits, and target materials.

Model Radar Land Mass Simulator, RF 017-05-7282. Curtiss Wright Electronics Division, Carlstadt, New Jersey; N61339-115A5; M. Kamenetsky.

This task is designed to accomplish the following: (1) define the capability of the photographic data storage system for handling not only topographic and intrinsic reflectance data but the effects of changing aspect as well; (2) determine methods of information "packing" of specular effects data compatible with the limitations of the photographic materials and with the mods of the radar simulation equipment and of the simulated scope presentation; (3) derive data for the coordination of FY 61 specular effects contract investigation with a factored transparency standard.

Engineering Study, Propulsion System for Remote Controlled Vehicles and Targets, RF 017-05-7281. Contractor to be determined in FY 61; T. Mongello.

This task covers an investigation of the feasibility of the application of various types of propulsion systems to propel remote-controlled remote-scoring target bearing vehicles. The study shall include reciprocating engines using newly developed fuels, high energy chemical fuel engines, battery power sources, fuel cells, etc.

This task will be used as a preliminary effort to more advanced study which will include the development of an experimental model of the system to be selected as a result.

Digital Computer for Actuation of OFT's (24F4), RF 017-05-7284. Sylvania Electric Products, Incorporated, Waltham, Massachusetts; N61339-40; M. Fisher.

To provide for the design, development and fabrication of a real time digital computer for flight trainers, and to provide for tie-in of this computer into two Operational Flight Trainers to be furnished as GFE; one OFT will be a Navy Aircraft and one of an Air Force Aircraft.

Application of Light and Image Intensification Techniques, Phase 1A Computer Activated Nonprogrammed, RF 017-05-7283. Daystrom Instrument Corporation, Archbald, Pennsylvania; N61339-656; H. Barkan.

To investigate techniques for the achievement of a system which will provide a nonprogrammed, wide-angle, visual display employing a self-illuminating screen that is activated by computer output. This system shall receive input information based on perspective equations resulting from movement of an observation point, and the intercept, on a special screen of the views thus created.

Deve'opment Model, Standard Simulated PPI Unit, RF 017-05-7287. NAVTRADEVCEN, On-Station; M. Lopez.

This task is for the development of characteristics in a Plan Position Indicator. The end product is intended to encompass all the common characteristics of indicators now used with Devices 24V2, RS8A, 14A1, 21B30, 21B52. Features which are not common to each indicator will be examined for feasibility of inclusion.

Investigate, Develop Techniques for Simulating Jamming on Synthesized Radar Scope, RF 017-05-7288. Reflectone Electronics, Incorporated, Stamford, Connecticut; N61339-842; F. Christie.

The project encompasses the investigation and analysis of all presently known types of jamming sources and the feasibility of their integration for presentation on a synthetic radar scope in conjunction with multiple radar targets.

Exploratory Development for New Techniques for Photographing Helicopter Recog. Models, RF 017-05-05-7289. K. Thomas.

A system of simulating the flight of helicopters

with photographic models has not been developed. It will be necessary to establish new concepts through the development of different techniques and systems of: (1) operating the rotors and propellers; (2) suspending the models in different altitudes to realistically simulate flight; (3) photography of models to represent aircraft (helicopter) in flight. Photographic models will be developed of the following helicopters: HOUND, HORSE, HARE, HOOK, HAT, HEN AND HOG.

Application of Light and Image Intensification to Automatic Target Tracking (16E7), RF 017-05-7290. Sylvania Electric Products, Incorporated, Salem, Massachusetts; N61339-288; H. Barkan.

A convenient way of presenting a target or targets for relative motion observation is by projecting the targets as spots of light on a screen. The configuration of spots at any one moment can show either the relative or geographical relationship between each one of the targets with respect to all the rest. This project will continue research in the application of light and image intensification techniques.

Map Development for Land Mass Radar Briefing (16C62), RF 017-05-7308. Boston University, Boston, Massachusetts; Nonr 492(03).

Development of optimum techniques for surfacing terrain models for use in accurately and completely simulating all types of radar targets appearing on land.

Spherical Photo Ortho Projector 16 G 10, RF 017-05-7311. Farrand Optical Company, New York, New York; Nonr 1901(00); J. Victoria.

Develop a system which will optically transform map projection coordinates from flat map projections to spherical coordinates while transposing cartographic or photographic intelligence from the flat map.

Intelligence Operations Models, RF 017-05-7312. Wood Work Specialties, Chicago, Illinois; N61339-703; R. Tyson.

Develop three dimensional models of ships and aircraft using government furnished drawings and photographs.

Experimental Model, No Atlantic Ocean Bottom, RF 017-05-7318. Panoramic Studios, Philadelphia, Pennsylvania; N61339-792; R. L. Wyener.

Produce an experimental terrain model of the No. Atlantic Ocean bottom displaying submarine topography.

Investigation of Heat Moldable Film for 3-D Terrain Models, Phase II, RF 017-05-7320. Horizons, Incorporated, Cleveland, Ohio; N61339-57; R. Entwhistle.

Development of photographic film capable of vacuum forming and resisting temperature of 270°F before exposure, and to be compatible with terrain model production techniques.

Terrain Map Simulation Technique, RF 017-05-7324. Contractor to be determined during FY 61; A. Musketos.

To provide a Land Mass Simulator utilizing the Dual Transparency and featuring simulation of 4 different attack radar systems.

In addition this task is to further develop Radar Land Mass Simulation Techniques in the areas of increased realism and standardization as it applies to the various weapon system trainers requiring Land Mass Simulation. Continued development is required to meet the ever-increasing requirements of associated Radar Simulation including TV and terrain clearance modes of operation.

Optical Consulting Services, RF 017-05-7364. University of Rochester, Rochester, New York; N61339-328; S. Domeshek.

To continue investigation of the broad problem of unprogrammed displays with a view to evolving techniques and equipment that would be successful for the general case of unprogrammed displays, and to apply the expert objective view point of the University's optical engineering personnel to the solution of specific optical problems as they arise during the course of the work at the center.

Indoc. Tng Equip Digital Computers (Solid State), RF 017-05-7367. Contractor deferred to FY 62.

Develop training devices to be utilized by instructors to assist in the presentation of the theory, operation and maintenance of digital computers.

Aviator Escape System Training Study, RF 017-05-7373. Courtney and Company, Philadelphia, Pennsylvania (Study); N61339-880; G. Chajet.

The objective of this task is to analyze and evaluate the tasks required of a pilot and aircrew member to escape from a disabled aircraft while in the air, on the land or in the sea. The significant tasks for which the pilot or aircrewman must be trained will be isolated and identified.

Simulator, Ground Surveillance Radar, Operator Tnr, RF 017-05-7387. Allen B. Dumont Laboratory, Incorporated, Clifton, New Jersey; N61339-925; J. Ruggiero.

This task entails developing a device or devices which will produce realistic and versatile video-aural targets. These simulated targets will be injected into Ground Surveillance radars and will provide a means of training operators to recognize, identify and track typical targets without being in a complex operational situation.

This device will be used to train and maintain proficient Ground Surveillance Radar Operators; and will be utilized in both formal classroom instruction and field type training exercises.

Indoctrination Tng Equip Small Digital Computer, RF 017-05-7422. Contractor to be developed during FY 61.

Provide training equipment necessary to instruct maintenance and operating personnel in computer techniques. The areas include "and" circuits "or" curcuits, memory registers, accumulators, gates, multiplier registers, clock (cycling generator), inputs and outputs.

Research, In-house Visual Systems Laboratory, RF 017-05-7438. Contractor to be determined during FY 61.

This will be a series of sub-tasks for investigating new visual systems that may be used in training applications; for testing applications to training of technological advances in the fields of Optics, Photo-Terrain Models and Photo-Technology; and to determine those new techniques, materials and equipments which will increase the efficiency and quality of various Optical, Electro-Optical, Opto-Mechanical and photographic methods for use with existing or future training devices.

Study, Simulated Wake for ASW Target, RF 017-05-7440. Contractor to be determined during FY 61; R. Dickman.

To investigate and try various means of accomplishing a wake effect with this device and to determine the feasibility of installing the wake equipment within the present hull of the device. The approach to the problem would be by dispersing a chaff, a trail of metallic particles, or gaseous bubbles from the device and determining if sufficient wake effect is obtained to confuse a trained sonar operator. Future versions of the ASW Submarine Target will be able to use this, and it will give the device a highly realistic capability for use as a submarine decoy.

Exploratory Model, Modular Target Motion Generator, RF 017-05-7441. Contractor to be determined in FY 61; J. Leskinen.

The purpose of this task is to effect standardization of course generators by repackaging a selected unit for removal of components from the front panel as modular elements. This will permit a number of variations in the assembly of course generators and will eliminate the necessity of redevelopment of course generators each time different functions are required. The existing target Motion Generator shall be repackaged in a modular form to permit different configurations for various applications requiring target motion generation.

Study, Incorporating Sound on Transparencies, RF 017-05-7442. Contractor to be determined during FY 61; A. Lewitt.

The problem is to get a transducer to scan the sound medium in a prescribed path and at a constant speed so as to always scan the correct information and faithfully reproduce the original audio content. If such a method can be developed, whole training programs can be incorporated on a series of slides, such as, for example, the ECM project and thereby consolidate the whole program on only one media.

Experimental Model Bio-Instrumentation for Control, RF 017-05-7489. Contractor to be determined during FY 61.

This task will provide the design and construction of a display panel indicating qualitative data to the instructor on a continuously changing environment, and specifically warning him when the environment is in the unsafe zone which will affect the trainee physiologically. This display will be particularly useful in future pressure chambers incorporating life support systems. Trainees will be indoctrinated for long duration high altitude flights involving carbon dioxide and odor scrubbing systems, oxygen and other gases for respiration, and all under varying pressures, temperatures and humidity.

Radiosonde Demonstrator, RF 017-05-7492. Contractor to be determined during FY 61; R. Wyener.

The device will consist of two display boards about 4' square on adjustable, collapsible legs. The device will have a shade that will be pulled down over the board so as to act as a shield. One board will have a continuous roll with the radiosonde record and the other board will have a continuous roll with the adiabatic charts displayed. The records and charts will be enlargements of the operational equipment with a surface that may be marked upon with grease pencil.

This device will be used to demonstrate procedures intaking information from the radiosonde record and transferring it to the adiabatic charts.

Model of Frontal Structure, RF 017-05-7494. Contractor to be determined during FY 61; R. Wyener.

The device will consist of three models of fronts: one showing a cold front, one showing a warm front, and one showing an occlusion. The device will be made so as to show the fronts in motion, when desired, with information showing the changes that occur as the front approaches, arrives and departs.

Tropospheric Circulation Demonstrator, RF 017-05-7495. Contractor to be determined during FY 61; R. Wyener.

This device will consist of two globes, one rotating within another showing movements of air masses. The device will illustrate in 3-D the general circulation, and associated features of the troposphere, and the abstract concept involved in this circulation considering a rotating earth.

F017-08 Drone Components

Target Control and Augmentation, WF 017-08-003. NADC, Johnsville, Pennsylvania, Allot. (102), Mr. F. X. Doyle, ED-2; Navy Missile Center, Pt. Mugu, Allot. (038), Code 5412; Undetermined Contractor, New (097), Unknown.

Objective: Determine the reflectivity characteristics of various targets, friendly aircraft, and target aircraft; coordinate all information available to the Navy Department on the radar reflectivity characteristics of airborne targets; establish NMC as a source of information to which the Bureau of Naval Weapons may direct all inquiries concerning radar reflectivity of both tactical targets and target aircraft.

Determine the fleets needs for radar augmentation both active and passive. Procure TWT's or similar augmentors, evaluate and test the procured equipment.

Modify and improve the AN/URS-1 portable UHF target tracking system. The AN/URS-1 is presently in the 400-460 mc band; CNO has ordered all drone equipment to get out of this frequency; therefore, we will modify the AN/URS-1 in order to meet CNO's requirements and demands. Improve the AN/URS-1 in order to meet the requirements for greater range. In addition a Tri-Service (Army-Navy-Air Force)

requirement is for a small, extremely reliable receiver for use as a flight safety receiver at various missile ranges and missile programs.

Miss Distance Indicators, WF 017-08-004. Naval Missile Center, Allot. (039), H. Felsenthal; Librascope Division, NOw 61-0698c (099), L. L. Paxson; U. S. Systems Development Laboratory, Contract (112) (# not assigned), R. J. Burke.

Investigate various MDI systems offered by industry. Evaluate promising systems and, from the evaluation, determine within the state of the art necessary design parameters for developments to support operational requirements and requirements for instrumentation to support weapon system development. Procurement of promising systems will be accomplished.

Systems considered promising are evaluated by engineering analysis within the Bureau of Naval Weapons and at field stations and laboratories. From such evaluations, decisions are made as to the capability of proposed systems to meet requirements. Industrial contracts are being supported to develop the most promising systems which will provide the required intercept data.

F018 WARFARE RESEARCH

F018-02 Systems and Operations Evaluation, Analyses, Studies, Etc.

Laboratory Animal Resources (U), RF 018-02-0031. National Academy of Sciences, Washington, D. C.; N7onr 291(46), NR 390-029; B. F. Hill.

This task was established for the purpose of examining and reporting on the status of laboratory animal resources. Closely connected with the function is a program for the improvement of supply, genetic background, nutrition and parasitological state of laboratory animals, as well as specific projects in such fields as animal caretaker training and the examination of problems connected with the national and international transportation of animals.

The Physics of Fluids (U), RF 018-02-0029. American Institute of Physics, New York, New York; MIPR 11-59 ONR, NR 390-027; W. Waterfall.

This task provides joint support, with the Air Force Office of Scientific Research, for the collection, evaluation, collating, and editing of scientific papers for a new and badly needed technical journal devoted to the physics of fluids, including the following topics: Hypersonic Physics, Shock and Detonation Wave Phenomena, Hydrodynamics, Dynamics of Compressible Fluids, Rarefied Gases and Upper Air Phenomena, Ionized Fluid and Plasma Physics, Hydromagnetics, Transport Phenomena, Boundary Layer and Turbulence Phenomena, Liquid State Physics and Superfluidity. Certain basic aspects of physics of fluids bordering geophysics, astrophysics, biophysics and other fields of science are also included. The journal is published by the American Institute of Physics as a bi-monthly, but may later become a monthly magazine.

Documentation (U), RF 018-02-0025. Library of Congress, Washington, D. C.; NAonr 36-60, NR 390-020; C. R. Brown.

Extensive literature searches are conducted in various subject areas in both domestic and foreign sources. Comprehensive bibliographies are compiled as the need for such compilations may arise. General direction and guidance are provided the contractor for each task which usually involves searching, evaluation, cataloging, abstracting, and indexing of relevant literature.

Bio-Sciences Information Exchange (U), RF 018-02-0027. The Smithsonian Institution, Washington, D. C.; Nonr 1354(01), NR 390-025; S. L. Deignan.

The Bio-Sciences Information Exchange was initiated by special action of the Interdepartmental Committee for Research and Development following recommendations contained in Mr. Steelman's Report to the President, "Science and Public Policy". It provided for the accumulation, organization, analysis, and dissemination of information concerned with current research in the biological sciences. Funding of this program has been assumed by ODDR & E and it is known as the Science Information Exchange.

Visual Range Determinations (U), SF 018-02-0538. University of California, Visibility Laboratory; NObs-84075; Dr. S. Q. Duntley.

Background. The detection, recognition, and classification of targets by optical means, including human observers, continues to be of major interest. Various devices are available to enhance these capabilities in military operations, such as photography, television, telescopes, and binoculars. A principal advantage is the passive nature of these processes, which in the case of human vision are associated directly with the interpretation and decision making functions.

By separate related studies, techniques have been developed for predicting the probable ranges of detection and recognition, taking into account such variables as target configuration, features, and speed; target background, such as sea surface, terrain, or sky; sun position or other illumination; atmospheric structures and other meteorological influences; and observer or camera speed, position, and capabilities. In view of the numerous variables in an operational situation, it is impossible otherwise to obtain any reliable estimate of such range for use in the planning of tactical or strategical naval operations, or the logical development of countermeasures against enemy reconnaissance of our sea forces.

Expansion of Navy Electronic Warfare Simulator (U), SF 018-02-7339. U. S. Navy Electronics Laboratory, V2-2, John B. Orr, Jack Rogers; Unassigned (Commercial).

The Navy Electronic Warfare Simulator (NEWS) installed at the Naval War College has been in operation for over two years. New Operational Requirements have been established by NAVWARCOL to incorporate capabilities for Subsurface Warfare, in addition to the present Surface and Air Warfare facilities. Additional equipments for display as well as two new Command Headquarters facilities are required.

Studies to determine the technical feasibility

of instrumenting the operational requirements have been completed and functional specifications have been established.

Design fabrication and testing of equipments is presently underway.

F019 ASTRONAUTICS

F019-02 Satellite Applications

Space Environment (U), WF 019-02-003. National Naval Medical Center, School Aviation Medicine, Aviation Medicine Experimental Laboratory.

To extend those studies and experiments relating to manned space flight.

By using existing aero-medical laboratories, information obtained from existing satellites such as GREB, PIONEER, EXPLORER, VANGUARD, TRANSIT, etc., and pick-a-back or space available payloads investigate and compile information on conditions in space which affect the survivability of a human in that environment.

R001 CHEMICAL SCIENCES

R001-01 Physical Chemistry

Solvent-Electrolyte Interactions (U), RR 001-01-0001. Yale University, New Haven, Connecticut, Department of Chemistry; Nonr 609(26), NR 051-002; R. M. Fuoss.

The interactions between electrolytes and solvents are investigated by measurements of conductance, osmotic pressure, viscosity, light scattering, dielectric constant, electrophoresis, reaction kinetics and solubility. Theoretical description of solvent/electrolyte interactions is an important part of this research. Attention is being given to 1-1 electrolytes in mixed solvents and to polyelectrolytes.

Gas Reaction Kinetics (U), RR 001-01-0003. Harvard University, Cambridge, Massachusetts, Department of Chemistry; Nonr 1866(36), NR 051-094; G. B. Kistiakowsky.

Special techniques have been developed for the observation of phenomena occurring in gaseous detonation waves, including means for measurement of effects having very short durations. Special instrumentation for these techniques include a high speed rotating-drum camera for photographic recording of detonation waves, an X-ray camera designed to detect the variable density of gas through a reaction zone, an optical spectroscope, and a mass spectrometer having a very high speed display of mass spectra features. Gaseous detonations induced by shock waves or otherwise are investigated with this equipment. Systems under study include hydrogen-oxygen, acetylene-oxygen, hydrocarbon-oxygen, and cyanogen-oxygen. Effects of inert diluents are also investigated.

Heterogeneity of Surfaces (U), RR 001-01-0007. Lehigh University, Bethlehem, Pennsylvania, Department of Chemistry; Nonr 2623(00), NR 051-186; A. C. Zettlemoyer.

The physical and chemical heterogeneities of surfaces of metals and inorganic compounds, and their modification by adsorbed films of gases were explored. Approach was through experimental determination of heats of adsorption, heats of immersion, and surface areas. Included in the systems studied were polar and nonpolar gases on nickel, iron and steel.

Radiofrequency Spectroscopy (U), RR 001-01-0008. University of Illinois, Urbana, Illinois, Department of Chemistry; Nonr 1834(13), NR 051-215; H. S. Gutowsky.

This investigation deals with characterization of new nuclear magnetic resonance phenomena and appraisal of their utility in the study of chemical systems. High resolution spectroscopy is used for determining the relationship between chemical shifts, the indirect spin-spin coupling and the electronic and bonding configurations of molecules. Spin-echo relaxation time is used in the examination of solids to determine the dynamics of molecular crystals. X-band electron spin resonance spectrometry is directed at organic free radicals, produced photochemically and by the dissociation of dimers. Pure quadrupole spectroscopy is directed primarily toward establishing the relation of the various phenomena involved (i.e., relaxation times, temperature and pressure dependence of the frequencies, effects of impurities) to molecular motions in the solid. Some of the results of this technique are applied to problems on the nature of chemical bonding.

Reactions and Properties of Alkyl Free Radicals (U), RR 001-01-0009. University of Washington, Seattle, Washington, Department of Chemistry; Nonr 477(14), NR 051-217; B. S. Rabinovitch.

Methods of chemical activation for the study of the reactions of alkyl radicals and other species are being developed. The H-atom effusion flame technique is employed to investigate the system hydrogen/alkene. Photochemical methods are used in addition to the effusion technique to extend the study of alkyl radical reactions as a function of the structure and energy of the species. Radicals containing halogen and oxygen are also investigated.

Kinetics of Fast Reactions (U), RR 001-01-0011. Cornell University, Ithaca, New York, Department of Chemistry; Nonr 401(30), NR 051-242; S. H. Bauer.

The kinetics of fast reactions, including relaxation effects, are being studied by several techniques. Emphasis is on gas-phase acid/base reactions using boron trifluoride as the acid and various bases, especially amines. Diluents are incorporated in the reacting systems to determine their effect on the efficiency of vibrational deexcitation and consequent stabilization of the product molecules. The effect of temperature on these reacting systems is given attention.

Properties of Detergent Solutions (U), RR 001-01-0012. Stanford University, Stanford, California, Department of Chemistry; Nonr 2256(00), NR 051-244; E. Hutchinson.

The thermodynamics of detergent solutions was investigated by determining heats of micellization. Fundamental information was sought on the thermodynamics of solubilization and on the mechanism whereby solubilizate is incorporated in the micelle by observing micellar energy changes and membrane distribution phenomena.

Homogeneous Fast Gas-Phase Reactions (U), RR 001-01-0013. University of California, Berkeley, California, Department of Chemistry; Nonr 222(56), NR 051-246; H. S. Johnston.

The development of techniques for the study of rapid reactions of oxides of nitrogen, with emphasis on the effect of inert gases on rates at low pressures. The work included extension of the theory of the effect of pressure on rates of unimolecular reactions. The reactions of oxides of nitrogen with chlorine and fluorine were investigated using spectrophotometry.

Fast Phenomena in Chemistry (U), RR 001-01-0014. California Institute of Technology, Pasadena, California, Department of Chemistry; Nonr 220(01), NR 051-248; N. Davidson.

The purpose of this task was the investigation of fast reactions by placing systems under high stress of short duration and measuring the rate of

the subsequent reaction. Among the initiating techniques used were high-intensity flash photolysis and shock waves. Reactions included in these studies were the nitrogen dioxide-dinitrogen tetroxide equilibrium, iodine recombination, and reactions of free radicals. An attempt was made to apply infrared spectroscopy to fast reactions occurring in shock tubes.

High Field Conductance of Electrolytes (U), RR 001-01-0015. Yale University, New Haven, Connecticut, Department of Chemistry; Nonr 2667(00), NR 051-249; A. Patterson, Jr.

The conductance of electrolytes under strong potential fields, by use of pulsed potentials, was investigated to study ion association in strong electrolytes and true dissociation constants of certain weak electrolytes. Polyelectrolytes under investigation were polyacrylic acid, polystyrene sulfonic acid, and polyvinylpyridinium bromide salts. Some emphasis was given to the behavior of strong mixed-valence type electrolytes.

Properties of Micelles (U), RR 001-01-0016. University of Southern California, Los Angeles, California, Department of Chemistry; Nonr 274(00), NR 051-254; K. J. Mysels.

The charge, shape, and size of micelles in aqueous solutions of colloidal electrolytes are being investigated by means of electrophoretic, self-diffusion, and light scattering experiments. Much attention is given to sodium lauryl sulfate as the colloidal electrolyte, with emphasis currently on the effects of counterions on micellar charge and weight. Exploration of the surface active properties of micellar solutions is planned.

Electrochemical Kinetics (U), RR 001-01-0017. Louisiana State University, Baton Rouge, Louisiana, Department of Chemistry; Nonr 300(00), NR 051-258; P. Delahay.

This research deals with the theoretical and experimental investigation of electrochemical kinetics. Relaxation methods are used to follow the mechanisms of electrode processes in aqueous and nonaqueous media. Attention is given to (a) methods for following the kinetics of reactions in fused salts; (b) investigation of the kinetics of electrode processes involving metal complexes, both organic and inorganic; (c) kinetics of electron transfer reactions in solution as compared with the kinetics of the same reactions at the electrode surface; (d) the occurrence of possible chemical steps preceding charge transfer; (e) electrode processes involving adsorption of reducible and oxidizable substances; (f) effect of the structure of the double layer in electrochemical kinetics.

High Temperature Properties of Gases (U), RR 001-01-0018. Columbia University, New York, New York, Department of Chemistry; Nonr 2943(00), NR 051-261; C. F. Bonilla.

Transport properties of selected gases at high temperatures are measured. Emphasis is on the viscosity and thermal conductivity of air and superheated steam up to temperatures of about 1500°C.

Reactions in Shock Waves (U), RR 001-01-0019. Princeton University, Princeton, New Jersey, Department of Chemistry, Nonr 1858(26), NR 051-275; D. F. Hornig.

An investigation of chemical processes in shock and detonation waves with emphasis on the formation of free radicals and observation of their spectra. The use of shock waves for determining thermodynamic properties of gases at high temperatures and pressures is applied to several chemical systems including the N_2 + CO reaction, ionization of argon, formation of CN-radicals, and emission and absorption spectra of simple organic halides.

Gas Expansion Dynamics (U), RR 001-01-0020. University of Maryland, College Park, Maryland, Institute of Molecular Physics; Nonr 595(02), NR 051-301; J. T. Vanderslice.

Highly specialized equipment, modeled after equipment in the van der Waals Laboratory of Amsterdam, was devoted to the general study of the properties and interactions of gases at pressures up to 20,000 atmospheres. Work was done with the Expansion Rate Measuring Apparatus. Dynamic measurements of gases such as air, carbon dioxide, argon and helium were made in the high-pressure, low-temperature region. Thermodynamic data, pressure, temperature, total energy and enthalpies were obtained.

Polysoaps (U), RR 001-01-0021. Rutgers University, New Brunswick, New Jersey, Department of Chemistry; Nonr 404(05), NR 051-308; U. P. Strauss.

The relationship between composition of cationic and anionic polysoaps and their physical chemistry is being investigated. Emphasis is placed on the colloidal behavior of these substances and its effect on solubilization. Other topics under study are the use of polysoaps in emulsion polymerization and in the catalysis of chemical reactions.

Molecular Interactions in Polymers (U), RR 001-01-0026. Cornell University, Ithaca, New York, Department of Chemistry; Nonr 401(17), NR 051-360; P. Debye.

This is an experimental and theoretical investigation on the determination of molecular interactions in polymers. The experimental technique involves measurement of the angular distribution of critical opalescence.

Topics in Theoretical Chemistry (U), RR 001-01-0027. Brandeis University, Waltham, Massachusetts; Nonr 1677(01), NR 051-362; S. Golden.

This is a theoretical investigation of the application of quantum and statistical mechanical methods to problems of atomic and molecular structure, molecular interactions and chemical reaction rates. Attention is currently given to the hydrogen molecule-ion in various excited states, to the hydrogen molecule, to the free-electron theory of metals, and to metal-ammonia solutions.

Adsorption of Polymers on Solids (U), RR 001-01-0029. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Chemistry; Nonr 839(19), NR 051-372; R. Ullman and F. Eirich.

This research was aimed at providing information on polymer/surface interactions by observing the adsorption of polymers on solids as a function of the properties of the polymer, the adsorbing solid, and the solvent. Under investigation were

polymethylmethacrylate, polydimethylsiloxane, polyvinyl pyridine and the corresponding pyridinium salts. Attention was given to adsorption reversibility and non-equilibrium effects.

Size and Shape of Large Molecules (U), RR 001-01-0030. Wayne State University, Detroit, Michigan, Department of Chemistry; Nonr 736(00), NR 051-380; W. Heller.

Optical methods are used in the theoretical and experimental quantitative determination of the size and shape of large molecules and colloidal particles. The determination of shape is based on anisotropic light scattering from particles oriented by external force vectors such as hydraulic shear. Attention is given to rigid macromolecules smaller than about 1000 angstrom units. An attempt will be made to apply the method to flexible macromolecules, including synthetic polymers.

Relaxation Processes in Liquids and Solids (U), RR 001-01-0031. University of Texas, Austin, Texas, Department of Chemistry; Nonr 375(05), NR 051-381; A. W. Nolle.

This was an experimental and theoretical investigation of relaxation processes in liquids, liquid crystals, and amorphous solids by ultrasonic-wave and nuclear magnetic resonance techniques. Much attention was given to high polymers. The effects of pressure, temperature, and frequency on magnetic relaxation were investigated.

Fundamental Study of Electrode Processes (U), RR 001-01-0033. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Chemistry. Nonr 839(22), NR 051-400; R. A. Marcus.

The behavior of ions in the interfacial region near the electrode was investigated theoretically and experimentally. The theory of electron transfer rate in solution, already developed by the principal investigator, was extended to electrode processes and to semiconductor electrodes. Also included was a treatment of the electrical double layer which considers all the ions involved as discrete charges. An experimental test of this treatment was made using the recently developed double-impulse method for the study of fast electrode reactions.

Catalytic Properties of Semiconductors (U), RR 001-01-0034. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Chemistry; Nonr 839(24), NR 051-405; E. Banks and E. M. Loebl.

The rates of the ortho-para hydrogen and deuterium conversions and the hydrogen-deuterium exchange reactions are studied as a function of the surface and bulk properties of the catalyst effecting the reactions. Catalysts under investigation are n- and p-type semiconductors of well-defined bulk properties and accurately known surface areas. Changes in surface properties of the catalysts are determined by X-ray and electron diffraction, and infrared transmission and reflectance spectra. Improvements in sensitivity of methods for detecting small changes in concentration of the reacting gases are sought to permit conducting the investigation eventually on well-defined single crystal surfaces.

Committee on Fire Research (U), RR 001-01-0036. Office of Civil and Defense Mobilization, Battle Creek, Michigan; NAonr 33-59, NR 051-412; W. S. Heffelfinger.

A Committee on Fire Research has been established by the National Academy of Sciences. This committee is considering all aspects of the problem of mass fires which could result from nuclear explosions and other causes. The functions of the Committee include consulting and advisory services, survey services, review of fire research proposals, assistance in placing fire research projects, and general coordination of fire research activities in Government, academic, and industrial circles. This task provided for the participation of the Department of Defense in the activities of the Committee.

Organo-Metallic Complexes (U), RR 001-01-0037. University College, Dublin, Eire, Department of Chemistry; N62558-2381, NR 051-417; D. A. Brown.

An attempt is made to obtain the best possible wave functions for the central metal atom in organo-metallic complexes, the results to be used in refined molecular-orbital treatments of such substances. Spectral parameters, e.g., repulsion integrals, spin-orbit coupling constants, are used in the calculations. Emphasis is mainly on half-sandwich complexes such as cyclopentadienyl-metal carbonyls and arene-chromium tricarbonyls. Attempts are made to synthesize certain symmetrical binuclear complexes predicted to exist as stable compounds through previous calculations of the principal investigator.

Defects in Solid Catalysts (U), RR 001-01-0038. University of Oklahoma Research Institute, Norman, Oklahoma, Department of Chemical Engineering; Nonr 982(08), NR 051-418; C. M. Sliepcevich, W. R. Upthegrove.

The influence of solid state dislocation densities on catalytic activity is studied; attention is also given to the stability of dislocation arrays during the catalytic reaction as a function of temperature. The particular reaction investigated is the decomposition of formic acid under the influence of a solid silver catalyst.

Potential Energy Curves of Interacting Species, (U), RR 001-01-0039. University of Maryland, College Park, Maryland, Institute for Molecular Physics; Nonr 595(14), NR 051-425; J. T. Vanderslice.

Potential energy curves of interacting chemical species are obtained from analysis of molecular scattering data, relaxation time measurements, observation of predissociation phenomena, and spectroscopic data. The curves are used to derive reaction mechanisms and bond energies of the interacting species. Some of the species to be investigated are C_2, CN, NH, BH, CH, SiH, SiO, and HCL.

Polymers at High Pressure (U), RR 001-01-0040. Cornell University, Ithaca, New York, Department of Chemistry; Nonr 401(44), NR 051-428; B. Wunderlich.

The high pressure behavior of synthetic long chain polymers is investigated. Measurements are made of the change in volume, near the melting range, of selected polymers at pressures up to 7000 Kg/cm^2. The results are analyzed to test current theories of the structure of solid and liquid

polymers. Initially, highly crystalline polyethylene will be studied.

Colloidal Dispersions in Oils (U), RR 001-01-4750. U. S. Naval Research Laboratory, Washington 25, D. C.; CO2-09; C. R. Singleterry.

Solubilization, adsorption and micelle formation by oil-soluble soaps are being investigated. Chromatographic, ultracentrifugal, interfacial tension, and contact angle measurements are being utilized to study solubilization, micelle size and shape, wetting and ice adhesion as they related to oil-soluble soaps dispersed in oils and in various hydrocarbon solvents. Accomplishments during 1960 include the demonstration of the usefulness of the ultracentrifuge for the study of micellar phenomena in many solvents, the characterization of adsorbed films deposited by sodium, barium, copper and cesium dinonylnaphthalene sulfonates from oil, and the measurement of the solubilization of methanol by several dinonylnaphthalene sulfonates in toluene.

Adsorption-Desorption Equilibria (U), RR 001-01-4751. U. S. Naval Research Laboratory, Washington 25, D. C.; CO2-10; W. A. Zisman.

Fundamental physicochemical research on phenomena occurring at the liquid/gas, liquid/liquid, solid/liquid, and solid/gas interfaces is conducted to determine the physical and chemical factors associated with specific functional behavior, such as wettability, lubricity, surface potential, etc. The controlled modification of the physical and chemical properties of liquid and solid surfaces by the adsorption of appropriate adsorbates provides surfaces selectively designed for studies of selective wetting, lubrication, corrosion inhibition, detergency, evaporation minimization, and desensitization of explosives.

Corrosion Inhibiting Films (U), RR 001-01-4752. U. S. Naval Research Laboratory, Washington 25, D. C.; CO2-12; H. R. Baker.

Corrosion inhibition in the presence of fuels, lubricants, greases or preservative compositions is under study. These investigations are concerned with the nature and physical properties of films formed by adsorption of additives from inhibited oils and fuels and with the mechanism by which additives inhibit the corrosion of metals. Additives that stabilize fluids against corrosion and deterioration at elevated temperatures are also under investigation. A report is being prepared on the first phase of the work on ashless corrosion inhibitors for lubricants and fuels. Progress on the stabilization of lubricating liquids at elevated temperatures has been reported.

Submarine Storage Batteries, Operational Studies of (U), RR 001-01-4753. U. S. Naval Research Laboratory, Washington 25, D. C.; CO5-05; J. C. White.

The purpose of this task is to provide the necessary facilities and experienced personnel required to carry out investigation of problems arising from difficulties encountered in the operation of submarine storage batteries in service as well as those in connection with new developments in such batteries. In addition to consultative services to the Bureau of Ships it is expected that some experimental work will be done in order to establish the cause of failure in service of the present lead calcium batteries in the nuclear powered submarines.

Fundamental Study of Electrode Reactions (U), RR 001-01-4754. U. S. Naval Research Laboratory, Washington 25, D. C.; CO5-13; S. Schuldiner.

Electrode processes are of predominant importance in such fields as corrosion, batteries, fuel cells, electroplating, electropolishing, electrometallurgy and electrochemical preparations. The complex systems require a systematic study of basic electrochemical phenomena in order to give the understanding necessary for the improvement of present electrochemical systems and the development of new and more specialized systems which will be necessary for future Naval use. Current effort is being devoted to the following areas: (a) Application of a new pulse technique to the study of electrode mechanisms. This method is being initially applied to a study of the hydrogen reaction of platinum and rhodium electrodes. The method is subsequently to be applied to systems whose surface properties are a function of the number of coulombs passed through the electrodes (film formation, gas solution, etc.). (b) Development of electrolytic cells and gas purification trains that will allow investigations in oxygen-free systems. This will be especially important in the study of the electrochemical development of oxide films and oxygen reactions on electrodes.

Electrochemical Sources of Power (U), RR 001-01-4755. U. S. Naval Research Laboratory, Washington 25, D. C.; CO5-14; A. C. Simon, J. B. Burbank, C. M. Shepherd.

This task is devoted to obtaining fundamental knowledge of the mechanisms of the electrode reactions which control the capacity and the rate of discharge of the newer and more important electrochemical sources of power. Current effort is devoted to an effort to better understand reactions in the silver oxide-zinc primary and secondary batteries and to resolve the difficulties associated with loss of capacity in the batteries of the nuclear powered submarines.

R001-02 Chemical Materials (Non-Metallic)

Heat Stable Polymers Based on Inorganic Fluorides (U), RR 001-02-0001. University of Florida, Gainesville, Florida, Department of Chemical Engineering; Nonr 580(03), NR 356-333; H. C. Brown.

Research was conducted in the synthesis of fluorides, including polymers, which contain no carbon-hydrogen bonds and few or no carbon-carbon bonds, such as (1) preparation of polymers from perfluorocarbonamidines, perfluorocarbonimidines, and perfluorocarbonitriles, (2) addition of hydrazine to perfluorocarbonitriles, (3) synthesis of perfluorodithioacids, thioketones, and thioaldehydes, (4) the synthesis of bis-azomethines and their polymer derivatives, (5) reactions of NF_3 with various unsaturated fluorine compounds, and (6) telomerization of $(CF_3)_2NF$ with olefins.

Properties of Plastics (U), RR 001-02-0002. Princeton University, Princeton, New Jersey, Plastics Laboratory; NAonr 37-48, NR 356-375; L. F. Rahm, B. Maxwell, H. A. Pohl, D. S. Trifan.

Electrical properties of polymers including metal doping of polymers and their pyrolysis products; dielectrophoresis of nonpolar polymers; and dielectric properties of polar polymers are being investigated. Research on dynamic mechanical properties of polymers including rheological properties under conditions of use and physical properties under condition of fabrication, polymer melt elasticity, and the effect of cold working on polycrystalline polymers is being conducted.

Viscoelastic Properties of Polymers (U), RR 001-02-0003. Princeton University, Princeton, New Jersey, Department of Chemistry; Nonr 1858(07), NR 356-377; A. V. Tobolsky.

A fundamental investigation of viscoelasticity of polymeric materials is being conducted, and basic data obtained by observing stress relaxation, creep, and other rheological effects of selected high polymers over a wide temperature range. Materials under examination include highly cross-linked polymers, such as epoxy and styrene-polyester resin, polymers of controlled crystallinity, such as polyethylenes and polypropylenes, plasticized polymers, polyblends, and polymers containing ionic side groups. Special emphasis is given to polymers known to have unusual resistance to high temperatures, e.g., silicones, fluorocarbons, polycarbonates. Also included are selected inorganic polymers such as phosphonitrilic chloride and its derivatives, polymers containing boron-nitrogen bonds, polyzincamminechlorides, and amorphous arsenic-selenium copolymer. Molecular weights are estimated by measurement of stress relaxation in bulk (undissolved) polymer.

Investigation of Structure of Polymers (U), RR 001-02-0004. University of Massachusetts, Amherst, Massachusetts, Department of Chemistry; Nonr 2151(00), NR 356-378; R. S. Stein.

The molecular structure of solid polymers, expecially polyethylene in film and bulk form, is investigated by low-angle light scattering, birefringence, dichroism, and X-ray diffraction. Attention is given to processes occurring within the polymer during the stretching of films of the material and during swelling in solvents. Also studied is the effect of temperature on the low-angle light scattering, the angular variation of scattering and the variation of polarization of the scattered light. Birefringence of stretched films of polyethylene immersed in swelling solvents is studied, and related X-ray diffraction observations are being carried out to clarify the nature of the processes occurring on an atomic basis. New techniques for measuring biaxial birefringence are being exploited. Similar studies are made on polypropylene in both isotactic and atactic forms.

Inorganic Polymers (U), RR 001-02-0005. Stauffer Chemical Company, Richmond, California; Nonr 2259(00), NR 356-387; E. G. Wallace.

Research was directed toward the synthesis of monomers and polymers characterized by C-N, N-B, C-N-B, C-P, C-P-B, Si-P, Si-P-B, and P-B bonds in the main chains with a minimum of C-H and C-C bonds. New methods of synthesis were explored, and products were isolated and identified by such techniques as gas-liquid partition chromatography, molecular weight determination, and infrared absorption spectroscopy. Perfluorocarbonamidine monomers and polymers (CFN polymers) were prepared and evaluated.

Synthesis of Perfluoroarylene Polymers (U), RR 001-02-0006. National Bureau of Standards, Washington, D. C., Polymer Section; NAonr 32-57, NR 356-389; L. A. Wall.

This research was directed toward the synthesis of fluorinated aromatic monomers, including selected derivatives such as amidines, silanes, stannanes, phosphides, nitrides, borides, carbonates, and others, and their polymerization and copolymerization to yield novel perfluoroarylene polymers.

Organogermanium Chemistry (U), RR 001-02-0007. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Chemistry; Nonr 1841(43), NR 356-391; D. Seyferth.

Organogermanium compounds are synthesized and investigated with the objectives of developing basic knowledge and of ascertaining the feasibility of obtaining thermally stable polymers. In analogy to the condensation of silanols to silicones the condensation of germanols is attempted to examine the effect of the larger covalent radius of the germanium atom on the chemistry. Synthesis of arylene germanium compounds, including phenylene-germanium polymers, is also planned. Metallic derivatives of triphenylgermanol with Si, Sn, B, Ti, Zr, and other metals are sought as first example of the Ge-O-metal linkage.

Metalloxane Polymers (U), RR 001-02-0008. Hughes Aircraft Company, Culver City, California; Nonr 2540(00), NR 356-395; J. Rust.

Polymers related to silicones are synthesized by reactions that permit maintaining control of the arrangement and sequence of constituent atoms. Polymer chains to be synthesized include Ti-O-, Ti-O-Si-O-, Al-O-Si-O-, Al-O-Ti-O-, $\boxed{\text{Ti-O}}_x\boxed{\text{Si-O}}_y$ and $\boxed{\text{Al-O}}_x\boxed{\text{Si-O}}_y$, where x and y are more than one and may be different. Side groups are to be trialkylstannoxyl, or chelate groups including 8-quinolinoxyl. Polymeric products are examined to determine physical, chemical, thermal, mechanical and electrical properties. Effects of curing phenol-formaldehyde resins with these synthetic silicone analogs are investigated.

Stress Relaxation and Structure of High-Temperature Elastomers (U), RR 001-02-0009. University of Akron, Akron, Ohio, Institute of Rubber Research; Nonr 2573(01), NR 356-401; M. Morton.

Continuous measurements of stress relaxation of selected elastomers were made under controlled conditions. A concurrent investigation of the equilibrium elastic properties was made. Information derived from these data was evaluated to determine the influence of chemical structure and type of cross-linking on elastomeric properties.

Polymer Structure and Properties (U), RR 001-02-0011. Mellon Institute, Pittsburgh, Pennsylvania; Nonr 2693(00), NR 356-407; T. G. Fox, R. D.

Spencer.

The principles relating the chemical and physical properties of polymers to their structure are investigated. Included in the investigation are (a) a test of the theory of copolymer cyrstallization, which seeks to relate the elastic modulus and degree of crystallinity to copolymer composition and temperature. Polymers are prepared containing methyl, ethyl, and larger substituents distributed at random along the chains and dilatometric measurements made through the melting ranges of these; (b) extension of the theory treating the configurations of polymer chains bearing regularly occurring substituents. Emphasis is on stereospecific chains and chain substituent interactions; (c) stress relaxation studies in amorphous linear polymers to elucidate the roles of temporary attachments resulting from chain entanglements or intermolecular attractions between functional groups. For this purpose, polymers are chosen in which cross-linkages are susceptible to rupture and reformation; (d) extension of current theories of flow properties (viscoelastic behavior) of polymers. Emphasis is on the dependence of flow on structural variations such as chain branching, stereoregularity, and chain length heterogeneity; (e) investigation of the rheological behavior of multiphase polymers. A second phase of the project deals with methods for controlling the stereochemical structure of polymers, especially model branched chains. The principal approach is through anionic polymerizations.

Inorganic Polymers (U), RR 001-02-0012. Pennsalt Chemicals Corporation, Philadelphia, Pennsylvania; Nonr 2687(00), NR 356-408; G. Barth-Wehrenalp.

By employing a number of procedures including polymerization by coordination, by condensation, by combination of fragments formed by pyrolysis or electric discharge, by combination of binary compounds (metal oxides, halides, sulfides), and by applying combination of pressures up to a hundred kilobars and temperatures up to 1500°C. to a large number of chemical systems, the synthesis of many types of polymers stable above 500°C. is being investigated. Included are polymers with the principal chains M-Z and M-Z-Q-Z- where M is Al, Ti, Cr, Zn, or Be, Z is O, OH, NH_2, CN, Cl or F, and Q is Si, As or P; polymers with principal chains formed from various sequences of atoms of two to five elements with particular emphasis at present upon reactions of certain phosphorus isocyanates and phosphorus azides; and analogs of known fluoaluminates. During the third year a search for inorganic chelating agents to be used in the preparation of stable coordinated metal compounds is being made among compounds containing the groups O-P-C-N, O-P-C-P-O, O-P-C-Si-O, O-Si-C-Si-O and O-Si-C-N. Pressures up to 100 kilobars will be used to force some of the reactions indicated.

Conference on Contractile Mechanisms (U), RR 001-02-0013. Mellon Institute, Pittsburgh, Pennsylvania; Nonr 2998(00), NR 356-420; P. J. Flory.

A conference on contractile mechanisms was held at the Mellon Institute, Pittsburgh, Pennsylvania, 27-30 January 1960. Presentation and discussions centered around recent work in physical chemistry of synthetic polymers and the application of the resulting theories and mechanisms to the problem of contraction in biological systems. Specifically, much attention was given to theories and experimental analysis of contractility in macromolecules from the point of view of fundamental principles with emphasis on molecular explanations when possible.

Fluoaluminate Dielectrics (U), RR 001-02-0014. Pennsalt Chemicals Corporation, Philadelphia, Pennsylvania; Nonr 3142(00), NR 356-423; G. Barth-Wehrenalp.

A study of the phase relations in the binary system $KAlF_4$-$RbAlF_4$, and in the ternary system $KAlF_4$-$RbAlF_4$- KBF_4 will be carried out, limited in each case to those compositional areas known to favor good crystal growth of $KAlF_4$-$RbAlF_4$ solid solutions. Concurrent measurement of the dielectric constant, dissipation factor, and insulation resistance of the melt compositions will be made, thus arriving at a simultaneous understanding of the various phases and their associated dielectric properties. Crystalline phases will be identified by X-ray diffraction, and associated optical measurements will be made. The data will be used to further the experimental development of a class of single crystal dielectrics based on fluoaluminate solid solutions, as well as the development of dielectric ceramics based on this chemical system.

Rubber Research (U), RR 001-02-4800. U. S. Naval Research Laboratory, Washington 25, D. C.; CO4-03; E. J. Kohn.

This task was established to acquire increased knowledge of new and old elastomeric materials, to develop new and improved materials, processing and fabrication techniques and to develop increased skill in adapting these materials to specific uses to meet the multiple and varied requirements for elastomeric components in weapons systems. The surface frictional behavior of elastomeric materials, the water vapor permeability of silicone elastomers and the lowering of the brittle point temperature of Viton Elastomers are presently being studied.

Polymeric Systems (U), RR 001-02-4801. U. S. Naval Research Laboratory, Washington 25, D. C.; CO4-04; R. B. Fox.

With the long-run objective of producing useful polymeric substances and elucidating knowledge necessary to the production of these materials, a broad program of synthesis involving both new products and new reactions had been instituted along with a continuing investigation of the processes involved in the modification of such materials to accentuate desired properties. The latter object is being pursued through a study of photodegradation processes and the means of inhibition of such degradation in practical polymeric systems.

Synthesis and Study of Inorganic Polymers (U), RR 001-02-4802. U. S. Naval Research Laboratory, Washington 25, D. C.; CO4-07; R. R. Miller.

This task was established to prepare and study polymeric materials which are intermediate between organic and inorganic compounds. Higher thermal stability should result from compounds made from

inorganic structures which contain organic chains for cross linking. Some of the good properties of both types of polymers should be retained in the mixed polymers.

Molecular Structure (U), RR 001-02-4803. U. S. Naval Research Laboratory, Washington 25, D. C.; C07-01; R. E. Kagarise.

This task was established to conduct research in any or all phases of molecular spectroscopy as applied to the determination of molecular structure, qualitative and quantitative analyses, and the interpretation of related optical, thermodynamic, physical and chemical properties of materials. The immediate objective includes the application of spectroscopy to the solution of chemical problems, the improvement of spectroscopic equipment and sampling techniques and the acquisition of spectral data required for subsequent application.

Analytical Mass Spectrometry (U), RR 001-02-4804. U. S. Naval Research Laboratory, Washington 25, D. C.; C07-02; F. H. Nestler.

The establishment of a research analytical mass spectrometry section may be considered an accomplished fact. Due to the lack of personnel, efficient operation as a service group and the pursuit of an active research program was not possible; however, a number of service type analyses were carried out for other research groups. With the acquisition of a Bendix time-of-flight mass spectrometer, the approach has been altered to one in which the capabilities of the instrumentation will be directed toward the solution of specific research problems. The initial task selected is a study of the permeability characteristics of elastomeric materials to various gases and vapors; this will be conducted in cooperation with the Elastomers Section, Physical Chemistry Branch.

Electron Diffraction (U), RR 001-02-4805. U. S. Naval Research Laboratory, Washington 25, D. C.; C07-03; J. Karle.

Electron and X-ray diffraction are tools which are very useful for determining the ultimate structure of matter. The two fields complement one another since electrons are most applicable to gases, surfaces and very thin samples, whereas X-rays are applicable to the internal structure of relatively massive materials. Thus electrons are used to study the chemical nature of surfaces, as in corrosion and lubrication problems, the structure and vibrational motion of gas molecules, and the energy states of gases and thin solid samples. X-rays may be used to study the structure of all types of crystals ranging from minerals to materials of biological interest.

Chemical (Non-Metallic Materials), WR 001-02-001. Naval Air Material Center; RRMA-04 013/200; RRMA-12.

To develop, test, and evaluate new and improved chemicals and chemical compounds for fleet and general service use in anticipation of future requirements. Materials which will operate satisfactorily in the temperature range of -100 to 1000°F are being sought.

New and improved general and special chemical compounds will be tested under various environmental conditions, as they are developed or tendered by industry. Specification requirements for these chemical compounds will be developed.

Various general and special chemicals for fleet use have been developed, tested, and evaluated. Examples of these materials are cleaning compounds, rain repellents, deicing compounds, paint removers, waxes, and solvents. Specifications for these materials have been issued.

R001-03 Organic Chemistry

Entropies of Reaction Transition States (U), RR 001-03-0001. Pennsylvania State University, University Park, Pennsylvania, Department of Chemistry; Nonr 656(03), NR 055-295; R. W. Taft, Jr.

This task included a detailed study of the mechanism of solvolysis reactions to obtain data on the stereochemical and rearrangement effects which accompany these reactions. The relation between the structures of compounds reacting in liquid solution, the relative entropies of these compounds in the gaseous state, and the relative entropies of the corresponding states in solution were determined. The research is being continued in conjunction with other related research by the same investigator under Task NR 005-328.

Reactions of Organic-Sulfur Compounds (U), RR 001-03-0002. Rensselaer Polytechnic Institute, Troy, New York, Department of Chemistry; Nonr 1787(00), NR 055-313; H. F. Herbrandson.

The synthesis and reactions of organic sulfur compounds are being investigated. Emphasis is directed toward elucidating the mechanism of epimerization and hydrolysis of sulfinate esters and determining specific rate constants of the reactions.

Polar and Steric Factors (U), RR 001-03-0003. Pennsylvania State University, University Park, Pennsylvania, Department of Chemistry; Nonr 656(05), NR 055-328; R. W. Taft, Jr.

This research includes (1) separation of polar, steric and resonance effects of substituent groups on reactivities of organic compounds, including studies on the quantitative correlation and prediction of inductive and resonance effects; (2) characterization of inductive parameters of new substituent groups, especially those containing boron atoms, from the F^{19} NMR shielding parameters of meta substituted fluoro benzenes, and investigations of substituent shielding parameters for B^{11} and P^{31} NMR spectra; and (3) determination of thermodynamic rate properties for acid-catalyzed reactions, including temperature coefficients of H_o acidity function dependence.

Solvation of Solutes in Mixed Solvents (U), RR 001-03-0004. Florida State University, Tallahassee, Florida, Department of Chemistry; Nonr 988(02), NR 055-330; E. Grunwald.

The thermodynamic properties of ions from salts and other components of the liquids in which organic reactions are carried out are being determined in order to relate the effects of all the chemical species present upon the reaction rates. Presently the work includes kinetic studies of the bimolecular displacement reactions of methyl bromide in

aqueous solutions containing detergent salts and various nucleophiles such as sodium cyanide, phenoxides, and nitrites. The nature of the products are determined by gas-phase chromatography. Also under investigation is the rate of exchange of water molecules between sulfonated polystyrene ion exchange resin and bulk water by nuclear magnetic resonance studies.

Liquid Phase Reactions Under High Pressure (U), RR 001-03-0005. Columbia University, New York, New York, Department of Chemistry; Nonr 2441(00), NR 055-353; C. Walling.

Research is conducted on the effects of high pressures (up to 13,000 atmospheres) on free radical polymerization, chain propagation and chain transfer processes in liquid phase reactions.

Nuclear Magnetic Resonance in Organic Chemistry (U), RR 001-03-0008. California Institute of Technology, Pasadena, California, Department of Chemistry; Nonr 220(26), NR 055-388; J. D. Roberts.

Research is conducted on nuclear magnetic resonance spectroscopy as applied to problems in organic chemistry. This technique is used to investigate problems involving structural and energy changes such as molecular rearrangements, molecular asymmetry, rotational energy barriers and molecular conformational analysis. Halogenated cycloalkanes and allylic Grignard reagents are being studied.

Reactions of Electron-Deficient Intermediates (U), RR 001-03-0010. Florida State University, Tallahassee, Florida, Department of Chemistry; Nonr 2560(00), NR 055-398; J. E. Leffler.

Reactions of electron-deficient intermediates containing carbon, phosphorus and nitrogen are sought and characterized. Other reactions being investigated are rearrangement (1) from boron to carbon, (2) silicon to nitrogen, (3) boron to nitrogen, (4) sulfur to nitrogen, (5) nitrogen to nitrogen, and (6) neighboring group effects in radicals. Some preference for reactions that occur at useful rates only at 300°C and above will be shown in the selection of reactions for investigation.

Tetravalent Boron Polymers (U), RR 001-03-0011. Rutgers University, New Brunswick, New Jersey, Department of Chemistry; Nonr 404(14), NR 055-409; C. E. Erickson.

An investigation of the chemistry and polymerization of organic compounds containing tetracovalent boron is being conducted. Amino and N-substituted aminobutaneboronic acids are being prepared and characterized and attempts made to prepare linear polymers containing B-O-B links therefrom in order to study the effect of internal coordination on the hydrolytic stability.

Alkylation of Pyrroles (U), RR 001-03-0012. University of Kansas, Lawrence, Kansas, Department of Chemistry; Nonr 2751(00), NR 055-411; C. A. VanderWerf.

This research was concerned with the determination of factors (temperature, dielectric constant of solvent) which influence the direction of alkylation and benzylation in metal salts of pyrrole. Studies were made of the reactions of pyrrylpotassium and other pyrrole metal salts with such halides as allyl chloride, crotyl chloride, and benzyl chloride in the presence of various solvents. Isomer products were fractionated and characterized and the percentages of 1- and 2-position alkylations calculated from the product ratio.

Reactions of Diazooxides (U), RR 001-03-0013. University of Chicago, Chicago, Illinois, Department of Chemistry; Nonr 2121(21), NR 055-422; M. J. S. Dewar.

A novel synthesis of biaryls from benzene diazooxides and the relation between structure and reactivity to radicals in benzenoid systems are investigated. The research includes (a) a survey of the reactions of 2,6-dibromo-4-diazobenzene oxide with monocyclic, polycyclic and heterocyclic benzenoid compounds; (b) the reactions of other diazooxides; and (c) a search for biradical intermediates.

Hydraulic Fluid (U), SR 001-03-0606. Engineering Experiment Station, 10101/RDT&EN 61.2411, C. L. Brown; Bureau of Mines, BuShips/1700S-683-61, Dr. M. G. Zabetakis; Celanese Corporation of America, NObs 78466, Joseph J. Romano, Joseph A. Vona; The Pennsylvania State University, NObs 78674, Dr. D. F. White.

The phosphate ester has been removed from the submarine hydraulic system. This was necessary because inherent leaks and spills that occur through the system might have a detrimental effect on electrical insulation, paint, floor coverings, etc. Therefore, a need exists for a fire resistant fluid that will operate in hydraulic systems under high pressure and wide temperature range. Low temperature (25°F.) characteristics are particularly important. The fluid must protect the system against salt water corrosion and operate without toxic effect. Fire resistance is required for certain applications. The availability of these fluids means greater speed of equipment response, greater flexibility and improved morale.

R001-04 Inorganic Chemistry

Boron Chemistry (U), RR 001-04-0001. University of Southern California, Los Angeles, California, Department of Chemistry; Nonr 228(13), NR 052-050; A. Burg.

Research on the synthesis, chemical behavior, and bonding of the boron hydrides and their derivatives, is conducted with a view toward developing new systems of covalent boron chemistry through discovery of unifying principles applicable also to other areas of chemistry. Included are borane complexes (Lewis-type adducts), substituted boranes derived from the borane complexes, polyborane carbonyls such as B_4H_8CO, and the interconversion of polyboranes by the action of Lewis bases. Phosphinoborane chemistry is presently being emphasized as a result of the discovery of thermally stable phosphinoborane polymers. New compounds are characterized by chemical and physical measurements supplemented by molecular structure determinations.

Crystal Structure and Chemical Bonding (U), RR 001-04-0003. Harvard University, Cambridge,

Massachusetts, Department of Chemistry; Nonr 1866(42), NR 052-178; W. N. Lipscomb.

Crystal structure studies are conducted at temperatures obtainable with liquid helium on O_2, N_2, F_2, and $Li(NH_3)4$. Problems associated with phase transitions and possible antiferromagnetism in the phases of O_2 are investigated. A concurrent synthesis program is under way to make compounds required for other phases, at present compounds containing boron-carbon or boron-metal bonds. Preparative work on the growth of single crystals below solid-solid transition temperatures--either from solution or from the gas phase--is also in progress. Structures of synthesized compounds are determined by X-ray diffraction supplemented by infrared and nuclear magnetic resonance techniques where necessary. Diborane and B_{11} compounds are among the present objects of vigorous theoretical study.

Polymeric Inorganic and Organometallic Compounds (U), RR 001-04-0005. Harvard University, Cambridge, Massachusetts, Department of Chemistry; Nonr 1866(13), NR 052-337; E. G. Rochow.

The synthesis and molecular structure of silicones and related compounds of silicon, germanium, and tin are investigated. Present emphasis is on polymers with principal chains of alternating silicon and nitrogen atoms or silicon, nitrogen and carbon atoms, and related compounds in which nitrogen is coordinated to metals and other acceptors. Stability to hydrolysis is studied by variation of the metal ion or other acceptor bonded to nitrogen and of the group attached to silicon.

Synthesis of New Inorganic Compounds (U), RR 001-04-0007. University of North Carolina, Chapel Hill, North Carolina, Department of Chemistry; Nonr 855(05), NR 052-371; S. Y. Tyree, Jr.

The purpose is to discover and characterize new types of bonds where one element is a metal element, and to investigate the hydrolysis and aggregation of polymeric ions. Phosphorus-nitrogen-metal and sulfur-nitrogen-metal systems are being studied. Research on X-oxygen-metal systems where X is phosphorus, sulfur, selenium, carbon, arsenic, or nitrogen is continuing. The new compounds are characterized by measurement of molecular weight, magnetic susceptibility, and conductance, and by infrared spectra. The hydrolysis and aggregation of copper (II), germanate, and molybdate ions are investigated by scattering of light and electromotive force titration.

Chemistry of Rare Earth Hydrides (U), RR 001-04-0009. University of Southern California, Los Angeles, California, Department of Chemistry; Nonr 228(15), NR 052-390; J. C. Warf.

Research is conducted on selected rare-earth metals and on the formation and characterization of their hybrides. Major emphasis is on the light rare-earth metals, lanthanum, cerium, praseodymium, and neodymium, and on the heavy rare-earth metals, europium and ytterbium; some work on the rare-earth-like metals, scandium and yttrium, is included.

Fluoro-Borane Chemistry (U), RR 001-04-0010. Oregon State College, Corvallis, Oregon, Department of Chemistry; Nonr 1286(04), NR 052-392; T. D. Parsons.

Research is conducted on the synthesis and reactions of perfluoralkyl boranes, in particular those compounds in which the boron atom is attached to one or more trifluoromethyl (CF_3) groups. Information is being developed regarding the stability of these compounds to hydrolysis and to disproportionation. Extension of present knowledge of electron-deficient bonding as exhibited in certain compounds of boron and aluminum is sought, with special effort to elucidate the extent to which a CF_3 group can form a "bridge" bond with boron atoms. Measurements of the dissociation constants of complexes of trifluoromethyl boranes with various amines or ethers, comparison with those of the corresponding methyl derivatives, and a study of the kinetics of disproportionation of unsymmetrical trifluoromethyl boranes are being made.

Bonding in Boron and Nitrogen Rings (U), RR 001-04-0011. Penssylvania State University, University Park, Pennsylvania, Department of Chemistry; Nonr 656(21), NR 052-402; L. Goodman.

Theoretical and experimental research was conducted on the electronic energy-level structure and wave functions in high-symmetry boron and nitrogen heterocyclic molecules, the objective being to increase our present understanding of the chemical bonding in such molecules. Molecular orbital (MO) theory and calculations were employed to predict energy-level sequences and spacings (of excited states) of the molecules under study. Experimental tests of theoretical predictions were accomplished by low-temperature ($4^oK.$ to $77^oK.$) rigid-glass solution absorption and emission spectroscopy, including determinations of emission polarization and emission lifetime.

Volatile Fluoro Compounds (U), RR 001-04-0012. University of British Columbia, Vancouver, B. C., Canada, Department of Chemistry; Nonr 2659(00), NR 052-403; H. C. Clark.

The objectives of this research are the preparation and study of the properties of compounds in which the trifluoromethyl (CF_3) group is bonded to germanium, tin, gallium, indium, boron, and aluminum, and of some volatile transition-metal fluorides, in particular VF_5, NbF_5, RuF_5, MoF_6. Synthesis of the latter class of compounds is attempted by the established technique of direct fluorination of the powdered metal at moderately high temperatures (about $300^oC.$). The volatile fluorides are reacted with anhydrous ammonia, pyridine and other nitrogen bases, SO_2, and SO_3. Synthesis of the trifluoromethyl compounds are attempted by (1) radical exchange of CH_3 and CF_3 groups between CH_3-metal compounds and CF_3Li, CF_3I, and $(CF_3)_2Hg$, and (2) reaction of the powdered metal with CF_3Li at elevated temperatures. Physical property measurements--in particular on the volatile fluorides (liquid state) --include specific conductivities, surface tensions, and viscosities in all cases where data are lacking but obtainable. Such data should reveal the possibility of self-ionization. Temperature dependence of their nuclear magnetic resonance absorption spectra is also examined, with a view toward clarifying both extent of fluorine exchange between molecules and chemical structure.

Polysilanes (U), RR 001-04-0013. Indiana University, Bloomington, Indiana, Department of Chemistry; Nonr 908(14), NR 052-410; R. Schaeffer.

Research is conducted in the synthesis, isolation, and identification of derivatives of higher silanes, and in the mechanisms of formation and reaction of these derivatives. The approach consists in part in devising satisfactory synthetic, product-isolation, and product-identification methods, employing gas chromatography for isolation and partial identification, supplemented by infrared, nuclear magnetic resonance, ultraviolet, and mass spectroscopy, and X-ray diffraction if needed, for completion of identification and assignment of structures. The remainder of the approach consists of the application of kinetics and structure-determination methods to the elucidation of reaction mechanisms, e.g., the mechanism of disproportionation of monochlorodisilane, $H_3Si - SiH_2Cl$.

Borazine Derivatives (U), RR 001-04-0014. St. Louis University, St. Louis, Missouri, Department of Chemistry; Nonr 2793(00), NR 052-413; L. F. Hohnstedt.

This research is directed toward the development of general methods for the preparation of a variety of substituted borazines, which are subsequently subjected to systematic study of the effect of the substituent groups on the thermal stability and chemical reactivity of the borazine ring.

Rare Earth Coordination Chemistry (U), RR 001-04-0015. Pennsylvania State University, University Park, Pennsylvania, Department of Chemistry; Nonr 656(24), NR 052-414; W. C. Fernelius.

This is an investigation of the coordination chemistry of the rare-earth elements by study of the properties of their coordination compounds with a number of new chelating agents (which must be synthesized). Formation constants are determined by the method of potentiometric titrations to ascertain how maximum coordination number varies with atomic number and to determine the relative stabilities of the complexes. Whether or not f-orbitals participate in the bonding, and whether or not the rare earths form pi-bonds, are questions which may also be answered from such data. The stabilization of unusual oxidation states of these elements by reaction with specially designed new chelating agents is studied both by simple synthesis and by measuring oxidation-reduction potentials in the presence of the various ligands.

Oxygen Exchange Reactions (U), RR 001-04-0016. University of Chicago, Chicago, Illinois, Department of Chemistry; Nonr 2121(16), NR 052-415; H. Taube.

Chemical exchange reactions in heterogeneous aqueous systems are investigated by appropriate isotope tracer techniques based on the observed fractionation of hydrogen and deuterium or O^{16} and O^{18}. Included are reactions between metal hydrides and aqueous solutions containing oxidizing agents, and the oxidation of metals and metal ions in such solutions. Of special interest is the study of the oxidation of reducing agents such as U^{+4}_{aq}, SO_2, and simple organic molecules--all of which increase their oxygen content on reaction--by a variety of metal oxides such as PbO_2, MnO_2, and NiO_2, which should clarify the role of the solvent in the reaction.

Si-O-Metal Polymers (U), RR 001-04-0017. Western Reserve University, Cleveland, Ohio, Department of Chemistry; Nonr 1439(07), NR 052-419; M. M. Chamberlain.

Research is conducted on the synthesis, properties, and reactions of arylorganosiloxy derivatives of metals and metalloids, including polymers, containing the Si-O-M linkage, where M = Cr, CrO_2, V, VO, Mo, MoO, P, PO, Sn, or B. Triphenylsilyl esters of the type $(Ph_3SiO)_nM$, and polymers obtained by substituting diphenylsilanediol, $Ph_2Si(OH)_2$, for the monofunctional triphenylsilanol, Ph_3SiOH, in appropriate reactions, are examples of the compounds sought. Thermal stability is investigated by differential thermal analysis and other methods. Correlation of parameters such as coordination number, oxidation state, electronegativity, and steric hindrance with thermal stability is attempted with a view toward prediction of thermally stable structures.

Vaporization of Solids (U), RR 001-04-0018. AVCO Manufacturing Company, Wilmington, Massachusetts; Nonr 3051(00), NR 052-416; C. H. Leigh.

Exploratory research is conducted on the use of plasma jets to investigate the effects of very high temperatures on the vaporization and reactions with environmental gases of refractory inorganic solids such as silicon carbide, boron nitride, and zirconium dioxide. The approach consists in (a) developing and instrumenting a probe which will sample a plasma for mass spectrometric analysis with minimum interference with the gas phase, the mass spectrometric work being supplemented by optical spectroscopy if practicable; (b) identifying molecular species present in the vapor and determining their relative abundances and approximate partial pressures insofar as practicable; (c) interpreting and correlating experimental data to yield not only the nature of the vaporization process and the solid-environmental gas interactions, but also thermodynamic information for quantitative description of the processes involved. Controlled environmental gases are introduced into the reaction zone by using them as the plasma-jet stabilizing media.

Intermetallic Delta Bonds (U), RR 001-04-0019. Tulane University, New Orleans, Louisiana, Department of Chemistry; Nonr 475(09), NR 052-424, H. B. Jonassen.

This research is concerned with the type of metal-metal bonding in bridged binuclear chelate complexes of copper (II) and transition-metal ions, known as delta bonding and attributed to exchange interaction between spins of unpaired d-electrons. The primary objective is to determine the effect of delta bonding on bond strength (stability) in binuclear coordination complexes involving a double back-bone, especially with reference to polynuclear coordination polymers where such a structure is repeated throughout the chain and could result in enhanced stability. Another objective is to develop rules for predicting necessary conditions for the formation of metal-organic polymers containing delta bonds. The approach is to

prepare bridged binuclear chelate complexes of copper (II), nickel (III), cobalt (IV), and other transition elements in appropriate oxidation states, using carefully selected ligands based on model studies. The electron-repelling strength of functional groups necessary to effect delta bonding is investigated by selecting as ligands a series of o,o'-substituted azo dyes in which the substituents have varying charge (-COOH, -OH, and $-NH_2$). Experimental measurements on the chelate complexes include magnetic susceptibilities and absorption spectra (both infrared and ultraviolet).

Metal Mercaptides (U), RR 001-04-0020. University of Western Ontario, London, Ontario, Canada, Department of Chemistry; Nonr 3325(00), NR 052-426; D. C. Bradley.

This research is concerned with the synthesis, physical properties, reactions, and structures of transition-metal mercaptides and with the nature of the metal-sulfur bond therein. These mercaptides may be represented as $M(SR)_x$, where M is a metal of valence x. Reaction of some of these mercaptides with substances such as H_2S to form metal sulfide-mercaptide polymers is attempted. Extension to selected selenium and tellurium analogues is also planned. One objective is to correlate physical properties and quantitative data on reactions (e.g., rates of hydrolysis) with (a) the valence, coordination number, and stereochemistry of the transition metal; (b) the nature of the alkyl group, R (size, degree of branching); (c) the strength of the primary M-S bond and number of d-electrons in the valence shell of the metal atom; (d) the strength of intermolecular M-S coordinate bonds (formed by expansion of the metal covalency to sulfur, which determines the tendency to form coordination polymers; and (e) the nature of the M-S bonds in metal sulfide-mercaptide polymers (which may be both coordinate and covalent by analogy to the known metal oxide-alkoxide polymers). A second objective is to interpret any correlations established in terms of current theories on the nature of the coordinate bond between metal and ligand.

R001-05 Analytical Chemistry

Radioactive Tracer Chemistry (U), RR 001-05-4850. U. S. Naval Research Laboratory, Washington 25, D. C.; C06-01; R. R. Miller.

Radioactive tracers are used to determine elements present in chemical and metallurgical processes where chemical methods fail. Tracers have been used on this task to determine dissolved metal atoms in liquid metals and metal atoms deposited from solution in liquid metal. In other cases foreign impurities in trace amounts have been determined in chemicals by irradiation or in chemicals which have been irradiated in use.

R001-06 Fuels and Propellants

Thermochemistry of High Temperature Oxidation of Light Elements (U), RR 001-06-0001. Ohio State University, Columbus, Ohio, Chemistry Department; Nonr 495(12), NR 092-501; D. White.

The measurements of infrared absorption, emission spectra and vapor pressures at temperatures above 1500°K are being used to obtain data leading to the thermodynamic functions of the light elements and their high temperature compounds. Systems being emphasized are the oxides and sulfides of boron with the extension of the techniques to other light element oxides and halogen containing species.

Vapor Explosion Hazards (U), RR 001-06-0003. Department of Interior, Bureau of Mines, Pittsburgh, Pennsylvania; NAonr 8-61, NR 092-502; J. Grumer.

To obtain information on the explosion and fire hazards of liquid propellants that will be useful in the development of fire and damage control techniques. Problem areas are (1) vapor ignition, (2) gas phase flame propagation and detonation and (3) flame spreading, radiation, and extinguishment.

Hybrid Combustion (U), RR 001-06-0004. North American Aviation, Incorporated, Rocketdyne Division, Canoga Park, California; Nonr 3016(00), NR 092-503; K. Mueller.

This task is to determine and investigate the important chemical and physical processes in reactions between gases and solids as they apply to hybrid propellant systems (solid fuel, liquid or gaseous oxidizer, or vice versa). The initial step is to clarify the relative roles of kinetic and mass transport processes under a suitable range of conditions.

Molecular Structures of Metal Oxide and Salt Vapors (U), RR 001-06-0005. Cornell University, Ithaca, New York, Chemistry Department; Nonr 401(41), NR 092-504; S. H. Bauer, R. F. Porter.

This task is to determine the molecular structure of metal oxide and salt vapors at high temperatures using electron diffraction and mass spectroscopy. From the data obtained thermodynamic functions are to be computed.

Combustion of Boron (U), RR 001-06-0006. Texaco Experiment, Incorporated, Richmond, Virginia; Nonr 1883(00), NR 092-506; C. Talley, L. Line.

This task is to study the oxidation of boron, including the effects of impurities, in various oxidizing atmosphere, oxygen, nitrogen, nitrogen oxides and fluorine containing oxidizers.

Burning Control in Solid Propellants (U), RR 001-06-0007. AeroChem Research Laboratories, Incorporated, Princeton, New Jersey; Nonr 2806(00), NR 093-344; H. F. Calcote.

This task undertook a study of the effect of gas and solid phase additives on the burning mechanism of solid propellants.

Mechanisms of Detonation Processes (U), RR 001-06-0008. Aerojet-General Corporation, Azusa, California; Nonr 2804(00), NR 093-345; D. L. Armstrong.

This task involved a fundamental experimental and theoretical investigation of the kinetic processes occurring in the initiation and propagation of detonation in solid explosives (or propellants).

Hydrogen Peroxide Studies (U), RR 001-06-0009.

Massachusetts Institute of Technology, Cambridge, Massachusetts; Nonr 1841(11), NR 093-008; C. N. Satterfield.

This task will seek information on the fundamental reactions of hydrogen peroxide. Specific investigations will concern the role of mass transfer in catalytic deconposition at a solid surface, in one case where peroxide is in the vapor phase and in the other where the peroxide is in the liquid phase.

Fluorine Propellants (U), RR 001-06-0011. North American Aviation, Incorporated, Rocketdyne Division, Canoga Park, California; Nonr 1818(00), NR 093-009; E. Lawton.

This investigation comprises the synthesis and chemistry of new compounds containing fluorine and nitrogen, and fluorine, nitrogen and oxygen.

Difluoramine Chemistry (U), RR 001-06-0012. Reaction Motors Division, Thiokol Chemical Corporation, Denville, New Jersey; Nonr 1878(00), NR 093-010; D. D. Perry.

This task is to study the chemical properties and reaction characteristics of interesting fluorine-containing compounds with emphasis in difluoramines.

Single Liquid Propellants (U), RR 001-06-0013. Hughes Tool Company, Culver City, California; Nonr 2440(00), NR 092-344; I. Shapiro.

Synthesis was attempted of new single-liquid monopropellants, consisting of a suitable salt of a fuel dissolved in an oxidizer. The objective was high energy systems, based on nitrate or perchlorate salts of boron hydride derivatives as the fuel, dissolved in nitric acid or perchloryl fluoride as the oxidizer.

N_2O_2 Complexes and Peroxyhydrates of Light-Metal Element Salts (U), RR 001-06-0015. University of Florida, Gainesville, Florida, Department of Chemistry; Nonr 580(08), NR 093-011; H. Sisler, G. E. Ryschkewitsch.

The objective of this task is the formation of chemical species with a high concentration of oxygen and the study of their properties. Two types of structures are of special interest: complexes of light metal nitrates with nitrogen oxides, and peroxyhydrates of light metal nitrates and perchlorates.

Polynitro Aliphatic Synthesis (U), RR 001-06-0016. Ohio State University, Columbus, Ohio, Chemistry Department; Nonr 495(14), NR 093-012; H. Shechter.

This task is a study of type reactions leading to synthesis of new mononitro and polynitro compounds and the study of mechanisms of reaction of nitro compounds with various metal hydrides. This will also include new compounds which are polyfluoro-polynitro in type.

Aliphatic Nitro Synthesis for Nitropolymers (U), RR 001-06-0017. Purdue Research Foundation, Lafayette, Indiana, Chemistry Department; Nonr 1100(13), NR 093-013; H. Feuer.

This research task embraces a program of organic chemical investigations to develop methods for the synthesis of polynitro aliphatic compounds containing functional groups. It also includes the synthesis of new nitro and fluoro-nitro monomers for polymerization.

Fluoro-Nitro Compounds (U), RR 001-06-0018. Aerojet-General Corporation, Azusa, California; Nonr 2655(00), NR 093-014; S. Skolnik.

This research seeks to develop and explore new techniques for fluoro-nitro synthesis and to prepare new fluoro-nitro and fluorine nitrogen structures for high energy applications.

Solid Propellant Information Agency (U), RR 001-06-0019. Johns Hopkins University, Solid Propellant Information Agency, Applied Physics Laboratory, Silver Spring, Maryland; NOrd 7386, NR 093-227; M. T. Lyons.

The Solid Propellant Information Agency was established by Bureau of Ordnance contract shortly after the close of World War II to serve as a clearing house for technical information on solid propellant research and development. This function includes abstracting solid propellants reports, distributing those abstracts in both transitory and permanent form, conducting the technical secretarial work in arranging the annual JANAF Solid Propellant Group Meetings, and issuing of the corresponding bulletins of technical papers.

Preparation and Properties of Aluminum Hydride (U), RR 001-06-0021. Pennsylvania State University, University Park, Pennsylvania, Chemistry Department; Nonr 656(22), NR 093-015; T. Wartik.

This task is to prepare and characterize complexes of aluminum hydride.

Non-Aqueous Micro-Encapsulation (U), RR 001-06-0022. National Cash Register Company, Dayton, Ohio; Nonr 2848(00), NR 093-016; L. Schleicher.

This is a study of the fundamentals of microencapsulation of moisture-sensitive or reactive materials by employing synthetic polymers in nonaqueous media.

Fluorine Chemistry (U), RR 001-06-0023. University of Washington, Seattle, Washington, Chemistry Department; Nonr 477(16), NR 093-018; G. H. Cady.

Research is conducted on the synthesis, properties, and reactions of novel compounds of fluorine. Kinetic and thermodynamic (equilibrium) studies of selected reactions are included. Attention is focused on compounds and reactions involving the OF bond and interhalogen compounds containing fluorine and two other halogens.

Nucleation and Condensation (U), RR 001-06-0024. Texaco Experiment, Incorporated, Richmond, Virginia; Nonr 3141(00), NR 092-505; L. Line, G. Courtney.

This is an experimental investigation to determine the mechanisms and rates of nucleation and particle growth in condensation processes and to determine the mechanism which controls such processes under rocket motor conditions.

Oxygen Fluorides (U), RR 001-06-0025. Research Institute of Temple University, Philadelphia, Pennsylvania; Nonr 3085(01), NR 093-017; A. V.

Grosse.

This task is to study the chemistry of the several oxides of fluorine, their substitution and addition products and to characterize these materials for possible high energy applications.

Fuels, Hydrocarbon (U), SR 001-06-0600. Engineering Experiment Station, 10101/RDT&EN 61.2411, Paul Schatzberg, J. W. MacDonald, N. Glassman; Naval Research Laboratory, 10173/RDT&EN 61.2411, Dr. J. E. Johnson, Dr. H. W. Carhart; Bureau of Mines, NObs 1700-S-576-am.5, C. C. Ward.

This project is concerned with the development of fuels adequate in supply to meet war requirements while giving maximum performance in shipboard equipment; development of shipboard purity monitoring methods and handling procedures to give maximum utilization of product and minimum contamination, waste, and operating troubles.

A test procedure for predicting storage stability has been developed but further evaluation is required. A formula for determining carbon forming tendencies of fuels in the gas turbine was developed. Equipments for determining solids and water in jet fuel have been evaluated and some show considerable promise.

The test method to predict storage stability and compatibility of fuel blends is being evaluated. Equipment for water and solids detection is being evaluated. Evaluation of fuels for gas turbine operation.

R001-07 Lubricants

Lubricants, WR 001-07-001. Naval Air Material Center, 03 200, RRMA-35; NEES, Annapolis, Maryland, 03 437, RRMA-35; U. S. Naval Research Laboratory, 03 566, RRMA-35.

To develop new and improved lubricants over the temperature range of -100°F to 1000°F. It is anticipated that the temperature range will be extended in future weapons systems from -300° to 2000°F. Fluids, lubes, dry films, and gaseous lubricants to meet these requirements are being sought.

New and improved materials are being tested as they appear. Theoretically promising formulations are investigated and new approaches are studied. The work includes the preparation of titanium-organic compounds for use as fluids and lubes; the formulation and testing of dry film lubricants, the application of Teflon coatings; the utilization of gaseous lubrication.

Steam Turbine Lubricating Oils (U), SR 001-07-0601. U. S. Naval Engineering Experiment Station; 10101/RDT&EN 61.2411; N. Glassman, L. Schneider.

The prospect of a moderate increase in gear loading and bearing temperatures requires continuing research and development to insure the availability of lubricants for the fleet. Rusting occurs in non-lubricated sections of gear systems.

Present work consists of study of lubricants and operating conditions relating to steam turbine operation and evaluation of factors relating to the use of steam turbine oil in hydraulic systems and air compressors.

Diesel Engine Lubricating Oils (U), SR 001-07-0618. U. S. Naval Engineering Experiment Station; 10101/RDT&EN 61.2411; M. Gordon.

Changes in Diesel Engine design which increase operational stresses require continuing study and development of lubricants to meet machinery requirements.

Effort is directed toward lubricants which will decrease port plugging and wrist pin bushing wear on present engines.

Shipboard Lubricating Oils (U), SR 001-07-0619. U. S. Naval Engineering Experiment Station; 10101/RDT&EN 61.2411; H. Halliwell, K. Warren.

Equipment casualties or operating difficulties involving lubrication or lubricants require continuing research to develop products to meet new machinery needs.

Present work consists of evaluation of factors relating to compressor lubrication and study of bearing corrosion mechanism.

Development of lubricants to reduce gear noises. Development of lubricants to reduce frettage in toothed couplings. Development of gear lubricants for special metal gearing. Assist on new problems arising in fleet.

Synthetic Lubricants (U), SR 001-07-0620. NEES; 10101/RDT&EN 61.2411; H. Halliwell.

Several explosions have occurred in high pressure air compressors using petroleum base lubricants. In other instances carbonaceous deposits, odors, and deformed discharge separator elements have indicated some level of combustion in compressor discharge piping. Two fire resistant phosphate ester lubricants were operated with success in two high pressure air compressors. However, some difficulties reported in fleet use of such lubricants indicate the need for improved lubricating ability as well as an urgent need for improved low temperature flow characteristics. For future higher pressure systems, lubricants of increased fire resistance, superior lubricity, and adequate performance life, with no toxicity hazard will be needed. Petroleum lubricants presently employed for many rotating machinery applications have definite temperature-stability limits under applications envisioned in future Navy machinery designs. New lubricants of improved characteristics will be needed for such uses.

Work is under way on development of phosphate ester lubricants with enhanced low temperature flow and lubricity properties although the ultimate goal desired has not been reached. Work has begun on lubricants of improved fire resistance for higher pressures but much remains before these fluids reach the needed level for lubricity in full scale machinery.

Lubricating Greases (U), SR 001-07-0602. NEES; 10101/RDT&EN 61.2411; K. Warren.

Concurrent with installation of increasingly specialized shipboard machinery, there is a tendency to provide a specialized lubricant for each new grease application. A continuous research and development effort must be pursued to control the proliferation of types and kinds of lubricating grease by providing more versatile and durable lubricants. Because of limited demand, there is

little commercial incentive for development of these superior greases so that the bulk of the continuing study must be done by the Navy.

Two satisfactory multipurpose greases have been established. Completed vertical shaft ball-bearing test machines for simulation of exacting service in shipboard pump motors.

Development and evaluation of multipurpose greases and greases for lubricated-for-life bearings, and studies of the compatibility problems attendant on periodic relubrication of bearings in service are under way. Factors in these major problems also under investigation include such grease properties as water resistance, rust prevention, mechanical stability, oil separation, and evaporation.

R002 PHYSICAL SCIENCES

R002-01 Instrumentation

High Altitude Physics (U), RR 002-01-0009. University of Minnesota, Minneapolis, Minnesota, Physics Department; Nonr 710(22), NR 211-013; E. P. Ney, J. R. Winckler.

A constant level plastic balloon will be used for fundamental studies of the atmosphere up to and including the mesosphere.

Project SKYHOOK (U), RR 002-01-0010. Winzen Research, Incorporated, Minneapolis, Minnesota; Nonr 1460(10), NR 211-020; O. C. Winzen.

Research under this task consists of conducting balloon flights to allow various investigators to make cosmic ray and other scientific explorations at extreme high altitudes for extended periods of time. In parallel with this service function, the contractor initiates research to improve the vehicle, extend its capability, and provide better flight control instrumentation.

Strato-Lab Astrophysics (U), RR 002-01-0011. Winzen Research, Incorporated, Minneapolis, Minnesota; Nonr 1460(09), NR 211-023; O. C. Winzen.

Research toward determining the feasibility and value of a manned plastic balloon system capable of carrying out significant scientific experimentation from the stratosphere. Research under this task is conducted in parallel and coordinated with other project tasks.

The primary areas of effort include balloon vehicle research and development of a satisfactory and compatible sealed cabin for personnel protection during flight.

The seal cabin investigations include research and development to determine the most practical methods of assuring adequate environmental control, testing on the ground during flight simulation tests, and experimental confirmation of adequacy during manned flights with duration up to 34 hours. Integration of intricate scientific instrumentation is included. Ground suspension tests and systems evaluation during flight are a part of the task.

Project SKYHOOK (U), RR 002-01-0012. Raven Industries, Incorporated, Sioux Falls, South Dakota; Nonr 2846(00), NR 211-025; J. R. Smith.

Research under this task consists of conducting balloon flights to allow various investigators to make cosmic ray and other scientific explorations at extreme high altitudes for extended periods of time. In parallel with this service function, the contractor initiates research to improve the vehicle, extend its capability, and provide better flight control instrumentation.

Upper Atmosphere Physics (U), RR 002-01-0013. Convair (CSRL), San Diego, California; Nonr 2397(00), NR 211-026; W. C. Erickson.

The high altitude constant level plastic balloon will be used as a vehicle for upper atmospheric basic research and a large radio telescope will be used for research in radio astronomy. By experimental measurements, an attempt will be made to obtain information on the properties of the upper atmosphere, solar gamma rays, and cosmic radio sources.

Super-Pressured Balloon (U), RR 002-01-0014. G. T. Schjeldahl Company, Northfield, Minnesota; Nonr 2445(00), NR 211-027; R. J. Slater.

Under this task the contractor designed, constructed and flew super-pressured balloons using "Mylar" polyester film of minimum thickness to determine the optimum characteristics of a system that will maintain constant level flight without ballast requirements.

Twenty-seven flights were made under this contract for the purpose of testing balloons of different sizes and shapes as well as testing instrumentation that measures balloon and ambient temperatures and pressures and telemeters the data to ground receivers. Sizes ranged from a 910 cu. ft. sphere to a 45,000 cu. ft., 170 ft. long cylinder. Floating altitudes were in the upper tropospheric regions with durations up to 101 hours.

Balloon Systems (U), RR 002-01-0015. Raven Industries, Incorporated, Sioux Falls, South Dakota; Nonr 2484(00), NR 211-028; J. R. Smith.

The contractor conducts research, development, and testing on new types of balloon and ballast systems.

Tropospheric Balloon Systems (U), RR 002-01-0016. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division ERⅅ Nonr 1589(05), NR 211-031; A. Zmeskal.

Research and development has been conducted on various unique balloon systems for primary utilization in the troposphere.

Project SKYHOOK (U), RR 002-01-0017. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division, ERⅅ Nonr 1589(04), NR 211-033; J. L. Cramer.

Research under this task consists of conducting balloon flights to allow various investigators to make cosmic ray and other scientific explorations at extremely high altitudes for extended periods of time. In parallel with this service function, the contractor initiates research to improve the vehicle, extend its capability, and provide better flight control instrumentation. The contractor also administers and operates the helium pool for ONR.

Hurricoon (U), RR 002-01-0018. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division, ERⅅ Nonr 1589(19), NR 211-037; D. A. Church.

Research under this task is aimed at demonstrating the feasibility of obtaining fundamental research information by balloon photography from hurricanes, thunderstorms, and other meteorological phenomena. The approach utilizes a specialized constant level plastic balloon system for photography (initially), and later television reconnaissance of hurricanes and other meteorological phenomena from high altitudes.

Project Stratoscope (U), RR 002-01-0019. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division, ERⅅ Nonr 1589(17), NR 211-038; J. L. Cramer.

Provide balloons, attachments and supporting equipment to carry astronomical equipment to high altitude. This task was in support of other tasks aimed at observations of the sun by means of a balloon-borne telescope. It included launching, tracking, recovery service, data analysis and reporting of the flight operations, including the altitude charts and flight trajectories.

A series of seven successful flights provided high resolution photographs of solar granular structure, the solar limb, and sunspot activity.

Open Strato-Lab Flights (U), RR 002-01-0023. Winzen Research, Incorporated, Minneapolis, Minnesota; Nonr 1460(12), NR 211-048; D. L. Foster.

Research is performed in the development of a suitable "open basket" balloon system for the conduct of scientific manned flights. Orientation control systems are included. Also included are the conduct of flights for indoctrination and check-out of balloon pilots and scientific observers.

Transosonde Balloon (U), RR 002-01-0024. G. T. Schjeldahl Company, Northfield, Minnesota; Nonr 2802(00), NR 211-049; R. J. Slater.

The contractor is developing super-pressure balloons of various shapes and sizes for in-flight testing to determine a suitable balloon of this type for use with a light load under the Navy Transosonde Program.

Heavy Load Balloon (U), RR 002-01-0025. G. T. Schjeldahl Company, Northfield, Minnesota; Nonr 2899(00), NR 211-051; R. J. Slater.

The contractor conducts research in the field of high tensile strength films with good tear resisting capabilities to determine their suitability and practicability for the fabrication of a constant level balloon capable of carrying loads in excess of 3,000 lbs. to the upper stratosphere. If these preliminary investigations are promising, the contractor will design, build and fly one or more of these vehicles.

International Cooperative Emulsion Flight Balloon (U), RR 002-01-0026. Winzen Research, Incorporated, Minneapolis, Minnesota; Nonr 1460(11), NR 211-052; D. L. Foster.

This work was a continuation of the program involving the development of a balloon system for carrying a 1500 lb. net scientific payload (photographic emulsions) at or near an altitude of 120,000 ft. for a maximum period of about 56 hours. The contractor conducted the balloon operations and provided auxiliary instrumentation for tracking, termination, and recovery of the payload.

USWB ICEF Support (U), RR 002-01-0028. U. S. Weather Bureau, Washington, D. C.; NAonr 27-60, NR 211-054; A. W. Youmans.

High altitude wind measurements were made by Weather Bureau facilities in the Caribbean area. Special extensible balloons were used and the data were made available for operational planning in connection with long duration constant altitude flights conducted as part of the Skyhook 60 (International Cooperative Emulsion Flight) program.

Stratospheric Wind Study (U), RR 002-01-0029. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division, Research Department; Nonr 1589(20), NR 211; A. D. Belmont.

Winds above 100 mb are to be compiled at various altitudes over the Northern Hemisphere on a monthly basis to develop a model of the mean atmospheric circulation.

Balloon Cloud Photography (U), RR 002-01-0030. Arthur D. Little, Incorporated, Cambridge, Massachusetts; Nonr 3202(00), NR 211-056; B. Vonnegut.

Under this task an investigation will be conducted to determine the feasibility and value of conducting cloud physics studies from high altitude constant level balloons appropriately instrumented with photographic equipment.

Coronascope (U), RR 002-01-0031. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division; Nonr 1589(21), NR 211-057; J. C. Swisher.

Scientific research utilizing the balloon as a research vehicle was supported. Instrumentation included a stabilization system, a coronagraph, photometer, spectrograph, and other auxiliary equipment.

Skyhook BRISTOL (U), RR 002-01-0032. G. T. Schjeldahl Company, Northfield, Minnesota; Nonr 3154(00), NR 211-058; C. P. Merrell.

Balloons and flight services were provided for scientists investigating cosmic radiation at balloon altitudes. On 20 April and 1 May 1960 flights were successfully flown. The photographic emulsion payloads were recovered, and are currently in process of being analyzed.

Project SKYHOOK (U), RR 002-01-0033. G. T. Schjeldahl Company, Northfield, Minnesota; Nonr 3288(00), NR 211-060; C. P. Merrell.

Balloons and flight services are to be provided for scientists investigating cosmic radiation at balloon altitudes.

Water Launched Balloons (U), RR 002-01-0034. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division; Nonr 1589(22), NR 211-061; D. A. Church.

Water based inflations and lauchings of plastic balloons using relatively small ships or boats are being investigated.

Synchrotron (U), RR 002-01-4900. U. S. Naval Research Laboratory, Washington 25, D. C.; H02-08; D. C. dePackh.

This was a study of the design requirements of an electron synchrotron of small aperture and high intensity, using no iron in the magnet. In the model investigated a novel form of external pulsed injector and quadrupole focusing system provided a beam remaining in the machine up to full energy and having an initial intensity of about 0.5 ampere.

Neutron Scintillation Detectors (U), RR 002-01-4901. U. S. Naval Research Laboratory, Washington 25, D. C.; H02-09; J. I. Hoover, B. J. Faraday.

The objective of this task is to study devices which will detect neutrons by observing their interaction with matter. Two interactions are utilized, the (n,p) and the (n,α) reactions. The approach to this problem has been to produce luminescent lithium hydride crystals through the incorporation of suitable activators. To date, about 70 activators have been tried. Nine of these produce measurable luminescence. Currently, large single crystals of the activated hydride are being prepared and their excitation by ultraviolet and alpha excitation at different temperatures is being studied.

Nuclear Instrument Development (U), RR 002-01-4902. U. S. Naval Research Laboratory, Washington 25, D. C.; H02-11; L. B. Clark, Sr.

The work performed under this task is principally of a support nature for other research being performed both in the Nucleonics Division and the Radiation Division. The principal effort is directed toward the construction of highly specialized glass and quartz apparatus. The approach to a problem in a specific instance is determined by the level of complexity of the equipment to be constructed. Much use is made of the experience and experimental techniques developed by the group over the years.

Nuclear Electronics (U), RR 002-01-4903. U. S. Naval Research Laboratory, Washington 25, D. C.; H02-18; G. F. Wall.

In order to properly utilize a research reactor and particle accelerators for nuclear research, the electronic instrumentation must keep pace with the physics requirements. New techniques have resulted in acquisition of large amounts of data in relatively short time, thus requiring improved methods of data handling. In addition, it is desirable to investigate the possible application of new components and/or devices to existing techniques and methods of data acquisition.

One of the previously designed and constructed 100 channel pulse height analyzers has been modified to provide live time control. In addition, a commercial curve plotter and reader have been modified to automatically provide a plot of the stored data.

A new window circuit has been developed using tunnel diodes and transistors. Level are set by peak amplitude and rate of rise. Coincidence circuits with 20 ns (1 ns = 10^{-9} seconds) resolution have been tested and have been incorporated into the above unit.

Intense Electron Beam Studies (U), RR 002-01-4904. U. S. Naval Research Laboratory, Washington 25, D. C.; H02-21; D. C. dePackh.

The intent is to study the properties of intense relativistic electron beams with an ultimate view to their applications in the fields of high current and charge density, intense bremsstrahlung, microwave power generation, and ultra-high energy accelerator design. During the past year the theory of static and dynamic behavior of relativistic beams, particularly the former, has come into a somewhat more satisfactory state, the 5-foot machine has been brought to full energy, 180-ampere beam at 350 kev has been obtained, construction on the mechanical part of the 30-foot storage ring has begun, the modulator for this is complete and the pulse generator for the inflector circuit is well underway. The precision of measurement in straight geometries has been greatly increased, and close agreement of measured and theoretical current density has been obtained.

R002-02 Solid State Physics.

Experimental Cryogenics (U), RR 002-02-0001. Columbia University, New York, New York, Department of Physics; Nonr 2230(00), NR 017-210; H. A. Boorse.

This task consists of investigations in experimental cryogenics. In particular, various details of the new Bardeen-Cooper-Schrieffer theory of superconductivity are being examined.

Thermodynamic and Magnetic Properties of Matter (U), RR 002-02-0002. University of California, Berkeley, California, Department of Physics; N6ori 211(04), NR 018-501; W. F. Giauque.

This task includes a variety of investigations of the thermal and magnetic properties of solids at low temperatures. Under study will be: (a) thermodynamics of cell Tl + 1/2 Cl_2 = TlCl; (b) work on interpretation of TlCl band spectra; (c) thermodynamics of Weston cell; (d) apparatus for isopiestic measurements of thermodynamic activities; (e) calorimetry of condensed gases at low temperatures $POCl_3$, POF_3, SO_2F_2, $COCl_2$; (f) thermodynamics of PbO_2 and lead storage cell; (g) thermodynamics of Clark cell; (h) construction and testing of a very high power solenoid for the production of intense magnetic fields.

Experimental Cryogenics (U), RR 002-02-0003. Pennsylvania State University, University Park, Pennsylvania, Department of Chemistry; Nonr 1789(00), NR 018-201; J. G. Aston.

The research covered by this task includes two phases: (a) a thermodynamic study of the properties of absorbed films and absorbent surfaces, and (b) a study of the magnetic and thermodynamic properties of crystalline salts of the iron group, especially at liquid helium temperatures.

Cryogenics (U), RR 002-02-0004. Amherst College, Amherst, Massachusetts, Department of Physics; Nonr 2144(00), NR 017-211; T. Soller.

In the research program of this task two separate fields of investigation are indicated: (1) microwave studies of metals at liquid helium temperatures and (2) investigation of the properties of the isotope of helium of mass 3. The properties

of He^3 are proving to be very instructive in regard to the theory of liquid Helium, since the two helium isotopes obey different statistics, and current theory indicates a fundamental dependence of the liquid properties on the statistics.

Cryogenics (U), RR 002-02-0005. William Marsh Rice University, Houston, Texas; Nonr 1829(00), NR 018-901; C. F. Squire.

Under this task, a variety of experimental investigations are carried out in the field of cryogenics. The dynamic peoperties of superfluid liquid helium are measured, as well as elastic constants, ultrasonic attenuation, and magnetic properties of solids at extreme low temperatures.

Low Temperature Physics (U), RR 002-02-0006. University of Texas, Austin, Texas, Department of Physics; Nonr 375(09), NR 017-455; J. C. Thompson.

This task is concerned with the properties of matter at extremely low temperatures. Investigations on transport effects in semiconductors, thermoelectric power, and Hall effect are being carried out.

Low Temperature Research (U), RR 002-02-0007. University of Kansas, Lawrence, Kansas, Department of Physics and Astronomy; Nonr 2775(00), NR 018-202; J. W. Culvahouse.

This task is concerned with physical phenomena peculiar to low temperature. The program of research being undertaken will investigate spin-spin interaction in paramagnetic salts and the magnetic ordering which such interactions produce at temperatures attained by adiabatic demagnetization.

Low Temperature Research (U), RR 002-02-0008. University of Connecticut, Storrs, Connecticut, Department of Physics; Nonr 2967(00), NR 017-212; C. A. Reynolds.

This task is concerned with the physical phenomena peculiar to low temperatures. Included in the investigations to be undertaken are (a) thermal conductivity and diffusivity and electrical resistivity of impure tin, (b) measurement of the γ-line of helium near the vapor pressure, and (c) resistance temperature characteristics of 1/10 watt carbon resistors.

Paramagnetic Resonance (U), RR 002-02-0009. Rutgers University, New Brunswick, New Jersey, Department of Physics; Nonr 404(08), NR 018-401; R. T. Weidner.

This task has two aspects. One is the experimental and theoretical study of relaxation mechanisms, line shapes, and saturation effects in electronic paramagnetic resonance. The experiments are carried out on salts of the transition elements and on organic free radicals. The second aspect of this task is the experimental study of the thermal and electromagnetic properties of superconductors as a function of chemical impurities and structure changes.

Investigations in Solid State Physics (U), RR 002-02-0010. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Department of Physics; Nonr 760(05), NR 018-301; S. A. Friedberg.

This task is a study of the physical properties of magnetic materials at low temperatures. Specific topics which are investigated are: magnetic susceptibility and specific heat of antiferromagnetic compounds, magnetoresistance of Cu-Ni alloys, heat transport in ferrimagnetic crystals, and attenuation of ultrasonic waves in ferrite crystals.

Thermal Conductivity (U), RR 002-02-0011. South Dakota State School of Mines and Technology, Rapid City, South Dakota; Nonr 2964(00), NR 017-208; R. G. Morris.

This task will measure and study the thermal conductivity of semiconductors and semiconductor contacts at high temperatures. The objectives will be (1) addition of new information to the basic study of heat transfer in semiconductors and (2) a better understanding of the nature of the mechanism of heat transfer across a contact.

Graded Gap Semiconductors (U), RR 002-02-0012. Texas Instruments Incorporated, Dallas, Texas; Nonr 3006(00), NR 017-209; R. E. Johnson.

This task will be devoted to the study of the alloy systems gallium-arsenide-phosphide, and gallium-aluminum-antimonide. It is desired to produce these materials having a graded energy gap along the length of a sample so that the material may have an optimized thermoelectric conversion ability.

High Pressure Research (U), RR 002-02-0013. University of Chicago, Chicago, Illinois; Nonr 2121(03), NR 017-305; A. W. Lawson.

Experimental studies are made of the electrical, mechanical, thermal, and transport properties of solids under pressures ranging to about 20,000 atm. Currently under investigation are the thermal and electrical transport properties of iron oxides, and other materials of interest in the study of the earth's interior; pressure-effects on mechanical properties of single crystals of selected metals and alloys; and self-diffusion in specially prepared crystals. Nuclear resonance studies are under way using a nonmagnetic pressure vessel.

Plastic Deformation of Solids (U), RR 002-02-0014. University of Illinois, Urbana, Illinois, Department of Physics; Nonr 1834(26), NR 017-307; J. S. Koehler.

Experiment and theory are used in this study of crystal defects; e.g., impurities, dislocations, vacancies and interstitials, in metals and ionic crystals. The principal goal is a quantitative theory of the mechanical properties of solids and the influence of defects. During this contract period, the topics of study will be (a) phase changes in elastically anisotropic cyrstals, (b) Bardoni peaks, and the observation of dislocations by use of visible light.

High Pressure Solid State Physics (U), RR 002-02-0015. Harvard University, Cambridge, Massachusetts, Department of Phyiscs; Nonr 1866(10), NR 017-308; H. Brooks, W. Paul.

Experimental and theoretical studies are made of properties of matter under high pressure. Current emphasis is on improved determination of optical, electrical, and magnetic properties of well-prepared semiconductors and materials under pressure are being made of the shift of the absorption edge

of germanium; on the ionization energy of gold impurities in germanium; on the Hall effect of alkali metals; dielectric constant of germanium and silicon; on the properties of ferrimagnetic materials; and on the energy gap in silicon through measurement on p-n junctions. Techniques are being developed to improve accuracy of measurements, and to increase the range of controlled temperatures, particularly toward liquid He temperatures, at which high pressure measurements can be made. Some work is devoted to development of high pressure components for use in solid state experimentation.

High Pressure Physics (U), RR 002-02-0016. Case Institute of Technology, Cleveland, Ohio, Department of Physics; Nonr 1141(05), NR 017-309; C. S. Smith.

This task is a study of crystal physics using high pressure techniques. Investigations into four sorts of microscopic aspects of crystals are carried out: (a) short-range ion core interactions; (b) electron-lattice interactions; (c) long-range Coulomb interactions; and (d) volume dependence of the normal mode frequency.

Photomechanical Effects (U), RR 002-02-0017. University of Notre Dame, Notre Dame, Indiana, Department of Metallurgy; Nonr 1623(07), NR 017-311; G. C. Kuczynski.

This task was an experimental study of the effect of light on the mechanical properties of semiconductors. Crystals of semiconductors such as germanium, silicon, and ionic compounds such as sodium chloride, potassium chloride, and lithium fluoride were used as samples. Influence of impurities and dislocations were investigated with the goal of better understanding their effect on electronic structure in semiconductors.

X-Ray Conference (U), RR 002-02-0018. University of Denver, Denver, Colorado, Denver Research Institute, Department of Physical Metallurgy; Nonr 2796(00), NR 017-312; W. M. Mueller.

The purpose of this task is to conduct a conference, international in scope, on the applications of X-ray techniques and the analysis of X-ray data. This conference is the tenth in a continuing series sponsored by the contractor. It was held in Denver, Colorado, on 9, 10, 11 August 1961.

Structure of Metals and Intermetallic Compounds (U), RR 002-02-0019. California Institute of Technology, Pasadena, California, Department of Chemistry; Nonr 220(33), NR 017-411; L. Pauling.

This task consists of experimental and theoretical investigations of the structure of metals and intermetallic compounds. Particular attention is paid to structures of considerable complexity, such as those of the alloys of Mg, Al, Cr, and Zn.

Dielectric and Semiconducting Solids (U), RR 002-02-0020. University of Illinois, Urbana, Illinois, Department of Physics; Nonr 1834(19), NR 017-412; R. J. Maurer.

Experimental research is conducted in dielectric and semiconducting solids. A systematic procedure is being applied to elucidate the role of lattice imperfections for these processes. Transport and optical properties are being investigated in the alkali halides.

Solid State Theory (U), RR 002-02-0021. University of Illinois, Urbana, Illinois, Department of Physics; Nonr 1834(12), NR 017-413; F. Seitz.

The work is basically theoretical in nature and centers about the application of modern atomic theory to the problems of solid state physics with particular reference to the behavior of the electronic states of solids. About half of the effort of the investigation is devoted to the study of insulators which exhibit the properties of photoconductivity and photoluminescence, whereas the other half is devoted to the properties of metallic substances. The work will provide understanding in the following areas: (a) the origin of luminescence in inorganic and organic crystalline solids; (b) the nature of the color centers induced in alkali halides and related crystals when bombarded with ionizing radiations or when produced in a state of stoichimetric unbalance; (c) the influence of point imperfections and dislocations on the electrical conductivity of metals; (d) factors influencing the diffusion of atoms and ions in salts and metals; (e) factors influencing the ductility and rupture strength of metals and insulating crystals; (f) processes which occur in solids when bombarded with fast ionizing radiations, such as deuterons and electrons; (g) magnetic resonance in imperfect solids; (h) factors influencing the differences in cohesion between metals and valence compounds; (i) the pinning of dislocations in salts.

Thermal Noise and Solid State (U), RR 002-02-0022. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Physics, Nonr 551(36), NR 018-103; H. B. Callen.

This task deals with the theory of solids, especially magnetism, irreversible statistical mechanics, and phase transformations. Current work includes theoretical investigations on noise in irreversible systems, ferromagnetic dynamical response, magnetocrystal line anisotropy, and interactions between spin waves and conduction electrons.

Ionic Conductivity in Solids (U), RR 002-02-0023. University of Michigan, Ann Arbor, Michigan, Department of Physics; Nonr 154(00), NR 017-416; E. Katz.

This task was an investigation of ionic conduction effects in ionic crystals. An effort was being made to observe the Hall effect in an alkali halide crystal.

Dielectric Materials Research (U), RR 002-02-0024. Massachusetts Institute of Technology, Cambridge, Massachusetts, Laboratory for Insulation Research; Nonr 1841(10), NR 018-801; A. R. vonHippel.

This task is devoted to the measurement and interpretation of the fundamental properties of dielectric and magnetic materials. One of its principal long-range objectives is the correlation of the so-called "engineering properties" of matter with the more fundamental ones. Current investigations in progress are in the fields of electrical conduction and breakdown, dielectric spectroscopy, saturation magnetization and permeability, magnetic resonance, and X-ray and neutron diffraction structure studies.

Galvanomagnetic Effects (U), RR 002-02-0025. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Physics; Nonr 839(06), NR 017-424; H. J. Juretschke.

This task is principally concerned with galvanomagnetic effects in metals and semiconductors. The research carried out may be divided into three phases: (a) transport properties and band structure of metals, (b) Hall effect and magnetoresistance of ferromagnetic thin films, and (c) D.C. effects in ferromagnetic resonance.

Physics of Carbons (U), RR 002-02-0026. University of Buffalo, Buffalo, New York, Department of Physics; Nonr 969(01), NR 018-702; S. Mrozowski.

This task is devoted to a thorough-going experimental study of wholly and partially graphitized carbons. The investigator and his staff are competent to make reproducible speciments of heat treated carbons. For these and for natural graphite specimens, they measure magnetic susceptibilities, electrical resistivities, Hall coefficients, microstructure, thermal conductivity, thermoelectric power, optical properties, paramagnetic resonance, etc.

Excess Noise in Semiconductors (U), RR 002-02-0027. Armour Research Foundation, Illinois Institute of Technology, Chicago, Illinois, Department of Physics Research; Nonr 1800(00), NR 017-432; J. J. Brophy.

This task is a theoretical and experimental study of current dependent noise in solids. The fundamental mechanism of the noise component whose power per cycle varies inversely with frequency is of primary concern. A considerable part of this program is devoted to the study of transport in cadmium sulfide. These studies will be extended to include surface studies and avalance processes. Further examination will be made on critical fluctuations in ferroelectric materials.

Effects of Various Crystal Imperfections on the Thermoelectric Properties of Bismuth (U), RR 002-02-0029. Battelle Memorial Institute, Columbus, Ohio; Nonr 2316(00), NR 017-434; A. C. Beer.

This task is an investigation of the effect of various crystal imperfections on the thermoelectric properties of Bismuth Telluride. Imperfections will be created by chemical additions, fast neutron bombardment, and plastic deformation. The Thermoelectric properties will be measured and analyzed.

Crystal Physics (U), RR 002-02-0031. Massachusetts Institute of Technology, Cambridge, Massachusetts; Nonr 1841(50), NR 018-703; A. Smakula.

This task is concerned with the growth of single crystals in the purest possible form including alkali halides, garnets, intermetallics of the Class III-V types. Measurements on the physical, electrical, optical and thermal properties on these samples are made. Thermal conductivity and thermoelectric power measurements also are made on appropriate systems.

Physical Properties of Single Crystals (U), RR 002-02-0032. New York University, New York, New York, Institute of Mathematical Sciences; Nonr 285(41), NR 017-439; M. Pope.

This task is concerned with the preparation and growth of organic single crystals and measurement of their optical and electrical properties. Typical of the organic crystals to be grown are naphthalene, diphenylanthracene, circumanthracene, diphenyl, and the metal phthalocyanines. The study of the modifications of crystal habit by the inhibition of growth along specific crystal planes, and the effect of such modification on the properties of the crystal will be undertaken. The electrical and optical properties to be studied include photoconductivity, polarization and photovoltaic effects, fluorescence, and paramagnetic resonance. These studies will be made as a function of temperature, wavelength, electrical field strength and frequency, and chemical treatment. A theoretical analysis of the data obtained will be carried out on the basis of present inorganic semiconductor theory, where applicable.

Surface Electron Energy (U), RR 002-02-0033. University of California, Berkeley, California, Division of Physical Sciences (Riverside); Nonr 1842(02), NR 017-441; A. M. Russell.

The distribution of the energy of electrons extracted from selected solids by high electric fields will be measured for the purpose of predicting the energy distribution of the electrons within the solid and the nature of the potential barrier at the surface. Both metals and semiconductors will be used as emitter samples.

Electric Transport (U), RR 002-02-0034. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Physics; Nonr 551(33), NR 017-442; J. M. Luttinger.

This task has been a theoretical study of the electric transport phenomena. The Kohn-Luttinger transport theory in the presence of weak magnetic fields has been investigated to obtain a theory of the Hall effect for electrons in degenerate bands, and in addition, to understand other types of transport, such as heat transport. The principal investigator has left the University of Pennsylvania and is now at Columbia University. Hence, work has been transferred to Columbia University under the same task number.

Field Ion Microscope (U), RR 002-02-0035. Pennsylvania State University, University Park, Pennsylvania, Department of Physics; Nonr 656(23), NR 017-443; E. W. Muller.

This task is to develop a field ion microscope adapted particularly for study of solid surfaces, dislocations, grain boundaries, diffusion, and other details of atomic dimensions. The design will incorporate new techniques such as an all metal structure, quick change tip specimen, and replaceable screen materials. These innovations will require considerable research for effective operation.

Semiconductor Transport (U), RR 002-02-0036. Shockley Transistor Corporation, Unit of Clevite Transistor, Division of Clevite Corporation, Mountain View, California; Nonr 2934(00), NR 017-444; W. Shockley.

This task studies the mean free path of phonons in various semiconductors. The research is

directed toward the development, empirically and theoretically, of a more thorough understanding of the mechanism of interaction between lattice vibrations (phonons) with electrons and holes in a semiconductor.

Titanium Dioxide Studies (U), RR 002-02-0037. National Bureau of Standards, Washington, D. C.; NAonr 1-60, NR 017-445; H. P. R. Frederikse.

This task investigates the electric, magnetic, and thermoelectric properties of titanium oxides. Attempts will be made to clarify the electronic energy structure of these substances.

Amorphous Inorganic Solids (U), RR 002-02-0038. A. O. Smith Corporation, Milwaukee, Wisconsin, Long Range Research Laboratory; Nonr 2965(00), NR 017-446; J. H. Healy.

This task investigates the preparation of and transport processes in amorphous materials. The specific goal is to understand this relatively unexplored area of solids and to find materials which will result in efficient thermoelectric conversion.

Thermal Conductivity (U), RR 002-02-0039. A. D. Little, Incorporated, Cambridge, Massachusetts; Nonr 2974(00), NR 017-447; P. E. Glaser.

This task attempts to prove the validity of measuring thermal conductivity by radiometric methods at high temperatures (greater than 1000°C). The measurement of thermal conductivity is directly dependent upon measuring small temperature differences accurately. The radiation from a solid is one indication of temperature. A novel method of determining the temperature by the radiation has been proposed. From this, the thermal conductivity can be calculated.

International Semiconductor Conference (U), RR 002-02-0040. U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland, Applied Physics Department; Allot. 552, NR 017-448; J. Zemel.

An International Conference on Semiconductor Surfaces was held 3-4 December 1959 at the U. S. Naval Ordnance Laboratory, White Oak, Maryland. This task provided assistance in preparation of the proceedings.

Normally Conducting Films on Superconductors (U), RR 002-02-0041. Stevens Institute of Technology, Hoboken, New Jersey, Department of Physics; Nonr 263(32), NR 017-449; H. Meissner.

The penetration of superconducting electrons into a thin film of normally conducting material deposited on the surface of superconductor is studied by means of microwave techniques.

International Conference on Electronic Conductivity in Organic Solids (U), RR 002-02-0042. U. S. Army, Office of Ordnance Research, Durham, North Carolina, Physical Sciences Division; M1PR 13-60, NR 017-450; H. Robl.

An international conference on Electronic Conductivity in Organic Solids was held 20-22 April 1960 at the Office of Ordnance Research, Durham, North Carolina. This task provided assistance to the Office of Ordnance Research so that more foreign attendees from Japan and Europe could be invited.

Irradiation of Alkali Halides (U), RR 002-02-0043. Tufts University, Medford, Massachusetts, Department of Physics; Nonr 3034(00), NR 017-451; K. A. McCarthy.

This task concerns the measurement and interpretation of the physical properties of insulating crystalline materials, particularly alkali halides, at low temperatures. The principal investigator has been examining the effects of irradiation of alkali halides with microwaves, X-rays, and electrons, and also studying plastic deformation in these substances. The present phase of this work will emphasize the study of thermal conductivity in these materials.

X-Ray Spectroscopy (U), RR 002-02-0044. State College of Washington, Pullman, Washington, Department of Physics; N7onr 330(07), NR 017-603; S. T. Stephenson.

This task is concerned with an investigation of electronic states of atoms, molecules and solids by means of X-ray absorption in the spectral range from 3 to 20 Angstroms. The polarized X-ray absorption spectra of single crystals of copper and germanium have been studied and effects of exciton states on the fine structure near absorption edges explored.

X-Ray Technique Development (U), RR 002-02-0045. Polytechnic Institute of Brooklyn, Brooklyn, New York; Nonr 839(13), NR 017-604; I. Fankuchen.

This task is concerned with development of X-ray diffraction techniques and their employment for the determination of crystal structures at both room nd relatively low temperatures. Some of the substances such as hydrocarbons investigated are either liquid or gaseous at room temperatures.

X-Ray Spectroscopy (U), RR 002-02-0046. Ohio State University, Columbus, Ohio, Department of Physics; Nonr 495(16), NR 017-606; E. L. Jossem.

This task is concerned with experimental investigation of electronic states of matter by X-ray methods. Precise information is obtained on the long wave-length X-ray spectra of metals, semiconductors and insulators.

Low Temperature X-Ray Diffraction (U), RR 002-02-0047. Brown University, Providence, Rhode Island, Department of Physics; Nonr 562(04), NR 017-607; G. B. Carpenter.

In this task, X-ray diffraction techniques are used to determine the structures of molecular crystals at temperatures below their freezing points. Hydrogen atoms can be located so that it is possible to determine the existence and importance of the type of intermolecular attractions (hydrogen bonds) involving them. An attempt will be made to study the arrangement of hydrogen atoms in cubic ice.

Electronic Structure of Matter (U), RR 002-02-0048. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Physics; Nonr 1841(34), NR 018-101; J. C. Slater.

This task is an intensive effort to improve the theoretical treatment of solids and molecules and to refine the computational techniques used in this theory. A variety of methods are being used to

compute binding energies and magnetic and electric properties of solids and molecules. These methods include configuration interaction, self-consistent field, augmented plane wave, and cellular methods. Automatic computing machines are used to facilitate the analysis of more realistic methods than would otherwise be possible.

The Quantum-Mechanical Many-Body Problem (U), RR 002-02-0050. University of Maryland, College Park, Maryland, Department of Physics; Nonr 1797(00), NR 017-618; R. A. Ferrell and W. M. MacDonald.

This task is concerned with applications and improvements of the theory of collective behavior of electrons. Among the specific topics being studied are momentum distribution in a degenerate electron gas, electron-phonon interactions in superconductors, and collective spin excitations in an electron gas and in nuclear matter.

Positron Annihilation in Matter (U), RR 002-02-0051. University of Virginia, Charlottesville, Virginia, Department of Physics; Nonr 474(07), NR 017-619; S. Berko.

This task is devoted to the study of positron annihilation in several different types of solids. Angular correlation of annihilation radiation has been studied in oriented, highly perfect single crystals of metals; the precision of this work will be further improved. Similar study of angular correlation of annihilation radiation from oriented single crystals of alkali halides is being initiated at present. The technique will be turned to investigation of momentum distribution of ferromagnetic electrons; this will require use of polarized positrons.

Electron Band Theory of Metals (U), RR 002-02-0052. Carnegie Institute of Technology, Pittsburgh, Pennsylvania; Nonr 760(13), NR 017-620; J. M. Radcliffe.

This task has been devoted to refinement of the electron-energy-band theory of metals and semiconductors. Its scope included theoretical considerations on the following topics: (1) electromagnetic properties of covalent semiconductors; (2) effects of charged particles in metals; (3) motion of Bloch electrons in a magentic field; (4) magnetic effects on impurity states in semiconductors; and (5) analytic character of energy bands and Bloch wave functions.

Heat Conduction of Solids as Function of Isotopic Constitution (U), RR 002-02-0053. Yale University, New Haven, Connecticut, Department of Physics; Nonr 609(33), NR 017-621; C. T. Lane, H. Fairbanks.

Measurements are made of heat conductivity of mainly dielectric liquids and solids as function of isotopic constitution, pressure and temperature. The solids include mixtures of hydrogen, helium and neon isotopes. Correlations with possible magnetic phase transitions of the helium isotopes will be examined.

Solid State Theory (U), RR 002-02-0054. Rutgers University, New Brunswick, New Jersey, Department of Physics; Nonr 404(13), NR 018-104; P. R. Weiss.

This task is a theoretical investigation of the electronic properties of solids and of relaxation phenomena in magnetic resonance. A topic of particular interest is the effect of impurities on the properties of solids.

X-Ray Diffraction Studies in Thermal Motions in Crystals (U), RR 002-02-0055. Georgia Institute of Technology, Atlanta, Georgia, Engineering Experiment Station; Nonr 991(06), NR 017-623; R. A. Young.

This task is devoted to X-ray diffraction studies of thermal motions in crystals. It is a first step in a general study of thermal motions in crystals, their role in other phenomena of interest in crystal physics, and in the range of and conditions for the validity and applicability of certain specified X-ray techniques for determining the details of thermal motion.

X-Ray Studies of Liquids and Solids (U), RR 002-02-0056. University of Arkansas, Fayetteville, Arkansas, Department of Physics; Nonr 2627(00), NR 017-624; A. E. Harvey.

Experimental studies will be undertaken of liquids and crystals using the X-ray diffraction techniques. Although it is initially planned to study elemental liquids, this work will be later extended to include compounds and solutions. As part of this program, similar experimental studies will be made on single crystals as are available.

Soft X-Ray Absorption (U), RR 002-02-0057. Cornell University, Ithaca, New York, Department of Physics; Nonr 401(37), NR 017-625; G. Tomboulian.

Measurements are made of the absorption coefficients for X-rays in the 10-100 volt range. Particular attention is given the spectral regions in the continuum away from the absorption edge and to elements of low atomic number. Comparisons with several approaches to improved theories are to be made. Measurement techniques are of particular concern.

Transport Processes (U), RR 002-02-0058. Cornell University, Ithaca, New York, Department of Physics; Nonr 401(38), NR 017-626; J. A. Krumhansl, G. F. Dresselhaus and R. H. Brout.

This task will aid in establishing a center for the investigation, both experimental and theoretical, of thermal transport in solids as a function of temperatures, imperfections, impurities, and other related physical phenomena.

Calculation of Thermal Conductivities (U), RR 002-02-0059. Stanford Research Institute, Menlo Park, California; Nonr 2766(00), NR 017-627; R. J. Marcus.

This task is responsible for developing a method of estimating thermal conductivities of liquids at high temperatures. A method that is "intermediate"; that is, it is neither completely empirical nor derived from first principles, has been used to calculate energies and entropies of vaporization of a number of liquids. This task is applying this method to the problem of estimating the thermal conductivity of liquids.

Solid State Magnetism Studies (U), RR 002-02-0060. University of California, Berkeley,

California, Department of Physics; Nonr 222(01), NR 018-102; C. Kittel.

This task is devoted mainly to a thorough experimental and theoretical study of the spin and orbital behavior of electronic charge carriers (conduction electrons and holes) in solids. In addition, some work is done on ferromagnetism, and anti-ferromagnetism, and related phenomena involving the interactions of strongly paramagnetic atoms or ions. Drs. Kittel and Kip and their colleagues have become one of the world's most productive research teams and have developed to fruition both the theory and the observational techniques of electronic cyclotron resonance and plasma resonance in solids.

Magnetic Resonance in Solids (U), RR 002-02-0061. University of California, Berkeley, California, Department of Physics; Nonr 222(10), NR 018-402; W. D. Knight, Jr.

This task is an experimental study of nuclear magnetic resonance and nuclear quadrupole resonance in solids. Particular experiments of special interest are (a) variation of line shape, width, and position of nuclear magnetic resonance in alloys as a function of composition, (b) dependence of spin relaxation phenomena on temperature in metals near the melting point, and (c) detection of nuclear magnetic resonance and nuclear quadrupole resonance in superconductors and study of various properties such as resonance frequency, Knight shift, and relaxation times during the normal-superconducting transition.

Magneto-Optical Study of Ferromagnetic Domains (U), RR 002-02-0062. Pomona College, Claremont, California, Department of Physics; Nonr 1606(00), NR 018-303; C. A. Fowler.

This task is a study of magnetic domain patterns in ferromagnetic materials by use of the Kerr and Faraday effects. Current efforts are centered on domain patterns in thin films and on the structure of domain walls.

Magnetic Studies of Salts (U), RR 002-02-0063. University of Chicago, Chicago, Illinois, Department of Physics; Nonr 2121(08), NR 018-403; C. A. Hutchison.

This task is an experimental and theoretical investigation of the magnetic properties of the rare earth metals and heavy elements. The principal experimental techniques used are electronic magnetic resonance and static magnetic susceptibility measurements. Among the materials to be investigated are the actinide elements and uranium and thorium compounds.

Studies of Antiferromagnetism (U), RR 002-02-0064. University of Chicago, Chicago, Illinois, Institute for the Study of Metals; Nonr 2121(13), NR 018-302; J. W. Stout.

This task is an experimental and theoretical study of the ferromagnetic and antiferromagnetic anhydrous fluorides of the transition elements. Among the types of experimental investigations carried out are magnetic susceptibility, magnetic anisotropy, Faraday effect, heat capacity, and optical spectroscopy. The theoretical studies are on topics closely related to these problems.

Paramagnetic Resonance (U), RR 002-02-0065. Washington University, St. Louis, Missouri, Department of Physics; Nonr 1758(00), NR 018-204; R. E. Norberg.

The equipment lent under this task was assembled for and is particularly suitable to the observation of paramagnetic and nuclear spin resonance in liquids and solids. Resonance studies are particularly useful in determining the structure and properties of organic free radicals and other atomic configurations exhibiting unpaired electrons or non-vanishing nuclear hyperfine splittings.

Nuclear Resonance (U), RR 002-02-0067. University of California, Berkeley, California, Department of Physics; Nonr 222(41), NR 018-404; E. L. Hahn.

This task is a study of interactions in crystals by means of nuclear and electronic magnetic resonance techniques. Spin echo resonance techniques are used to detect nuclear quadrupole interactions and to measure low temperatures and nuclear spin relaxation times in the region below $1^{o}K$. Electronic paramagnetic resonance is used to study spin echo transients, Overhauser effects, and spin-lattice relaxation processes in electron spin systems.

Paramagnetic Resonance (U), RR 002-02-0068. National Bureau of Standards, Washington, D. C., Department of Cryogenics; NAonr 3-60, NR 018-405; H. E. Radford.

In this task, the technique of microwave magnetic resonance is used to study the properties of paramagnetic salts and free radicals. Of particular interest are fine and hyperfine structure in the high frequency spectra, properties of metastable states, relaxation times in electron spin systems, and dynamic polarization of nuclei.

Optical and Resonance Properties of Insulation (U), RR 002-02-0069. Cornell University, Ithaca, New York, Department of Physics; Nonr 401(15), NR 018-406; D. F. Holcomb.

This task is divided into two parts, Part I being a broad study of the optical properties of insulators and including photoconductivity, UV transmission and reflection measurements, external photoemission, luminescence under UV stimulation, and development of new instrumentation for UV investigations. In Part II, nuclear magnetic resonance is used to study spin-lattice relaxation times and the interactions of F- and M-centers in alkali halides; electronic paramagnetic resonance studies are made of electron and hole traps in silver-halides, and spin-lattice relaxation times in p-type silicon and in defect centers in various ionic crystals.

Magnetic Materials (U), RR 002-02-0070. Lehigh University, Bethlehem, Pennsylvania, Department of Metallurgy; Nonr 2340(00), NR 018-802; G. P. Conard.

The equipment lent under this task is particularly suited to aid in permanent-magnet research involving (a) studies of precipitation hardening systems with a view to determining the influences of heat treatment in a magnetic field on the nature and occurrence of the second phase and on the magnetic properties of alloys; (b) studies of manganese-base ferromagnetic alloys in an attempt

to develop permanent-magnet materials which show satisfactory properties but require no critical alloying elements. Further, these studies may provide an increased understanding of the origin of ferromagnetism.

Magnetic Studies of Solids (U), RR 002-02-0071. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Physics; Nonr 551(28), NR 018-902; K. R. Atkins and M. Caspari.

This task is an experimental study of (a) specific heats of ferrites and other solids at low temperatures, (b) magnetic anisotropy of binary alloys, and (c) nuclear magnetic resonance in ferromagnetic alloys.

Resonance in Solids (U), RR 002-02-0072. University of California, Berkeley, California, Department of Physics; Nonr 222(59), NR 018-409; A. F. Kip and A. M. Portis.

This task is an experimental study of paramagnetic and diamagnetic resonance in solids with particular emphasis on very high frequency (sub-centimeter micro-wave) measurements. Among the experiments planned are microwave Faraday rotation studies of thin films of semiconductors and noise studies in superconductors.

MM-Wave Effects in Solids (U), RR 002-02-0073. University of California, Berkeley, California, Department of Physics; Nonr 222(58), NR 018-407; M. Tinkham.

This task is a study of the far infrared and mm-wave spectroscopy of solids at low temperatures. Topics currently being investigated are the energy gaps in superconductors and the infrared spectra of antiferromagnetic crystals.

Spin Interaction in Solids (U), RR 002-02-0074. University of California, Berkeley, California, Department of Physics; Nonr 222(61), NR 018-408; C. D. Jeffries.

This task is a study of the interaction of one system of spins with another system of spins or with lattice vibrations. Particular topics currently under investigation are dynamic orientation of nuclei, the determination of nuclear magnetic moments, nuclear cooling and nuclear ferromagnetism, and phonon-spin interactions. The research utilizes the techniques of solid state physics, nuclear physics, radio-frequencies and microwaves, and cryogenics.

Intense Magnetic Fields (U), RR 002-02-0075. University of California, Berkeley, California, Department of Physics; Nonr 222(64), NR 018-502; A. C. Helmholz.

This task is devoted to the detailed engineering design and operation of a laboratory for experiments with intense magnetic fields. An air core magnet will be installed, provided with auxiliary instrumentation, and operated for a year at a temporary site. An engineering study will be made of the design of a 2-megawatt power supply for a permanent installation.

Electric and Magnetic Properties of Magnetic Alloys (U), RR 002-02-0078. Minneapolis-Honeywell Regulator Company, Hopkins, Minnesota, Research Center; Nonr 2732(00), NR 018-803; O. S. Lutes.

This task is an experimental study of the electric and magnetic properties of metallic alloys at low temperatures. The principal investigations are at present magnetization measurements on dilute alloys of Mn, Cr, and Ti in noble metals.

Nuclear Resonance in Magnetic Materials (U), RR 002-02-0079. Case Institute of Technology, Cleveland, Ohio, Department of Physics; Nonr 1141(07), NR 018-410; G. Wagoner.

In this task, nuclear magnetic resonance studies are made on diamagnetic, paramagnetic, antiferromagnetic, and ferrimagnetic materials. The variation of such properties as resonance frequency, line-width, and spin-lattice relaxation time as functions of temperature, composition, and type of magnetic material is investigated both experimentally and theoretically.

Properties of Metals (U), RR 002-02-0080. Catholic University of America, Washington, D. C.; Nonr 2249(03), NR 018-903; P. H. E. Meijer and R. Meister.

This task is an experimental and theoretical study of ultrasonic attenuation in metals at low temperatures and in the presence of magnetic fields. The principal aim of the task is to obtain information about the size, shape, and structure of the Fermi surface in metals and alloys.

Low Temperature Research (U), RR 002-02-0081. California Institute of Technology, Pasadena, California, Electrical Engineering Department; Nonr 2988(00), NR 018-804; G. D. McCann.

This task is a comprehensive long-range program in the electrical and magnetic properties of materials. Specific items now being investigated are preparation and switching times of ferromagnetic thin films and superconducting thin films, high speed switching instrumentation, and properties of semiconductor materials and p-n junctions at low temperatures.

Studies of Materials Using Pulsed High Magnetic Fields (U), RR 002-02-0082. McGill University, Montreal, Canada, Electronics Research Laboratory; Nonr 3013(00), NR 018-503; R. E. Stevenson.

This task is an experimental study of the properties of matter in high pulsed magnetic fields. The magnetic susceptibilities of various compounds in the 100-500 kilogauss range are currently being investigated. Future work will include studies of the diamagnetism of excitons in semiconductors and the magnetoresistance of indium antimonide.

Properties of Nonmetallic Solids at Low Temperature (U), RR 002-02-0083. Ohio State University, Columbus, Ohio, Department of Physics and Astronomy; Nonr 495(20), NR 018-412; J. G. Daunt.

This task is concerned with the physcial properties of nonmetallic solids at low temperature, and in particular, the dependence of these properties on the isotopic content of the solids. Specific topics which will be investigated are (1) the influence of paramagnetic impurities and radiation damage on nuclear spin relaxation time, (2) the use of nuclear magnetic resonance techniques to determine activation energies for molecular

diffusion and reorientation, and (3) the use of nuclear magnetic resonance techniques to study phase transitions and phase diagrams in solids at low temperatures. In the last problem, special attention will be paid to the effects of isotopic composition.

Magnetic Susceptibilities of Free Radicals (U), RR 002-02-0084. University of Santa Clara, Santa Clara, California, Department of Physics; Nonr 2985(01), NR 018-203; W. T. Duffy, Jr.

This task is a study of the static magnetic susceptibility of organic free radicals as a function of temperature and as a function of the solvent from which the radical was crystallized.

High Resolution Magnetic Resonance (U), RR 002-02-0085. Duke University, Durham, North Carolina, Department of Physics; Nonr 3022(00), NR 018-411; W. Gordy.

Measurements are made of electron and nuclear resonance induced by radiation in selected materials. In particular, measurements are made on single crystals at low temperatures, and on organic crystals; also on glasses and biological materials such as proteins.

Color Centers in Alkali Halides (U), RR 002-02-0086. Oregon State College, Corvallis, Oregon, Department of Chemistry; Nonr 1286(05), NR 018-701; A. B. Scott.

Steady-state and transient photoconductance, magnetic susceptibility, and optical absorption measurements are made on alkali halide crystals in order to identify and characterize the various color centers. At present, the effect of anion impurities on F centers and on the initial photocurrent in colored crystals is being investigated.

High Pressure Chemical Physics (U), RR 002-02-0087. University of California, Berkeley, California, Department of Physics; Nonr 222(65), NR 017-310; G. Jura.

Measurements are made of electrical and state properties of selected materials under high pressures. The materials under investigation are dielectrics or semiconductors at atmospheric pressure. A special compact design of high pressure apparatus has been used successfully in this work.

Instrumentation Research (U), RR 002-02-0088. National Bureau of Standards, Washington, D. C., Office of Basic Instrumentation; NAonr 21-57, NR 017-313; W. A. Wildhack.

Under this task, a wide variety of activities are being pursued in the field of instrumentation. These activities can be grouped under three main headings: (1) An instrument reference and consultation center is being maintained and developed at the Office of Basic Instrumentation, National Bureau of Standards. This reference center consists of a rapidly growing systematized library of current instrument developments, and a group of instrument specialists available for consultation on instrument problems. (2) The center will spend considerable time in the development of reference systems and retrieval devices relevant to the reference system. (3) Research projects leading to the development of new or improved instruments are undertaken when the resulting instrument prototype is new in principle or of especially wide applicability.

Elements of Electrical Instrumentation (U), RR 002-02-0089. Masachusetts Institute of Technology, Cambridge, Massachusetts, Department of Biology; Nonr 1841(08), NR 017-452; K. S. Lion.

Under this task, the field of electrical instrumentation is being surveyed and material is being gathered for a series of technical reports covering various elements of instrumentation. Reports deal systematically with the advantages and limitations of various elements for sensing pressure, magnetic field intensity, etc., and with methods of processing the signals produced by the sensing elements.

Electric Transport (U), RR 002-02-0090. Columbia University, New York, New York, Department of Physics; Nonr 266(80), NR 017-454; J. M. Luttinger.

This task is a theoretical study of the electric transport phenomena. The Kohn-Luttinger transport theory in the presence of weak magnetic fields is being investigated to obtain a theory of the Hall effect for electrons in degenerate bands and, in addition, to understand other types of transport, such as heat transport. Work is also being undertaken on the existence and meaning of the Fermi-surface for a system of interacting electrons using the grand partition function.

Solid Friction Conference (U), RR 002-02-0091. Midwest Research Institute, Kansas City, Missouri, Mathematics and Physics Division; NAonr 6-51, NR 017-453; S. L. Levy.

An international conference on the nature of Solid Fraction was held at the Midwest Research Institute, Kansas City, Missouri, 26-28 September 1960. This task provides assistance in organizing and reporting on the meeting.

Theoretical Investigation of the Electronic Energy Band Structure of Solids (U), RR 002-02-0092. RCA Laboratories, Princeton, New Jersey; Nonr 3170(00), NR 017-629; F. Herman.

This task will be devoted to systematic machine calculation of the energy band structure of a selected group of semiconductors and insulators and to the improvement of methods for such calculations. A self-consistent "Orthogonalized-Plane-Wave" method will be employed. The intention is to make calculations in sufficient detail for enough different crystals to indicate systematically the band structure within homologous series and "iso-electronic" families.

Electron Microscope (U), RR 002-02-0093. Columbia University, New York, New York, School of Engineering; Nonr 1081(00), NR 017-630; J. R. Dunning.

Under this task an electron microscope is maintained at the Electron Microscope Laboratory at Columbia University. This microscope is employed on a number of research projects and supplies electron microscope pictures and diffraction patterns of colloids, aerosols, other small particles and surfaces.

Electron Band Theory (U), RR 002-02-0094. University of California, La Jolla, California,

Department of Physics; Nonr 2216(11), NR 017-631; W. Kohn.

This task is devoted to analysis and development of the theory of electrons in crystalline solids. One major aspect is the determination of the exact sense in which the conventional band-theory is valid for semi-conductors and the precise limits of this validity. Another is the extension of important results already obtained for non-degenerate semi-conductors to the cases of degenerate semi-conductors and metals. The proper interpretation of the "Fermi-surface" for a metal is being sought and its significance for the vibrational behavior analyzed.

Electron Theory of Solids (U), RR 002-02-0095. University of Chicago, Chicago, Illinois, Institute for the Study of Metals; Nonr 2121(22), NR 017-632; M. Cohen.

This task is a broad program of basic research on the electron theory of solids. The investigations in progress range from a study of the foundations of the theory through calculations of specific electronic properties based on models of the theory and interpretation of individual experiments. Some of the topics now being studied are the self-consistent field approach to the many-body problem, the foundations of transport theory, simple models for valence electrons, exchange and correlation effects in semiconductors, theory of diamagnetic susceptibility of metals, ultrasonic attenuation in magnetic fields, and indirect absorption of light in semi-metals.

Magnetic Theory (U), RR 002-02-0096. University of California, Los Angeles, California, Department of Physics; Nonr 233(63), NR 018-105; D. I. Paul.

The purpose of this task is to contribute to the fundamental knowledge of the magnetic behavior of solids. It attempts to place the basic theories of ferromagnetism and antiferromagnetism on a more rigorous basis. A fundamental objective is to obtain a theory which will be sufficiently basic and detailed to yield the variation in the magnetic behavior of the 3d transition elements such as titanium, vanadium, chromium, iron, cobalt, and nickel.

Mossbauer Effect (U), RR 002-02-0097. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Department of Physics; Nonr 760(20), NR 018-304; S. DeBenedetti.

In this task, the resonant scattering of X-rays (Mossbauer effect) is applied to various problems in physics. Among the topics to be investigated are (a) internal magnetic and electric fields in solids, (b) relativistic contraction of clocks, (c) improvement of basic instrumentation, and (d) possible application of the technique to measurements of velocity and temperature.

Micro-Acoustic Studies of Solids (U), RR 002-02-0098. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Physics; Nonr 839(29), NR 018-413; M. Menes.

This task is a study of electronic and nuclear spin-lattice interactions in solids by acoustic techniques. Part of the effort is devoted to the extension of resonant acoustic attenuation measurements to frequencies as high as 10^9 cps and the remainder to the application of such measurements, coupled with electronic and nuclear magnetic resonance, to the investigation of the spin-lattice interactions.

High Magnetic Field Facility (U), RR 002-02-0099. U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland, Applied Physics Department; Allot. 507, NR 018-504; T. R. McGuire.

The purpose of this task is to help provide a high magnetic field facility for the U. S. Naval Ordnance Laboratory, White Oak. An air core magnet will be purchased and installed in the solid state physics laboratory.

X-RAC Fourier Analysis (U), RR 002-02-0100. Pennsylvania State University, University Park, Pennsylvania, Department of Physics; Nonr 269(16), NR 018-705; R. Pepinsky.

This task is devoted to the improvement and maintenance of X-RAC analogue computer and to the development of new computing techniques for crystallographic and molecular structure analysis.

Growth and Structure of Solids, RR 002-02-4950. U. S. Naval Research Laboratory, Washington 25, D. C.; PO4-01; Paul H. Egli.

The task includes both work on crystals for specific applications and studies aimed at new growth techniques and the mechanism of crystal growth. The applications of immediate interest include filters for the ultra violet, scintillation materials, infrared photoconductors and thermoelectric materials. Work on the growth mechanism is concerned with relating metastability inherent to a system to the quality of crystals growth and with the effect of chemical additives to both the foregoing factors in solution, melt, and vapor phase. Work on growth techniques is primarily concerned with high temperature techniques, particularly with the use of arc images for growth of refractory materials.

This task is also concerned with a study of imperfections and the effect of imperfections on the properties of solids. The task has emphasized optical, etch and X-ray techniques for gross imperfections. One of the more sensitive techniques now being explored is scattering of visible light. The materials being investigated include a variety of water soluble crystals ranging from simple cubic alkali halides both pure and containing various additives, and complex structures such as ammonium phosphate. This range of materials provides a broad spectrum of textures including some with no readily detected flaws. It has been shown that impurity centers are the primary sources of scattering in all currently available alkali halides and that light scattering provides a sensitive tool for detection of such impurities. Application of the various techniques for detecting texture differences, particularly impurity distributions, to solution-grown crystals has demonstrated the importance to crystal growth of gross features such as seed shape.

Thermal and Magnetic Properties of Solids (U), RR 002-02-0101. Duke University, Durham, North Carolina, Department of Physics; Nonr 1181(12), NR

018-904; H. Meyer.

This task consists of experimental and theoretical studies in the following areas: (a) nuclear magnetic resonance of solid H_2, D_2, and HD at very high hydrostatic pressures and at liquid helium temperatures, (b) specific heat of aluminum in its superconducting transition range, and (c) calculation of the specific heat of several rare earth iron garnets.

X-Ray Analysis (U), RR 002-02-4951. U. S. Naval Research Laboratory, Washington 25, D. C.; PO4-04; L. S. Birks.

The X-ray optics program is twofold: first, it makes use of basic principles and theory to develop specialized instruments and techniques for spectrochemical analysis such as electron probe measurements of minute precipitates in alloys in situ or the variation in composition across diffusion regions or corrosion regions near surfaces. Second, it makes use of experimental results from these specialized instruments to further develop principles and theory for intermedallic diffusion, generation of characteristic X-ray spectra, or control of crystal properties.

R002-03 Molecular Physics

Spectroscopy (U), RR 002-03-0001. University of Chicago, Chicago, Illinois, Department of Physics; Nonr 2121(01), NR 014-101; R. S. Mulliken.

Theoretical studies are conducted on structure and spectra of molecules and solids. The aim is to obtain a better, more quantitative understanding of the levels and electronic transitions of molecules and free radicals, and, thereby, of structural chemistry and chemical kinetics. Experimental work in high resolution vacuum ultraviolet spectroscopy of diatomic and simple polyatomic molecules is correlated with the theoretical calculations.

Isotope Shift and Hyperfine Structure (U), RR 002-03-0002. University of Southern California, Los Angeles, California, Department of Physics; Nonr 228(14), NR 014-102; J. R. Holmes.

Techniques of precision spectroscopy are applied to the measurement of wavelengths of spectral lines in the visible and near infrared of selected light weight and heavy isotopes. Particular attention is being given to isotope shifts in the spectrum of silicon.

Oscillator Strengths of Spectral Lines (U), RR 002-03-0003. California Institute of Technology, Pasadena, California, Department of Physics; Nonr 220(06), NR 014-103; R. B. King.

Relative oscillator strengths of atomic spectral lines are obtained by measurement of absorption spectra of an atomic beam produced with a special high temperature oven. Emission spectra of highly excited states of atoms in electric arcs are measured with a novel, instantaneous method using a double photocell photometer and electronic comparison methods. Absolute oscillator strengths of some atomic lines are being determined.

Structure of Matter (U), RR 002-03-0004. University of Wisconsin, Madison, Wisconsin, Department of Physics; Nonr 1404(00), NR 014-104; J. E. Mack, W. W. Beeman.

The equipment lent under this task will be used in studies of the hyperfine structure of hydrogen, the hyperfine structure of the spectra of the heavy elements, the isotope shift of these lines, and the study of the nuclear moments of hydrogen-like elements. Other equipment will be used in studies of small angle X-ray scattering and X-ray spectroscopy.

Electronic Levels of Complex Molecules (U), RR 002-03-0005. Florida State University, Tallahassee, Florida, Department of Chemistry; Nonr 1562(00), NR 014-202; M. Kasha.

Spectroscopic investigations are made of the optical transitions of complex molecules such as the nitrogen heterocyclics, porphyrin types, and the chlorophylls. The experimental techniques involve freezing the molecules in a glassy matrix at low temperatures, excitation by ultraviolet flashes, and measurement of emission and absorption spectra as functions of time. Correlated theoretical interpretations are made of electronic energy level schemes, and with mechanisms of inter- and intra-molecular energy transfer.

Atomic Spectroscopy (U), RR 002-03-0009. Purdue University, Lafayette, Indiana, Department of Physics; Nonr 1100(08), NR 014-106; K. L. Andrew.

Using an atomic beam source and a Fabry-Perot interferometer, precise measurements are made of emission spectra. Determinations of levels and multiplet structure of alkali atoms and ions from Li to Rb are made. Using a beam of a single isotope, effects of nuclear moments and size are investigated. Techniques are being developed for extending the measurements into the infrared. Another study to be made is the analysis of high frequency discharges in alkali vapors.

Molecular Structure of Condensed Phases (U), RR 002-03-0011. Princeton University, Princeton, New Jersey, Department of Chemistry; Nonr 1858(27), NR 014-203; D. F. Hornig.

Experimental and theoretical investigations are made on the structure and spectra of molecules, free radicals, and crystals. Current emphasis is on obtaining and interpreting the spectra of molecular crystals at low temperatures, particularly the Raman and infrared spectra related to lattice vibrations. A theoretical study is also being made of the relation of infrared vibrational spectra to charge distribution.

Oxygen Spectrum (U), RR 002-03-0012. University of Colorado, Boulder, Colorado, Department of Physics; Nonr 1147(05), NR 014-404; M. Mizushima.

Theoretical and experimental work is being performed on the microwave spectrum of the oxygen molecule. The line shift, line widths, and integrated absorption coefficient are being measured as a function of rotational state using a special spectrometer constructed by Dr. Richardson at the NBS Boulder Laboratories. Special attention will be given to resolving present discrepancies between theory and experiment.

Electronic Spectrum of Polyatomic Molecules (U),

RR 002-03-0014. University of Rochester, Rochester, New York, River Campus Station, Department of Chemistry; Nonr 668(15), NR 014-107; A. B. F. Duncan.

The vacuum ultraviolet spectra of polyatomic molecules are measured with a view to understanding the electronic structure of the molecule. Theoretical calculations closely following the experimental work are carried out. Present interest lies in extending the spectra of benzene, ammonia, and acetone as well as investigating the fluorescence of sulfur dioxide.

Molecular Excitation (U), RR 002-03-0015. University of Western Ontario, London, Ontario, Canada, Department of Physics; Nonr 2895(00), NR 014-108; R. W. Nicholls.

This task is concerned with the study of the excitation of molecules. Methods of exciting the molecules are shock waves, electrical discharges, heavy ion beams, and flames. The excited states are investigated by means of their spectra, emission and absorption. The experimental results are correlated with the quantum theory of molecular structure and with collision characteristics of the gases.

Electronic Structure of Atoms (U), RR 002-03-0016. University of Oklahoma, Norman, Oklahoma, Research Institute; Nonr 982(07), NR 014-109; C. C. Lin.

Theoretical work will be conducted to study the spectroscopic properties such as excitation energy, ionization potential, ultraviolet and visible absorption; magnetic susceptibilities and molecular quadrupole moments of atoms and molecules. The results of this investigation may furnish a clear description of their structure. A critical examination of the present theory of atomic and molecular structure will be made by comparing the theoretical results with the experimental data. It is expected that the results of the comparison will suggest new methods for refining the theoretical treatment.

Molecular Orbital Theory (U), RR 002-03-0017. Catholic University of America, Washington, D. C., Department of Chemistry; Nonr 1220(00), NR 014-110; V. Griffing.

The molecular orbital theory of quantum mechanics is applied to the calculation of the potential energy of the interaction in 2-, 3-, or 4-atom molecules as a function of the atoms' relative positions. The calculation of the energy will be carried out with a self-consistent field variational procedure using molecular orbitals made up of a linear combination of atomic orbital wave functions.

Energy Levels in Polyatomic Molecules (U), RR 002-03-0018. Pennsylvania State University, University Park, Pennsylvania, Department of Physics; Nonr 656(12), NR 014-401; D. H. Rank.

Highly precise measurements are made of infrared spectra and thereby of energy levels and structure of polyatomic molecules. Wavelength standards are being established in the region between 1 and 3 microns. A systematic attempt is being made to improve precise measurement methods and techniques in the infrared.

The Nature of Chemical Bonding and Molecular Interactions (U), RR 002-03-0019. University of Washington, Seattle, Washington, Department of Chemistry; Nonr 477(19), NR 014-402; P. C. Cross.

High resolution spectra of polyatomic molecules and free radicals are obtained and analyzed theoretically. A rotation-vibration band of ozone in the 9 mu region is being analyzed with a new spectrograph, capable of high resolution. Rotation-vibration bands of simple polyatomic free radicals such as NH_2, CH_3, HO_2, BH_2, and their deuterated analogues, are under investigation. The absorption spectra of some small ring organic compounds and of some unique fluorine or boron compounds are studied. Work is commencing on the spectra of transitions to electronically excited states.

Infrared Spectra of Polyatomic Molecules (U), RR 002-03-0020. The Ohio State University, Columbus, Ohio, Department of Physics and Astronomy; N6onr 225(26), NR 014-403; H. H. Nielsen.

This task is concerned with rotation-vibration interaction energies, anhormonic forces, and the contribution of these to the specific heats and thermodynamic potentials of the molecules will be determined by measuring and analyzing infrared spectra of various polyatomic molecules. The rotation-vibration energy levels are being determined to the fourth order of approximation, as required for interpretation of current experimental data.

Dielectric Properties and Structure of Matter (U), RR 002-03-0021. Princeton University, Princeton, New Jersey, Department of Chemistry; Nonr 1858(09), NR 014-201; C. P. Smyth.

The absorption and dielectric constants of liquids and solids, principally organic compounds, are measured in the microwave and radio frequency spectrum. Correlations are established with dipole moments, structural features of individual molecules, and structures of quasi-cyrstalline aggregates. Analyses are made of dielectric relaxation mechanisms involving rotation, breaking of hydrogen bonds, and proton transfer, and of the relations of these to the mechanisms of viscous relaxation. Viscosity data are being taken for the calculation of the solute-solvent viscous interaction and its effect on dielectric relaxation.

Microwave and Infrared Spectroscopy (U), RR 002-03-0022. Harvard University, Cambridge, Massachusetts, Department of Chemistry; Nonr 1866(14), NR 014-405; E. B. Wilson.

An experimental and theoretical investigation is under way on the microwave spectra of polyatomic molecules. Measurements are made of the microwave absorption in a waveguide using the Stark and Zeeman effects. The latter technique is utilized also to obtain electric field gradients in molecular crystals by measurement of nuclear quadrupole resonance. Current theoretical work centers on treatment of levels of polyatomic molecules with possible hindered internal motions, on centrifugal distortion, and on interpretation of the Stark effect for rotational states.

Microwave Magnetic Resonance Absorption (U), RR

002-03-0023. Yale University, New Haven, Connecticut, Department of Physics; Nonr 609(11), NR 014-306; V. W. Hughes.

Experiments are performed on magnetic resonance of atoms and on schemes to produce a beam of polarized protons. Work currently under way includes: a precise measurement of G_j factor for atomic fluorine in its ground state; measurement of the nuclear magnetic moment of the stable isotope He^3; and an experimental investigation of techniques which have been proposed to produce a beam of polarized protons.

Atomic Vapor Resonance (U), RR 002-03-0024. Varian Associates, Palo Alto, California; Nonr 2520(00), NR 014-309; M. E. Packard.

Experimental and theoretical studies are made of optical pumping and associated parameters governing the performance of the alkali vapor magnetometer. Also, a proptotype magnetometer will be fabricated.

Polarization Exchange (U), RR 002-03-0025. University of Washington, Seattle, Washington, Department of Physics; Nonr 477(25), NR 014-307; H. Dehmelt.

The method of polarization exchange resonance which has been used to measure the spin magnetic moment of the free electron is to be extended to measurement of magnetic moments of selected atoms, and ions. In addition, the influence of relaxation processes on optical pumping, particularly the effect of a nonrelaxing wall coating, is to be investigated.

Optical Pumping of Atoms (U), RR 002-03-0026. Arthur D. Little, Incorporated, Cambridge, Massachusetts; Nonr 2962(00), W. Franzen.

The purpose of this task is to undertake a detailed experimental study of the relaxation by spin resonance of an optically aligned alkali metal vapor. In addition, an investigation will be made of the mechanism of spin disorientation in alkali-rare gas collisions and of the basic physical phenomena associated with the dynamics of the orientation process.

Molecular Beams and Surfaces (U), RR 002-03-0027. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Department of Physics; Nonr 760(11), NR 014-301; P. M. Marcus.

An experimental program was under way using molecular beam techniques to measure numbers and velocities of molecules scattered from solid surfaces. Apparatus was constructed to allow a velocity analysis of the ingoing beam, as well as of the scattered beam. Quantitative evaluations of accommodation coefficients and their dependence on velocity and surface type and condition. Single crystals of metals such as U, Au, Ge, Cu and alkali halides such as KCl and LiF were used to provide test surfaces.

Molecular Beam Investigation (U), RR 002-03-0038. Columbia University, New York, New York, Department of Physics; Nonr 266(45), NR 014-302; P. Kusch, I. I. Rabi.

Molecular beam techniques are combined with methods of selective excitation and detection to study the interactions of electrons and nuclei in the ground and excited states of atoms, ions, and molecules. Information is thereby obtained on the spin, magnetic and electrical moments of nuclei together with interaction of these with their electronic environment.

Radio-Frequency Spectra of Molecules (U), RR 002-03-0039. Syracuse University, Syracuse, New York, Department of Physics; Nonr 669(09), NR 014-303; J. W. Trischka.

By means of the molecular beam electric and magnetic resonance methods, measurements are made of molecular constants such as rotational magnetic moments, electrical dipole, and moments of inertial of alkali halide molecules in the ground and excited vibrational states. Values of spin, magnetic moments, quadrupole moments, and nuclear spin-spin-interactions of nuclei are obtained.

Molecular and Atomic Beam Research (U), RR 002-03-0040. University of California, Berkeley, California, Department of Physics; Nonr 222(70), NR 014-304; W. A. Nierenberg.

Magnetic dipole and electrical quadrupole moments of stable and radioactive nuclei are obtained by magnetic resonance techniques. The measurements are being extended to families of related isotopes, and results are closely correlated with current theories of nuclear structure and moments. The experimental techniques of optical pumping will be applied to the above problems and also to collisional energy and spin exchange. In addition, theoretical studies will be performed on collision scattering and the processes of excitation and ionization will be investigated.

Determination of Intermolecular Potentials from Molecular Beam Scattering (U), RR 002-03-0044. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Chemistry; Nonr 1841(23), NR 014-305; I. Amdur.

Measurements are made of scattering of molecular beams to determine intermolecular forces between simple molecules such as between He and N_2, He and CO, A and CO, A and N_2, and between rare gases and carbon compounds such as CH_4, CH_3F, CH_2F_2. Existing beam apparatus is to be modified to improve intensity and energy resolution, particularly at lower energies. Calculations of gaseous transport properties, particularly of air constituents at high temperatures, will be made using the experimental results.

High Accuracy Atomic Wave Functions (U), RR 002-03-0056. University of Pennsylvania, Philadelphia, Pennsylvania, Nonr 1727(00), NR 014-105; L. C. Green; Haverford College.

A study is made of methods of obtaining wave functions of high accuracy for atoms having two electrons such as He, H^-, and Li^+. Evaluations are made numerically, largely with extensive use of high speed automatic computers. The more promising methods are applied to obtaining energy levels and transition strengths of atoms of particular interest in the study of planetary and stellar atmospheres.

Study of Atmospheric Impurities with Magnetic

Resonance Techniques (U), RR 002-03-0057. Ohio State University, Columbus, Ohio, Department of Physics; Nonr 495(10), NR 014-406; D. Williams.

This task deals with the detection and identification of atmospheric impurities by nuclear magnetic resonance (NMR) and electronic magnetic resonance (EPR) techniques. Special features of the problem which are being studied are the use of paramagnetic catalysts to improve the sensitivity and the development of appropriate methods of collection and filtering impurities.

R002-04 Cosmic Radiation

Meson Properties and Showers (U), RR 002-04-0001. Massachusetts Institute of Technology, Cambridge, Massachusetts, Laboratory for Nuclear Science; AT (30-1) 2098, NR 026-001; B. Rossi, D. O. Caldwell, W. L. Kraushaar, G. W. Clark.

Two general problems are being undertaken by the group working under this task. The first is an investigation of the production, interaction, and decay of the many new unstable particles found in cosmic radiation and in the reactions induced by the Brookhaven Cosmotron beam. The second involves a study of very-high-energy (about 10^{19}ev) cosmic ray particles by an analysis of the secondary events, such as large air showers, that they produce in the atmosphere. Also included in this problem is an attempt to formulate a theory which will explain the origin of such high-energy particles.

Mesons and Showers (U), RR 002-04-0002. University of California, Berkeley, California, Physics Department; Nonr 22240, NR 021-0007; R. B. Brode, R. Brown, W. B. Fretter, K. Anderson.

The investigators are conducting fundamental research in nuclear physics including: (1) the study of the production of particle-showers in dense media by incident high-energy radiation; (2) observations of the properties of mesons by the use of intense magnetic fields; (3) precision cloud chamber studies of the properties of new unstable subnuclear particles produced in cosmic rays; (4) high-altitude observations of cosmic ray events using a variety of detectors; and (5) long-term monitoring of various cosmic ray components at sea-level with the aim of correlation with solar phenomena.

Cosmic Ray Studies (U), RR 002-04-0003. California Institute of Technology, Pasadena, California, Physics Department; Nonr 22017, NR 021-008; C. D. Anderson, H. V. Neher.

Emphasis is being placed on the study of the heavy mesons and hyperons present in the cosmic radiation. An attempt is being made to classify these particles and gain information on the mode of decay, energy spectrum, etc., using improved equipment and techniques. This task also includes a study of cosmic radiation in the atmosphere at high altitudes and various latitudes, using automatic ionization chambers. In addition, the nature, intensity, and distribution of cosmic rays will be analyzed.

Cosmic Ray Showers (U), RR 002-04-0004. Franklin Institute, Swarthmore, Pennsylvania, Barto! Research Foundation; N6ori 14401, NR 026-021; M. A. Pomerantz.

The intensity of the various components in primary cosmic radiation is being determined as a function of geomagnetic latitude. Also included is an investigation of the correlation of cosmic rays with various solar phenomena by means of neutron monitors at Thule, in the Antarctic, and on an airplane.

Meson Properties (U), RR 002-04-0005. Washington University, St. Louis, Missouri, Physics Department; Nonr 81609, NR 021-046; R. D. Sard.

The contractor is concerned with investigations at ground level, below ground, and at mountain altitudes on the mechanism of production, absorption, and disintegration of mesons and hyperons in cosmic radiation. New bubble chamber techniques are also being developed under this task.

Ultra-High Energy Physics (U), RR 002-04-0006. University of Chicago, Chicago, Illinois, Department of Physics; N6ori 02055, NR 021-052; M. Koshiba, E. Lohrmann, D. M. Haskin.

Under this task, the following fields of cosmic ray research are being investigated: (1) meson production, including multiple production at extremely high energies; (2) nature and composition of the primary cosmic radiation; (3) nuclear interactions of primaries; (4) the occurrence of heavy nuclei of the primary cosmic radiation; (5) very high energy nuclear events occurring in the upper atmosphere; (6) disintegration and nuclear capture of low energy mesons.

Cosmic Ray Neutrons (U), RR 002-04-0007. New York University, New York, New York, Physics Department; Nonr 28521, NR 021-058; S. A. Korff.

An investigation of the production of neutrons by the cosmic radiation was conducted under this task. The study included a determination of the altitude and latitude dependence of the neutron intensity, the energy spectrum of the neutrons, and the correlation of these factors with other physical phenomena. Measurements were made at balloon and mountain altitudes.

Heavy Particle Component of Cosmic Radiation (U), RR 002-04-0008. University of Minnesota, Minneapolis, Minnesota, Physics Department; Nonr 71019, NR 021-060; E. P. Ney, J. R. Winckler, P. S. Freier.

This group is studying cosmic ray phenomena in the stratosphere at various latitudes by means of cloud chambers, coincidence counters, Cerenkov counters, and photographic emulsions, carried to high altitudes on balloon flights. Particular emphasis is placed on the heavy nuclei component of the cosmic radiation, air showers, minimum ionization sprays, and high-energy nuclear events.

Cosmic Ray Showers (U), RR 002-04-0009. University of Michigan, Ann Arbor, Michigan, Physics Department; Nonr 122407, NR 021-064; W. E. Hazen.

The work under this task is programmed to cover investigations on the intensities of the various cosmic ray components, including relative intensities of the components and their variations with measurements are made underground, at sea level,

and mountain altitudes. Also included is a study of the effect of material absorbers on cosmic ray showers.

Ultra High Altitude Cosmic Ray Research, RR 002-04-0011. State University of Iowa, Iowa City, Iowa, Physics Department; N9onr 93803, NR 021-147; J. A. Van Allen.

This group studied the entire spectrum of particles in space. They have used rockets, rockoons, satellites, and deep space probes as vehicles for their detectors.

Cosmic Radiation (U), RR 002-04-0012. Ohio University, Athens, Ohio, Physics Department; Nonr 1496(00), NR 021-199; C. A. Randall, Jr.

Studies are conducted on the composition of the cosmic radiation. A full knowledge of this composition is necessary to deduce properly the nature, origin, and interactions of such radiation. (Equipment Loan Contract)

Cloud Chamber Studies (U), RR 002-04-0014. Wayne University, Detroit, Michigan, Physics Department; Nonr 178300, NR 021-220; R. V. Adams.

Under this task a magnetic cloud chamber is used with associated counters to obtain data on the cosmic ray events which give rise to heavily ionizing particles. (Equipment Loan contract)

Cosmic Protons and Alphas (U), RR 002-04-0015. University of Chicago, Chicago, Illinois, Department of Physics; Nonr(G) 00010-60, NR 021-338; P. Meyer.

This was a study of the low-energy proton and alpha particle spectrum of the primary cosmic radiation by means of scintillation counter assemblies carried to high altitudes by balloons. The time dependence of this spectrum was investigated.

R002-05 Elementary Particles

Elementary Particle Scattering (U), RR 002-05-0001. Massachusetts Institute of Technology, Cambridge, Massachusetts, Laboratory for Nuclear Science; AT (30-1) 2098, NR 026-001; F. E. Low, V. F. Weisskopf.

Research is being conducted in all phases of high energy elementary particle physics at the Brookhaven Cosmotron, the Bevatron and the 350 Mev electron synchrotron (which was designed and constructed under this task). Particular emphasis in the synchrotron work is being placed on photomeson production from complex nuclei and deuterium, the search for pair-production of mesons, and the nuclear compton effect in order to check on various meson theories. Besides the continued use of nuclear emulsions, this program also provides for work using counter techniques at the Cosmotron, for the development of synchrotron analyzing magnets, for the implementation of a bubble chamber program, and for the development of luminescent chambers. Included under this task is a strong team of theorists attacking problems of fundamental field theory and in the properties of the elementary particles.

Nuclear Physics Studies (U), RR 002-05-0002. University of Illinois, Urbana, Illinois, Physics Department; Nonr 1834(05), NR 026-005; E. L. Goldwasser, G. Ascoli, L. J. Koester, A. O. Hanson, W. Wattenberg, R. D. Hill, C. S. Robinson, E. M. Lyman.

The investigators have designed and constructed a 300 Mev betatron and are using this and other accelerators developed by the contractor in a program of fundamental high-energy nuclear physics research. Included are studies of photonuclear events such as the yields from gamma-neutron and gamma-proton reactions, the photo-production of mesons and their nuclear interactions, and energy distribution in the "Bremsstrahlung" from high-energy electrons. They are now planning a broad program of research at multi-Bev particle accelerators, particularly the Argonne 12 Bev synchrotron. (Other phases of this contract are described under project RR 002-06.)

High Energy Particle Interactions (U), RR 002-05-0003. Harvard University, Cambridge, Massachusetts, Physics Department; Nonr 1866(19), NR 026-012; R. Wilson, K. Strauch, W. Preston, J. C. Street, N. F. Ramsey.

A 95-inch cyclotron capable of accelerating protons to 160 Mev has been designed and build and is now being used in an investigation of proton scattering from nucleons and light nuclei. Work is also being done using bubble chambers and emulsions at the Cosmotron and Bevatron in the study of K-mesons, hyperons, and pion-nucleon interactions. (Other phases of this contract are described under project RR 002-06.)

High Energy Proton Studies (U), RR 002-05-0004. Columbia University, New York, New York, Physics Department; N6ori 11001, NR 022-003; J. Rainwater, L. Lederman, A. Sachs, W. F. Goodell, J. Steinberger, V. Hughes.

The main objects of study under this task are the subnuclear particles, the pion and muon--both of which are produced by bombarding nuclei with protons from the Nevis 400 Mev synchrocyclotron. Principal problems under investigation now are the scattering of pions by complex nuclei, the decay modes of the pion and muon, the magnetic moment and gyromagnetic moment of the muon, the properties of muonium (an atom consisting of a muon and an electron), and the properties of atoms in which electrons are replaced by muons.

Bev Reactions (U), RR 002-05-0005. Stanford University, Stanford, California, Physics Department; N6onr 25116, NR 002-026; W. K. H. Panofsky, R. Hofstadter, W. C. Barber, R. Mozley, B. Richter.

The research under this task utilizes beams from two linear electron accelerators constructed at Stanford. The first accelerates electrons to 40 Mev, and is used primarily for studying photonuclear reactions. The second accelerates electrons to 960 Mev. With the larger accelerator, a systematic series of measurements of the distribution of electrical charge within nuclei and nucleons is being carried out, and will be extended. Experiments on pion, and muon production by electrons and photons, and experiments on the limits of validity of quantum electro-dynamics are also being carried out. Finally, at the higher energy, studies of the photoproduction and other properties of K mesons will be pursued.

Photo Meson Reactions (U), RR 002-05-0006. Cornell University, Ithaca, New York, Physics Department; Nonr 401(26), NR 022-038; R. R. Wilson, R. M. Littauer, V. T. Cocconi, B. D. McDaniel, J. W. DeWire.

The 1.2 Bev electron synchrotron, designed and constructed under this task, is now being used in an extensive program of research primarily on the production of pions and K mesons by gamma rays, and on the interactions of these mesons with nucleons.

Work is underway to increase the beam intensity by an order to magnitude, utilizing a linear electron accelerator as an injector.

Fundamental Interactions (U), RR 002-05-0007. Princeton University, Princeton, New Jersey, Physics Department; Nonr 185806, NR 022-048; G. T. Reynolds, V. L. Fitch, T. Bowen, J. Cronin.

Investigations are being conducted at the Brookhaven Cosmotron and Berkeley Bevatron on the properties of the subnuclear particles, the K mesons and Hyperons.

Highly advanced detectors and electronic circuitry are developed and used by this group. They are currently developing a large rapid cycling bubble chamber, luminescent chambers, and triggered spark chambers.

High Energy Proton Studies (U), RR 002-05-0008. University of Chicago, Chicago, Illinois, Physics Department; N6ori 02022, NR 022-057; H. L. Anderson, V. L. Telegdi, S. C. Wright, R. Hildebrand.

The program of this group centers on the use in fundamental nuclear research of a 170-inch F-M cyclotron, designed and constructed under this task, which is capable of accelerating protons to an energy of approximately 450 Mev. A general program of high-energy nuclear physics is being undertaken. This includes a study of nucleon-nucleon scattering; nucleon-inducted reactions; and meson production, analysis, and interaction with nuclei.

High Energy Interactions (U), RR 002-05-0009. Duke University, Durham, North Carolina, Physics Department; Nonr 1181(04), NR 022-090; W. M. Nielsen, M. M. Block.

This group is studying high energy nuclear events, and the properties of the heavy mesons and hyperons. Most of the experiments are now being performed at the Berkeley Bevatron using a helium bubble chamber developed by this group. They now have in operation a device for automatically analyzing bubble chamber photographs. Such techniques will undoubtedly become increasingly important as the number of photographs now being taken numbers in the hundreds of thousands.

Meson Theory (U), RR 002-05-0010. Cornell University, Ithaca, New York, Physics Department; Nonr 40112, NR 022-186; H. A. Bethe, E. E. Salpeter, T. Kinoshita.

A broad spectrum of problems at the forefront of theoretical physics is being studied under this task. Primary emphasis is presently being given to a basic study of the weak interactions, studies of photo-production processes, the basic nuclear force problem, and some astro-physical investigations.

Development of Luminescent Chambers and Their Use in High Energy Physics (U), RR 002-05-0011. University of Michigan, Ann Arbor, Michigan, Physics Department; Nonr 1224(23), NR 022-274; L. W. Jones, M. L. Perl.

This group is one of the world's leaders in the race to develop "Solid Luminescent Chambers". This is simply a scintillating material connected to light amplifiers having sufficient gain so that photographs can be taken of the tracks of ionizing particles passing through the scintillator. Such a device will be extremely valuable in elementary particle research. This group has already photographed tracks of cosmic ray particles, and is now performing experiments at the Bevatron. Also, further development of luminescent chambers and triggered spark chambers is being pursued.

High Energy Reactions (U), RR 002-05-0012. Syracuse University, Syracuse, New York, Physics Department; Nonr 669(12), NR 022-296; E. M. Harth, J. Leitner, N. Horowitz.

The research under this task is devoted to the study of the elementary particles of nature. The principal research of the group is now being devoted to a study of the interactions of multi-Bev π and K mesons in a liquid He bubble chamber.

Particles and Showers (U), RR 002-05-0013. University of Washington, Seattle, Washington, Physics Department; Nonr 477(12), NR 022-079; S. H. Neddermeyer, J. J. Lord, Y. B. Kin, G. E. Masek, R. W. Williams.

The research under this task is devoted to experimental study of the interactions of multi-Bev particles with nuclei. This group uses cloud chambers, emulsions and a bubble chamber as experimental tools. They are also developing equipment for generating pulsed megagauss magnetic fields to be used in conjunction with nuclear emulsions.

Nuclear Emulsion Studies (U), RR 002-05-0014. Stevens Institute of Technology, Hoboken, New Jersey; Nonr 2066(00), NR 022-326; S. Taylor.

The research under this task is devoted to the study of the properties of the elementary particles utilizing photographic emulsions as the detector. (Equipment Loan)

Tenth High Energy Physics Conference (U), RR 002-05-0015. University of Rochester, Rochester, New York, River Campus Station; Nonr (G)-0004-60, NR 022-336; R. E. Marshak.

This task provided partial support for the Tenth Annual Conference on High Energy Physics.

The Annual Conference on High Energy Physics is one of the most important international conferences in nuclear physics. This conference is held every third year in the United States at the University of Rochester. In intervening years it is held in western Europe (Geneva, Switzerland, 1958) and the U.S.S.R. (Kiev, U.S.S.R., 1959).

Lead Procurement (U), RR 002-05-0016. General Supply Stores Office, Philadelphia, Pennsylvania; Requisition No. 14/60355/60, NR 022-342.

This task provided for the payment to the General Stores Supply Office for 600,000 pounds of pig lead, presently on loan to ONR and in use by

Stanford University under task RR 002-05-0005.

R002-06 Nuclear Structure

Nuclear Energy Levels and Radioactivity (U), RR 002-06-0001. Massachusetts Institute of Technology, Cambridge, Massachusetts, Laboratory for Nuclear Science; AT (30-1) 2098 (AEC Management), NR 026-001; W. W. Bruechner, M. Deutsch, V. F. Weisskopf, H. Feshback, R. J. Van de Graaff.

This research group conducts a broad program of research in the general field of nuclear structure. Included are the maintenance and use of 4-Mev and 8-Mev positive-particle electrostatic generators, a 17-Mev linear accelerator and a 15-Mev cyclotron in nuclear reaction studies, and an analysis of radioactive decay, as well as the theoretical investigation of nuclear interactions and nuclear structure. (Other phases of this contract are described under projects RR 002-04 and RR 002-05.)

Energy Levels of Nuclei (U), RR 002-06-0002. Yale University, New Haven, Connecticut, Physics Department; Nonr 609(14), NR 024-002; F. E. Steigert.

Investigations were made on the energy level structure of light- and medium-weight nuclei by an analysis of particles or gamma rays emitted by the nucleus when it is bombarded by protons, deuterons, or alpha particles.

Nuclear Physics Studies (U), RR 002-06-0003. University of Illinois, Urbana, Illinois, Physics Department; Nonr 1834(05), NR 026-005; R. I. Hulsizer, H. Frauenfelder, J. S. Allen, C. P. Slichter, P. Axel.

Information is sought on the structure of the nucleus from the measurement of the spin and magnetic moments associated with different nuclear energy levels. The techniques include the analysis of the angular correlation of decay products from radioactive nuclei and from cyclotron particle-induced reactions, and the study of nuclear alignment at very low temperatures by magnetic fields as well as the more conventional magnetic resonance investigations. (Other phases of this contract are described under project RR 002-05.)

Beta and Gamma Spectra (U), RR 002-06-0004. University of Indiana, Bloomington, Indiana, Physics Department; Nonr 1705(01), NR 024-006; A. C. G. Mitchell, M. B. Sampson, L. M. Langer, R. G. Wilkinson, D. W. Miller, J. H. Martin.

The characteristics of nuclear energy levels are studied by two main methods under this task. For natural or artificially radioactive nuclei, the techniques of nuclear spectroscopy have been refined and are applied to the problem. This work is supplemented and extended to other nuclei by an analysis of instantaneous reactions induced by particle bombardment.

Precision Scattering (U), RR 002-06-0005. University of Minnesota, Minneapolis, Minnesota, Physics Department; Nonr 710(18), NR 024-009; A. O. Nier, J. M. Blair.

The work of this task is done by two groups. One group is investigating the properties and interactions of fundamental nuclear particles by studies of the scattering of neutrons, protons, and deuterons by protons, deuterons and other nuclei of light, isotopically separated elements, and by an analysis of the scattering cross-sections, angular distributions, and resonances for nuclear reactions occurring under positive ion bombardment. The other group does research and development work in mass spectrometer techniques, and applies these to nuclear physics problems. They are now engaged in measuring the masses of nuclei with greater accuracy than has ever been done before.

Nuclear Moments (U), RR 002-06-0006. Stanford University, Stanford, California, Physics Department; Nonr 225(19), NR 024-011; F. Bloch, W. E. Meyerhof. W. A. Little.

Precision studies of the magnetic moments of the elementary nucleons and nuclei by the methods of nuclear induction and microwave resonance are conducted under this task. In addition, studies of nuclear energy levels are made using a cyclotron and various types of nuclear spectrometers. A new Van de Graaff accelerator is being installed. Nuclear alignment at very low temperatures is investigated.

Nuclear Moments (U), RR 002-06-0007. Harvard University, Cambridge, Massachusetts, Physics Department; Nonr 1866(19), NR 026-012; E. M. Purcell, N. F. Ramsey, R. V. Pound, K. T. Bainbridge.

Nuclear properties and structure of the nucleus are studied under this task, using the methods of molecular beams, nuclear magnetic resonances, and the mass and beta-ray spectroscopy. Investigations of the gravitational red shift using nuclear techniques have been made. (Other phases of this contract are described under project RR 002-05.)

Beta and Gamma Ray Studies (U), RR 002-06-0009. University of Pennsylvania, Philadelphia, Pennsylvania, Physics Department; Nonr 551(17), NR 024-019; W. E. Stephens, J. Halpern, B. C. Cook.

A study was conducted of the various interactions, such as scattering and absorption, that occur between gamma rays and nuclei or nuclear particles at energies up to 22 Mev. The study also includes an investigation of gamma-ray induced radioactivity and the resulting beta and gamma spectra. The results of these experiments are correlated with theories of the photonuclear process and with nuclear structural properties.

Nuclear Energy Levels (U), RR 002-06-0010. The Franklin Institute, Swarthmore, Pennsylvania, Bartol Research Foundation; N6ori 144(01), NR 026-021; F. R. Metzger, V. K. Rasmussen, C. P. Swann.

The structure of the nucleus is indicated by the characteristics of its energy levels. This task supports the maintenance and operation of two electro-static generators as well as the design of improved nuclear detectors and associated circuits to study some of these characteristics, such as the "width" in energy and the lifetime of the level. The research also includes an investigation of angular correlations of radiations from radioactive nuclei. (Another phase of this contract is described under project RR 002-04.)

Low Energy Levels (U), RR 002-06-0011.

University of Notre Dame, Notre Dame, Indiana, Physics Department; Nonr 1623(05), NR 024-022; B. Waldmann, S. E. Dardon, W. C. Miller, C. P. Browne.

A 3-Mev electrostatic electron accelerator has been designed and constructed under this task. It is being used now for the study of energy spectra of artificially radioactive nuclei, and for the study of the energy loss phenomena of electrons passing through different materials. Construction of a positive ion source for the accelerator has been completed which permits additional investigations of positive ion reactions. In addition, theoretical work is being done on the interactions of relativistic electrons with nuclei.

Levels in Light Nuclei (U), RR 002-06-0012. California Institute of Technology, Pasadena, California; Nonr 220(18), NR 024-029; W. F. Fowler, T. Lauritsen, C. C. Lauritsen, R. R. Christy, W. Whaling.

The research done under this task centers around three main types of problems. The first, and most intensively studied, is the structure of the light nuclei by bombardment with particles from electrostatic accelerators. The second type of problem under investigation is the energy loss processed for charged particles passing through matter. Finally the group has recently become very active in applying nuclear physics to astrophysical problems. A tandem Van de Graaff accelerator is being installed which will significantly increase the research capability of this group.

Proton Scattering Studies (U), RR 002-06-0013. University of California, Los Angeles, California, Physics Department; Nonr 233(44), NR 024-053; J. R. Richardson, K. McKenzie.

A recently completed 50-Mev cyclotron of advanced design is to be used in nuclear physics research. The studies being conducted include nuclear spectroscopy of short-lived isotopes produced in the cyclotron, proton scattering and capture studies, and range-energy studies for high energy protons.

Nuclear Structure Theory (U), RR 002-06-0014. Yale University, New Haven, Connecticut, Physics Department; Nonr 1338(00), NR 024-055; G. Breit.

This task covers the loan of special equipment in connection with fundamental theoretical work in nuclear structure and elementary particle scattering.

15-Mev Nuclear Reactions (U), RR 002-06-0015. University of Pittsburgh, Pittsburgh, Pennsylvania, Physics Department; Nonr 624(10), NR 024-068; A. J. Allen, J. N. McGruer, B. Cohen, N. Austern.

A study is being conducted on nuclear interactions by means of the precision scattering, and reactions of nuclear particles with energies from 5 to 30 Mev. By means of a series of focusing, selecting, and analyzing magnets, a collimated beam of protons with well defined energies can be obtained from a cyclotron. This makes possible precision experiments at energies for which such accuracy has not been possible previously.

Beta Ray Spectra (U), RR 002-06-0016. University of Southern California, Los Angeles, California, Physics Department; Nonr 2495(00), NR 024-071; H. H. Forster.

This is an Equipment Loan task which supports an examination of the beta decay spectra of various nuclei.

Excited Levels of Nuclei (U), RR 002-06-0017. University of Kansas, Lawrence, Kansas, Department of Physics and Astronomy; Nonr 2471(00), NR 024-096; L. W. Seagondollar.

The purpose of this Equipment Loan task is to do research on the excited levels of nuclei using, but not limited to, proton-neutron and proton-gamma ray reactions.

Neutron Scattering (U), RR 002-06-0018. Louisiana State University, Baton Rouge, Louisiana, Physics Department; Nonr 1290(00), NR 022-183; D. C. Ralph.

The energy spectrums of 2.5-Mev neutrons which have been inelastically scattered from various materials are being studied. The work may be extended to study angular distribution of both elastically and inelastically scattered neutrons and the use of neutrons with incident energies up to 14 Mev.

This task covers the loan of scientific equipment in support of the above effort.

Nuclear Reaction in Light Nuclei (U), RR 002-06-0019. Ohio State University Research Foundation, Columbus, Ohio; Nonr 1284(00), NR 024-210; J. C. Harris.

Under this Equipment Loan task an electrostatic generator is used for research in nuclear reactions in light nuclei. Attention is focused on measurements of the energy losses of nuclear particles traversing matter.

Photonuclear Reactions (U), RR 002-06-0020. Montana State University, Missoula, Montana, Physics Department; Nonr 1662(00), NR 024-212; M. J. Jakobson.

It is the purpose of this Equipment Loan task to construct a 7-Mev linear electron accelerator for the purpose of studying photonuclear reactions in light nuclei.

Radio-Isotope Studies (U), RR 002-06-0021. Rensselaer Polytechnic Institute, Troy, New York, Physics Department; Nonr 1719(00), NR 024-217; W. A. McKinley.

This is an Equipment Loan task which is devoted to studies of radioactive decay schemes, slowing down of electrons in matter, and the application of radio-isotopes to solid state diffusion studies.

Photonuclear Reactions (U), RR 002-06-0022. University of Virginia, Charlottesville, Virginia, Department of Physics; Nonr 2348(00), NR 024-250; F. L. Hereford, W. D. Whitehead.

Photonuclear reactions in the energy range 25-75 Mev are studied under this Equipment Loan task. Results of these experiments are correlated with theories of the photonuclear process and with nuclear structural properties.

Cluster Model Theory (U), RR 002-06-0023. Florida State University, Tallahassee, Florida, Department of Physics; Nonr 998(09), NR 024-333; K. Wildermuth.

Theoretical calculations on the structure and

properties of nuclei will be carried out using the Cluster Model.

The understanding of nuclear forces and the structure of nuclei is one of the most important of the fundamental problems in physics. Many models of the nucleus have been proposed which provide a framework for understanding certain nuclear properties but each model is restricted to a particular class of properties or a particular range of nuclei. Using the Cluster Model it seems possible to understand the different existing nuclear models from a unified point of view. Using this model unambiguous predictions of nuclear properties can be made which can be tested experimentally.

Radioactive Decay (U), RR 002-06-0024. The George Washington University, Washington, D. C., Physics Department; Nonr 2599(00), NR 024-287; L. Slack.

Under this Equipment Loan task beta and gamma ray spectra and coincidence studies are made of various radioactive isotopes.

Nuclear Structure Investigations (U), RR 002-06-5000. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-01; J. O. Elliot.

Investigations are being undertaken in the field of nuclear physics utilizing the radiations produced by the Naval Research Laboratory research reactor. The program includes studies employing the thermal, epithermal, and "cold" neutron radiation; studies of the nuclear parameters of short-lived radioactive isotopes prepared by neutron bombardment in the reactor; and studies of transmission, scattering, and general interactions of nuclear radiations with various materials.

Neutron Physics (U), RR 002-06-5001. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-04; K. L. Dunning, R. O. Bondelid, E. A. Wolicki.

This is a continuing series of experimental investigations using a 5-Mv electrostatic accelerator to obtain information concerning: (a) the interaction of neutrons and the charged elementary particles with matter, (b) nuclear structure, and (c) critical nuclear constants such as mass, half-life, and reaction energy. Many important findings in these fields have been made and described in progress reports and in the open literature.

Low Energy Nuclear Physics (U), RR 002-06-5002. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-05; J. W. Butler.

This task was established to investigate the nature of atomic nuclei. Various target materials (such as oxygen, nickel, copper, zinc, etc.) are bombarded with particles (protons, deuterons, alpha particles, tritons, or He^3 nuclei) having energies up to 2 million electron volts. The reaction products (neutrons, gamma rays, etc.) are analyzed as to energy, direction, and intensity and the results interpreted and compared with various theories.

Nuclear and Atomic Physics (U), RR 002-06-5003. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-06; E. J. Schremp.

Theoretical investigations, in some cases correlated with experimental work, are conducted on: the theory of elementary particles, quantum theory, and the theoretical study of intense electron beams.

High Energy Physics and Cosmic Radiation (U), RR 002-06-5004. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-07; M. M. Shapiro.

The lifetimes of the neutral pi meson and of the sigma hyperons have been measured. A search for the process whereby a positive sigma hyperon decays into a proton and photon has been carried out. A program of elementary particle research using bubble chambers, to supplement the investigations with nuclear emulsions, has been initiated. Physicists and scanners have received training in the new techniques. The experimental portion of an investigation on the relative abundance of the elements Li, Be, and B in the primary cosmic radiation has been completed.

Photonuclear Reactions (U), RR 002-06-5005. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-09; J. McElhinney.

X-rays or electrons from the 22 million volt betatron are directed against a sample. Individual atomic nuclei which are struck by the X-rays or electrons may undergo nuclear reactions resulting in the emission of particles, gamma rays, or in fission into two main components. By the detection and measurement of the emitted particles and/or gamma rays, or by the measurement of the induced radioactivity, various properties of the atomic nuclei are determined.

Nuclear Cross Section Investigations (U), RR 002-06-5006. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-10; L. A. Beach.

Interactions of neutrons, protons and electrons with matter are studied by observation of the spectral distribution of radiations emitted during or after these nuclear interactions. Intensity and energy of gamma rays emitted during neutron and proton scattering interactions with matter are measured with scintillation spectrometers. Measurements are also made on gamma rays emitted from various isotopes activated by proton and neutron reactions with matter. The results of these measurements are useful to determine nuclear decay schemes and verify various nuclear theories and methods of calculating nuclear properties.

R002-07 Radiation and Optics

Semiconductor Optics (U), RR 002-07-0002. National Bureau of Standards, Washington, D. C.; NAonr 12-60, NR 015-214; H. P. R. Frederikse.

This task is concerned with the study of electrical and optical properties of intermetalic and oxide semiconductors.

Fundamental Properties of Semiconductors (U), RR 002-07-0003. Alfred University, Alfred, New York, Department of Ceramic Research; Nonr 1503(01), NR 015-215; T. J. Gray.

This task is a fundamental investigation of the properties of semiconducting materials. Single crystals of selenides, tellurides, and oxides are being grown and their dielectric and photoconductive properties are being measured under controlled

conditions of purity, temperature and gas atmosphere. The variation of these properties with stoichiometric relationship and with the introduction of controlled impurities is being investigated. Another aspect of the work is the preparation of hot pressed samples of various semiconductors and the investigation of their properties.

Fundamental Properties of Semiconductors (U), RR 002-07-0004. University of Detroit, Detroit, Michigan, Department of Physics; Nonr 1511(01), NR 015-218; H. Payne.

This task is an investigation of the fundamental properties of semiconducting crystals. Single crystals of zinc sulfide and cadmium sulfide are grown both in the pure state and with controlled amounts of impurities. The lattice parameters are obtained by X-ray diffraction, and the absorption coefficient, index of refraction, and photoconductivity are measured as a function of wavelength. Measurements are made of resistivity and of the temperature dependence of the dielectric constant. The crystals are also bombarded with protons and deuterons to determine the effect on the crystal structure and on optical and electrical properties.

Electrical and Optical Properties of Gray Tin (U), RR 002-07-0005. Northwestern University, Evanston, Illinois, Department of Physics; Nonr 1228(06), NR 015-219; A. W. Ewald.

This is a study of the fundamental properties of semiconducting gray tin. Work will continue on both the optical properties and the transport and galvanomagnetic effects in crystals of gray tin. As a high degree of purity is required for good measurements, concurrent work will be done in new methods of purification. The studies will involve both tin in the pure state, as well as tin with controlled amounts of impurities.

Photoconductivity in Germanium, Silicon and Indium Antimonide (U), RR 002-07-0006. Purdue University, Lafayette, Indiana, Department of Physics; Nonr 1100(04), NR 015-221; H. Y. Fan.

This task consists of a series of measurements directed toward (1) direct investigation of photoconductivity, and (2) studies of infrared optical properties of semiconductors. Considerable emphasis has been placed on the lifetime of photoexcited carriers and the determination of mechanism of recombination. This work will be extended to other semiconductors including germanium and silicon.

Infrared Research and Instrumentation (U), RR 002-07-0007. Johns Hopkins University, Baltimore, Maryland, Laboratory of Astrophysics and Physical Meteorology; Nonr 248(01), NR 015-301; J. D. Strong.

This task consists of a number of projects in infrared research and instrumentation. (a) Applications of interferometry: to measure relative motion of points widely separated (several hundred meters) on the surface of the earth--such motion as is caused by earth tides. (b) Pressure effect: to continue study of the self- and foreign-gas line broadening on lines of water vapor in the 13-25 μ region under high resolving power. (c) Atmospheric transmission: to continue study of atmospheric gases in the 100-foot absorption cell. (d) Studies of pressure broadening are being carried out.

Dispersion of Atmospheric Gases (U), RR 002-07-0008. University of Maine, Orono, Maine, Department of Physics; Nonr 2284(00), NR 015-302; C. E. Bennett.

Under this task, an experimental investigation of the dispersion of various atmospheric gases was carried out. Measurements were made on the molar refractivity of CO_2 and a possible dependence of this molar refractivity upon density was investigated. Studies were undertaken to discover the effects of small amounts of contaminants such as CO on the molar refractivity.

Optical Interferometer Study of Iodine Vapor Absorption (U), RR 002-07-0011. The Johns Hopkins University, Baltimore, Maryland, Institute for Cooperative Research; Nonr 248(48), NR 015-321; J. H. Fastie.

The absorption spectra of iodine and mercury are studied under high resolution. The influence of temperature, pressure, electric, and magnetic fields on the line width and wavelength are studied with a view to determine the suitability of these absorption lines for primary wavelength standards.

Gas Emissivities and Spectroscopy (U), RR 002-07-0015. California Institute of Technology, Pasadena, California, Division of Engineering; Nonr 220(03), NR 015-401; S. S. Penner, Jr.

Measurements and calculations are made on the absorption and emissivity of technically important gases such as air, water vapor, nitric oxide, oxides of carbon, at elevated temperatures. Using shock tube techniques, the time-history of the radiative properties of transiently heated gas is obtained using photoconductive detectors. Correlations are made with theory of molecular structure and with high temperature gas kinetic reaction schemes.

Molecular Structure and Flame Spectroscopy (U), RR 002-07-0016. Duke University, Durham, North Carolina, Department of Physics; Nonr 1181(05), NR 015-404, H. Kohn, H. Sponer.

Spectroscopic measurements are made on flames containing controlled concentrations of atoms for which absorption and emission data are known. Intensities and shape of atomic lines are recorded for optical paths traversing different parts of the flames. Atom densities and excitation temperatures, inferred by theoretical analysis, are correlated with kinetic schemes of chemical species, degrees of dissociation energies.

Molecular Energy Conversion Rates (U), RR 002-07-0017. Oregon State College, Corvallis, Oregon, Department of Chemistry; Nonr 1286(03), NR 015-405; J. C. Decius.

This task is an investigation into the conversion of vibrational energy into translational energy in gases. Gas is in spectrophone cell is illuminated with radiation whose wavelength corresponds to an absorption band of the gas. Molecules excited by the radiation lose their energy to translational motion at a rate which depends

on the lifetime before inelastic collision of the excited vibrational state. If the radiation is chopped, the conversion of vibrational to translational energy results in a periodic change in temperature in the gas, and the resulting pressure variation can be picked up with a microphone. The phase lag of the periodic pressure variation behind the chopped radiation is measured and gives information on the process of conversion of vibrational to translational energy.

Ultraviolet Sensitive Photomultipliers (U), RR 002-07-0019. Radio Corporation of America, Princeton, New Jersey, David Sarnoff Research Center; Nonr 2263(00), NR 015-906; G. A. Morton.

This task is an investigation of optical materials for use in the ultraviolet. The work is divided into two main parts: (1) research on semiconductors to provide materials having an energy gap, electron affinities, and other properties necessary for high quantum efficiency photoelectric emission in the 1000-2000 Angstrom region; (2) research on materials suitable for windows in this region.

Properties of Metallic Deposits and Smokes (U), RR 002-07-0020. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Chemistry; N5ori-07839, NR 015-902; L. Harris.

Under this task the theory of the sintering of metals was being extended through a study of the optical properties and infrared absorbing properties of metal smokes. The use of smokes as blackening materials for thermal receivers was investigated. A program has been worked out which enabled the Whirlwind I computer to obtain the optical constants of the thin metal films from the observed reflectance and transmission data. This resulted in a tremendous increase of speed over the manual methods formerly used. Measurements and computations were carried out for gold black and other films in a range extending from the visible to the microwave region.

Infrared Information and Analysis (U), RR 002-07-0021. University of Michigan, Ypsilanti, Michigan, Willow Run Laboratories; Nonr 1224(12), NR 015-903; W. L. Wolfe.

Under this task, a center for Infrared Information and Analysis (IRIA) has been established and is being maintained. The responsibilities and activities of IRIA include: (a) to prepare briefly annotated bibliographies, including contract literature made available, reports from military laboratories, selected articles appearing in technical journals, and selected reports dealing with nongovernment sponsored research; (b) to prepare state-of-the-art reports covering fields of interest to the military departments, which will summarize the present state-of-the-art, indicate areas of research where significant progress has been made, and highlight the technical contributions and their utility to certain applications; (c) when called upon IRIA will assist the military departments in sponsoring technical symposia and will initiate sponsorship upon approval of the Steering Committee, assuring no overlap of activities already planned by any of the military departments; (d) IRIA will provide efficient and beneficial information services to all authorized contractors who request such information by mail or who visit IRIA, in either case having previously established need-to-know and security clearance.

Proceedings of IRIS (U), RR 002-07-0022. Office of Naval Research Branch Office, Pasadena, California, Scientific Department; Allot. #80904, NR 015-904; A. R. Laufer.

ONR Pasadena and ONR Boston sponsor a series of classified meetings for contractors working in the field of infrared. At these meetings, recent advances in the field are discussed and there is an occasional invited paper. Under this task, classified proceedings of this Infrared Information Symposium (IRIS) were prepared and distributed to government agencies and contractors. The proceedings included contributed papers, infrared notes, announcements of meetings, and additional material as appropriate. This editorial work will be continued under NR 015-903.

Optical and Electrical Properties of Stannic Oxide Crystals (U), RR 002-07-0023. Oklahoma State University, Stillwater, Oklahoma, Research Foundation; Nonr 2595(01), NR 015-222; E. E. Kohnke.

This task is an investigation of the electrical and optical properties of SnO_2 crystals. Recent effort has centered on photoconductivity and optical transmission studies.

Diffraction Grating Ruling Engine (U), RR 002-07-0024. Diffraction Products, Incorporated, Maywood, Illinois; Nonr 1874(00), NR 015-905; E. Liebhardt.

Under this task a ruling engine capable of ruling large diffraction gratings is being constructed. The engine is of the Rowland type and when completed will be capable of ruling lines eight inches long on ruled surface up to thirteen inches in width. The engine is designed to rule as many as 30,000 lines per inch. The system is now ruling 3- and 6-inch gratings with 15,000 lines per inch.

Infrared Spectroscopy (U), RR 002-07-0026. Group for the Advancement of Spectrographic Methods (GAMS), Paris, France; N62558-2720, NR 015-908; J. Lecomte.

This task will study the spectral distribution of the light emitted by cadmium sulphite bombarded with 25,000 volt electrons. An attempt will be made to intepret all data, both that presently available and future results, in the light of solid state theory.

Radiation Transfer Theory for Light Distribution (U), SR 002-07-0520. University of California, Visibility Laboratory; NObs 72092; Dr. S. Q. Duntley.

Military operations depend on the use of the visual processes, by direct human vision, photography, or television, and in air or under water. Modern warfare concepts demand the capability of predicting the results which can be obtained by the visual processes under prevailing conditions. These problems could not be solved, however, until an adequate theoretical basis was developed.

The work under this task has provided the basis of the development of instrumentation for the

measurement of the optical properties of ocean waters and the atmosphere; the development of guiding principles on underwater light transmission as it applies to television, photography, and the prediction of visibility by underwater swimmers; and the development of procedures for determining the visibility through the atmosphere of ships, aircraft, and missiles from the sea surface or ships and from aircraft or high altitudes. The large fund of knowledge developed has been made available also through consultative advice and assistance to various sectors of the Navy, Air Force, Army, Coast Guard, other government agencies, and contractors on war game studies, missile range operations, missile control studies, reconnaissance operations, the Sam Clemente missile base operations, and instrumentation and equipment development related to visibility, illumination, and search, and detection in the visual and near-visual part of the spectrum.

R002-08 Acoustics

Russian Translation (U), RR 002-08-0001. National Science Foundation, Washington, D. C., Foreign Science Information Program; NAonr 40-59, NR 384-101; P. F. Feinstein.

In 1955, The Russian Academy of Sciences began the publication of an acoustical journal, AKUSTICHESKII ZHURNAL, in an effort to centralize the reporting of acoustical work in the USSR. This journal is somewhat comparable to the coverage of U. S. acoustical work by the JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA; therefore, many of the papers are of direct interest to the Navy acoustics program. By transfer of funds to the National Science Foundation's Russian Translation Program, this task provided for the establishment of routine translation and publication of this document under the title, SOVIET PHYSICS - ACOUSTICS. Support was also given to the complete translation of the monograph, "Waves in a Layered Media", by L. M. Brekhovskikh.

Propagation of Sound in Matter (U), RR 002-08-0002. University of California, Los Angeles, California, Department of Physics; Nonr 233(48), NR 384-302; R. W. Leonard, I. Rudnick.

Problems basic to the understanding of sound propagation in materials in the gaseous, liquid and solid states are being studied. In gases current work is concerned with mixtures of the oxides of nitrogen. In addition, a program of measurements of the relaxation times of several substances in both gaseous and liquid phases is being instrumented. The acoustic properties occupy a large portion of the attention in this task and several experimental studies with different techniques are exploring the frequency region from 20 kc to greater than 1 Mc for temperatures from 1^{o} to 70^{o}K for various metals.

Ultrasonic Research into the Propagation of Sound Through Matter (U), RR 002-08-0003. National Bureau of Standards, Washington, D. C.; NAonr 35-60, NR 384-303; M. Greenspan.

The problems being undertaken under this task are characterized by a requirement for high precision in experimental techniques. Considerable effort is currently being directed to the development of techniques and instrumentation for precise measurements of the velocity of sound in water both in situ in the ocean and in the laboratory. Current emphasis is also being given to studies of cavitation phenomena and measurements of internal friction in quartz crystals using ultrasonic techniques.

The Application of Ultrasonic Waves to Electrochemistry (U), RR 002-08-0004. Western Reserve University, Cleveland, Ohio, Chemistry Department; Nonr 1439(04), NR 384-305; E. Yeager.

A variety of problems concerned with the application of ultrasonic techniques to electrochemistry are being undertaken. These include the use of ultrasonic techniques to obtain basic information on electrochemical systems and processes, the study of electrochemical methods for quantitative acoustic measurement purposes and the investigation of possible practical applications of the results of these investigations. Current work includes the study of ultrasonic velocity and absorption in liquids, heterogenous relaxation processes and ultrasonic polymerization.

Relaxation Processes in Gases (U), RR 002-08-0005. University of Mississippi, University, Mississippi, Department of Physics and Astronomy; Nonr 3078(01), NR 384-307; F. D. Shields.

Under this task relaxation phenomena in gases are being studied using acoustic techniques. Data on the variations in absorption and velocity of sound waves with frequency, temperature and pressure for the halogen vapors and other gases are obtained and used to compute the relaxation times for the transfer of energy for the translational motion of the molecules to vibrational motion. A knowledge of these relaxation times is of considerable importance in developing theories of molecular collision processes and ultimately understanding all gas dynamics.

Velocity of Sound at Very High Altitudes (U), RR 002-08-0006. Columbia University, New York, New York, School of Engineers; Nonr 266(54), NR 384-308; C. M. Harris.

The object of this program is to measure the absorption and propagation velocity of sound in gases over a wide range of temperature, pressure, frequency and chemical composition, and to use the resulting data to check and expand existing theories on propagation in gases. The velocity is measured by tuning a 66-inch diameter spherical resonator to resonance and the attenuation measured by the decay of sound in the sphere. Current emphasis is on measurements of acoustic velocity and absorption in air at pressures and temperatures similar to those at high altitudes, and also in various classical gases such as argon, helium, and neon.

Propagation of Ultrasonic Waves in Liquids (U), RR 002-08-0007. John Carroll University, Cleveland, Ohio; Nonr 2577(01), NR 384-309; E. F. Carome.

This task features measurements of sound propagation at ultrasonic frequencies in various liquids and solids. The program emphasizes the precision measurements of these quantities and the application of the results to current theories on

propagation. Use is made of both interferometric and pulse techniques and particular attention is given to the diffraction and wave guide phenomena affecting absorption data. In addition a program of measurement of ultrasonic propagation in single crystal solids is being set up.

Acoustics of High Polymers (U), RR 002-08-0008. National Bureau of Standards, Washington, D. C.; NAonr 17-60, NR 384-310; R. S. Marvin.

This is a theoretical study relating the propagation constants of acoustic waves in rubberlike materials at various frequencies and temperatures to the molecular weight and molecular weight distribution of the material. The dynamic moduli (and therefore the sound velocity and attenuation) of rubberlike materials depend strongly on frequency and temperature; therefore, the ability to predict the acoustical properties of rubber under a wide variety of conditions from simple static measurements would produce a tremendous saving in time and effort for practical applications as well as contribute to basic understanding of rubber elasticity. Necessary mathematical theory and techniques are being worked out and comparison between theoretical curves and experimental data are being undertaken to test the various hypotheses.

Ultrasonic Absorption in Liquids at Ultra High Frequencies (U), RR 002-08-0009. University of Illinois, Urbana, Illinois, Biophysical Research Laboratory; Nonr 1834(29), NR 384-311; W. J. Fry.

This task is concerned with the determination of the acoustic absorption of liquids at the ultra high frequency range, using a small thermocouple probe as the detector of the acoustic field. Current effort is largely devoted to improvement and refinement of the techniques and instrumentation so that measurements up to 1000 Mc can be made. As an aid to the instrumentation development absorption data is being obtained and studied on various oils at frequencies up to 500 Mc.

Physical and Chemical Phenomena in Liquids due to Ultrasonic Waves (U), RR 002-08-0010. Laboratoire de Physiologie Acoustique Domaine de Vilvert, Jouy-en-Josas (S. & O.), France; N62558-2215, NR 384-312; R. G. Busnel.

A study is being undertaken of various effects of ultrasonic radiation--such as cavitation, oxidation, luminescence, etc.--in liquids. Emphasis will be on the variations with hydrostatic pressure--both above and below atmospheric. Data are currently being obtained using chemical reactions and optical means to study these effects of ultrasonic radiation.

Determination of the Velocity of Sound in Steam at High Pressures and Temperatures by Ultrasonics (U), RR 002-08-0011. North Carolina State College, Raleigh, North Carolina, Department of Engineering Research; Nonr 486(05), NR 384-313; J. Woodburn.

This task is primarily an experimental study of the velocity and attenuation of sound in steam under high pressures. A variable path acoustic interferometer has been developed to study the velocity and attenuation from atmospheric conditions to 1000 psig and 750°F. Data are being obtained and analyzed to furnish basic information on steam under the given conditions, and also to be a guide for practical applications of steam. Experimental measurements are now being carried out to extend the range up to 2000 psig steam pressure and 750°F.

Dynamic Mechanical Measurements on Viscoelastic Solids from 10 to 15,000 cps (U), RR 002-08-0012. The Pennsylvania State University, University Park, Pennsylvania, Department of Physics; Nonr 656(26), NR 384-314; E. R. Fitzgerald.

This task undertakes the development of an apparatus for and the obtaining of acoustic data on various viscoelastic material--including elastomers, crystalline plastics, metals, single crystals, etc.--in the frequency range 10 to 15,000 cps and over the temperature range -100°C to 150°C. The instrument development phase is currently in progress.

Representation and Analysis of Signals (U), RR 002-08-0014. Johns Hopkins University, Baltimore, Maryland, Department of Electrical Engineering; Nonr 248(53), NR 384-501; W. H. Huggins.

This task is concerned with investigation and description of complex exponential acoustic signals, in order to develop effective processing and analysis techniques. Initial work has concentrated upon orthonormal synthesis and analysis of transient signals, both theoretically and experimentally. In order to gain understanding of the general operations performed in acoustics signal processing, operational notation similar to that of Dirac has been developed.

Study of Sound Fields in Enclosures by Correlation Methods (U), RR 002-08-0015. University of Rochester, Rochester, New York, Department of Electrical Engineering; Nonr 668(17), NR 384-505; W. R. Stroh.

This task undertakes to study experimentally and theoretically some of the basic problems associated with the detection of an acoustic signal in a background of noise. This will be done using a correlation technique and will be closely related to the similar problem of determining the effect of reverberation in a room on the intelligibility of speech.

Acoustic Research (U), RR 002-08-0016. Massachusetts Institute of Technology, Cambridge, Massachusetts, Research Laboratory of Electronics; Nonr 1841(42), NR 384-901; U. Ingard.

Basic exploratory research is carried on in the generation, propagation and absorption of sound and vibration in matter. Interest centers particularly in the areas of nonlinear acoustics, of the acoustics of moving media, the acoustic properties of liquids with emphasis on such problems as the interaction of sound waves with each other, nonlinear acoustics in moving media, the properties of random fields and the acoustics of liquid helium.

Transmission of Ultrasonic Radiation Through Solids, Liquids and Gases (U), RR 002-08-0017. Brown University, Providence, Rhode Island, Physics Department; Nonr 562(13), NR 384-902; R. B. Lindsay.

This task undertakes the study of transmission of high frequency sound through solids, liquids and gases under varying conditions of temperature and

pressure. The chief interest in solid acoustics is in the measurement of ultrasonic attenuation in superconducting metals at very low temperatures, particularly below the transition temperature, and comparison of the results with those predicted by current theories. The work on liquid acoustics is being directed at attenuation measurements, using both pulse and reverberation techniques, in order to detect relaxation mechanisms and to study second order effects. In the case of gases, attention is being given to propagation in water vapor at low pressures and in steam at high pressures and temperatures.

Physical Acoustics Research (U), RR 002-08-0018. Harvard University, Cambridge, Massachusetts, Cruft Laboratory; Nonr 1866(24), NR 384-903; F. V. Hunt.

A broad program of fundamental research in physical acoustics is being conducted at the pre- and post-doctoral level, covering a diversity of problems of direct pertinence to Naval applications of acoustic techniques. Some of the problems currently being investigated are concerned with analytical and experimental research on the acoustics of thunder; studies of transducer materials, design and calibration; ultrasonic dispersion in gases and the synthesis of prescribed modification of noise spectra.

Ultrasonic Relaxation Phenomena in Gases, Liquids and Solids (U), RR 002-08-0019. The Catholic University of America, Washington, D. C., Department of Physics; Nonr 2249(02), NR 384-904; M. C. Henderson, T. Litovitz.

Ultrasonic propagation in gases and liquids is being studied both experimentally and theoretically, particularly in relation to relaxational phenomena. In gases, extensive studies of oxygen and nitrogen are under way. The liquid study is concerned with various types of relaxation effects in various liquids and emulsions.

Research Consultants (U), RR 002-08-0020. National Academy of Sciences, Washington, D. C.; Nonr 2300(02), NR 384-910; W. Atwood.

Under this task the National Academy of Sciences provides intermittent consulting services to the Office of Naval Research or its contractors. These services are used primarily for the purpose of insuring that the most highly qualified specialized foreign scientists contribute directly to the planning or progress of ONR research programs. In addition to performing a useful function in scientific liaison in general, this task has resulted in the initiation of several collaborative tests and experiments in applied work between the British Admiralty and the U. S. Navy. Since its inception this task has sponsored the visits of 126 foreign scientists to the U. S. for purposes of consultation on specific scientific problems peculiar to Navy needs.

Theory of Turbulence (U), RR 002-08-0020. University of Michigan, Ann Arbor, Michigan, Research Institute; Nonr 1224(32), NR 384-600; W. C. Meecham.

This task was concerned with the development of the theory of turbulence. Particular attention was given to improvement of the understanding of problems involving the interaction of acoustic radiation with fluid turbulence such as the scattering of acoustic radiation by turbulence and prediction of the form of the power spectrum for the self noise of turbulent flow. (This work is being continued under task RR 002-08-0021.)

Theory of Turbulences (U), RR 002-08-0021. University of Minnesota, Minneapolis, Minnesota, Aeronautical Engineering Department; Nonr 710(40), NR 384-601; W. C. Meecham.

This task is concerned with the development of the theory of turbulence. Particular attention is given to improvement of the understanding of problems involving the interaction of acoustic radiation with fluid turbulence such as the scattering of acoustic radiation by turbulence and prediction of the form of the power spectrum for the self noise of turbulence flow. (This is a continuation of work begun under task RR 002-08-0020.)

Study of Effects of Acoustic Energy on the Combustion Rate of Solid Propellants (U), RR 002-08-0022. Pneumodynamics Corporation, Bethesda, Maryland; Nonr 3155(00), NR 384-700; E. Deslauriers.

This task is undertaking an analytical study of the process by which acoustic energy may be employed to affect the combustion rate in solid propellants, placing primary emphasis on the interaction of acoustics, chemical kinetics and gas dynamics. The results of this effort are pointed toward an evaluation of the percentage of thrust modulation which might be practically achieved by acoustic means, with recommendations concerning the characteristics of energy sources which might provide such modulation. An added advantage of the acoustic system is that it offers the potential of insuring proper burning of the propellant and thereby maintaining combustion stability.

Non-Gaussian Random Processes (U), RR 002-08-0023. Purdue University, Lafayette, Indiana, School of Electrical Engineering; Nonr 1100(15), NR 384-502; J. A. McFadden.

This task is concerned with the theoretical study of the output of a linear system when the input is a stationary random process which is not Gaussian. Particular attention is given to problems of practical significance in underwater acoustic data-processing systems.

Analysis of Signal Processing Systems (U), RR 002-08-0024. Rensselaer Polytechnic Institute, Troy, New York; Nonr 591(09), NR 384-503; M. J. Jacobson.

The signal-processing properties of simple array-correlator and similar array-processor systems are studied under different statistical states of knowledge of the signal and noise acoustic fields, using non-steerable uniform collinear arrays, non-ideal delay line conditions, finite distant point sources, and using pressure gradient receivers.

Research into the Analysis of Transients (U), RR 002-08-0025. National Bureau of Standards, Washington, D. C.; NAonr 31-60, NR 384-504; E. Corliss.

This task is a theoretical study of limits

existing in acoustic signal analysis. Errors and limiting performance are found in terms of frequency analyzer processing time and folter bandwidth, signal spectrum and duration, and state of knowledge concerning the signal. The basic purpose is to find the factors governing optimum use of simple analyzers with limited or with no storage.

Second Order Effects of Ultrasonic Waves Transmitted in Liquids (U), RR 002-08-0026. University of Oregon, Eugene, Oregon, Department of Physics; Nonr 2771(03), NR 384-316; K. Zankel.

This investigation undertakes to study second order effects of ultrasonic waves transmitted in liquids. Such effects include radiation pressure, increase of absorption with pressure, finite amplitude distortion and interaction of ultrasonic waves. The investigations emphasize the use of optical techniques to study these phenomena.

Research in Acoustic Cavitation (U), RR 002-08-0027. University of Rochester, Rochester, New York, Department of Electrical Engineering; Nonr 668(18), NR 384-317; H. G. Flynn.

This is a series of fundamental studies in the behavior of transient cavities created in liquids by negative pressures. Transient cavities are small bubbles that grow explosively from small gas nuclei in liquids and then collapse with great violence. The objectives of this research are to gain a clearer understanding of the dynamics of transient cavities, to maximize the pressures and temperatures created by the collapse of such bubbles and to see how the extreme conditions inside collapsing cavities might promote useful reactions.

R002-09 Plasma and Ionic Physics

Photoionization Parameters (U), RR 002-09-0001. University of Southern California, Los Angeles, California, Department of Physics; Nonr 228(11), NR 012-101; G. L. Weissler.

Measurements of absorption coefficients of atmospheric and other technically important gases are made with a grazing incidence vacuum spectrograph. Values of photoionization efficiency are obtained by selective irradiation and ion counting. A mass spectrometer and an electron velocity analyzer are being used to obtain more accurate values of photoionization cross sections, and to correlate these with alternative mechanisms giving different end products.

Low Velocity Ion Scattering (U), RR 002-09-0002. University of Florida, Gainesville, Florida, Department of Physics; Nonr 580(01), NR 012-102; T. L. Bailey.

Experiments are under way to measure elastic and total inelastic scattering cross sections of negative ions on molecules and noble gas atoms, in the energy range from four to several hundred electron volts. With a mass spectrometer, an analysis is made of the particles leaving the scattering chamber enabling correlation with inelastic scattering mechanisms such as electron detachment or charge exchange. Data are obtained on yields of an ion source involving electron bombardment of hydrocarbons or water vapor, and thereby on a stability of certain negative ions. An rf-type ion accelerator source for producing monoenergetic ions and an rf mass spectrometer will be used to obtain data on ion-molecule reactions.

Photodissociation of Negative Ions (U), RR 002-09-0003. National Bureau of Standards, Washington, D. C., Atomic Physics Department; NAonr 15-60, NR 012-103; L. M. Branscomb.

Direct determination of electron affinities and photodetachment probabilities is made using a crossed beam technique. Current emphasis is on extending the sensitivity of previously successful technique, by increasing the efficiency of the electron detector and the intensity of the photon beam, in order to open the field of negative ion spectroscopy. Measurements are being made on light ions such as lithium, sodium and carbon and on free radicals and ions of possible astrophysical interests.

Capture Loss and Ionization Cross Sections of Ions and Neutral Particles (U), RR 002-09-0004. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Physics; Nonr 624(06), NR 012-104; T. M. Donahue.

Inelastic scattering processes of the following four types, for energies between 2 Kev and 140 Kev, are investigated: (a) charge capture and loss by ions, (b) charge capture and loss by neutral particles, (c) ionization by charged and uncharged beams of particles, and (d) excitation by charged and uncharged beams. A novel scattering chamber has been constructed which is capable of measuring cross sections for the first three types of reactions by several alternative methods. Theoretical calculations are to be made where feasible of cross sections for charge exchange and ionization, with special attention to energies near threshold.

Atomic Scattering of Electrons (U), RR 002-09-0005. New York University, New York, New York; Nonr 285(15), NR 012-105; B. Bederson.

Experimental and theoretical studies are made of scattering of electrons from atoms and molecules. The electron energies range from slightly above excitation and ionization threshold down to the neighborhood of 1/2 volt. In addition to the measurement of total scattering of cross sections, velocity analysis is used to measure differential cross sections, and a magnetic analyzer is used to measure specific exchange contributions to the scattering. A special beams tube is being constructed, with which direct measurement of atomic polarization would be attempted.

Low Energy Electron Scattering (U), RR 002-09-0006. St. John's University, Jamaica, New York, Department of Physics; Nonr 2604(00), NR 012-106; S. N. Milford.

The task is to calculate cross sections for collisions of electrons with hydrogen atoms in excited states, the transitions to be investigated lying in the range $nlm \rightarrow n'l'm'$, where $n = 3$ to 30, $n' = 3$ to 30 and the continuum. For fast electrons (above 100 electron volt) the Born and Bethe approximations will be used, while for slow electrons several techniques will be attempted: (a) a new semi-empirical improvement on the Born

approximation, (b) the scattering matrix, (c) the Bethe-Seaton method, and (d) threshold formulae. Applications are made to conditions expected to exist in the outer atmospheres of stars.

Investigation of Interaction Cross Sections for Electrons with Atomic Species of Molecular Cases (U), RR 002-09-0007. Stanford Reseach Institute, Menlo Park, California, Department of Physics; Nonr 2588(00), NR 012-107; C. J. Cook.

Using a crossed beam method, measurements are made of cross sections for scattering of low energy electrons from several species present in the upper atmosphere such as O, N, O_2. A specially designed electron gun is being used, together with a novel high intensity source. Scattering results are to be studied as a function of electron energy from a few tenths of a volt to kilovolts with as high resolution as practicable, and with emphasis on the energies near inelastic thresholds.

Atomic Interactions (U), RR 002-09-0008. General Atomic, Division of General Dynamics Corporation, San Diego, California; Nonr 2786(00), NR 012-108; W. Fite.

Measurements are made of the following cross sections:

a. Electron-atom collisions involving electron interactions with atomic oxygen and hydrogen.
b. Ion-atom collisions, involving impacts between protons and atomic hydrogen and oxygen for studies of ionization by impact; also interactions between protons and hydrogen atoms, on the one hand, and interactions between ions of hydrogen (or oxygen) and the corresponding neutral species for charge exchange interactions.
c. Ion-ion collisions, particularly the interaction between protons and negative ions of hydrogen in neutralization reactions.

Atomic Scattering Problems (U), RR 002-09-0009. New York University, New York, New York, Department of Physics; Nonr 285(49), NR 012-109; S. Borowitz.

Theoretical studies are to be carried out with a view towards better understanding of atomic scattering phenomena. Particular attention will be given to the problems of electron scattering from ions, atoms, and molecules. Complimentary to the studies of atomic scattering, work will be done on the approximation of atomic wave functions by simpler mathematical expressions which are more easily used for cross section calculations.

Molecular Processes (U), RR 002-09-0010. Queen's University of Belfast, Belfast, North Ireland, Department of Applied Mathematics; N62558-2637, NR 012-110; D. R. Bates.

Theoretical calculations on atomic and molecular processes will be carried out with particular emphasis on the processes of associations, dissociation, X-radiation absorption, electron capture, and excitation and ionization by electron and ion impact. These calculations will of necessity use approximation methods such as first and second Born, Schwinger, and distortion. It is hoped that more reliable calculations on the above processes with oxygen and nitrogen will be carried out.

Molecular Cross Sections (U), RR 002-09-0011. National Bureau of Standards, Washington, D. C.; NAonr 2-61; NR 012-111; L. M. Branscomb.

A wide variety of atomic and molecular cross sections are to be determined experimentally. Cross sections for reactions such as excitation or ionization by electron impact, elastic collisions, photoionization, photodetachment, charge exchange and charge neutralization will be investigated. Also, research will be performed on determining radiative transition probabilities. The reaction rate coefficients corresponding to some of the above cross sections will be investigated employing r-f measuring techniques in plasmas. In addition, a data center is to be established for the purpose of collecting and evaluating data on transition probabilities and molecular cross sections. These annotated data could subsequently be made available through reports of the National Bureau of Standards.

Cesium Charge Exchange (U), RR 002-09-0012. Electro-Optical Systems, Incorporated, Pasadena, California; Nonr 3305(00), NR 012-112; R. C. Speiser.

This task is devoted to the experimental investigation of cesium-cesium ion scattering. In particular, the scattering cross section and the efficiency of charge exchange will be measured.

Corona Studies (U), RR 002-09-0013. University of California, Berkeley, California, Department of Physics; Nonr 222(44), NR 012-201; L. B. Loeb.

This task is devoted to experimental investigations of the mechanism operative in spark breakdown in gases, stable discharges, and corona. Specialized electronic, photometric, high vacuum, and surface cleaning techniques are employed to study the microscopic mechanism involved in various processes of electrical discharges in gases. The photoelectric effect and secondary emission in insulating solids is also studied.

Atomic and Nuclear Theory (U), RR 002-09-0014. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Department of Physics; Nonr 760(15), NR 012-202; M. Baranger.

A theoretical attack is made on the problem of the shape of atomic spectral lines emitted from a plasma. The influence of the plasma oscillations on the emission will be accessed. The method of investigating the analytic properties of scattering amplitudes will be applied to the problem of inelastic scattering of electrons on atoms. Further, the ideas of Bardeen, Cooper, and Schrieffer which have proved so useful in explaining superconductivity will be applied to nuclei which do not fit the single particle or the collected model.

Spark Spectroscopy (U), RR 002-09-0015. University of Arizona, Tucson, Arizona; Nonr 2360(00), NR 012-203; L. Blitzer.

This equipment loan provides apparatus to study the time history of the spectral characteristics of a spark discharge by means of a time-resolution spectrograph. This consists of a detailed study of the individual spectral lines (shifts, asymmetries, intensity profiles) and the associated continuum. Whenever possible, the excitation temperature in the discharge column is determined. In the future, studies of this type are to be made for

discharges in atmospheres other than air and at reduced pressures.

Atomic Collisions Relating to the Ionosphere (U), RR 002-09-0016. Westinghouse Research Laboratory, Pittsburgh, Pennsylvania; Nonr 2584(00), NR 012-204; M. A. Biondi and A. V. Phelps.

Measurements are made of the cross sections for microscopic processes of interest for ionospheric physics. These processes include: elastic and inelastic collisions of slow electrons with atmospheric constituents, ion-electron recombinations, particularly dissociative recombinations, such as $N_2^+ + e \rightarrow N + N^*$; and electron attachment. A number of special experimental techniques will be combined such as mass spectrometric techniques in combination with drift tube and microwave discharges.

Thirteenth Gaseous Electronic Conference (U), RR 002-09-0017. Office of Naval Research Branch Office, San Francisco, California; Allot. 906, NR 012-205; J. Froman.

The thirteenth Gaseous Electronics Conference was held at the United States Naval Post Graduate School, Monterey, California, 12-14 October 1960. Under this task, abstracts of the papers presented are published, partial travel expenses for some foreign invited speakers are provided, and clerical and mailing expenses covered.

Gaseous Discharge Plasmas (U), RR 002-09-0018. University of Minnesota, Minneapolis, Minnesota, Department of Electrical Engineering; Nonr 710(37), NR 012-206; H. J. Oskam.

Under this task investigations are to be carried out on the decaying plasma generated by a pulsed microwave discharge. Experimental techniques employed will include but not be limited to (a) microwave probing for electron densities, (b) mass spectrographic identification of ion species diffusing to the plasma boundaries, and (c) optical spectroscopy for determining the densities of various excited states.

Airglow, Afterglow and Collision Processes (U), RR 002-09-0019. University of Washington, Seattle, Washington; Nonr 477(32), NR 012-207; R. Geballe, K. C. Clark.

Measurements will be made on the excitation of atmospheric gases by fast charged particles; the absorption of radiation by gases in afterglow conditions; and electron-ion and ion-ion collision processes. The theoretical work necessary for the interpretation and understanding of the experimental results may also be undertaken.

Plasma Diagnostics (U), RR 002-09-0020. University of Maryland, College Park, Maryland, Department of Physics; Nonr 595(10), NR 012-301; H. R. Griem.

Measurements are to be made of spectral intensities of the emission and absorption in high temperature plasmas. The spectral line shapes for simple systems may be predicted theoretically and then used as a measure of the conditions existing in the plasma. For more complicated atoms or ions, the line shapes and intensities will be used to obtain information on transition probabilities. The simpler emitting systems are atomic hydrogen, singly ionized helium, etc., while the more complicated atoms of interest are the rare gases, oxygen, carbon, and nitrogen.

Magento Convective Instabilities (U), RR 002-09-0021. University of Chicago, Chicago, Illinois, Department of Physics; Nonr 2121(20), NR 012-302; S. Chandrasekhar.

Studies were made of the behavior of an electrically conducting fluid in the presence of a magnetic field, a thermal gradient, and rotation of the fluid. Experiments were performed on inhibition of thermal convection by a magnetic field, and on instability of a layer of mercury heated below and subject to simultaneous magnetic field and rotation. The effects of a magnetic field on inhibiting the onset of instability were studied in the configuration of the conducting fluid flowing between two concentric cylinders, with the cylinders either conducting or nonconducting. Applications of the results of the theoretical considerations and the experimental measurements were to be made to physical, geophysical, and astrophysical problems.

Plasma Energy Transfer (U), RR 002-09-0022. Johns Hopkins University, Baltimore, Maryland, Department of Physics; Nonr 248(57), NR 012-304; D. E. Kerr.

Studies will be made on the energy transfer occurring in the process of rapid heating of a plasma. The emphasis of the experimental research will be on understanding the mechanisms of (1) transfer of energy from changing fields to the plasma; (2) the exchange of this kinetic energy in excited and ionized atomic systems; and (3) the loss of energy from the plasma by radiation processes.

Sputtering of Solids (U), RR 002-09-0023. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division; Nonr 1589(15), NR 012-401; G. K. Wehner.

Experimental measurements are made on the sputtering caused by incident ions of energy between 20 to 400 ev. The sputtering yield will be studied as a function of the properties of the bombarded materials, the energy of the incident beam, and for the ions of mercury and the rare gases. The ejection patterns of the sputtered materials will also be observed. Plans also include studies on metallic oxides and germanium with spectroscopic and mass spectroscopic investigations of the sputtered materials.

Sputtering Mechanisms (U), RR 002-09-0024. University of Houston, Houston, Texas, Deaprtment of Physics; Nonr 2594(01), NR 012-402; H. K. Reynolds, J. C. Allred.

Measurements of sputtering yields were made in the energy range of bombarding ions between 6 Kev and 200 Kev. The dependence of yield on atomic constitution and structure of the solids was investigated. Radioactive collection techniques were used for assessing yields.

Sputtering (U), RR 002-09-0025. Convair Astronautics, Division of General Dynamics Corporation, San Diego, California, Applied Research Group; Nonr 3157(00), NR 012-403; D. Garber, D. McKeown.

Under this task the interaction of ions and neutral molecules with solid surfaces will be studied. The ions and molecules will be incident on the surfaces with velocities comparable with the velocities of satellites and missiles. Principally, work will be done on sputtering in this energy range.

R002-10 Fundamental Physics

Experimental and Theoretical Investigation of Gravitation (U), RR 002-10-0001. Princeton University, Princeton, New Jersey, Palmer Physical Laboratory; Nonr 1858(30), NR 013-101; R. H. Dicke.

Primarily, experimental investigations are made on physical effects associated with the gravitational field of the earth and solar systems. Three types of experiments are made: (1) experimental checks of the results of theories of general relativity; (2) experimental checks of the basic assumptions of the theories; and (3) experimental investigations of possible implications of Mach's principle.

Relativistic Effects (U), RR 002-10-0002. University of North Carolina, Chapel Hill, North Carolina, Institute of Field Physics; Nonr 855(07), NR 013-102; B. S. DeWitt, C. M. DeWitt.

Studies are made of general relativistic theories and their implications for the understanding of structure of fundamental particles, for prediction of observable phenomena, and for possible tests of the general theory. Particular attention is given the relation of relativistic theories to quantum theory.

Quantum Field Theories (U), RR 002-10-0003. Brandeis University, Waltham, Massachusetts, Department of Physics; Nonr 1677(03), NR 013-103; S. S. Schweber.

Theoretical studies are made of several fundamental problems of quantum theory: (1) the role of Planck's constant in the classical limit of the Feynman formulation of quantum mechanics; (2) the influence of requirements of causality and relativistic invariance on the scattering matrix, and on propositions analogous to the Luders, Pauli, Schwinger Theories; (3) the "particle" interpretation of relativistic field theories.

Electrodynamic Equations of Motion with Radiative Reaction (U), RR 002-10-0004. Aeronutronic Systems, Incorporated, Glendale, California; Nonr 2706(00), NR 013-104; G. N. Plass.

This task consists of theoretical studies of (a) the influence of radiative reaction on the motion of a charged particle in classical electrodynamics and (b) the relativistic action at a distance theories of gravitation. Under (a), work is being done on establishing the types of potentials for which physically acceptable solutions exist. Under (b), attempts will be made to construct an action function leading to the correct relativistic solutions to the problems of the gravitational red shift, the bending of light in a gravitational field, and the precession of the perihelion of a planet.

The Transition from Quantum to Classical Mechanics and from Maxwell's Equations to Geometrical Optics (U), RR 002-10-0005. Stevens Institute of Technology, Hoboken, New Jersey, Department of Physics; Nonr 263(30), NR 013-105; S. I. Rubinow, R. Schiller.

Studies are made of the relationship of classical to quantum mechanical formulations of physics, and of related questions such as the relationship of ray to wave optics. An attempt is being made to find useful generalizations of the WKB method and similar approximations. Particular attention is paid roles of angular momentum in classical and quantum theories; a classical model of electron spin; and conditions relativistic invariance.

Scattering Interactions (U), RR 002-10-0006. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Physics; Nonr 839(30), NR 013-106; H. E. Moses.

This task is a theoretical program of basic research to obtain interactions in quantum mechanical systems from scattering data, and to determine conditions on interactions imposed by relativistic requirements.

Skyhook Solar Astronomy (U), RR 002-10-0007. Princeton University, Princeton, New Jersey, The Observatory; Nonr 1858(03), NR 013-201; M. Schwarzschild.

This project is concerned with obtaining high resolution photographs of the solar disk and limb, planets, galaxies, nebulae and star clusters, and the analysis of these photographs. The photographs are taken at altitudes of 80,000 feet or higher.

Strato-Lab Telescope (U), RR 002-10-0008. Johns Hopkins University, Baltimore, Maryland, Laboratory for Astrophysics and Physical Meteorology; Nonr 248(52), NR 013-202; J. D. Strong.

This task involves the design and construction of (a) special telescopes and spectrographs for use with the Strato-Lab balloon and high altitude aircraft to undertake astronomical and astrophysical studies, and (b) the development of a new infrared pyrometer applicable to the study of atmospheric absorption and emission. The observational program includes: (a) the study of near infrared spectrum of the sun, (b) study of infrared line spectrum and radiometric measurements of emissions of Venus, Mars, and the moon.

Interstellar Spectrophotometry (U), RR 002-10-0009. Princeton University, Princeton, New Jersey, The Observatory; Nonr 1858(13), NR 013-203; L. Spitzer.

A two-photocell photometer has been constructed for use with high dispersion spectroscopes--especially with applications to astronomy. The equipment will be used with the 100" Mt. Wilson telescope to look at stars in the far reaches of the galaxy and observe the spectral difference between low and high veolicty stars. Work will also continue on improving the photometer.

High Altitude Physics (U), RR 002-10-0010. University of Colorado, Boulder, Colorado, High Altitude Observatory; Nonr 393(05), NR 013-204; G. Newkirk. Jr., W. O. Roberts.

This task is an investigation of the types and

distributions of contaminating aerosols in the earth's atmosphere, and a study of the solar corona out to at least three solar radii.

Basic Solar Research (U), RR 002-10-0011. University of Michigan, Ann Arbor, Michigan, The Observatory; Nonr 1224(19), NR 013-205; O. C. Mohler.

This task is concerned with research on the solar and terrestrial atmosphere. Emphasis is being placed on (a) study of the fine structure of the solar atmosphere, in particular temperature and velocity fluctuations, as revealed by the variations in intensities, displacements, and shapes of the photospheric lines using a spectrograph of high resolution, (b) study of the vibrational spectra of molecules in the sun's atmosphere to obtain isotopic abundances, and (c) the study of solar activity, with special reference to the relation between optical and radio disturbances on the sun, and between solar disturbances on terrestrial events, such as ionospheric disturbances, auroral displays, geomagnetic storms, etc.

Balloon Dynamics (U), RR 002-10-0012. Arthur D. Little, Incorporated, Cambridge, Massachusetts; Nonr 3164(00), NR 013-206; A. G. Emslie.

This task is concerned with the dynamic stability of large plastic balloons. To be studied are the motional modes of balloons coupled to loads. Of particular interest are the couplings and excitations of these modes.

Electron Image Tubes for Astronomical Purposes (U), RR 002-10-0013. University of California, Mt. Hamilton, California, Lick Observatory; Nonr 2898(01), NR 013-207; G. E. Kron.

The methods of conversion of weak light signals through the very sensitive photoelectric detection process to photographic images are being studied with a view to simplifying the methods of operation. Effort is concentrated on the photoelectric image converter designed and operated by Professor A. Lallemand of Paris. Professor Lallemand's instrument has proven successful in detecting very faint astronomical events which cannot be detected photographically. However, the converter must be rebuilt every day and it is this problem for which corrective techniques are sought.

Rocket Solar Astronomy (U), RR 002-10-0014. U. S. Naval Research Laboratory, Washington, D. C.; Allot. 501, NR 013-208; H. Friedman.

Measurements are made of the X-ray spectra emitted during a solar flare. These measurements are carried out from a sounding rocket above the atmosphere of the earth. Other spectroscopic observations of the sun are also made.

Theoretical Physics of Molecular Structure and Solid State Physics (U), RR 002-10-0015. University of Michigan, Ann Arbor, Michigan, Engineering Research Institute; Nonr 1224(15), NR 013-301; G. E. Uhlenbeck.

A coordinated attack is being made on a number of theoretical problems in which members of the theoretical group at Michigan have a common interest. These problems center on the problem of interaction of many particles. The investigation includes the study of transport processes in rather dense gases; the "hindered motion" of atoms in molecules and solids; the dynamics of charge carriers in solids, and the study of the general symmetry properties of wave equations.

Statistical Mechanics of Interacting Particles (U), RR 002-10-0016. The Johns Hopkins University, Baltimore, Maryland, Department of Physics; Nonr 248(10), NR 013-302; T. K. Berlin.

This is a study of the foundations and applications of statistical mechanics. One of the principal subjects of interest is the fundamental question of the introduction of statistics on the basis of mechanics. There are also programs of research on the statistical mechanical theory of transport processes in dense gases at high temperatures, and the role of metastable states in statistical mechanics.

Statistical Mechanics of Gravitating Systems (U), RR 002-10-0017. Western Reserve University, Cleveland, Ohio, Department of Physics; Nonr 1439(05), NR 013-304; G. E. Tauber.

A theoretical study was made of the statistical mechanics of gravitating systems. An approach has been found to a proper form of general relativistic statistical mechanics which was followed to attempt to obtain explicit solutions for rotating systems. Studies were made of the effect of Coriolis forces in astrophysical applications, and of magnetohydrodynamic effects. The possibilities of an observational check by computing critical stability radii of white dwarfs were to be developed.

Statistical and Field Theories (U), RR 002-10-0018. Brandeis University, Waltham, Massachusetts, Department of Physics; Nonr 1677(04), NR 013-305; D. L. Falkoff, E. Gross.

Studies are made of the statistical mechanical descriptions of equilibrium and nonequilibrium phenomena. The methods of attack are purely analogous to those recently developed in quantum mechanics--the Feynman path integral approach--and in the theory of Markoff processes. Applications will be made to the theory of irreversible processes.

R002-99 Other Physical Sciences

Penetration and Diffusion of High Energy Radiations (U), RR 002-99-0001. National Bureau of Standards, Washington, D. C.; NAonr 9-60, NR 028-165; U. Fano.

This program is concerned with the formulation of methods to compute the penetration and diffusion of high-energy radiation together with its association secondaries, through thick barriers such as nuclear reactor shields.

Oceanic Radioactivity (U), RR 002-99-0002. Catholic University of America, Washington, D. C., Physics Department; Nonr 2249(04), NR 028-317; C. Cowan.

The work of this task includes developing and using high-efficiency radioactivity detectors for measuring the radioactivity of sea water with an accuracy and sensitivity previously unattainable and investigating a nuclear physics approach for sensing small variations in the earth's magnetic

field caused by metallic objects.

Cryomagnetism, RR 002-99-5050. U. S. Naval Research Laboratory, Washington 25, D. C.; P05-01; J. R. de Launay.

New phenomena, the description and analysis of which have contributed to the elucidation of theories of behavior of electrons, atoms, molecules and free radicals in solids, have been discovered and studied. These investigations, which have included interactions, encompass magnetic properties of paramagnetic substances both for cooling and reservoirs below 1°K; general magnetic interactions leading to ferromagnetism, antiferromagnetism, ferrimagnetism, and metamagnetism, magnetic oscillatory phenomena, possible ferromagnetic superconductors, determination of quantum mechanical constants of rare earth and actinide elements and compounds from experiments and the systematic approach to absolute zero for better understanding the nature and behavior of solids.

Cryogenic Properties of Matter, RR 002-99-5051. U. S. Naval Research Laboratory, Washington 25, D. C.; P05-02; J. R. de Launay.

The coordinated theoretical and experimental program which has been in progress for the past few years will be continued along the following specific lines: experiments on the critical fields of superconductors will be conducted in an effort to define more accurately the conditions pertinent to the occurrence of superconductivity. Investigation of the behavior of a gas near its critical point will be continued, probably in the direction of calorimetric measurements. The study of the intermediate state of superconductors by means of the Faraday effect will be further developed. Theoretical values of the specific heat for fcc materials will be calculated from the vibration spectra now available. Apparatus for nuclear cooling will be constructed for experiments near 10^{-6} degrees absolute.

Radiation Effects (U), RR 002-99-5052. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-17; V. J. Linnenbom.

This task is an investigation of the chemical reactions induced by the action of ionizing radiation. Possible applications of aqueous redox systems as chemical dosimeters, effects of radiation on high molecular weight polymers, and methods for calculating absorbed dose are currently being looked into.

Electron Loss Processes (U), RR 002-99-5053. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-18; G. F. Wall.

It is proposed to observe electron lifetimes in air by pulsing a very intense beam of electrons and observing the attenuation of a microwave signal passing through the beam. It is planned to carry out attenuation measurements over a large range of electron density, gas composition and density. These data will allow the electron attachment coefficient, recombination coefficient and ambipolar diffusion coefficient to be determined as a function of gas pressure. Knowledge of these fundamental constants will permit the determination of microwave attenuation under any conditions.

A large differential pumping system has been designed and installed to bridge the pressure difference between the tank at 10 mm Hg. and the electron gun at 10^{-6} mm Hg. The microwave measuring system has been tested in a bench mock-up and preliminary electron gun test made.

A design for the heater-cathode of the electron gun has been completed and after initial tests appears satisfactory. The design of a periodic focusing system to transport the electron beam through the differential pumping sections has been completed and components are under manufacture.

High Temperature Physics (U), RR 002-99-5054. U. S. Naval Research Laboratory, Washington 25, D. C.; H01-11; W. R. Faust.

Research has been directed toward the production of temperature of the order of 10^{7}°K and the problems of confining gases at such temperatures. The development of a controlled thermonuclear reaction requires that heavy hydrogen isotopes be heated to such temperatures that fusion may occur and simultaneously the hot gases must be contained long enough for thermalization to occur and to allow sufficient energy releases.

Research work has continued on the magnetic compression experiments utilizing the 300-joule condenser bank. Considerable effort has been devoted to the design and actual construction of a 2-megajoule condenser bank. The 2-megajoule bank is virtually completed and preliminary critical measurements are being conducted to test the bank.

Plasma Physics and Applications (U), RR 002-99-5055. U. S. Naval Research Laboratory, Washington 25, D. C.; H03-27; W. H. Bennett.

This work involves basic research in the studies of ionized systems and of ionization. One system being studied involves the possibility of producing a steadily running, magnetically self-focusing, space-charge neutralized stream of relativistic particles radiatively thermostated. Another system being studied involves the possibility of producing a highly energized, fully ionized aggregate which is contained by an axially symmetric arrangement of electric and magnetic fields of a particular kind.

Extreme Ultraviolet Spectroradiometry (U), RR 002-99-5056. U. S. Naval Research Laboratory, Washington 25, D. C.; N01-02; R. Tousey, W. R. Hunter.

Knowledge of the absorption and ionization processes in gases for this spectral region are of importance in connection with the ionosphere and the physics of the upper atmosphere where ultraviolet of these wavelengths, originating from the sun, becomes absorbed. The results will also aid in the solution of theoretical problems connected with the solid state, semiconductors, surface layers and molecular structure. The study of the reflectance of new metallic and non-metallic layers leads to greatly improved mirrors and gratings for use in spectrographs. This field also offers new possibilities in spectrochemical analysis and is a new tool for studying the mechanism of the electric discharge.

Low Brightness Photometry (U), RR 002-99-5057.

U. S. Naval Research Laboratory, Washington 25, D. C.; NO1-03; G. T. Hicks.

This task is concerned with the various possible measurements on light at the threshold of detectability. Involved in these measurements is a necessary knowledge of the following basic items: (1) the light source, (2) the detector, and (3) the attenuating medium. In this task, we attempt through experiments, theoretical analysis, and review of the literature to mesh together the three basic items into an information detection system for night time operations.

Optical Properties of Materials (U), RR 002-99-5058. U. S. Naval Research Laboratory, Washington 25, D. C.; NO1-07; L. F. Drummeter.

The reflectance of black surfaces is being studied as a function of incident and observation angles. The absorptance and emittance of certain materials are being investigated by calorimetric methods in vacuum.

Studies of Optical Instruments, RF 002-99-5059. U. S. Naval Research Laboratory, Washington 25, D. C.; NO1-08; L. F. Drummeter, Jr.

A preliminary study of the optical instrumentation needs in the field of High Temperature Physics has been completed. It has been determined that the prime need in this field is for a high speed, high dispersion, fast f/number spectrograph of moderate cost. The specific characteristics of the instrument have been formulated. Many optical designs have been studied to date and all but one have been rejected. It is believed that the key to the solution has been recognized.

R003 MATHEMATICAL SCIENCES

R003-01 Theoretical Mathematics

Differential Equations and Analytical Mechanics (U), RR 003-01-0002. University of Minnesota, Minneapolis, Minnesota, Department of Mathematics; Nonr 710(16), NR 043-041; S. E. Warschawski.

Research is being carried out in the fields of partial differential equations and function theory. Special emphasis is placed on existence and uniqueness theorems for parabolic equations. The major effort in function theory is in the area of conformal mapping, and includes the development of improved procedures for the effective determination of mapping functions.

Differential Equations (U), RR 003-01-0003. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Mathematics; Nonr 1841(38), NR 043-065; N. Levinson.

Research is being carried out in abstract analysis and its applications. The principal areas of investigation include ordinary and partial differential equations, functional analysis, function theory, operator theory, analytic number theory, probability and stochastic processes.

Studies in Eigenvalue Problems (U), RR 003-01-0004. University of Kansas, Lawrence, Kansas, Department of Mathematics; Nonr 583(04), NR 043-066; N. Aronszajn.

The general field of eigenvalue problems is being investigated. Emphasis is placed equally on analysis of the differential problems as theoretical background for the application of approximation methods, and on the further development of the approximation methods themselves.

Mathematics Advisory Committee (U), RR 003-01-0007. National Academy of Sciences, Washington, D. C., Division of Mathematics; Nonr 2300(04), NR 043-155; S. S. Wilks.

The contractor furnishes the necessary personnel, facilities, and consultants for an Advisory Committee on Mathematics whose primary function is to advise on the organization of a well-rounded program of contract research in the more basic phases of mathematics.

Topics in Algebraic Topology (U), RR 003-01-0008. Cornell University, Ithaca, New York, Department of Mathematics; Nonr 401(20), NR 043-167; P. Olum.

Various topics in algebraic topology are being investigated. The main effort is on the problems of extension and homotopy classification through the study of algebraic invariants. Other areas being investigated are duality theories in homotopy theory; topological properties of the group of rotations in Euclidean n-space; characterization of homotopy groups through axiom systems; and homology properties of topological groups.

Differential Geometry in the Large (U), RR 003-01-0009. University of Washington, Seattle, Washington, Department of Mathematics; Nonr 477(15), NR 043-186; C. B. Allendoerfer and A. Hijenhuis.

Research is being undertaken in differential geometry in the large and related areas. The main objectives include studies of (a) exterior differential systems; (b) vector-valued differential forms, deformations of complex structures, integrability properties of vector 1-forms, applications to Lie algebras; (c) convexity of Riemannian manifolds; (d) singular differential forms and their use to characterize topological invariants; (e) invariant operations on tensor fields.

Number Theory (U), RR 003-01-0010. University of Illinois, Urbana, Illinois, Department of Mathematics, Nonr 1834(18), NR 043-194; P. T. Bateman.

Research is being undertaken in a variety of topics in number theory, including: general theorems on slowly oscillating functions, multipartite partition problems, convolution questions in lattice point problems, additive prime number theory in algebraic number fields, the zeros of the Riemann zeta-function, the error terms in certain formulas in analytic number theory.

The Unpublished Scientific Works of John von Neumann (U), RR 003-01-0011. Institute for Advanced Study, Princeton, New Jersey, Digital Computer Laboratory; Nonr 1358(06), NR 043-201; A. H. Taub.

This task involved the study and editing of such of the works of the late John von Neumann as have not hitherto been accessible in the scientific literature, and as are, in the opinion of the editor and his consultants, suitable for publication.

Lattice-ordered Rings (U), RR 003-01-0012. Purdue University, Lafayette, Indiana, Department of Mathematics; Nonr 1100(12), NR 043-205; M. Henriksen.

Investigation leading to a complete structure theory for lattice-ordered rings is being undertaken. Attention is focussed on an important class of these, namely that of the f-rings, which appear as subdirect sums of totally ordered rings. Some needed preliminary results from the theory of totally ordered Abelian groups have been developed.

Homological Manifolds and Non-Commutative Topological Groups (U), RR 003-01-0013. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Mathematics; Nonr 551(30), NR 043-206; M. Goto.

Research was undertaken on the theory of Lie groups. A systematic approach to the theory was compiled and the principal investigator prepared an exposition of significant work in the field, including new theorems produced under this task.

General Topology (U), RR 003-01-0014. University of Washington, Seattle, Washington, Department of Mathematics; Nonr 477(21), NR 043-207; E. Michael.

Research was undertaken in general topology. Two topics were given special consideration: (1) the theory of "continuous selections" developed by the principal investigator; (2) the properties and characterizations of various kinds of topological spaces, such as metric spaces and paracompact spaces.

Spectral Analysis and Perturbation Theory of Operators in Hilbert Space (U), RR 003-01-0015. University of Washington, Seattle, Washington, Department of Mathematics; Nonr 477(20), NR 043-208; F. H. Brownell.

The research was in the spectral analysis and perturbation theory of explicitly given operators in Hilbert space, particularly partial differential operators. The theory was applied to some central problems in quantum electrodynamics.

Finite Groups (U), RR 003-01-0016. University of Wisconsin, Madison, Wisconsin, Department of Mathematics; Nonr 1202(11), NR 043-209; C. W. Curtis.

A broad study of the problems in the field of group representation is being undertaken. This study will result in a monograph on the subject coauthored by Professor C. Curtis at the University of Wisconsin and Professor I. Reiner of the University of Illinois. These special problems are being investigated: (1) the connection between certain finite groups and restricted Lie algebras of prime characteristics, (2) the possibility of an algorithm for computing the irreducible representations of finite groups, and (3) the Galois correspondence between groups of automorphisms of simple rings with minimum condition and subrings of the simple rings.

Group Representations (U), RR 003-01-0017. University of Illinois, Urbana, Illinois, Department of Mathematics; Nonr 1834(23), NR 043-210; I. Reiner.

Research is being carried out in the theory of group representations. Four problems are being given special consideration: (1) the connections between integral and induced modular representations of a finite group, (2) the uniqueness, under unimodular equivalence, of the indecomposable constituents of a group of matrices whose entries are integral relative to some finite set of valuations, (3) the classification of the ideals in a polynomial domain in several variables, and (4) the application of cohomology theory to the classification of the indecomposable rational integral representations of finite cyclic groups.

Algebra and Topology (U), RR 003-01-0018. Columbia University, New York, New York, Department of Mathematics; Nonr 266(57), NR 043-212; S. Eilenberg.

An intensive research program is being carried out in topology, homological algebra, differential algebra, and algebraic geometry. The problems being investigated are among the most difficult, and at the same time most challenging, confronting today's pure mathematician. These problems include the topology of transformation groups, the foundations of fiber bundles and Algebraic Topology, the connection between the Galois theory of differential fields and the theory of group varieties, and the class field theory for function fields over algebraic number fields.

Inductive Probability (U), RR 003-01-0025. University of California, Los Angeles, California, Department of Philosophy; Nonr 233(55), NR 043-223; R. Carnap.

Professor Carnap is continuing his pioneering work on the development of a new theory of probability which is based on the conception that all non-deductive inference (i.e., inductive or scientific inference, including statistical inference) is probability inference.

Summer Program in Analysis (U), RR 003-01-0026. University of Chicago, Chicago, Illinois, Department of Mathematics; Nonr 2121(12), NR 043-225; A. P. Calderon.

A number of specialists in harmonic analysis and partial differential equations were assembled at the University of Chicago in the summer of 1960 to pursue a concentrated research program in the above areas. During the summer of 1959 a similar program was devoted to the field of abstract algebra.

Functional Analysis and Differential Equations (U), RR 003-01-0028. University of California, Los Angeles, California, Department of Mathematics; Nonr 233(60), NR 043-229; R. Arens.

Research is being undertaken in a number of areas of mathematics related to functional analysis and differential equations. These include investigations of (a) approximation and ideal structure in linear algebras with topological structure, expressly dispensing with an adjoint operation; (b) spectral theory of differential operators; and (c) application of the theory of semigroups of linear bounded operators to the Cauchy problem for dissipative linear hyperbolic partial differential equations with time invariant coefficients.

Diophantine Approximation (U), RR 003-01-0029. University of Oregon, Eugene, Oregon, Department of Mathematics; Nonr 2771(02), NR 043-230; I. Niven.

Research is being undertaken in two areas of diophantine approximation: on recurrence time problems and on single diophantine approximation. Generalizations are being sought for previous results of the investigator concerning the average value of the least integral multiple of an arbitrary real number which approximates an integer to a preassigned degree. Work is also being done on obtaining extensions of theorems which measure how closely numbers of a given type can be approximated by rational numbers.

Transformation Groups (U), RR 003-01-0030. University of Michigan, Ann Arbor, Michigan, Department of Mathematics; Nonr 2942(00), NR 043-231; C. N. Lee.

Research was carried out in the field of topological transformation groups. In particular, an attempt was made to compute the integral cohomology of an orbit space for general compact abelian Lie groups.

Lie Algebras and Groups (U), RR 003-01-0031. Columbia University, New York, New York, Department of Mathematics; Nonr 2909(00), NR 043-232; E. S. Rapaport and R. Lee.

Research was carried out in the theory of topological groups and in Lie algebras.

Differential Geometry (U), RR 003-01-0032. Yale University, New Haven, Connecticut, Department of Mathematics; Nonr 609(36), NR 043-233; R. C. Sacksteder.

Research was carried out in differential geometry. Special attention was given to the applications of maximum principles in partial differential equations and to differential geometry.

Algebraic Topology (U), RR 003-01-0033. Northwestern University, Evanston, Illinois, Department of Mathematics; Nonr 2919(00), NR 043-234; D. S. Lissner and M. A. Geraghty.

Research was carried out in the fields of algebraic topology, fibre bundles, and algebraic groups.

Triangulable Manifolds (U), RR 003-01-0034. University of Illinois, Urbana, Illinois, Department of Mathematics; Nonr 2989(00), NR 043-237; S. S. Cairns.

Research was carried out on fundamental problems in analysis and topology on a manifold. In particular, attention was given to the problem of making a triangulable manifold analytic.

Homotopy Theory (U), RR 003-01-0036. Johns Hopkins University, Baltimore, Maryland, Department of Mathematics; Nonr(G) 00031-60, NR 043-240; M. A. Arkowitz.

The principal investigator will continue his past research on the generalized Whitehead product, determining when such products generate all multiple homotopy operations for homotopy groups with coefficients. This work suggests new approaches to the moot and interesting question of secondary homotopy operators which will be explored in detail.

Functions of a Complex Variable (U), RR 003-01-0037. Cornell University, Ithaca, New York, Department of Mathematics; Nonr(G) 00013-60, NR 043-241; G. R. Blakley.

The principal investigator has, in the course of previous research, found formulae expressing the power series coefficients of the kth power of an infinite series explicitly as polynomials in the a_n with coefficients which are number theoretic functions. His methods can be adapted to more general expansions and to power series in several variables. It is proposed to investigate applications of his results to number-theoretic and function-theoretic problems.

Fiber Bundles (U), RR 003-01-0038. Yale University, New Haven, Connecticut, Department of Mathematics; Nonr(G) 00012-60, NR 043-242; R. H. Szczarba.

Research is being carried out in algebraic topology, specifically in the theory of fiber bundles over spheres, real projective spaces and more complicated spaces.

Topology and Topological Groups (U), RR 003-01-0039. University of Virginia, Charlottesville, Virginia, Department of Mathematics; Nonr(G) 00011-60, NR 043-243; J. M. Kister and L. N. Mann.

Dr. Kister is working on problems concerned with isotopic deformations and related transformation types in 3-manifolds and n-dimensional Euclidean spaces and spheres. Dr. Mann is pursuing research on transformation groups, where his work has been closely related to that of Professor Floyd (at the University of Virginia) on the fixed point sets of the toral group operating on homological manifolds.

Lattice Theory (U), RR 003-01-0040. University of Washington, Seattle, Washington, Department of Mathematics; Nonr 477(31), NR 043-244; P. L. Crawley.

Previous work of the principal investigator, in lattice theory, has led to deep problems concerning the decomposition theory for compactly generated atomic lattices. The importance of these lies in the fact that any lattice of congruence relations of an algebraic system is compactly generated. Certain specific examples have led to interesting theorems and are capable of richer generalizations.

Discrete Groups and Riemann Surfaces (U), RR 003-01-0041. Brown University, Providence, Rhode Island, Department of Mathematics; Nonr(G) 0002-61, NR 043-245; L. Greenberg.

An investigation was made of the groups of conformal self-transformations of Riemann surfaces. In addition to general problems, such as the nature of conformal groups associated with Riemann surfaces of a given genus, an attempt was made to answer the basic question: is every finite group realizable as the conformal group of some compact Riemann surface?

Partial Differential Equations and Lie Groups (U), RR 003-01-0042. Yeshiva University, New York, New York, Department of Mathematics; Nonr 3259(01), NR 043-246; L. Ehrenpreis.

Research is being done in abstract analysis and its applications to partial differential equations,

primarily those with constant coefficients, where such phases as (1) general boundary value problems, (2) eigenfunction expansion, (3) lacunas, and (4) pseudoconvexity questions will be studied. Secondarily, the extension of these results to variable coefficient equations will be attempted, and other independent attacks will also be explored. In the second phase of the research, previous results (of the principal investigator and others) in the theory of semi-simple Lie groups will be extended, with divers applications.

Differential Geometry (U), RR 003-01-0043. Dr. Harley Flanders, Berkeley, California; Nonr 3262(00), NR 043-247; H. Flanders.

The principal investigator pursed his past results in the investigation of convex hypersurfaces described by a function of n-variables in the Euclidean space of n+1 dimensions. The basic problems were concerned first with the determination of all minimal hypersurfaces defined in the whole Euclidean n-space by such a function, and secondly with the question of which relations between the invariants of the matrix of second derivatives of a convex hypersurface force the function defining the surface to be quadratic.

Constructive Consistency Proof for Classical Analysis (U), RR 003-01-0044. Ohio State University Research Foundation, Columbus, Ohio, Department of Mathematics; Nonr 495(23), NR 043-248; C. Spector.

A thorough study of inductive definitions is planned, with attention to the possibility of answering four questions: (1) is Kreisel's new induction axiom derivable within the accepted formalism of the intuitionistic theory of functionals of finite type? (2) if not, can it be accepted as an intuitionistic axiom? (3) can the new axiom be made more convincing as a derivation or as an intuitionistic axiom by restricting the class of functionals under consideration? and (4) what is the proper definition of "constructive"? Some time may be spent on applying the methods developed to systems richer than analysis, and to making the consistency proofs even more constructive.

Combinatorial and Algebraic Topology (U), RR 003-01-0045. Dartmouth College, Hanover, New Hampshire, Department of Mathematics; Nonr 3309(00), NR 043-250; R. Z. Norman and R. H. Crowell.

The techniques of homological algebra will be applied to knot theory. Computation of invariants from the matrix of certain group representations will be programmed on machines capable of handling symbolic computation. Another aspect of this investigation will be analysis of the interrelation of the topic of linear inequalities (including linear programming) with that of combinatorial analysis (including graph theory). Work will be done concerning the problem of enumerating combinatorial structures, including enumeration of transitive relations, self-dual graphs, strongly connected directed graphs, planar graphs, and others.

R003-02 Applied Analysis and Mathematical Physics

Fluid Dynamics and Related Mathematical Studies (U), RR 003-02-0001. New York University, New York, New York, Institute of Mathematical Sciences; Nonr 285(46), NR 041-019; J. J. Stoker.

The Institute of Mathematical Sciences of New York University, whose basic research activities are partially supported by this task, constitutes certainly one of the strongest groups of applied mathematicians in the United States. It pursues an integrated program of fundamental research combined with the training of junior personnel in the fields of advanced mathematical analysis, mathematical physics, numerical analysis, and theoretical mechanics, particularly fluid dynamics.

Work is in progress, or has recently been completed, on the flow of compressible fluids around bodies with and without the formation of cavities, on the motion of a ship in a seaway, on the general theory of floating bodies, on the instability of liquid surfaces, on the existence and uniqueness of solutions of partial differential equations (especially those of fluid dynamics), on numerical methods for solving partial differential equations, on the motion of shock waves, on shock diffraction, on the buckling of elastic shells, etc.

Mathematical Mechanics (U), RR 003-02-0002. Indiana University, Bloomington, Indiana, Graduate Institute for Mathematics and Mechanics; Nonr 908(09), NR 041-037; J. W. T. Youngs, V. Hlavaty, E. Hopf and T. Y. Thomas.

Investigations of a number of related phases in the theory of partial differential equations are carried on as needed for solving problems in the mechanics of continuous media. Particular attention is being given to the following: (a) the characterization by means of methods of differential geometry of surfaces and other loci playing a role in describing the dynamic behavior of a continuous medium (shock surfaces and streamlines in fluid flows, slipping surfaces and acceleration discontinuities in the deformation of plastic solids are examples); (b) the study of fluid flows with free boundaries exploiting variational and comparison methods; (c) the derivation and analysis of partial differential equations describing on a phenomenological basis nonclassical effects in the mechanics of fluids and solids, e.g. non-Newtonian viscous behavior, non-Hookian elasticity, etc.; (d) the use of measure-theoretical methods and functional analysis in problems of statistical fluid mechanics with attention to turbulence.

Applied Analysis (U), RR 003-02-0003. Stanford University, Stanford, California, Department of Mathematics; Nonr 225(11), NR 041-086; D. Gilbarg.

This task supports an outstanding research group in applied mathematics whose investigations, built around the exploitation of new analytical methods, cover basic mathematical problems in various fields. The primary effort is in hydrodynamics and related fields of fluid mechanics, emphasis being given to cavities, water entry, and subsonic fluid flow. Numerical aspects of the theory of free surfaces and a unified treatment of cavitation and detached shock waves will be stressed. The methods employed are of the modern variational type which identify á flow field or some important and characteristic aspect thereof by extremal properties which furnish

a basis for establishing the existence and assist in the explicit construction of specific flows. Three-dimensional cavity flows, water entry flows around missile heads, surface waves, etc., are being analyzed in this fashion. Some specific problems of military interest in these contexts are being treated.

In addition there will be basic investigations in the fields of electromagnetic theory, nonlinear oscillations, existence problems of nonlinear partial differential equations, operator methods for partial differential equations in three independent variables, and numerical aspects of eigenvalue problems.

Differential Equations and Applications (U), RR 003-02-0005. University of Southern California, Los Angeles, California, Department of Mathematics; Nonr 228(09), NR 041-152; D. H. Hyers.

Research is being undertaken in various areas of applied analysis: (a) the study of existence theorems for certain hydrodynamical problems will be continued, with a shift of emphasis to cases involving nonlinear boundary conditions (it is hoped that the study of particular nonlinear eigenvalue problems will shed light on the problems in the large for surface waves); (b) reducibility criteria for systems of ordinary differential equations are being investigated (these yield stability criteria and results on the asymptotic behavior of solutions of related nonlinear equations); (c) the theory of elliptic partial differential equations is being applied to differential geometry in the large. Attempts are being made to generalize results in the theory of minimual surfaces to other classes of surfaces, such as surfaces with constant mean curvature.

Fluid Mechanics and Diffusion Theory (U), RR 003-02-0007. Harvard University, Cambridge, Massachusetts, Department of Engineering and Applied Physics; Nonr 1866(34), NR 041-188; S. Goldstein and G. Birkhoff.

Important problems in a number of areas in applied mathematics are being investigated. These include questions in compressible flow, turbulence, stability of laminar flows, wave resistance, magneto hydrodynamics, slowing down of neutrons, and reactor theory.

Boundary Value Problems of Electromagnetic Diffraction (U), RR 003-02-0008. Brown University, Providence, Rhode Island, Department of Engineering; Nonr 562(24), NR 041-199; R. D. Kodis.

Research is being conducted in a number of areas in electromagnetic theory including radiation problems, high frequency scattering, excitation of harmonic currents in a plasma, and tropospheric propagation.

Elliptic Partial Differential Equations (U), RR 003-02-0009. University of California, Berkeley, California, Department of Mathematics; Nonr 222(62), NR 041-214; C. B. Morrey and H. Lewy.

Research is being undertaken in a number of areas of partial differential equations, and on problems concerning analytic functions of several complex variables as viewed from the theory of partial differential equations. In addition, there will be research on general boundary value problems for elliptic and parabolic equations. The following are some of the problems investigated: (a) the theory of linear and quasilinear elliptic equations, in particular with reference to a priori estimates inside and on the boundary of a domain; (b) the study of atypical differential equations and their relation to over-determined systems. The approach will involve the theory of regular functions of several complex variables; (c) free boundary problems for parabolic equations; (d) the application of harmonic functions and integrals to questions of differential geometry in the large; (e) the geometry and topology of analytic manifolds as applied to the theory of analytic functions of several complex variables; (f) generalizations of the Maximum Principle.

Differential Equations of Wave Propagation (U), RR 003-02-0010. University of California, Berkeley, California, Department of Mathematics; Nonr 222(60), NR 041-221; B. Friedman and S. P. Diliberto.

The ordinary and partial differential equations occurring in wave propagation and coupled oscillations are being studied under Professors Friedman and Diliberto. In particular, the following questions are examined in some detail: (a) the generalization of Floquet's theorem to ordinary differential equations with almost periodic coefficients, (b) the expansion theory for non-self-adjoint eigenvalue problems with methods of locating complex and virtual eignevalues, (c) the asymptotic behavior of solutions of the wave equation at large distances from the scatterers.

Quantum Field Theory (U), RR 003-02-0011. New York University, New York, New York, Physics Department; Nonr 285(40), NR 041-224; B. Zumino.

Problems of the quantum theory of fields and its application to the theory of elementary particles are being investigated. Group theory and function theory are used to classify all possible Lorentz-invariant quantum field theories for free as well as interacting fields. The same methods are also being used in the hope of developing a systematic theory of the origin and role of dispersion relations in quantum field theories. In addition, previous work of van Hove and Zumino is being applied to the development of a consistent perturbation theory, to all orders, for the construction of the physical states describing decaying particles.

Nonlinear Controls (U), RR 003-02-0012. N. Minorsky, Domaine de L'arc, Aix-en Provence, France; N62558-2167, NR 041-226; N. Minorsky.

As a logical continuation to his work on the theory of nonlinear oscillations, Dr. Minorsky has recently turned his efforts to the development of a comprehensive mathematical theory of nonlinear control systems, taking into account the significant advances which have been made since World War II, especially in the U.S.S.R. The very powerful operational methods, which have been so successful for linear systems, and linear approximations of mildly nonlinear ones, will be augmented by direct analysis of the governing nonlinear differential equations along the lines of the intensive Russian work of recent years. In addition, methods of synthesis

will be investigated, wherein nonlinearities are introduced in a system to produce a desired result.

Mathematical Physics (U), RR 003-02-0013. New York University, New York, New York, Institute of Mathematical Sciences; Nonr 285(44), NR 041-228; R. Courant.

Research is being undertaken in partial differential equations, particularly of hyperbolic type. This work will lead to a complete revision of "Methods of Mathematical Physics" by Courant-Hilbert. This treatise has served for decades as the authoritative source for mathematical methods and techniques associated with the numerous problems representable as boudary value problems. In view of the great strides which have been made in recent years in such areas as partial differential equations and functional analysis, many of them at N.Y.U. under Professor Courant's direction, there has been increasing demand for revision and updating of "Courant-Hilbert".

Ising Model (U), RR 003-02-0014. Institute for Advanced Study, Princeton, New Jersey, Department of Mathematics; Nonr 2969(00), NR 041-235; S. Sherman.

Research was carried out on the Ising Model for Ferromagnetism. Recent developments were extended to cover the as yet unsolved cases of (1) positive external magnetic field with nearest neighbor interaction, and (2) zero external magnetic field with next nearest neighbor interaction.

Symposium on Ordinary Differential Equations (U), RR 003-02-0015. RIAS, Baltimore, Maryland; Nonr 2996(00), NR 041-236; J. P. LaSalle and S. Lefachets.

The contractor held a symposium on Differential Equations at the National University of Mexico from 7 September to 12 September 1959. This symposium stressed modern work in nonlinear differential equations in which the Russian effort has been outstandingly successful.

Seminar in Physical Theories (U), RR 003-02-0016. American Mathematical Society, Providence, Rhode Island; Nonr 3081(00), NR 041-238; G. L. Walker.

The purpose of this task was to organize a summer seminar on "Modern Physical Theories and Associated Mathematical Developments".

The seminar consisted of lectures and discussions in the forefront of modern mathematical physics. The aim was to bridge the gap between recent physical theories and newer advances in mathematics. A very distinguished group of physicists and mathematicians delivered the main lectures.

Electromagnetics and Magnetohydrodynamics (U), RR 003-02-0017. Adelphi College, Garden City, New York, Graduate Mathematics Department; Nonr 3360(01), NR 041-252; H. C. Kranzer and J. Radlow.

Work will be directed at some basic problems of magnetohydrodynamics, e.g. the role of slow magnetohydrodynamic waves, the stability of "mixtures" of plasma and magnetic fields in magnetic mirror machines, and the shock dynamics of the so-called guiding center fluid. A second phase of the research will be directed toward special problems of classical electromagnetism.

Applied Analysis and Mathematical Physics, SR 003-02-0001. David Taylor Model Basin, 10169, 820- Dr. F. Theilheimer; Midwest Research Institute, Mr. Y. L. Luke; George Washington University, Dr. N. T. Grisamore; Scripps Institution of Oceanography, Dr. W. H. Munk; Brown University, Professor R. D. Kodis; Carneigie Institute of Technology, Professor J. Muth.

The task of Research in Mathematical Techniques is primarily concerned with the development of new improved methods of solving problems in the field of Applied Mathematics with the particular view of utilizing digital high-speed computers in the solution of such problems.

The previously developed methods for the determination of power spectra have been extended. A considerable number of analog data on magnetic tape representing the output of hydrophones were transformed into a form acceptable to a digital computer. Then the various methods for finding spectra by digital methods were applied. This was done primarily with the view to testing methods for classification of sound sources. The methods developed primarily for spectral analysis of underwater sound could also be adapted to a number of problems arising in the Hydromechanics and Structural Mechanics Laboratories of DTMB.

In the study of the applications of high speed computer techniques to the determination of ship lines the methods were extended so that a list of full scale offsets for LPD-1 could be determined in a problem submitted by New York Naval Shipyard.

R003-03 Numerical Analysis

Numerical Methods (U), RR 003-03-0001. University of Illinois, Urbana, Illinois, Digital Computer Laboratory; Nonr 1834(27), NR 044-001; D. E. Muller.

Research is being undertaken in numerical analysis, on Monte Carlo tecnniques, and on the theory of switching functions. Work in numerical analysis includes the study of iterative methods for solving large systems of linear algebraic equations. Monte Carlo techniques are used for solving problems in theoretical physics and physical chemistry. The object of the research in switching theory is to investigate the logical structure and behavior of information handling devices and to develop mathematical methods for describing and synthesizing them.

Whirlwind (U), RR 003-03-0002. Massachusetts Institute of Technology, Cambridge, Massachusetts, Computation Center; N5ori 6001, NR 044-008; P. M. Morse.

This task supported research in numerical analysis and the formulation of scientific problems in forms suitable for computation on a high-speed automatic computer. A faculty committee selected from the applicants for support and computer time those whose problems were of the greatest scientific interest and utility and which, at the same time, were likely to lead to improved methods for the application of automatic computers. This task provided partial support of both the

maintenance of the Whirlwind computer and the research conducted in connection with the development of high-speed digital computer components, particularly magnetic memory devices.

Numerical Analysis Research (U), RR 003-03-0003. University of California, Los Angeles, California, Department of Mathematics; Nonr 233(24), NR 044-144; C. B. Tompkins.

The objectives of the Numerical Analysis Research group generally include basic research in mathematics pertaining to, or requiring the use of, high speed automatic computing machinery, dissemination of the results of this research, and training personnel in the efficient application of mathematical techniques to the operation of high speed computing machines. Support is required for the functions described separately below: (a) research in mathematics basic to numerical analysis with particular attention being paid to problems developing from experience with the SWAC computing facility; (b) continuing use of a computing facility (including SWAC) to support research involving extensive computation with the understanding that the University will continue to maintain the computer; (c) providing a specialized library in subjects important in numerical analysis for area use.

Numerical Analysis and Related Topics (U), RR 003-03-0004. National Bureau of Standards, Washington, D. C., Department of Commerce; NAonr 16-60, NR 044-151; M. Newman.

Research is being conducted on mathematical topics relevant to the development of numerical analysis; special attention is being given to discrete structures appearing in algebra and number theory. Relationship to computer practice plays an important role in the direction of the research effort.

General Harmonic Analysis (U), RR 003-03-0005. University of Rochester, Rochester, New York, Department of Mathematics; Nonr 2405(00), NR 044-195; W. F. Eberlein.

Research was undertaken in general harmonic analysis and ergodic theory, with particular emphasis on the theory of numerical integration. Work on the development of a new type of integral defined over spaces of analytic functions was continued. The behavior of partial sums of power series as martingales and the problem of classification of ergodic measure preserving transformations on an infinite measure space were studied.

Eigenvalue Computations (U), RR 003-03-0007. Stanford University, Stanford, Connecticut, Department of Mathematics; Nonr 225(37), NR 044-211; G. E. Forsythe.

This task is concerned with new methods for (a) computing eigenvalues of elliptic differential equations by finite difference methods; (b) computing eigenvalues of non-symmetric matrices; and (c) computing zeros of analytic functions by iterative methods. In addition, further investigation is being made of the Jacobi method for computing eigenvalues. Both theoretical analysis and machine testing are required for all these problems.

Computations in Algebra and Analysis (U), RR 003-03-0008. California Institute of Technology, Pasadena, California, Department of Mathematics; Nonr 220(31), NR 044-213; A. Erdelyi and J. Todd.

Investigations in numerical analysis and differential equations are carried out under this task. The research emphasis is on approximation methods for eigenvalue problems in finite and infinite dimensional spaces. In addition, theoretical background studies are being made in relevant areas of algebra and differential equations.

Symbolic Operations on Computers (U), RR 003-03-0009. Dartmouth College, Hanover, New Hampshire, Department of Mathematics; Nonr 2549(00), NR 044-222; J. G. Kemeny.

A study was made of the ability of high speed digital computers to handle symbols and formulas and to get symbolic solutions to problems. Investigation covered (a) exploring the general problem of how a digital computer can be used for symbolic work, (b) developing a machine language in which symbolic work can be easily carried out, (c) writing a detailed "flow-diagram" adaptable to any high speed machine for the carrying out of one important class of problems, (d) writing a program according to this "flow-diagram" for the IBM 704 and (e) making recommendations for new designs in computing machines that would adapt them better for symbolic work.

Methods for High Speed Computing (U), RR 003-03-0010. Syracuse University Research Institute, Syracuse, New York, Department of Mathematics; Nonr 669(14), NR 044-196; H. J. Maehly.

This task is concerned with formulating efficient procedures for solution on high speed automatic computers of large systems of algebraic equations, partial differential equations, integral equations, and other problems arising out of mathematical physics and applied mathematics. In particular, the following three areas are being investigated: (a) the approximation of transcendental functions by rational expressions involving division, such as continued fractions, with an analysis of rates of convergence, (b) the automatic computation of all roots of polynomials without requiring an initial guess, and (c) computation of the eigenvalues of real nonsymmetric matrices.

Motions of the Major Planets (U), RR 003-03-0011. Yale University, New Haven, Connecticut, Department of Astronomy; Nonr 609(15), NR 044-239; D. Brouwer.

This joint research task sponsored by the Yale University Observatory and the Naval Observatory is directed toward obtaining accurate knowledge of the motions of the principal planets of the solar system and of the configuration of the solar system. Another objective is the determination of expressions for the coordinates of the principal planets in a form capable of evaluation over any period of time, and which actually will represent all the existing observed positions. In conjunction with this research, the possibilities which new computing machines will offer for the solution of astronomical problems will be exploited.

Development of the International Computer Language ALGOL (U), RR 003-03-0012. University of

California, Berkeley, California, Department of Mathematics; Nonr 222(80), NR 044-249; R. DeVogelaere.

The work is divided into three phases: (a) a general investigation of the iteration and discretization methods and application of special cases to specific problems, namely nonlinear eigenvalue problems like those corresponding to the buckling of shallow spherical shells, the torsion rigidity of two-dimensional domains, etc.; (b) collaboration in the development of the international language ALGOL--an algebraic language to be adopted for international use in describing algorithms to any automatic computer; (c) development and evaluation of various methods of integrating differential equations, of solving boundary value problems, and eigenvalue problems of matrices.

Solution of Naval Engineering Problems (U), SR 003-03-0003. David Taylor Model Basin; 10169; TMB Code 840, Dr. J. W. Wrench, Jr.

A large number of original engineering problems have been programmed and solved on the IBM 704 system. The relevant fields of research include: energy spectrum analysis; strain distribution in reinforced cylindrical shells; response of a ship hull to an arbitrary transient excitation; transient motion of a submerged, elastic, non-uniform mooring cable; evaluation of signal strength and noise associated with very low frequency radio wave transmission; determination of stresses in new submarine hulls; shallow water sound transmission and reverberation; statistical analysis of tests of low-power transistors; neutron distribution after an arbitrary number of scatterings; noise isolation studies; antenna pattern calculations; the determination of the forces and moments on a submerged body due to a sea state; the design of nuclear reactors; and the energy spectrum analysis of underwater sound records.

Present work includes the analysis and programming of problems in these and similar fields, as well as the solution of recurrent engineering problems on high-speed digital computers. A major effort is being devoted to the programming of a three-dimensional burnout code for the ultra high-speed computer LARC, which will permit the expeditious calculation of life histories of nuclear reactors.

Such electronic computer calculations will continue on advanced computer systems such as the IBM 7090 and the LARC. Research and consultation on the solution of nuclear reactor design problems with Navy contractors such as the Bettis Atomic Power Division and the Knolls Atomic Power Laboratory will continue indefinitely.

Technical Solution of Data Analysis Problems, SR 003-03-0004. DTMB; 10169; Code 850, Mr. M. Siegel.

The objective of this task is the development and application of mathematical and computer techniques to the solution of large scale data analysis problems required in the management concerned with the design, construction, maintenance, and finance of U. S. Naval ships. During the past year, several important and far-reaching extensions to older Bureau of Ships problems have been undertaken. In addition to these, two new vital problems have been started. Research in the field of automatic programming has been chiefly confined to the development of advanced programming systems for LARC.

Many significant steps (including an on-the-scene study of the over-all operations of the Bureau of Ships, Code 625) have been taken to extend the Bureau of Ships Electronic Installation Record System Problem to include reports and data involving the procurement and allocation of electronic equipment. Major extensions have also been completed on the Bureau of Ships' Modified Bills of Materials Program which now provides answers to a wide variety of requests in the material requirements area.

R003-05 Mathematical Statistics and Probability

Statistical Inference (U), RR 003-05-0001. University of Chicago, Chicago, Illinois, Statistical Research Center; Nonr 2121(09), NR 042-001; P. Meier.

The purpose of this task is to extend knowledge in the field of statistical inference which embraces the broad problem of drawing conclusions from empirical data. Work centers around the development of the statistical basis of decision making, as well as the development of analytical methods serving as the basis of new techniques. The underlying theory of probability is being extended, and research work is done on nonparametric inference, stochastic processes, and sequential analysis.

Research in Statistical Aspects of Quality Control (U), RR 003-05-0002. Stanford University, Stanford, California, Applied Mathematics and Statistics Laboratory; Nonr 225(53), NR 042-002; G. Lieberman.

The objective of this research program is to extend statistical theory for quality control, including decision making rules, sampling, and quality estimation procedures for application by the three Military Services of the Department of Defense. The program includes the development of statistical methods for acceptance inspection of procured material, process control of manufactured material, surveillance of material in storage, and maintenance of material in use. In developing statistical quality control procedures consideration is given to the economic and administrative aspects of their application.

Mathematical Models for Quality Control (U), RR 003-05-0003. University of Minnesota, Minneapolis, Minnesota, Statistics Department; Nonr 710(31), NR 042-003; I. R. Savage.

Research under this task is for the development and analysis of statistical methods of quality control. Emphasis is being placed upon single stage sampling with suitable loss functions, two-stage sampling inspection plans, the study of stopping rules, inspection of items structured from components whose lot quality is known, and the economic value of statistical quality control.

Development of Statistical Methods for Quality Control and Surveillance Testing (U), RR 003-05-0005. Virginia Polytechnic Institute, Blacksburg, Virginia, Department of Statistics; Nonr 2352(01), NR 042-019; R. J. Freund.

Under this task research centered on the development of statistical methodology for use in quality control and surveillance for the Department of Defense. Research included the investigation of problems in experimental design, non-parametric tests of significance (including ranking techniques) and the analysis of data where observations were recorded by subjective ratings. Such techniques aid in statistical planning for the collection of useful data and in its analysis by providing economic and effective tools which have a proper balance of simplicity in application and power in control of risks incurred in making decisions.

Small Sample Theory (U), RR 003-05-0006. Princeton University, Princeton, New Jersey, Department of Mathematics; Nonr 1858(05), NR 042-023; S. S. Wilks.

In research and development work the number of tests or trials of a piece of apparatus or a procedure is often severely limited by expense or time. Under such conditions the statistical theory of small samples is important in evaluating the reliability of conclusions and in determining the number of trials required to assure a specified degree of confidence in conclusions reached from sample observations.

Multivariate Analysis and Stochastic Processes (U), RR 003-05-0007. University of North Carolina, Chapel Hill, North Carolina, Department of Statistics; Nonr 855(06), NR 042-031; H. Hotelling.

Research is being conducted on the problem of moments. Of particular interest are extensions of the theory of inequalities on a distribution, designs for experiments involving the finding of a maximum of a function of more than one variable, and an approach to moments through use of orthogonal polynomials.

Decision Theory and Sequential Analysis (U), RR 003-05-0008. Columbia University, New York, New York, Department of Mathematical Statistics; Nonr 266(33), NR 042-034; T. W. Anderson.

This task conducts research in the theory of statistical decision functions and statistical inference. Emphasis is placed on the extension of theory for multivariate analysis; sequential analysis; and decision among several hypotheses (more than two); on formulation of various principles of statistical inference including the non-parametric case; on statistical theory and methods pertaining to measurement problems; and on the investigation of statistical and mathematical problems in genetics and evolution.

Statistical Estimation and Testing Hypotheses (U), RR 003-05-0009. University of California, Berkeley, California, Department of Mathematical Statistics; Nonr 222(43), NR 042-036; J. Neyman.

The purpose of this task is to extend the theory of mathematical statistics and probability in three main directions: (a) theories of testing statistical hypotheses and methods of estimation; (b) theory appropriate to special fields of application including astronomy and logistics; and (c) probability theory with reference to convergent sequences of sums of independent random variables, and to sums of a random number of random variables.

Selection Theory and Non-Parametric Inference (U), RR 003-05-0010. University of Washington, Seattle, Washington, Laboratory of Statistical Research, Department of Mathematics; Nonr 477(11), NR 042-038; Z. W. Birnbaum.

This task investigates statistical problems associated with selection procedures (such as those used in personnel selection), problems involving non-parametric methods and distribution-free statistics, stochastic processes, and selected problems in reliability. In each of these main lines of research the problems are carried through the full development from the basic mathematical theory to the formulation of techniques applicable in practical work.

Research in Probability and Statistics (U), RR 003-05-0011. Cornell University, Ithaca, New York, Department of Mathematics; Nonr 401(03), NR 042-064; J. Wolfowitz.

Research is performed in probability and mathematical statistics. In probability theory emphasis is placed on the theory of stochastic processes which has important applications in many fields and which is also indispensable for the development of modern statistical methods; stochastic approximation and sequential search methods are also investigated. In statistics the emphasis is on the Wald theory of statistical decision functions, experimental design, the classical theory of estimation, and non-parametric inference. There is also work in the theory of games, particularly in its points of contact with decision functions.

Statistical Classification Techniques (U), RR 003-05-0012. Purdue University, Lafayette, Indiana, Statistical Laboratory; Nonr 1100(11), NR 042-074; H. Teicher.

The purpose of this task was to develop techniques for the classification of individuals as belonging to one of several populations on the basis of measurements of the individuals and of samples drawn from the populations. Research included study, comparison and extension of various classification techniques including the generation of empirical distributions and study of the robustness of classification statistics. Research in probability theory, particularly on the mixture of probability distribution, was also conducted.

Time Series Analysis and Random Processes (U), RR 003-05-0014. Indiana University, Bloomington, Indiana, Department of Mathematics; Nonr 908(10), NR 042-094; M. Rosenblatt.

Research was performed on estimation and prediction in time series which is of direct value in communication engineering, aerodynamic turbulence, and ocean wave analysis.

This line of research is now being pursued under task NR 042-217.

Research in Statistical Theory (U), RR 003-05-0015. Harvard University, Cambridge, Massachusetts, Department of Statistics; Nonr 1866(37), NR 042-097; W. G. Cochran.

Research is being conducted for the extension of statistical theory in several important fields including (a) sampling methods; (b) decision theory for multivariate distributions; (c) experimental

design; (d) regression methods; (e) discriminatory analysis.

Statistics and Probability Research in Surveillance and Maintenance Quality Control (U), RR 003-05-0017. Columbia University, New York, New York, Department of Statistics; Nonr 266(55), NR 042-099; C. Derman.

Research under this task is for the development of statistical theory for economic control of the quality of materials in storage or in use by surveillance sampling methods. It includes research leading to the determination of stock issue policies which specify the ages at which items should be withdrawn from inventory to maintain a desired level of quality.

Statistical and Probabilistic Aspects of Decision Problems (U), RR 003-05-0018. University of Minnesota, Minneapolis, Minnesota, Department of Statistics; Nonr 2582(00), NR 042-200; I. R. Salvage.

Research under this task is for the development, extension, and application of methods of mathematical statistics, probability and econometrics to problems which arise in decision making under uncertainty and/or risk. Emphasis is placed on nonparametric inference for decision making, multivariate analysis and stochastic processes.

Statistical Research on Life Testing, Fatigue Testing and Reliability (U), RR 003-05-0019. Wayne State University, Detroit, Michigan, Department of Mathematics; Nonr 2575(00), NR 042-201; B. Epstein.

This task is for basic research in the statistical theory of the life and fatigue testing aspects of reliability. This research includes the study of accelerated life tests, development of statistical methods for analysis of variance and regression theory in designing life tests and evaluating reliability needs; models for inferring reliability of complex assemblies from the reliability of subassemblies; role of the conditional rate of failure function in life testing and reliability; tests for validity of the exponential assumption and robustness studies of statistical tests based on the exponential assumption.

Statistical Theory for the Interpretation of Experimental Data (U), RR 003-05-0020. North Carolina State College, Raleigh, North Carolina, Department of Experimental Statistics; Nonr 486(04), NR 042-202; C. Cockerham.

This task conducted research in statistical theory as related to practical questions of data interpretation. Research was conducted in multivariate analysis, including discriminatory analysis for classification problems, regression for dependent and independent variables, inference from discrete data, and an application to the problem of reliability of a process or mechanism of many individual stages or components. Statistical inference by non-parametric methods and sequential sampling methods of estimation for population proportions formed part of the research program.

Theory of Toeplitz Forms and Its Relation to Certain Stochastic Processes (U), RR 003-05-0021. University of Minnesota, Minneapolis, Minnesota, Department of Mathematics; Nonr 710(28), NR 042-203; F. Spitzer.

This task is for research in probability theory with emphasis on the development of the theory of Toeplitz forms and its application to stochastic processes. In particular, Markov processes and general stationary processes are being considered.

Probability Theory and Application (U), RR 003-05-0023. Columbia University, New York, New York, Department of Mathematics; Nonr 266(59), NR 042-205; H. E. Robbins.

The purpose of this task is to extend the theory of probability and its applications. Emphasis is placed on stochastic processes, e.g., processes arising in renewal theory, queueing, statistical mechanics and the statistics of particles. Probability limit laws and methods of stochastic approximation are among other topics for investigation.

Statistical Methods and Programming Mathematics (U), 003-05-0024. New York University, New York, New York, Institute of Mathematical Sciences; Nonr 285(38), NR 042-206; W. Hirsch.

Research under this task deals with statistical theory of estimation and testing hypotheses, the refinement and extension of probability limit laws, problems in queueing and other distribution systems, linear programming problems other than the simplex method, and with problems of dynamic programming. In both estimation theory and testing hypotheses emphasis is placed on creation of a theory which is both useful and practical from the point of view of the empirical scientist. Regarding investigations in the areas of linear programming and dynamic programming, emphasis is directed toward applications to solve logistical problems.

Statistical Design of Experiments (U), RR 003-05-0025. Iowa State University of Science and Technology, Ames, Iowa, Statistical Laboratory; Nonr 530(05), NR 042-207; O. Kempthorne.

Under this task, research is conducted in mathematical statistics for the statistical design and analysis of experiments. Particular attention is given to multi-factor experiments for exploring the response surface of a variable as a function of many factors operating at various levels.

Inverse Fourier Transforms (U), RR 003-05-0026. Oregon State University, Corvallis, Oregon, Department of Mathematics; Nonr 1286(07), NR 042-208; F. Oberhettinger.

This task was for the preparation of a table of inverse Fourier transforms which will be included as part of a catalog of Fourier transforms of distribution functions.

Multiple Decision Theory (U), RR 003-05-0027. Professor E. L. Lehman, Mathematics Institute, University of Zurich, Zurich, Switzerland; Nonr 2842(00), NR 042-209; E. L. Lehmann.

Under this task, research was conducted to extend the theory of multiple decision procedures which extended the classical theory of testing statistical hypotheses as a decision rule for choosing between two completing hypotheses to a

decision procedure for choosing among many (more than two) hypotheses.

Evaluation of the Use of Certain Statistical Techniques in Reliability Analysis (U), RR 003-05-0028. Battelle Memorial Institute, Columbus, Ohio, Mathematical Physics Division; Nonr 2864(00), NR 042-210; A. E. Mace.

Research under this task was to evaluate, from a logical and rigorous theoretical basis in mathematical statistics, the use of a combination of statistical techniques which have been applied with success in the evaluation and selection of electronic components for improving equipment reliability. In addition, a careful exposition of the method together with its evaluation was to be prepared for consideration by other research workers.

Development and Testing of Statistical Genetic Models (U), RR 003-05-0029. Cornell University, Ithaca, New York, Department of Plant Breeding, Biometrics Unit; Nonr 401(39), NR 042-212; W. T. Federer.

The research under this task is for the development of statistical procedures in estimation and testing of quantitative genetic models constructed for studying the inheritance of quantitative characteristics. Complicating phenomena such as linkage, epistasy and differential fertility will be considered. Genetic experiments will be conducted as a basis for testing and modifying the models. The statistical theory of stochastic processes for studying selection processes, experimental design, and regression analysis for the study of phenotypic distributions for a collection of genotypes will be investigated.

Theory of Stochastic Processes (U), RR 003-05-0030. University of North Carolina, Chapel Hill, North Carolina, Statistics Department; Nonr 855(09), NR 042-214; W. L. Smith.

The purpose of this task is to extend the theory of stochastic processes and its applications, and to extend the theory of sequential analysis. Emphasis is placed on renewal theory, including inference problems for superposed renewal processes, and on characterizing stochastic processes such as those which arise in the theory of queues and dams and electronic counter processes.

Statistical Procedures for Computers, Basic Research and Time Series (U), RR 003-05-0031. Rutgers - The State University, New Brunswick, New Jersey, Statistics Center; Nonr 404(16), NR 042-215; M. B. Wilk.

This task is to conduct research on statistical theory and methods to fill the need for methods suitable for high speed computers, to work on statistical techniques to meet the current needs expressed by investigators carrying out basic research, and to conduct research on stochastic processes. Specifically, this task will be concerned with problems such as: optimum computing programs (numerical and logical) for doing general linear hypotheses regression computations; generally appropriate computing procedures for nonlinear least squares; classifications of and tests for certain kinds of non-additivity in n-way arrays; investigations of non-central t and beta distributions; practical procedures for defining confidence regions when the unknown parameters appear non-linearly; and measures of experimental error in situations where the nature of the appropriate model is unknown.

Statistical Decision Theory (U), RR 003-05-0032. Stanford University, Stanford, California, Department of Statistics; Nonr 225(21), NR 042-993; C. Stein.

The purpose of this task is to conduct research on problems relating to statistical decision theory. Asymptotic decision procedures are being developed and used in connection with classification procedures and prediction theory. The application of decision theory to problems of the design of experiments and to special classes of distributions, including multivariate distributions, will be studied. Research will also be done on the theory of statistical inference for stochastic processes including statistical communication theory.

Statistics in Geology (U), RR 003-05-0034. University of Chicago, Chicago, Illinois, Department of Geology; N6ori 020(58), NR 042-998; R. L. Miller.

This task was for research in the application of statistics to geology. Various statistical methods were surveyed with the aim of determining their suitability for application in the Earth Sciences. Illustrative examples and problems from actual cases in the various branches of Geology were discussed. The use of nonparametric methods was stressed.

Subjective Testing and Quality Evaluation (U), RR 003-05-0035. The Florida State University, Tallahassee, Florida, Department of Statistics; Nonr 988(08), NR 042-004; R. A. Bradley.

Research under this task is concerned with the use of experimental designs and quality evaluation in production, experimentation on the effects of environmental conditions on items in storage, and the use of ranking and scoring experiments based on subjective appraisals of individuals on quality and stability of quality of items such as foods, photographic materials, and military commodities.

Statistical Inference in Stochastic Processes (U), RR 003-05-0036. Michigan State University, East Lansing, Michigan, Department of Statistics; Nonr 2587(02), NR 042-216; H. Rubin.

The purpose of this task is to investigate problems of statistical inference in stochastic processes. Research will be directed towards studying processes which assume only discrete states, estimating points of discontinuity in differential processes, estimating parameters of differential processes from discrete observations, and probabilistic problems in quantum mechanics.

Statistical and Probabilistic Analysis of Random Time Processes (U), RR 003-05-0037. Brown University, Providence, Rhode Island, Department of Mathematics; Nonr 562(29), NR 042-217; M. Rosenblatt.

Research is being conducted on stochastic processes and statistical and probabilistic techniques associated with time series analysis.

Statistical Aspects of Life-Testing and Reliability (U), RR 003-05-0038. Cornell University,

Ithaca, New York, Industrial and Engineering Administration; Nonr 401(43), NR 042-218; H. P. Goode.

The purpose of this task is to conduct research in the statistical aspects of life-testing and reliability in the following directions: (a) the construction of new acceptance-sampling plans for reliability inspection, (b) the devising of new quality control procedures for use with reliability data, (c) the formulation of meaningful increased-severity tests which can be used in conjunction with (a) and (b), (d) the undertaking of basic statistical research as needed for (a), (b), and (c).

Multivariate Analysis (U), RR 003-05-0039. Professor T. W. Anderson, University of Paris, Paris, France; Nonr 3279(00), NR 042-219; T. W. Anderson.

The research to be carried out under this contract will be on problems in multivariate analysis and statistical decision theory. Problems to be considered are (1) decision theoretic properties of classical multivariate decision rules and (2) prediction methods with multivariate measurements.

Stochastic Processes and the Reliability of Many Component Systems (U), RR 003-05-0040. Professor Z. W. Birnbaum, Institute Henri Poincare, Paris, France; Nonr 3352(00), NR 042-220; Z. W. Birnbaum.

This research is mainly concerned with Chebyshev type inequalities for stochastic processes and with the theory of reliability of systems with many components. The reliability of many component systems bears on practical problems of great interest to the Department of Defense.

Statistical Spectral Analysis of Time Series (U), RR 003-05-0041. Institutet for Forsakringsmatematik och Matematisk Statistik, Stockholm VA., Sweden; Nonr(G) 0003-61, NR 042-300; U. Grenander.

Research is being conducted on the statistical spectral analysis of stationary time series. In particular, the following are being investigated: (a) distribution of spectral estimates, including the use of saddle point approximations; (b) how to modify the standard method when more sophisticated sampling plans are used; (c) the design of spectral estimates and tests for stationarity when the process is harmonizable but not necessarily stationary; and (d) obtaining of approximations that are valid for non-Gaussian processes.

Statistical Quality Control, SR 003-05-1313. Stanford University, N6onr 25126, Professor G. J. Lieberman; Virginia Polytechnic Institutes, N6onr 2352(1), Professor R. J. Freund; Illinois Institute of Technology, Nonr 1406(05), Professor G. J. Resnikoff, Professor L. A. Wickstrom.

Research studies will be continued for the development and application of new theories, principles, techniques and methods which will be used to provide high assurance that Naval Equipment is of specified quality and reliability.

Stanford University, under contract with Office of Naval Research, is conducting studies and research in mathematical statistics for application to the evaluation of manufactured products. This project is supported by funds from BuOrd, BuWeps, BuDocks, Army Department and Air Force Department, as well as BuShips, and is a continuing program. Forty reports have been submitted by the contractor. Benefits are higher quality at no greater cost; reduced maintenance; longer life.

Life Test Acceptance Theory, SR 003-05-1300. Contractor, Contract, and principal investigator not yet selected.

To develop procedures which will enable testing for life length of material parts and equipment of specified life which is long in comparison with testing time. This work is to proceed along two lines: (1) non-parametric methods--to develop procedures which do not depend upon an assumption as to the underlying life distribution but which are almost as powerful as those which make such an assumption; (2) develop criteria for the selection of life distribution assumption and/or develop sampling acceptance procedures which simultaneously choose a failure rate assumption and estimate the parameters involved.

Reliability Measurement (U), SR 003-05-1303. Booz Allen Applied Research, Incorporated; NObs 84408; Dr. C. H. McCall, Jr.

Develop methods for determining a proper balance between the cost of demonstrating that a specified equipment reliability has been achieved and the degree of conformance to specified reliability.

Develop economic methods of evaluating the degree of reliability achieved at various stages of development of equipments and systems.

Redundancy Theory and Application (U), SR 003-05-1307. Contractor, contract, and principal investigator not yet selected.

Develop and extend mathematical probability formulation of redundancy to define design principles of use of redundancy to obtain higher reliability. Not always will the use of redundancy result in increased reliability--also, there is the matter of trade-offs as to costs, etc. Some work has been done. It is expected to provide funds for joint efforts with Bureau of Weapons in this area.

Robustness of Sampling Procedures Based on Exponential Distribution, SR 003-05-1317. Contractor, contract, and principal investigator not yet selected.

The purpose of this task is to (1) perform the necessary computations for robustness (degree to which departure from assumptions effect conclusions) for a wide variety of sampling plans in the forthcoming Department of Defense Handbook on life test inspection plans; (2) develop criteria for choosing from among available sampling plans (of identical operating characteristic curves).

Predictive Testing Techniques (U), SR 003-05-1311. Contractor, contract, and principal investigator not yet selected.

Develop techniques for the determination of life expectancy of parts from early characteristics measurements.

Statistical Design and Analysis of Experiment, SR 003-05-1314. Iowa State College, Ames, Iowa; NR 042-207; Professor O. Kempthorne.

The purpose of this task is to do research in statistical design and analysis of experiment. Particular attention is being paid to multi-factor

experiments for exploring the response surface of a variable as a function of many factors operating at various levels. Also attention will be given to the development of experimental designs which can be compared on bases which are invarient with regard to scales used for the input variables.

Funding will enable BuShips to contribute support to ONR on cooperative funding basis.

Computational Procedures for Multivariate Analysis, SR 003-05-1315. Contractor, contract, and principal investigator not yet selected.

The purpose of this task is to develop computational procedures for the solution of multivariate problems. These solutions are to be such that these computations will be feasible on the desk calculator.

Multivariate Analysis and Statistical Decision Theory, SR 003-05-1316. University of Paris, Paris, France; NR 042-219; Professor T. W. Anderson.

The purpose of this task is to do research in the problems in multivariate analysis and statistical decision theory. Two problems are to be considered: (1) decision theoretic properties of classical multivariate decision rules, (2) prediction methods with multivariate measurement.

R003-07 Logistical Analysis and Simulation

Naval Logistics Planning Studies (U), RR 003-07-0001. The George Washington University, Washington, D. C., Office of the Coordinator of Scientific Activities; Nonr 761(05), NR 047-001; W. H. Marlow.

This task is primarily concerned with the application of modern mathematical techniques and the use of data processing equipment in investigations of naval logistical problems. Such work involves the use of the techniques of operations analysis, mathematical statistics, econometrics, and simulation techniques, with or without the use of data processing equipment. Areas of investigation include: numerical simulation of naval actions in terms of logistical support; inventory management studies; transportation studies; and development of resupply procedures.

Combinatorial Problems of Mathematical Logistics (U), RR 003-07-0002. Princeton University, Princeton, New Jersey, Department of Mathematics; Nonr 1858(21), NR 047-002; A. W. Tucker.

Research under this task deals in general with combinatorial problems having their background in mathematical aspects of logistics. Particular subjects of investigation include (a) theory of 2-person and n-person games; (b) network theory--the relation between problems of distribution and transportation, and the topological and electrical theory of networks; (c) generalized programming methods.

Production Planning Study (U), RR 003-07-0003. University of California, Los Angeles, California, Department of Mathematics; Nonr 233(02), NR 047-003; J. R. Jackson.

The intent of this investigation is (1) to explore the possibilities of increasing the speed, accuracy, and efficiency of programming activities, and of allocating resources in production, through the development, test and simulated application of mathematical models of industrial production; (2) to develop qualitative description of the computing machinery necessary for high-speed computations required in such models; and (3) to explore the general application of mathematical methods to further managerial problems of production as these are encountered in and have an effect upon the basic study.

The Efficiency of Decision Making in Economic Systems (U), RR 003-07-0004. Stanford University, Stanford, California, Department of Economics; Nonr 225(50), NR 047-004; K. Arrow.

The purpose of this task is to investigate the character and efficiency of decision making in an economic system, particularly with regard to the mode of adjustments to external conditions. Research will be conducted to further the development and simplification of fundamental theorems on the existence and stability of competitive equilibrium and on conditions for optimal allocation of resources by competition and other devices. Research will be conducted concerning the actual behavior of the business world (business cycles).

Probabilistic Aspects of Logistics (U), RR 003-07-0005. Columbia University, New York, New York, Department of Industrial Engineering; Nonr 266(04), NR 047-005; S. B. Littauer.

Research under this task is devoted primarily to research in information theory. It is concerned with problems in coding, memory, and transmission of messages subject to chance errors. Various probabilistic and statistics problems relevant to decision theory, optimization of experimental design, and the methodology of logistics are being investigated.

Decision Making Under Uncertainty (U), RR 003-07-0006. Yale University, New Haven, Connecticut, Cowles Foundation, Department of Economics; Nonr 3055(01), NR 047-006; T. C. Koopmans, A. S. Manne.

Extended knowledge is being sought in the general area of decision making under uncertainty, particularly in decision situations characterized by the desire to optimize the value of some measure of accomplishment. The three fields of interest are (a) decisions by a single person; (b) decision problems arising in organizations; (c) the market economy as a particular form of decentralized organization.

Planning and Control of Industrial Operations (U), RR 003-07-0007. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Graduate School of Industrial Administration; Nonr 760(01), NR 047-011; G. L. Bach.

Research under this task is concerned with job shop and more generally, factory scheduling, analysis of control and coordination within organizations with emphasis upon information flow and information systems, and other special topics in the theory of decision making and control.

Study of Underdeveloped Resources in the U. S.

by Means of Modern Mathematical Methods (U), RR 003-07-0008. Princeton University, Princeton, New Jersey, Department of Economics; Nonr 1858(02), NR 047-017; O. Morgenstern.

This investigation was undertaken in cooperation with the National Academy of Sciences for the purpose of developing suitable methods for rational decision-making with respect to underdeveloped resources using modern mathematical and econometric techniques. The manganese problem was selected because of its immediate importance and because the problem includes a sufficient number of factors and complications to provide a real test of the applicability of proposed quantitative methods. Two models representing the manganese situation were developed. The first was a non-stochastic model. The second model also contained the main technological characteristics of the manganese situation and at the same time took into account the uncertainty of political forecasts ten years ahead of time.

Contributions to the Mathematical Theory of Programming (U), RR 003-07-0009. Brown University, Providence, Rhode Island, Department of Mathematics; Nonr 562(15), NR 047-018; D. Gale.

Research under this task is concerned with certain aspects of the theory of economic models. Specifically the major effort is directed towards problems with particular emphasis on problems of capital growth. The problems treated are closely related to some problems in mathematical programming.

Mathematical Methods in the Theory of Decision Making (U), RR 003-07-0010. Stanford University, Stanford, California, Department of Mathematics; Nonr 225(28), NR 047-019; S. Karlin.

The research conducted under this task is centered around the use of mathematical methods in the theory of decision making. In addition, it encompasses research in the management sciences including optimal inventory policies, variable demand distributions and variable and stochastic costs.

Time Constrained Logistical Decisions (U), RR 003-07-0012. Northwestern University, Evanston, Illinois, Department of Mathematics; Nonr 1228(10), NR 047-021; A. Charnes.

The contractor is conducting research in the general field of management sciences. Problems in temporal planning and management decision under risk and uncertainty are being attacked. Aspects of such problems are: (a) management models for assessing the timing of decisions related to expenditures and scarcity of funds; (b) the effect of obsolescence and/or the expectation of price change on acquisition decisions in time; (c) the evaluation of opportunity costs of fiscal decision and associated program effects; (d) the effect of risk and uncertainty in modifying plans; (e) techniques for handling uncertainty with a minimum of quantitative statistical knowledge; (f) models for assessing systems costs (joint costs) and evaluation of systems effort; (g) techniques for assessing the role and effect of competition on system behavior and status; (h) mathematical Models (or theories) which simulate the behavior of a system.

Linear Programming Theory (U), RR 003-07-0013. Rensselaer Polytechnic Institute, Troy, New York, Department of Mathematics; Nonr 591(13), NR 047-022; C. E. Lemke.

Research under this task is devoted to the area of mathematical theory techniques of linear programming. Particular efforts are being directed toward: (a) devising computational techniques for solving special classes of problems; (b) extending existing techniques to accommodate larger classes of problems; (c) extending the general theory of linear programming to special types of non-linear problems.

Digital Simulation Methods (U), RR 003-07-0014. Cornell University, Ithaca, New York, Department of Industrial and Engineering Administration; Nonr 401(32), NR 047-023; R. W. Conway.

Research was conducted on simulation techniques by the use of digital computers for management science and logistics problems. Digital simulation is a technique of using a numerical and logical model to reproduce the operating characteristics of a real physical system. Research was carried out to develop methods of digital simulation, determine properties of the technique and produce a general purpose simulation program leading to increased use as a valuable tool by government, industry and educational facilities. Emphasis was on medium-scale computers which are in general use, such as the IBM 650.

The Mathematical Structure of American Type Economics (U), RR 003-07-0020. Princeton University, Princeton, New Jersey, Department of Economics and Sociology; Nonr 1858(16), NR 047-086; O. Morgenstern.

Research conducted under this contract is concerned with: (a) the development of mathematical structures which will provide models relevant to the interrelation of production and supply in complex economic systems; (b) devising criteria and methods to permit selection of a single model which will match the American economic pattern; (c) attacking problems pertinent to Naval supply activities in the areas of logistics and strategy.

Logistics Computer Service (U), RR 003-07-0021. The George Washington University, Washington, D. C., Office of the Dean for Sponsored Research; Nonr 761(03), NR 345-107; W. H. Marlow.

The purpose of this task is to provide for maintenance and repair services, operation and continued research toward progressive design improvements for the Logistics Computer and other peripheral equipment to be operated for research purposes by the George Washington University Logistics Research Project. The operation of this equipment, which must necessarily include adequate maintenance, is an integral part of the research undertaken by the Logistics Research Project on the exploitation of electronic computer capabilities for purposes of effective logistic planning and control.

Port Terminal Operations Studies (U), RR 003-07-0022. University of California, Los Angeles, California, Department of Engineering; Nonr 233(07), NR 347-002; R. R. O'Neill.

Studies are being conducted on the land-water-land sequence of materials handling, including

tributary functions of transport from shipment origin to water site and the reverse; leading to (1) determination of time-space-energy utilized, minimum energy required and cost relationships for the loading of ships; (2) recommendation of changes in packaging, mechanisms, and procedures based upon minimum costs, time and/or energy required.

A Solution of Naval Logistics Problems by Means of Numerical Simulation (U), RR 003-07-0023. The George Washington University, Washington, D. C., Logistics Research Project; Nonr 761(06), NR 347-008; W. H. Marlow.

Research under this task is concerned with the use of established simulation techniques to determine optimum solutions of various problems in the logistics area. In addition, effort will be directed toward development of new simulation methods. It is expected that results will provide a bridging of the gap in communications between research and operating personnel. It is likely that alternate military plans involving logistics, strategy, and tactics will be generated and rapidly evaluated. Thus a means will be provided for facilitating the entry of research results into practice and compressing the time interval between conception of basic ideas and practical application of derived techniques. This task is an integral part of the overall "Applied Logistics Research" program and a substantial portion of the input for it comes from task NR 047-001, Logistics Planning Studies.

Symposium on Mathematical Methods in the Social Sciences (U), RR 003-07-0025. Stanford University, Stanford, California, Department of Economics; Nonr 225(49), NR 047-024; K. J. Arrow.

A symposium on Mathematical Methods in the Social Sciences was conducted under this contract. The primary aim was to present in an effective way the current research areas in which mathematical methods are being used to attack problems in the social and management sciences. The symposium was planned so that contributions would illustrate not only mathematical problems which arise in these areas but also substantive problems that have been or are being effectively tackled by the use of mathematical methods.

Error Estimation (U), RR 003-07-0026. Case Institute of Technology, Cleveland, Ohio, Department of Engineering Administration; Nonr 1141(06), NR 047-025; B. Dean.

The two general areas of research investigated were (1) information processing and (2) control procedures for dynamic systems. It is hoped that the theoretical results obtained will be applicable to the decision rules used in current and proposed naval inventory and supply systems.

Dynamic Economics (U), RR 003-07-0027. Purdue University, Lafayette, Indiana, Department of Economics; Nonr 1100(16), NR 047-026; S. Reiter.

Basic research is being conducted in mathematical economics and related subjects. The main problems under study are those concerning the relationship of modes of economic organization to the dynamic function of the economy. In addition, problems of interest are being considered from the fields of econometrics, operation research, management sciences, decision processes, and game theory.

Management Sciences Group (U), RR 003-07-0028. University of Maryland, College Park, Maryland, Mathematics Department; Nonr 595(13), NR 047-027; L. Cohen.

The group of mathematical scientists established at the University of Maryland and referred to as the Management Sciences Group, MSG, is engaged in problem-oriented research in the Management Sciences. The topics studied by MSG are generated basically by the problems encountered by the Management Sciences Staff, MSS, of the Navy Management Office. These problems are generally concerned with decision making in administrative and industrial activities. The raison-d'etre for each project is, fundamentally, some practical problem faced by Navy management. The emphasis is, however, in developing general mathematical theories and methodology which will be applicable to wide classes of problems rather than in developing methods and techniques for highly specific cases.

Data Processing (U), RR 003-07-0029. David Taylor Model Basin, Washington, D. C., Applied Mathematics Laboratory; P.O. 726, NR 047-028; H. Polachek.

At the request of Chief of Naval Operations the Navy Management Office conducted a study to determine the feasibility of a scientific approach to the problem of scheduling of aircraft assignments, overhauls, conversions, and procurement. A mathematical model of this problem was developed and a test problem utilizing historical data was generated. A computer routine was written for use on an IBM 704, which was used for the solution of this test problem. This task covered the computer time required to run the problem.

Economic Problems of Organization and Information (U), RR 003-07-0030. University of California, Berkeley, California, Department of Economics; Nonr 222(77), NR 047-029; R. Radner.

Research will be conducted on (a) the analysis of basic information systems, (b) estimation of future processing and computational requirements in large scale organizations, (c) methods for centralized and decentralized decision processes, and (d) linear and non-linear programming.

Basis for Determination of Research Level (U), RR 003-07-0031. Arthur D. Little, Incorporated, Cambridge, Massachusetts; Nonr 2516(00), NR 047-030; J. C. Hetrick.

The principle objective of this task will be to study some of the mathematical relationships between the segments of the research and development process as a means of gaining insight concerning optimal levels of effort in each segment of the process.

Sequential Decision Models (U), RR 003-07-0032. Case Institute of Technology, Cleveland, Ohio, Operations Research Group; Nonr 1141(08), NR 047-031; R. L. Ackoff.

Research is being conducted on developing "models of sequential decision making" which are decision making procedures which incorporate the

maximum amount of information which could be available before the decision must be made.

Conference of Mathematical Optimization Techniques (U), RR 003-07-0033. University of California, Berkeley, California, Statistics Department; Nonr(G) 0001-61, NR 047-032; R. M. Oliver.

Under this task, a Conference on Mathematical Optimization Techniques was conducted under the direct sponsorship of the University of California and the RAND Corporation for bringing together scientific speakers and discussants to stimulate the exchange of scientific information on mathematical optimization techniques.

Mathematical Models for Design and Control of Systems (U), RR 003-07-0034. University of California, Berkeley, California, Institute of Engineering Research; Nonr 222(83), NR 047-033; G. B. Dantzig.

Research under this task is concerned with mathematical models for the effective planning and control of operational systems. Techniques for integrating, in a precise way, the planning and execution function of large scale systems is being developed, including considerations of decentralized decision-making processes. Particular mathematical models for use in decision making are being considered, including linear models for product allocation and distribution network flow, queueing, and inventory models.

Construction of Econometric Models (U), RR 003-07-0035. Uppsala University, Uppsala, Sweden, Statistics Institute; N62558-2618, NR 047-300; H. O. A. Wold.

Research is being conducted on problems in the construction of econometric models. In particular, among other topics, the following comparisons are being investigated: (a) comparisons between interdependent systems with explicit causal chains; (b) comparisons between implicit causal chains and explicit causal chains; and (c) comparisons between bicausal chains and circular chains. Additionally, some work is being done towards the completion of a bibliography on time series and stochastic processes.

R003-08 Theories and Techniques of Information Processing

Logical Design of Computer Nets (U), RR 003-08-0001. University of Michigan, Ann Arbor, Michigan, Department of Philosophy; Nonr 1224(21), NR 0490114; A. W. Burks.

This task is devoted to the study of the logical design of computer nets. Four basic problems in logical design are being investigated: behavior specification, analysis, synthesis, and minimality.

Multidimensional Information Theory (U), RR 003-08-0002. Syracuse University, Syracuse, New York, Electrical Engineering Department; Nonr 669(10), NR 049-117; S. Goldman.

This task is concerned with the theoretical study of multidimensional information. An attempt is being made to generalize the concepts of a one-dimensional information theory to several dimensions. Studies of the natural biological world are used to suggest optimum methods of information transmission.

Digital Computer Communication Problems (U), RR 003-08-0003. Princeton University, Princeton, New Jersey, Electrical Engineering Department; Nonr 1858(22), NR 049-118; F. S. Acton.

The purpose of this task was to explore the suitability of special languages, similar to English, for communicating well-formulated problems to computing machines. Programming of present day computers is extremely complex and generally requires considerable training. It was hoped to simplify programming by the use of specially designed languages and procedures.

Speech Analysis and Synthesis (U), RR 003-08-0004. University of Michigan, Ann Arbor, Michigan; Nonr 1224(22), NR 049-122; G. E. Peterson.

This task encompasses basic investigations in the general field of language automation. Specific studies include the analysis, automatic recognition, and artificial synthesis of human speech.

Research Into Biological Type Computer (U), RR 003-08-0005. University of Illinois, Urbana, Illinois, Electrical Engineering Department; Nonr 1834(21), NR 049-123; H. Von Foerster.

This research study is directed toward the realization of "Biological Type Computers", a term used to describe the general class of computer systems which are composed of components characterized by low reliability and high complexity but which are organized--or capable of organizing themselves--so that the overall system reliability remains high.

Statistical Information Theory (U), RR 003-08-0006. University of California, Berkeley, California, Electrical Engineering Department; Nonr 222(53), NR 049-124; A. J. Thomasian.

This task is a cooperative effort, by both statisticians and electrical engineers, to investigate formally various formal problems of information processing. Specifically, information theory techniques used in engineering are examined to determine their applicability and bounds of validity, and extensions of the techniques are sought.

Mechanical Language Translation (U), RR 003-08-0008. Wayne State University, Detroit, Michigan, Department of Slavic Languages; Nonr 2562(00), NR 049-128; H. H. Josselson.

This task is a joint endeavor by linguists, mathematicians, programmers, computer engineers, and systems engineers to do research on the Mechanical Translation of Languages by the use of high speed digital computers. The aim is to translate from Russian to English with a finished product which is as good as is possible by human translation.

Information Retrieval Studies (U), RR 003-08-0009. Hebrew University, Jerusalem, Israel, Department of Philosophy of Sciences; N62558-2214, NR 049-130; Y. Bar-Hillel.

This task is devoted to the theoretical study and analysis of the general information retrieval and mechanical translation problems. It is expected

that general principles will evolve leading to practical solutions of these problems. General principles along which future equipment research should proceed will be developed.

Adaptive Control Systems (U), RR 003-08-0010. Stanford University, Stanford, California, Electronics Research Laboratory; Nonr 225(38), NR 049-132; G. F. Franklin.

This task is concerned with study of various types of digital control systems. Problems studied in particular include (1) the self-adaptive system in which the digital controller adapts its control action to its environment and to the system being controlled, and (2) digital systems for which the sampling interval is a function of the data to be sampled.

Information Theory and Observations (U), RR 003-08-0011. Columbia University, New York, New York, Department of Physics; Nonr 256(56), NR 049-133; L. Brillouin.

This task is concerned with the application of the principles of information theory to determination of the limits of scientific experiments and observations. In particular, certain restrictions are studied which information theory places upon the limits of observation and which lead to general uncertainty principles.

Nonlinear Predictors and Filters (U), RR 003-08-0012. Columbia University, New York, New York, Department of Electrical Engineering; Nonr 266(60), NR 049-134; R. J. Schwarz.

This task is concerned with the study of nonlinear predictors and filters. In particular, optimum nonlinear predictors and filters are to be determined for various types of discrete and continuous signals.

Automatic Programming Languages (U), RR 003-08-0014. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Computation Center; Nonr 760(18), NR 049-141; A. J. Perlis.

The purpose of this task is to develop a command type language for communicating with digital computers without requiring a specialized knowledge of the operation of the computer.

Information Retrieval (U), RR 003-08-0015. University of Pennsylvania, Philadelphia, Pennsylvania, Institute for Co-operative Research; Nonr 551(35), NR 049-143; J. O'Connor.

This task is devoted to the basic general study of information retrieval theory and systems. It is expected to develop basic principles that will lead to practical solutions for the retrieval of large amounts of non-numerical types of information. Designs for machines to be used in coding and for machines capable of performing retrieval are investigated. The broad objectives are the establishment of specific design criteria leading to the best systems that can be constructed with the available means and the generalized understanding of the means and methods of representing and storing retrieval information.

Cognitive Systems Research (U), RR 003-08-0016. Cornell University, Ithaca, New York, Department of Psychology; Nonr 401(40), NR 049-147; F. Rosenblatt.

This task is a basic theoretical investigation of "intelligent" systems. The program includes study of the mathematics, physics, physiology, and engineering of cognitive systems, both in living organisms and in artificial brain analogs, with the intent of providing a fundamental understanding of the principles involved in complex electronic systems which are capable of partially emulating the behavior of sensory organs, nerve nets, and the brain. Most of the theoretical work on the perceptron is proceeding under this task.

Pattern Perceiving and Learning Networks (U), RR 003-08-0017. University of Chicago, Chicago, Illinois, Committee of Mathematical Biology; Nonr 2121(17), NR 049-148; H. D. Landahl.

This task is devoted to investigation of a relatively simple network which can exhibit pattern perception. The objective is not to recognize the entire pattern but rather to isolate certain constancies, or "Gestalten". A formal analogy appears to exist between equations describing such networks and certain equations of quantum mechanics, and a primary objective of the study is to investigate and develop this analogy.

General Theory of Cybernetic Systems (U), RR 003-08-0018. Burden Neurological Institute, Bristol, England; N62558-2404, NR 049-149; W. R. Ashby.

This task was to develop a theory of generalized dynamic systems. Point-set principles were used to describe topologically systems which exhibit large numbers of equilibrium states, particularly self-organizing systems which emulate various activities of the human brain.

Digital and Sampled Data Control Systems (U), RR 003-08-0019. Purdue University, Lafayette, Indiana, School of Electrical Engineering; Nonr 1100(18), NR 049-150; J. T. Tou.

This task is an investigation of a class of problems involving digital, sampled-data control systems. Objectives of the study are the development of programming techniques for synthesis of adaptive control systems, better understanding of the use of variable-rate sampling for adaptive control systems, and improving adaptive system performance through application of non-linear control methods.

Logical Realization of Billion-Gate Computers (U), RR 003-08-0020. George Washington University, Washington, D. C., Department of Electrical Engineering; Nonr 761(07), NR 049-152; R. S. Ledley.

In anticipation of the approaching realization of electronic computers with logic networks comparable in magnitude and complexity to the human brain, this task was an effort to determine (a) the unique potentialities of such a computer, (b) the logical design principles involved in realizing such potentialities, (c) the constraints imposed by extreme size, and (d) means of programming contemporary computers for automatic design of the required logic. Boolean algebra and an associated developed matrix theory served as the primary analytical tools, and analogies with the human brain form guidelines.

Logical Realization of Billion-Gate Computers (U), RR 003-08-0021. National Biomedical Research Foundation, New York, New York; Nonr 3265(01), NR 049-160; R. S. Ledley.

In anticipation of the approaching realization of electronic computers with logic networks comparable in magnitude and complexity to the human brain, this task is an effort to determine (a) the unique potentialities of such a computer, (b) the logical design principles involved in realizing such potentialities, (c) the constraints imposed by extreme size, and (d) means of programming contemporary computers for automatic design of the required logic. Boolean algrebra and an associated developed matrix theory serve as the primary analytical tools, and analogies with the human brain form guidelines.

Fundamental Studies Relating to Electron Spin Echo Storage (U), RR 003-08-0022. University of California, Berkeley, California, Department of Physics; Nonr 222(78), NR 049-151; E. L. Hahn.

This task is concerned with basic research to explain and control electron spin echo phenomena which may be utilized for serial type high-speed computer memory.

Multi-List Information Processing Systems (U), RR 003-08-0023. University of Pennsylvania, Philadelphia, Pennsylvania, Moore School of Engineering; Nonr 551(40), NR 049-153; N. S. Prywes.

This task is an investigation of a new method for storing and indexing information to facilitate retrieval of data. The system involves storing with each item of data several "descriptors" which serve to associate the item with others related to it; searches are then conducted along lines of association.

Commercial Computers Comparison and Capabilities Survey (U), RR 003-08-0024. Auerback Electronics Corporation, Philadelphia, Pennsylvania; Nonr 3235(00), NR 049-155; I. L. Auerback.

This study would compile specific comparative data on commercially available computers. The various design specifications and performance capabilities will be reduced to a common base and tabulated so that direct comparisons of similar or dissimilar machines can be evolved. Supplemental listings and tabulations will be issued at regular intervals.

Optical Reader Decoding (U), RR 003-08-0025. United Research Incorporated, Cambridge, Massachusetts; Nonr 3215(00), NR 049-157; G. Kraft.

This task is a study of the printed character recognition problem. Specifically, various techniques are being explored which will permit specific character identification despite imperfections and irregularities in the observed characters. The study also attempts to optimize the structural interrelation of theorized component units for an optical character reader employing the principles derived from the first part of the study.

Nonlinear Control Systems Synthesis (U), RR 003-08-0026. Lehigh University, Bethlehem, Pennsylvania, Department of Electrical Engineering; Nonr 610(04), NR 049-159; L. G. McCracken.

This task is concerned with advancing the techniques available for nonlinear control system synthesis. Specific areas of concentration include the orderly classification of realizable control systems, examination of the requisite complexity for achieving certain network transferences, and establishment of practical design curves for frequently occurring classes of nonlinear systems.

Real Time Computer Time Sharing (U), RR 003-08-0027. Massachusetts Institute of Technology, Cambridge, Massachusetts; Nonr 1841(69), NR 049-161; P. M. Morse.

The purpose of this task is to explore and develop methods for several persons to enjoy essentially simultaneous use of a single large-scale computer. This requires (a) effective close-coupled human-machine communications, and (b) automatic means for switching machine operation between users on a (sophisticated) priority basis.

R003-09 Information Processing Systems and Devices

Digital Computer Component Research (U), RR 003-09-0001. University of Illinois, Urbana, Illinois, Digital Computer Laboratory; Nonr 1834(15), NR 048-102; W. J. Poppelbaum.

The object of this task is to develop computer components and circuitry of very high speed and high reliability. Research is directed toward, but not limited to: cathode ray and magnetic core memories, arithmetic and control, transistor circuitry, magnetic switching circuits, and input-output.

This task supports peripheral studies for the new high speed computer currently under construction at the University of Illinois and supported jointly by the ONR and Atomic Energy Commission under an A.E.C. contract.

Application of Persistent Internal Polarization (U), RR 003-09-0003. New York University, New York, New York, Department of Physics; Nonr 285(25), NR 048-105; H. Kallmann.

This task is concerned with basic investigations into the theory and applications of the phenomenon of persistent internal polarization. Specifically the possibility of using materials which exhibit this phenomenon for high speed and high density storage in electronic digital computers, and the possibility of using these materials for long wavelengths infrared detectors and photography is being studied. The present emphasis is being placed on the computer applications of these materials.

Very High-Speed Digital Computer (U), RR 003-09-0004. University of Illinois, Urbana, Illinois, Digital Computer Laboratory; NAonr 36-58, NR 048-106; J. E. Robertson.

This task is concerned with the research on, and the construction of, a computer of very high speed and reliability. The basic circuits which have been evolved during several years of study of high-speed transistor systems and logic have operation times of between 5 and 40 millimicroseconds. The computer will have a multiplication time of about 4 microseconds and an addition time of about 0.3 microseconds. The memory is of the word arrangement type consisting of 8192 words of 52 bits each with

an access time of 1.5 microseconds.

Digital Computer Reliability (U), RR 003-09-0005. Hermes Electronics Company, Cambridge, Massachusetts; Nonr 2133(00), NR 048-107; R. Wasserman.

The purpose of this task is to investigate improvements in electronic computer design through redundancy techniques. The problem is being approached not only experimentally but also theoretically to determine optimum reliability with minimum increase in the number of components. Equipment design concepts are being expanded into demonstration models.

Superconductive Computing Elements and Devices (U), RR 003-09-0008. Burroughs Research Center, Paoli, Pennsylvania; Nonr 2145(00), NR 048-111; R. A. Tracy.

This task is a study of superconductive thin films and application to computing elements and logical devices.

Ferroelectricity and Ferroelectric Materials Research (U), RR 003-09-0010. Naval Ordnance Laboratory, Corona, California; Allot. 67014, NR 048-119; H. H. Weider.

This task is concerned with formulating general theories of ferroelectricity and ferroelectric materials in order to permit use of the phenomena in computer devices. The program is concerned primarily with certain crystalline solid materials which have a net polar moment and a reversible, bistable, spontaneous polarization.

Printed Character Recognition (U), RR 003-09-0011. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Mechanical Engineering; Nonr 1841(14), NR 048-120; D. M. Baumann.

This task is concerned with high density photographic storage techniques for printed character recognition and with techniques for printed character recognition. The feasibility and preliminary development of such devices and techniques is being investigated.

Analysis of Automatic Pattern Recognition (U), RR 003-09-0012. Cornell Aeronautical Laboratory, Incorporated, Buffalo, New York; Nonr 2381(00), NR 048-121; R. Stevens.

This task is a study and evaluation of an electronic model patterned in part after the brain, called "the perceptron". The pilot model, which has now been fabricated, is capable of "learning" or generalizing responses to ordinary visual patterns or forms. The system employs new theory of memory storage (the theory of statistical separability) which permits the recognition of complex patterns with an efficiency far greater than that attainable by existing computers. Devices of this sort are expected ultimately to be capable of concept formation, language translation, collection of military intelligence, and solution of problems through inductive logic. The eventual objective is to understand and eventually to design a sophisticated useful apparatus.

Semiconductor Device Research (U), RR 003-09-0013. Stanford University, Stanford, California, Stanford Electronics Laboratories; Nonr 225(31), NR 048-122; J. G. Linvill.

This task concerns a research program involving both semiconductor devices and transistor circuitry, with strong interaction between the two. Emphasis is placed upon the development of processes for producing semiconductor devices to meet the circuit requirements of various systems applications. In particular, the neuristor, a device which could lead to new forms of computer structure, is studied. Primary emphasis is placed on defining the simple properties which the structure should have and identifying the means by which neuristors can be interconnected to perform any computational function.

Electron Spin Echo Storage (U), RR 003-09-0014. Lockheed Missiles System Division, Palo Alto, California; Nonr 2541(00), NR 048-125; H. N. Leifer.

This task is concerned with devising a serial type computer memory by the use of electron spin echoes in the solid state. By utilizing the method of pulsed nuclear or electron magnetic resonance, radio frequency energy in the form of pulses can be stored serially and recalled at an arbitrary later time within the memory or relaxation time of the spin sample.

Cryotron Research (U), RR 003-09-0015. Space Technology Laboratories, Incorporated, Los Angeles, California; Nonr 2542(00), NR 048-126; D. G. Fladlien.

This task is concerned with research on thin-film cryotrons to determine their usefulness both as logical elements and as memory units in computer circuitry. Cryotrons are small, low-temperature devices whose superconducting threshold is a function of a surrounding magnetic field.

Digital Technology Research (U), RR 003-09-0016. University of California, Los Angeles, California, Department of Engineering; Nonr 233(52), NR 048-129; G. Estrin.

This task is devoted to the study of and research in the physics and engineering of basic digital components, digital computer and control systems organization, and computer and systems applications. The logical design of a new scientific computer concept "the fixed plus variable structure" is also being considered.

Superconductive Very Thin Films (U), RR 003-09-0017. University of North Carolina, Chapel Hill, North Carolina, Physics Department; Nonr 855(08), NR 048-131; R. E. Glover.

This task involves basic investigation of the low-temperature electric and magnetic properties of very think films. Specifically, studies being made include critical current, critical temperature, and Hall coefficient as functions of film thickness, and the "persistent current" method is employed in attempts to determine the minimum film thickness at which superconductivity can be achieved. Investigation results will contribute to the design of thin film elements as computer logic and memory devices.

Basic Data Retrieval Study (U), RR 003-09-0018.

Benson-Lehner Corporation, Los Angeles, California; Nonr 2666(00), NR 048-135; B. Benson, J. C. Pitchford.

This task was a study of the fundamental aspects of data retrieval and data storage, and included recording, storage, retrieval, and display. The objective was a unique data retrieval system achieving high speed through parallel retrieval and featuring references in coded form, text in human language, and these two physically associated.

High Speed Photomemory (U), RR 003-09-0019. Hydel Systems, Los Angeles, California; Nonr 2668(00), NR 048-136; H. Mori.

This task is to examine the feasibility of a compact, very high speed, high density photographic storage device for general computer application.

Thin Magnetic Film Domain Wall Storage (U), RR 003-09-0020. Laboratory for Electronics, Boston, Massachusetts; Nonr 2676(00), NR 048-137; H. W. Fuller, H. Rubinstein.

This task is concerned with the utilization of the domain walls of thin magnetic films and the motion of these walls to fulfill the requirements for vastly improved bulk storage memories. The principles investigated involve the domain wall as a scanning medium in order to read and write digital information on another thin magnetic film. The system would involve only electromagnetic scanning with no mechanical parts and should be capable of storage densities of about 10^5 bits per linear inch.

Multi-Aperture Magnetic Logic Devices (U), RR 003-09-0021. Stanford Research Institute, Menlo Park, California; Nonr 2712(00), NR 048-138; D. Bennion.

The purpose of this task is to investigate the operation and application of a type of completely passive logical element called a Multi-Aperture Device. This device consists essentially of a magnetic toroidal core with certain geometrical variations and containing a number of small apertures. These devices permit the simple development of computer and logical circuitry without any active components.

Electron-Activated Microminiaturization (U), RR 003-09-0023. Stanford Research Institute, Menlo Park, California; Nonr 2887(00), NR 048-145; C. A. Rosen, K. R. Shoulders.

The ultimate goal of this program is to be able to fabricate minute electronic packaged assemblies containing over a million components suitably inter connected and coupled to perform complex system functions. The processes which have been developed and used are such as to be readily controllable by automatic means. It is contemplated that fabrication, including testing and modification during the process, can be programmed and directed by a suitable computer.

Biax Computer Elements (U), RR 003-09-0024. Aeronutronic Systems, Incorporated, Glendale, California; Nonr 2913(00), NR 049-146; C. L. Wanlass.

This task is an investigation into the suitability of Biax elements for use as Perceptron association units. The Biax, originally conceived as a computer memory and logical gating element, offers strong possibilities because of its integrating ability combined with a non-destructive read out characteristic.

Linear Storage Tubes (U), RR 003-09-0025. Compagnie Generale de Telegraphie, Sans Fil (C.S.F.), Domaine de Corbeville, Orsay (S. & O.), France; N62558-2275, NR 048-140; G. Wendt.

The (accomplished) objective of this task was to develop a low noise electrostatic storage tube in which the output varies linearly with the input voltage. Such a tube was required for certain data processing applications, particularly in the radar field.

Esaki Diode Ultra High Speed Switching Circuits (U), RR 003-09-0026. California Institute of Technology, Pasadena, California, Electrical Engineering Department; Nonr 220(39), NR 048-154; G. McCann.

This task is to conduct research on very high speed switching circuit components and associated circuitry. Primary emphasis is on spot-type and distributed Esaki diodes, and composite circuit configurations suitable for operations at a basic clock rate of 1000 megacycles, or higher.

Neuristor Devices and Systems for Computer Applications (U), RR 003-09-0027. Stanford Research Institute, Menlo Park, California; Nonr 3212(00), NR 048-158; H. D. Crane.

A neuristor is a homogeneously distributed, active-passive structure in the form of a one-dimensional "fiber." Fibers perform the dual role of "device and wire" so that arbitrarily complex logic systems can be constructed with nets of fibers properly related geometrically (i.e., via appropriate fiber "junctions"). No other components are required. This task proposes (a) to further study the theoretical system properties that are possible with neuristor devices; (b) to study both analytically and experimentally the realization possibilities of neuristor devices; and (c) to study more practical large-scale realization possibilities in terms of the results of parts (a) and (b), to pave the way for practical application of these techniques.

Analog Computers and Data Processing (U), RR 003-09-5100. U. S. Naval Research Laboratory, Washington 25, D. C.; B02-01; W. P. DeWitt.

Work now in progress includes the following:

1. Study of shock mitigation system for use in connection with the launching of ballistic missiles from seagoing vessels;
2. Continuing study of vibration spectra of crystal lattices;
3. Analog study of a system for assessment of atmospheric radioactivity;
4. Continuing study of the data reduction problem associated with the NRL satellite solar photometry experiment.

Theory of Programming and Error Analysis (U), RR 003-09-5101. U. S. Naval Research Laboratory, Washington 25, D. C.; B02-03; B. Lepson.

Large-scale general purpose digital computers, such as the NAREC which has been designed and constructed at the U. S. Naval Research Laboratory and

which is now being used for the solution of research and development problems at the Laboratory, have already made an extremely important contribution to the research and development program of the Navy. However, for their most efficient utilization, it is imperative that research be done in the fields of automatic programming, numerical analysis, and computer logic. Additions to the NAREC sub-routine library have included new and improved fixed point and floating point integration routines, a Fourier analysis routine, and a general conversion program to prepare normal NAREC output for an automatic plotter. Preparation of these routines, as well as the analysis of individual problems, also included the derivation of new numerical techniques.

Engineering, Development and Maintenance of High-Speed Computer Equipment, SR 003-09-0005. David Taylor Model Basin; 10169; Code 860, Mr. A. C. Rosenberg.

Studies leading to the development of high speed digital computers and peripheral equipment were conducted by this group. Studies leading to specifications for a Computer Data Format Translator, and the adoption of a high-speed printer and plotter system were completed. Modifications of various pieces of complex electronic equipment were completed. Consultation services were provided to DTMB, BuShips, and other government agencies in the field of data handling and data reduction, both digital and analog.

Consultation services to DTMB, BuShips, and other government agencies in the field of data handling and data reduction, both digital and analog, are continuing. In addition, preparation for the maintenance of the LARC Computing System is now in its final stages. This group is also maintaining and developing modifications of the research computer, Philco Transac CXPQ.

R003-10 Mathematical Topics Relevant to Specific Military Problems

Applied Mathematics and Statistics Research Group (U), RR 003-10-0001. Stanford University, Stanford, California, Applied Mathematics and Statistics Laboratory; Nonr 225(52), NR 342-022; H. Chernoff.

The problems on which this research group works originate in military research and development activities of the Defense Department and its contractors. These problems are assigned to this research group by the Joint Services Advisory Group for Research Groups in Applied Mathematics and Statistics after being screened for military significance. The areas of major activity are (1) statistical aspects of chemical, radiological and biological warfare; (2) probability and statistical decision problems arising in communication theory; and (3) inference in stochastic processes. Some of the specific problems currently being investigated in these areas are (a) development of statistical techniques which tell the experimenter when to stop experimenting and announce one of two drugs as superior; (b) development of methods for analyzing the number of counts recorded in the presence of radioactive material; (c) statistical problems in submarine location; and (d) a sampling inspection problem.

Applied Mathematics and Statistics Group (U), RR 003-10-0002. University of Chicago, Chicago, Illinois, Statistical Research Center; N6ori 020(35), NR 342-043; P. Meier.

The specific problems on which the personnel of this group work originate in military research and development activities of the Defense Department and its contractors. These problems are assigned to this task by the Joint Services Advisory Group for Research Groups in Applied Mathematics and Statistics. Particular problems being attacked by this group include (a) analysis of present test methods and designing of new methods for body armor testing; (b) design and analysis of experiments in Army installations that probe relationships between productivity of civilian employees and personnel programs; (c) collaboration in planning of large-scale weather modification experiments; (d) analysis of procedures for acceptance testing of instant coffee.

Quality Control Methods (U), RR 003-10-0003. Illinois Institute of Technology, Chicago, Illinois, Department of Industrial Engineering; Nonr 1406(05), NR 342-100; G. Resnikoff.

This task was to organize, amplify, extend and present some of the probabilistic and statistical results in quality control in a form suitable for use in the quality control programs of the Department of Defense.

Statistical Analyses and Data Processing (U), RR 003-10-0004. Corporation for Economic and Industrial Research, Arlington, Virginia; Nonr 2937(00), NR 342-101; J. Moshman.

At the request of the Bureau of Supplies and Accounts, the Logistics Research Project, the George Washington University is conducting a joint study with the Bureau of Supplies and Accounts, Code OW, of the Programmed Usage Replenishment System (PURS) used by the Aviation Supply Office (ASO) for replenishment of aviation spare parts. Certain tests of data will be made in connection with this study utilizing an IBM 709 computer. This task covers the programming and computer services incident to these tests.

Project SCAMP (U), RR 003-10-0005. University of California, Los Angeles, California, Department of Mathematics; Nonr 233(29), NR 342-153; C. B. Tompkins.

This task deals with theoretical and computational aspects of some statistical and mathematical problems with discrete variables, for which important applications exist.

Applied Mathematics Group (U), RR 003-10-0006. North Carolina State College, Raleigh, North Carolina, Department of Mathematics; Nonr 486(06), NR 342-046; J. Cell.

The problems on which this research group works originate in military research and development activities of the Defense Department and its contractors. These problems may originate in the research group or are assigned to this group by the Joint Services Advisory Group for Research Groups in Applied Mathematics and Statistics after being

screened for military significance. It is expected that problems will include, but not necessarily be restricted to, the following areas: (1) systems of ordinary linear or non-linear differential equations; (2) singular and non-singular integral equations; (3) tensor and vector techniques; (4) partial differential equations; and (5) matrix methods in numerical analysis.

R004 EARTH SCIENCES

R004-01 Earth Physics

Properties of Metals and Minerals at High Pressures and Temperatures (U), RR 004-01-0001. University of Texas, Austin, Texas, Department of Physics; Nonr 1633(00), NR 081-002; D. S. Hughes.

The physical properties of metals and minerals at temperatures and pressures up to those equivalent to a depth of 20 kilometers in the earth's crust are being determined. It is planned to work primarily on determining elastic constants and wave velocities.

Deep Seismic Studies (U), RR 004-01-0002. Carnegie Institution of Washington, Washington, D. C.; N7onr 290(01), NR 081-039; M. A. Tuve.

The geologic structure of the earth is being determined down to 80 kilometers. In order to obtain seismic data for the determination of this structure, large explosive charges are required together with a great number of recording stations, some of them several hundred miles away from the explosion point. Observations in special land areas, selected for geological interest, such as the Atlantic Coastal Plain and the Canadian Shield, are being made. Seismic model studies are also conconducted.

Crystal Chemistry of Silicates (U), RR 004-01-0003. University of Chicago, Chicago, Illinois, Department of Geology; Nonr 1123(00), NR 081-014; J. R. Goldsmith.

Under this task fundamental information on the crystalline state was obtained. This task was restricted to thermal, chemical, X-ray and petrographic work on minerals, particularly on the silicates.

Geophysical and Geological Investigations of Ocean Areas (U), RR 004-01-0004. Princeton University, Princeton, New Jersey, Department of Geology; Nonr 1858(10), NR 081-067; H. H. Hess.

Available geophysical and geological information on certain oceanic areas is correlated in order to work out the mechanics and processes by which the earth is deformed. This includes preparation of the necessary bathymetric charts.

Microseisms (U), RR 004-01-0005. Fordham University, New York, New York; Nonr 2509(00), NR 081-094; J. J. Lynch.

This work is to furnish equipment for the determination of the relationship between weather and microseisms. Also to examine the determination of the nature and origin of microseisms through the operation of three or four tripartite stations.

Research in Applied Soil Mechanics (U), RR 004-01-0006. Princeton University, Princeton, New Jersey, School of Engineering; Nonr 1858(34), NR 081-117; G. P. Tschebotarioff, W. E. Schmid.

The stress-strain relationships existing in clays both disturbed and undisturbed at different stages of consolidation will be determined. From this information new theories will be developed on the behavior of soil backfills, in particular the cohesive soils in a partially saturated state.

The Nature of Seismic Pulses Produced by Explosions (U), RR 004-01-0007. Pennsylvania State University, University Park, Pennsylvania, School of Mineral Ind.; Nonr 1661(00), NR 081-121; B. F. Howell, Jr.

A study is going forward on the shape of the pulse of seismic energy produced by detonation of a small charge of dynamite in the ground. The objective is to determine the spreading of a pulse as it is transmitted through a non-elastic medium, such as loose soil, and to develop a method of predicting pulse shape and length in terms of type and quantity of explosive used, distance and nature of the ground.

Crystal Chemistry of Minerals (U), RR 004-01-0008. University of California, Berkeley, California, Department of Geology; Nonr 2150(00), NR 081-129; A. Pabst.

The contractor has been determining the crystal structure of certain minerals. The nature and causes of the metamict state are also being studied.

Geochemistry of Mineral Associations (U), RR 004-01-0009. University of Chicago, Chicago, Illinois, Department of Geology; Nonr 1547(00), NR 081-179; G. W. DeVore.

The problem was to assemble analytical data on minerals, in order to determine the general principles which govern the composition of these minerals. The role of the minor constituents was of particular interest.

Isotopic Ratios in Volcanic Gases (U), RR 004-01-0010. University of Hawaii, Honolulu, Hawaii; Nonr 2135(00), NR 081-185; J. J. Naughton.

Volcanic gases are collected from areas of volcanic activity in Hawaii. The chemical and isotopic compositions of these gases are determined. The reasons for the compositional variations are being sought and their significance in terms of geology and geophysics will be studied.

Geochemistry of Carbon (U), RR 004-01-0011. Yale University, New Haven, Connecticut; Nonr 2569(00), NR 081-186; E. S. Deevey.

This is a task which ONR supported at one time and which is now supported by the National Science Foundation. Our role is to lend certain items of equipment purchased under our terminated contract. This equipment is for the investigation of the geochemistry of carbon and radiocarbon geochronometric techniques.

Earth Physics (U), RR 004-01-0012. University of Wisconsin, Madison, Wisconsin; N7onr 28512, NR 081-197; G. P. Woollard.

This task is to develop a better understanding of the physical nature of the earth through seismic, magnetic and gravimetric studies. Financial support is received from the U. S. Committee of the IGY, National Science Foundation, State of Wisconsin and others while ONR facilitates the loan of GFE.

Magnetization of Rocks (U), RR 004-01-0013. University of California, Berkeley, California, Department of Geological Sciences; Nonr 2131(00), NR 081-203; J. Verhoogen.

The task is to measure the intensity and direction of magnetization in rocks. This data will be used to determine the history of the earth's magnetic field such as movements of the magnetic poles and reversals of the magnetic field.

Marine Gravity Investigations (U), RR 004-01-0014. University of California, Los Angeles, California, Institute of Geophysics; Nonr 233(19), NR 081-206; L. B. Slichter, J. C. Harrison.

The work on this task involves measuring the value of gravity at sea and the development of improved equipments for this purpose. From gravity data we can calculate a more precise shape of the earth, and determine its strength and structure. A surface ship gravity meter has been tested and proven satisfactory.

Lake Erie Geological Studies (U), RR 004-01-0015. Ohio State University, Columbus, Ohio, Department of Natural Resources, Division of Geological Survey; Nonr 2260(00), NR 081-207; H. J. Pincus.

The Lake Erie Geological Research Program, a combined effort of several Ohio agencies and the State University, is concerned with problems of shore erosion and sediment transport in Lake Erie.

Geodetic Measurements through Lunar Observations (U), RR 004-01-0016. U. S. Naval Observatory, Washington, D. C.; Allot. 801-60, NR 081-216; W. Markowitz, G. Hall, C. Waxler, I. Bush, M. Sherman.

This problem has been to locate more precisely the positions of the continents with respect to one another. The approach has been to locate 15 to 20 astronomical observatories precisely by measurements with the moon camera. This camera was developed by the Naval Observatory. A latitude and longitude program has been added to supplement the lunar observations.

Oxygen Isotope Ratios in Natural Water (U), RR 004-01-0017. California Institute of Technology, Pasadena, California; Nonr 220(15), NR 081-220; S. Epstein.

The O^{16}-O^{18} ratios in natural water including ice were determined. The variations in this ratio in a natural water appeared to be related to their origin and/or past history. This study led to a better understanding of the movement of water in the oceans, in the atmosphere, in and on the earth, and between these media.

Mineral Synthesis (U), RR 004-01-0018. University of California, Los Angeles, California, Institute of Geophysics; Nonr 233(28), NR 081-222; G. T. Kennedy.

An experimental investigation into the formation of minerals under conditions of high pressure and temperature is being made. The behavior of feldspars under these conditions is currently under investigation. The necessary high pressure and temperature vessels are being developed.

Physical Characteristics of Marine Soils (U), RR 004-01-0019. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Civil Engineering; Nonr 1841(29), NR 081-227; T. W. Lambe, R. V. Whitman, R. T. Martin, R. M. Harkness, R. M. Quigley.

The physical characteristics of submerged marine soils are being investigated. The investigation is principally concerned with the strength of these soils.

Oscillations of the Earth (U), RR 004-01-0020. Institute of Science, Incorporated, New York, New York, American Committee for the Weizmann; Nonr 1823(00), NR 081-229; C. L. Pekeris, A. Alterman, H. Jarosch.

Theoretical investigations of the oscillations of the earth are being made. They include the following: (1) the determination of the periods and modes of the free oscillations of the earth; (2) the interpretation of the observed long period (one hour) waves in earthquake records in terms of the free oscillations of the earth; (3) the development of a working theory of the earth's bodily tide; (4) the interpretation of tidal records of gravity in terms of a theory of the earth's bodily tide based on the actual properties of the earth as they are known to date; (5) the development of a theory of oceanic tides.

Marine Seismology (U), RR 004-01-0021. California Institute of Technology, Pasadena, California, Seismological Laboratory; Nonr 2763(00), NR 081-231; F. Press.

In order to obtain seismograph records along oceanic paths free from the confusing effect of continental structures, a station was set up on a suitable island off the California coast. The data will be used for the solution of problems related to the structure of the earth, in particular that of the oceanic basins. Equipment is made available.

Geodetic and Time Data from Lunar Observations (U), RR 004-01-0022. San Diego State College Foundation, San Diego, California, Astronomy Department; Nonr 2222(00), NR 081-236; C. E. Smith.

The task is to obtain photographs of the moon with the Markowitz camera, and to obtain precise longitude and latitude determinations with the Danjon impersonal astrolabe. This material will be used by the U. S. Naval Observatory under NR 081-216.

Marine Geology (U), RR 004-01-0026. University of Chicago, Chicago, Illinois, Department of Geology; Nonr 2583(00), NR 081-243; R. G. Johnson.

This task is to lend equipment for quantitative studies of the organization of marine communities, a study of geologic and hydrodynamic control of the sediment patterns in Tomales Bay, California, and a study of the distribution of benthonic

foraminifera in Tomales Bay.

Flow in Porous Media (U), RR 004-01-0027. Rensselaer Polytechnic Institute, Troy, New York; Nonr 591(11), NR 081-244; R. L. Schiffman.

This task is to study the hydrodynamics of fluid flow through soils. The specific object is to determine the flow patterns developed in a soil mass under conditions of multiple sources and sinks, with vaying geometric configuration.

Geochemistry of Mineral Associations (U), RR 004-01-0028. Florida State University, Tallahassee, Florida, Department of Geology; Nonr 3195(00), NR 081-246; G. W. Devore.

The problem is to assemble analytical data on minerals, in order to determine the general principles which govern the composition of these minerals. The role of the minor constituents is of particular interest.

Mathematical Model of Rotating Vertical Drill String in Water (U), RR 004-01-0029. David Taylor Model Basin, Washington, D. C.; Allotment 10501, NR 081-247; T. Walton.

Theoretical analyses of vibrations in a rotating uncased drill pipe in 12,000 feet of water.

R004-02 Atmospheric Physics

Airborne Particles (U), RR 004-02-0001. New Mexico Institute of Mining and Technology, Socorro, New Mexico, Research and Development Division; Nonr 81502, NR 082-013; W. D. Crozier.

This task supports an investigation of particulate matter in the atmosphere. The investigation includes the collection, identification, sizing and determination of concentration of particulate matter. The present emphasis is on magnetic spherules of meteoritic sources.

Marine Meteorology (U), RR 004-02-0002. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Nonr 1721(00), NR 082-021; J. S. Malkus, A. F. Bunker, J. H. Webster, D. B. Clarke.

Ocean atmosphere energy transport mechanisms in the tropics are studied under this task to learn something about the primary energy transport mechanisms in the tropics between the sea surface and the atmosphere. The principal vehicle for this energy transport in the tropics and trade wind areas is the cumulus cloud. Therefore, the project also includes detailed studies of the dynamics of cumulus clouds and the turbulent processes that occur in and below them.

Theoretical Climatology (U), RR 004-02-0003. Florida State University, Tallahassee, Florida, Department of Meteorology; Nonr 1600(00), NR 082-071; S. L. Hess, W. A. Dryden, S. E. Asplund.

The aim of this task is to improve our understanding and interpretation of the statistics of climatology. The improvement will be sought by attempting to furnish a physical basis and explanation for the statistics. Following such a course of research, it should be possible eventually to make interpretations in terms of meteorological processes, topography, and other physical factors that determine the climatology.

Properties of Ice (U), RR 004-02-0004. New Mexico Institute of Mining and Technology, Socorro, New Mexico, Research and Development Division; Nonr 815(01), NR 082-094; G. W. Gross.

This is a study of the basic properties of ice (as particles), particularly the growth, structure and electrical properties. The aim of the research is to provide more exact information about the nucleation process of liquid water in the atmosphere and the source of cloud electrification.

Arctic Atmosphere (U), RR 004-02-0005. University of Alaska, College, Alaska, Geophysics Institute; Nonr 1289(00), NR 082-097; W. B. Murcray.

The purpose of this research is to study infrared emission and absorption spectra of the Arctic atmosphere and to compare them with similar studies of the atmosphere in temperate latitudes.

Meteorological Vortices (U), RR 004-02-0006. The Johns Hopkins University, Baltimore, Maryland, Civil Engineering Department; Nonr 248(31), NR 082-104; R. R. Long, H. C. Kao, H. P. Poa.

The general features of vortices as they apply to meteorological cyclonic systems are being investigated under this contract by means of rotating fluid models. Scaling factors can be selected to cover several sizes of meteorological systems from the smallest (excluding dust devils) tornadoes, the next largest, hurricanes, and then the large cyclonic storm that can cover whole sections of a country. The rotating models are equipped with fluid sources and sinks, heat sources and sinks, and photographic equipment.

Dynamics of the General Circulation (U), RR 004-02-0007. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Nonr 1143(00), NR 082-110; B. Bolin, E. Palmen, P. Welander, A. J. Faller.

This task is general in its approach to the study of the general circulation. It inciudes a study of the chemistry of the particulate matter of the atmosphere and also those gaseous elements which are variable, such as those of the nitrogen cycle and carbon dioxide. In addition, the general circulation is studied quantitatively by use of an electronic computer.

Tropical Energy Source (U), RR 004-02-0008. The University of Chicago, Chicago, Illinois, Department of Meteorology; Nonr 2121(19), NR 082-120; J. Riehl.

This task supports research on the large dynamical systems of the atmosphere and their relationship to temperate zone weather. It also seeks relationships between tropical occurrences and temperate zone development.

Cyclone Development (U), RR 004-02-0009. New York University, New York, New York, College of Engineering; Nonr 285(09), NR 082-121; J. Spar, H. Newstein, D. Spiegler, L. Cohen.

A specification of the weather conditions under which a storm develops is the aim of the research supported under this contract.

Sea Salt Nuclei (U), RR 004-02-0010. Woods Hole Oceanographic Institution, Woods Hole,

Massachusetts; Nonr 798(00), NR 082-124; A. Woodcock, D. C. Blanchard, A. T. Spencer, L. Friedman.

Sea salt nuclei has an effect on weather. The purpose of the research supported by this task is to determine the extent and mechanism of that effect. The effect of sea salt nuclei on weather is associated with the ability of the sea salt to serve as a nucleus around which water vapor in the atmosphere will condense to form cloud, fog, rain, etc.

Storm Electrification (U), RR 004-02-0012. A. D. Little, Incorporated, Cambridge, Massachusetts; Nonr 1684(00), NR 082-128; B. Vonnegut, C. B. Moore.

The purpose of the research supported under this task is to investigate the properties of and the mechanism of the electrification of thunderstorms. The investigation is carried out by measurements at the surface below the cloud, in the cloud, and above the cloud; and before, during build-up and during dissipation of the storm.

Freezing Rain Conversion (U), RR 004-02-0013. Cornell Aeronautical Laboratory, Buffalo, New York; Nonr 2250(00), NR 082-129; S. S. Chapman.

The object of the research on this task is to develop a practical means of converting freezing rain to ice pellets. Once such a technique is developed, an attempt will be made to apply the technique to the problems of an airship entering an area of freezing rain.

Brango's Sphere (U), RR 004-02-0015. Winzen Research, Incorporated, Minneapolis, Minnesota; Nonr 1460(05), NR 082-134; O. Winzen, D. L. Foster. R. M. Enderson.

The effort under this task will be devoted to the development and production of an inflatable polyethylene sphere. The sphere is to be packaged in such a way that it can be dropped from an aircraft over water in the eye of a hurricane. The sphere will inflate on coming into contact with the surface, and the inflation apparatus will automatically detach and submerge after inflation is complete.

Constant Level Balloon Data (U), RR 004-02-0016. University of California, Los Angeles, California, Department of Meteorology; Nonr 233(21), NR 082-140; M. G. Wurtele, R. P. Emig, N. Sanders, B. Finke.

Under this task an attempt will be made to incorporate the data from the tracking of constant pressure balloons (CPB) into dynamic models of the atmosphere. The same data will also be applied to a study of atmospheric turbulence and diffusion.

Contrails (U), RR 004-02-0017. Cornell Aeronautical Laboratory, Buffalo, New York, Department of Physics; Nonr 1854(00), NR 082-144; J. Ford, R. J. Pilie, J. E. Jiusto.

Condensation of the combustion products of jet aircraft engines generally leaves behind the aircraft a trail known as a contrail. The physical processes incident to the formation and dissipation of contrails is studied under this contract.

Geophysical Models (U), RR 004-02-0018. University of Chicago, Chicago, Illinois, Department of Meteorology; N6ori 02060, NR 082-148; D. Fultz.

The effort under this task will be devoted to the arrangement of a symposium on the use of models in geophysical fluid dynamics. A set of original research contributions will be sought from a selected group of specialists from both this country and abroad. The results will be published in book form.

Solar Relationships in Meteorology (U), RR 004-02-0019. University of California, Los Angeles, California, Institute of Geophysics; Nonr 233(45), NR 082-151; C. E. Palmer, S. V. Venkateswaran.

This task seeks to establish a relationship between the variations of solar activity and the development of certain high level storms that occur in the oceanic tropics.

Electronic Computation Applied to Dynamic Meteorology (U), RR 004-02-0020. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Meteorology; Nonr 1841(18), NR 082-152; J. G. Charney.

The purpose of the research under this task is to apply the computing capacity of electronic computer to the equations of dynamic meteorology. The ultimate purpose is to produce an objective weather forecast.

Instrumentation of Rocket Nose Cone (U), RR 004-02-0021. New Mexico State University, Las Cruces, New Mexico, Physical Science Laboratory; N9onr 953(02), NR 082-153; R. G. Moore, R. L. Ammons, C. Mozer.

This task supported an attempt, using rocket techniques, to photograph a hurricane. The National Hurricane Research Project is conducting an extensive survey of hurricanes along the East Coast of the United States. In connection with this project an overall picture of the cloud systems connected with these storms was desired. This task was to provide a recoverable camera package to obtain these and other meteorologically important photographs.

Atmospheric Water Cycle (U), RR 004-02-0022. The University of Arizona, Tucson, Arizona, Institute of Atmospheric Physics; Nonr 2173(02), NR 082-154; R. Kassander, J. E. McDonald, C. H. Reitan.

An attempt is made under this task to determine certain features of troposphere-stratosphere (lower-higher atmosphere) interaction and also of the hydrologic cycle. The trajectory of air in the lower (troposphere) atmosphere that originated in the upper (stratosphere) is of especial interest in this task. The items of interest in the hydrologic cycle for this research are the sources, sinks, and trajectories of water vapor, and the average amount of precipitable water vapor in the atmosphere.

Radiative Energy Change (U), RR 004-02-0023. Massachusetts Institute of Technology, Cambridge, Massachusetts; Nonr 1841(45), NR 082-156; L. B. Kaplan, W. S. Benedict.

A computation of the radiative temperature change in the atmosphere that can be incorporated in the meteorological forecast was the objective

of the research supported by this task. The particular forecast concerned was that made numerically on the basis of a physical model of the atmosphere. If the radiative temperature changes of the atmosphere could be successfully computed, the computations would furnish information on sources and sinks of energy in the atmosphere.

Storm Electrification (U), RR 004-02-0024. Mt. Washington Observatory, Lexington, Massachusetts; Nonr 2450(00), NR 082-158; J. Kuettner.

The purpose of this research is to determine whether thunderstorm electrification is due to a specific precipitation process. The atmospheric phenomenon which suggests the research is the usual co-existence of strong electric fields and solid precipitation, especially of the "graupel" type which grows by accretion in supercooled clouds. The method is to study the electrical effects incident to riming on metal rods exposed to the atmosphere on Mt. Washington at the Observatory.

Atmospheric Structure Profiles from an Allpurpose Rocket for the Collection of Atmospheric Soundings (U), RR 004-02-0025. Atlantic Research Corporation, Alexandria, Virginia; Nonr 2477(00), NR 082-159; W. C. Roberts.

The purpose of this task is to obtain by means of small sounding rockets, wind and temperature profiles for the upper atmosphere. The stratum to be sounded for temperature and wind is bounded on the lower side by the existing limits of balloon-borne radiosonde. The upper limit of the stratum will be that attainable by the sounding rocket.

ARCAS Fabrication (U), RR 004-02-0026. Atlantic Research Corporation, Alexandria, Virginia; Nonr 2926(00), NR 082-159A; W. C. Roberts.

The purpose of this task is to obtain ARCAS sounding rockets and launchers for use in ONR supported atmospheric research being conducted by various contractors of the Geophysics Branch. Among the parameters to be measured by sensors carried in the ARCAS are ozone, CO_2, water vapor, pressure temperature, X-ray radiation and Lyman Alpha radiation.

Mid-Atmospheric Rocket Research (U), RR 004-02-0027. New Mexico State University, Las Cruces, New Mexico, Physical Science Laboratory; N9onr 953(03), NR 082-160; H. A. Dow, R. L. Ingraham.

The purpose of this task is to conduct research on the properties of the earth's middle atmosphere in the stratum from approximately 20 to 200 miles above the surface. Measurement of the various atmospheric parameters needed to describe the structure, composition properties and dynamic processes involved is to be made where possible by utilization of small sounding rockets. Suitable instrumentation for obtaining these measurements will be developed as required.

Cyclones and Jetstreams (U), RR 004-02-0028. The University of Chicago, Chicago, Illinois, Department of Meteorology; Nonr 2121(10), NR 082-161; C. W. Newton, R. C. Byers.

A detailed synoptic analysis of extratropical cyclones and the associated current systems, especially the jet stream, was the aim of the research supported under this task.

Atmospheric Sound (U), RR 004-02-0029. Colorado School of Mines, Golden, Colorado; Nonr 2580(01), NR 082-162; A. R. Jordan.

This task supports research on the kind of sound energy in the atmosphere generated by meteorological processes such as a boiling cumulus cloud, the shear zone of the jet stream, passage of a frontal zone, a tornado or squall line, etc.

Cloud Dynamics (U), RR 004-02-0030. The University of Arizona, Tucson, Arizona, Institute of Atmospheric Physics; Nonr 2173(03), NR 082-164; J. E. McDonald, L. J. Battan, L. Sims, W. D. Sellers, C. R. Green, D. O. Staley.

This task supports work on the dynamics of cloud systems. The types of problems selected for research are those that will contribute toward an understanding of the physical processes in clouds that lead to precipitation.

Ozonosonde (U), RR 004-02-0031. New Mexico State University, Las Cruces, New Mexico, Physical Science Laboratory; N9onr 953(04), NR 082-165; R. G. Moore, C. Mozer.

The purpose of the research under this task is to adapt the photometer portion of the Paetzold ozonosonde to the ARCAS rocket and to furnish the necessary auxiliary equipment for transmission of the observation and its reception at the ground. When completed this equipment (the photometer in the rocket and ground reception equipment) will be used at several locations in the equatorial region of the Pacific to make profiles of ozone concentration from the surface to 200,000 feet.

Stormetron (U), RR 004-02-0037. University of Saskatchewan, Saskatoon, Canada, Institute of Upper Atmospheric Physics; Nonr 2671(00), NR 082-166; P. A. Forsyth.

This task is an investigation of the problems related to the morphology of auroral displays. To gain some idea of the effect and orbits of incident proton showers a "stormetron" is used. The "stormetron" is a piece of equipment in which a proton stream can be created and then directed in various ways by means of a variable magnetic field.

Thunderstorm Properties (U), RR 004-02-0032. New Mexico Institute of Mining and Technology, Socorro, New Mexico; Nonr 815(03), NR 082-167; M. Brook.

The aim of the research supported by this task is to obtain and accumulate certain special kinds of field data in connection with thunderstorms. These data include the character of the sound spectrum produced by thunder, perturbations in the magnetic field and in the earth currents, and high resolution and high speed lightning photographs.

Atmospheric Processes (U), RR 004-02-0033. National Bureau of Standards, Boulder, Colorado, Boulder Laboratories; NAonr 18-60, NR 082-169; D. M. Gates.

How the dynamics of the ionosphere are coupled to the dynamics of the stratosphere--if, in fact, there is coupling--is unknown to meteorology. The mechanism is unknown because we do not know what

occurs quantitatively, nor even have a good description of this stratum of the atmosphere--say from about 45 to 80 km. The purpose of this research task is to apply the techniques of spectrophotometry and photometry to this portion of the atmosphere in order to gain a better description of the ionization processes and their extent and also the composition of the stratum.

Artificial Meteorite (U), RR 004-02-0034. New Mexico State University, Las Cruces, New Mexico, Physical Science Laboratory; N9onr 953(05), NR 082-170; R. G. Moore.

The purpose of this research was to apply an artificial meteorite as a tool for atmospheric investigations. The initial information gained was data on atmospheric composition in the high atmosphere and data on the density of meteorites.

Atmospheric Research Information Exchange Studies (U), RR 004-02-0035. Science Communication, Incorporated, Washington, D. C.; Nonr 3071(00), NR 082-171; D. W. O'K. Myatt.

This task was to collect existing data on the structure of the atmosphere in the strata between 30 and 300 km. Also under this task an investigation was made of the problems which are encountered in any effort to establish any permanent atmospheric information exchange services of such an information exchange service. Recommendations as to the organization and services of such an information agency were also made.

Atmospheric Dynamics (U), RR 004-02-0036. Columbia University, Palisades, New York, Lamont Geological Observatory; Nonr 266(70), NR 082-172; R. L. Pfeffer.

Efforts to make numerical predications of atmospheric motion using dynamical theory of meteorology are now largely based on linearized and stability analyses. There are, however, complex nonlinear interactions that take place among finite amplitude disturbances, for the study of which the stability approach is severely limited. The purpose of the research supported by this contract is to study those non-linear interactions with a view to improving the prediction equations.

Aeronomy Symposium (U), RR 004-02-0038. National Academy of Sciences, Washington, D. C.; Nonr(G) 0006-61, NR 082-174; W. W. Atwood, Jr.

This task provided support for a symposium on Aeronomy held in Copenhagen, Denmark, during the period of 19-22 July 1960.

ARCAS Videosonde (U), RR 004-02-0039. Thompson Ramo Wooldridge Incorporated, Michigan City, Indiana, Dage Television Division; Nonr 3247(00), NR 082-175; S. T. Spengler.

This task is for the purpose of obtaining a small rocketborne television system. The system is to be used to gather local weather information. A television camera is used in order to avoid the recovery problem.

Ozone Genesis (U), RR 004-02-0040. Datronics Engineers, Incorporated, Bethesda, Maryland; Nonr 3345(00), NR 082-177; F. E. Hatch.

Ozone in the atmosphere is generally but not universally considered to originate mostly in the tropics as a result of the actinic effect of ultraviolet rays. The purpose of this contract is to support a small computational program aimed at supplying an alternative theory about the origin of ozone in the atmosphere.

Microseisms and Microbarisms (U), RR 004-02-0041. New Mexico Institute of Mining and Technology, Socorro, New Mexico; Nonr 815(04), NR 082-178; E. J. Workman.

The purpose of the research supported by this task is to study very weak convective processes and pressure waves in the atmosphere. The instrumental means of observing such phenomena will be the movement of very large volumes of air through small orifices--as in a Helmholtz resonator.

Atmospheric Electricity (U), RR 004-02-5150. U. S. Naval Research Laboratory, Washington, D. C.; AO2-15; R. V. Anderson, (Mrs.) E. M. Trent.

The electrical characteristics of the troposphere and their relations to physical and synoptic meteorology are studied to determine their effects on human environment and their possible uses in weather prediction and modification and applications to naval science.

Atmospheric Radioactivity Studies (U), RR 004-02-5151. U. S. Naval Research Laboratory, Washington, D. C.; AO2-13; L. B. Lockhart, Jr.

Representative samples of radioactive material in the air are collected at a number of sites in both the Northern and Southern Hemispheres. The contribution of fission products to the total radioactive background is determined by gross β-measurements, and the contribution of such isotopes as Sr^{89}, Sr^{90}, Y^{91}, Cs^{137}, Ce^{141}, Ce^{144} and W^{185} or Pb^{210} is determined by radiochemical analyses of monthly collections. The routine monitoring of the levels of radon, thoron and gross fission products in the air is continuing at several other locations. This information is being related to atmospheric mixing processes, stratospheric residence times and deposition processes.

Scattering and Twinkle of Light (U), RR 004-02-5152. U. S. Naval Research Laboratory, Washington, D. C.; AO2-17; L. F. Drummeter, J. A. Curcio.

This task is a continuing investigation into the propagation of ultraviolet, visible, and infrared radiations through the lower atmosphere. Current work includes measurement of scattering coefficients as a function of wavelength over the range from 0.4μ to 3.0μ. It also includes a study of the propagation of radiation over the horizon by scattering.

Atmospheric Physics/Meteorological Processes (U), WR 004-02-001. Naval Research Laboratory, Washington, D. C., PROJ. ORD. 1-0015, Dr. J. E. Dinger; A. D. Little, Incorporated, Cambridge, Massachusetts, Nonr 1684(00), Dr. Bernard Vonnegut; Cornell Aeronautical Laboratory, Buffalo, New York, Nonr 1854(00), Mr. Roland Pilie.

Provide for research and investigation into meteorological phenomena resulting from atmospheric processes and for the development of methods and techniques by which correlations can be established

and/or weather control and weather modification possibilities definitely determined.

Various seeding materials are being used. The role of atmospheric electricity in the formation of convective clouds and thunderstorms is being studied. The effect of carbon black as a weather modifier is being investigated. Contrail formation and suppression is being studied.

Considerable correlation between electrification and precipitation occurrence has been indicated. Certain physical properties of contrails have been determined and studied. Some seeding operations have been conducted with inconclusive results.

R004-03 Oceanography

Oceanographic Studies, Pacific (U), RR 004-03-0002. University of California, La Jolla, California, Scripps Institution of Oceanography; Nonr 2216(01), NR 083-005; R. R. Revelle, W. H. Munk, H. W. Menard, C. S. Cox, W. S. Wooster, M. N. Bramlette, F. S. Goldberg, J. A. Knauss.

This task is defined in general terms to permit investigations of all phases of oceanography. Major emphasis is placed on (1) waves, (2) description oceanography and circulation systems studies, (3) deep anchored buoys, (4) free instruments, (5) organisms in sediment, (6) bathymetry, sea floor structure and composition, (7), chemical oceanography, (8) geochemistry, (9) mechanics of sedimentation, (10) submarine valleys and deep sea sands, (11) instrumentation, (12) general oceanography, (13) support of marine operations.

Northeast Pacific Oceanography (U), RR 004-03-0003. University of Washington, Seattle, Washington, Department of Oceanography; Nonr 477(10), NR 083-012; R. H. Fleming, C. A. Barnes, R. G. Paquette, M. Rattray, Jr., F. A. Richards, J. S. Creager.

This task supports oceanographic research in physical, chemical and biological oceanography; marine geology; instrumentation; use of tidal models; and supporting work in methods, data processing, and presentation of results. Interest centers primarily on the water properties, circulation and water exchanges; plankton and bottom sediments of the coastal and offshore waters of the northeast Pacific, from Northern California through Bering Sea, thence into the Chukchi Sea and adjacent portions of the Arctic Ocean. Particular attention will be given to Puget Sound and its seaward approaches.

Oceanographic Studies Chesapeake Bay (U), RR 004-03-0004. Johns Hopkins University, Baltimore, Maryland, Chesapeake Bay Institute; Nonr 248(20), NR 083-016; D. W. Pritchard, R. B. Montgomery, D. E. Carritt, J. H. Carpenter.

The research activities under this task are directed towards a basic study of: (1) the physical and chemical hydrography of the Chesapeake Bay and its tributary estuaries, (2) the theory of movement and mixing in littoral waters in general, (3) the flushing of estuaries and embayments, (4) turbulent velocity structure and turbulent diffusion in estuarine and coastal waters, (5) the development of incipient and early stage wind waves in inshore waters, (6) Project BUTTERFLY, (7) special military oceanographic studies, (8) the use of analytical oceanography in the study of serial observations from the deep oceans; and to provide for the continued establishment of specific curricula and facilities within the University for fundamental training in the oceanographic sciences.

Oceanographic Survey of the Gulf of Mexico (U), RR 004-03-0005. Agricultural and Mechanical College of Texas, College Station, Texas, Department of Oceanography and Meteorology; N7onr 487(02), NR 083-036; D. F. Leipper, H. J. McLellan, R. O. Reid, J. D. Cochrane, K. M. Roe, R. G. Bader.

The oceanographic research being carried out under this task is part of a general project designed to furnish pertinent information concerning the various oceanic areas around our continent. Military applications of this task are mainly concerned with the build-up of a background of information on the general characteristics of the Gulf of Mexico. From this will come the data necessary for sound propagation studies, and calculation of the ocean currents. Part of the task has as its objective an exhaustive study of the thermal structure of the upper layers of the oceanic water and the heat transfer processes operative between the ocean and atmosphere. The results of the study will enable the development of an ability to forecast changes in the characteristics of the thermocline. This task is of interest to the Bureau of Naval Weapons and the Weather Bureau in that it complements their work with weather buoys in the Gulf of Mexico. A portion of this investigation will include the technical test and evaluation of anchored buoys in the Gulf of Mexico. Additionally, the oceanic thermal structure will be investigated in the vicinity of the buoys and the oceanographic and weather buoy data collected. These investigations will form a part of a coordinated BuWeps/ONR effort to improve environmental forecasting techniques.

The oceanographic program at Texas A & M is being rounded out by the addition of a group working in Marine Geophysics. Initially, the group will concern itself with seismic and gravity studies of the ocean bottom. They have already acquired some experience in this field with their participation in the MOHO Expedition off Puerto Rico and their previous shipboard use of the LaCoste gravity meter.

Ocean Atmosphere Interaction (U), RR 004-03-0006. New York University, New York, New York, Department of Oceanography and Meteorology; Nonr 285(03), NR 083-046; G. Neumann, W. J. Pierson.

Work under this task is directed toward a further development of the theory of ocean currents and waves as well as a study of the interaction between the ocean surface and the atmosphere. Particular emphasis is placed on improvement of wave forecasting techniques and the development of a complete statistical description of the properties of real ocean waves.

Biological Oceanography (U), RR 004-03-0007. University of Rhode Island, Kingston, Rhode Island, Narragansett Marine Laboratory; Nonr 396(02), NR 083-054; C. J. Fish, M. P. Fish.

The task covers research in the fields of

physical oceanography, marine geology and biological oceanography with emphasis on the latter. The efforts in biological oceanography are twofold in nature. The first concerns the study of the life cycles of zooplankton in the open ocean. The second includes investigations and analyses of all noise producing fish in the New England area, including physiological studies of the noise producing mechanisms and a study of the reasons the animals produce the noise.

Tropical Oceanography (U), RR 004-03-0008. University of Miami, Miami, Florida, Marine Laboratory; Nonr 840(01), NR 083-060; F. Koczy, C. Emiliani, J. Geiss, R. Bourret, F. Chow, G. Rusnak.

This task is defined in general terms to permit investigations into several problems in tropical oceanography. These are studies in kinematics and dynamics, water masses and mixing, basic constants of ocean water, sedimentology, geochemistry, bathymetry, and geophysics, micropaleontology, absolute dating and isotopic composition of sea water.

Oregon Oceanographic Studies (U), RR 004-03-0010. Oregon State College, Corvallis, Oregon, Department of Oceanography; Nonr 1286(02), NR 083-102; W. V. Burt, J. G. Pattulla, H. F. Fralander.

The primary objective of this task is to continue and expand the studies of descriptive oceanography of the nearshore waters of the Oregon coast. Oceanographic factors to be determined are distribution of temperature, salinity, plankton, ocean currents and bottom sediments. The circulation and mixing patterns in Oregon coastal estuaries will be studied by mathematical and statistical methods, and field measurements. The microthermal structure will also be studied and possibly other research with direct ASW potential.

Delaware Bay Equipment Loan (U), RR 004-03-0011. Rutgers - The State University of, New Brunswick, New Jersey, Department of Zoology; Nonr 1775(00), NR 083-114; H. Haskins.

This task is for the purpose of conducting research in the Delaware Bay. The oceanographic environment of estuaries such as Delaware Bay is extremely complicated and variable. A continuous program is necessary to obtain a reasonable understanding of the observed variations.

Support of Aircraft R4D-6R for Woods Hole Oceanographic Institution (U), RR 004-03-0012. Office of Naval Research Branch Office, Boston, Massachusetts; Nr 083-122, Allot. 67003; Commanding Officer.

This allotment is intended to cover the cost of operating an R4D-6R aircraft at Woods Hole Oceanographic Institution. The aircraft is on bailment contract from the Bureau of Aeronautics to Woods Hole. The funds will cover specifically fuel, oil, minor repairs and minor overhaul. This aircraft is flown in support of contract Nonr 2196(00), Nonr 769(00), and Nonr 1721(00). The task covers general oceanographic and meteorological research at sea, particular studies of clouds, infrared radiation measurements of the sea surface, aerial photography, airborne magnetometer flights and diffusion processes in the ocean. Work could not proceed without use of this aircraft.

Project Bathyscaph (U), RR 004-03-0013. Committee for Oceanographic Research by the Bathyscaph TRIESTE, Lausanne, Switzerland; Nonr 2589(00), NR 083-133; J. Piccard.

This contract covers the services of J. Piccard to cooperate with civilian and military personnel of the U. S. Navy Electronics Laboratory in planning the scientific program of the TRIESTE and training U. S. Naval officers in its operation.

Committee on Oceanography (U), RR 004-03-0015. National Academy of Sciences, National Research Council, Washington, D. C.; Nonr 2300(03), NR 083-136; L. Hoover, R. C. Vetter.

This task provides a center where the diverse problems of the national effort of the United States in oceanography may be brought to a focus. The Committee on Oceanography is supported jointly by the Office of Naval Research, National Science Foundation, Atomic Energy Commission, U. S. Coast and Geodetic Survey and the Bureau of Commercial Fisheries. In addition to providing advice on current oceanographic problems, the Committee provides counseling, planning, and coordination for the national long range oceanographic research programs.

Bathyscaph Investigations (U), RR 004-03-0017. U. S. Navy Electronics Laboratory, San Diego, California; NR 083-140, Allot. 953; Commanding Officer and Director.

This task is designed to cover research and operations with the bathyscaph, TRIESTE. Included in this program will be oceanographic studies including submarine geology, physical and chemical and biological oceanography; underwater acoustics, and engineering developments of equipment and instruments for use under high pressure.

Marine Geophysics (U), RR 004-03-0019. Columbia University, Palisades, New York, Lamont Geological Observatory; Nonr 266(48), NR 083-142; W. M. Ewing, J. L. Worzel, B. C. Heezen, R. J. Menzies.

The objective of this task is to conduct a program of marine geophysical studies. Work under this task includes geophysical, geological, biological, and oceanographic investigations. This work will be integrated for the purpose of obtaining a better understanding of the physical conditions and processes existing in the oceans and of the origin and structure of the oceanic basins.

Ocean Wave Studies (U), RR 004-03-0020. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Nonr 2734(00), NR 083-143; H. G. Farmer, R. G. Stevens.

This task was concerned with the measurement of both the one and two dimensional spectrum of natural wind-generated waves at a wave tower facility in Buzzards Bay for a variety of wind velocities. Analyses of these records were made and compared with the theoretical work of Neumann and others on spectrum analyses of wind generated waves. Further application of these results were used in determining the ranges of applicability of the Pierson-St. Denis Theory of ship motions in irregular seas.

Marine Geology (U), RR 004-03-0021. University of Southern California, Los Angeles, California;

Nonr 228(17), NR 083-144; K. O. Emery.

This task is defined in general terms to permit investigations in all phases of Marine Geology. Currently, the research is directed toward the study of foreshore sand movement by use of fluorescent-dyed sand. Inherent in the objectives is the improvement of this method of measuring the movement of sediments. The contractor is presently completing the analysis of the data gathered during his studies of the oxygen in the ocean basins off Southern California.

Atomic Waste Dispersal (U), RR 004-03-0023. University of Pittsburgh, Pittsburgh, Pennsylvania; Graduate School of Public Health; Nonr 3027(00), NR 083-146; M. A. Shapiro.

This task includes a basic study of the environment and ecology of the OHIO river downstream from the Shippingport Atomic Power Station. This combination of basic ecology and environmental control, termed radio-ecology, will enhance our understanding of the distribution of radioactive materials in the water, their uptake by the biological organisms, and their eventual disposition.

Ocean Data Processing (U), RR 004-03-0024. CONVAIR, Division of General Dynamics, San Diego, California; Nonr 3062(00), NR 083-147; H. E. Siebert.

The objective of this task is to conduct a study of the present techniques in handling oceanographic information and to make recommendations for the application of modern high speed techniques to oceanographic data acquisition and handling. This work will be carried out with the cooperation of instrumentation experts from leading oceanographic institutions and the Navy Hydrographic Office.

Gulf Coast Oceanography (U), RR 004-03-0025. Gulf Coast Research Laboratory, Ocean Springs, Mississippi; Nonr 3198(00), NR 083-148; F. Chew.

The objective of this task is to develop a better understanding of the Gulf of Mexico in vicinities of large sounds and rivers. For example, the discharge of the Mississippi river modifies greatly the physical, chemical, geological and biological environment of the adjacent Gulf area. This task will study both the special and temporal variations of the environment.

Deep Current Studies (U), RR 004-03-0026. Stanford Research Institute, Menlo Park, California; Nonr 3160(00), NR 083-149; G. M. Cresswell.

The objective of this task is to investigate the deep water circulation in the ocean with an emphasis on direct observations of the deep currents. As our knowledge of the oceans enlarges, it becomes more and more clear that our present conception of deep oceanic circulation is not much better than a qualitative description. In order to determine quantitative figures for the deep currents, it is necessary to observe the currents directly in many places and over long periods of time. New techniques such as the Swallow neutrally buoyant float now make such observations possible.

Oceanographic Instrumentation (U), RR 004-03-0027. Bureau of Commercial Fisheries, Naval Air Station, Seattle, Washington, Instrumentation Laboratory, NAonr 34-60, NR 083-150; R. Van Haagen.

This task is to provide for the development of new and advanced techniques in oceanographic instrumentation. One of the greatest shortcomings in oceanography is the lack of use of sophisticated instruments by oceanographers. This task represents a part of an integrated program being sponsored by ONR to develop an efficient, useful system of continuously collecting data at sea.

Baltic Oceanography (U), RR 004-03-0028. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Nonr 3260(00), NR 083-152; P. M. Fye.

This task includes studies into the circulation and mixing processes taking place in the Baltic Sea, the chemical composition and geological processes of those waters, biology of the Baltic herring, structure and strength of sea ice, and reaction kinetic studies of sulphur compounds and CO_2 in sea water.

Marine Geological Investigations (U), RR 004-03-0029. Cambridge University, Cambridge, England, Department of Geodesy and Geophysics; N62558-2704, NR 083-153; M. N. Hill.

The objective of this task is to conduct a program in marine geology. This includes the collection and analysis of sea rocks, sediment coring, heat flow measurements, seismic reflection and refraction studies and magnetic measurements.

Deep-Water Internal Wave Study (U), RR 004-03-0030. Lockheed Aircraft Corporation, Burbank, California, California Division (ASW Systems); Nonr 3348(00), NR 083-155; A. J. Carsola.

The research activities under this program will consist of measurements of the short period portion of the spectrum of natural internal waves in the deep ocean and to attempt to determine their origin. Internal waves are known to affect the propagation of underwater sound. Recently, it has also been shown that objects moving in the vicinity of the thermocline may cause internal waves which provide a clue to the presence of the disturbing source. There is no considerable knowledge already available on the spectrum of short-period internal waves in shallow water and long-period waves in deep water. Hence, the specific objective of this task will be to extend the knowledge of internal waves to include the short-period spectrum in deep water.

TENOC Preparation (U), RR 004-03-0031. John I. Thompson Company, Washington, D. C.; Nonr 3329(00), NR 083-156; G. L. Maton.

The purpose of this task is to compile a planning document for the Navy's effort in oceanography. This will be composed of three sections: (a) the need for oceanographic research, (b) the current status, and (c) a comprehensive plan for the next ten years of effort in this field.

Long Range Marine Geophysics (U), RR 004-03-0032. Columbia University, Palisades, New York, Lamont Geological Observatory; Nonr 266(79), NR 083-500; M. Ewing.

The objective of this task is to conduct research in areas of marine geophysics that are of long range interest to the Navy. Efforts will be

made toward the improvement of techniques, instruments and methods of data collection, processing, and interpretation in the field of gravity and magnetometer measurements, narrow beam soundings, sub-bottom depth recording and sound transmission. A considerable part of the field program will be devoted to Arctic areas.

Long Range Physical Oceanography (U), RR 004-03-0033. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; NR 083-501, Nonr 3351(00); P. M. Fye.

The objective of this task is to conduct research in areas of physical oceanography that are of long range interest to the Navy. Efforts will include the installations of a line of self-recording remote oceanographic data collecting buoys across the Gulf Stream; development of radio telemetering buoys; surface wave research, development of data handling methods, improved navigational techniques; and studies into the prediction of oceanographic parameters.

Long Range Pacific Oceanography (U), RR 004-03-0034. University of California, La Jolla, California, Scripps Institution of Oceanography; NR 083-502, Nonr 2216(12); R. R. Revelle.

The objective of this task is to conduct research in areas of oceanography that are of long range interest to the Navy. Efforts will include the study of deep oceanic currents; reconnaissance and detailed surveys of bathymetry and magnetic anomalies; multipoint measurements of low frequency swells; studies of internal waves; numerical methods of recording and processing oceanographic surveys; and investigations into deep anchored buoys.

Hydrodynamics of the Sea, SR 004-03-0526. NEL; NEL L4-1; Dr. A. A. Hudimac.

Until this writing, Task 0526 covered all NEL problem L4-1 (PT-1), now covered by tasks 0580, 0539 and this task, which is for the study of hydrodynamic effects alone. It is the purpose of this task (together with Task 0213 supported by BuWeps Special Projects) to investigate the effects upon sea motions and other ocean characteristics produced by the passage of ships and submarines, and to determine the feasibility of detecting submarines by the hydrodynamic disturbances they create.

Study of physical, chemical, biological and acoustic phenomena related to internal waves and surface slicks. Processing of data and derived equations for speed and direction of waves. Water in or near a slick has lower oxygen content, lower surface tension and is more opaque than adjacent water. Theoretical work has begun on the motion of a body in a fluid with a free surface and irregular solid boundary and on ship waves in a stratified ocean. Theoretical studies of momentum transfer of energy are being made from the viewpoint of creation and dissipation of internal temperature waves, particularly those in the thermocline.

Oceanographic Research Vehicles, SR 004-03-0528. U. S. Navy Electronics Laboratory; L4-1 (PT-2); A. Rechnitler.

Suitable platforms for oceanographic research are required. This task covers the bathyscaphs and deep submersibles, towers and other vehicles and platforms, their construction (when RDT&E) installation and instrumentation. This is a continuation of the same task under SR 0040301, heretofore mainly concerned with the Bathyscaph TRIESTE. (The Office of Naval Research will discontinue scientific support in 1962.)

Project Nekton, deepest dive was made to 35,800 under a joint program of NEL and ONR. Project Nekton II followed, including first determination of pressure coefficient of sound velocity in the ocean itself. Both the Deep and the 20,000-foot spheres have been disassembled and partly overhauled. The present float has been improved, also power for additional mobility, improved TV and lighting, etc. As time and funding permit, improved instrumentation is installed.

Radioactivity in the Sea, SR 004-03-0529. U. S. Navy Radiological Defense Laboratory; contract to be assigned.

The background level of radioactivity in the ocean areas must be determined in order to note any dangerous changes, either from radioactive waste disposal or bomb tests, etc. No suitable measuring system is available, a serious lack in view of the fact that the TRIESTE (bathyscaph) can go to all depths for in situ measurements.

Preliminary consideration has been given to the development of suitable instruments, if possible for use in the field without requiring concentration of samples for Laboratory analysis.

Visual Transmissibility in the Sea (U), SR 004-03-0531. University of California, Visibility Laboratory, NObs 72090, Mr. J. E. Tyler; S. Q. Duntley, NObs 72039, Dr. S. Q. Duntley.

Undersea operations include submarine tactics, anti-submarine warfare, mine warfare, mine defense, underwater demolition, and salvage. The need for solutions to problems in these areas requires the extension of knowledge on water clarity and other properties governing the transmission of light and visual images underwater and the development of techniques and doctrine pertinent to underwater search, detection, identification, and classification by swimmers, television, and photography.

Instruments have been developed for laboratory investigations, the Inshore Survey program, and exploratory water transparency measurements at sea. Experimental measurements have been made to supplement and substantiate theoretical studies (SR 002-07-01) by which practical underwater visibility problems can be solved. A manual on the prediction of underwater visibility by swimmers has been completed, and studies have been completed on the transmission of light from underwater sources. This task also provides for the use of an underwater test area through BuDocks Contract Noy(R) 49310.

Sea Floor Studies, SR 004-03-0539. U. S. Navy Electronics Laboratory; NEL L4-1 Part 1; Dr. E. Hamilton, Code 2250.

This is a continuation of part of the work previously covered by NEL Prob L4-1, Part 1 (SR 004-03-01). Studies on a continuing basis have been made of the sediment properties and distribution and the topography and structure of the sea floor

with special emphasis on the relations to acoustic problems.

Thickness and distribution of continental shelf sediments were studied off Southern California, in the Gulf of California, and the Bering and Chukchi Seas. The velocity and attentuation of sound and other mass physical properties of sediments have been correlated. Sediments and sedimentary processes have been studied by diving and deep-sea camera.

Studies underway: thickness, physical properties, and distribution of sediments of the Bering and Chukchi Seas; velocity and attenuation of sound in sediments using special probes; deep-sea photography and mass physical properties of sediments.

Project OASIS and Acoustic Surveys, SR 004-03-0541. U. S. Navy Underwater Sound Laboratory; 1-122-00-00; Guy Harris.

There continues to be a requirement for acoustic deep sea investigations, for example, the AMOS MEDEA, and other multiple ship surveys. Certain areas are of particular interest in connection with high priority programs including POLARIS. Joint funding and participation by several activities under coordination of USL is contemplated.

Presentations and planning documents have been distributed in anticipation of approval of Project OASIS.

Two AGS-type ships are included in the Navy's TENOC plan.

Acoustic Data Center, SR 004-03-0542. USL, 1-420-00-00, Guy Harris; ONR (411), Nonr 3353(00), AVCO.

The former title of this task, "Acoustic Model of Oceano", has been changed to "Acoustic Data Center", as broader and more inclusive. It is contemplated that acoustic data from Government Labs and commercial Labs will be analyzed, filed and stored in such manner that questions may be asked in the future with at least qualitative answers. Eventually, acoustic information (which is now inadmissable to the National Oceanographic Data Center, NODC, because classified) may become a part of the NODC.

AMOS, MEDEA and the acoustic measurements together with environmental observations have been reduced to puch cards, analyzed and used for empirical equations. This file is fundamental acoustic information on the ocean.

Collect, systematic acoustic measurements from all sources and develop an analytical facility including Ph. D.'s and high speed computer.

Biological Oceanography, SR 004-03-0544. USNEL, contract when assigned; other.

The requirements for marine fouling prevention and ship surface preservation are dealt with in other tasks. However, with these two exceptions, this task is for investigation of biological processes and factors in the oceans which affect the design and operation of ships and underwater vehicles, mines and submerged equipments of all kinds. Included are investigations of organisms with the following characteristics:

1. Deep-living and affecting deep vehicles.
2. Concentrating radioactive materials.
3. Indicating changes in the biotope.
4. Tracing circulation or diffusion.
5. Indicating the presence of foreign objects.
6. Lighting and bioluminescent.
7. Affecting surface tension, etc.
8. Concentrating in layers.

Chemical Oceanographic Research, SR 004-03-0545. NEL; contract when assigned.

The chemical composition of sea water is important from the viewpoints of determinations of density, acoustic absorption, bubble persistence, productivity, light refraction, etc. The determination of the defined quantity "Salinity", for instance, is important in identifying a water mass, in computing density and underwater sound velocity.

This task is for the necessary collection of samples of ocean water, particularly at great depth, their chemical analyses--including Carbon 14, Tritium, Deuterium, oxygen, phosphate, or other properties, and the development of necessary instrumentation.

Oceanographic Research, SR 004-03-0580. U. S. Navy Electronics Laboratory; NEL L4-1, Part 1; Code 2250, Dr. E. C. LaFond.

Continuing studies have been made at the Sea Surface, near surface and deep-water oceanographic phenomena and their relations to acoustic problems.

Studies have been made of the nature of internal waves, and their sound focussing action, sea-surface slicks, and other physical properties of near-shore waters. Sound velocity distributions and convergence zone effects have been studied.

Studies under-way include properties and movement of near shore waters (especially internal waves); sound velocity distributions and convergence zone studies and computational techniques for forecasting sound velocity structures.

Underwater Sound Propagation, SR 004-03-8112. Lamont Geological Observatory (Columbia University); NObsr 85077; J. Ewing.

Contract NObsr 85077 continues applied research under contract NObsr 64547 and NObsr 43355. Dr. Maurice Ewing and his group have paved the way for the majority of underwater acoustics systems now in effect. The continued study of bottom acoustical characteristics and long range transmission in the deep sound channel is of direct use to Bureau of Ships in ASW, communication and countermeasures programs.

The following are a few of the items for which this group has unique claim to first development: Sofar and Rafos Systems, and the basis for all present wave-guide propagation in deep water acoustics, detection and location of small explosions, deep water photography and identification of wrecks, Ray Theory for underwater sound transmission, a workable bathythermograph, the submarine bathythermograph, explanations of Afternoon Effect and prediction of sonar ranges, gravity measurement from submarine and surface ships, improved coring devices, sound dispersion in shallow water, normal mode propagation acoustic beacons, precision depth recorders, underwater beacons, bottom recording underwater sound measurements in deep ocean study stations.

Ambient Noise Generated by Waves, SR 004-03-

8113. Marine Laboratory (University of Miami, Florida); New Contract; John C. Steinberg.

BuShips has maintained limited annual support under Contract NObsr 72626 (and preceding contracts) for measurement and recording of ambient and ship noise. This research has developed a considerable capability at MLUM for precise U/W acoustic measurements. Dr. John Steinberg, recently added to the faculty, is conducting a program for ONR (Code 411) on Low Frequency Ocean Sound Sources and the Bureau of Ships has reoriented its support to tasks indicated below under "Future Plans".

Ambient noise in the Tongue of the Ocean has been analyzed and described. U/W sound propagation across the Tongue was measured in anticipation of AUTEC Program. Ship noises in Key West were recorded and mine field measurements were made.

Low Frequency Ambient Noise Research, SR 004-03-8119. U. S. Navy Electronics Laboratory; Prob L2-4; Gordon M. Wenz.

Low frequency ambient noise has been studied for several years and several locations with emphasis on 10-1000 cps frequency range. Noise characteristics as a function of frequency, direction (azimuth and elevation), and other relationships including geographic location, water depth, hydrophone depth, Sea State, etc., are determined, particularly the nature of noise near the bottom in off-shore areas.

Sound pressure analyses from Cape Prince of Wales, Alaska and autocovariance studies--covering many seasonal conditions; a 3000-ft. cable and radio link from San Clemente Island gathered data for 2 years, now P. Sur and San Nicholas. A small diurnal amplitude variation of L. F. Ambient noise has been noted with a maximum near midnight local standard time. Causes and sources are being determined. Instrument developments and improvement include: computer programming procedures, automatic recording deep sea buoy, an unconstrained submersible unmanned vehicle (sonodiver) for recording at great depths, and development and modification of Third Octave Data Analysers (TODA).

R004-04 Geography (except Arctic)

Photographic Documentation of Vegetation Changes (U), RR 004-04-0023. University of Arizona, Tucson, Arizona, Department of Botany; Nonr 2173(01), NR 387-018; W. S. Phillips.

Field investigations are being conducted to re-examine and re-photograph the vegetation in selected places to record and analyze the changes that have occurred since these sites were studied and photographed by H. L. Shantz 25 to 50 years ago. Exact photographic documentation, description and interpretation of alterations in plant cover, soil and land use are included. The studies in southern and eastern Africa have been completed, and current work is concerned with sites in the U. S. Great Plains, and Southwest Desert.

Photo Interpretation of Coastal Sand Dunes and Associated Features (U), RR 004-04-0024. University of Massachusetts, Amherst, Massachusetts, Department of Geology; Nonr 2242(00), NR 387-019; H. T. U. Smith.

Research has been conducted on processes of sand dune development and on guides which can be used by aerial photo interpreters in analyzing the physical characteristics of dunes.

Terrain Analysis by Photo Interpretation (U), RR 004-04-0026. Columbia University, New York, New York, Department of Geography; Nonr 266(50), NR 387-021; A. N. Strahler.

Through photo interpretation, field and laboratory work, and statistical analysis, research has been conducted to develop methods of objective, quantitative terrain analysis and to determine the extent to which physical terrain properties, such as roughness, slope, soil strength and vegetation density may be predicted through air photo observations.

Aerial Sensing of Environmental Conditions on the Ground (U), RR 004-04-0027. University of Wisconsin, Madison, Wisconsin, Department of Meteorology; Nonr 1202(07), NR 387-022; R. A. Bryson.

This research is directed toward improvement of capabilities of determining environmental conditions on the ground by rapid aerial survey methods. A wide variety of airborne sensors is being used including several cameras with different types of filters and films, several kinds of radiometers and radar. Aerial survey data will be used in conjunction with data collected by field investigators on the ground. The area being studied extends from Wisconsin to the Arctic. In this area emphasis is being given to the study of the thermal and ice regimes of lakes and to vegetation as major indicators of environmental conditions. An essential part of the research involves the determination of relationships between environmental factors, especially on a seasonal basis, so that some conditions can be inferred from the "sensing" of other conditions.

Use of Electronic Scanners to Analyze Geographic Distributions (U), RR 004-04-0028. Bowling Green State University, Bowling Green, Ohio; Nonr 3004(01), NR 387-023; J. P. Latham.

The basic purpose of this research is to develop better methods for rapid and accurate analyses of geographic phenomena from maps and aerial photographs. The ultimate objective is to devise an electronic scanning, computing, and recording system which will possess the capability of rendering an accurate enumeration, measurement, and description (by differentiation) of various complex distributions depicted on maps or photographs. A thorough study of electronic scanning devices, densitometers, computers and other instruments is being conducted. An investigation of the possible application of each device is being made and selected equipment is being tested to determine which devices and combination, with any necessary adaptations or modifications, can most feasibly and economically be incorporated with the recommended methodology.

Interpretation of Glacial Deposits from Color Air Photos (U), RR 004-04-0029. University of Notre Dame, Notre Dame, Indiana, Department of Geology; Nonr 1623(08), NR 387-024; E. M. Winkler.

With the use of aerial photographs, a detailed study of various types of glacial drift and associated geomorphology is being perfomed. Different

types of standard and special-purpose films, particularly infrared, are being utilized in taking aerial photos of a section of northern Indiana and southern Michigan. These photographs are being examined and compared with each other, and with conventional black-and-white photos of that area, to determine the advantage of using selected films in the study of glaciated terrain. Particular emphasis is being placed on the recognition of the kind and character of glacial drift materials and the detection of subsurface water (ground water). Photographic flights are being made at various selected times in the year in order to permit evaluation of the tone-difference characteristics which are associated with seasonal changes.

Spectral Reflectance of Forest Vegetation (U), RR 004-04-0030. University of Illinois, Urbana, Illinois, Department of Forestry; Nonr 1834(31), NR 387-025; L. C. Bliss, C. E. Olson.

Improved techniques for the determination and utilization of spectral reflectance characteristics of objects which are frequently subject to aerial photography are being studied. These techniques are being employed in a systematic investigation of the properties of light reflected from forest vegetation. Environmental factors being carefully noted, representative foliage samples of selected tree species are being collected periodically and subjected to spectrophotometric and foliar analysis. Data obtained from the spectrophotometric measurements will then be transformed to standard terms of color differences and statistically analyzed. An interpretation of these analyses and a discussion of their implications in aerial photography and photographic interpretation will be made.

Geography of Coral Atolls (U), RR 004-04-0031. National Academy of Sciences, Washington, D. C., Pacific Science Board; Nonr 2300(12), NR 388-001; H. J. Coolidge, H. J. Wiens.

An enormous amount of information has been collected by the teams of scientists who conducted intensive field study of five Pacific coral atolls, typical of contrasting conditions. In addition, a considerable quantity of information was accumulated by earlier field research conducted under the CIMA and SIM programs, and under the coral atoll bibliography phase of this task. Much of this information is highly specialized in subject, localized in scope and, in itself, provides little understanding of the regional geography of the low islands of Oceania. Under this task research is being conducted to organize, synthesize and interpret these data and to develop valid generalizations concerning the nature and characteristics of coral atoll environments and the people who inhabit these islands. Additional studies of Pacific Islands are also being undertaken.

Coastal Morphology (U), RR 004-04-0032. Louisiana State University, Baton Rouge, Louisiana, Coastal Studies Institute; Nonr 1575(03), NR 388-002; R. J. Russell, J. P. Morgan.

Detailed and comparative studies are being made of alluvial and other coastal areas to determine (1) morphology, distribution and relations of surface phenomena, (2) dominant geomorphic processes and resulting forms, both past and present, (3) rates of change of beaches, shoreline, channels, and other features, (4) depth of waterways, nature of bottom, and other factors affecting navigability, (5) mechanical, physical and other characteristics of surficial materials affecting trafficability, and (6) significance and indicator value of distinguishing features on aerial photographs. The research is primarily based on field observations, measurements and sampling, supplemented by laboratory analyses and interpretations of aerial photographs.

Identification and Classification of Coastal Features (U), RR 004-04-0033. University of California, Los Angeles, California, Department of Geology; Nonr 233(06), NR 388-013; W. C. Putnam, H. P. Bailey.

Research has been conducted to formulate an orderly, systematic guide in which coastal terrain and environmental features are grouped into realistic assemblages as they are actually found and associated in the various coastal zones of the world. Classification systems have been devised and applied on a world-wide basis to depict coastal landforms, climates and vegetations.

Beach Environmental Investigations (U), RR 004-04-0034. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Nonr 1254(00), NR 388-018; J. M. Zeigler.

This research is concerned with the nature and rate by beach development and modification. By repeated observations and measurements, qualitative and quantitative data have been collected at several sites along the Massachusetts coast. The selected study sites provided a wide range of beach environments and a variety of beach-types having different exposure to wind and wave conditions, different amounts and availability of beach and shoal materials, differing tidal ranges and different slopes of offshore bottoms.

Comparative Study of African Ports (U), RR 004-04-0036. Columbia University, New York, New York, Graduate School of Business; Nonr 266(29), NR 388-022; W. A. Hance, I. S. van Dongen.

The basic purpose of this research is to extend the knowledge of African port geography. This involves analysis of the ports, their hinterlands, actual and potential connections with these hinterlands, trade and traffic, and maritime contacts. This study includes field investigations of both major and minor ports on both the east and west coasts south of the Sahara. The research is providing a factual framework for comparative analysis of African ports.

Physical Geography of the Guiana Coast (U), RR 004-04-0038. Louisiana State University, Baton Rouge, Louisiana, Department of Geography; Nonr 1575(02), NR 388-028; J. H. Vann.

A field study is being made of the tropical lowland coast of Surinam and British, French and Brazilian Guiana to determine the physical characteristics, distribution and relationships of landforms, waterways and vegetation, and to define the processes involved in the formation of the features of this coast. Comparisons and contrasts are being made between the physical features of this coast

and those of the chenier area of coastal Louisiana, and between the mangrove zone of the Guianas and that of Colombia. The coastal areas of both Louisiana and Colombia have been intensively studied under tasks NR 388-002 and NR 388-059. This field investigation and comparative analysis is contributing important information on the coastal geography of a little-known area and on the genetic principles involved in coastal development.

Organic Reef Terminology Index (U), RR 004-04-0039. National Academy of Sciences, Washington, D. C., Pacific Science Board; N7onr 29165, NR 388-037; H. J. Coolidge.

An annotated alphabetical index of terminology covering reefs, coral and algal, their facies and development is being compiled. The index includes references to the places of publication of the principal usages and the sources of definitions used by leading authors of reef literature. This index should do much to clarify the present confusion in terms and usage. It will provide the basis for the development of a rational and acceptable reef terminology.

Geography of Indian Coasts (U), RR 004-04-0042. Sacramento State College Foundation, Sacramento, California, Division of Social Sciences; Nonr 2329(00), NR 388-041; D. E. Sopher.

Both the physical and human aspects of the coastal geography of Ceylon, Pakistan and parts of India have been investigated through intensive and extensive field study. The physical characteristics of the coastal zone have been examined to determine the occurrence and relationship of the features. Human use and economy of the zone were studied particularly with regard to the utilization of strand resources, fishing activities and the use of boats, and the character and extent of seafaring.

Geographic Aspects of Offshore Claims (U), RR 004-04-0043. Harpur College, Endicott, New York, Department of Geography; Nonr 1349(03), NR 388-044; L. M. Alexander.

Using the North Sea as a laboratory area, a study was made of the methods of delimiting territorial seas and contiguous zones to define the geographic aspects and problems of applying legal concepts to actual shoreline conditions. Specific practices of boundary delimitations and claims to offshore areas of the seven North Sea nations have been analyzed in terms of their geographic implications.

Caribbean Trade Geography (U), RR 004-04-0045. Indiana University, Bloomington, Indiana, Department of Geography; Nonr 908(13), NR 388-051; O. P. Starkey.

Field and library research has been conducted on the internal and external trade of selected Caribbean islands to determine the nature, characteristics, patterns and trends of maritime trade and its relation to various physical and human geographic factors. The current situation as well as that of the recent past was studied to evaluate and interpret the basic economic geography of this island area.

Relations of Nearshore Oceanographic Conditions to Local Climates (U), RR 004-04-0046. Robert E. Stevenson, Fullerton, California; Nonr 2679(00), NR 388-052; R. E. Stevenson.

Detailed observations, measurements, and analyses of meteorologic and oceanographic records have been made to refine the knowledge of relations of local coastal climates to nearshore water types and movements of air. Using the east coast of England as a study area, local water types and their controlling factors have been identified. The details, magnitude, and areal extent of the influences of these water types have been determined in an effort to establish criteria for recognizing, and possibly predicting, climatic variations and weather situations resulting from specific oceanographic and meteorologic conditions.

Geomorphology of Mexican Lagoons (U), RR 004-04-0047. University of California, La Jolla, California, Scripps Institution of Oceanography; Nonr 2644(00), NR 388-053; G. C. Ewing, F. B. Phleger.

Research is being conducted on selected lagoons and barrier island areas along the west coast of Mexico to: describe the distribution and characteristics of different types of lagoons; study the methods of formation of lagoons, processes of sedimentation, and ecology of some of the organisms; and study the history of lagoon shoreline development.

Port Studies in Brazil (U), RR 004-04-0048. University of Miami, Coral Gables, Florida, Department of Geography; Nonr 840(11), NR 388-054; S. C. Rothwell.

A field study has been made to describe and interpret the changing geographical relations of the three main ports of the State of Rio Grande Do Sul, Brazil, and their hinterlands. The research includes analysis of port location and facilities, trade volume and composition, transportation ties to hinterlands, and characteristics of hinterlands, such as physical features, population distribution, productivity, and pattern of consumption. The ports studied were Porto Alegre, Rio Grande, and Pelotas.

Quantitative Study of Beach Morphology and Processes (U), RR 004-04-0049. Columbia University, New York, New York, Department of Geology; Nonr 266(68), NR 388-057; A. N. Strahler.

A quantitative study is being made of beach forms and processes, Various methods, including statistical analyses, are being applied, to identify and measure the factors that control beach behavior. Emphasis is upon the design of experiments in which morphological and structural elements are dependent variable with respect to a series of independent variables including wave characteristics, tides, currents, and meteorological elements. The area selected for the study is Sandy Hook, New Jersey.

Selected Processes of Beach Aggradation (U), RR 004-04-0050. Columbia University, New York, New York, Department of Geology; Nonr 266(69), NR 388-060; R. W. Fairbridge.

A study has been made at selected sites along the north shore of Long Island to determine processes and rates of change of shoreline forms, and

to trace the development of sand spits and salt marshes. Analysis of two to three centuries of records has been supplemented by data obtained from field measurements of sediments movement, current and wave conditions, nearshore bottom features, and subsurface materials.

Caribbean Geography (U), RR 004-04-0051. University of California, Berkeley, California, Department of Geography; Nonr 222(11), NR 388-067; J. J. Parsons, C. O. Sauer.

Field investigations are being conducted to provide new and accurate scientific data on the environment, coastal topography and morphology, beach and reef features, climate and vegetation of little-known parts of the tropical islands and the lowlands of the Caribbean, Middle American and Northern South America. This program of coordinated studies is designed to fill the need for comprehensive and detailed geographic information on this important area.

Advisory Committee for Geography (U), RR 004-04-0053. National Academy of Sciences, Washington, D. C., Earth Sciences Division; Nonr 2300(07), NR 389-008; E. B. Espenshade, Jr.

The broad scope of the field of geography includes a great variety of regional and topical specialties. Thus the planning of a geographic research program encompassing the numerous subfields requires specialized guidance in order to assure scientific validity and a realistic approach. This task provides for an advisory committee of leading geographers to assist in developing the ONR program, to make recommendations concerning the scientific merits of proposed studies, to furnish information on the research activity and progress throughout the world, and to stimulate and promote basic geographic research.

Climate Changes in Chile (U), RR 004-04-0054. American Geographical Society, New York, New York; Nonr 641(04), NR 389-120; C. J. Heusser.

Research was conducted to establish the chronology of environmental changes which have occurred in southern Chile since recession of glaciers of the last ice age. Three major methods of study were used: analysis of pollens in peat deposits, radiocarbon dating, and study of recent glacier variations as measured and dated from ages and growth patterns of local woody plants.

Measurement of Geographic Association (U), RR 004-04-0057. State University of Iowa, Iowa City, Iowa, Department of Geography; Nonr 1509(02), NR 389-095; H. H. McCarty.

The objective of this task is to develop and test methods for measuring the degree of spatial association of various features and conditions on the earth's surface. The methods involved include certain standard statistical techniques which have been little used in geographic research and some newly devised statistical and cartographic procedures.

Cave Studies (U), RR 004-04-0058. National Speleological Society, Vienna, Virginia; Nonr 1427(00), NR 389-098; B. Faust.

New information is being provided on the distribution and character of caves and on physical and chemical processes, flora, fauna, atmosphere, and water of caves. The Society brings together specialists such as geologists, hydrologists, geographers, meteorologists, biologists, and scientific photographers for these investigations. This broad scientific approach is necessary to solve the complex environmental problems of caves.

Team Research in Hydrology and Climatology (U), RR 004-04-0059. C. W. Thornthwaite Associates, Elmer, New Jersey; Nonr 2997(00), NR 389-101; C. W. Thornthwaite.

To obtain a better knowledge of the earth's water balance, and the exchange of heat and moisture between the earth's surface and the atmosphere research is being conducted (a) to improve methods of computing water balance from climatic data, (b) to determine and analyze the water balance at specific areas, and (c) to develop and test instruments for measuring the heat and moisture flux. In the conduct of this microclimatological research particular attention is paid to such factors as vertical and horizontal wind velocity, air and soil temperature, air moisture content, precipitation, radiation, and evapotranspiration.

Foreign Field Research (U), RR 004-04-0060. National Academy of Sciences, Washington, D. C., Division of Earth Sciences; Nonr 2300(09), NR 389-105; E. B. Espenshade, Jr.

The purpose of this task is to increase and improve geographical field research in foreign areas. The Division of Earth Sciences, NAS-NRC, stimulates interest and activity in this type of research and aids in selection of the most capable investigators and most promising programs of research.

The Anomalous Climates of the Earth (U), RR 004-04-0062. University of Wisconsin, Madison, Wisconsin, Department of Geography; Nonr 1202(06), NR 389-117; G. T. Trewartha.

This task was concerned with research on the genesis of climates which are considered to be anomalous. This included research on, e.g., the dry littonals of Yucatan, Ecuador and Ghana, on areas where night rainfall strongly predominates as along the west coast of Colombia and portions of the Guinea Coast, and on the occurrence of the mid-summer secondary minimum of rainfall characteristic of much of the Caribbean and China Sea areas.

Recent Geographical Changes in Italy (U), RR 004-04-0063. University of Michigan, Ann Arbor, Michigan, Department of Geography; Nonr 1224(28), NR 389-122; G. Kish.

In Italy the period following World War II brought significant changes in land tenure, land use, and settlement patterns. These changes have taken place at various times and places on varying scales. This research is concerned with the decription and explanation of these changes and with assessing their impact on the landscape and economy.

Comparative Studies of Central Places (U), RR 004-04-0065. University of Chicago, Chicago, Illinois, Department of Geography; Nonr 2121(18), NR 389-126; H. M. Mayer, B. J. L. Berry.

The aim of this research is to develop formal,

precise, predictive central place theory through the use of new statistical methods and advanced quantitative procedures. The basic concept of central place theory is that there exists a hierarchy of nodal places, which serve as centers for production and diffusion of services, goods, and ideas. Data are being collected and analyzed to develop a valid model of central places, central place functions and threshold requirements, and complementary regions in North America. The developed theory will then be tested in other geographical areas.

High Latitude Settlements (U), RR 004-04-0066. University of Wisconsin, Madison, Wisconsin, Department of Geography; Nonr 1202(05), NR 389-127; K. H. Stone.

The settlements of northern Norway, Sweden, Finland, Canada and Alaska are being studied in terms of their geographic, economic and sociologic aspects. Statistical, cartographic, photo interpretation and field techniques are being applied in the analysis of the factors which influence the permanence of the settlements and the degree of mobility of the settlement frontier. Coastal settlements in northern Norway, Sweden, and Finland are being studied in detail, and comparisons are being made with inland settlements and with Alaskan and Canadian settlements in similar environments.

Origin of Silts (U), RR 004-04-0067. Iowa State University, Ames, Iowa, Department of Geology; Nonr 2991(00), NR 389-128; C. J. Roy.

The purpose of this research is to investigate the origin, properties, and geomorphic history of silt (so-called loess) deposits. The study area is the Missouri River Valley. Through the use of borings, aerial photographs, sample analysis and other geomorphic techniques, definitive evidence is being procured which not only will decipher the local landscape evaluation, but will solve the controversy concerning the origin of these silts.

Application of Perceptrons to Photo-Interpretation (U), RR 004-04-0068. Cornell Aeronautical Laboratory, Buffalo, New York; Nonr 3161(00), NR 387-026; A. E. Murray.

The "perceptron" is a recently developed and unique electronic cognitive system, with self-organizing biological-type componetry, which is capable of performing pattern perception, recognition, and learning functions. It is the purpose of this research task to apply perceptron principles to the design and development of an automatic photo-interpretation device. The initial phase of this research has comprised basic analytical and experimental studies directed towards the preliminary engineering design of a perceptron-centered mechanized photo-interpretation system. A necessary study of the operational requirements and specific photo-interpretation missions which should and can be performed by such an automated system is also being conducted.

Stereo Photography (U), RR 004-04-0069. Pick Laboratories, Saratoga, California; Nonr 3205(00), NR 387-027; R. M. Tripp.

This task is investigating methods of making depth perception aerial photographs. The technique with which the Pick Laboratories is primarily concerned involves the photographic compositing of a succession of slightly different images of the same subject into one picture and doing it in such a manner that each eye sees a different image, and if the viewing position is shifted slightly, the two eyes see a new pair of images as would happen if viewing the actual subject instead of the picture.

North American Port Hinterlands (U), RR 004-04-0070. University of Maryland, College Park, Maryland, Department of Geography; Nonr 595(05), NR 388-033; D. J. Patton.

The objective of this research was to isolate and study meaningful indicators of the features and forces in the hinterlands of North American ports which have influenced and are influencing the growth and relative trade position of these ports. The situation and spatial relations of the major ports of the Atlantic and Gulf coasts were studied, and analyses were made of the nature and functioning of the hinterlands of these ports. This study increased the understanding of the causative factors affecting the status of American ports and provided a more accurate basis for predicting and appraising future trends.

Geography of Canary, Madeira and Cape Verde Islands (U), RR 004-04-0071. University of California, Riverside, California, Division of Social Sciences; Nonr 1842(03), NR 388-058; H. H. Aschmann.

A detailed geographic study is being made of the Canary Islands, together with studies of the Madeira and Cape Verde Islands for comparative purposes. The objectives of this field study are to obtain up-to-date, accurate physical and economic geographic information on these incompletely-known island groups, and to assess the significance of such factors as insular environment, immigrants, and settlement sequence in the development of current geographic patterns.

Geologic and Hydrologic Study of Two Florida Bays (U), RR 004-04-0072. Florida State University, Tallahassee, Florida, Oceanographic Institution; Nonr 988(07), NR 388-061; D. S. Gorsline, H. G. Goodell.

Detailed, quantitative surveys are being conducted in Apalachicola Bay and Florida Bay to determine basic processes and regimes controlling sedimentation and water circulation. Studies are being made to ascertain the patterns of water circulation, to measure the characteristics of the water masses, and to isolate, define and measure the relations between these factors and such elements as the sedimentation pattern, amounts and kinds of sediments, rates of sedimentation, and the resulting bottom topography and bay configuration. Observations are being made of the prevailing weather conditions and the surface state of bay waters to determine the relation between wave energy and shoreline type. The data from these studies will be analyzed and synthesized in the construction of a theory of bay evolution and as a basis for predicting future changes in bay shapes and characteristics.

Recent Physical Changes on the Oregon Coast (U), RR 004-04-0073. University of Oregon, Eugene, Oregon, Department of Geography; Nonr 2771(04), NR 388-062; S. N. Dicken.

Field, laboratory and archival research is being conducted to determine and explain the extent and rate of physical changes on the Oregon coast. Special attention is given to the effects of the works of man in modifying or accelerating the natural processes that alter coastal features.

Geography of Northern Tanganyika Coast (U), RR 004-04-0074. University of Illinois, Urbana, Illinois, Department of Geography; Nonr 1834(35), NR 388-063; C. S. Alexander.

A field study is being conducted in the coastal region of northern Tanganyika to determine surface configuration; relations among rock and soil types, vegetation and climate; and physical characteristics of the coastline and beaches. In addition to the concise delimitation of landforms, slope development and mass movement are also being investigated.

Sediments and Geomorphology of Coastal Virginia and Adjacent Continental Shelf (U), RR 004-04-0075. Yale University, New Haven, Connecticut, Department of Geology; Nonr 609(40), NR 388-064; J. E. Sanders, R. F. Flint.

An intensive study is being made of the coastal area of Virginia south of the James River estuary and of adjacent parts of the continental shelf. The main objectives of the research are to determine the pattern and environment of deposition of sediments on the emerged and submerged parts of the coastal plain and their relations to former sea level changes, and to discover the relation of coastal and shelf sediment patterns. In the initial phase of the work, a device for underwater sand coring has been developed.

Land-Sea Movements in Connecticut (U), RR 004-04-0076. Cornell University, Ithaca, New York, Department of Geology; Nonr 401(45), NR 388-065; A. L. Bloom.

A systematic study of Connecticut coastal morphology and stratigraphy is being conducted to establish the rates, times and causes of changes in sea level position. Through analysis of pollen, geological and archeological evidence, the relations between crustal movement and eustatic fluctuation of sea level will be determined.

Pacific Information Center (U), RR 004-04-0077. Bernice P. Bishop Museum, Honolulu, Hawaii; Nonr(G) 0005-61, NR 388-066; E. H. Bryan, Jr.

The purpose of this task is to aid in the establishment of a Pacific Scientific Information Center to serve the research needs of the many scientists working in the Pacific. Data, maps, photographs and other source material, accumulated for many years by the Bernice P. Bishop Museum, are being organized and made available so that maximum use may be made of this unique and valuable collection.

Near East Climatic Changes (U), RR 004-04-0078. University of Minnesota, Minneapolis, Minnesota, Department of Geology and Mineralogy; Nonr 710(33), NR 389-129; H. E. Wright.

Studies are being made in various Near East localities to obtain data on climatic changes that have occurred since late-glacial time. Among the possible study sites are southern Turkey, Syria, Lebanon, Israel, Iraq and southwestern Iran. At several selected localities cores were taken of pollen-bearing sediments, and correlation data were collected on the present vegetation composition and distribution, and other pertinent environmental factors, such as terrain conditions. From statistical studies of the pollen, analyses of the mineral, fossil and organic composition of the sediments, and radiocarbon dating, a chronology of climatic fluctuations will be developed, and compared with the detailed chronologies for Europe.

Drainage Systems Development Forms and Rates (U), RR 004-04-0079. Montana State University, Missoula, Montana, Department of Geology; Nonr 3254(00), NR 389-130; M. Morisawa.

Using as a laboratory area the newly exposed southern shore of Hebgen Lake, uplifted during the earthquake of 18 August 1959, a detailed morphometric study is being made to determine the rates and characteristics of the development of drainage systems. Measurements will be made of drainage factors, such as stream length, gradient, area, angle of bifurcation and relief. These and other data will be statistically analyzed to identify associations between drainage factors and sediment characteristics.

Map of the Ocean Floor (U), RR 004-04-0080. Richard Edes Harrison, New York, New York; Nonr 961(P), NR 389-131; R. E. Harrison.

A map of the topographic features of the floor of the oceans of the world has been prepared at a scale of 1:50,000,000 on the Briesemeister Elliptical Equal-Area projection.

R004-05 Arctic Geography

Arctic Laboratory and Field Research (U), RR 004-05-0001. Arctic Institute of North America, Washington, D. C.; Nonr 1138(01), NR 307-105; R. C. Faylor.

The contractor is responsible for submitting a broad program of basic arctic research to the Chief of Naval Research and for making recommendations concerning fields of research which need to be exploited. The contractor cooperates in making recommendations to the Chief of Naval Research concerning projects at the Arctic Research Laboratory and at field sites on the Arctic Slope of Alaska served by the laboratory. Valuable assistance is given to ONR by bringing the facilities and opportunities of the ARL to the attention of scientists and by recommending particularly capable investigators who can most profitably execute such arctic research projects as are approved by ONR. Administration of sub-contracts is a major function.

Arctic Research Laboratory (U), RR 004-05-0002. University of Alaska, College, Alaska; Nonr 1381(01), NR 307-106; W. R. Wood.

The contractor provides administrative, operative, and maintenance facilities for the operation of the Arctic Research Laboratory at Point Barrow, Alaska; carries out directives of ONR in supplying logistic support to individuals, or teams of investigators conducting research at Point Barrow, and other areas on the Arctic Slope and in the

Arctic Seas falling within the scope of ONR interest and ARL responsibility; maintains and guards buildings and equipment at Point Barrow, and field sites; and coordinates and facilitates activities of research teams at the ARL and in the field.

Permafrost Investigations in Alaska (U), RR 004-05-0003. U. S. Geological Survey, Washington, D. C.; NAonr 5-59, NR 307-107; W. H. Diment.

Thermal profiles, gradients and conductivities in permafrost and sea ice are determined through thermistor cables installed in wells drilled for oil exploration and holes drilled beneath buildings and in selected topographic sites. Thermal effects caused by seasonal temperature changes, the heat from buildings and heat caused by engineering construction and use are investigated. Although these data are in part limited to empirical interpretation, the range of application of the data is being extended by formulation of general principles for a known set of conditions and by derivation of mathematical equations consistent with the laws of heat conduction. Studies are in progress to determine the necessary constants of thermal conductivity, thermal diffusivity, and volumetric specific heat of permafrost and the active layer.

Juneau Ice Field Study (U), RR 004-05-0004. American Geographical Soceity, New York, New York; N9onr 83001, NR 307-233; C. J. Heusser.

The contractor provided data on the physical characteristics, environmental controls, and historic and current fluctuations of snow and ice fields and glaciers. Emphasis was placed on investigations of the energy exchange at snow and ice surfaces and on calculations of the hydrological budget based on measurements of accumulation and wastage, glacier volume and on determination of the three-dimensional field of motion of ice masses. The study provided instrument development and testing, a training ground for personnel, and fundamental data on glacier regiment for the glaciological program of International Geophysical Cooperation.

Crystal Fabric Studies of Sea and Glacier Ice (U), RR 004-05-0006. University of Washington, Seattle, Washington; Nonr 477(18), NR 307-244; P. E. Church.

The purpose of this task was to determine by optical petrographic and other techniques the physical properties of ice of glaciers and arctic pack ice. Crystal fabric structure of ice is related to exchange of mass and energy between ice and its meteorological and/or oceanographic environments. Evidence for annual layering of pack ice, necessary for understanding of the ice budget, was sought by study of variations of crystal structure of old ice and re-frozen, salt-free ice. Comparative studies were made of petrofabrics of glacier ice, of frozen melt-water ponds on sea ice surfaces and of the old ice of pressure ridges and hummocks in the polar pack. Vertical displacement by creep deformation of hydrostatically adjusted hummocks was utilized as a technique to determine low-stress strain rates. Additionally, salinity of sea ice, including frozen and unfrozen brine, and permeability characteristics of ice as a factor in brine mobility, were investigated.

Structural and Mechanical Properties of Sea Ice (U), RR 004-05-0007. University of Alaska, College, Alaska; Nonr 2601(01), NR 307-247; H. R. Peyton.

This investigation is establishing the primary parameters determining the strength of sea ice, freshwater ice and materials of perennially frozen ground. Strength is studied in relation to structure and mechanical properties and as a function of composition, temperature environment, solute concentration, time and rate of natural and superimposed artificial loading. In situ measurements of elastic and plastic strain in the field are compared with results of laboratory testing. Triaxial shear tests provide data on the fundamental parameters related to tensile, compressive and shear stresses as well as to elastic and plastic deformation. The tri-axial shear concept is extended to include plastic flow in an attempt to establish explanations of deformation of pack ice and flow of glaciers.

Engineering Properties of Soils (U), RR 004-05-0008. Iowa State College, Ames, Iowa, Iowa Engineering Experiment Station; Nonr 2625(00), NR 307-249; C. J. Roy, D. T. Davidson.

Investigations of engineering properties of various types of sediments of glacial and eolian origin collected in Alaska. Materials were subjected to laboratory tests designed to yield solutions to problems of soil stabilization, trafficability and road construction. Positive correlations have been made between trafficability and such field conditions as topography vegetation cover and agricultural practices, but correlation is poor in relation to standard engineering properties of soil materials.

Sea Ice Drift in Relation to Winds (U), RR 004-05-0009. University of Washington, Seattle, Washington; Nonr 477(23), NR 307-250; P. E. Church.

This task provided for the development of improved ice forecasting techniques for the Arctic Basin through a study of the factors controlling the drift of arctic pack ice and a re-examination of the theories pertaining to ice drift. Knowledge about factors affecting ice drift was obtained by analyzing specially prepared symoptic charts upon which the ratio of ice drift to wind speed and the angular deviation of drift from wind direction have been plotted. Data used in the construction of these maps came from observation made on the drifting stations, Alpha, Charlie, the Russian North Pole 7, and from Ptarmigian Reconnaissance Flights.

Arctic Drift Station (U), RR 004-05-0011. University of Washington, Seattle, Washington; Nonr 477(24), NR 307-252; P. E. Church.

This task provides for a diverse scientific program conducted on ice floes, ice islands, and natural shore-fast, or artificially prepared, ice surfaces on the Arctic Ocean. The program includes basic scientific investigations related to the formation, dissipation, movement and physical properties of the Polar pack ice; the physical environment of ice and open water of leads; oceanography and ocean bottom characteristics beneath the ice; and crystal fabric studies of ice.

Arctic Oceanography (U), RR 004-05-0012.

University of California, La Jolla, California, Scripps Institution of Oceanography; Nonr 2216(06), NR 307-253; F. B. Phleger.

The objective of this task is to provide data on physical oceanography and marine geology and biology of arctic waters as represented by the Bering, Chukchi, and Beaufort Seas, including nearshore areas and lagoons. The investigation consists principally of analysis of tides and the making of standard oceanographic stations. Shore and ice-mounted tide gauges at Point Barrow and other selected points provide data on astronomic and wind-generated tides. Hydrographic data, including temperature, salinity, current and depth measurements, bottom collections, ice thickness, and meteorological measurements are obtained at stations made either from surface craft or from the ice by landing with bush planes. Temperature and salinity data contribute to tide studies by defining steric changes of sea level. Seasonally, as conditions permit, additional research objectives include observations on formation movement and dissipation of sea ice, studies of the bathymetry and origin of the Barrow Sea Valley-Submarine Canyon System, analysis of the primary productivity of phytoplankton observation and analysis of coastal sediments, and studies of Foraminifera distribution.

Drift Station CHARLIE (U), RR 004-05-0013. Alaskan Air Command, Elmendorf Air Force Base, Anchorage, Alaska; MIPR 7-60, NR 307-255; J. Smith.

This task provided for the logistic support of Drift Station CHARLIE, a scientific research station in the Arctic Pack. The scientific investigations included a broad range of meteorological, geophysical, oceanographic, marine biological, sea ice and underwater acoustic research necessary to understanding of arctic environments and to successful Navy operations in polar areas.

Arctic Drifting Station, Meteorology (U), RR 004-05-0014. U. S. Weather Bureau, Department of Commerce, Washington, D. C.; NAonr 51-59, NR 307-258; F. W. Reichelderfer.

This task provides a weather station on Drift Station Bravo in the Arctic Ocean. Both standard surface observations and twice daily upper air observations are made.

Earth Current Studies at Drift Stations and Point Barrow, Alaska (U), RR 004-05-0016. University of Alaska, College, Alaska, Geophysical Institute; Nonr 3010(01), NR 307-261; V. P. Hessler.

The objectives of this task are to record and analyze the occurrence, characteristic forms, amplitude and frequency or period of fluctuations of earth currents in the Arctic Basin and fringing lands. Ionospheric disturbances to North-South and East-West components are studied comparatively at central Alaska, and coastal stations as well as on Drift Stations CHARLIE and ARLIS-1 deep within the auroral zone.

Arctic Basin Geophysics (U), RR 004-05-0017. University of Wisconsin, Madison, Wisconsin, Department of Geophysics; Nonr 1202(16), NR 307-262; G. P. Woollard.

The objective of this task is the determination of the structure and surficial geology of the continental shelf and oceanic basin north of Alaska. Such an objective can best be accomplished through an analysis of seismic, gravity, magnetic, bathymetric, and bottom sediment measurements from the most scientifically significant areas in the Arctic Basin. The determination of these strategic areas is the immediate objective of this task and can be accomplished by a reconnaissance study of the thickness, structure, and lithic characteristics of the surface sedimentary and basement crystalline rocks beneath the Arctic Ocean.

Icelandic Coastal Studies (U), RR 004-05-0018. Middlebury College, Middlebury, Vermont, Department of Geology and Geography; Nonr(G) 0009-60, NR 307-263; V. H. Malmstrom.

The objectives of this task include a study of the two contrasting coasts of Iceland and an analysis of the relationship between the climatic conditions of the interior of the island and its soils, vegetation and permafrost. The coastal studies will consist of a detailed field analysis including comparative studies of the strandflats along the south and west coasts and the marine terraces of the north and east coasts. Detailed maps of these coasts will be made and their analysis, coupled with an evaluation of the dominant coastal processes, will be used to determine post-glacial changes in sea level in Iceland.

Analysis of Tundra Ecosystems (U), RR 004-05-0019. University of California, Berkeley, California; NR 307-264; A. M. Shultz.

This task studies the nitrogen and phosphorous (and possibly other elements) in the economy of an arctic tundra ecosystem by two concurrent methods. These include mapping time distributions of nutrients with one complete lemming population cycle as a base, and by mapping areal distribution of nutrients at several stations known to be out of place with regard to the lemming cycle. Transport of mineral nutrients into and out of the ecosystem will be taken into consideration in this study. The relation of the nutrient economy of the ecosystem to fluctuations in vegetation and animal production will be studied also.

Drift Station Marine Biology (U), RR 004-05-0020. University of Southern California, Los Angeles, California; Nonr 228(19), NR 307-270; J. L. Mohr.

This task provides for marine biological studies of the deep waters in the Arctic Basin, shallower waters over the continental shelf, and brackish waters in coastal lagoons near Point Barrow. Research from drifting ice stations is emphasized and includes the collection and analysis of the floating and anchored fauna and flora, qualitative and quantitative measurement of metabolic reserves through annual cycles of marine animals, statistical analysis of planktonic organisms, and levels of parasites upon the commoner marine animals. Fresh biological samples from the ocean waters and bottom sediments are examined in the field and specimens are preserved for later detailed laboratory analysis.

Radiation Sea Ice Studies (U), RR 004-05-0021. U. S. Naval Electronics Laboratory, San Diego,

California; NR 307-241; W. K. Lyon.

Total shortwave and net longwave radiation measurements are made upon horizontal surfaces at a height of 3.0 meters. Air temperature gradients are measured between 1.5 and 3.0 meters above the surface. These and similar data collected at the NEL station at Wales, Alaska, are analyzed at NES San Diego to compute the heat budget of the Chukchi-Bering Seas. Heat budget results are correlated with formation, behavior and dissipation of sea ice recorded by time lapse photography of the ice surface during the periods of freeze and break-up.

Arctic Visibility and Concealment (U), RR 004-05-0022. U. S. Naval Electronics Laboratory, San Diego, California; NR 307-242; R. S. Gales.

This task consists of the collection of basic optical data of typical Arctic Ocean environments over an extended period of time. It provides the necessary input data for making visual detection and recognition range calculations of a large variety of military targets for various times of the year. The task includes the design and testing of a variety of high and low visibility measures for military use in the Arctic.

AFCRL Arctic Communication (U), RR 004-05-0023. Cambridge Research Laboratory, Boston, Massachusetts; NR 307-243; K. Toman.

The spatial and temporal variation of ionization associated with aurora is studied by means of radio propagation between a receiver station at ARL inside, and a transmitting station outside the auroral zone.

Ionospheric Research (U), RR 004-05-0024. National Bureau of Standards, Boulder Laboratories, Boulder, Colorado; NR 307-246; H. G. Sellery.

By use of 10, 15 and 20 mc transmitters installed at the ARL, experimental information is obtained on high frequency auroral propagation factors affecting performance of modulation techniques for continuous and pulse communications. Fading rates are recorded continuously along the transmission path passing through the zone of maximum auroral activity to the receiver site at Boulder, Colorado. Magnetic tape recordings of carrier envelope voltages of the received signals are made at intervals by the FM subcarrier recording techniques. Programs of vertical ionospheric soundings and measurement of phase perturbations of received continuous wave signals are also maintained.

Ice Construction Techniques (U), RR 004-05-0025. U. S. Naval Civil Engineering Laboratory, Port Hueneme, California; NR 307-254; A. B. Chilton.

The principal objective is the development of techniques for construction of thickened ice masses on the Arctic ice pack. Pumping and spraying equipment is designed, cold-weather tested, and utilized under arctic winter condition at the ARL. Variations in rate, quantity and form of application of sea water to ice surfaces of differing areal extent, either diked or undiked, under differing temperature environments, provide ice of known history which is subjected to analysis of physical properties in relation to strength. Field trials and laboratory testing provide comparative data on natural sea ice and that resulting from artificial thickening.

Secondary investigations associated with the foregoing, but not necessarily related, are cold weather testing of wheel and track-laying vehicles, motors, earth-moving and lifting machines and sanitation systems.

Air Force Lake Peters Alaska Studies (U), RR 004-05-0026. U. S. Geological Survey, Washington, D. C.; NR 307-256; G. W. Holmes.

This investigation is a cross-disciplinary study being conducted by AFCRL in the vicinity of Lake Peters, Alaska, near the eastern end of the Brooks Range. Environmental information is provided in many fields including glaciology, micrometeorology, geology, including permafrost studies, pedology, ecology and limnology.

Arctic Slope Geology (U), RR 004-05-0027. U. S. Geological Survey, Washington, D. C.; NR 307-257; C. R. Lewis.

The geology of the Arctic Coastal Plain and adjacent piedmont region of Northeastern Alaska is being studied and mapped through a series of river and aerial traverses. Field emphasis is placed on the mapping of the surficial deposits and on the determination of their relative age. An appraisal of the engineering characteristics of surficial materials is also being made.

Geomagnetic Studies (U), RR 004-05-0028. U. S. Coast and Geodetic Survey, Washington, D. C.; NR 307-260; J. Campbell.

Periodic determinations are made of the declination, horizontal intensity, and vertical intensity of the magnetic field at the Barrow Geomagnetic Observatory. Changes in the magnetic field, which are recorded photographically, are studied and all magnetic storms are analyzed.

Arctic Gravity Survey (U), RR 004-05-0029. U. S. Geological Survey, Washington, D. C.; NR 307-265; I. Zietz.

This task provides a program of terrestrial and oceanic gravity measurements at numerous locations not previously traversed. Such data greatly increase knowledge of the regional geology of Alaska and the Arctic Basin, supplement reconnaissance aeromagnetic profiles, and provide data necessary to calculation of the shape of the geoid in the area.

Sipre Ice Engineering (U), RR 004-05-0030. U. S. Army Snow Ice and Permafrost Research Establishment, Wilmette, Illinois; NR 307-266; W. L. Nungesser.

This task entails the application of highly concentrated loads, simulating aircraft gear assemblies or wheeled vehicles, to fresh and salt-water ice. Tests including rapid loading and long-time application of "parked" loads are applied until breakthrough occurs. Experiments will include tensile, compressive, shear and deformation tests, and sonic tests for the determination of elastic properties. The effect of light loads of long duration, simulating buildings emplaced on ice, will also be studied.

Investigating Underwater Magnetic Variation in

Arctic Regions (U), RR 004-05-0031. U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland; NR 307-267; W. W. Schwendinger, C. A. Rowzee.

This task furnishes arctic environmental background information essential for meeting NOL objectives in the development of weapons and detectors. Continuous recordings of wave background pressures and variations in the earth's magnetic field are made at water depths of 30-150 feet in the Arctic Ocean at Point Barrow, Alaska.

Integrative Mechanisms in the Pairing of Predatory Birds (U), RR 004-05-0032. Syracuse University, Syracuse, New York, Department of Zoology; NR 307-268; T. J. Cade.

This task provides a broad background of observational information touching on many aspects of the behavior and ecology of certain species of predatory birds on the Alaskan Arctic Slope. In particular this study provides a naturalistic frame of reference within which more specific and analytical studies on the pairing of these species may find a proper interpretation. This work also constitutes general contribution to the life history studies of North American birds.

R004-06 Astronomy and Astrophysics

Photographic Photometry of Extragalactic Nebulae (U), RR 004-06-0002. California Institute of Technology, Pasadena, California, Astronomy Department; Nonr 1897(00), NR 046-170; F. Zwicky.

The photographic magnitudes of nebulae brighter than $m_p = +15$ were determined. All fields centered on points 5^o apart in right ascension were photographed directly and Schraffiert over areas 1" x 1" arc (by manual guiding of the 18" Schmidt telescope). The one square minute Schraffur permits the determination of good magnitudes as faint as $m_p = +15.0$ and sometimes $m_p = 15.5$ when the sky is exceptionally dark.

Photoelectric Photometry (U), RR 004-06-0003. Washburn University, Topeka, Kansas, Physics and Astronomy Department; Nonr 2326(00), NR 046-185; R. S. Alexander.

Photometric observations were made of eclipsing variable star systems. These were made simultaneously in two colors (yellow and blue) with a photoelectric photometer.

Photometry and Polarization of Astronomical Objects (U), RR 004-06-0004. Indiana University, Bloomington, Indiana, Astronomy Department; Nonr 2536(00), NR 046-202; A. M. J. Gehrels.

Photometric measurements are being made of asteroids, the moon, Mars and Venus. The work will be extended to other objects such as comets, Mercury, reflection nebulae, and possibly the Zodiacal Light. Of major interest is the wavelength dependence of the polarization of light from those objects and its variation with phase angle.

Advisory Committee on Astronomy (U), RR 004-06-0009. National Academy of Sciences, Washington, D. C.; Nonr 2300(06), NR 046-286; J. S. Coleman.

This task provides for a committee of leading astronomers which will conduct investigations and surveys in the field of astronomy; suggest programs to be undertaken by the Office of Naval Research under contract; and review and make recommendations with respect to the scientific merit and scope of proposed research and the qualifications of the institutions and investigators concerned.

Solar Research (U), RR 004-06-0011. High Altitude Observatory of the University of Colorado, Boulder, Colorado; Nonr 1223(00), NR 046-734; W. O. Roberts.

Various equipment is made available to the contractor for use in a continuing program of basic solar research. The main item is a 26-foot equatorial table upon which can be mounted a coronagraph and auxiliary equipment or any specialized equipment required for a particular phase of the program.

Analysis and Interpretation of 1952 Eclipse Spectra (U), RR 004-06-0013. High Altitude Observatory of the University of Colorado, Boulder, Colorado; Nonr 393(01), NR 046-737; R. G. Athay.

This research was initiated at the request of the U. S. Naval Research Laboratory to provide an optical equivalent of the Naval Research Laboratory's solar radio experiment, related to kinetic temperatures and electron densities of the sun's chromosphere, conducted at the total eclipse of 1952 at Khartoum. All major reduction and analysis of data from the eclipse spectrograms have been completed. A compilation of the data and a unified summary of the work re-interpreted in the light of the most recent theories of chromospheric structure and dynamics are being prepared.

Spectrophotometry of Stars and Galaxies (U), RR 004-06-0014. University of Wisconsin, Madison, Wisconsin; Nonr 1536(00), NR 046-738; A. D. Code.

Equipment on loan is being used in a large continuing program of spectrophotometric investigations of stars and galaxies.

Physics of the Solar Corona (U), RR 004-06-0015. High Altitude Observatory of the University of Colorado, Boulder, Colorado; Nonr 393(04), NR 046-740; D. E. Billings.

In order to increase our understanding of the physical processes in the solar corona new techniques developed under this task for analysis of the corona are being applied to a large number of coronal phenomena. Specific investigations include (1) an attempt to substantiate evidence of hydromagnetic waves in the corona by the study of detailed distribution of line widths in coronal regions; (2) mapping of magnetic field patterns in coronal regions; (3) investigation of the theoretical aspects of magnetic fields in an attempt to determine the magnitude as well as the direction of the field and to solve the more difficult problem of a three-dimensional field configuration; and (4) a re-appraisal of the 5694-5445 problem in an attempt to resolve the question of whether these lines always occur in the same intensity ratio or in a variable ratio.

Infrared Observations of Planetary Spectra (U), RR 004-06-0017. University of Chicago, Williams Bay, Wisconsin, Yerkes Observatory; Nonr 1880(00),

NR 046-749; G. P. Kuiper.

Infrared and near-infrared spectra of Mars, Saturn, Jupiter and its satellites, Venus, Uranus, and other objects are being analyzed and interpreted.

White Dwarf and Coronal Stars (U), RR 004-06-0018. University of Minnesota, Minneapolis, Minnesota, Department of Astronomy; Nonr 1892(00), NR 046-752; W. J. Luyten.

This is a program to study faint blue coronal stars and white dwarfs. Many of these objects have been discovered through several surveys and measurements are being made to determine which of the blue stars are white dwarfs and the properties of the real coronal stars. The program is being expanded to measure the proper motions for many more stars, in both northern and southern hemispheres, in order to obtain more reliable and more extensive data on their mean absolute magnitude and its dispersion, which is necessary for the determination of the distances and the space distribution of these faint blue stars.

Energy Distributions in Stars (U), RR 004-06-0019. University of Michigan, Ann Arbor, Michigan, Department of Astronomy; Nonr 2328(00), NR 046-756; W. Liller.

In an attempt to solve some of the many problems of stellar evolution the evolutionary effects on the continuous energy distribution of stars were investigated. Model atmospheres of a white dwarf star were constructed.

Photoelectric Line Intensity Photometry (U), RR 004-06-0020. University of Chicago, Williams Bay, Wisconsin, Yerkes Observatory; Nonr 2331(00), NR 046-757; B. Strömgren.

A two-beam photoelectric line photometer was constructed and tested. Many measures of the $H\beta$-index 1 were made with the photometer at Lick Observatory and $H\beta$-line photometry was carried out at McDonald Observatory.

Distribution of Galaxies by Stellar Populations (U), RR 004-06-0022. University of Chicago, Williams Bay, Wisconsin, Yerkes Observatory; Nonr 1891(00), NR 046-759; W. W. Morgan.

A revised system of classification of the forms of galaxies has been developed which makes possible a fairly accurate assignment of the stellar populations for the majority of galaxies. This classification will be extended to as many systems as can be classified with high accuracy on the original photographs of the Palomar Sky survey in order to study the arrangement in space of galaxies with regard to their stellar populations.

Variables in Cluster M15 (U), RR 004-06-0023. Mount Holyoke College, South Hadley, Massachusetts, Department of Astronomy; Nonr 2544(00), NR 046-761; M. C. Sandage.

The characteristics of the region of instability in the H-R (color-magnitude) diagram were studied through the detailed photographic photometry of RR Lyrae stars belonging to the Globular Cluster M15.

Radio Astronomy of the Planets (U), RR 004-06-0024. University of Florida, Gainesville, Florida, Department of Physics; Nonr 580(06), NR 046-762; A. G. Smith.

Observations at radio frequencies are being made of the planets Jupiter, Saturn, Uranus and Venus to determine and examine sources of radio bursts. Studies of detected radio noise are being made to increase our knowledge of planet structure and characteristics and to correlate its occurrence with solar or geophysical phenomenon. Photoelectric observations are being made to see whether luminance variations accompany the radio outbursts.

Three-Color Photometry of Galactic Clusters (U), RR 004-06-0025. Lowell Observatory, Flagstaff, Arizona; Nonr 2570(00), NR 046-763; H. L. Johnson.

The color-magnitude diagrams of galactic clusters are being determined through a program of the photoelectric and photographic observations in three colors of a large number of stars in each of about 70 selected galactic clusters.

Double Star Orbital Motion (U), RR 004-06-0027. Naval Observatory, Washington, D. C.; P. O. 501-707, NR 046-765; K. Aa. Strand.

Photographic measures of double stars with separations larger than 2.5 seconds of arc were made. Approximately 125 stars were included in the program. Further modifications of the 26-inch refractor at the Naval Observatory, Washington, were made. Observations were also made with the 24-inch refractor at the Lowell Observatory, Flagstaff.

A Search for Luminous Stars in the Milky Way (U), RR 004-06-0028. Case Institute of Technology, Cleveland, Ohio, Warner and Swasey Observatory; Nonr 2797(00), NR 046-766; J. J. Nassau.

This is part of a large program participated in also by the Hamburg Observatory in Germany and the Boyden Observatory in South Africa. The Warner and Swasey Observatory at Case is responsible for that part of the Milky Way between declination 25° and -10°. A survey is being made for all highly luminous stars of spectral classes O to G2 between the 8th and the 14th photographic magnitudes. Approximate spectral classes, luminosities, magnitudes, and positions with an accuracy of about 2" will be determined.

Variable Stars in Sagittarius (U), RR 004-06-0029. Maria Mitchell Association, Nantucket, Massachusetts, Maria Mitchell Observatory; Nonr 2819(00), NR 046-767; D. Hoffleit.

Variable stars in Sagittarius were studied to determine their magnitudes, types of variation and periods, with the ultimate purpose of analyzing the space distribution of the periodic intrinsic variables and possibly making studies of the relation between the apparent distribution of the dust lanes and peculiar irregular variables which abound in this region.

Isophotometry of Galaxies in the Virgo Cluster (U), RR 004-06-0030. University of Michigan, Ann Arbor, Michigan, The Observatory; Nonr 2815(00), NR 046-768; M. H. Liller.

The distribution of luminosity in a number of elliptical galaxies in the Virgo Cluster was determined with modern photometric techniques. The results will be used for two studies: (1) if

possible, to distinguish spherical systems from oblate ones in circular projection; and (2) to determine the magnitudes of galaxies in preparation for a large-scale attack on the velocity-distance relationship for distant galaxies.

Analysis of Stellar Motions (U), RR 004-06-0031. University of Indiana, Bloomington, Indiana, Department of Astronomy; Nonr 2821(00), NR 046-769; F. K. Edmondson.

The data from the Wilson Radial Velocity Catalogue is being transferred to punch cards. An observing program is expected to yield 150 spectra of faint A-stars for which the radial velocities will be measured and reduced. Programs for the analysis of these A-stars data as well as faint K-star data now on hand will be developed for the IBM 650.

Radial Velocities of Diffuse Nebulae (U), RR 004-06-0032. University of Wisconsin, Madison, Wisconsin, Department of Astronomy; Nonr 2824(00), NR 046-770; D. E. Osterbrock.

In order to provide important data on the motions of interstellar gas clouds the radial velocities of diffuse galactic nebulae will be determined. Objects selected for measurement will be those gas clouds which are optically identifiable and for which their spatial relation to stars is known.

M-Type Dwarf and Other Double Stars (U), RR 004-06-0033. University of California, Mount Hamilton, California, Lick Observatory; Nonr 2813(00), NR 046-771; W. P. Bidelman.

A survey of all known M-type dwarf stars accessible from Lick Observatory is being made with the 36-inch refractor to determine whether they are members of binary or multiple systems. As a second part of the program, whatever micrometric measures are necessary to improve our knowledge of the duplicity characteristics of the northern stars with apparent magnitudes brighter than 6.5 will be made.

Photoelectric Photometry of W Ursae Majoris Systems (U), RR 004-06-0034. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Astronomy; Nonr 551(34), NR 046-772; L. Binnendijk.

A systematic study is being made of several W Ursae Majoris systems by observing photoelectrically in two wavelengths with a photometer on the 28-1/2 inch telescope of the Flower and Cook Observatory. In addition to the determination of light curves orbital computations are being made if possible.

Transport in Plasmas (U), RR 004-06-0035. New Mexico State University, University Park, New Mexico, Department of Physics; N9onr 953(06), NR 046-773; O. N. Theimer.

A statistical description of the electrical microfield in a plasma, which takes into account the shielding between positive and negative charges, was undertaken. The results were to be applied to the study of transport coefficients and line broadening in ionized gases.

Electron Excitation of Forbidden Lines in Gaseous Nebulae (U), RR 004-06-0036. University of Detroit, Detroit, Michigan, Physics Department; Nonr 2820(00), NR 046-774; S. J. Czyzak.

Radial wave functions for various ions are being calculated. Cross-sections will be computed for the collisional excitation of forbidden lines arising from metastable levels in the ground configuration of certain light atoms, notably ionized sulphur, chlorine and argon which are of particular astrophysical interest.

Solar Radio Astronomy (U), RR 004-06-0037. Rensselaer Polytechnic Institute, Troy, New York, Observatory of R.P.I.; Nonr 591(14), NR 046-775; R. Fleischer.

This task provided for several phases in a program of observational radio astronomy conducted at the R.P.I. observatory. One phase related to observations of ionospheric effects of solar disturbances and included the recording of variations at 18 and 517 megacycles, a continuous recording at 27 kilocycles, and the operation of a device for monitoring the intensity of the aurora borealis. A second phase was concerned with the completion, testing and evaluation of the receiving equipment for the 157 megacycle interferometer.

Problems of Star Formations (U), RR 004-06-0038. Princeton University, Princeton, New Jersey, Institute for Advanced Study; Nonr 1858(33), NR 046-776; B. Strömgren.

Extensive observational tests of a theoretical picture of our galaxy will be carried out. Photoelectric narrow-band photometry is being used in an effort to determine for a large group of stars in a sample volume the frequency function of the atmospheric heavy-element content of the stars, i.e., the relative number of stars per interval of heavy-element content, and the distribution of distance from the galactic plane for groups of stars subdivided according to relative heavy-element content. Toward this end the absolute magnitudes, and hence distances, an index of heavy-element content and an index of effective temperature independent of chemical composition are being determined. Theoretical interpretations of the observational results will be undertaken in an attempt to clarify the evolutionary picture of our galaxy.

Recurrent Nova RS Ophiucus (U), RR 004-06-0039. Observatoire de Paris, Paris, France; Nonr(G) 0001-60, NR 046-777; J. C. Pecker, S. R. Pottasch.

Spectra obtained during a recent outburst of the recurrent nova RS Ophiucus are being analyzed to obtain (1) wavelengths and identifications of all lines in the range 3500-8900 as a function of time; (2) absolute intensities of the emission lines and the equivalent widths of the absorption lines, all as a function of time; (3) the absolute intensities of the continuum from 3500-8900; and (4) the profiles of the Balmer lines as a function of time and the profiles of the forbidden lines. With these observational data it is proposed to expand earlier work of Pottasch to investigate theoretically the following points: (1) the method of formation of the continuous spectra as a function of time, and the prediction of the light curve; (2) a detailed description of the shell as a function of time; (3) the temperature and radius of the central star of the nova; and (4) the abundances of the elements

in the nova shell.

Correlation of Jupiter Optical and 20-Megacycle Radiation (U), RR 004-06-0040. Yale University, New Haven, Connecticut, Department of Astronomy; Nonr(G) 0002-60, NR 046-778; H. J. Smith.

A search is being made to determine whether there is an optical radiation correlated with Jupiter's non-thermal radiation in the 20-megacycle region. An effort is being made to measure fluctuations in total light and fluctuations in the strength of any detectably H-alpha radiation as compared with the optical continuum near the H-alpha line.

Radial Velocities of Faint OB Stars (U), RR 004-06-0041. California Institute of Technology, Pasadena, California, Mount Wilson and Palomar Observatories; Nonr 3113(00), NR 046-779; G. Munch.

The spectroscopic distance moduli and radial velocities of about 30 faint OB stars are being determined. These stars were selected from a survey of regions with relatively small obscuration at great distances from the sun which was made with the Schmidt telescope at Tonanzintla Observatory in Mexico. Observations of the selected stars are being made at Mount Wilson Observatory.

UBV Measurements of Stars in Clusters and External Galaxies and of Cepheid Variables (U), RR 004-06-0042. University of Texas, Austin, Texas, Department of Astronomy; Nonr 3197(00), NR 046-780; H. L. Johnson.

In a program of photoelectric photometry the color-magnitude diagrams will be determined for galactic and globular clusters and external galaxies from UBV measurements of the individual stars in the clusters and galaxies. With the same techniques the light curves of a large number of Cepheid variables will be observed.

Mechanics of the Solar System (U), RR 004-06-0043. University of California, Berkeley, California, Leuschner Observatory; Nonr 1726(00), NR 046-158; L. Cunningham.

This is a comprehensive observing program planned to secure more accurate continuous and uniform observations of position and brightness for short period comets and unusual minor planets. Large-scale photographs are obtained at Lick and Mount Wilson, then referred to comparison stars with known accurate positions through use of field plates of the Carnegie Astrograph.

Radio Astronomy (U), RR 004-06-5200. U. S. Naval Research Laboratory, Washington 25, D. C.; A01-07; E. F. McClain.

This task was established to make measurements of and to interpret the natural emission and/or absorption of radio waves by the sun, the moon, the planets and the atmospheres of these bodies; the galaxy; radio stars; other galaxies; interstellar gases; the atmosphere of the earth; and to measure and interpret the reflection of locally transmitted radio waves by celestial objects or by reflecting discontinuities in the atmosphere. These studies provide basic information about the types, numbers, distributions, distances, and physical characteristics of the sources of cosmic radio emission or absorption; as well as otherwise unavailable information about the radio propagation characteristics of the entire atmosphere of the earth and of the space between the earth and celestial objects. This information along with theoretical analyses contributes basic knowledge of the physical characteristics of the earth's atmosphere, the space outside the atmosphere and celestial objects.

R004-07 Underwater Acoustics

Underwater Sound Bibliography (U), RR 004-07-0001. U. S. Naval Research Laboratory, Washington, D. C.; P. O. 10009, NR 385-101; M. Benton.

This task covers the preparation, maintenance and distribution of a current annotated bibliography of classified underwater sound research and development reports. The bibliography serves as a continuation of one covering reports issued prior to 1955 which is being worked on by the Library of Congress.

Undersea Warfare Bibliography (U), RR 004-07-0002. U. S. Naval Research Laboratory, Washington, D. C.; P. O. 10010, NR 385-102; M. Benton.

This task covers the preparation, maintenance and distribution of a current annotated bibliography of undersea warfare research and development reports. It is composed of references submitted by the British, Canadians and Americans.

Review, Compilation and Summary of Basic Underwater Acoustic Data (U), RR 004-07-0003. The Pennsylvania State University, University Park, Pennsylvania, Ordnance Research Laboratory; NOrd 16597, ONR Req No. 14/60054/58, NR 385-103; J. C. Johnson.

A critical review of published work in the area of acoustic scattering occurring in the bulk of the medium was completed. This included a theoretical discussion of the distribution of inhomogeneities in the ocean and of the corresponding types of scattering and extended to the interrelation between back scattering information--important in reverberation--and the coefficient of variation of transmitted signal fluctuation.

Non-Linear Acoustics (U), RR 004-07-0004. Brown University, Providence, Rhode Island, Physics Department; Nonr 562(17), NR 385-204; A. O. Williams.

Experimental and theoretical studies are being made of the generation, speed and attenuation of high amplitude sound in liquids as a function of frequency, amplitude, static pressure and temperature. Among effects currently being considered are the interference of two high amplitude beams, nonlinear acoustic effects near bubbles, and nonlinear attenuation of high amplitude sound beams in liquids. In addition to the high amplitude work this group conducts theoretical studies of shallow water propagation.

Marine Bottom Acoustics (U), RR 004-07-0005. University of Rhode Island, Kingston, Rhode Island, Narragansett Marine Laboratory; Nonr 396(04), NR 385-205; F. T. Dietz.

The main effort in this task is being devoted to the measurement and analysis of shallow water ambient noise. A measurement program extending

over a year has been completed and a detailed study is now being made of the relationship of ambient noise to wind, sea surface, and other environmental factors. Current emphasis is being given to extending measurements to a low frequency limit of 10 cps.

Sound Velocity Structure of the Atlantic Ocean (U), RR 004-07-0006. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Nonr 891(00), NR 385-207; R. R. Brockhurst.

Studies of the sound velocity versus depth structure of the North Atlantic and adjacent waters are being carried out on a continuing basis. This involves compilation, analysis and conversion of hydrographic field data and preparation of charts for use as aids in sonar and acoustic navigation studies. Current effort is being devoted to compilation of acoustic structure data on the Mediterranean Sea, the Norwegian Sea, the Arctic and other special areas. In addition, work is being carried out on theoretical problems relating to acoustic transmission and experimental measurements of pressure pulses from an underwater spark.

Theory of Explosive Sound in Shallow Water (U), RR 004-07-0007. American Committee for the Weizmann Institute of Science, New York, New York; Nonr 2189(00), NR 385-208; C. L. Pekeris.

The theory of the propagation of explosion sound waves in shallow water is studied as a function of range, water depth and acoustic properties of the bottom. Exact solutions are being derived for various types of propagation in a layered solid. Rayleigh waves for periods of 50-3200 seconds are also being studied.

Fluctuations of Acoustic Waves in Water (U), RR 004-07-0008. Yale University, New Haven, Connecticut, Laboratory of Marine Physics; Nonr 609(29), NR 385-209; D. Mintzer.

This is a theoretical and experimental investigation of the fluctuation of acoustic waves in water due to transmission through a region with a controlled thermal microstructure. A test tank with controlled heat sources and associated acoustic equipment has been completed and extensive experimentation and data analysis has been accomplished. Spatial, temperature and acoustic fluctuations are being measured and compared with theoretical predictions. The resulting data will provide a basis for further laboratory and field studies.

Research in Underwater Acoustics (U), RR 004-07-0009. University of Miami, Miami, Florida, The Marine Laboratory; Nonr 840(16), NR 385-211; J. Steinberg.

This task is concerned with establishing the long- and short-time relationships of sound velocity microstructure variation on the transmission of acoustic energy along an established path in a given area, the physical and chemical characteristics of which are known. An experimental study of the transmission of sound in the Tongue of the Ocean was completed using explosion shots. Under partial support of the contract a hydrophone-cable assembly was installed with one hydrophone in 10 fathoms and the other in 200 fathoms off Bimini. The properties of signals and ambient noise will be compared with this installation.

Origin of Ambient Noise in the Ocean (U), RR 004-07-0011. Geophysical Interpretation Company, Houston, Texas, Nonr 2726(00), NR 385-301; C. B. Officer.

Studies are being conducted to assess the contributions of possible sources of noise in the ocean to the ambient noise observed. The work is confined to theoretical investigations and supporting analysis of available field data. In addition to clarification of the origin of observed ambient noise, the studies will aid the summary of available ambient noise data in the design of future field work.

Research on Transducer Materials (U), RR 004-07-0012. Clevite Research Center, Cleveland, Ohio; Nonr 1055(00), NR 385-410; R. Gerson.

The research of this task is aimed at better understanding of the mechanical and electrical properties of ferroelectric materials, such as lead titanate zirconate, now being used in underwater transducers. This is supplemented by a study of the characteristics of other materials which may assist in understanding ferroelectric ceramics. Among the parameters being investigated are effects of certain additives and changes in firing procedure.

Vibration of Thick Shells (U), RR 004-07-0013. J. G. Engineering-Research Association, Baltimore, Maryland; Nonr 2733(00), NR 385-412; J. E. Greenspon.

The central objective is to study the dynamic behavior of thick shells mainly with a view toward their application as deep sea transducers.

During the past year close contact has been maintained with the Underwater Sound Laboratory. Cylindrical shell radiators are now being designed to use with the available oscillators at USN USL. The main objective is to develop a high-power, low-frequency radiator which can be made inexpensively. It has been found from the studies conducted during the year that plastic tube radiators offer great promise in view of their light weight and low sound velocity.

Acoustic Similitude Studies (U), RR 004-07-0014. Cambridge Acoustical Associates, Incorporated, Cambridge, Massachusetts; Nonr 2739(00), NR 385-413; M. Junger.

This task is concerned with various sound radiation problems and the vibration of elastic shells (both model and full-scale). The principal work explored this year was (a) the use of spherical coordinates to evaluate radiation impedances for transducer and submarine hull elements, (b) the analysis of non-symmetrical modes of prolate spheroid shell and (c) the effect of surface reflections on directive radiators, especially as related to directivity patterns and sound power of dipole and quadrupoles in the vicinity of rigid and pressure release boundaries.

Sound from Spheroid Shells (U), RR 004-07-0015. Columbia University, New York, New York, Department of Civil Engineering and Engineering Mechanics;

Nonr 266(67), NR 385-414; F. L. DiMaggio.

This task is a theoretical study of the sound from thin prolate spheroidal shells. Initial studies have resulted in solving differential equations of axi-symmetric motions (in a vacuum) in terms of prolate spherical coordinates. For the torsional mode, numerical values for frequencies as a function of eccentricity have been obtained. The present attack is directed toward being able to consider similar solutions of the vibrations of such shells when immersed in an acoustic medium.

Acoustical Information Processing Research (U), RR 004-07-0015. Edo Corporation, College Point, Long Island, New York; Nonr 2288(00), NR 385-415; C. J. Loda.

This task is concerned with the theoretical and experimental study of two major areas within the field of acoustic signal processing: (a) combining and applying in a coherent fashion the most advanced existing theoretical techniques from such fields as communication and information theory, optics, radar, and radio astronomy; (b) performing experimental and theoretical research on space-time acoustic signal processing, with special emphasis on transient phenomena.

Design, Development and Testing of Flexible Line Hydrophones (U), RR 004-07-0018. Chesapeake Instrument Corporation, Shadyside, Maryland; Nonr 2505(00), NR 385-417; J. W. Fitzgerald.

This task covers the continuing of research and experiment toward the development of long, flexible hydrophone units, with adequate tensile strength for towing and with optimum low frequency response. The studies are aimed particularly at achieving a design or designs with a minimum of self-noise when under tow. Towing studies at the David Taylor Model Basin (NR 385-418) have theoretically and experimentally developed techniques to tow lines of such elements. Special units up to 30' long (capable of submergence to 1500') have been fabricated and towed successfully from surface ships and submarines. Units up to 200' long will be produced. Simple steering techniques are in the planning stage.

The Determination of Towing Characteristics of Distributed Hydrophone Elements (U), RR 004-07-0019. David Taylor Model Basin, Washington, D. C.; P. O. 501-726, NR 385-418; L. F. Whicker.

This task covers theoretical and experimental studies directed to developing methods to tow lengths of distributed element hydrophone cable with a minimum of self-noise in towing arrangements. The arrays towed in these studies are developed under NR 385-417. Units have been towed successfully to 25 knots from submarines and 16 knots from surface ships. Additional studies are in progress how to tow longer lines and how to stream such arrays from a positioning vehicle 60^{o} arc above and below a towing submarine.

Studies of Magnetostrictive Transducers Operated at Large Power Densities (U), RR 004-07-0022. Armour Research Foundation, Chicago, Illinois, Illinois Institute of Technology; Nonr 2900(00), NR 385-421; R. R. Whymark.

This is a study of magnetostrictive transducers for the production of acoustic energy of high density. It emphasizes theoretical and experimental investigations of the non-linear magnetic and magnetostrictive effects which invalidate existing theories of conversion processes. Especial attention is being applied to the change of sound output with static stress and the improving of the linear theory of magnetostrictors.

Optical Methods for Absolute Measurement of Sound Pressure In Liquids (U), RR 004-07-0023. Michigan State University, East Lansing, Michigan, Physics Department; Nonr 2587(01), NR 385-425; E. A. Hiedemann.

This investigation is concerned with the use of optic and electronic methods for transducer calibration, sound pressure measurements and distortion analysis. Particular attention is being given to the effects of a distorted acoustic wave as a function of pressure on a light beam, using both narrow and wide beams of light. Optical methods of sound analysis have the advantage of great reliability and precision and their use does not disturb the acoustic field as would an ordinary probe microphone. One phase of the current effort is concerned with using these optical techniques to study reflection of finite waves at a boundary.

A Study to Determine Practical Methods and Techniques for Evaluating and Testing Sonar Transducers (U), RR 004-07-0024. University of Texas, Austin, Texas, Defense Research Laboratory; NObsr 72627, NR 385-426; C. M. McKinney.

This task is a general study of underwater acoustic transducer calibration requirements. It encompasses a critical review and analysis of calibration measurement requirements in the research, preliminary design and development, manufacturing, shipboard, and repair and test phases. An important part of this program is the investigation and exploration of possible new techniques for calibration, both theoretically and, where appropriate, experimentally, in order to evaluate their practicality. Promising developments have been made on a technique by which far-field transducer patterns can be extrapolated from selected near-field measurements. The study of this technique is being continued and extended.

Propagation of Flexural Waves in Elastic Structures (U), RR 004-07-0025. Bolt, Beranek and Newman, Incorporated, Cambridge, Massachusetts; Nonr 2322(00), NR 385-427; I. Dyer.

This task is concerned with wave propagation through complex structure. The structure is described in terms of assemblies of simplified elements, and the input and output mechanical impedance characteristics of such elements are derived. Configurations of such elements are also investigated and the associate sound and vibration distributions studied for various conditions.

Prediction of Far-Field Phenomena from Near-Field Measurements (U), RR 004-07-0026. Stanford Research Institute, Menlo Park, California; Nonr 3049(00), NR 385-428; V. Salmon.

This task is a theoretical and analytical study to develop means of predicting far-field performance from near-field acoustic data. The results

are particularly applicable to the calibration of large sonar transducers as well as providing theoretical assistance to understand submarine radiated noise measurement problems.

Radiation Impedance of Arrays (U), RR 004-07-0027. Chesapeake Instrument Corporation, Shadyside, Maryland; Nonr 3087(00), NR 385-429; R. Urick.

This problem involved the investigation of the radiation impedance of arrays, especially with regard to interaction effects. A model of small, finite spherical sources and their interaction in hypothetical square arrays of elements was studied theoretically. Experimental studies at 2 and 3kc were also accomplished to measure directly the interaction impedance of 2 transducers in various proximity configurations. The model has been shown to be adequate as a rough guide for engineering studies.

Extraction of Information from Periodically Varying Random Wave Forms (U), RR 004-07-0031. Massachusetts Institute of Technology, Cambridge, Massachusetts; Nonr 1841(57), NR 385-504; W. M. Siebert.

This task was concerned with theoretical studies relating to the extraction of information from a pair of periodically varying random waveforms. It has been helpful in providing a basic study related to techniques for estimating the position of a signal source in a noise background when the signal was received at separate receivers. It was conceived and directed particularly to furnish information for use in the design and operation of the PUFFS system of passive acoustic ranging.

Theory of Resonant Reflectors for Sonar Application (U), RR 004-07-0032. Harris Transducer Corporation, G. I. Anti-Submarine Warfare Laboratory Division, Woodbury, Connecticut; Nonr 2720(00), NR 385-540; H. K. Farr.

Theoretical and analytical studies have been conducted on the suitability of use as reflectors for deep operation of multi-element arrays of passive resonant elements. Various types of monopole and dipole resonators as reflecting elements were also studied.

Sound Transmission Through Plates (U), RR 004-07-0010. University of Michigan, Ann Arbor, Michigan, Engineering Research Institute; Nonr 1224(24), NR 385-601; W. C. Meecham.

This task is concerned with the theoretical and experimental study of the propagation of sound waves through plates, shells, and reinforced structures in water. The aim of these studies is to develop basic principles governing such transmission that may be applied to the case of an array of receiving or generating elements in a reinforced structure such as a sonar dome.

Basic research in Ocean Sound Transmission (U), RR 004-07-0034. Columbia University, New York, New York, Lamont Geological Observatory; Nonr 266(65), NR 385-904; M. Ewing.

Studies of the generation, propagation, and reception of low frequency sound are being carried out on a continuing basis. This task supported part of sound propagation studies of the research vessel VEMA in the Indian Ocean. A transmission of 12,000 miles was received from Australia to Bermuda. In addition 20 cycle signals (believed biologic in origin) are being tracked and studied near Bermuda; experiments were conducted using seismographs in the deep sea and monitoring energy from 1/6 to 5 cps. Towed lines for reception of very low frequency signals are being fabricated. This latter phase is being coordinated with tasks NR 385-417 and NR 385-418.

Acoustic Transients Research (U), RR 004-07-0035. Woods Hole Oceanographic Institute, Woods Hole, Massachusetts; Nonr 2672(00), NR 385-905; H. E. Sawyer.

This task is concerned with the study of the generation, propagation, reflection and reception of transient pressure pulses under water. In these studies use is being made of an "IMP", an impact energized sound source, having the characteristics of high reproducibility, high peak pressure level and a considerable range of variation in the character of the radiated pressure pulse. IMP I has been completed and successfully tested. IMP II, a larger version, is being completed to establish the limiting intensity levels possible to achieve by this technique.

Low Frequency Ambient Noise Research (U), RR 004-07-0037. Minneapolis-Honeywell Regulator Company, Seattle, Washington, Seattle Development Laboratory; Nonr 3411(00), NR 385-300; T. F. Hueter.

The purpose of this project is to develop a measuring technique and to apply this technique to the study of the nature and causes of ambient noise in the ocean. Small instrumented buoys will be adapted to obtain acoustic measurements over a long time interval in a given area. Emphasis is on the development of synoptic techniques and the correlation of acoustic and oceanographic factors that result in contributions to the sea ambient noise.

A Study of Underwater Scatterers (U), RR 004-07-0038. Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, Research Laboratories; Nonr 3118(00), NR 385-303; A. Nelkin.

This is an experimental investigation, using acoustical and photographic techniques, to determine the nature of the discrete scatterers responsible for volume reverberation in the ocean. The scatterers are first located with a high resolution echo ranging sonar and then photographed. Experimentation is now under way to develop and refine the technique and to analyze results already obtained.

Study of Underwater Sound Scattering (U), RR 004-07-0039. AVCO Corporation, Cincinnati, Ohio, Marine Electronics Engineering Department; Nonr 3102(00), NR 385-304; H. W. Marsh.

This task carried out an analytical interpretation of empirical sea surface scattering data derived from sound propagation studies in a manner designed to reveal the physical processes involved and to provide more general application of the scattering data to propagation and reverberation phenomena. Semi-empirical relationships have been obtained of sea surface scattering loss versus the

acoustic frequency-mean wave height product. These and other contributions to this field have been made available in the literature.

Research on the Physics of Microbubbles (U), RR 004-07-0040. Vitro Laboratories, Silver Spring, Maryland; Nonr 3159(00), NR 385-305; W. R. Turner.

This task undertakes an experimental and theoretical investigation of acoustic propagation in water containing microbubbles--that is, cavities of air so small that they are invisible in a body of water. Experimental evidence exists of abnormally large acoustic attenuation at high frequencies in water with such bubbles, and the present investigation undertakes further study of these effects. Information is also being sought on the nature of such bubbles and conditions under which they will exist in natural bodies of water.

Study of Underwater Sound Transmission (U), RR 004-07-0041. AVCO Corporation, Norwich, Connecticut, Research and Development Division; Nonr 3353(00), NR 385-306; W. Marsh.

This task is undertaking to create a uniform and comprehensive method for the quantitative estimation of underwater sound transmission loss. It is assembling, reviewing and collecting information on sound transmission from all available sources in order to represent a comprehensive analytical model of the ocean suitable for representing sound transmission.

Hydroacoustic Transducers for Deep Submergence Environments (U), RR 004-07-0042. Stromberg-Carlson Company, Rochester, New York; Nonr 3098(00), NR 385-430; J. Bouyoucos.

This task is concerned with the research and development of a sound source driven by an electro-hydroacoustic system that utilizes hydraulic rather than electronic drives for major power conversion. Emphasis in the current program is to design for lower frequencies at very high power outputs. Hydrodynamic feedback is used with special servoamplifiers so that it is possible to achieve stable velocity amblification over a pass-band of frequencies, i.e., $\pm$10% of a chosen center frequency.

Magnetic Sound Transducer (U), RR 004-07-0043. MHD Research Incorporated, Newport Beach, California; Nonr 3117(00), NR 385-431; R. C. Brumfield.

This task studies experimentally and theoretically the feasibility of generating underwater sound by the use of high-intensity magnetic fields generated by high current pulsing of submerged induction coils and the interaction of these fields with the electrolytic medium. The work this year has qualitatively shown the feasibility of producing sound in fluids by electromagnetic coupling. A theoretical investigation compatible with the new experimental arrangement is now underway and it is hoped that forthcoming results will establish a technique to quantitatively measure and fully understand the process.

Vibrating Bar Transducers (U), RR 004-07-0044. Compagnie Generale de Telegraphie Sans Fil, Orsay (S & O), France; N62558-2575, NR 385-432; J. C. Simon.

This task covers an investigation of the general characteristics of vibrating bar transducers, using the "end-fire" principle, for use in the low kilocycle frequencies. Provisions for prototype devices of this type with appropriate exciters is included as an essential part of the work.

Mechanical Type Sonic Projector for Extended Acoustic Ranging (SPEAR) (U), RR 004-07-0045. United Aircraft Corporation, Windsor Locks, Connecticut, Hamilton Standard Division; Nonr 3350(00), NR 385-433; J. S. Tupper.

An analytical and experimental study is being made of a bar and piston method of producing low frequency, high power sound in water. This method of transduction offers promise of being a relatively efficient method of producing sounds of high power without depth limitations. This study includes the construction and evaluation of 1/5 scale models.

Ferrite Ring Transducer (U), RR 004-07-0046. Kearfott Division of General Precision, Incorporated, Clifton, New Jersey; Nonr 3204(00), NR 385-434; C. Wood.

This task covers research and development on the use of magnetostrictive ferrites in toroidal ring magnetostrictive transducers with built-in permanent magnet polarization. It embraces study of the techniques of construction of the ferrite ring, optimization of the permanent magnet positions, and provision of a half wave length stack of ferrite rings suitable for acoustic measurement purposes. Ferrite rings representing optimum design are being furnished to the U. S. Naval Research Laboratory for further study.

Hydroacoustic Transducer Research (U), RR 004-07-0047. Raytheon Company, Newport, Rhode Island; Nonr 3323(00), NR 385-435; S. Wisotsky.

The purpose of this task is to allow test, calibration, and evaluation of a high-power, hydraulically-operated sound source developed by the Raytheon Company. The tests not only include acoustic power output at various frequencies but also system reliability, and suitability for packaging compatible with Navy requirements. The criteria developed will be applied to hydroacoustic studies of Stromberg-Carlson (385-430) and mechanical sound sources at Hamilton-Standard (385-433).

The Field Near a Finite Acoustic Source in a Finite Chamber (U), RR 004-07-0048. American University, Washington, D. C., Department of Physics; Nonr 3341(00), NR 385-436; M. Harrison.

This task undertakes a theoretical and experimental study of the relationship between the disturbance of the near field of a transducer as a function of the relative sizes of the enclosing chamber and the transducer itself. The purpose of the investigation is to provide criteria for the calibration of large transducers at low frequencies in small tanks of water.

Compliant Tube Lens (U), RR 004-07-0049. Convair, A Division of General Dynamic Corporation, San Diego, California; Nonr 3377(00), NR 385-437; W. Toulis.

This task is concerned with the development and testing of a 15' diameter, acoustic version of a

Luneberg lens to demonstrate primarily that such a system can focus acoustic projectors in discrete directions for greater security or to create high sound pressure fields with a minimum of acoustic power. In addition, the lens will be used as a receiver system to focus underwater sound simultaneously from more than one direction.

Analog Digital Processing (U), RR 004-07-0050. G. C. Dewey Company, New York, New York; Nonr 3158(00), NR 385-505; W. G. Chesnut.

The purpose of this study is to examine, largely through empirical measurement of real-world sequals, actual processing differences between the best analog correlator techniques and the best existing and proposed digital techniques. The measured effect of actual fluctuation, variation, and state of knowledge concerning signal and noise characteristics are of prime interest.

Theory of Signal Detectability (U), RR 004-07-0051. University of Michigan Research Institute, Ann Arbor, Michigan, Electronic Defense Group; Nonr 1224(36), NR 385-506; T. G. Birdsall.

The objective of this study is to apply decision and information theories to basic problems of signal processing in underwater acoustics. Specific areas of activity include examination of the effect of uncertainties in state of knowledge upon processing procedure and effectiveness, comparison of optimum and non-optimum processors, sequential decision analysis, and higher order processing investigations. Basic mathematical research in the areas of decision theory, game theory, information theory and statistical testing, and the theoretical physics of underwater acoustics has provided an adequate framework which now needs internal development and application oriented along the line of basic Naval needs.

ASW Acoustic Signal Processing Study (U), RR 004-07-0052, Melpar Incorporated, Watertown, Massachusetts; Nonr 3151(00), NR 385-507; D. Van Meter.

Calculations of the output S/N of a correlator when used against non-white noise and using a game theory approach to noise spectrum specification have shown that only a fraction of a db is lost in correlation vs optimum processing for this case. Work is being continued as task 0053.

Application of Communication Theory to Anti-Submarine Warfare Acoustic Signal Processing (U), RR 004-07-0053. Litton Industries, Waltham, Massachusetts; Nonr 3320(00), NR 385-508; D. Van Meter.

The objective of the proposed research is to find the effects upon correlator processing of four types of adverse noise statistics, and to determine the characteristics of spatial and temporal data necessary to determine pertinent statistical processing parameters of underwater acoustic fields. Non-stationary noise, non-white noise, non-gaussian noise, and non-additive noise will be considered. Taking as a referrent the correlation process, the results of this contract are intended to provide a more realistic framework in which to judge correlator performance and to develop the most promising lines of processor principles. These results are also intended to contribute to the design of experiments from which data most useful in signal processing can be obtained.

Application of Statistical Communication Theory to Sonar System Design and Analysis (U), RR 004-07-0054. Raytheon Company, Newport, Rhode Island; Nonr 3381(00), NR 385-509; J. T. Kroenert.

The objective of this task is to develop useful signal processing theory in three areas of particular interest in underwater acoustics: non-parametric-adaptive processing, impulse noise, and spatial signal processing, applying where possible experimental facilities to test, verify, and extend the theory. It is important that non-parametric techniques, both those well-known and those now under development, be investigated within the specific constraints of underwater acoustics, and compared with both existing techniques and those suggested by decision theory. In both time and span, it is necessary to tie impulse noise investigations to existing steady state studies, and to relate transient and steady-state optimization.

Study of Factors Affecting the Reflection and Absorption Coefficients of Resonant Absorbers in Liquid Media (U), RR 004-07-0055. Rose Polytechnic Institute, Terre Haute, Indiana, Department of Physics; Nonr 3255(00), NR 385-541; W. W. Meeks.

This is a theoretical and experimental study of resonant acoustic absorbers for absorption of underwater sound. This study is concerned particularly with thin absorbent layers of polymeric materials containing resonant gas-filled cavities. The absorption of acoustic energy for various frequencies, hydrostatic pressures and temperatures will be investigated with various materials, layer designs and backing impedances. Instrumentation has been essentially completed and the formulation and evaluation of various designs are now under way.

Measurement of the Dynamic Mechanical Properties of Materials (U), RR 004-07-0056. Chesapeake Instrument Corporation, Shadyside, Maryland; Nonr 2678(00), NR 385-542; J. W. Fitzgerald.

The objective of this research task is to investigate the dynamic mechanical properties of viscoelastic materials. The study will emphasize the shear properties as a function of frequency and temperature but will also consider other types of vibration. The research will be directed toward the compilation of data on existing materials and the developing of new materials with high internal loss for possible use as panel damping coatings, anechoic coatings, and isolation mounts.

Application of Viscoelastic Materials as Energy Absorbers of Low Frequency Acoustic Vibrations (U), RR 004-07-0057. B. F. Goodrich Company, Research Center, Brecksville, Ohio; Nonr 3304(00), NR 385-543; H. F. Neff.

This task undertakes a theoretical and experimental investigation to study specific layer structures which will dissipate acoustical and vibrational energy in water. This study emphasizes both tactical coatings for underwater objects and the suitable designs for use in water-filled tanks for acoustic experimentation and testing.

Sound Survey Tape Recorder Capsule (U), RR 004-07-0058. Lockheed Electronics Company, Plainfield, New Jersey, Stavid Division; Nonr 3165(00), NR 385-700; L. S. Churchill.

This task covers the design and construction of a precision quantitative-type, tape recorder (to fit into spar buoy)--battery powered with miniaturized electronic control circuitry. Included in the circuitry are low-noise transistorized electronic amplifiers, automatic step attenuators for compressing signal, and tone signals to allow marking of step-attenuator settings.

Ocean Sound Propagation, RR 004-07-5250. U. S. Naval Research Laboratory, Washington 25, D. C.; S01-01; C. W. Searfoss, R. L. Steinberger.

The idealistic aim of the work is to determine quantitatively the manner in which sound in the ocean travels so that its intensity at a given point can be predicted when all the environmental conditions existing at the time of prediction are measured and taken into account. The realistic aim is to approach the ideal as closely as possible. Typical conditions are temperature and salinity variations with depth, bottom topography and composition, sea and swell conditions, turbulence, currents. In August 1959, an expedition was made into the deep water east of Newfoundland where measurements similar to those in 1958 off Puerto Rico were made except that the cross-section of the sound field was determined down to a depth of 1000 feet. The fourth expedition is now in progress (17 October - 28 October) in the deep water north of Puerto Rico. The new aspect of this expedition is the use of very low frequency and extending the field of measurement down to 2000 feet.

Ultrasonics, RR 004-07-5251. U. S. Naval Research Laboratory, Washington 25, D. C.; S01-02; V. A. Del Grosso.

The accurate measurement of acoustic propagation parameters utilized in underseas and antisubmarine warfare is the principal objective. In particular, the pressure (depth), temperature, and salinity coefficients of the speed of sound and the dependence of the spatial absorption coefficient on frequency, salinity, temperature, and pressure is investigated with techniques of the highest precision consistent with the demonstrated ambiguities and anomalies of existing data. Existing theory is extended and modified with experimental verification to permit a description of sonar propagation parameters although the experiments are conducted in the ultrasonic region.

Scale Model Studies, RR 004-07-5252. U. S. Naval Research Laboratory, Washington 25, D. C.; S01-04; W. G. Neubauer.

This is a task involving precision measurement of underwater acoustic propagation under precisely controlled laboratory conditions. The work is being done to serve as guide for experimental work in the field where conditions cannot be controlled. It is expected that ultimately the detailed scattering of sound about an exact replica of a submarine may be determined experimentally in the laboratory.

Flow Acoustics, RR 004-07-5253. U. S. Naval Research Laboratory, Washington, D. C.; S01-05; C. W. Votaw.

This work concerns the study of boundary layer noise and the propagation of sound in a flow. The first experiments in this field have been directed to finding the mechanism by which a perforated disk produces discrete tones when rotated in an infinite viscous fluid. These tones are a discontinuous function of the speed and are believed to occur when the frequency of vortex shedding at the perforation corresponds to the frequency of one of the normal modes of the disk. Vortex shedding at an isolate protuberance will normally produce line components in the spectrum of the turbulence. The mean square pressure fluctuations may be a large percentage of the stagnation pressure. The pressure fluctuations may excite vibrations of the ship's hull plating or of bubbles in the flow under the ship. The bubbles and the plating, acting as radiators of sound, may constitute a large part of the noise generated by a ship at high speeds. It is hoped that this research will lead to design information concerning the size and type of roughness which is allowable based on noise considerations.

Oceanology (U), RR 004-07-5254. U. S. Naval Research Laboratory, Washington 25, D. C.; S01-19; C. L. Buchanan.

Measurement of oceanological factors using telemetry techniques will involve research on new instruments not presently adapted or designed for use in this field. Values of as many variables as possible on a practically simultaneous basis will be one objective of this problem.

R005 BIOLOGICAL SCIENCES

R005-01 Stress Physiology

Comparative Physiology of Wild and Laboratory Animals (U), RR 005-01-0001. University of Wisconsin, Madison, Wisconsin, Department of Zoology; Nonr 2247(00), NR 102-025; P. R. Morrison.

Comparative studies are being carried out on energy metabolism, plasma proteins, and cardiac characteristics of small wild mammals and mammals of the experimental laboratory type. Present work is devoted to (1) the energy metabolism of hibernating animals, that is, hibernation as a response to cold environment; (2) seasonal variations in the level and distribution of plasma proteins, with particular emphasis on the hibernation responses to cold environment; and (3) electrocardiograms as affected by anesthesia and environmental cold.

Tolerance of Forces Affecting Posture and Balance (U), RR 005-01-0003. Federal Aeronautics Administration, Washington, D. C., Medical Division; NAonr 25-58, NR 102-074; J. J. Swearingen, E. B. McFadden, J. D. Garner, J. G. Blethrow.

This study was directly concerned with the influence of disorienting force components which may act on the body in varying circumstances and with a variety of force vectors. Data on the effective forces resulting from wind blast, explosions, etc., was collected for use in modification or redesign of protective gear. Human voluntary tolerances to vertical impact were determined while (1) standing with knees stiff, (2) standing with knees bending, (3) squatting, and (4) seated in a rigid chair.

Physiology and Instrumentation of Respiratory Response (U), RR 005-01-0004. The Johns Hopkins University, Baltimore, Maryland, Department of Environmental Medicine; Nonr 248(22), NR 102-101; R. L. Riley, R. H. Shepard, T. Enns, S. A. Talbot.

The purpose of this task is to develop and apply modern instrumentation to the study of pulmonary function. Studies are being carried out in a number of areas: (1) control of respiration; (2) diffusing capacity of the lung; (3) theoretical studies of distribution effects; (4) and studies of the relationship between pulmonary resistance and the state of inflation of the lung in patients with various pulmonary and cardiac disorders. Present approaches being applied to the study of blood-gas distribution and diffusion characteristics of the lungs include evaluation and application of maximal diffusing capacity as a test of physical fitness.

Effects of Alpha Radiation on Mammalian Cells (U), RR 005-01-0005. Emory University, Atlanta, Georgia, Department of Pathology; Nonr 1386(02), NR 102-181; A. Golden.

The mechanism of cell damage produced by ionizing particles has been studied by injecting experimental animals with different types of colloidic alpha active substances to produce active alpha deposits. Polonium solutions of different activity were used to generate varying levels of densely ionizing radiation at the cellular level. The investigation included histologic and radioautographic study of alpha radiation; electron microscopic studies of the radiated tissue specimens; determination of threshold damage from heavy nuclei for radiosensitive tissue (mice embryos).

Study of Factors which Influence the Oxygen Tension of Arterial Blood (U), RR 005-01-0006. University of Colorado, Denver, Colorado, Department of Medicine; Nonr 1147(04), NR 102-214; G. F. Filley, G. H. Fayette, C. Keener.

Methods developed to determine accurately alveolar and arterial oxygen tensions in man during rest and strenuous exercise are being applied to study (1) those factors that govern the maintenance of oxygen and carbon dioxide pressure in the lung gases and the blood leaving the lungs; (2) the diffusion characteristics of the membrane that separates the blood from the gas phase of the lungs; (3) the role of these factors in limiting the uptake of oxygen in normal and pathological subjects at rest and during exercise.

A Study of the Gaseous Exchanges in the Pulmonary Alveoli (U), RR 005-01-0007. Ohio State Univeristy, Columbus, Ohio, Research Foundation; Nonr 1094(00), NR 102-250; F. A. Hitchcock.

The specific objectives of this task are (1) a study of the composition of air in the respiratory passages with emphasis on analysis of single respiratory cycles including the inspiratory phase; (2) a correlation between blood gas tensions and alveolar air tensions with emphasis on possible changes which occur during a single respiratory cycle; (3) a study of factors influencing the respiratory dead space, using the mass spectrometer for rapid, continuous analysis of respiratory gases.

Effects of Thermal Radiation on Skin (U), RR 005-01-0008. University of Pennsylvania, Philadelphia, Pennsylvania, School of Medicine, Department of Physiology; Nonr 551(12), NR 102-257; J. D. Hardy.

The objectives of this task were (1) measurement of temperature change in the human skin due to exposure to thermal radiation with particular reference to the relation between hyperthermia and tissue damage; (2) study of the effects of subthreshold burns on the pain threshold, production of cutaneous hyperalgesia, and the relation of the hyperalgesia to the threshold for burn production; (3) study of the effect of reducing skin temperature following mild burns as a procedure in reducing burn severity; and (4) study of the effect of heating the skin with microwave radiation.

Cardiorespiratory Changes as a Function of Environment (U), RR 005-01-0009. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Pharmacology; Nonr 551(14), NR 102-279; C. J. Lambertsen, R. Gelfand, H. Wollman.

The major objective of this task is to study the cardiovascular and pulmonary problems related to aviation, diving, and submarine operations. Two general areas of research are under investigation: (1) the interactions of respiration, blood gaseous composition, brain circulation and brain metabolism under conditions of extremely high and low inspired oxygen pressures, and (2) to elucidate

mechanisms of cerebral cellular acid-base oxygen homeostasis.

Mechanism of Nitrogen Narcosis (U), RR 005-01-0010. University of Rochester Medical School, Rochester, New York, Department of Physiology; Nonr 668(11), NR 102-281; W. O. Fenn.

The narcotic effect of high nitrogen pressures has been well established but the mechanism of the effect is still hypothetical. The present objectives are (a) to investigate the possibility that high pressures of nitrogen might modify the metabolic rate of isolated tissues and so produce their narcotic effects and (b) more specifically, to confirm a previous incidental observation which appeared to show a rise in CO_2 output by muscle subjected to high partial pressures of nitrogen.

Electrical and Mechanical Properties of Biological Materials (U), RR 005-01-0011. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Physical Medicine, Department of Electrical Engineering; Nonr 551(05), NR 102-289; H. P. Schwan, J. Maczuk, H. Pauly, D. Shen.

Electric and acoustic impedance of biological material in the electrical frequency range from 10 to 1000 megacycles and in the acoustic frequency range from 200 kilocycles to 10 megacycles are being measured and analyzed. Application of these ultrahigh frequency waves as biological tools can yield information, not otherwise obtainable, on blood, protein solutions, and cell membranes.

Studies in Pulmonary Physiology (U), RR 005-01-0012. University of California Medical Center, San Francisco, California, Cardiovascular Research Institute; Nonr 222(55), NR 102-323; J. H. Comroe, Jr., K. Wasserman, N. Staub, W. Storey, J. Widdicombe.

By use of continuous gas analyzers, such as the nitrogen meter, infrared CO and N_2O analyzers, and mass spectrometer, more complete information is being assembled on the uptake and elimination of respiratory gases as a measure of pulmonary ventilation, alveolar capillary diffusion, pulmonary capillary blood flow, pulmonary capillary blood volume and pulmonary tissue volume. Kinetics of gas uptake by intraerythrocytic hemoglobin are being determined. Effects in man and experimental animals of inhaled chemical substances and pharmacologic agents on the pulmonary and systemic circulations (direct and reflex effects) and on the lungs are also to be studied.

Influence of Body Type and Composition on Work Capacity and Thermal Regulation (U), RR 005-01-0013. University of North Carolina, School of Medicine, Chapel Hill, North Carolina, Department of Physiology; Nonr 855(03), NR 102-344; C. S. Blyth, B. W. Lovingood, W. C. Taylor.

The objectives of this task are (a) to measure and evaluate the separate influences of body type and body fat content on the metabolic cost of work, on endurance and on capacity for maintaining thermal balance in temperate and hot environments; (b) to determine the influence of body type and body composition on the impairment of work capacity and thermal regulation produced by graded dehydration; (c) to measure changes in body composition resulting from the usual types of physical conditioning programs, and to determine the influence of such changes on work capacity and thermal regulation.

Muscle Conditioning Factors Affecting Muscular Endurance Performance (U), RR 005-01-0014. University of Oregon, Eugene, Oregon, School of Health and Physical Education; Nonr 1759(00), NR 102-351; H. H. Clarke, K. Reiser, D. H. Clarke.

The following phases of muscle conditioning and endurance performance are being studied: (1) muscle load and speed of contraction as related to work output energy cost, and increase in muscular strength and endurance; (2) the crosstransference of conditioning factors between muscle groups; (3) the effect on muscular endurance of various types of motivation, and (4) the possibility of an exercise tolerance test based upon fundamental conditioning factors.

Biological Effects of Microwaves (U), RR 005-01-0015. Tulane University, New Orleans, Louisiana, Biophysics Laboratory; Nonr 475(03), NR 102-359; R. T. Nieset, R. Baus, Jr., J. D. Fleming, Jr., R. D. McAfee.

The subjects of this task were the physiological relationships and possible hazards of microwave radiation to biological subjects, particularly to humans. Recent work was directed primarily toward determining effects of microwave absorption without concurrent increases in overall body temperature. As part of this work, the temperature distribution due to microwave absorption was being established analytically and experimentally.

Biological Effects of Microwave Irradiation (U), RR 005-01-0016. St. Louis University, St. Louis, Missouri, Department of Physiology; Nonr 1304(02), NR 102-362; A. W. Richardson.

Studies are being conducted on the physiologic and pathologic effects of CW and pulsed microwaves on biologic tissues and intact animals. This includes the biophysical aspects of microwave exposure. The frequency dependence of the biological effects are being analyzed and applied to the problem of dosimetry. The spectral range under consideration is from infrared to 200 cm.

A Physical Approach to Study of Circulatory Dynamics (U), RR 005-01-0017. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Physiology; Nonr 551(18), NR 102-387; L. H. Peterson, E. O. Feigl, P. Gouras.

Investigations are being pursued on (1) the mechanical properties of the cardiovascular system in intact, living animals, which relate to blood flow and the force causing the flow; (2) effects of various environmental factors on this system; (3) effects exerted by the neurohumoral system and by certain drugs; (4) how these characteristics effect the output of vascular sensory receptors, and (5) how the central nervous system integrates this information and controls the cardiovascular system.

Blood and Immunochemical Alterations in Cold Adaptation (U), RR 005-01-0018. California Institute of Technology, Pasadena, California, Department of Immunochemistry; Nonr 220(22), NR 102-392;

D. H. Campbell.

Blood coagulation time and the rate of antibody formation and decay in cold adapted animals including humans are being determined. This includes (1) continuation of the study of cold stress and mountain altitudes on plasma proteins and antibody formation; (2) exploration of the role of thyroxin and metabolic activity in immune mechanisms; (3) effect of high altitude on induced asthma; and (4) development of an immunophysiological approach to the problem of antibody formation, with emphasis directed toward an understanding of the situations predominating under various stress conditions.

High Altitude Physiology (U), RR 005-01-0019. University of California, Berkeley, California, Department of Physiology; Nonr 222(38), NR 102-405; N. Pace.

Studies are conducted on organisms at levels of organization ranging from cell particulates to the total individual as it responds to environmental extremes. A portion of the work is conducted at the White Mountain High Altitude Research Station. The specific physiological measurements being made on both men and animals include respiratory alterations reflected by CO_2 response tests, total physical work capacity measured on a bicycle ergometer, blood hemoglobin levels, estimation of adrenocortical activity by analysis of blood and urine samples.

Study of the Dynamics of the Lung Thorax System (U), RR 005-01-0020. Duke University School of Medicine, Durham, North Carolina, Department of Physiology and Pharmacology; Nonr 1181(07), NR 102-416; W. E. Hull, E. C. Long, L. Jones.

This investigation is concerned with (1) the limits of trachael airflow velocity under grossly elevated transthoracic pressures; (2) the limits of increased transthoracic pressure-time relationships within which the chest wall and lung move in normal phase; (3) the extent to which grossly altered transthoracic pressures influence thoracic circulation; and (4) the site and magnitude of the events during sudden thoracic decompression which may lead to impairment of the circulation or damage to aerating portions of the lungs.

Effect of Stress on Thyroid Hormone Utilization (U), RR 005-01-0021. University of California, School of Medicine, Los Angeles, California, Department of Medicine and Radiology; Nonr 233(36), NR 102-421; D. H. Solomon, L. R. Bennett, M. T. Hays, V. Schaeffer.

This is a study of the mechanism and direction of the effects of a variety of stresses on the production of thyroid hormone and, more significant, on the amount of hormone released to and utilized by the tissues. In human studies on the effect of semi-chronic administration of epinephrine on thyroid hormone release rate, initial observations showed a slowing of the rate of release. Final data on these studies show that there is an inconsistent reduction in thyroid uptake when epinephrine is administered 30 minutes after iodine is given. A consistent reduction in thyroidal iodine uptake results when epinephrine is given before iodine.

Physiological Responses to Alterations in the Gravitational Field (U), RR 005-01-0022. University of California, Davis, California, Department of Poultry Husbandry; Nonr 2211(01); NR 102-448; S. A. Arrington, C. F. Kelly, A. H. Smith, F. Lory, J. O. Nordstrom.

Experimental animals are being submitted to centrifugation for periods up to 50 days at G forces of 1.6 to 2.5. Maximum gravitational field to which the animals can adapt, and the physiologic and anatomic changes associated with such adaptation are being determined. Animals fully adapted to tolerate high gravitational force existence are restored to a normal gravitational field to study the immediate and long term effects of "partial weightlessness" on physiological processes. A strain of birds resistant to high acceleration effects is being developed.

Effects of Prolonged and Chronic Intermittent Exposure to High and Low O_2 Tension (U), RR 005-01-0023. Albert Einstein College of Medicine, Bronx, New York, Department of Pathology; Nonr 1765(02), NR 102-465; A. Angrist, R. M. Rosenbaum, M. Wittner, C. I. Rolon.

The physiological effects of prolonged exposure to high and low O_2 tensions are being studied from the following aspects: (1) relationship of age to susceptibility and adaptation; (2) histological changes in heart valves, lung and connective tissue; (3) effects of varying gas mixtures on oxygen poisoning; (4) effects of temperature and pressure on oxygen poisoning.

The Application of Underwater Acoustics to the Diagnosis of Heart Disease (U), RR 005-01-0025. Philadelphia General Hospital, Philadelphia, Pennsylvania; Nonr 2744(00), NR 102-470; D. H. Lewis.

A detailed study in the area of cardiovascular physiology is being conducted chiefly by applying the techniques of underwater acoustics using the intracardiac phonocatheter. Normal and abnormal heart sounds obtained by this technique are compared with those observed by the usual methods employing the stethoscope. The applicability of intracardiac phonocardiography to the diagnosis of heart disease in man is being investigated.

International Congress of Physiological Sciences (U), RR 005-01-0026. National Academy of Sciences, National Research Council, Washington, D. C.; Nonr 2300(11), NR 102-482; J. S. Coleman.

This task provided support of travel expenses of American scientists attending the XXI Congress of Physiological Sciences held in Buenos Aires, Argentina.

High Altitude and Maintenance of the White Mountain Research Station (U), RR 005-01-0027. University of California, Berkeley, California, Department of Physiology; Nonr 222(35), NR 102-483; N. Pace.

The White Mountain Research Station laboratories are supported for the purpose of providing unique research facilities--i.e., laboratories maintained year round at altitudes of 10,150 and 12,470 feet and a summit lab at 14,250 available on request. The Station is available to any qualified scientist who wishes to carry out research involving the high altitude environment. This

task supports more specifically research in the physiology of adaptation to high altitudes.

Studies of Pulmonary Mechanics, Circulation and Gas Exchange (U), RR 005-01-0028. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Physiology and Pharmacology; Nonr 2535(00), NR 102-485; R. E. Forster, A. B. DuBois.

Techniques of measuring airway resistance, ventilation, pulmonary blood flow, capillary bed volume and gas exchange are being applied to studies of the basic cardiopulmonary function in man. Investigations include the problems presented by abnormal atmospheres, toxic vapors, braces, and various orthopedic procedures. The rates at which various gases can combine with intracellular hemoglobin and the influence of these rates on pulmonary diffusion are being determined.

Neurological Aspects of High Barometric Pressure (U), RR 005-01-0029. University of Buffalo, Buffalo, New York, School of Medicine; Nonr 969(04), NR 102-489; H. W. Gillen.

This is a study of the effects of, and alterations produced by, exposure to high pressures of carbon dioxide upon the nervous system in mammals. The initial phase is an attempt to correlate elevated pCO_2 with anatomical and histological changes. A further phase of the task will be to study the effects of high partial pressures of biologically inert gases and oxygen in relation to alteration of function of the nervous system.

Biological Instrumentation for Airborne Human Subjects (U), RR 005-01-0030. American Electronic Laboratories, Incorporated, Philadelphia, Pennsylvania, Instrumentation Division; Nonr 2703(00), NR 102-503; J. H. Busser, S. Markowitz.

The objectives of this contract were to develop transducers and a miniature recording system to obtain the following information during flight and after ejection of the pilot from the aircraft: (1) anoxia level; (2) anoxia warning indication; (3) body temperature; (4) environmental temperature; (5) suit pressure; (6) environmental pressure.

Histopathological Effects of CO_2 (U), RR 005-01-0031. Yale University, New Haven, Connecticut, School of Medicine; Nonr 609(37), NR 102-507; A. A. Liebow.

A histopathological study is being conducted on fixed tissue slides prepared from test animals from CO_2 exposure experiments. The objectives are (1) to study the effects of various concentrations of increased CO_2 in the inhaled air on the tissues of exposed animals (guinea pigs and rats) with particular emphasis on changes produced by prolonged exposure; (2) to attempt correlation of the histopathologic findings with physiologic and biochemical data obtained under similar experimental conditions.

High Pressure Physiology (U), RR 005-01-0032. University of Buffalo, Buffalo, New York, Department of Physiology; Nonr 969(03), NR 102-511; H. Rahn, E. H. Lanphier.

This is an investigation of basic problems related to high pressure physiology. Among the problems being explored are (1) the general respiratory effects of submersion and increased ambient pressures; (2) effects and interrelationships of factors affecting control of respiration; (3) effects of high oxygen partial pressures; and (4) inert gas effects in normal and high pressure environments.

The Development of Telemeters for Measuring Physiological Variables (U), RR 005-01-0034. American Electronic Laboratories, Incorporated, Philadelphia, Pennsylvania; Nonr 2912(00), NR 102-519; J. H. Busser, S. Markowitz.

The general problems in monitoring and telemetering biological activity are being investigated for the purpose of developing new measures of physiological function and improved telemetering instrumentation. Further objectives include instrument design which will minimize interference with normal function and activity of the subject and improvements in accuracy, precision and range.

Observations of Neuromuscular Mechanisms (U), RR 005-01-0035. University of Wisconsin, Madison, Wisconsin, Lathrop Hall; Nonr 2944(00), NR 105-522; F. A. Hellebrant, J. C. Waterland, F. Z. Cumbee.

Techniques and devices permitting precise graduation of exercise dosage and the overload of systematically selected muscle groups are applied to a study of the influence of muscle training on the antagonists of the muscle group subjected to ergographic exercise. Neuromuscular responses will be studied by sychronized photographic, electromyographic and ergographic observations of compensatory mechanisms revealed when stresses are sufficiently severe to induce breakdown in performance to determine if the resources called upon reveal fundamental patters of organization.

Physiological Problems of Man in Artificial Environments (U), RR 005-01-0037. Ohio State University, Research Foundation, Columbus, Ohio; Nonr 495(19), NR 102-525; F. A. Hitchcock, R. W. Stacy, E. T. Carter, J. H. Dines.

The objectives of the task are to test (a) the long standing hypothesis that the absence of nitrogen per se without the associated hypoxia has no significant physiological effect on man, and (b) the assumption that low ambient pressure per se has no significant physiological effects once denitrogenation has occurred.

Dynamics of the Circulation and of Air Flow and Mechanisms of Cardio-Respiratory Adjustment (U), RR 005-01-0039. Medical College of Virginia, Richmond, Virginia, Department of Medicine; Nonr 1134(01), NR 102-607; J. L. Patterson.

The output of the heart and the relative distribution of the blood to the various parts of the body are being studied at rest and under a variety of conditions of physiological stress. The situations and states included are: change of posture, muscular exercise, radial acceleration, reduced barometric pressure, hyperventilation, administration of drugs affecting the circulation, neurocirculatory asthenia, anxiety, hypertension and cardiac failure.

Epidemiologic Evaluation of Coronary Artery Disease in Flight Personnel (U), RR 005-01-0041.

Seton Hall College of Medicine and Dentistry, Jersey City, New Jersey, Medical Center; Nonr 3181(00), NR 102-524; B. J. Duffy, T. M. Gocke.

This is a study of the epidemiologic aspects of coronary heart disease in flight personnel of the U. S. Navy and counterpart civilian populations at various ages. It aims (1) to compare the incidence of coronary heart disease by means of a cohort follow-up of flight personnel in the 40-50 year age group with that expected in a civilian and a military but non-flight population; (2) to evaluate some of the theories of causation of coronary heart disease.

Variation of CO_2 Sensitivity with Wakefulness (U), RR 005-01-0042. University of Lund, Lund, Sweden, Department of Neurology; N62558-2580, NR 102-531; D. H. Ingvar, K. Bülow.

During sleep, the responsiveness of the respiratory center to carbon dioxide is lowered, leading to an increased partial pressure of carbon dioxide in the alveolar air. From this, it should be possible to predict a correlation between the brain's activity shown by the electroencephalogram and the partial pressure of arterial CO_2 when the level of wakefulness changes. The existence of this relationship is being investigated and, if established, an attempt will be made to use CO_2 sensitivity as an expression of central respiratory excitability and as a means of evaluating the general excitability of brain stem centers regulating consciousness.

Requirements of a Pre-Flight System (U), RR 005-01-0043. Man-Machine Systems, Incorporated, South Arlington, Virginia; Nonr 3107(00), NR 102-541; L. T. Bonner, Jr.

This is a research study to define and measure the pre-flight conditions and use of the Navy MK IV full pressure suit system and to formalize the data obtained into a recommended specification of the system requirements. The information thus provided will enable the Navy to verify, amend and/or revise the component specifications in order to optimize the pre-flight system.

Force Distributing Fabrics (U), RR 005-01-0044. National Textile Research, Incorporated, Raleigh, North Carolina; Nonr 3147(00), NR 102-542; W. H. Payne, J. D. Brooks.

The aim of this research is to determine, experimentally, new weaves, fabrics and configurations that might be incorporated into unique deceleration protection garments which would have inherent optimum load distribution qualities without the encumberances of the usual belts, straps, webbings, etc.

Prevention of Heat Casualties in Recruit Training Centers (U), MR 005-01-0001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt D. Minard, MC, USN.

A five-year survey (1956-60) of the incidence of heat casualties at the Marine Corps Recruit Depot, Parris Island, South Carolina, indicates that the preventive program adopted in 1956 has been effective in maintaining the low incidence rate observed in 1956 ("Prevention of Heat Casualties", NMRI Report NM 41 01 00.01.01). A Navy training film NM 8965 film has been produced depicting the application of the hot weather regulations to recruit training. Incidence rates of heat casualties in other training categories of the Marine Corps were found to be significantly higher than in recruits at Parris Island. A new Marine Corps order (MCO 6200.1A of 5 Oct 1960) extends procedures for preventing heat casualties tested at Parris Island since 1956 to hot weather training in these other categories. Physiological measurements of heat strain in machinery room watch standers, laundry crew and subjects performing standard exercises in their areas were correlated with environmental measurements of heat stress. Heat stress was significantly greater in the laundry than in the machinery room. Results indicated the need for better distribution of ventilating air in the machinery space, as well as improved working conditions in the laundry. Present indices of heat stress are not satisfactory in predicting physiological strain in the complex thermal environment of a ship's machinery space.

Effects of Excessive Cold on Physiological Adaptation and Performance (U), MR 005-01-0021. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Esther Hardenbergh, Ph.D., David Minard, Capt, MC.

Studies of experimental freezing injury in animal extremities have shown that blood flow is reduced in the part during freezing and is restored to control levels temporarily after thawing. Vascular reactivity to vaso-active drugs is dimished in the frozen and thawed tissue. Factors found to affect survival of frozen tissue are: Duration of the freezing time; severity of cold during exposure, and temperature of rewarming. Although vascular proliferation and accelerated healing occur in rapidly rewarmed tissue as opposed to a generalized cellular necrosis which takes place after slow thawing, histological studies reveal reactive endothelial proliferation which may in time produce occlusion of the vessels involved. Mice maintained in a state of suspended animation of 0^{o} while their tails are frozen experience more local tissue necrosis than normothermic mice given the same freezing injury. Current work has concerned further examination of the circulatory effects of local freezing: (1) Altered vascular pressure relationships can be observed in arteries, small vessels, and veins in a frozen and thawed part; there is a significant increase in venous pressure after the freezing injury, which must contribute to the formation of edema and stasis through increased capillary filtration pressure; (2) Experiments are being conducted on the effects of interruption of vascular innervation (sympathectomy) on tissue survival in an experimentally frozen part. Both of these aspects of the work will be continued in 1961.

The Effect of Environmental Factors on the Performance of Marine Corps Personnel (U), MR 005-01-0030. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; MarCorps, 17X1319.2717, P. O. 1-0009; J. J. Martorano, Cdr, MSC, USN.

The objective of this study is to determine the effects on the operational performance of Marine Corps personnel resulting from such environmental factors as temperature and humidity.

Present studies have been directed toward the

effects of body armor and load-carrying systems on the operational performance of the infantry Marine, both under field and laboratory (climatic chamber) conditions.

This year an evaluation was made on the performance of Marine Corps personnel wearing load-carrying systems (Standard Marine Corps Pack with Modified Pistol Belt, M1936, and two experimental Jerkin load-carrying systems). These were worn with fighting loads (32 lbs.) and marching loads (52 lbs.). Physiological and psychological measurements were made while subjects performed a controlled amount of work (e.g., walking on a motor-driven treadmill) in a climatic chamber under controlled conditions of temperature and humidity.

A preliminary report on the results of this study has been submitted. In this it was concluded that on the basis of physiological responses measured, neither model of the experimental Jerkin load-carrying system was warmer or caused significantly greater adverse effects than when the Standard Marine Corps Pack with the Modified Pistol Belt, M1936, was worn. The psychological evaluation also indicated that insofar as comfort was concerned there was no real difference between the three load-carrying configurations tested.

R005-02 Blood and Tissue Substitutes

Studies on the Use of Preserved Tissues in Surgery (U), MR 005-02-0001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt C. A. Ostrom, DC, USN.

Preliminary results indicate an increase in resorption rate of ED extracted bone treated with chondroitin sulfate. Current animals are scheduled to be sacrificed in May and July 1961 for 3 and 4 year data. Through cut dentin, ED bone was less toxic than $Ca(OH)_2$; as a pulp capping agent, ED bone was as successful as $Ca(OH)_2$; and uniform dentinogenesis with no pulpal osteogenesis further supported prior indications that ED bone contains no osteogenic factor. Multiple implantations at varying intervals demonstrated no antigenic response to ED or boiled-defatted bone in dogs or monkeys. Pulpotomy implantation in process will be completed in 1961. Four bilateral areas were implanted with both homogenous and heterogenous osseous materials in three clinical patients. Six months postoperative examinations indicated clinical host acceptance of the grafts, the alveolar ridges were firm and possessed prosthetically acceptable contour. Additional cases will be operated during the coming year. In connection with the freeze-drying of biological materials, further studies have been carried out on the drying of spermatozoa and erthyrocytes. Unsolved difficulties have arisen with spermatazoa and work on this cell has been temporarily suspended. Erythrocytes, however, can now be dried and reconstituted with sufficiently good recovery to warrant optimism regarding dried storage for transfusion. The critical agent in successful reconstitution is a component developed in PVP during aging in solution. Efforts are underway to isolate and identify this agent. Several collaborative projects have also been undertaken with other laboratories interested in freezing or drying of specific micro-organisms.

Studies on the use of Preserved Tissue in Surgery (U), MR 005-02-0002. Naval Medical School, Bethesda, Maryland; R. B. Gresham, LCdr, MC, USN, Director, Tissue Bank Department.

A comparison of homogenous and autogeneous graft results was undertaken during the year. Basic data on the autogenous graft cases is still being collected and there are insufficient cases on hand at this time to be statistically significant. The feasibility of converting the Graft Registry from the Remington Rand statistical cards to an IBM punch card system is under study. A Tissue Bank Technicians Manual is in preparation. Processed the curriculum for Tissue Culture Technician school. Protective freezing and low temperature preservation of animal and human bone marrow is being studied. Fractionation of the components of bone by preliminary treatment with solvents and selective extraction of crystal or organic phase has been carried out and is still in progress. The Burn Toxin antitoxin study was reported in detail to Office of Naval Research via BuMed (Code 7) in CO, NMS ltr Serial 3 dtd 4 Jan 1961 with enclosure.

Studies on the Use of Preserved Tissues in Surgery, MR 005-02-0002. Historadiology Laboratory and Departments of Pathology, Nuclear Medicine, and Tissue Bank, U. S. Naval Medical School, NNMC, Bethesda, Maryland; T. C. Hartney, Lt, MC, USN.

Utilizing the facilities of the NMS Hematology laboratory, the REEL, (and the predecessor Historadiology laboratory in the NucMed department of NH) and the NMS Tissue Bank technical development of the method for tritiated thymidine culture has begun. Assay of the result has been by gas-flow and liquid scintillation counting and autoradiography. As of the last day of the reporting period, sixty-eight (68) cultures of human skin epithelial cells (Source NMS Tissue Bank, vice Lt Perry), thirty-five (35) cultures of human bone marrow (Source NMS Hematology, vice Cdr McFarland and other staff physicians of NH whose patients have been studied in NMS Hematology laboratory), and three (3) guinea pig marrows (Source Dr. Johnston, NMRI), have been studied with this technique.

Results to date demonstrate that the hypothesis of tritiated thymidine culture and radioactivity assay is a tenable one. All phases of the technique have been successfully accomplished, but replication of results has not yet been achieved. Our first modification in the initial technique was the adoption of a CO_2-rich atmosphere during culture; this produced a marked improvement in tritium uptake in those cultures done since mid-October 1960 when the necessary gassing equipment was obtained.

Studies in Vascular Replacement (U), MR 005-02-0008. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt R. B. Brown, MC, USN.

In a series of 48 dogs, the abdominal aorta was replaced with either a homograft preserved in buffered formalin solution or a crimped teflon prosthesis. In the experimental series of animals, the operative area was contaminated with feces. The animals were then followed until death or sacrifice. Eight animals remain alive for long-term studies.

The formalin preserved homograft appeared to be more resistant to disruption in the presence of

contamination than homografts preserved by other methods; however, functional results were not superior to those obtained with the plastic prostheses. Therefore, formalin preserved homografts are not recommended for use in contaminated fields when plastic prostheses are available. During war or mass civilian casualties, the availability of formalin preserved homografts may be advantageous.

Physical and Chemical Studies of Substances of Biological Importance (U), MR 005-02-1001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Cdr S. W. Handford, MSC, USN.

At the request of the Research Division, BuMed, Lot 18 glycerol pectate was triple Zeitz filtered and administered to dogs which were sacrificed at appropriate intervals post fusion for the study of tissues for evidence of storage of the material in organs. Dextran and unfiltered glycerol pectate were infused into dogs for control purposes. This work is complete and will be reported as soon as the histo-pathology report is forthcoming from the Division of Pathology, NMRI.

Study of Transfusion of Packed Red Blood Cells After Deep Freeze Preservation in Certain Anemic Patients not Requiring Blood Volume Replacement, MR 005-02-1003. Medical Service, including Radioisotope Laboratory, Laboratory Service, including Blood Bank, Blood Research and Blood Preservation Laboratories; Capt H. L. Jones, MC, USN.

To date approximately forty (40) selected patients with chronic or subacute anemia due to various causes or associated with various diagnoses or dyscrasias of unknown etiology have been given one or more units of deglycerolized thawed "packed" red blood cells.

Although the data obtained on these cases have not been collated, the impression continues that the reaction rate to deglycerolized thawed red cells is definitely less even in this group, in which reactions to ACD blood is usually much higher than in anemias due to simple blood loss. This observation, as well as the original findings that a number of these patients had shortened in vivo survivals of CR51 tagged deglycerolized erythrocytes, has led to a gradual shift in emphasis to studies of etiologic factors and pathogenetic mechanisms in anemic and potentially anemic patients.

Hence the fruitful search for hemostatic defects in peptic ulcer is being continued. Judging from the preliminary results reported, these are apparently far more common than originally suspected. The commonest deficiency is in ascorbic acid, which has shown high correlation with "suboptimal" dietary intake and capillary fragility, responsive to supplemental therapy. Simplification of the usual ascorbic acid saturation test has enabled its serial performance in many cases. The usual tourniquet test has been refined to a point where it is believed to be more valid, especially when repeated before, during and after repletion of ascorbic acid deficits. These techniques, employed as they are with the usual screening tests for hemostatic defects, would appear to be especially indicated in the light of increasing experimental and sporadic clinical evidence for scorbutigenic hemostatic defects other than pure capillary fragility.

R005-03 Regulatory Physiology

Biological Effects of Ultrasonic Irradiation (U), RR 005-03-0001. Brown University, Providence, Rhode Island, Graduate Division of Applied Mathematics and Department of Biology; Nonr 2314(00), NR 101-007; J. W. Wilson, R. Truell.

The objectives of this research program are (1) to study the effects of continuous and pulsed ultrasound upon biological systems; (2) to elucidate the relationship between the dosage parameters and the nature and extent of injury produced by ultrasound; (3) to apply the knowledge of the effects of ultrasound to other studies in biological and medical research. Frequency ranges of 1-27 megacycles are used.

Nutritional Factors in Tissue Synthesis and Destruction (U), RR 005-03-0002. University of Chicago, Chicago, Illinois; Nonr 2429(00), NR 101-012; R. W. Wissler.

This is a study of nutritional problems in health and in disease. Specific objectives are (1) study of atherosclerosis in the rat and monkey; (2) study of the role of renal injury in producing hyperlipemia; (3) study of the metabolic effect of amino acid inhibition by B-3 thienylalanine and the renal lesions of potassium deficiency.

The Extrapyramidal System of the Brain (U), RR 005-03-0003. Northwestern University Medical School, Chicago, Illinois, Department of Anatomy; Nonr 1768(00), NR 101-046; R. S. Snider.

The main emphasis of this study is on the relationship of the extrapyramidal system of the brain stem (subcortical connecting system) to the cerebellum, the reticular system, basal ganglia, and amygdaloid complex. The nerve tracts forming circuits between and among these various structures have been traced and their individual and combined functions are being worked out. These areas of the brain play an essential role in modulating muscle control and movement. These studies seek to establish the mechanisms involved in such motor dysfunctions as epilepsy. Drugs which might be used to modify these functions are also being investigated.

Circulatory Abberations and Experimental Therapy in Thermal Burns (U), RR 005-03-0004. Medical College of South Carolina, Charleston, South Carolina, Department of Anatomy; Nonr 1660(00), NR 101-065; M. H. Knisely.

Pathologic circulatory factors causing shock and death following burn are being studied. This includes analysis of factors such as changing of the blood to a sludge, prolonged spasms of peripheral blood vessels, spasms of hapatic outlet valve sphincters, spasms of pulmonary arteries, and spasms of cerebral veins.

Study of the Effect of Ultrasound on Nerve Tissue (U), RR 005-03-0005. University of Illinois, Urbana, Illinois, Department of Electrical Engineering; Nonr 1834(00), NR 101-075; W. J. Fry.

The broad aim of this task is to determine and study the effects of ultrasonic energy on biological

tissue and to use this radiation to investigate both the cellular and intracellular organization and structure of biological systems. Ultrasonic instrumentation has been designed and developed for the purpose of irradiating tissues in the central nervous system under quantitative dosage conditions. This apparatus enables biological preparations to be irradiated at a variety of base temperatures, hydrostatic pressures, and variables which characterize the acoustic field. Investigations on the basic physical factors involved in the selective actions of ultrasound on the tissue components have been extensively pursued. Comprehensive histological studies of ultrasonically produced lesions in the brains of cats and monkeys have furnished information concerning the time course of changes following exposure of the various tissue components to high level ultrasound. The vascular system within the region of a lesion (white or grey matter) in which all neural components are destroyed can be left intact and functioning. A number of studies have been made on the effects of high intensity ultrasound on the mechanical and electrical responses of excised frog skeletal muscle. A new ultrasonic irradiator, operating at a frequency of four megacycles per second, is being used in irradiation of the pituitary gland in cats.

Studies on the Mechanism of Shock (U), RR 005-03-0006. The Rockefeller Institute, New York, New York, Cytology Department; Nonr 2532(00), NR 101-079; D. H. Moore.

This task explores such physiological components of burn shock as transfer of proteins and electrolytes in body tissues, changes in amino acid levels, and effects of temperature on survival. Histological and biochemical studies of blood, spleen, kidney, and liver are being made in an attempt to define the primary site and mechanisms of shock state. Specifically, current studies concern the capillaries of mouse legs after various periods of ischemia produced by tourniquet. While the tourniquet is applied and for a short time after its removal, there is a marked transfer of fluid from the vascular bed to the muscle and the interstitial spaces. A great difference in the thickness and density of the basement membrane surrounding the capillaries is also observed. The reason for this variation and the role the basement membrane plays in the transfer of fluid is the primary concern of the present investigation.

Compositions and Properties of Nerve Proteins (U), RR 005-03-0007. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Biology; Nonr 1841(27), NR 101-100; F. O. Schmitt.

This nerve chemistry program consists of a coordinated attack on the structural, chemical and biophysical properties of peripheral nerve fibers. An attempt is made to relate these properties to nerve function. Axoplasm from the giant nerve fibers of the squid are used for the analyses which include (1) investigation of the organic acids and bases and other dialyzable substances, (2) isolation of proteins, particularly the fibrous protein which composes the neurofibrils, (3) determination of amino acid composition. Investigations are also being made of the sheath, including the Schwann cells.

Experimental Concussion (U), RR 005-03-0008. University of Washington, Seattle, Washington, Division of Neurosurgery; Nonr 942(00), NR 101-127; A. A. Ward.

When the brain has been injured by trauma, alterations occur in the electroencephalogram characterized by the replacement of normal activity by slow wave or delta activity. Thus, as a part of a broad program investigating the physiological mechanisms in closed head injury, it becomes pertinent to obtain an understanding of the genesis of such slow wave activity in the EEG. The physiological mechanisms underlying the generation of such slow wave activity are generated by graded response tissue and may be largely generated in the dendrites of neurons of the cerebral cortex. It is known that such dendritic activity is not necessarily directly related to the transmission of all-or-none activity by the cell bodies. As one approach to this problem, the interactions between spontaneous dendritic activity and activity evoked by input from various sources are being studied. Local responsivity of membranes is pharmacologically manipulated by the topical application of various compounds including gamma aminobutyric acid. The role of standing d. c. fields in the generation of slow wave or delta activity will also be investigated as well as other local mechanisms which may play a role in the generation of summed, rhythmic activity of this type.

Metabolism of the Nervous System in Relation to Function (U), RR 005-03-0009. University of Illinois, College of Medicine, Chicago, Illinois, Department of Psychiatry; Nonr 1459(03), NR 101-128; L. G. Abood.

The over-all objective of this research is to study the metabolic and chemical changes in the nervous system during normal activity, during certain pathological conditions, and under the influence of certain neurotrophic drugs. The problems are being studied at various levels of cellular organization. Specific approaches include studies of (1) the metabolic, physico-chemical, and electrical properties of mitochondria from neural and muscular tissue; (2) chemical and biochemical changes in isolated amphibian nerves during excitation; (3) effect of neurotropic drugs on brain metabolism in relation to function; (4) toxic effects of certain substances arising from inherent metabolic disorders such as found in phenylketonuria; (5) electrical, morphogenetic, and biochemical properties of single neurons grown by tissue culture of human and mammalian cerebral cortex.

Cytological Change in Pituitary Gland following Severe Burn (U), RR 005-03-0010. University of Miami School of Medicine, Coral Gables, Florida, Department of Anatomy; Nonr 840(09), NR 101-140; J. C. Finerty.

This series of studies is intended to increase knowledge of the mechanisms which regulate the elaboration of ACTH and adrenal cortical hormones in response to unfavorable environmental stresses, particularly severe burns and ionizing radiation. Research to clarify some aspects of ACTH release

and adrenal response in severe stress is being conducted along three general lines: (a) study of the effects of stress on adrenal response in hypophysectomized rats with anterior pituitary gland autografts; (b) study of the effects of posterior hypothalamic homotransplants or posterior hypothalmic homotransplants or posterior pituitary autografts on maintenance of anterior pituitary autografts in hypophysectomized rats; and (c) study of neurosecretory changes in the paraventricular and supraoptic nuclei of rats after severe stress to ascertain possible relationships with ACTH release. In addition, a compilation of a bibliography on pituitary structure is being made in preparation for a comprehensive review covering the period 1939-1959.

Codeine Substitution Studies (U), RR 005-03-0011. U. S. Public Health Service, Bethesda, Maryland, NIMH Addiction Research Center; NAonr 14-60, NR 101-149; H. Isbell.

Sixty percent of the Armed Forces' requirements for narcotics is for codeine, the supply of which is dependent upon imports. At present there is no adequate substitute. A number of drugs are being tested clinically under this task to determine whether any are sufficiently free of toxic effects and addiction liability to be a safe substitute. The possibility of combining codeine with a compound which will increase its intensity and prolong the effect is also being explored as a means of increasing the use of present supplies of codeine.

The Relation of the Nervous System to Visceral and Glandular Function (U), RR 005-03-0012. University of Washington, Seattle, Washington, Department of Physiology and Biophysics; Nonr 477(07), NR 101-150; T. C. Ruch.

The ultimate objective of this research program is to elucidate the mechanisms involved in "psychosomatic" disorders. There are three immediate goals: (a) to determine the influence of various environmental and motivational factors upon the spontaneous activity of monkeys; (b) to study the neurology of emotion and motivation in the rat; and (c) to investigate the neural control of the cardiovascular system. Activity measurements are being used to determine the response of an organism to various internal and external influences. The response of prefrontal lobectomized monkey to temperature changes is being studied. Work on the genesis of pulmonary edema has implicated the hypothalmus in the control of the cardiovascular system. Some light has been shed on the structures involved by a study of the neural control of the cardiovascular system, using implanted gauges to measure left ventricular diameter, left ventricular pressure and aortic flow.

A Study of Perfusates of Thermally Injured Skin (U), RR 005-03-0013. University of Illinois, Chicago, Illinois, Institution for Tuberculosis Research; Nonr 1459(02), NR 101-161; S. R. Rosenthal.

Experimental evidence that a "toxin-antitoxin" phenomenon exists in blood of burned or injured animals and humans was first presented in 1937. The present research program is a continuation of this earlier work. Objectives are: (a) to obtain by newly developed direct in vivo and in vitro techniques, substances liberated from the skin following thermal injury; (b) to determine the mechanism of liberation, the biological action, and the identity of these substances.

Eventually, it is proposed to produce an antigen from human burned skin (artifically produced in vitro) to use for the active immunization of those most likely to sustain such injuries and for the active immunization of animals. Such an antigen and corresponding antibodies have already been produced in animal and human studies.

Casual Factors in Production of Blood Cell Types (U), RR 005-03-0014. University of Kansas, Lawrence, Kansas, Department of Anatomy; Nonr 1766(00), NR 101-182; P. G. Roofe.

Information is lacking on the mechanism of blood formation, the role of protein, and the effect of protein deficiency on this process. It is the purpose of this task to ascertain the number of all types of blood cells present in a given volume of tissue from various body organs of animals on both normal and protein-deficient diets. With this background information, it is planned to investigate the mechanism of differentiation of these cell types and to ascertain the role of amino acids in the process. In addition histochemical and bioelectric studies of the developing nervous system are being carried out.

Neurophysiology of Central and Spinal Pathways and Structures (U), RR 005-03-0015. University of Oregon Medical School, Portland, Oregon, Department of Neurosurgery; Nonr 1779(02), NR 101-219; G. M. Austin.

This project is studying fundamental neurophysiologic concepts of importance to the human, including stereotaximetry, blood brain barrier (as applied to brain tumors), basic factors in Parkinson's disease, and pain mechanisms. Basic neurophysiologic mechanisms are being investigated in lower animals prior to work with humans; this phase includes the study of the sprouting of new synaptic terminals in spasticity and the possibility of this occurring after cerebral ablation; and the study of basic sensory mechanisms typified by the dorsal root reflex and patterns of firing of dorsal root ganglion cells.

Properties and Metabolism of Natural Fats and Fatty Acids (U), RR 005-03-0016. Texas A & M Research Foundation, College Station, Texas, Department of Biochemistry and Nutrition; Nonr 1450(00), NR 101-225; R. Reiser.

The manner in which natural fats and fatty acids resulting from the digestion of food fats are carried to and used by the cells is being studied. Paper chromatographic techniques are being developed for the analysis of the biological interconversions of the polyunsaturated fatty acids. A unique approach to these studies has been devised--laying hens are fed fat free rations until fatty acids in their eggs are reduced to a minimum, and then fed conjugated fatty acids and other polyunsaturated acids in pure form. Subsequent eggs are analyzed to determine the interconversions. The origin of marine fatty acids is also bein investigated.

Physical Mechanism of Oxidation-Reduction

Processes in Living Cells (U), RR 005-03-0017. Washington University, St. Louis, Missouri, Department of Botany and Physics; Nonr 816(10), NR 101-227; B. Commoner.

The primary aim of this task is to demonstrate experimentally the presence of free radicals (i.e., compounds with one or more unpaired electrons) in biological media by application of the technique of paramagnetic resonance absorption and to investigate the role of these free radicals in the biological system. Indirect evidence has long indicated that free radicals must occur as reaction intermediates in oxidation-reduction processes in living cells, in the action of ionizing radiations on biological systems, and in chemical carcinogenesis. A detailed study of free radicals in heart particles has been completed. Free radicals have been observed in the following living tissues from mouse and guinea pig: liver, heart, spleen, adrenal, skeletal muscle, and kidney.

Mass Spectrometry (U), RR 005-03-0019. Howard University, Washington, D. C., Department of Physics; Nonr 2357(00), NR 101-230; H. Branson.

Under this contract, a 180° mass spectrometer has been rebuilt and is now operating and yielding good data on relative abundances, eg. N^{15}/N^{14}, C^{13}/C^{12}. New units for a 60° spectrometer are being constructed. The objectives of this program are (1) to note the kinetic and other effects in biophysical systems studied with stable isotopes and, (2) to initiate mass spectroscopic studies of organic compounds of biophysical interest.

Mechanisms of Neuromuscular Function (U), RR 005-03-0020. Johns Hopkins University, Baltimore, Maryland, Department of Environmental Physiology; Nonr 248(34), NR 101-241; K. L. Zierler.

This project is a broad investigation of the metabolic, electrical, and mechanical events in neuromuscular function in man and the experimental animal. It attempts to understand these processes and thereby to gain some insight into mechanisms involved in clinical manifestations of disturbances of these functions. Specific studies currently include (1) metabolic exchanges in forearm of man (a technique has been developed for simultaneous measurement of blood flow to the forearm and local arterio-venous concentration differences); (2) dependency of muscle oxygen consumption on muscle blood flow; (3) permeability of muscle membrane; (4) effect of insulin on muscle membrane potential.

Studies on the Mechanism of Muscular Contraction (U), RR 005-03-0022. Institute for Muscle Disease, Incorporated, New York, New York, Division of Physiology; Nonr 2878(00), NR 101-130; A. Sandow.

This study is concerned with the fundamental aspects of mechanochemical coupling and excitation contraction coupling of energy sources in muscular activity. Particular aspects of the investigation include (1) studies of the skeletal muscle of normal and dystrophic mice; (2) studies of iodoacetate rigor of frog skeletal muscle; (3) study of the rigor produced in skeletal muscle by ryanodine; (4) the effects of anions on the veratrine response of skeletal muscle.

Electrode Studies of Brain (U), RR 005-03-0023. Yale University School of Medicine, New Haven, Connecticut, Aeromedical Research Unit; Nonr 609(08), NR 101-320; J. M. R. Delgado.

New techniques were developed by this investigator whereby electrodes could be permanently implanted within the skulls and brains of experimental animals, permitting studies to be made without the limitations of restraint and anesthesia. Further miniaturization and improvement in instrumentation has resulted in development of a miniature transistor simulator, a small timer and a tiny battery, carried by the animals, around the neck. This permits programmed stimulations of any cerebral joint with unlimited freedom of movement. Utilizing these procedures, studies are being carried out (1) to investigate the possible roles of different cerebral structures in epileptic phenomena; (2) to study the site of action of CO_2, O_2, and anti-epileptic and tranquilizing drugs; (3) to analyze the neurophysiological basis of behavior by means of intracerebral stimulation in monkeys, completely free within a colony; (4) to study clinical applications of the findings of this project.

Ascorbic Acid and Adrenal Cortex Relationships (U), RR 005-03-0024. George Washington University, School of Medicine, Washington, D. C., Department of Physiology; Nonr 2543(00), NR 101-324; C. A. Hogben.

The role of adrenal corticosteroids in their control of electrolyte metabolism is being investigated. While it is known that these hormones have a profound effect on salt metabolism in vivo, it has been difficult to isolate this control in an in vitro system. A preparation of isolated amphibian intestine has been developed which specifically responds to adrenal corticosteroids by increasing its transport of salt and water. An attempt is being made to analyze the specific transport systems affected by the steroids.

Relationship of Bio-electric Phenomena to Intravascular Thrombosis (U), RR 005-03-0025. State University of New York, Downstate Medical Center, Brooklyn, New York, Department of Surgery; Nonr 2539(00), NR 101-330; P. N. Sawyer.

This is a study of the electrical potential differences in both normal and injured arterial walls with particular emphasis on those bioelectric changes which occur in injured or thromobosed arteries. The relationship of potential changes occurring with both fresh and freeze-dried aortic grafts to success of grafting procedure and rate of healing has been explored. As a further extension of this work, studies are being conducted on (1) EMF of exteriorized arterial and venous wall and the changes caused in the EMF by changes in pH, trauma, physiologic buffering agents, and anticoagulants; (2) the possible active transport of ions across the vascular membranes, determined by radioactive isotope transport techniques. The second step is a means of determining the origin of the electric charge found in blood vessels and the way in which it is maintained.

Studies on Neurosecretion (U), RR 005-03-0026. Albert Einstein College of Medicine, New York, New York, Department of Anatomy; Nonr 1630(00), NR 101-335; E. A. Scharrer.

The research program investigated neuro-endocrine relationships, particularly the neurosecretory cells which are the connecting links between the nervous system and the endocrine system. Particular studies included (1) how darkness and light affect the organs of internal secretions of blind and seeing animals; (2) the relationships in birds among the seasonal photoperiodicity, the amount of neurosecretory material in the pituitary stalk and the size of the gonads; (3) the influence of nervous stimuli on endocrine activities in insects; (4) the fine structure of the median eminence in the toad Bufo marinus.

Electromagnetic Studies on Separation of Neutral Particles (U), RR 005-03-0027. University of California, Los Angeles, California, Department of Biophysics; Nonr 233(38), NR 101-342; A. Kolin.

This research is concerned with the utilization of electromagnetic forces in obtaining biological data and in accomplishing separation of biological particles. The immediate objectives are (1) the perfection of an electromagnetic blood flow meter for physiological studies requiring precise blood flow measurements, and (2) electromagnetrophoretic "centrifugation" of biological entities such as viruses, bacteria, and intracellular components of unicellular and multicellular organisms.

Endocrinology and Normal Function (U), RR 005-03-0028. Harvard University, Cambridge, Massachusetts, Peter Bent Brigham Hospital; Nonr 1866(22), NR 101-345; J. C. Opsahl.

Placental ACTH is being fractionated and purified in order to obtain a clinically usable product. Clinical evaluations and comparisons of ACTH from placental and pituitary origins with respect to adrenocorticotrophic action in the inhibition of the hyaluronidase-enhanced spreading reaction will be made. As as adjunct of these endocrine studies, methodology involving reflectance spectrophotometry for measuring melanocyte-stimulating hormone or hormones (MSH) will be developed as a means of further elucidating the activity of the hypothalamico pituitary tract.

Molecular Studies of Neuronal Structure and Function (U), RR 005-03-0029. University of Maryland, Baltimore, Maryland, Psychiatric Institute; Nonr 595(03), NR 101-355; R. G. Grenell.

The study of anoxia, narcosis, and various drug actions was approached at the level of the chemical functioning of central nerve tissue. The objectives were to determine (a) the roles played by these stressors in both resting and functioning metabolism of central neurons; (b) the alterations in intracellular molecular structures which they produce; and (c) the relationship these molecular shifts have to functional activity. These analyses were carried out by optical methods, including infrared, ultraviolet, and X-ray.

The Coordinated Action of Muscles at Body Joints (U), RR 005-03-0030. University of Michigan Medical School, Ann Arbor, Michigan, Department of Anatomy; Nonr 1224(08), NR 101-370; W. T. Dempster.

This task approached the study of muscle-joint action by correlating anatomical, mechanical, and electromyographical data on movements under specified conditions. Free-choice push and pull forces of the arm with body in various postures and against varying magnitudes of force were analyzed from photographs in terms of vectors and torques for the different arm joints. Simultaneously potentials of individual arm muscles were measured in order to determine comparative activity and importance for any given action. The placement of electrodes for the electromyographic records were based on anatomical studies of the muscle and joints. These studies were designed to answer the following questions: (1) how are gross muscular forces and body weight actually maneuvered under voluntary control to produce different magnitudes of pull, (2) how are the over-all body forces that are produced distributed and shared by the different joint systems involved, and (3) how are the forces at a given joint distributed among the muscles concerned.

Axone Reflexes and Innervation of Cutaneous Effectors (U), RR 005-03-0031. University of California, Los Angeles, California, Department of Physiology; Nonr 233(30), NR 101-385; R. R. Sonnenschein.

Cutaneous erythema "flare" produced by trauma or by intradermal injection of histamine is believed to be mediated by a local neuronal mechanism, the so-called axone reflex. Evidence suggests that the fibers involved are of the posterior root system. An analogous mechanism involving cutaneous sympathetic fibers has been postulated to explain sweating and piloerection following injection of acetylcholine and other nicotinic drugs. The mechanism of initiation of the sympathetic axone reflexes is in some ways similar in its pharmacology to the mechanism of transmission at autonomic ganglia. This program plans to (1) test the hypothesis of axone reflex mechanisms further; (2) elucidate the intimate mechanisms whereby specific stimuli excite the neural elements involved in the axone reflexes; (3) investigate the relationships between the peripheral phenomena and the central nervous system; (4) determine the physiological significance of cutaneous axone reflexes.

Vascular Factors in Relation to Brain Injury (U), RR 005-03-0032. Wayne State University, Detroit, Michigan, Department of Neurology; Nonr 2399(00), NR 101-401; J. S. Meyer.

Effects of various types of brain damage on cerebral vascular factors, such as local O_2 concentration, blood flow, arterial, intracranial and venous pressures, and O_2 saturation of the blood are being studied. These and other effects are being observed on cats and monkeys for several days after injury. Observed changes will be correlated with local effects on the EEF and direct current potentials of the brain. Attempts will be made to confirm, within clinical limitations, similar observations on man.

Control of ACTH Synthesis and Secretion (U), RR 005-03-0033. University of California, Los Angeles, California, Departments of Physiological Chemistry and Anatomy; Nonr 233(33), NR 101-402; S. Roberts.

Methods employing microchromatographic separation of pituitary proteins and the estimation of their hormonal content and biosynthetic rate by bioassay and isotope techniques are used to make direct estimations of ACTH secretion. With these

techniques hypothalamic areas can be located which are essential (1) for normal secretion of ACTH, and (2) for modification of this process in response to stress, epinephrine, adrenal steroids, etc. Coincidentally, studies are being carried out on variations in hypothalmic and hypophyseal metabolism in vitro which accompany changes in ACTH synthesis and secretion.

Role of Proteolytic Enzymes in Thermal Injury (U), RR 005-03-0034. University of Pittsburgh, Pittsburgh, Pennsylvania, Biochemistry Department; Nonr 1833(00), NR 101-412; A. E. Axelrod.

The characterization of the proteolytic enzymes of rat skin has been undertaken in the belief that such biochemical knowledge represents an essential prerequisite for the proper assessment of proteolytic enzyme involvement in the necrotizing process following thermal injury. This project has three immediate aims: (1) to isolate and characterize the proteolytic enzymes of rat skin and their naturally-occurring inhibitors; (2) to study the effect of thermal injury upon these enzymes; (3) to determine the physiological role of these proteolytic enzymes. Proteinase A, Proteinase C, the A_1-esterase, and the A_2-esterase have been studied intensively in extracts of rat skin acetone power.

Methods for Study of Fat Absorption and Metabolism (U), RR 005-03-0036. Sinai Hospital of Baltimore, Incorporated, Baltimore, Maryland, Department of Medicine; Nonr 2424(01), NR 101-430; D. A. Turner.

Isotopic methods are being applied to the study of absorption, utilization, and deposition of fat. A method based on quantitative determination of radioactive iodine (I-131) labeled neutral fat and fatty acid is being tested for validity and applicability and compared with other isotopic methods and with conventional chemical analyses. When suitable procedures have been determined, they will be applied to studies of normal and abnormal fat metabolism resulting from surgical, pathological and congenital alterations of normal function in humans, with particular emphasis on blood lipids and atherogenesis, tissue deposition of lipids, and the digestion and absorption of lipids.

Hormonal Effects on Perfused Kidney (U), RR 005-03-0037. American Friends of the Hebrew, University, Incorporated, New York, New York; Nonr 2448(00), NR 101-435; J. Gross.

This task is designed to determine (a) the best conditions for the maintenance of a good metabolic state in the isolated perfused rabbit kidney and (b) the effects of hormonal agents on this metabolic system. The "best conditions" of (a) will be determined by comparison of the perfused kidney preparation with known levels of in vivo kidney function, with respect to O_2 consumption, CO_2 production, glomerular filtration rate, effective renal plasma flow, Na and K in blood and urine, chloride, phosphate, and glucose levels. The adjusted perfusion preparation will then be used to determine the effects of a variety of hormones on kidney metabolism.

Correlator Studies of Sensory Pathways of the Brain (U), RR 005-03-0039. Massachusetts General Hospital, Boston, Massachusetts, Neurological Laboratory; Nonr 2298(01), NR 101-445; M. A. B. Brazier.

By means of an analogue correlator, developed in this laboratory, discrete recordings of sensory stimuli are being made, free of unrelated competing potentials which render conventional electrophysiological recordings inaccurate and nonspecific. Records are being made from electrodes inserted in many different way stations between the sensory receptor being stimulated and the cortex. By cross correlation it can then be determined (1) which potentials are initiated by the stimulus, (2) by what pathways they have traveled, (3) what neuronal delay there has been from one recording point to the next, and (4) what change in waveshape has resulted from these trans-synaptic journeys.

Integrative Mechanisms in Groups of Neurons (U), RR 005-03-0040. University of California, Los Angeles, California, Department of Zoology; Nonr 233(51), NR 101-454; T. H. Bullock.

This task utilizes the nine-celled cardiac ganglion of the lobster, which provides a unique preparation for study of the integrative interactions of neurones--unique in that it is a complete functioning unit consisting of an observable number of components. Extra- and intracellular electric measurements are made from the nine cells during spontaneous activity and activity altered by stimulation. These electrophysiological analyses are aimed at determining: what the pacemaker of the nine cells is at any moment; how it reaches the final motor neurons, directly or indirectly; how the consistent features of the complex burst of general impulses in each of the nine cells are determined; whether there is any feedback, positive or negative, upon the pacemakers, and, if not, how the reciprocal effects of the observed parameters may be produced.

Biological Refractometry (U), RR 005-03-0041. Columbia University, New York, New York, Department of Anesthesiology; Nonr 266(62), NR 101-462; R. Jonnard.

This investigator has developed an interferometric refractometer capable of accurately and automatically recording refractive index data at different wave lengths. This instrument is being used (1) to explore the value of refractive index measurements in the spectral regions of high dispersion as a general method of analysis; (2) to achieve continuous recording of this variable with high sensitivity by interferometry and (3) to evaluate this method in biochemical research on unstable molecules or in dynamic systems.

A Study of Living Gas-filled and Fluid-filled Systems (U), RR 005-03-0042. Institute of Medical Research, Collis P. and Howard Huntington, Memorial Hospital, Pasadena, California; Nonr 2574(00), NR 101-464; H. L. Berry.

This study of living convoluted systems was made from an engineering viewpoint to evaluate the mechanism by which the intestine and other similar gas- or fluid-filled animal systems maintain mobility and flexibility under a significant range of pressure differentials. Observations were compared with those made on mechanical systems with structural

detail comparable to the living gut.

Ice Crystal Formation in Living Tissues (U), RR 005-03-0043. American Foundation for Biological Research, Madison, Wisconsin, Biophysics Laboratories; Nonr 2437(00), NR 101-471; B. Luyet.

The physical and physiological factors involved in the damage caused by the freezing of biological tissues are being studied. The specific objectives of the project are (1) to determine the amount of ice formed under various freezing conditions; (2) to check the accuracy of the methods used for that purpose; (3) to develop new methods for particular conditions; (4) to investigate various phase transitions, such as, solidification in the amorphous state, recrystallization, eutectic freezing, etc. Methods being used include dilatometry and oscillometry of freezing solutions and microscopic examination of ice crystal formations. Four types of solution are being studied (1) aqueous media containing substances with protective effect against freezing injury, such as polyhydroxy alcohols, amides, etc.; (2) solutions containing water "binding" compounds such as gelatin, starch and gums, which reduce freezing ability by other than colligative properties; (3) protoplasm simulators such as solutions or suspensions of albumins, albuminoids, etc.; and (4) living protoplasm.

Metabolism of Hibernation (U), RR 005-03-0044. University of Illinois, Chicago, Illinois, School of Medicine; Nonr 1459(05), NR 101-478; F. E. South.

The aim of this task is to determine and isolate those factors in metabolism and contraction which may be responsible for the continued function of the hibernant's heart at temperatures which are inimical to the function of that organ in non-hibernants. The general approach consists of investigating various rate processes carried on by cardiac and other selected tissues in vitro throughout an extended temperature range (48° to 0°C). Tissue slices, homogenates, and cell fractions will be incubated at selected temperatures in this range, and rates of oxygen consumption and anaerobic glycolysis determined at each temperature. A correlative study of the contractility, energy production and oxygen consumption of cardiac muscle preparations will be carried out.

Anaphylactic Studies (U), RR 005-03-0045. Stanford University, Stanford, California, Department of Physiology; Nonr 225(46), NR 101-479; G. A. Feigen.

The general purpose of the program is to determine the nature of the substances released in tissue anaphylaxis, and to assess how the interaction of antigens and antibodies on the tissue can release these physiologically active substances. Specifically, it aims to (1) determine whether there is a quantitative relationship between the antibody adsorbed to the tissue and the physiological effect; (2) determine the pharmacological behavior of the material released from the tissue during specific challenge with antigen; and (3) study the kinetics of the appearance and disappearance of pharmacologically active materials.

Neurohormone Functions (U), RR 005-03-0046. Stanford University, Stanford, California, Department of Physiology; Nonr 225(45), NR 101-488; R. Grant.

This task is designed to study hypothalamic control of the release of catechol amines and serotonin and to determine the central nervous system effects of these "neurohormones." Spectrofluorimetric techniques will be applied in order to assay small quantities of these substances in adrenal and peripheral blood. The following studies will be made: (1) effect of hypothalamic stimulation by means of healed-in electrodes on differential adrenal medullary hormone output in unanesthetized cats; (2) effect of muscular exercise, exposure to cold, conditioned emotional stress, and hypotension on differential output of adrenal medullary hormones, using trained dogs or goats and/or human subjects; (3) determination of arteriovenous difference in catechol amine and serotonin content of cerebral blood under different conditions of brain activity.

Spinal Anoxia Effects (U), RR 005-03-0047. California Institute of Technology, Pasadena, California, Department of Physiology; Nonr 220(34), NR 101-493; A. Van Harreveld.

This task will investigate the phenomenon of increased reflex activity after recovery from asphyxiation. Asphyxiation of the spinal cord is achieved by ligating a section and forcing Ringer solution into the dural cavity under a pressure higher than blood pressure. After a two weeks recovery period standard electrophysiological techniques will be applied to measure reflex action potentials during anoxia. Subsequent histo-anatomical examination of the spinal cords will be made in an attempt to ascertain what remaining structures are responsible for the hyperactivity of reflexes following asphyxiation.

Photosynthesis (U), RR 005-03-0052. Florida State University, Talahassee, Florida; Nonr 988(10), NR 101-272; H. Gaffron.

The contract supports studies on the conversion of visible radiation into chemical energy within living organisms, and related phenomena. The reduction of CO_2, the formation of energy-rich phosphate bonds, the evolution of O_2 and the utilization of numerous hydrogen donors are partial reactions which in conjunction with the photochemical primary transformation of light into chemical energy within a living chlorophyll complex constitute the process of photosynthesis.

Biochemical Abnormalities Produced by Thermal Burns (U), RR 005-03-0053. Hahnemann Medical College, Philadelphia, Pennsylvania, Department of Biological Chemistry; Nonr 2828(00), NR 101-383; A. W. Wase.

This is a study of the biochemical and endocrine disturbances following thermal burns. The investigation follows this plan: (1) burning of laboratory animals; (2) isolation of the polypeptides responsible for the post-thermal toxic effects; (3) analysis of the amino-acid content and sequence of the toxic material; (4) attempts to render the polypeptide antigenic. Studies are being conducted on such laboratory animals as rats, dogs and monkeys.

Problems in Molecular Physiology (U), RR 005-03-

0054. Stanford University, Stanford, California, Department of Physiology; Nonr 225(22), NR 101-426; G. A. Feigen.

This work was made up of a group of related studies in the general area of molecular biology. The principle topics of investigation were (1) the fate of plasma expanders in the body, (2) the acceleration of red cell sedimentation by long-chain polymers, (3) immunological heart damage, (4) contractile machinery of working biochemical and mechanical model of the heart, and (5) metabolic concomitants of tissue anaphylaxis.

Hormonal Regulation of Electrolyte Balance (U), RR 005-03-0055. University of West Virginia, Morgantown, West Virginia, Department of Surgery; Nonr 3256(01), NR 101-441; B. Zimmermann.

The objective of this task is to obtain further and more precise information on the hormonal mechanisms for electrolyte and water metabolism and to apply such information to a rational electrolyte therapy following trauma and surgery. Attention will be directed to (1) collecting further clinical data on the post-operative excretion of aldosterone (a potent sodium-retaining hormone) and (2) determining, through both clinical and laboratory tests, the factors contributing to this excretion. Clinically attempts are made to manipulate the extracellular levels of sodium chloride and potassium after surgery in such a way as to see if the level of aldosterone excretion can be altered. On experimental animals adrenal arterial blood will be perfused with varying concentrations of sodium ion and potassium ion as well as glucose or dextran solutions and aldosterone determinations made on adrenal venous blood.

Physiological Responses of the Cerebral Cortex in Relation to Conscious Sensory Perception in Man (U), RR 005-03-0056. Mount Zion Hospital, San Francisco, California, Department of Neurosurgery; Nonr 2968(01), NR 101-505; B. Feinstein.

This is a study of the relationship between the measurable electrophysiological activity of the cerebral cortex and the appearance of conscious sensory perception in man. The investigation is designed to gain evidence as to which kinds and locations of activities in the cerebral cortex, judging these by the known electrical events, are necessary or significant to the occurrence of a conscious sensory perception.

Skin Exposure (U), RR 005-03-0057. University of Washington Graduate School, Seattle, Washington, Department of Meteorology; Nonr 477(27), NR 101-515; K. J. K. Buettner.

Some of the practical aspects of water penetration through human skin are being investigated under this contract. Work has already shown that water passes through human skin by sweating, sorption or desorption in the stratum corneum and by diffusion. Apparently, there is an active transfer or "pump" somewhere in the subskin. This is enhanced in people suffering from edema. It is absent for 3-4 days after the stratum corneum is removed by stripping. The amount of water transferred is mainly regulated by the diffusion barrier which is the stratum corneum conjunctum. This layer is being investigated by X-ray diffraction, electromicrogram, in vitro vapor transfer and separation by tape.

Ascending Spinal Pathways for Pain Conduction (U), RR 005-03-0058. College of Medical Evangelists, Los Angeles, California, Department of Neurosurgery; Nonr 3343(00), NR 101-517; B. Campbell.

Conduction over the very small myelinated and the unmyelinated pathways in the spinal cord, which subserve pain, temperature and light touch, will be studied under this contract. Lissauer's tract, an area of branched ascending and descending fibers of the small fiber system, will be the first site studied because it courses longitudinally near the surface of the spinal cord. The techniques of electrode placement and the interpretation of electrical potentials from the small fiber systems will be determined on this tract. Cats will be used initially for the studies. Other problems to be attacked will be the use of blocking techniques in stimulation of the high threshold fibers of the peripheral nerves, the further miniaturization of the metal-filled glass (Svaetischin) electrodes, and the problem of the Herring Phenomena in small fibers.

Ultrasound in Biology and Medicine (U), RR 005-03-0059. University of Illinois, Biophysical Research Laboratory, Urbana, Illinois; Nonr 3134(00), NR 101-543; W. J. Fry.

This contract is for partial support of the Third Biophysical Research Laboratory Symposium on Ultrasound in Biology and Medicine. The use of ultrasound as a basic research tool will be covered in formal papers and informal discussions. The program will include the following subjects: (a) effects of intense sonic radiation on the structure and function of various biological tissues and the mechanisms of action of the sound on tissue components; (b) application of intense ultrasound in neurological investigations; (c) human neurosonic surgery; (d) biological action of acoustic radiation on unicellular organisms; (e) physical mechanism of the action of intense sound on biological structures; (f) ultrasonic instrumentation for use in investigations of biological systems, (g) ultrasonic visualization of soft tissue structure; and (h) ultrasonic microscopy.

Body Defenses Against Hemorrhage in Health and Disease (U), RR 005-03-0060. State University of New York, Syracuse, New York, Department of Medicine; Nonr 1557(00), NR 101-749; E. L. Lozner.

By means of light scattering photometry determinations were made on the effects of thrombin and platelet concentrations and of clot retraction on fibrin strand widths. Biophysical studies on polymerization of fibrinogen were conducted along with determinations of the utilization of platelets in maintaining capillary integrity.

Investigation in General Comparative Physiology (U), RR 005-03-0061. Mount Desert Island Biological Laboratory, Salisbury Cove, Maine; Nonr 1448 (00), NR 101-868; A. F. Rieck.

The summer program of the Mt. Desert Island Laboratory allows scientists from related fields to spend up to three months doing intensive research in this unique setting with its abundance of

experimental animals from both marine and fresh water environs. Studies are conducted in two general areas: (1) cardiovascular-renal physiology, and (2) tissue culture. The first group of studies have led collectively to development of methods for measuring the rate of glomerular filtration, renal blood flow, and tubular function in man as well as in experimental animals. The second group deal with problems of growth of excised plant and animal tissues and organs, with special emphasis on the development of media composed of fully defined synthetic nutrients.

Studies in Hepatic Physiology, MR 005-03-0020. Clinical Investigation Center, U. S. Naval Hospital, Oakland, California; Cdr P. D. Doolan, MC, USN.

Changes in the oxygen saturation of the blood obtained from straight and balloon fitted catheters placed in the hepatic vein are being followed in an attempt to learn more about the hemodynamic relations existing between the hepatic artery and vein. In the first 27 patients variable results have been encountered and the studies must be extended before it is known whether this approach will provide definite and specific information.

Human Calorimetry, MR 005-03-0050. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; T. H. Benzinger, M.D., Ph. D.

Corroborating evidence has been obtained during 1960 for the discovery made in 1958 and 1959 that an internal sensory receptor organ not the skin determines human "physical" heat regulation in warm environment. Other experiments demonstrating the fallacy of rectal measurements of body temperature have explained why classical temperature physiology failed to make this basic observation. Furthermore, the absence of sudden responses in sweating to sudden stimulation of skin thermoreceptors has been demonstrated.

Methods have been prepared to investigate the mechanism of human "chemical" heat regulation and important evidence has already been obtained in this matter.

The Energetics of Reactions of Biological Significance as Primarily Measured by Microcalorimetry, MR 005-03-0301. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; T. H. Benzinger, M.D., Ph. D.

Experimental work in microcalorimetry was continued on two lines (though the major efforts and most of the time of the entire bio-energetics group were concentrated on Project MR 005-03-0301).

1. Technical development of metal vessels for microcalorimetry was pursued for adapting the present instrument to work in which changes of pH or ionic strength take place. New glass models for faster and more sensitive microcalorimetry are being tried out.
2. Investigations of heat changes during the formation of double or triple helixes from randomly coiled poly-uridylic and poly-adenylic acids are being carried out in collaboration with Dr. Robert Steiner, NMRI.

Technical development and thermodynamic studies of polynucleotide interactions will be continued during the next year.

An Investigation of the Relationship of Movement to Visual Perception (U), MR 005-03-1001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt H. G. Wagner, MC, USN.

The principal objective of this research has been to determine the functional organization of the retina. One of the principal methods has been to use electrophysiological techniques to detect cellular activity in the retina in response to illumination. Many types of electrical potentials may be observed reflecting functional activity in different cells and in different parts of the retina. Earlier work on the frog and on Limulus has established many of the fundamental mechanisms operative in photo reception. Recent interest has turned to the gold fish retina because it permits the elucidation of a number of additional mechanisms. "On" and "off" potentials recorded from retinal ganglion cells of these animals have been correlated with luminosity and color responses. These ganglion cell responses reflect the presence of two antagonistic processes: (1) an excitatory process giving rise to the "on" discharge and (2) an inhibitory process. The "off" discharge arises as a post inhibitory rebound from the inhibition. These processes may have their origin in distinct receptor groups of different spectral sensitivities. Each receptor group initiates both excitatory and inhibitory processes and the ganglion cell response is the resultant of several combinations of these influences. Receptive field studies indicate that the sensitivities of the two receptor groups are highest in the center of the field but may change at different rates as the stimulus moves to the periphery.

The following work was undertaken on the investigation of electric current production by the photoreceptor of the squid eye. Electrophysiological methods, isotope tracer techniques and chemical microanalysis have been used to measure the distribution of electrolytes in the receptors in light and darkness. Investigation of the conversion of of light to heat by isolated photoreceptors: Using small, specially developed film thermopile, it has been shown that light absorbed in packed, isolated retinal rods is largely converted to heat and results in a small increase in the electrical conductivity of the preparation as a whole. Further experiments are planned to determine the exact thermochemical changes occurring during photolysis of photopigments in the living retina.

R005-04 Toxicology

Advisory Center for Toxicology (U), RR 005-04-0001. National Academy of Sciences, Washington, D. C., Advisory Center for Toxicology; N7onr 291 (61), NR 303-366; H. W. Hays.

The Advisory Center on Toxicology (formerly the Toxicological Information Center) has been established to meet the need for a central source of toxicological information, especially data bearing on the health of military personnel. The Center provides full-time service for toxicological information and advice and functions as a clearing house and medium of toxicological data and interpretations thereof.

Sub-clinical Toxicity, Its Detection and How It Is Produced (U), RR 005-04-0002. University of Michigan, Ann Arbor, Michigan, Department of Pharmacology, Medical School; Nonr 1224(26), NR 303-424; E. J. Cafruny.

Low grade toxicity in man such as can be caused by long exposure to small concentrations of chemicals may give no sign of its existence and only a few ill-defined symptoms. This is a project to develop and quantitate criteria for detection of low-grade toxicity. An attempt will be made to determine (a) whether changes in tissue permeability can be detected and measured in excretory and detoxifying tissues (kidney and liver) of animals treated with small quantities of organomercurials; (b) whether chronic heavy metal poisoning affects sulfhydryl (detoxifying) enzyme systems in liver and kidney; and (c), if so, whether these effects can be correlated with changes in tissue permeability.

Submarine Toxicology (U), RR 005-04-0006. National Academy of Sciences, Washington, D. C., Advisory Center for Toxicology; Nonr 2300(15), NR 303-450; H. W. Hays.

The prolonged submergence capabilities of nuclear-powered submarines have resulted in at least two new kinds of toxicological problems: (a) effect of continuous 24-hour exposure to atmospheric contaminants for long time periods, and, (b) effect of exposure to new chemicals for which there are as yet few or no toxicity data. Toxicity evaluations are therefore being done on all potentially toxic chemicals known to be present in submarine atmospheres.

Organo-Tin Toxicology (U), RR 005-04-0007. University of Michigan, Ann Arbor, Michigan, Department of Pharmacology, Medical School; Nonr 1224 (27), NR 303-439; T. M. Brody.

This project is concerned with the toxicity of organic tin compounds which are being put to new uses as constituents of fungicides and industrial plastics. Two lines of investigation are involved: (1) determination of pharmacological properties of a series of organic tin compounds in a variety of experimental animals, and (2) elucidation of pharmacological phenomena in terms of biochemical activity.

Cholinesterase Inhibition (U), RR 005-04-0008. University of Washington, School of Medicine, Seattle, Washington, Department of Pharmacology; Nonr 477(29), NR 303-447; T. A. Loomis.

Certain organic phosphate compounds inhibit the enzyme cholinesterase which is essential for transmission of nerve impulses. Moderate inhibition of the enzyme is slowly reversible and can be favorably influenced by chemical compounds (reactivation). This is an investigation of (a) whether reversibility represents spontaneous reactivation of existing enzyme or synthesis of new enzyme, or, perhaps, a combination of both processes; and (b) the comparative rates of pharmacological and chemical recovery of the inhibited enzyme under the influence of a series of chemical reactivators.

War Gas Antidotes (U), RR 005-04-0009. University of Wisconsin, Madison, Wisconsin, Department of Pharmacology and Toxicology, Service Memorial Institute; Nonr 1202(15), NR 303-449; J. L. Way.

Certain alkyl phosphates which are effective as insecticides and war gases are presumed to act by inhibiting the enzyme acetyl cholinesterase in nervous tissue. This inhibition can be partially counteracted in vivo by pyridine-2-aldoxime methiodide (PAM). It is the purpose of this task to find methods for increasing the effectiveness of PAM and to test the effectiveness of some of its analogs as antidotes to the toxic alkyl phosphates.

Development of New Avian Embryo Techniques for Toxicity Evaluation (U), RR 005-04-0010. College of the Pacific, Institute for Pharmacological Research, Stockton, California, Department of Physiology and Pharmacology; Nonr 3002(01), NR 303-464; N. S. Van Matre, C. C. Riedesel.

A recent improvement in the manipulation of chick embryos again suggests that they may be adapted as test animals for the evaluation of the toxicity of chemical compounds. This project is an investigation of the possibility of utilizing the new technique to determine degree, site, and mechanisms of action of chemical compounds.

Toxicology (U), SR 005-04-604. U. S. Navy Toxicology Unit, National Naval Medical Center, Bethesda, Maryland, Allotment No. 358, Capt J. Siegel; Advisory Center on Toxicology, National Research Council, National Academy of Sciences, Washington, D. C., Requisition No. EN24/634A-19459, Dr. Harry Hays.

SECNAV INSTRUCTION 6260.2 of 7 Nov 1955 requires toxicological evaluation of new materials prior to shipboard use. Because of the closed environmental cycle involved, such evaluations are particularly important for submarine materials. Guidelines are almost completely lacking for such continuous exposures. The Advisory Center makes rapid and intensive search of existing literature on chemicals in question. If the data originally available are insufficient, the Toxicology Unit performs biological tests to provide interim basis for estimate of safe limits. The Toxicology Unit also conducts on-site analyses to determine whether shipboard environments present significant personnel hazard.

At request of the Special Projects Office, lists have been screened covering several thousand material items intended for FBM submarines. Also, work has been initiated on all contaminants detected thus far during habitability cruises on nuclear-powered submarines.

A Toxicological Study of Hydraulic Fluids (U), MR 005-04-0001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt H. C. Sudduth, MC, USN.

Metabolic studies are underway in regard to mechanisms of tri ortho tolyl phosphate poisoning. In particular, the oxidative phosphorylation of brain and liver mitochondria from poisoned and normal hens was performed using succinate and glutamate as substrates. Preliminary results show that brain mitochondria do not uncouple after paralysis with tri ortho tolyl phosphate using succinate as metabolic substrate. Other metabolic

investigations in general area of phosphate metabolism are under active investigation.

Health Hazards of Military Chemicals in New Operations, MR 005-04-0003. U. S. Navy Toxicology Unit, National Naval Medical Center, Bethesda, Maryland; Capt J. Siegel, Lt A. Getzkin, Lt H. Rudolph, Lt R. Fultyn.

1. Most of the studies conducted during this period dealt with problems relating to the POLARIS submarine. Pertinent findings were as follows:
   a. No residual of Malathion in air could be detected twenty-four (24) hours after spraying a 3% solution of Malathion in water.
   b. Exposure of animals to mists of triaryl phosphate (5 mg/M^3) continuously for 180 days did not cause any paralysis.
   c. Fumes from enamelling kit for F.B.M. subs were of no health significance.
   d. Fumes from cement in modelling kit for F.B.M. subs was potentially toxic. Later replaced by a non-toxic cement.
   e. Mists of triaryl phosphates generated by compressors aboard F.B.M. submarines were evaluated. Engineering changes were subsequently made which reduced the contaminant to a level well below acceptable levels.
   f. Long-term inhalation studies are underway on paint thinner, benzol, nitrogen dioxide, and petroleum-base hydraulic fluid.
2. Four (4) new propellants were evaluated for BuWeps for skin irritation and oral toxicity.
3. A study on the combustion products from mattresses of various compositions was made for BuShips.
4. A study was made of the synergistic effect of triaryl phosphate on Malathion in order to develop a rapid test for toxicity of various batches.

R005-05 Microbiology

Bacterial Drug Resistance (U), RR 005-05-0001. University of Chicago, Chicago, Illinois, Department of Medicine; Nonr 2701(00), NR 103-013; C. P. Miller.

The effect of antibiotics on the susceptibility of mice to an enteric infection is being studied with special attention to those members of the intestinal microflora concerned with the protection of the gastrointestinal tract against such an infection. Individual strains of anaerobes isolated from normal feces are being tested for their protective activity against infection with enteric organisms.

Marine Bacteria Activities (U), RR 005-05-0002. University of California, La Jolla, California, Scripps Institution of Oceanography; N6onr 27518, NR 103-020; C. E. ZoBell.

Apparatus developed at the Scripps Institution of Oceanography was used to study the physiological activities of bacteria and allied microorganisms at high hydrostatic pressures such as occur in the deep sea. Experiments were carried out to determine the effects of pressure and temperature on equilibrium constants of ions which affect bacterial activity.

Bacterial Spore Formation (U), RR 005-05-0003. University of Texas, Austin, Texas, Department of Bacteriology; Nonr 146(00), NR 103-025; J. W. Foster.

Fundamental biological and biochemical processes in microorganisms are being studied in an investigation on spore formation and germination in bacteria. One phase of this project deals with the biosynthesis of dipicolinic acid in spores of bacteria. A systematic study of the enzymatic constitution and heat resistance of various enzymes in spores stripped of this acid has been initiated. Chemical composition of the spore wall also is being investigated.

Microbial Drug Resistance (U), RR 005-05-0004. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Microbiology; Nonr 395(00), NR 103-045; M. G. Sevag.

These studies are concerned with the biochemical differences between pairs of drug-susceptible and drug-resistant microorganisms. Investigations on reversing the resistance character or resensitizing the resistant cells to a given drug are being continued. The isolation and study of transformylase and pteroicases is being carried out for the enzymatic differentiation of drug-sensitive and drug-resistant strains of microorganisms.

Germ-Free Animal Studies (U), RR 005-05-0005. University of Notre Dame, LOBUND, Notre Dame, Indiana; Nonr 1623(04), NR 103-067; R. E. Thorson.

This research program involves the rearing of large numbers of germ-free animals in order to extend studies on infectious agents and the effect of microbial life on nutrition, immunity, and many other problems. The basic research includes the descriptive survey of germ-free life, studies on nutritional requirements, and investigations on the host-contaminant relationship with special reference to the mechanisms of resistance.

Study of the Influence of Pasteurella Tularensis on the Metabolism of Animal Hosts (U), RR 005-05-0006. University of Tennessee, Knoxville, Tennessee, Department of Bacteriology; Nonr 811(02), NR 103-088; J. M. Woodward.

The protective effect of phosphorus compounds in tularemia infections is being further investigated in studies on the levels of a high energy form of these compounds found in infected and in treated animals. Studies on the role of cellular defenses in normal and tularemic rats will be continued with experiments to determine the specific types of leucocytes that are important in immunity. Attempts will be made to determine the immunogenic effect of extracts prepared from leucocytes harvested from immune rats.

Cellular Immunity (U), RR 005-05-0007. University of California, Berkeley, California, Department of Bacteriology; Nonr 222(72), NR 103-093; S. S. Elberg.

Brucella and mycobacteria organisms were used in quantitative studies on the fate of the bacilli intracellularly located in the monocytes of normal and vaccinated animals. Investigations on the

serum component present in antisera were made in an attempt to determine whether the serum factor is operating on the bacterium or monocyte or both. A second aspect of these studies was concerned with the activity of enzymes found in the monocyte.

Spore Germination (U), RR 005-05-0009. Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa; Nonr 585(00), NR 103-109; F. G. Smith.

The physical and chemical conditions controlling the growth and differentiation of uredospore germ tubes of Puccinia are being determined in this study. Investigations of the role of cations in germ tube growth and development will be continued by employing metal-chelating agents and ion exchange resins. A more complete survey will be made of the occurrence of self-inhibition in greenhouse and field collections of spores and tests of the efficacy of chemical treatment in counteracting self-inhibition will be extended.

Biophysical Investigations on Bacteriophages (U), RR 005-05-0010. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Biophysics; Nonr 624(03), NR 103-110; M. A. Lauffer.

These studies were concerned with fundamental principals of virus behavior. Study of the dual sedimentation phenomenon was made with determination of the specific factors responsible for the extension and collapse of the particles' filaments and assessment of the prevalence of the phenomenon among bacterial viruses. Efforts were made toward refinement of the volume displacement method for determining the hydration of molecules in solution.

Virus Infection Mechanism (U), RR 005-05-0011. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Biological Sciences; Nonr 2166(00), NR 103-127; R. Buchsbaum.

These experiments have been designed to give information regarding the mechanism of invasion of living cells by viruses and rickettsia. The studies employ a method for exposing living cells in a perfusion chamber. Normal and virus-infected cells are being treated with various agents and the modification of the disease process in the cells recorded.

Induced Enzyme Synthesis (U), RR 005-05-0012. University of Illinois, Urbana, Illinois, Department of Bacteriology; Nonr 1834(24), NR 103-136; S. Spiegelman.

The mechanism of the formation of enzymatically active protein is being investigated in the study of subcellular systems derived from microorganisms. The nature of the precursor being converted into enzyme is being studied by means of tracer experiments which determine the amount of carbon of a newly formed enzyme molecule that is derived from preexisting cellular carbon. The nature of the specificity of the enzyme forming mechanism will be determined by examining a series of synthetic inductors for their capacity to induce enzyme synthesis as well as their interaction with one another.

Non-specific Urethritis (U), RR 005-05-0013. University of North Carolina, Chapel Hill, North Carolina, Department of Bacteriology; Nonr 2177(00), NR 103-139; G. P. Manire.

Equipment which was made available for a study of factors involved in the cause of non-specific urethritis is being used for the completion of certain aspects of the investigation. The isolation of viruses and other infectious agents from cases of this disease is being continued by employing cultures of human epithelial carcinoma cells. Attempts are being made to prepare antigens for complement fixation and other serological tests using tissue culture and broth cultures.

Weil's and Chagas' Diseases (U), RR 005-05-0014. University of Texas Medical Branch, Galveston, Texas, Department of Bacteriology and Parasitology; Nonr 1746(00), NR 103-161; A. Packchanian.

Continuation of research on two exotic diseases has been made possible by use of special equipment. Studies on Weil's disease are being pursued from immunological and chemotherapeutic points of view. The work includes the following: electrocardiographic studies, immuno-chemical study, epidemiologic and chemotherapeutic studies.

Bodily Defense Mechanisms (U), RR 005-05-0015. University of Texas Medical Branch, Galveston, Texas, Department of Anatomy; Nonr 1598(01), NR 103-163; C. M. Pomerat.

This study of cell injury by anti-organ sera was concerned with investigations of an anti-pituitary cytotoxin in in-vitro systems. The cytotoxin was used to challenge cultured cells from the anterior and posterior lobe of the rat in perfusion chambers. Experiments employing phase contrast, time-lapse cinematography were carried out to determine possible overlapping tissue and species specificity and to observe the action of cytotoxins directed at particular synthetic complexes.

Studies of Yeast Infections Following Antibiotic Therapy (U), RR 005-05-0016. University of North Carolina, Chapel Hill, North Carolina, Department of Bacteriology; Nonr 2228(00), NR 103-166; W. R. Straughn.

The equipment under this task is being employed on investigations concerning the biological mechanisms involved in the development of yeast infections following antibiotic therapy. Studies of anti-yeast activities of microorganisms from the intestinal tract of mice and humans are being carried out. Attempts are being continued to determine more specifically the nature of the anti-yeast effects produced by E. coli and lactobacilli.

Studies on Paramecia (U), RR 005-05-0018. University of Southern California, Los Angeles, California, Department of Zoology; Nonr 1815(00), NR 103-179; T. T. Chen.

The maintenance of numerous cultures of "killers" of Paramecia is provided for in this task. Extensive studies are being made on the problem of genetics of this protozoan. The various stages of growth of the organisms are being investigated in a variety of mating types.

Pleuropneumonia-like Organisms and Their Relation to Bacteria (U), RR 005-05-0022. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Microbiology; Nonr 551(31), NR 103-199;

H. E. Morton, P. F. Smith.

Current work on this investigation of pleuropneumonia-like organisms (PPLO) is concerned with further study of the components of the lipoproteins growth factor. Studies will be made to define conditions for reliable experimentation on oxidative activity of the organisms. The relationship of PPLO and other microbial species is being investigated further in work on the conversion of the organisms in bacteria.

Biological and Immunological Studies on Exotic Diseases (U), RR 005-05-0023. University of Texas Medical Branch, Galveston, Texas, Department of Bacteriology and Parasitology; Nonr 1061(00), NR 103-200; A. Packchanian.

This task is concerned with a study of the factors influencing the attenuation and virulence of flagellate protozoae (trypanosomes). Restoration of infectivity and increased virulence of cultures will be attempted by reducing the resistance of susceptible animals by physical and chemical means. Vaccines prepared from various phases of growth of the organisms will be tested in experimental animals. The development and standardization of agglutination and precipitation tests are to be undertaken by various techniques.

Metabolism of Shigella (U), RR 005-05-0024. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Epidemiology and Microbiology; Nonr 2759(00), NR 103-207; H. M. Gezon.

Work to determine the key site of action of antibiotics on the metabolism of dysentery organisms (Shigella) is being continued in an effort to obtain information on the mechanisms of protein and nucleic acid synthesis by these organisms. The equipment provided under this task is also being used in experiments on the action of antibiotics upon these synthetic processes.

Microbial Resistance to Chemical and Physical Agents (U), RR 005-05-0025. Long Island Biological Association, Cold Spring Harbor, Long Island, New York; Nonr 2863(00), NR 103-208; A. Chovnick.

This research is concerned with recombinational studies of small regions of the genetic material of bacteria. Initial experiments, involved in the leucine locus, employ three-point transduction tests to determine the functional and molecular structure of that gene. The work is designed to develop a composite map of the genetic structure of the locus in terms of complementation between different portions, mutagen stability, and degrees of sensitivity of different parts to specific mutagens.

Systemic Mycotic Pathogens (U), RR 005-05-0026. University of Utah, Salt Lake City, Utah, Department of Bacteriology; Nonr 3100(00), NR 103-212; S. Marcus.

This work comprises a study of the serologic properties of polysaccharides derived from systemic mycotic pathogens. Comparison of the skin test activity of polysaccharide preparations will be made with that of broth filtrate material.

Action of Fungicides (U), RR 005-05-0028. Colorado State University, Fort Collins, Colorado, Department of Botany and Plant Pathology; N9onr 824(02), NR 103-216; R. G. Hacker.

The fungicidal effect of systemic chemicals and antibiotics against stem and leaf rusts of cereals is being investigated to determine the mechanisms of such compounds and the factors which govern their operation. The fluorescent dye technique will be used to trace the entry and movement of the compounds in test plants grown under controlled conditions. Direct bioassays for presence of fungicides in tissues will also be made. The effect of the test compounds on inhibition or prevention of rust infections is to be determined by inoculation with rust fungi at varying inoculum densities.

Concurrent Effect Between Virus and Bacteria in Enteric Infections (U), RR 005-05-0029. The State College of Washington, Pullman, Washington, Department of Veterinary Microbiology; N7onr 33006, NR 103-225; T. Moll.

Experiments were designed to investigate the concept that enteric infections such as dysentery involve a primary virus infection, followed by a bacterial invasion which may be instrumental in bringing about the severe symptoms. Employing young calves, this theory was studies by a comparison of the clinical and pathological effects produced by inoculation of bacteria and virus alone and by both virus and bacteria combined. Filterable agents involved in enteric infection were isolated and propagated in tissue culture.

Measurement of Small Absorbancy Changes in Microspectroscopy (U), RR 005-05-0030. University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania, Johnson Research Foundation; Nonr 551(26), NR 103-242; B. Chance.

This research is to investigate factors limiting the measurement of small absorbancy changes in microspectrophotometry and of small intensities in microfluorimetry. Current interest is centered on the application of a sensitive microspectrophotometer for the observation of cytoplasmic cytochromes at room and low temperatures. In addition, a differential microfluorimeter of high sensitivity is being used for measuring enzymes in living cells.

Bacterial Enzymic Activity (U), RR 005-05-0031. University of Minnesota, Minneapolis, Minnesota, Department of Bacteriology and Immunology; Nonr 1514(00), NR 103-250; H. C. Lichstein.

This research is being directed towards an understanding of the influence of nutritional factors on the enzymic activity and/or constitution of bacterial cells. The nature of the inhibitary effect of glucose on certain enzyme systems concerned with amino acid metabolism is being investigated to determine the effect of temperature on nutritional demands of microorganisms and on the synthesis of enzymes.

Study of Bacterial Spores (U), RR 005-05-0032. University of Illinois, Urbana, Illinois, Department of Bacteriology; Nonr 1834(09), NR 103-251; H. O. Halvorson.

The current problem involves a further study of the biochemical changes occurring during sporulation. A number of compounds which specifically inhibit sporulation are being used in experiments

designed to determine the mechanisms involved in the synthesis of dipicolinic acid and in conferring heat resistance to the spore enzymes.

Control of Dysentery (U), RR 005-05-0033. George Washington University, Washington, D. C., Department of Bacteriology; Nonr 761(02), NR 103-260; L. W. Parr and M. L. Robbins.

Various aspects of antibiotic substances produced by coliform bacteria ("colicines") are being studies in this investigation on the control and treatment of shigellosis. Work will be continued on the nature, properties and utilization of colicines, including the relationship between these substances and gastro-intestinal disease. The effect of extracted colicines on enteric viruses is being studied in cultures of various continuous cell lines.

Nature of Pathogenicity (U), RR 005-05-0034. The University of Chicago, Chicago, Illinois, Department of Botany; Nonr 2121(14), NR 103-267; E. D. Garber.

Procedures are being employed to study the nature of resistance and susceptibility to infectious agents. Experiments have been designed to correlate virulence and avirulence of microorganisms with the presence or absence of an enzyme (exotoxin). A survey of the types of biochemical mutants produced in certain toxigenic species will be continued and the exotoxin produced by each species will be characterized. The role of the nutritional status of the host and its specific response to parenthal and mutant strains of the organisms is also being investigated.

Enzymes and the Pathogenesis of Allergic and Infectious Diseases (U), RR 005-05-0035. University of Pennsylvania, Philadelphia, Pennsylvania, The Henry Phipps Institute; Nonr 551(24), NR 103-271; A. M. Dannenberg, Jr.

Tuberculosis is being used as a model for these studies on the role of various enzymes in the pathogenesis of infectious diseases. Work at the cellular level is concerned with a study of the changes in mononuclear enzymes caused by thyroid and adrenal hormones. A method involving the preparation of antibodies to specific enzymes and their use with fluorescent techniques is being used to determine the enzyme's site in tissue sections. In another phase of this study pharmacological agents that may stimulate or inhibit specific enzymes will be administered to intact tuberculous animals to determine their effect on the course of the disease.

In Vivo Role of Complement (U), RR 005-05-0037. State University of Iowa, Iowa City, Iowa, Department of Bacteriology; Nonr 1509(01), NR 103-276; A. P. McKee, W. S. Jeter.

The production of antibody against the complement (a substance found in normal serum that is destructive to bacteria and other cells) in both the guinea pig and human being has been successfully carried out in this laboratory. One phase of the current investigation is to determine the effect of anticomplement on the formed elements of the blood and vascular endothelium. A second aspect is concerned with studies to determine the area of complement production in the body.

Microbial Oxidation of Hydrocarbon Gases (U), RR 005-05-0039. Louisiana State University, Baton Rouge, Louisiana, Department of Bacteriology; Nonr 1575(01), NR 103-289; R. J. Strawinski.

A systematic study of the representative groups of methane, ethane, propane, and butane oxidizers is being made to determine the basic physiological reactions and characteristics of these microorganisms. Investigations are being continued on the metabolism of the hydrocarbon gases. Field studies are included in this program to determine application of basic findings for developmental purposes.

The Relationship of a Bacterial Toxin to the Pathogenesis of Rheumatic Fever (U), RR 005-05-0041. Columbia University, New York, New York, Department of Opthalmology; Nonr 266(32), NR 103-295; S. P. Halbert.

The relationship of one of the streptococcal toxins, streptolysin "O", to the pathogenesis of rheumatic fever is being investigated. Efforts are directed toward purification of streptolysin "O" and of the antigens or "toxins" detected by agar precipitin analysis. Each fraction will be studied for toxicity, enzymatic activity and its ability as an immunizing agent. Pharmacologic studies on the cardiac effects of purified streptolysin "O" will be continued with experiments designed to determine the mechanism of lethal intoxication.

Heat Inactivation of Virus (U), RR 005-05-0042. The University of Massachusetts, Amherst, Massachusetts, Department of Bacteriology and Public Health; Nonr 1812(00), NR 103-302; W. Litsky, R. M. Dutcher.

This investigation was designed to compare the degree of antigenic alteration of viruses during inactivation by a method of rapid heating with that caused by inactivation with formalin. A common pool of virus was used for inactivation by the two methods and the inactivated virus was inoculated into rabbits to obtain immune sera. Serum neutralization and complement fixation tests were carried out in order to determine the antibody response.

Salt Water Fungi (U), RR 005-05-0043. The University of Miami, Coral Gables, Florida, Marine Laboratory; Nonr 840(18), NR 103-305; E. S. Reynolds.

This program is concerned with studies of physiology, metabolism and other biological aspects related to the activities of salt water fungi in the sea. Detailed investigations of cellulolytic activity in marine fungi include experiments to determine the ability of these organisms to attack lignincellulose substrates. Chromatographic studies of the water soluble consittuents of selected woods will be made prior to and during fungal infestation. Ecological studies will be continued to substantiate the laboratory analyses of the chemical and physical determinants of fungal activity.

Incidence and Treatment of Parasitism in Animals (U), RR 005-05-0044. Loyola University, Chicago,

Illinois, Department of Biological Sciences; Nonr 2689(00), NR 103-307; B. J. Jaskoski.

The equipment under this contract is being used for the study of parasites obtained from captive animals. Centrifugal sugar flotation techniques are being employed for examination of specimens and quantitative analyses are being made of the numbers of ova and/or cysts. Emphasis is being placed on the use of certain chemotherapeutic agents in attempts to reduce the incidence and level of parasitic infections. Data from these studies will be analyzed for information relative to diseases of animals transmissible to man.

Cell Division in Bacteria (U), RR 005-05-0045. University of Maryland Medical School, Baltimore, Maryland, Department of Biochemistry; Nonr 595(06), NR 103-317; E. J. Herbst.

The chemical mechanisms of cell division in bacteria and the participation of polyamines in the process are being investigated in this study employing Neisseria perflava as the test organism. The experimental procedure involves analyses of cells from polyamine-deficient and polyamine-supplemented cultures of this organism for deoxyribonucleic acid, ribonucleic acid, polyamine and protein. Another phase of the investigation will be the application of the methods of bacterial cytology to achieve a direct and visual demonstration of the effects of polyamine growth factors on recognized stages of cell division in bacteria.

Factors Affecting the Permanent Efficiency of the Antibody-Producing Mechanism (U), RR 005-05-0046. University of California, Los Angeles, California, Department of Zoology; Nonr 233(40), NR 103-323; A. M. Schechtman.

This task is designed to increase knowledge of the mechanism of antibody formation and to determine the factors responsible for individual variations in resistance to infectious diseases. Current work is directed toward further study of the mechanism involved in stimulation of antibody production in the adult animal as a result of cortisone administered to the neonatal. Cellular immunity in the young organism also is being studied by various methods to demonstrate tissue-fixed antibody.

Bacterial Transformation (U), RR 005-05-0047. Columbia University, New York, New York, Department of Microbiology; Nonr 266(40), NR 103-327; S. M. Beiser.

These studies on bacterial transformation are directed toward the correlation of biological activity with structure of a chemical substance (desoxyribonucleic acid) derived from bacteria. Quantitative studies will be continued on the transforming and inhibiting activities of individual fractions obtained by ion-exchange chromatography. Attempts will be made to obtain new transformable properties and to transform additional bacterial species.

Immunity of the Lungs (U), RR 005-05-0048. University of California School of Medicine, San Francisco, California, Department of Microbiology, Nonr 1867(00), NR 103-328; R. S. Speck.

A bacterial pneumonic infection in mice is being used to determine the effects of various types of vaccines and routes of vaccination. The lungs are examined histologically to observe cellular response to various procedures and infections. The effect of ionizing radiation on this infection and on vaccination are also under study.

Virus Protein Analyses (U), RR 005-05-0050. Iowa State College, Ames, Iowa, Department of Bacteriology; Nonr 1869(00), NR 103-349; L. Y. Quinn.

This task was designed to provide a comparative determination of amino acid composition of virus protein and an elucidation of the mechanism whereby this protein is synthesized. Bacterial viruses (phages) of the "T" series were subjected to refluxing with acid to hydrolyze the protein and separate its constituent amino acids. Biosynthesis of phage protein was investigated also by incorporating carbon 14-labeled amino acids in the growth medium.

Cell Adaptation to Virus (U), RR 005-05-0051. Cornell University, Ithaca, New York, Virus Research Institute; Nonr 401(23), NR 103-352; J. A. Baker.

Studies employing the hog cholera virus--pig host system will be continued to determine the effect of age on the degree of viral parasitism; the nature of the substance in colostrum that prevents parasitism and a better definition of nutrition. These findings are being extended to other viruses in pigs and to viruses in other species of animals with the aim of having a better assay method.

Adaptation of Viruses to Resistant Hosts (U), RR 005-05-0052. University of Miami School of medicine, Coral Gables, Florida, Department of Bacteriology; Nonr 3310(00), NR 103-371; M. M. Sigel.

A study of virus infections in tissues from susceptible animals transplants to resistant animals will be continued. Growth curves of virus multiplication in transplants will be done by subinoculation into in vitro cultures of susceptible cells and this work will be correlated with experiments analyzing the factors influencing latency in tissue culture.

Antibody Response to Multiple Antigen Stimulation (U), RR 005-05-0053. University of Wisconsin, Madison, Wisconsin, Zoology Department; Nonr 1202 (12), NR 103-390; H. R. Wolfe.

This research is concerned with the factors that influence antibody production in the rabbit and chicken. Such factors as antigenicity of substance used, the secondary and tertiary stimuli, molecular size of antigen age, and species of animal used in antibody production are being studied. Experiments are now in progress to show the effect of administering one antigen and then injecting a second and different antigen at various intervals.

Effect of Cortisone on the Growth of Viruses (U), RR 005-05-0054. University of Rochester, Rochester, New York, Department of Bacteriology; Nonr 668(13), NR 103-393; R. B. Stewart.

This study undertakes to investigate the physiological basis of virus production in a pure line of cells. It is based on the observation that the yield of virus in a cortisone-treated host system

is associated with a depressed rate of glucose metabolism. Studies are being carried out in an attempt to discover the nature of the changes that are induced by cortisone and their effect on virus growth. The current approach involves experiments to confirm that cortisone suppresses viral synthesis and not the release of virus from the cell.

Marine Bacteria Metabolism (U), RR 005-05-0055. University of Georgia, Athens, Georgia, Department of Bacteriology; Nonr 2337(00), NR 103-398; W. J. Payne.

Marine bacteria are being studied with respect to their abilities to utilize uronic acids found in decomposing plant and animals residues. Attempts are being made to determine that the induction of enzymes in these organisms is dependent on sodium ions. Additional studies will be made to identify the intermediates in the breakdown in mannuronic acid.

Parasitic Mechanisms (U), RR 005-05-0056. University of Kansas, Lawrence, Kansas, Department of Bacteriology; Nonr 583(10), NR 103-399; D. Paretsky, C. M. Downs.

A model system consisting of Rickettsia akari grown in the embryonated egg is being employed in this investigation to determine the events which occur when rickettsiae parasitize a host cell. The current work will extend the information already obtained on the physiology of rickettsiae. Emphasis is being placed on the development of a medium of known composition for propagation of rickettsiae in vitro and attention will be directed to the altered events in the parasitized host cell.

Marine Bacteria Activities (U), RR 005-05-0057. College of Charleston, Charleston, South Carolina, Fort Johnson Marine Biological Laboratory; Nonr 2439(01), NR 103-404; J. R. Merkel.

This task is concerned with microbial degradation and synthesis of some of the higher molecular weight organic compounds. Chemical studies on the amount and types of carotenoids and their decomposition products in marine waters, organisms, and sediments have been expanded to include the possible decomposition by marine bacteria of hydrocarbons other than the carotenoids. Warburg studies to determine the nature of the inhibition of bacterial respiration by betacarotine will be continued.

Tests for Viral Diseases (U), RR 005-05-0058. The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, Research Department; Nonr 2267 (00), NR 103-413; W. Henle.

The effects of this task are directed primarily toward the development of reliable and specific reagents for the diagnosis of viral infections. Strain-specific complement fixation tests are being evaluated in the identification of influenza viruses and the serodiagnosis of the disease. Studies also have been undertaken to determine the antigenic inter-relationships among members of the myxo group of viruses.

Bacterial Physiology (U), RR 005-05-0059. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Biological Sciences; Nonr 624(07), NR 103-429; E. Englesberg.

This task is designed to explore the bacterial genetics involved and the mechanism concerned in the diauxie phenomenon and to determine the nature and genetic basis for transport unit production regarding adaptation to citrate utilization. Special techniques in bacterial genetics are being employed in additional studies of genes in attempts to elucidate enzymatic activities in the production of transport units.

Enteric Infections (U), RR 005-05-0060. The Jefferson Medical College, Philadelphia, Pennsylvania, Department of Bacteriology and Immunology; Nonr 2504(00), NR 103-430; R. Freter.

This is a study of the mechanism by which bacterial pathogens produce the symptom complex of diarrhea and the mechanism by which protective immunity to enteric diseases is induced. These problems are being investigated with a method of experimental enteric infection of laboratory animals developed by the principal investigator. The efficacy of coproantibody in protection against enteric infections is being investigated and studies concerning the mechanism of bacterial antagonism are being carried out by employing a continuous flow culture method.

Bacterial Oxidations (U), RR 005-05-0061. University of Florida, Gainesville, Florida, Department of Bacteriology; Nonr(G) 0006-60, NR 103-431; W. S. Silver.

Biochemical studies are being conducted on species of nitrifying bacteria that oxidize ammonia to nitrous acid or that convert nitrous acid to nitric acid. The mechanism of the two oxidative processes is being investigated with use of both whole cell and cell-free preparations in order to obtain precise information as to the physiologic activities involved. The enzyme system of the cell-free extracts is being fractionated to define the essential components of the system and the role of cytochrome--569 in nitric oxidation will be established.

Corrosion of Iron (U), RR 005-05-0062. The University of Texas, Port Aransas, Texas, Institute of Marine Science; Nonr 375(10), NR 103-433; C. H. Oppenheimer.

This task is to study the fundamental principles involved in microbial corrosion of iron in marine environments. Determination is being made of the oxygen consumption by microorganisms in marine sediments and in pure culture, and total numbers of bacteria, plants, and animals in bay sediments and water will be estimated. Acids produced by bacterial activity will be measured and organic acids separated and tested for their ability to corrode iron. The effect of hydrogenase on the corrosion of iron also is under investigation.

Nutrition of Spores (U), RR 005-05-0063. Arizona State College, Tempe, Arizona, Division of Life Sciences; Nonr 2794(01), NR 103-435; R. M. Johnson.

With use of microtechniques, the process of sporulation in single cell isolates of the bacillus genus is being studied by observing changes taking place from the young vegetive cell to the mature

spore. Experiments are in progress to establish the amino acid or inorganic nitrogen requirements for sporulation at the cellular level. A synthetic medium in which the nitrogen source can be varied is being employed to study nitrogen metabolism in the sequence from vegetative cell to spore.

Ascarid Hypersensitivity (U), RR 005-05-0065. Cornell University Medical College, New York, New York, Department of Microbiology and Immunology; Nonr 2725(00), NR 103-440; K. A. Laurence.

This task comprised a study of the hypersensitive reactions of laboratory animals to ascarid infections. The allergic response of immunized and/or infected animals to extracts of sonically disrupted egg and larvae stages, and the adult perienteric fluids of this parasitic worm, were correlated with electrochromatographic separation and identification of these substances. The hypersensitive reactivity was studied by passive transfer of both the immediate and delayed type, by active anaphylaxis, and by development of a specific skin testing agent.

The Cellular Slime Molds (U), RR 005-05-0066. Brandeis University, Waltham, Massachusetts, Department of Biology; Nonr 2636(00), NR 103-441; M. Sussman.

The elucidation of developmental phenomena in cellular differentiation is being attempted in this study of the slime molds. The lines of investigation include: determination of the genetic mechanisms which are involved in the production of the required cellular varieties during differentiation, isolation and identification of chemotactically active substances which appear to play a role in the developmental cycle, and examination of the possibility of sexuality in this group of organisms.

Immunity and Specificity (U), RR 005-05-0067. University of California, Los Angeles, California, Department of Zoology; Nonr 233(56), NR 103-446; D. Heyneman.

These studies on the nature of immunity and parasite specificity will be continued in conjunction with a project on Kala Azar that is underway at NAMRU #3, Cairo. Both laboratory and field studies have been planned to determine possible control of the disease by immunological means. One phase of the program includes biological investigations to determine the specific vector and its habits. Laboratory studies also are being undertaken to culture the organism and to test its physiologic response in vitro.

Methods of Measurement and Exploration of Drugs to Increase Resistance to Disease (U), RR 005-05-0068. New England Inst. for Medical Research, Ridgefield, Connecticut; Nonr 2610(01), NR 103-448; J. H. Heller.

Recently developed quantitative techniques are being employed in this investigation on the functional activity of a system in the body which is involved in the primary defense mechanism. The effectiveness of various substances in stimulating (or repressing) phagocytosis is being determined, and the substances are being fractionated and their stimulative potency assayed. Further study of these quantitative techniques is planned in an effort to develop new methods of measurement.

The Nature of Mutation (U), RR 005-05-0069. University of Oregon, Eugene, Oregon, Institute of Molecular Biology; Nonr 2771(00), NR 103-434; A. Novick.

This investigation into the nature of mutation consists of studies of both spontaneous and induced mutations in bacteria. Accurate measurement of mutation rates will be made with the chemostat, a device for the continuous culture of bacteria. A variety of compounds related to nucleic acids will be tested for their effect on the rate of mutation to resistance to T5 virus. The mutagenic action will be tested under conditions where the nucleic acid metabolism of the bacteria has been disturbed.

Rheumatic Fever Etiology (U), RR 005-05-0070. Vanderbilt University, Nashville, Tennessee, Department of Preventive Medicine and Public Health; Nonr 2837(00), NR 103-454; R. W. Quinn.

This research proposes to test the clonal selection theory of antibody production of Burnet and Fenner in relation to the problem of the etiology and pathogeneis of rheumatic fever. The working hypothesis is that a "Forbidden antibody" may be produced by "forbidden clones" of antibody forming cells in the pharyngeal lymphoid tissue as a result of a stimulus by streptococcal antigens.

Microbial Associations (U), RR 005-05-0071. University of Maryland, College Park, Maryland, Department of Microbiology; Nonr 595(12), NR 103-455; M. J. Pelczar, Jr.

The biological processes which may occur in microbial associations will be investigated in this study involving two systems of mixed cultures. The enhancement of sporulation in one species of microorganism by another is to be studied with the use of a chemically defined medium. A case of nutritional symbiosis between a lactobacillus and a streptococcus will be used as a model to further investigate the role of p-aminobenzoic acid.

Studies on Sea Sediments (U), RR 005-05-0072. Brooklyn Botanic Garden, Brooklyn, New York; Nonr 3018(00), NR 103-456; P. R. Burkholder.

This task consists of bacteriological and biochemical studies on marine sediments designed to determine the role of marine bacteria in organic and inorganic transformations of materials in the sea. The metabolic activity of bacteria in cores obtained from shallow waters and deep sea areas are being studied and the physical and chemical properties of the microorganisms will be investigated in relation to concentration of ions and consolidation of sediments. Another aspect of this program will be to determine the concentration of important specific substrates in products of microbial activity in the sediments.

The Genetics of Yeast (U), RR 005-05-0073. University of Wichita, Wichita, Kansas, Department of Biology; Nonr 201(02), NR 103-459; A. Sarachek.

This task is concerned with the genetic maintenance of the aerobic respiratory mechanism of Saccharomyces. A group of partially respiration deficient microorganisms that undergo spontaneous transformation into stable respiration sufficient

or respiration deficient individuals will be studied. Experiments have been designed to define the entitity other than the specific gene or extrachromosomal factors now known to control cellular respiration which is involved in these transformations. The studies include kinetic analyses and genetic analyses of totally and partially respiration deficient variants and determination of the physical and chemical factors which may be capable of directing the spontaneous differentiation.

Nucleic Acid Metabolism (U), RR 005-05-0074. University of Wichita, Wichita, Kansas, Department of Biology; Nonr 2772(00), NR 103-461; V. W. Woodward.

A study of pyrimidine biosynthesis in a fungus (Neurospora crassa) was made with the aid of numerous mutants, each of which was incapable of growing in the absence of exogenous pyrimidine. Experiments were carried out to cast the mutants in 4-point crosses to determine whether the recombinants were due to the reciprocal chromosome exchange or due to mutation of one allele by another or by some unknown mechanism involved in meiosis.

Bacterial Virus Growth (U), RR 005-05-0075. The Institute for Cancer Research, Philadelphia, Pennsylvania; Nonr 2791(00), NR 103-462; T. F. Anderson.

Autoradiographic techniques and high resolution electron microscopy were employed in this investigation on the physical, chemical and biophysical characterization of viruses and virus systems. The studies included elucidation of the mechanisms by which exogenous genetic material may be introduced into bacteria by conjugation with other bacteria or by infection by bacterial viruses and determination of the nature and functional anatomy of virus particles.

Halophilic Bacteria (U), RR 005-05-0076. University of Illinois, Urbana, Illinois, Department of Bacteriology; Nonr 1834(30), NR 103-463; H. O. Halvorson.

The mechanism of tolerance of microorganisms to high concentrations of salt is being investigated in halophilic bacteria. Appropriate experiments are being made to determine (1) whether halophiles develop specific enzymes which require high concentrations of salt for function or (2) whether halophiles contain compounds with a high affinity for water. Studies have been designed to obtain information on the enzymes and the effect of salt on their activity and genetic make-up of the organisms.

Study of Bacterial Toxins (U), RR 005-05-0077. Sir William Dunn School of Pathology, University of Oxford, Oxford, England, Department of Bacteriology; N62558 2281, NR 103-474; W. E. van Heyningen.

This study on bacterial toxins includes the biochemistry and physics of the toxins and their susceptible substances and their biology in relation to mechanisms of bacterial pathogenicity. The mode of action of tetanus toxin is being investigated to determine the primary biochemical lesion underlying the pharmacological actions of the toxin. A second phase of this task is concerned with the nature of the two components of staphylococcal leucocidin.

Marine Tissue Culture (U), RR 005-05-0078. University of Miami School of Medicine, Coral Gables, Florida, Department of Bacteriology; Nonr 840(15), NR 103-476; M. M. Sigel.

The major efforts of this research are devoted to the establishment of reliable technics for the collection of marine animals and to the determination of proper procedures for taking blood specimens and preparation of tissues. The investigation includes studies of the effects of homologous and heterologous blood and of tissues juices from embryonic, immature and mature fish on the cultures.

Localization of Antibodies (U), RR 005-05-0079. University of Texas Medical Branch, Galveston, Texas, Department of Preventive Med. and Pub. Health; Nonr 2564(00), NR 103-981; L. Anigstein.

The study of localization of antibodies in vivo with the use of isotopes is being followed by investigations on physiological responses of the rat to the administration of anti-organ immune sera. The rat pituitary is being employed as antigen for the antibody formation in the injected rabbit. Comparative studies are being made of the biological activities of the antipituitary serum and of antigrowth hormone serum using the purified growth hormone as antigen.

Animal Viruses and WBC (U), RR 005-05-0080. Southern Illinois University, Carbondale, Illinois, Department of Microbiology; Nonr 3127(00), NR 103-481; I. L. Shechmeister.

This work involves a study of interaction between large animal viruses, such as meningo pneumonitis virus, and certain phagocytic white blood cells. Possible effect of virus and virus products on this will include determination of migration of white blood cells and assay of ingestion and digestion of virus particles by these granulocytes. Attempts will be made to isolate and purify certain active compounds from extracts of white blood cells and to establish their action on virus(es) in vitro.

Productivity of the Sea (U), RR 005-05-0081. Marine Biological Laboratory, Woods Hole, Massachusetts; Nonr 3070(01), NR 103-486; Wm. D. McElroy.

This task is concerned with the productivity of the sea. The role of bacteria, viruses, bacteriophages, algae, fungi, and protozoans will be studied. The biochemical, nutritional, genetic and ecological viewpoints will be considered marine productivity. Microbiological studies have been designed to obtain basic information on the nature of interrelationships between different species of microorganisms and their contributions to productivity.

Culture of Marine Bacteria (U), RR 005-05-0082. University of Washington, Seattle, Washington, Department of Microbiology; Nonr 477(26), NR 103-487; E. Ordal.

This task is concerned with the changes occurring in enriched cultures of aquatic and marine bacteria. Chemical studies on the amount and types of substances, both antagonistic and stimulatory, occurring in mixed cultures are being carried out by

means of microchemical analyses, spectrophotometric and chromotographic procedures to obtain data on the mechanisms which control or influence bacteria in competition. Bacteriological studies have been designed to obtain information on the general character of a marine bacterial population under laboratory conditions which simulate the open sea or aquatic environment.

Biologic Nitrogen Fixation (U), RR 005-05-0083. South Dakota State College, Agriculture and Mechanic Arts, College Station, Brookings, South Dakota, Bacteriology Department; Nonr 3089(00), NR 103-488; R. M. Pengra.

This investigation is concerned with the role of molecular hydrogen and/or the enzyme hydrogenase in the mechanism of biological nitrogen fixation. Experiments will be made to determine if molecular nitrogen competitively inhibits oxidation or liberation of hydrogen by a nitrogen fixing organism, Aerobacter aerogenes. Several assay methods will be employed for the production of hydrogenase by this organism during fixation of nitrogen.

Genetics of Actinophages (U), RR 005-05-0084. University of Minnesota, Minneapolis, Minnesota, Department of Bacteriology and Immunology; Nonr 710(36), NR 103-490; S. G. Bradley.

This research is to determine the modification of actinophages (parasites of fungi) by growth in diverse hosts and/or the genetic alteration of the host. Isolation and characterization of the actinophages will be carried out by established techniques. Methods for induction of lysogenic strains and for lysogenization will be developed for use in studies on the transfer of genetic material. Studies of actinophage recombination also will be undertaken.

Viruses and Tumor Formation (U), RR 005-05-0085. Germfree Life Research Center, Tampa, Florida; Nonr 3176(00), NR 103-501; J. A. Reyniers.

Germfree animals are being employed in this investigation to determine if the presence of a microscopic substance in abnormal cells is associated with the formation of tumors. Isolation of subcellular particulates will be made by homogenization of the cells. After separation and purification the substances will be tested in germfree tissue culture systems for their ability to promote proliferation of the tumor cells.

Microforms and Marine Water (U), RR 005-05-0086. University of Washington, Seattle, Washington, Department of Microbiology; Nonr 477(30), NR 103-502; C. A. Evans, R. E. Kallio.

The initial phase of this program is concerned with the establishment of a simple system for study of microorganisms in the marine environment. An apparatus will be devised to permit chemical and microbiological analyses of filtered sea water under controlled conditions. Certain microflora will be investigated to determine the effects of changing conditions upon the environment-organism relationship. Concurrently, isolation and cultivation of the specific microorganism will be performed to establish optimal and limiting values for the environmental factors in pure culture and to compare them with those of more natural conditions.

Bodily Defense Mechanisms (U), RR 005-05-0087. Pasadena Foundation for Medical Research, Pasadena, California, Tissue Culture Laboratory; Nonr 3306 (00), NR 103-510; C. M. Pomerat.

The mechanisms of injury and repair in the living cell is being investigated by study of the sequence of events following the introduction of noxious chemical substances in cell cultures. Anti-pituitary cytotoxin prepared in rabbits against the pituitary of the rat will be used to challenge cultured cells from the anterior and posterior lobe of the rat in perfusion chambers. Phase contrast, time-lapse cinematography will be employed to record the effects. Cine recordings of the effect of staphylococcus antigen upon living cells will also be studied.

Development and Evaluation of BW Medical Countermeasures for Naval Application, MR 005-05-0002. Naval Medical Research Unit #1, Berkeley, California.

Emphasis is being given to developing and evaluating medical countermeasures against candidate BW agents being investigated in this country. This project is designed to develop and evaluate antibiotics and drugs in the prophylaxis and therapy of disease produced by potential BW agents under study by the Naval Biological Laboratory.

Development and Evaluation of BW Medical Countermeasures for Naval Application, MR 005-05-0003. Biological Warfare Laboratories, Ft. Detrick, Frederick, Maryland.

This task is in support of the Army Chemical Corps program to develop and evaluate biological means of prophylaxis and therapy of disease caused by certain selected candidate BW agents.

R005-06 Biochemistry

Chemistry of Growth in Streptococcus faecalis (U), RR 005-06-0003. The Institute for Cancer Research, Fox Chase, Philadelphia, Pennsylvania, Department of General Biochemistry; Nonr 2731(00), NR 108-039; G. Toennies.

The bacterium Streptococcus faecalis utilizes amino acids from a chemically defined nutrient medium to synthesize proteins and for no other purpose. Therefore, it is peculiarly suited for studies on mechanisms of protein synthesis. The chemical constitution and chemical activity of S. faecalis are being studied at different stages of growth and in media of controlled variable composition. The data obtained will be examined for relevance to protein synthesis and its relation to (a) the general problems of cell growth, differentiation, ageing, and death, and (b) special problems of bacterial growth and behavior.

Physico-Chemical Properties of Hydrogenase (U), RR 005-06-0004. Columbia University, New York, New York, Department of Biochemistry; Nonr 266(02), NR 108-047; D. Rittenberg.

The enzyme hydrogenase is being isolated, concentrated, and characterized. Hydrogenase is unique in that it acts on a chemically simple

substrate, hydrogen. It catalyzes a number of reactions in which molecular H_2 is acted upon or produced, among them the dissociation of molecular H_2, conversion of para to ortho H_2, and the transfer reaction $D_2 + H_2O = H_2 + D_2O$. Because of the simplicity of the substrate, its interaction with the enzyme should be relatively uncomplicated in comparison with other enzyme-substrate reactions. This system therefore appears to offer particular promise for deriving an unequivocal general explanation of the mechanism of enzyme action.

Sulfur Metabolism (U), RR 005-05-0005. Jefferson Medical College of Philadelphia, Philadelphia, Pennsylvania; Nonr 1757(00), NR 108-048; R. H. De Meio.

This task is concerned with the role of sulfur in animal metabolism. Particular emphasis is being placed on the sulfuric acid esters, the mechanisms of their biogenesis, and their functions in tissue repair and detoxication processes.

Enzyme Kinetics (U), RR 005-05-0006. University of Pennsylvania, Philadelphia, Pennsylvania, Johnson Foundation for Medical Physics; Nonr 551(15), NR 108-053; B. Chance.

Analog and digital computer techniques are being applied to various mathematical representations of the sequence of enzyme reactions that constitute the respiratory chain. Various theorems and generalities of the properties of such an enzyme sequence are derived and applied to the experimental data obtained by spectrophotometric and other means on the kinetics of such enzyme systems.

Extractives of Marine Invertebrates (U), RR 005-06-0007. Yale University, New Haven, Connecticut, Department of Chemistry; Nonr 609(38), NR 108-065; W. Bergmann.

Lipids and nucleic acids of marine invertebrates (sponges, algae, and coelenterates) have been systematically studied. It was possible to demonstrate a diversity of lipids in these animals. The distirbution and composition of the lipids particularly the sterols, waxes, and triglycerides, are characteristic for certain phyla, their classes and even their families. This finding will be useful in future taxonomic studies. Several new sterols, waxes and nucleosides were found and their structures established. In the course of this work the first generally applicable chemical method for splitting pyrimidine nucleosides without destruction of the sugar moieties was developed, along with an electrophoretic method for differentiating ribosides and arabinosides. A vapor phase chromatorgraphic separation method for waxes was also developed.

Metabolism of Glutathione, Glutamine and Related Compounds (U), RR 005-06-0008. New York State Psychiatric Institute, New York, New York, Department of Pharmacology; Nonr 369(00), NR 108-069; H. Waelsch.

Widely distributed in microorganisms, plants and animals there are enzymes (transamidases) which mediate the metabolism of certain of the amino acids and their derivatives (glutamine, glutathione, asparagine, histidine). They thereby set up the conditions necessary for protein or peptide synthesis from these compounds. These enzymes and their activities are being studied in microorganisms and in brain, liver, muscle, and peripheral nerve tissue with the intention of finding out the various ways in which the compounds are utilized and particularly to add to our knowledge of brain metabolism with which glutamine appears to be intimately involved.

Immunochemical Criteria of Purity of Proteins and Polysaccharides (U), RR 005-06-0009. Columbia University, New York, New York, Department of Neurology, College of Physicians and Surgeons; Nonr 266(13), NR 108-100; E. A. Kabat.

The objectives of this project are (a) to evaluate existing methods and to develop new immunochemical methods for establishing purity of proteins and polysaccharides; (b) to study fundamental mechanisms of antigen-antibody combinations; and (c) to correlate structure of polysaccharides with immunochemical specificity.

Immunochemistry (U), RR 005-05-0010. Boston University, Boston, Massachusetts, School of Medicine, Department of Biochemistry; Nonr 1873(00), NR 108-102; W. C. Boyd.

This is a broad immunochemical research program with 4 separate components: (a) investigation of whether continued antibody formation involves the persistence of antigen in the animal, (b) study of the reaction of highly purified antibody with synthetic haptens of known composition, (c) study of the reaction and amino acid composition of certain plant proteins (lectins) which can be used as blood grouping reagents, (d) development of practical sources of cheap blood grouping reagents.

Mechanisms of Immunity (U), RR 005-06-0011. The Johns Hopkins University, Baltimore, Maryland, Department of Microbiology, School of Hygiene and Public Health; Nonr 248(17), NR 108-104; M. M. Mayer.

The objectives of this task are (1) to elucidate the mechanisms whereby specific antibody, acting alone or in conjunction with complement, brings about the direct or indirect destruction of living cells; and (2) to test the concept that antibody against red blood cells functions in an enzymatic manner while complement acts as a reactant.

Hemoglobin Metabolism (U), RR 005-06-0012. Albert Einstein College of Medicine of Yeshiva University, New York, New York, Department of Medicine; Nonr 2981(00), NR 108-124; I. M. London.

This research includes work on the mechanism of biosynthesis of hemoglobin with respect to both the porphyrin and protein moieties. Specific problems are determination of their relative rates of formation, determination of the effect on the formation of hemoglobin of agents that dissociate formation of the total hemoglobin molecule, and the role of compounds such as purine nucleotides in maintaining production and viability of mammalian erythrocytes.

Structure and Mode of Action of Proteolytic Enzymes (U), RR 005-06-0013. University of Washington, Seattle, Washington, Department of

Biochemistry, School of Medicine; Nonr 477(04), NR 108-152; H. Neurath.

The purpose of this task is to find and characterize the catalytically active regions of proteolytic enzymes. These substances will be modified in a predetermined manner by subjecting them to the action of other enzyme and then tested for proteolytic activity.

Organic Synthesis (U), RR 005-06-0014. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Chemistry; Nonr 1841(15), NR 108-160; J. C. Sheehan.

New, effective methods are being developed for the laboratory synthesis of proteins, peptides, and steroids. These methods in turn are being applied to the synthesis of proteins and steroids that act as antibiotics or as hormones. Attention is directed especially toward reactions which make possible the building of peptide chains by adding segments of two, three, or more amino acids in a single operation.

Characterization of Viral Proteins (U), RR 005-06-0015. University of California, Berkeley, California, Virus Laboratory; Nonr 222(47), NR 108-175; H. K. Schachman.

The structure of viruses is being studied. Attempts are being made to break virus particles into their component parts, and to determine the chemical nature of these parts and how they are arranged to constitute the infectious virus. Particular emphasis is being placed on the nucleic acid component of viruses.

Thyroid Hormone Mechanisms (U), RR 005-06-0016. University of Wisconsin, Madison, Wisconsin, Institute for Enzyme Research; Nonr 1202(09), NR 108-176; H. A. Lardy.

The mode of action of the thyroid hormone(s) is being determined. Several lines of investigation are in progress as follows: Compounds similar to thyroxine are being synthesized in an effort to determine the minimum structural requirements that a compound must have to show thyroid hormone activity. The pathway of metabolism of thyroxine in surviving animal tissues is being worked out. The effect of thyroid hormones on various enzyme systems in vitro and in the intact animal is being studied. The relationship between activity of thyroid hormones and adrenalin and the relationship between activity of thyroid hormones and estrogens are being explored. In order to get some clue to the site of action of the hormones, a study is being made of differences existing in animals that respond to thyroid hormone and those that do not.

Structure and Biological Activity of Peptides (U), RR 005-06-0018. Columbia University, Low Memorial Library, New York, New York, Department of Microbiology; Nonr 266(44), NR 108-260; B. F. Erlanger.

The following results have been obtained on each of three aims outlined at the beginning of the task: (1) synthesis of peptides related to the antibiotic decapeptide, Gramicidin S: Five such peptides were synthesized, 4 in crystalline form. None had activity against PR8 influenza virus. The linear peptides differed from the cyclic forms in that they acted as metabolic inhibitors, (2) study of the enzyme systems of Bacillus brevis, the microorganism which elaborates Gramicidin S: Two proteolytic enzymes were isolated and partially characterized, (3) development of synthetic substrates as a method of isolating and purifying enzymes: Some success has been attained in synthesizing substrates which will selectively remove enzymes from a mixture of enzymes in aqueous solution. The method also shows promise as a tool for identifying the active sites of enzymes. This part of the work will be expanded into an individual project--NR 108-501, Nonr 226(73).

Photosynthetic Enzymes (U), RR 005-06-0019. University of California, Berkeley, California, Department of Plant Nutrition; Nonr 222(27), NR 108-268; D. I. Arnon.

The object of this work is to isolate, identify, and characterize, the enzyme systems involved in photosynthesis. The ultimate objective is the reconstruction in vitro of linked enzyme systems which will be capable of reproducing steps involved in the path of carbon during photosynthesis. Attention will be concentrated on those systems active in chloroplasts that have been separated from plants and which have been shown to carry on photosynthesis in vitro.

Physico-Chemical and Immunological Characterization of Allergens (U), RR 005-06-0020. Cornell University, Ithaca, New York, The New York Hospital; Nonr 401(13), NR 108-295; M. H. Loveless.

The object of this task is to learn more about those substances in the blood of allergic individuals which take part in an allergic reaction--how many such substances there are, with what part of the blood serum they are associated, what they are chemically, and how they act to produce or prevent symptoms.

Iron Metabolism (U), RR 005-06-0021. University of California, Berkeley, California, Department of Biochemistry; Nonr 222(39), NR 108-296; J. B. Neilands.

Two aspects of iron metabolism are under investigation: Determination of the chemical structure of ferrichrome and ferrichrome A, two newly discovered iron-containing peptides, and elucidation of the mechanism of iron incorporation into porphyrins by cell-free systems.

Development of C^{14}-Labelled Biochemical Compounds (U), RR 005-06-0023. Schwarz Laboratories Incorporated, Mt. Vernon, New York; Nonr 2178(00), NR 108-316; D. R. Schwarz.

Methods were developed for preparing, by biosynthesis, C^{14}-labelled ribonucleic acid and deoxyribonucleic acid, and their component moieties.

Chemistry of Ribonuclease (U), RR 005-06-0025. State University of Iowa, Iowa City, Iowa, Department of Biochemistry; N9onr 91500, NR 108-327; G. Kalnitsky.

The enzyme ribonuclease is being fragmented. Various fragments will be tested for activity, their amino acid composition and C- and N- terminal groups determined, and a study made of the relationship between chemical configuration and

enzymatic activity.

Heat-Stable Enzymes (U), RR 005-06-0026. Western Reserve University, Cleveland, Ohio, Department of Microbiology, School of Medicine; Nonr 1439(06), NR 108-330; L. L. Campbell.

Thermophilic bacterial species, which thrive at temperatures in the range of 45°C - 75°C, and mesophilic bacteria of the same species, which grow at 20°C - 44°C, are presumed to have the same kinds of enzyme systems. However, enzymes from the mesophilic form can be inactivated by heating to 50°C - 60°C. The question under investigation is how do these enzyme systems remain active in the thermophilic forms. Amylases and proteinases from both forms of a given bacterial species are being isolated, purified, and compared in an effort to supply an answer to the question.

Amino Acid Metabolism (U), RR 005-06-0027. Rutgers University, New Brunswick, New Jersey, Institute of Microbiology; Nonr 404(12), NR 108-335; H. Vogel.

Enzyme systems and chemical compounds involved in interconversions among amino acids, particularly ornithine, proline, and glutamic acid, are being isolated and characterized. Typical interconversions are being described for bacteria, algae, fungi, and protozoa with the object of detecting broad evolutionary relationships.

The Binding of Steroids by Blood Proteins (U), RR 005-06-0028. University of California, Los Angeles, California, Department of Zoology; Nonr 233 (39), NR 108-336; B. H. Levedahl.

The mechanism of action of steroid hormones is being studied in order to determine how they are transported in the blood stream and whether they act in a free state or conjugated with other compounds. Current phases of the work include determination of chemical configurations involved in hormone-protein interactions and a study of changes in permeability of cell membranes induced by interaction of hormones and cell-membrane proteins. The rotatory dispersion technique has been developed to apply to the problem. Rotatory dispersion characteristics of nucleic acids are also being determined.

Experimental Study of Enzyme Systems (U), RR 005-06-0029. Edsel B. Ford Institute for Medical Research, Detroit, Michigan, Department of Biochemistry; Nonr 1656(00), NR 108-337; T. P. Singer, E. B. Kearney.

The mechanism of energy exchange in the succinic oxidase enzyme system is being studied. This system appears to be architecturally organized to permit rapid passage of electrons through it with concomitant formation of high energy bonds which are then utilizable for endergonic reactions. It is intended to isolate and characterize individual components of the system and then to reconstitute it by chemical or physical means in order to get an idea of the spatial arrangement of the active constituents.

Hydrogen Transfer (U), RR 005-06-0030. Indiana University, Bloomington, Indiana, Department of Chemistry; Nonr 908(12), NR 108-387; H. R. Mahler, V. H. Shiner, Jr.

Many energy-yielding chemical reactions in living things involve the transfer of hydrogen by the mediation of enzymes. The details of the hydrogen transfer are not known. In order to try to determine all the steps in the hydrogen transfer process, deuterium ("heavy hydrogen") will be substituted for hydrogen in pyridine nucleotide enzymes and in substrates which participate in typical hydrogen transfers. A thorough study will then be made of physico-chemical characteristics of the hydrogen compounds as compared with the deuterium compounds and of the kinetics of the reactions involving both types of compounds.

Structure Of Antibiotics (U), RR 005-06-0031. University of Wisconsin, Madison, Wisconsin, Department of Chemistry; Nonr 1202(10), NR 108-389; E. E. van Tamelen.

Research is being conducted on the chemical structures of antibiotic materials with particular emphasis on the structures of several apparently related Streptomyces antibiotics. The objective is to determine the relationship between antibiotic activity and structure.

Proteolytic Enzymes (U), RR 005-06-0032. Columbia University, New York, New York; Nonr 266(49), NR 108-398; I. Mandl.

Dermatophytes, or skin fungi, attack hair, nails, and superficial layers of the skin giving rise to such conditions as ringworm and athletes' foot. It is proposed to study the enzyme systems of these organisms and to try to correlate enzyme formation with capacity to cause lesions. These enzymes will also be compared with bacterial enzymes with respect to ability to attack animal tissues.

Marine Biochemistry (U), RR 005-06-0033. Oregon State College, Corvallis, Oregon; Nonr 1286(06), NR 108-402; V. H. Cheldelin, T. E. King.

Marine organisms, particularly those that behave as fouling agents or serve as food sources, are being st lied in order to determine nutritional requirements and metabolic patterns. The investigators propose to determine nutritional requirements and metabolism of the marine borer (Limnoria spp.), of the bay mussel (Mytilis edulis), of barnacles (Balanus spp.), and of the oyster (Ostrea lurida).

Polynucleotide Synthesis (U), RR 005-06-0034. University of Southern California, Los Angeles, California, Department of Chemistry; Nonr 228(21), NR 108-405; R. Simha.

Nucleotide polymers are being studied from the standpoints of the mode of polymerization, and kinetics and statistics of the reactions involved. Determination of characteristic rate constants, of distribution of sequences of varying chain lengths and compositions, as well as composition and chain length distribution of the whole polymer is being attempted.

Mechanism of Enzyme Action (U), RR 005-06-0035. Cornell University, Ithaca, New York, Department of Chemistry; Nonr 401(36), NR 108-406; H. A. Scheraga.

The mechanism of action and the nature of the "active center(s)" of the enzymes thrombin, trypsin, ribonuclease, and lysozyme are being studied.

Relationship of Structure to Activity in the Enzyme Trypsin (U), RR 005-06-0036. Cornell University, Ithaca, New York, Department of Biochemistry and Nutrition; Nonr 401(35), NR 108-417; G. P. Hess.

The enzyme trypsin is being studied in order to determine the chemical configurations which are responsible for its activity. The enzyme is being fragmented by autolysis under varying conditions of time, temperature, pH, ionic strength, etc. The different fragments so obtained are being isolated, tested for activity, and their chemical identity determined. The disulfide bridges in trypsin are also being investigated.

Study of Protein-Fat Complexes in Human Serum and Tissues (U), RR 005-06-0037. University of Wisconsin, Madison, Wisconsin, Department of Physiological Chemistry; Nonr 1202(13), NR 108-413; H. F. Deutsch.

Human serum and tissue lipoproteins of the β1- and α1- globulin types are being studied with respect to their immunochemical properties and relationships. An attempt is being made, on the immunochemical basis, to find out whether the protein moieties of these substances differ in normal and diseased conditions (hypercholesterolemia, hypothyroid conditions, xanthomatous conditions, etc.) and whether chemical precursors are present in liver, where these substances are presumably synthesized.

Purine-Peptide Compounds (U), RR 005-06-0038. The University of Vermont, Burlington, Vermont, Department of Biochemistry, College of Medicine; Nonr 2714(00), NR 108-423; A. H. Schein.

This is a study of the conjugation of amino acids with purine and pyrimidines. An attempt will be made to synthesize such compounds. If successful, a search will be made for naturally occurring ones, and their metabolism in animals and in cell cultures will be investigated.

Cell Wall Biosynthesis (U), RR 005-06-0040. City of Hope Medical Center, Duarte, California, Department of Biochemistry; Nonr 2702(00), NR 108-432; J. T. Holden.

The goal of this work is the elucidation of the bacterial cell wall biosynthetic mechanism. The immediate objectives are (a) to continue studies on the effect of nutritional deficiencies, particularly of vitamin B6, on cell wall composition and structure in Lactobacillus arabinosus, (b) to continue studies on incorporation of wall constituents designed to characterize the enzymatic reactions which limit cell wall formation in a variety of nutritional deficiency states, (c) to study the enzyme composition of bacterial membranes and (d) to undertake an investigation of cell-free enzymes which participate in the incorporation of D-amino acids into cell wall and precursors thereof.

Native Glycogens: Characterization, Biosynthesis and Metabolism (U), RR 005-06-0041. Louisiana State University, New Orleans, Louisiana, School of Medicine; Nonr 2684(00), NR 108-436; E. Bueding, S. Orrell.

The synthesis, structure, and metabolism of glycogen have been the subject of numerous studies using glycogen extracted with alkali at 100°C or with cold trichloracetic acid. It now appears that glycogen obtained in this manner is partially degraded in comparison with H_2O-extracted glycogen. It is therefore planned to reinvestigate the characteristics and behavior of glycogen using the water-extracted material, so-called "native" glycogen. The work will require the development of an ultracentrifuge especially adapted for use with poly-disperse macromolecular systems of biological origin.

Insulin Action Mechanism (U), RR 005-06-0044. The Scripps Clinic and Research Foundation, La Jolla, California; Nonr 3007(00), NR 108-455; H. I. Nakada.

The mechanism by which insulin performs one of its major functions, the synthesis and storage of glycogen in the animal body, is not known. This is an attempt to find pathways for glycogen synthesis other than the one already known, to isolate and characterize the enzymes involved, and to determine the effect of insulin on the isolated enzymes.

Carbon, Nitrogen, and Sulfur Metabolism (U), RR 005-06-0045. City of Hope Medical Center, Duarte, California, Department of Biochemistry; Nonr 3001 (00), NR 108-458; E. Roberts.

A wide variety of marine organisms are being characterized with respect to their nitrogen metabolism and their free amino acid content. Specific phases of the work include identification of hitherto unrecognized substances in amino acid chromatograms, sulfur metabolism (biosynthesis of taurine) in marine animals, the mechanism of the biosynthesis of carnosine and anserine in fish muscle, and metabolic characterization of the basal disc of sea anemones.

Synthesis of Chemicals for Inhibiting Cellular Growth and Differentiation (U), RR 005-06-0046. Midwest Research Institute, Kansas City, Missouri; Nonr 2946(00), NR 108-468; B. W. Beadle.

This task is devoted to the synthesis of special chemical substances and to the study of the effects of these chemical substances on cellular growth and differentiation.

Organic Acid Metabolism (U), RR 005-06-0047. University of Illinois, Urbana, Illinois, Department of Chemistry and Chemical Engineering; Nonr 1834(28), NR 108-508; I. C. Gunsalus.

The transformations of the organic acids that participate in metabolism are being studied at an enzymatic level in order to determine essential cofactors and reaction mechanisms and to understand the energetic coupling essential to biosynthesis. These studies involve a determination of the overall flow patterns of metabolites in living cells, and of the sequence of steps they undergo in performing their cellular functions.

Biosynthesis of Cellulose (U), RR 005-06-0048. University of Texas, Austin, Texas, The Plant Research Institute; Nonr 1438(00), NR 108-675; W. G. Whaley.

This is a study of plant growth. It includes (a) determination of mechanisms of cellulose

synthesis; (b) establishment of relationships between cellulose synthesis and other phases of plant metabolism; and (c) a correlation of structural changes, with chemical changes that occur during growth and differentiation in rapidly growing tissues such as root apices.

Metabolism of Connective Tissue Constituents (U), RR 005-06-0049. University of Vermont and State Agricultural College, Burlington, Vermont, Department of Biochemistry, College of Medicine; Nonr 1171(00), NR 108-793; W. van B. Robertson.

Collagen and mucin are two of the basic protein constituents of the connective tissue system in mammals and as such are intimately involved with the kind of tissue replacement that occurs during wound healing. Studies are being made on the relationship of vitamin C to the content and properties of collagen and mucin in acutely and chronically vitamin C-deficient guinea pigs.

Antigen-Antibody Reactions (U), RR 005-06-0051. Indiana University, Bloomington, Indiana, Department of Chemistry; Nonr 3104(00), NR 108-035; F. Haurowitz.

Antibody formation is one of the few cases in which it is possible to interfere with the biosynthesis of proteins. After injection of an antigen the organism forms proteins which are complementarily adjusted to the shape of the antigen molecules and which, therefore, combine specifically with the antigen and act as antibodies. The purpose of this work is to gain more insight into the mechanism of antibody formation and of protein biosynthesis in general.

Metabolism of Insect Pests (U), RR 005-06-0052. University of Wisconsin, Madison, Wisconsin, Department of Zoology; Nonr 1202(14), NR 108-441; W. H. McShan.

Biochemical mechanisms of insect flight are being studied. Mitochondria and submicroscopic granules from insect (roaches) flight muscles will be investigated with regard to gross chemical composition, enzyme constituents, and fine structure. These same properties will also be studied under the influence of insecticides, changes in temperature, and changes in degree of activity of the insects.

Steriod Glucuronidates (U), RR 005-06-0053. Columbia University, Low Memorial Library, New York, New York, Department of Obstetrics and Gynecology; Nonr 266(75), NR 108-445; S. Lieberman.

The objective of this research is to investigate the kinetics of hydrolysis of steroid glucuronidates with a view to the development of superior chemical methods for the cleavage of these conjugates. Model compounds, representing many varieties of urinary conjugates, will be employed as substrates.

Sulfur in Algal Metabolism (U), RR 005-06-0054. University of Southern California, Los Angeles, California; Nonr 228(18), NR 108-448; R. F. Jones.

This is the study of the properties and mechanism of formation of the galactan sulfates formed by a red marine alga, Porphyridium cruentum. Specific aims are (a) to study the mechanism of sulfate uptake, using unlabelled and labelled sulfate, (b) to study the utilization of organic sulfur compounds, e.g. methionine, in the presence of inorganic SO_4, (c) to extract and analyze the various cell wall fractions for their respective sugar components and degree of sulfation, (d) to determine the presence of low molecular weight sulfated compounds such as sulfated nucleotides, sulfur-containing nucleotide-peptides, and sugar sulfates, and (e) to study the incorporation of radiosulfate into such compounds.

Chemical Studies on Urease (U), RR 005-06-0055. Oklahoma State University, Stillwater, Oklahoma, Department of Chemistry; Nonr 2595(02), NR 108-486; G. Gorin.

This is a study of the chemical nature of the enzyme urease, including determination of its physico-chemical properties, its amino acid composition with special reference to the sulfur-containing amino acids, its inhibition by heavy metal ions, and its controlled oxidation and reduction.

Steriods from Protozoa (U), RR 005-06-0056. Bryn Mawr College, Bryn Mawr, Pennsylvania, Department of Chemistry, Department of Biology; Nonr 2829(02), NR 108-494; F. B. Mallory, R. L. Conner.

Biologically active steroids synthesized by the protozoon, Tetrahymena piriformis, will be extracted and their structures determined.

Biochemistry of the Luminescence of Marine Organisms (U), RR 005-06-0057. University of Illinois, Urbana, Illinois, Department of Chemistry; Nonr 1834(34), NR 108-495; J. W. Hastings.

The chemistry of the reactions producing luminescence in marine bacteria and protozoa will be studied. In the case of the bacteria, since all components involved in the reaction are known, the work will involve purification, possible crystallization and physico-chemical characterization of a participating enzyme. In the case of the protozoa, extraction, purification and identification of the factors necessary for light emission will be undertaken.

Polypeptides (U), RR 005-06-0058. Harvard University, Cambridge, Massachusetts, Department of Chemistry; Nonr 1866(25), NR 108-497; P. M. Doty.

The objectives of this research are (1) synthesis of novel polypeptides and copolypeptides, (2) study of polymerization kinetics, (3) determination of the structure and properties of products, and (4) investigation of the relationship between polypeptide structure and composition and polypeptide biological activity as observed in antibodies, hormones and enzymes.

Single-Injection, Repository Therapy of Allergy (U), RR 005-06-0059. Cornell University, New York, New York, Department of Medicine of the New York Hospital, Cornell Medical Center; Nonr 401(42), NR 108-498; M. H. Loveless.

An improved therapy for allergy has been developed which utilizes a single desensitizing injection in a season. Conventional therapy requires a series of injections over a period of time to achieve desensitization. It is planned to make a controlled test of the efficacy of the new method

on representative groups of adults from various parts of the country, including military personnel, if this is feasible.

Enzyme-Substrate Reactions (U), RR 005-06-0060. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Chemistry; Nonr 839(31), NR 108-499; H. Morawetz.

A systematic investigation on the use of synthetic polymers as specific reagents for the isolation and concentration of enzyme is being carried out. It includes exploration of the relative advantages of soluble and cross-linked polymers in enzyme concentration processes and determination of the influence on the efficiency of the process of such variables as balance of polar and non-polar residues, degree of swelling, and density of specifically interacting groups along the polymer chain. A parallel study of the catalytic activity of polymers in the non-enzymatic hydrolysis of phenyl and thiol esters will also be done.

Enzyme Specificity (U), RR 005-06-0061. Columbia University, Low Memorial Library, New York, New York, Department of Microbiology; Nonr 266(73), NR 108-501; B. F. Erlanger.

Kinetic studies will be made on the reversible adsorption of proteolytic enzymes (chymotrypsin, chymotrypsinogen, pepsin, etc.) on solid substrates (insoluble peptide esters), principally to define the chemical basis of attachment and the nature of the bonding involved. Attempts will be made to use this principle for the resolution of enzyme mixtures into their components and for the purification of enzymes.

Free Amino Acid Symposium (U), RR 005-06-0062. City of Hope Medical Center, Duarte, California, Department of Biochemistry; Nonr(G) 0009-61, NR 108-531; E. Roberts.

A conference will be held on the occurrence and metabolic role of free amino acids in biological systems.

Protein Metabolism (U), RR 005-06-0063. The Burke Foundation, White Plains, New York, Nutrition and Metabolic Research Division; Nonr 3145 (00), NR 108-975; A. A. Albanese.

This work concerns protein metabolism in convalescents, aged persons, and infants. It includes studies on amino acid supplements in diets, protein-sparing action of carbohydrates, and determination of alterations in normal metabolism induced by disease, surgical trauma or other stress.

Problems in Surface and Colloid Chemistry of Biological Significance (U), MR 005-06-0001. Naval Medical Research Institute, Bethesda 14, Maryland; R. F. Steiner, Ph. D.

Research has been continued upon synthetic ribonucleic acids, with a view toward clarifying the relationship between nucleotide composition and chemical and physical properties. In particular polymers of the following compositions were synthesized and studied: Adenylic and uridylic, adenylic and inosinic, adenylic and cytidylic, inosinic and cytidylic, and inosinic and uridylic. All of these synthetic ribonucleic acids, except the last, were found to possess a fractional helical content, as is the case with natural ribonucleic acid.

In collaboration with Dr. H. Edelhoch of NIH, work was also done upon the properties of thyroglobulin, using the technique of fluorescence polarization, for which this laboratory is well equipped. The loss in internal structure, as reflected by a loss in rigidity, which occurred under various denaturing conditions, was studied by this technique. The results of this collaborative work will be published in the Journal of the American Chemical Society (March, 1960).

In addition to continuing the above work upon the properties of mixed polynucleotides, it is hoped to undertake some calorimetric work upon helix-coil transitions in synthetic polynucleotides, in collaboration with Dr. Benzinger and Dr. Kitzinger.

Enzymology and Pharmacology of Acetylcholine Analogs (U), MR 005-06-0010. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; S. L. Friess, Ph. D.

Work on this project has proceeded expeditiously over three related avenues of approach. (1) New tertiary and quaternary aminoalcohol derivatives in the cyclohexane, tropine and pseudo-tropine series have been synthesized, and studied as stereospecific inhibitors of the in vitro acetylcholinesterase system derived from nervous tissue. (2) These derivatives have also been studied intensively as blocking agents on isolated mammalian neuromuscular and ganglionic preparations, as depressants at the CNS level in animals, and as neurotoxins on single excitable nodes of medullated nerve. Important mechanistic information on modes of transmission and blockade in these biological units has been obtained, and cross-correlations between findings in (1) and (2) have indicated that the esterase does not exert a unique control function in the biochemical events associated with excitation-conduction. (3) Certain of these acetylcholine analogs and related natural products have been investigated with respect to toxicologic responses evoked in intact mammals and spontaneous kinetics of their in vitro hydrolysis, as a function of stereochemical variations in their molecular architecture, in efforts to clarify physical details of in vivo drug-biological receptor interaction processes. This work is continuing.

Studies in Acetylcholine, the Enzymology and Pharmacology and Its Analogs (U), MR 005-06-0020. Naval Medical Field Research,laboratory, Camp Lejeune, North Carolina; BuMed 17X1319.1813; E. B. Cook, Cdr, MSC, USN.

Three manuscripts covering work on mice, guinea pigs, and rabbits have been prepared and are being subjected to administrative processing and should be ready for release shortly after January 1961. These papers compare the Magnus and modified Magnus techniques along with certain instrument and chemical factors inherent in the biological assay procedures with isolated tissues (ileal segments). The results emphasize the absolute necessity of carefully delineating the techniques employed in order to make meaningful inter-laboratory comparison of data. Additional work is in progress utilizing tissue homogenates which is designed to measure the distribution of cholinesterase in the

intestinal tract of rabbits (duodenum, jejunum, and ileum) with an attempt to establish a relationship between the cholinesterase levels and these anatomical areas to acetylcholine chloride.

Solubility of Sulfur Hexafluoride in Biological Fluids (U), MR 005-06-0030. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland; J. Sendroy, Jr., Sc. D.

Practically nothing more has been done on this problem in 1960 owing to the necessity of work on other projects.

The effects of proteins and lipids in plasma and whole blood accounting for the marked increase over the solubility in water will be studied for final evaluation. The effect of other hemoglobins, such as CO hemoglobin and methemoglobin, will be compared with that of reduced hemoglobin. To rule out any possible factor of adsorption, Henry's Law will be tested.

Studies on Blood Serum and Its Constituents (U), MR 005-06-0040. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; J. Sendroy, Jr., Sc. D.

Work on subtask 1 has been completed and the subtask will be terminated. In connection with subtask 2, a rapid, precise and convenient spectrophotometric method for the determination of plasma serum or whole blood pH at 37° has been developed. The method requires no standard solutions and a minimum of special apparatus. The effect of protein indicator binding, common to previous colorimetric and spectrophotometric methods has essentially been eliminated by an indicator-diluent solution containing 0.01 M sodium naphthalene-β-sulfonate. Spectrophotometric determination of blood, plasma and serum pH of man, dog, ox and rabbit yielded values 0.13 (+0.03) pH unit more alkaline than glass electrode measurements on the undiluted sample. In the development of this method it was found necessary to obtain added knowledge concerning the dissociation of the indicator phenol red. For this purpose the apparent pK' of phenol red was determined in buffered NaCl solutions of known composition at 25° and 37°, by both spectrophotometric and visual colorimetric measurements. A small but statistically significant difference was obtained by the two procedures, confirming earlier work by Sendroy and Hastings that the Debye-Hückel theory was applicable to the dissociation behavior of the indicator. In a further study of the behavior of phenol red in respect to protein, the plasma serum of 4 species has been shown to interact with phenol red. Spectrophotometric and ultrafiltration studies indicate that the finding is highly species-dependent. These studies have been carried out also with crystallized bovine albumin, within a pH range from 5 to 10.5. The monovalent acid form of the indicator is bound twice as tightly as the divalent alkaline form.

In the future, additional quantitative measurements of the indicator binding by purified human serum albumin will be made.

The Specificity Characteristics of the Erythrocyte Membrane (U), MR 005-06-0050. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Cdr D. E. Goldman, MSC, USN.

The movement of cations across the membrane of the cat erythrocyte has been studied as a function of the physical chemical parameters of the suspension medium. The results can be interpreted in terms of a membrane "carrier" which binds sodium ions but not potassium ions. As in other systems, lithium behaves like sodium; cesium and rubidium behaves like potassium. To explain the different affinities of these ions to the "carrier" a theoretical study of ions in aqueous solution has been made.

Biochemical Reactions of Blood and Its Components, MR 005-06-0051. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; K. C. Hoerman, Cdr, DC, USN, Head, Biochemistry Division.

Preliminary studies were made on the electrophoretic distribution patterns of both permanent and temporary residents of the area with the basic purpose of establishing validity of microsample technics on finger blood in comparison with macro technics on various bloods. Micro and macro technics yielded comparable distribution patterns in temporary (American) residents but significant variations were encountered in permanent residents indicating that micro technics may be misleading in study of nutritional problems in the area. Work on this was terminated by transfer of the principal investigator.

More important was the development of new technics of electrophoresis utilizing starch gel media and ion-modifying compounds in the study of blood hemolyzates. These technics made possible the separation of the abnormal hemoglobin occurring in Thalassemia major from fetal hemoglobin. Hemoglobin E was identified in a native Egyptian. A column electrophoretic apparatus was constructed which is effective in separation of large quantities of pure hemoglobin components. A new catalase zone was demonstrated.

Biochemistry of Erythropoiesis (U), MR 005-06-0060. U. S. Naval School of Aviation Medicine, Research Department, U. S. Naval Aviation Medical Center, Pensacola, Florida; Mr. James K. Colehour, M.S.

An experiment on erythropoietic stimulating factor production has been completed with the following conclusions: Erythropoietic stimulating factor (ESF) is produced in BDF1 mice after a 6-hour exposure to 22,000 feet. It was further demonstrated that these mice have augmented response to hypoxia at the time of increased endocrine function at puberty. Experiments are now in progress in which the erythropoietic effect of various humoral factors are being tested in animals.

R005-07 Hydrobiology

Metabolism of Shell Forming Tissues in Molluscs (U), RR 005-07-0001. Duke University, Durham, North Carolina, Department of Zoology; Nonr 1181(06) NR 104-016; K. M. Wilbur.

This is an investigation of the physiological and biochemical mechanisms operating in the formation of the shell in marine molluscs. Emphasis is placed on the mechanics of shell deposition, the

nature and role of the enzymes active in the production of shell material and the sources of shell carbonate.

Studies of Respiratory Photoinhibition (U), RR 005-07-0002. University of Minnesota, Minneapolis, Minnesota, Department of Botany; Nonr 710(35), NR 104-030; A. H. Brown.

The objective of this task is to study the interrelations of photosynthesis and respiratory metabolism in plants. These interrelations have been investigated over a range of plant materials from free chloroplast preparations to the leaves of higher plants. The investigator has employed isotopes of oxygen and carbon dioxide in experimental vessels, the gas space of which has been monitored with a continuously recording mass spectrometer.

Studies of Coenzymes by Means of Biochemical Mutants (U), RR 005-07-0003. Johns Hopkins University, Baltimore, Maryland, McCollum-Pratt Institute; Nonr 248(02), NR 104-033; W. D. McElroy.

This is an investigation of the role and nature of coenzymes in cell metabolism. Mutant forms of molds and bacteria which require coenzymes or derivatives for growth, are used as test organisms since changes in the mutations following changes made in the coenzyme of the substrate, can be used as a definitive indicator of type and extent of coenzyme effects. Thus, this investigation is both a study of biochemical reactions and the development of a technique for such studies.

Dynamics of Biological Productivity of Plankton (U), RR 005-07-0004. University of Rhode Island, Kingston, Rhode Island, Narragansett Marine Laboratory; Nonr 396(03), NR 104-100; D. M. Pratt.

The objectives of this investigation are the identification and measurement of the environmental factors governing the production and distribution of a marine biological population under the wide range and continuous variation of conditions existing in an estuary. Emphasis is on the distribution and dispersal of plankton blooms, the zooplankton-phytoplankton-bacteria relationships and the effects of the bottom sediments on the productivity of the water mass. Also stressed during the renewal period will be the study of the bottom and near bottom dwellers and their contribution to the ecology of the estuary.

Limiting Factors in Mass Culture of Unicellular Algae (U), RR 005-07-0005. University of Maryland, College Park, Maryland, Department of Botany; Nonr 556(00), NR 104-101; R. W. Krauss.

This task is a basic physiological study of the mechanisms which limit the growth of large populations of unicellular algae. The research is concerned, for example, with nitrogen metabolism, the role of the chemicals in the culture medium, and the action of the metabolic inhibitors on the algae and contaminants in the non-sterile culture. The investigator is also considering the relationships of this research to closed ecological systems and the effects on the viability of unicellular organisms of the environment of a satellite traveling in extra-atmospheric space.

Biological and Oceanographic Characteristics of Long Island Sound (U), RR 005-07-0006. Yale University, New Haven, Connecticut, Bingham Oceanographic Laboratory; Nonr 711(00), NR 104-118; G. A. Riley.

This investigation was designed to determine the species composition, total quantities, and rates of production of phytoplankton, zooplankton, bacteria, and bottom fauna; as well as to examine the relationships between the biological characteristics and the physical and chemical features, including circulation, bottom conditions, dissolved organic and inorganic substances, temperatures, salinities, etc.

Environmental Factors Influencing Certain Marine Biological Populations in Woods (U), RR 005-07-0007. Marine Biological Laboratory, Woods Hole, Massachusetts; Nonr 097(02), NR 104-130; P. B. Armstrong.

This task is designed as a comprehensive study of the total ecology of the nearshore marine environment. It will emphasize the relationships of animal populations to the physical, chemical and geological aspects of the normal substrata.

Nutritional Physiology of Limnoria Lignorum (U), RR 005-07-0009. University of Washington, Seattle, Washington, Department of Zoology; Nonr 477(05), NR 104-142; D. L. Ray.

Limnoria, one of the two most destructive marine wood boring organisms, is one of the few marine animals thought to be able to digest wood by the production of the enzyme cellulase without the assistance of bacterial action. Many questions have arisen in the course of this study of the nutritional physiology of this animal, including such questions of the role of cellulose in the diet, the action of marine fungi in the breakdown of wood fiber, their role in the nutrition of Limnoria, and the possibilities of differences in nutrition or physiology of different species of Limnoria. Visiting investigators from the United States and abroad are being invited to conduct research at the Friday Harbor Marine Biological Laboratory in studies generally related to these problems.

Biology of Underwater Hearing in Amphibians (U), RR 005-07-0010. State University of Iowa, Iowa City, Iowa, Department of Zoology; Nonr 1020(00), NR 104-145; E. Witschi.

The investigator is studying the morphological and physiological characteristics of the amphibian ear in both the larval, water-dwelling and the adult, land and water-dwelling stages of its metamorphosis. This research is directed not only to the clarification of the evolutionary adaptations of the hearing mechanism in the media of air and water but also of the transmission and reception of sound in these media.

Studies on Growth of Attached Barnacles (U), RR 005-07-0011. Duke University, Durham, North Carolina, Department of Zoology; Nonr 1181(10), NR 104-194; J. D. Costlow.

This task is a histological study of the growth processes of the barnacle with emphasis on the possibilities of hormonal or enzymatic control of the molting cycle. Three major areas of study are explored. One entails histological analyses of the developmental stages of the barnacle to determine

changes associated with metamorphosis; two, cytological studies of glandular and nervous tissues which may control molting; and, three, studies of enzyme systems associated with shell deposition and body growth.

Factors Determining Growth in Marine Algae and Protozoa (U), RR 005-07-0012. Haskins Laboratories, New York, New York; Nonr 1111(01), NR 140-202; L. Provasoli.

This is a study of nutritional needs of various members of the marine phytoplankton. Both the production of vitamins and hormones by organisms in the sea and the various requirements of different groups of organisms are being investigated. The complex biochemical relationships among users of nutrients, producers, and competitors are also being examined.

Iodine Utilization by Marine Organisms (U), RR 005-07-0013. Columbia University, New York, New York, Department of Zoology; Nonr 1762(00), NR 104-208; A. Gorbman.

This investigation is designed to study the pathways and rates of absorption of iodine in a number of marine invertebrates and aquatic lower vertebrates. Radioactive iodine is being administered to the organisms and the areas of absorption as well as the sites of deposition and of utilization are being studied histologically and physiologically.

Studies in Marine Biology (U), RR 005-07-0014. Marine Biological Laboratory, Woods Hole, Massachusetts; Nonr 1497(00), NR 104-235; P. B. Armstrong.

A number of relatively short-term field and laboratory investigations are supported under this contract in an effort to fill in important gaps in the present state of knowledge regarding the population fluctuations, distributions and physiologies of marine organisms.

Factors Influencing the Intensity of Bioluminescence (U), RR 005-07-0015. Princeton University, Princeton, New Jersey, Department of Biology; Nonr 1353(00), NR 104-253; F. H. Johnson.

This is a basic study of energy exchange in living systems. The emission of visible light, through metabolic reactions of living organisms or reactions of their products, occurs among representatives of most of the major groups of invertebrates, fishes, bacteria and fungi. Thus, since the phenomenon of bioluminescence presents an easily recognizable indicator of energy exchange, it becomes an excellent tool for investigations of energy transfer. This task includes studies of the mechanisms of energy conversion which result in the emission of visible light as well as the effects of inhibitors, temperatures, and pressure on the luminescence systems of various organisms.

General Biology of Marine Borers (U), RR 005-07-0016. University of Miami, Miami, Florida, Marine Laboratory; Nonr 840(03), NR 104-271; C. E. Lane.

This research project was designed to investigate the fundamental biology of marine borers, with particular attention paid to studies of (1) the respiratory regulation and control in Teredo, (2) survival aspects of the Teredo in wood when removed from water, (3) the complex of cellulase enzymes contained in Teredo, (4) the reproduction of Teredo, and (5) the sensory mechanisms responsible for the Teredo's orientation in its burrowing patterns.

Immunology of Marine Animals (U), RR 005-07-0017. University of California, Santa Barbara College, Goleta, California, Department of Bacteriology; Nonr 035(03), NR 104-272; J. E. Cushing.

This research in the relatively new field of immunology emphasizes the study of the marine animals, their serology, antibody production and their immune reactions, of which very little is known. The investigator is studying two problems specifically; (1) the occurrence of erythrocyte antigens in single species of fish and other marine animals that will be useful in separating different breeding populations within the species; and (2) the ability of organisms other than warm-blooded vertebrates to synthesize antibodies. During the coming period he will emphasize the blood typing of whales and relate his findings to population analyses and evolution.

Behavior and Specificity in Marine Symbioses (U), RR 005-07-0018. University of California, Santa Barbara College, Santa Barbara, California, Department of Zoology; Nonr 035(02), NR 104-275; D. Davenport.

Evidence has been presented that host specificity of commensal species of marine animals with distantly related hosts may depend upon a powerful chemotaxis binding one partner to the other, the attractant being produced by the host. In certain cases these substances affect the behavior of commensals at a distance while in others close proximity is necessary. This research is designed to determine the manner whereby marine symbionts perceive their specific partners. Emphasis is placed on the role and nature of chemical factors which determine host colonization.

Energetics of Ciliary Motion (U), RR 005-07-0019. University of Delaware, Newark, Delaware, Department of Biological Sciences; Nonr 1506(00), NR 104-280; R. R. Ronkin.

Ciliary activities are extremely important to vital processes, such as feeding, reproduction, respiration, locomotion, coordination and response to stimuli in many types of marine and terrestrial organisms. Little is known, however, of the energetic transformations which ultimately result in ciliary motion. In view of the essentially continuous nature of ciliary activity, its energetic conversions may be studied as rate processes and compared with other power manifestations. Thus, this research is designed to investigate the energetics of ciliary motion by correlating measurements of heat production, oxygen consumption, and other metabolic manifestations with ciliary activity.

Physiology of Deep Sea Animals (U), RR 005-07-0020. Bermuda Biological Station for Research, St. George's, Bermuda; Nonr 1135(02), NR 104-281; S. K. Roberts.

This task is an investigation into the physiological adaptations of animals living at great

depths in the sea. Emphasized at this stage will be the integral or organismic physiology of deep sea animals accounting for the expected continuation of the action of the biological "clock" and its evolutionary significance.

Physical and Biological Causes of the Deep Scattering Layer (U), RR 005-07-0021. University of California, La Jolla, California, Scripps Institution of Oceanography; Nonr 233(31), NR 104-305; B. Boden.

This task is an investigation of the relationship between the biological sonic scattering layers of the sea and submarine illumination. The energy spectrum of the illumination at various depths is being measured as are the spectral sensitivities of the organisms associated with the layers. The contributions of bioluminescence to the total illumination is being examined and particular interest is being directed to the occurrence of a photosensitive pigment in Euphausiids.

Mechanisms of Ionic and Osmotic Regulation (U), RR 005-07-0022. University of California, Riverside, California, Division of Life Sciences; Nonr 1842(01), NR 104-309; W. J. Gross.

This study is designed as an examination of the regulating mechanisms by which animals survive and adapt to osmotic stresses in their environment. The study animals are intertidal invertebrates which are normally subjected to a series of changes ranging from near desiccation to submergence in both concentrated and dilute sea water.

Estuarine Ecology (U), RR 005-07-0023. Johns Hopkins University, Chesapeake Bay Institute, Baltimore, Maryland; Nonr 248(46), NR 104-317; D. Carritt.

This is a study of the "energy-chain" as it operates in an estuarine environment (Chesapeake Bay). The investigators are relating the amounts and kinds of inorganic nutrient materials dissolved in the water to the total productivity of the Bay in a step-by-step examination of the constituents of the biological population. Thus, they consider the flow of fixed carbon (energy) from inorganic materials to organic by photosynthesis in the phytoplankton thence through the biota in a series of prey-predator relationships up the food chain. Environmental factors are closely studied to determine their influences on the progress of this energy flow. The problem is seen as a multiple cause-single effect system in which the environment is the cause and the continuation of the biological population is the effect.

The Effect of Temperatures on Marine Borer Growth (U), RR 005-07-0025. Columbia University, Palisades, New York, Lamont Geological Observatory, Biology Department; Nonr 266(41), NR 104-328; R. J. Menzies.

This task is designed with the following objectives (1) to study the apparent relationship between different environmental conditions, principally temperature, and size in Limnoria (gribble) population; (2) to analyze variations in morphology of populations differing in location, environment, size, genetic history, etc.; (3) to investigate the genetic validity of the species under study.

Marine Biology of the Mediterranean (U), RR 005-07-0027. Anton and Reinhard Dohrn Foundation, Naples Zoological Station, Naples, Italy; Nonr 2100(00), NR 104-346; P. Dohrn.

This research project comprises a group of relatively short-term field and laboratory studies to be conducted at the Naples Zoological Station in an effort to fill in important gaps in the present state of knowledge regarding marine biological populations and productivity, and hydrographic conditions in the Mediterranean Sea and its coastal waters.

Studies on Isolated Nerve Fibers (U), RR 005-07-0028. Marine Biological Laboratory, Woods Hole, Massachusetts; Nonr 097(01), NR 104-355; H. P. Smith.

This task has been set up primarily to supply live squid to approximately fifty neurophysiologists and marine biologists investigating nerve impulse transmission and other fundamental aspects of nerve functions. The squid is particularly useful in such experiments because it has exceptionally long nerve fibers which can be dissected out for bioelectric and biochemical studies. Studies of squid eyes, eggs, and chromatophores are also being conducted and depend on the regular supply of live specimens.

Biological Investigation of the SCUBA Zone (U), RR 005-07-0029. Pamona College, Claremont, California, Department of Zoology; Nonr 2246(00) NR 104-365; W. E. Pequegnat.

This project was a study of the ecology, systematics, and zoogeography of the zone below tide level off Corona del Mar, California. The investigator and his students, with the use of self-contained underwater breathing apparatus (SCUBA), observed and collected biological material and environmental notes, and collaterally, in the laboratory, conducted research into the life cycles, growth rates and food preferences of selected species. They also developed techniques for employing the SCUBA as a new and economical instrument for precise marine biological observations.

Fundamental Investigations in Marine Biology (U), RR 005-07-0030. The Rockefeller Institute, New York, New York; Nonr 2317(01), NR 104-378; D. W. Bronk.

A marine biological research post has been established at the Jacques Loeb Laboratory of the Rockefeller Institute for Medical Research at Woods Hole, Massachusetts, and is being supported jointly by the Office of Naval Research and the Rockefeller Institute. Each year a professor of biology preferably from a college of liberal arts is chosen by the Institute and the Office of Naval Research to fill this post for one year. The associate spends a portion of his time at the Institute in New York with a member of the Institute faculty on a research problem of mutual interest. The rest of the year is spent in residence at the Marine Biological Laboratory at Woods Hole.

Segmental Characters of Fishes as Indicators of Coastal Circulation (U), RR 005-07-0031. University of Oregon, Eugene, Oregon, Department of Biology; Nonr 2762(00), NR 104-386; R. W. Morris.

The investigator is examining a series of stages

in the embryonic development of certain fishes for variations in such meristic characters (meristic characters are those that can be characterized by numbers) as vertebrae, fin rays and fin spines. He plans to show that these variations in morphology can be correlated with environmental conditions in the supporting water mass during the embryonic period. The demonstration of such a relationship would prove a valuable tool in tracing the movements of water masses and the pelagic movements of fish populations as well as the mechanisms of speciation in mixed populations.

Effect of Small Organisms on Ultrasonic Waves (U), RR 005-07-0032. Catholic University of America, Washington, D. C., Physics Department; Nonr 2249(01), NR 104-388; R. Meister.

Attenuation and interference by small marine organisms with the propagation of sound in sea water is being studied quantitatively. Ultra-sonic wave transmission is emphasized. The investigator is comparing the velocity and absorption effects of various concentrations of Scenedesmus (an alga) and the eggs of Artemia (the brine shrimp), these representing a difference in size of about 100 times.

Hydrobiological Aspects of Mine Countermeasures Problems (U), RR 005-07-0034. Florida State University, Tallahassee, Florida, Oceanographic Institute; Nonr 988(06), NR 104-396; S. W. Fox.

This project is designed to be a hydrobiological study of the shallow waters in the Northeastern Gulf of Mexico. It will concern itself specifically, with identifying the environmental factors of importance in mine countermeasures problems.

Coral Reef Investigations (U), RR 005-07-0035. New York Zoological Society, New York, New York, College of the West Indies; Nonr 2306(00), NR 104-400; T. Goreau.

This is a systematic reconnaissance and exploration of coral reefs in the Caribbean using skin diving and photographic equipment. Quantitative studies of population densities, growth forms and reef topography are being related to one another and to the ambient hydrographic regime.

Studies in Marine Fouling and Boring (U), RR 005-07-0036. William F. Clapp Laboratories, Duxbury, Massachusetts; Nonr 2318(00), NR 104-403; A. P. Richards.

This task is a study of the occurrence, characteristics and degree of activity of marine borers and fouling organisms on a world-wide basis. Specially constructed test panels which collect both types of organisms are distributed at many stations in the U. S. and foreign waters and are periodically sampled to determine seasonal, geographical and environmental distribution of the various species.

Effects of Polarized Light on Cellular Development (U), RR 005-07-0037. Brandeis University, Waltham, Massachusetts, Department of Biology; Nonr 1677(02), NR 104-406; L. Jaffe.

This was an investigation into the mechanisms by which polarized light is able to influence form and direction of growth. The test materials were the zygotes of the seaweed Fucus and the spores of the common moss Funaria hygrometrica. Differing polarotropisms of the rhizoids and protonemal filaments in response to different wavelengths of light were observed and analyzed. (This work is being continued under RR 005-07-0088 at the University of Pennsylvania.)

Hydrobiological Characteristics of Bottom Sediments (U), RR 005-07-0038. Chesapeake Biological Laboratory, Maryland Department of Research and Education, Solomons, Maryland; Nonr 2299(00), NR 104-408; J. H. Manning.

Seemingly slight disturbances of shallow water and bottoms by natural or mechanical means may contribute to drastic changes in the plant and animal ecology of the shore zone. The investigator is therefore examining the effects of periodic shallow dredging on micro and macroscopic plant and animal populations in certain areas of Chesapeake Bay. The investigator has surveyed the test areas thoroughly analyzing the bottom sediments for particle size distribution, percentage of organic matter and total phosphorus and has been obtaining ground and aerial surveys of rooted aquatic plants and detailed quantitative samples of the micro and macro-faunal population. The bottoms are disturbed with a clam dredge and resurveyed, repeating the initial procedures, at three month intervals. The more basic aspect of this study, the ecological relations between the benthic organisms and the bottom, represents research with ramifications into every phase of hydrobiology.

Cellular Reorganization in Relation to Antigen-Antibody Reactions (U), RR 005-07-0039. Drake University, Des Moines, Iowa, Department of Biology; Nonr 2345(00), NR 104-410; P. Meglitsch.

This research is an investigation and analysis of physiological development at the tissue level of organization. Both growth and repair development are being studied. Supplementary studies are being conducted on the effects of changes in environmental factors upon division rates and reorganization time; and also, on the effects of antisera on reorganization.

Marine Biology in the Central Western Tropical Pacific (U), RR 005-07-0040. Stanford University, Stanford, California, George Vanderbilt Foundation; Nonr 2506(00), NR 104-434; R. R. Rofen.

The investigator studied the ecology of the reef and open waters around the islands of the central western tropical Pacific, particularly the relationships between the biota and hydrographic conditions. These relationships were compared as they differ in lagoons, open ocean waters, reef waters, etc.

Geographical Distribution of Marine Fouling Organisms (U), RR 005-07-0041. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Nonr 3033(00), NR 104-449; B. H. Ketchum.

The investigator collected zooplankton populations for special chemical analysis conducted at a Navy Laboratory. Extensive samplings were made in designated areas. Correlative information, such as salinity, temperature, the abundance of nutrient salts and phytoplankton was obtained routinely. The biomass of the zooplankton populations was also determined.

Marine Phytoplankton Productivity (U), RR 005-07-0042. University of Hawaii, Honolulu, Hawaii, Department of Botany; Nonr 2591(00), NR 104-450; M. S. Doty.

This task is a quantitative study of phytoplankton production of the sea surface in the tropical far western Pacific Ocean. The investigator is using specially designed apparatus and radioisotope techniques developed in his laboratory for intensive quantitative examination of primary oceanic productivity.

Hydrobiological Studies in the Caribbean (U), RR 005-07-0043. University of Puerto Rico, Mayaguez, Puerto Rico, Institute of Marine Biology; Nonr 2468(00), NR 104-456; J. A. Rivero.

The staff of the Institute conduct large scale studies in the hydrobiology of the Caribbean Sea and island waters. Special research by visiting investigators on specific but related short-term studies are coordinated into the total program.

Population Dynamics of Barnacles (U), RR 005-07-0046. University of California, Santa Barbara College, Goleta, California, Department of Zoology; Nonr 035(04), NR 104-465; J. H. Connell.

This is a study of the development and behavior of populations of fouling organisms and the factors which determine the number and distribution of the animals. These factors include population density, competition for limited resources, and interrelationships of predator and prey. Barnacles are used as study animals not only because of their interest to the Navy but because they possess properties which permit accurate assessment of population changes. Their sessile nature allows accurate counting and their intertidal distribution and small size allow experimental manipulation of the environment with sufficient replication to enable estimates of variability to be made. The investigator uses experimental techniques which he developed during past studies of this problem. The study is being conducted at Santa Barbara, California, and comparisons made with similar populations at Friday Harbor, Washington.

Studies of Osmoregulation in Fishes (U), RR 005-07-0047. University of California, Santa Barbara College, Goleta, California, Department of Zoology; Nonr 035(05), NR 104-466; E. L. Triplett.

This is an investigation of the ontogeny of the fish Amphistichus argenteus; with emphasis on the mechanism of interchange of nutrient and waste materials between mother and embryo, and its osmoregulatory system during its development to the adult form.

The body fluids of marine fishes usually have an osmotic potential somewhat less than that of sea water. The regulatory mechanism that prevents dehydration in adults appears in preliminary observation to operate by the elimination of salt through the gill membranes against the diffusion gradient. The embryo, however, is not able to adjust osmotically to sea water. The investigator is attempting to discover the point in development at which the osmotic controlling mechanisms become operative, the time of changes in enzyme activity, and in the differentiation of certain regulatory cells suspected as being active in chloride secretion in these fish. The investigator will also study the development of tissue specificity in these fishes.

Shark Studies (U), RR 005-07-0048. Cornell University, Ithaca, New York, Department of Zoology; Nonr 401(33), NR 104-471; P. W. Gilbert.

This task is concerned with the anatomy and physiology of sharks as a requisite for the evaluation of their behavioral response to sensory stimuli. In examining the physiological mechanisms involved in stimulus reception and response, the investigator utilizes chemical and physical influences and relates the responses to such behavior as locomotion and feeding. He is continuing to study the anatomy of the sense organs of sharks and other elasmobranchs.

Biological Effects of X-radiation on Certain Protozoa (U), RR 005-07-0049. Temple University, Philadelphia, Pennsylvania, Department of Biology; Nonr 2517(00), NR 104-475; R. Wichterman.

The investigator is conducting studies in the effects of several types of radiation on a variety of protozoans. He observes the different levels of resistance of flagellate, ameboid, and ciliate protozoa; determines the effects of radiation on reproductive rates, feeding behavior, cell fragmentation, rate of development of mutants; and compares cytologically, the nuclei of irradiated and non-irradiated cells. He is also attempting to develop and improve standard techniques for the irradiation of micro-organisms.

Biological Problems in Acoustic Systems (U), RR 005-07-0050. University of Maryland, College Park, Maryland, Department of Zoology; Nonr 595(09), NR 104-489; H. Winn.

This is a study of the acoustic characteristics of sounds emitted by aquatic organisms, particularly marine fishes. The investigator will compare the data obtained last year with similar observations on a series of other fishes. He will relate this information to behavioral significance of sounds and its seasonal variation. The investigator will also study the relationship between sound production and electrical discharge in certain of the electric fishes.

Comparative Biochemistry of Proteins (U), RR 005-07-0053. University of Kansas, Lawrence, Kansas, Department of Zoology; Nonr 2724(00), NR 104-497; C. A. Leone.

This task covers three aspects of protein studies (1) the comparative biochemistry of proteins from marine animals; (2) the evaluation of protein homologues in studies in systematics; and (3) the effects of ionizing radiations on the structure of proteins.

Factors Affecting Shark Behavior (U), RR 005-07-0056. University of Hawaii, Honolulu, Hawaii, Department of Zoology; Nonr 2756(00), NR 104-503; A. L. Tester.

This task consists of comparative field and tank investigations of shark behavior in response to a variety of sensory stimuli. Their acuity in perception of visual, auditory, olfactory, electrical, and other stimuli; the effects of environmental

conditions on their responses; the different reactions by single sharks or sharks in schools and by different species of sharks are all being studied.

Antibacterial Activity of Antartic Plankton (U), RR 005-07-0057. Virginia Polytechnic Institution, Honolulu, Hawaii, Department of Zoology; Nonr 2352(02), NR 104-504; J. McN. Sieburth.

The investigator has observed a marked antibacterial activity in the gastric contents of penguins and has traced this activity through the food chain, including the Euphausid shrimp and the plankton. He plans to verify and extend the observation of this activity of Antarctic plankton, to cultivate the active forms and to determine the role of marine bacteria adhering to the plankton.

Fluctuations in Marine Organisms Correlated with Fluctuations in Hydrographic Factors (U), RR 005-07-0066. Stanford University, Pacific Grove, California, Hopkins Marine Station; N6onr 25127, NR 104-901; R. L. Bolin.

The research was designed to investigate the effect of fluctuations in hydrographic factors upon size and movements of populations of marine organisms, and to identify the environmental factors which determine the comparative success or failure of reproductions and early development of the organisms. Populations of marine organisms fluctuate greatly in number seasonally and geographically. Reasons for these fluctuations are not completely understood. In some cases, active migration of the organisms is responsible; in others, the success or failure of spawning has its effect on survival. This investigation considered the seemingly minor changes in the environment which determine the survival of marine populations.

Silica Deposition at the Diatom Surface (U), RR 005-07-0068. University of California, La Jolla, California, Scripps Institution of Oceanography; Nonr 3221(00), NR 104-392; J. C. Lewin.

This research is designed to study the relationship in the diatoms between the protoplasmic cell surface and the silica test by means of electron microscopy, enzyme studies, analyses of developmental changes during division and other stages in the life cycles. Attempts will be made to demonstrate and isolate the chemical mechanism responsible for the deposition and re-solution at the diatom surface.

Trophic Structure and Productivity (U), RR 005-07-0069. University of Texas, Port Aransas, Texas, Department of Marine Sciences; Nonr 375(11), NR 104-435; H. T. Odum.

The Laguna Madre on the Texas coast presents a natural, experimental environment in which a wide range of high salinities (60-100 parts per thousand) is produced by alternate flooding from the Gulf, and evaporation of the sea water in this shallow embayment. The investigator is analyzing the patterns and principles controlling the productivity of the lagoon attempting to relate the distribution of the population components with the salinity gradient and studying the influence of the evaporite conditions on organic deposition and on the metabolism of the planktonic and benthonic elements of the biomass.

Behavior of Plankton in Relation to Hydrographic Factors (U), RR 005-07-0070. University of Miami, Coral Gables, Florida, Marine Laboratory; Nonr 840(12), NR 104-437; H. B. Moore.

This is an analytical study of the reactions of the large, heterogeneous group of marine organisms known as plankton, to certain factors in the changing oceanic environment. Copepods will be used most often as the representative group because they execute an extensive diurnal migration (as much as 250 meters each way) and are small enough to be adequately sampled by nets. Statistical comparisons are made by means of a specially constructed mechanical computer. Work to date indicates that a series of endogenous rhythms are involved which appear to govern the distributions of various species. Verification and amplification of this will be sought.

Nutrients Limiting Phytoplankton Growth in the Sargasso Sea (U), RR 005-07-0071. Bermuda Biological Station, St. George's West, Bermuda, British West Indies; Nonr 1135(03), NR 104-494; J. H. Ryther.

This task is an analysis of the chemistry of the surface waters of the Sargasso Sea as related to the photosynthetic activity of the phytoplankton. The investigator emphasizes the dynamic character of the assimilation and replenishment cycle of nutrients and seeks a meaningful method for the measurement of oceanic productivity.

Bioacoustics (U), RR 005-07-0072. University of Miami, Miami, Florida, Marine Laboratory; Nonr 840(13), NR 104-495; J. C. Steinberg.

This task is a study of acoustical interference of marine biological origin. It considers both active interference by sonic animals and passive interference by suspended plankton and detritus. In studying sonic animals emphasis is placed on the acoustic characteristics of the sounds and the identification of the sound makers. Currently it is planned to install an experimental hydrophone and cable assembly off Bimini, which will terminate in the acoustics laboratory of the Lerner Marine Laboratory, for the study of marine animal sounds and the ambient noise characteristics of the area.

Marine Biology in the Bermuda Area (U), RR 005-07-0073. Bermuda Biological Station for Research, Bermuda, British West Indies; Nonr 1135(04), NR 104-502; W. H. Sutcliffe.

This task provides biological information about the waters surrounding Bermuda. The investigators study phases of marine biology in relation to these particularly interesting waters, or whose research relates directly to the organisms inhabiting this area.

Nitrogen Fixation by Marine Algae (U), RR 005-07-0074. Kaiser Foundation Research Institute, Oakland, California; Nonr 3015(00), NR 104-507; M. B. Allen.

Nitrogen is one of the elements which limits growth of organisms in marine environments. This investigation is aimed at determining whether or not atmospheric nitrogen is used by marine organisms and, if so, what part marine blue-green algae and bacteria play in community utilization of this

nutrient element.

Underwater Sounds of Biological Origin (U), RR 005-07-0075. Laboratoire de Physiologie Acoustique, Juoy-en-Josas (S. and O.), France; N6-2558-2226, NR 104-510; R. G. Busnel.

The investigator examines and characterizes marine biological sounds in terms of their physical parameters, i.e., frequencies, range, intensities; their geographic, seasonal and depth distribution and their origin. In addition, he plans to study the behavior of the sonic organisms in terms of causation of sound making and response to other sounds, biological or non-biological.

Biological Sound and Other Field Research (U), RR 005-07-0076. American Museum of Natural History, Lerner Marine Laboratory, Miami, Florida; Nonr 552(07), NR 104-511; J. A. Oliver.

Primarily this is a series of studies on the mechanisms and characteristics of biological sound as produced and utilized by marine animals. In addition, research on shark development and behavior especially under natural conditions is being conducted.

Benthic Marine Flora of Pacific Central America (U), RR 005-07-0077. Beaudette Foundation for Biological Research, Solvang, California; Nonr 3096(00), NR 104-520; E. Y. Dawson.

El Salvador is essentially unknown biologically; to date there does not exist any account of any species of the major phyla of marine algae. The investigator is examining the collections of algae made by botanists using SCUBA outfits along the coasts of El Salvador. He will identify the specimens and relate their occurrence to ecological factors observed in the field during the collecting. He will also relate this information to that collected from Viet Nam, Marshall Island, Eniwetok, Palmyra, Baja California, and other areas he has studied.

Chemical Analysis of Shark Repelling Substances (U), RR 005-07-0078. Fishery Technological Laboratory, Fish and Wildlife Service, Boston, Massachusetts; NAonr-42-59, NR 104-525; M. A. Steinberg.

It has frequently been observed, both in field experience and in experimentation, that rotting shark meat is an especially effective substance for repelling sharks. The objectives of this proposed research, therefore, are to isolate the active components and to identify them chemically.

Shark Studies Under Field Conditions (U), RR 005-07-0079. American Museum of Natural History, Lerner Marine Laboratory, Miami, Florida; Nonr 552(08), NR 104-526; H. Kritzler.

In order to conduct meaningful research on shark development and behavior it is necessary to be able to observe them in their natural environment. Tests of sensory acuity or responses to sensory stimuli, also require the open water conditions for comparison with laboratory results. This task provides, therefore, for field research into shark development and sensory influences on behavior.

Distribution of Sharks and Shark Attacks (U), RR 005-07-0080. U. S. National Museum, Washington, D. C., Smithsonian Institution; Nonr 1354(07), NR 104-527; L. P. Schultz.

This provides for the establishment and storage of a reference collection of sharks and other elasmobranchs to be used by the investigator as well as by visiting scientists in their research on the systematics, distribution, and physiology of sharks. Portable storage cases will be built as repositories from which preserved specimens can be removed and examined. The central reference file on shark biology, maintained under the basic contract, can be effectively utilized concurrently.

Production of Lipids by Plankton Organisms (U), RR 005-07-0081. Texas A and M Research Foundation, Fort Crockett, Galveston, Texas, Galveston Marine Laboratory; Nonr 2119(03), NR 104-553; A. W. Collier, Jr.

This research represents an attempt to determine the specific origins of organic materials which cause "slicks" on the sea surface, to identify the organic materials, and to trace the physiological and physical activity which results in their release. The investigator will also determine the taxonomic position of the organisms involved and the role of the ecological regime in contributing to the phenomenon.

Coral Reef Investigations (U), RR 005-07-0082. New York Zoological Society, New York, New York, College of the West Indies; Nonr (G)-0003-60, NR 104-556; T. Goreau.

This is a systematic reconnaissance and exploration of coral reefs in the Caribbean, using skin diving and photographic equipment. Quantitative studies of population densities, growth forms and reef topography are being related to one another and to the ambient hydrographic regime.

Systematics of Marine Fauna (U), RR 005-07-0083. U. S. National Museum, Washington, D. C., Smithsonian Institution; Nonr 1354(09), NR 104-566; F. A. Chace.

A large part of the collections made in the tropical Pacific during the past century, including those made recently, such as the "Crossroads" and "Bikini" Resurvey expeditions, the Coral Atoll project and the U. S. Geological Survey collections, are housed in the Smithsonian Institution's U. S. National Museum. This task provides for the systematic review of the material in these collections. This review will provide accurate identifications of the individual specimens and determinations of the taxonomic structure of the groups to which they belong.

Hydrobiological Studies of the Caribbean (U), RR 005-07-0084. University of Puerto Rico, Mayaguez, Puerto Rico, Institute of Marine Biology; Nonr 3203(00), NR 104-571; J. A. Rivero.

This project will encompass a series of related studies of various aspects of the marine environment around Puerto Rico to be conducted by visiting scientists. These studies will be coordinated with the continuing large scale studies of the hydrobiology of the Caribbean being conducted by the staff of the University of Puerto Rico Institute of Marine Biology, as well as with the projects of member institutes of the Association of Island Marine

Laboratories, a group of institutions cooperating in the study of the hydrobiology and oceanography of the Caribbean Sea.

Sea Animal Locomotion Studies (U), RR 005-07-0085. U. S. Naval Ordnance Test Station, China Lake, California, Oceanic Research Division; P. O. 501-747, NR 104-573; T. Lang.

The investigator is examining the hydrodynamic characteristics of live porpoises to determine what anatomical and physiological factors contribute to its remarkably rapid, turbulence-free and silent propulsion and its precise maneuverability. The investigator will measure drag coefficients, maximum power expended, top speed, extent of laminar boundary layer flow, flow pattern around the swimming animal as well as such physiological factors as metabolic rates, characteristic activity of propulsive muscles and muscles under the skin which may act to damp the boundary layer flow actively or passively.

Deoxyribonucleic Acid in the Maturation of Echinoderm Eggs (U), RR 005-07-0086. Jefferson Medical College, Philadelphia, Pennsylvania; Nonr 2504(02), NR 104-577; A. Marshak.

The investigator will attempt to determine by radioautographic procedures whether DNA, the primary genetic substance of cells according to current theory, deteriorates into low molecular weight fragments during certain phases of cellular activity or not; and whether if it does, these fragments in the nucleus, or dispersed in the cytoplasm might not be considered precursors of DNA.

General Biology of the Coelenterate Physalia (U), RR 005-07-0087. University of Miami, Miami, Florida, Marine Laboratory; Nonr 840(17), NR 104-589; C. E. Lane.

The investigator plans to study the biology of Physalia, the "Portugese Man O'War" in relation to its special structural and physiological adaptations to its habitat, locomotion, and food catching methods. He will investigate particularly the mechnisms for the gas secretions into the float, which controls the animal's movement, the circulation of the gastro-vascular fluid and the morphology and cytogenesis of the nematocysts, the poison carrying barbs.

Effects of Polarized Light on Cellular Development (U), RR 005-07-0088. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Biology; Nonr 3330(00), NR 104-597; L. Jaffe.

This is an investigation into the mechanisms by which polarized light is able to influence form and direction of growth. Several test materials have been used, including zygotes of the seaweed Fucus and the spores of the common moss Funaria hygrometrica. Different polarotropisms of the rhizoids and protonemal filaments in response to different wavelengths of light are observed and analyzed. (This is a continuation of work formerly under Task RR 005-07-0037 at Brandeis University.)

Mechanism of Antifouling Action in Paints (U), SR 005-07-1200. University of Miami, Marine Laboratory; NObs-78333; Dr. Chas. Lane.

The contractor is making a detailed morphological study of the processes of normal settlement and attachment of fouling organisms to provide a background against which to determine specific effects of toxic additives.

Once the detailed morphology of attachment is understood in normal animals, it is proposed then to identify the morphological location of functional aberrancies induced by copper, mercury and silver compounds. The specific microscopic localization of ingested toxic materials will be accomplished by techniques of autoradiography.

Since copper, mercury and silver are specific inhibitors of certain metabolic processes, the contractor will determine the direct biochemical effects of these materials when added to isolated enzyme systems of barnacle cyprids.

These approaches to the solution of the problem should provide an explanation for the antifouling action of copper, mercury, and silver. Possibly, they may reveal susceptibilities of attack on the fouling organisms by less critical material than the usual metallic compounds.

Work to date has covered the development settling and metamorphosis of the dominant barnacle in waters off Miami, Florida including a hitherto neglected transitional stage and the process whereby accumulation of copper in tissues is prevented. The attachment process has been investigated with indication that two ingredients are involved. The structure and respiration rates are being determined.

Marine Borer Physiology Study (U), YR 005-07-001. Miami University; NOy 81879, Appn:17x1319.2504, RDT&E Bu. Control No. 25/10696; Sigmund Miller.

The objective of this study was to investigate the life history of marine borers, develop techniques for laboratory culture of larvae suitable for testing specific poisons and control measures under laboratory conditions, and to conduct toxicity studies for the evaluation in control measures.

Greenheart Studies (U), YR 005-07-002. NCEL; Appn:17x1319.2514, RDT&E Bu. Control No. 10601; H. Hochman.

This study is one aspect under an overall program being done at NCEL. The objective was to isolate the component or components of Greenheart which render it naturally resistant to some marine boring organisms. It was then planned to synthesize them and use these artificially produced materials for treatment of other woods to render then also resistant. Nine new alkaloids were isolated which appeared to be somewhat toxic to Toredo larvae. O'Methylated Alkaloids E and F were purified by the chromatography when ether was used as the eluent. More extensive decomposition occurred when the eluent was methylene chloride.

Basic Chemistry (U), YR 005-07-003. Naval Research Laboratory; Appn:17x1319.2504, RDT&E Bu. Control No. 25/10696/701; T. R. Sweeney.

The objective of this task was to study the chemistry of creosote and the relationships of its chemistry to its protective action against marine borers. New work is being undertaken to study the toxicity of organic tin compounds to marine borers.

The work is being performed by the Naval

Research Laboratory with the joint support of ONR and BuDocks, and with the assistance of Marine Laboratory of the University of Miami. Basically, the investigations are concerned with the analysis of the various components of creosotes to determine their toxicity and retention in woods, either alone or in various combinations. The purpose of this is to determine the most suitable combination to use for the prevention of marine borer damage and to develop a standard creosote adequately covered by realistic specifications.

Ecological Studies (U), YR 005-07-004. Clapp Laboratory; NBy 17810, Appn:17x1319.2504 RDT&E Bu. Control No. 25/10696; P. Richards.

The objective is to investigate, by the use of test boards and other reports from Naval stations and other shore activities throughout the world, the incidence and severity of attack by various marine organisms. By analysis of such reports, it is hoped to ascertain the influence of environmental conditions on marine borers and their activity. The information produced is also useful for determining the design requirements of new waterfront structures by providing the level of activity to which these structures will be subjected. Also, the data obtained serves warning of the need for corrective maintenance of existing structures by revealing any changes in the level of borer activity in specific locations.

Piling Preservative Threshold Studies (U), YR 005-07-005. Clapp Laboratory, Duxbury, Massachusetts; Mr. P. Richards.

The objective is to systematically evaluate the retention of different preservatives until the level of preservative is lowered, by leaching, to the point at which attack by marine borers occurs. Failure of wood preservatives against marine borer attack after a period of exposure indicates that the various preservatives have a threshold limit, at which time, the borers begin their attack. This study will attempt to determine the threshold limit of the various most promising preservatives.

Marine Piling Analysis (U), YR 005-07-006. Forest Products Laboratory, Maridon, Wisconsin; Dr. Roy Baechler.

The objective is to have various Naval activities submit samples of exposed piles to the above Laboratory for analysis. The samples desired are: below the mud line, from mud line to water level and above water level.

The results of this study should aid materially in determining the expected service life of piles exposed at different locations. It may also provide information to determine factors concerned with good and bad performance of piles at the various locations.

Chemical Wood Preservative Treatments (U), YR 005-07-007. NCEL; Appn:17x1319.2514, RDT&E Bu. Control No. 10601; H. Hochman.

The objective is to develop materials and/or chemicals and techniques for treating timbers to retard or prevent borer attack.

R005-08 Biophysics

Studies of the Excitatory Process in Biological Systems (U), RR 005-08-0001. University of Minnesota, Institute of Technology, Minneapolis, Minnesota; Nonr 710(34), NR 301-018; O. H. Schmitt.

This investigation is designed to identify and characterize the mechanisms of the excitatory process in biological systems by the use of improved biophysical and biochemical techniques. Living organisms present uniquely efficient models of mechanisms for coordination of complex functions, and a large body of information is available regarding the physiology of the nervous system in higher animals. Much less is known, however, about the physical forces which initiate and operate during the excitatory process in biological systems or the essential chemical transformations involved during this process.

Polarized Light and the Compound Eye (U), RR 005-08-0002. Yale University, New Haven, Connecticut, Osborn Zoological Laboratory; Nonr 609(23), NR 301-091; T. H. Waterman.

In order to study the utilization of polarized light by those underwater animals equipped to detect it, this project includes the study of submarine light polarization; the degree, the effects of the sun's position, the effects of physical properties of the water, and the types and amount of intelligence obtained from this phenomenon by the organism.

Comparative Physiology of Sensory Mechanisms of Orientation (U), RR 005-08-0003. Harvard University, Cambridge, Massachusetts, Biological Laboratories; Nonr 1866(12), NR 301-219; D. R. Griffin.

This task represents a comparative study of orientation mechanisms in a series of organisms. Such mechanisms include not only stimuli receptors but also signal emitters by which animals orient both actively and passively. Past studies having uncovered extremely sensitive auditory capabilities among certain bats, the investigator is now analysing by electrophysiological means, the highly specialized central nervous system of these various species of bats whose orientation behavior has been observed. The investigator is also extending his experiments on long-distance navigation of blinded bats and other animals. Additional research is being conducted on the neurophysiology of the auditory nervous system and the means by which it enables bats to resist jamming of their signals by ambient noise.

Biochemistry and Biophysics of the Mitotic Apparatus (U), RR 005-08-0004. University of California, Berkeley, California, Department of Zoology; Nonr 2643(00), NR 301-237; D. Mazia.

Having succeeded in developing a method for the isolation of quantities of the mitotic apparatus (the structural machinery that operates in cell division) and in discovering several important facts concerning the chemical nature of the mitotic apparatus, the investigator now plans to examine the various components of the apparatus, the centrosomes and chromosomes particularly. He plans also to study the effects of antimitotic agents in inducing changes in structure and disruption of orientation during various stages of mitosis. He will also continue immunochemical studies in an

effort to discover and identify the "precursors" of the mitotic apparatus in the cell before division.

Studies of Orientation in Animals (U), RR 005-08-0005. Duke University, Durham, North Carolina, Parapsychology Laboratory; Nonr 1181(03), NR 301-244; J. G. Pratt.

This task is designed to study the systems and mechanisms involved in migration, homing, navigation, and orientation of birds. Quantitative and qualitative measurements are being made of performance. Stress is being placed upon critical testing to resolve past controversies on the role of random search in orientation as well as to establish the importance of various environmental and geographic stimuli in homing.

Rhythmic Variations in Metabolic Rate (U), RR 005-08-0006. Northwestern University, Evanston, Illinois, Department of Biology; Nonr 1228(03), NR 301-245; F. A. Brown.

The aim of this task is to examine the persistent long-cycle physiological rhythms which have been noted in most living organisms, to determine their functional significance in metabolism. It is also planned to study the mechanisms by which the cycles are set up and phases changed and to characterize the still unidentified external physical factor giving rise to the exogenous protoplasmic fluctuations. Experimentation on magnetic and electrostatic forces will be conducted to determine their effects on orientation and metabolic rhythms.

Hydrodynamics and Sensory Mechanisms of Fishes (U), RR 005-08-0007. American Museum of Natural History, New York, New York, Department of Fishes and Aquatic Biology; Nonr 552(04), NR 301-257; C. M. Breder, Jr.

This investigation is concerned with orientation and locomotion in fishes. Sensory mechanisms of obstacle detection, detection of eddy currents and other water movements, and the possible use of these movements in locomotion and navigation are under study. The investigators are also measuring the expenditure of energy during swimming to discover any special adaptations which may permit long sustained, rapid movement especially in large fishes.

Studies of Photoperiodic Influence on Animals (U), RR 005-08-0008. Washington State University, Pullman, Washington, Department of Zoology; Nonr 1520(00), NR 301-263; D. S. Farner.

It has been ascertained that photoperiodism (the influence of light-darkness patterns) may be an important factor governing the physiological activities and gross behavior of many animals. This task is designed to study the animal cells and tissues exhibiting photosensitive responses and to determine the photoperiodic reactions involved. Efforts will be made to characterize the physiologically active substances liberated in response to photoperiodic stimuli, study their metabolic pathways in the organism and ultimately determine their influence on the behavior of the intact animal. Birds are being used as experimental animals in these studies because of their pronounced reactions to photoperiodic stimuli.

Nature and Significance of Sounds Produced by Fishes (U), RR 005-08-0009. American Museum of Natural History, New York, New York, Department of Animal Behavior; Nonr 552(06), NR 301-322; W. N. Tavolga.

Of growing interest to biologists and acousticians is the phenomenon of underwater biologic noise, its nature and its significance. At present very little is known about this phenomenon. This research is concerned with the analysis and significance of sounds produced by gobiid fishes which are very common sound producers in various geographic localities.

Bird Navigation (U), RR 005-08-0010. Pennsylvania State University, University Park, Pennsylvania, Department of Physics; Nonr 656(14), NR 301-327; H. L. Yeagley.

This task is an effort to determine whether or not or to what degree, birds can discriminate between vertical magnetic field increments and/or can detect radar waves. Results of these studies may provide clues to the nature and action of the mechanisms by which birds are able to orient during migration and homing. These investigations represent an outgrowth of earlier research in which the investigator analyzed various hypotheses concerning animal orientation based on solar, magnetic and coriolis forces.

Comparative Physiology and Chemistry of Biological Clocks (U), RR 005-08-0011. Princeton University, Princeton, New Jersey, Department of Biology; Nonr 1858(28), NR 301-455; C. S. Pittendrigh.

It has become increasingly evident, from this investigator's research and from related studies elsewhere, that many, and perhaps all plants and animals, follow a persistent, periodic rhythm in their metabolic and behavioral processes, which is related to the long period of the solar day. This investigator believes that his evidence implies that these rhythms are endogenous, being based on fundamental mechanisms of self-sustaining oscillations which exist on a subcellular level of complexity, since they are observable in organisms ranging from single celled forms through mammals. This study is directed therefore at the problems of discovering the mechanisms of these self-sustaining oscillations in cellular activity and their role in such major features of biological "clocks" as long natural periods, high precision, and virtual independence from temperature effects.

Telemetric Tracking of Living Organisms (U), RR 005-08-0012. American Electronic Laboratories, Inc., Philadelphia, Pennsylvania, Communications Division; Nonr 2835(00), NR 301-522; R. S. Markowitz.

The American Electronic Laboratories, Inc., will conduct the necessary research and development of a transistorized beacon transmitter which can be carried by various animals for the purpose of relaying information concerning their location, speed and direction of movement with respect to a tracking station. In addition, it is expected that experimentation will be able to provide information necessary for the development of a system for the transmission of physiological data from test animals under natural conditions.

Partial Support of Facility for Studies in Mammalian Intelligence (U), RR 005-08-0013. Communications Research Institute, St. Thomas, U. S. Virgin Islands; Nonr 2935(00), NR 301-541; J. C. Lilly.

On the basis of remarkable findings with regard to the IQ of porpoises, this investigator plans to explore the capabilities of these animals for rapid training for complex tasks. He will use first, brain stimulation by implanted electrodes and attempt to interpret the variety of sounds produced by the porpoise to determine if these highly developed animals communicate with one another by some form of language.

Orientation and Migratory Movements of Aquatic Animals (U), RR 005-08-0014. University of Wisconsin, Madison, Wisconsin, Department of Zoology; Nonr 1202(04), NR 301-903; A. D. Hasler.

This study is an exploration of the sensory mechanisms used by fishes both in their home territory and in migration. Concentrations of schools of fish in spawning migration and during other seasons are mapped using echo-sounding equipment. Attempts are being made also to determine the degree of movement of these concentrations diurnally and seasonally.

Structure of Proteins (U), RR 005-08-0015. California Institute of Technology, Pasadena, California, Gates and Crellin Labs. of Chemistry; Nonr 220(38), NR 304-110; L. Pauling, R. B. Corey.

The structural configuration of natural proteins is under study with the eventual object of accomplishing the laboratory synthesis of proteins and protein-like compounds. Information on amino acid composition and sequence, spatial relationships involved in the folding and coiling of the molecule, and similar details is being obtained by chemical determination, X-ray diffraction studies, construction of precise molecular models, enzyme specificity studies, etc.

Properties of Gels (U), RR 005-08-0016. University of Wisconsin, Madison, Wisconsin, Department of Chemistry; N7onr 28509, NR 304-155; J. D. Ferry.

The mechanism of the formation of gels by proteins, nucleic acids, pectins, and other macromolecules is being investigated by means of a detailed study of the physico-chemical properties and behavior of the gels.

Absorption Spectra of Peptides and Proteins in the Far Ultraviolet (U), RR 005-08-0017. The Chicago Medical School, Chicago, Illinois; Nonr 1655 (01), NR 304-303; L. J. Saidel.

The ultraviolet absorption of proteins and of their component protides are being determined and compared with the object of developing another technique for establishing amino acid sequences in proteins. The same thing is being done for proteins and their component protides after treatment with cross-linking agents in order to determine (a) the amino acids irreversibly affected, and (b) the pairs of amino acids so situated that they will be joined by cross-linking agents. Insulin will be the first substance studied in this phase of the project because the amino acid sequences in its double chain are already known.

Relationship between Protein Structure and Protein Function (U), RR 005-08-0018. University of Minnesota, Minneapolis, Minnesota, Institute of Technology, School of Chemistry; Nonr 710(15), NR 304-306; R. Lumry.

To investigate, through the study of reaction kinetics, how the structure of a protein affects its activity. Dielectric properties are being studied and depolarization of fluorescence experiments are being carried out. Proteins under investigation are hemoglobin, enzymes, and the chlorophyll-lipoprotein complex found in higher plants.

Mechanism of Photosensitization in Photosynthesis (U), RR 005-08-0019. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Chemistry; Nonr 624(08), NR 304-416; J. L. Rosenberg.

Electronic energy transfers during photosynthesis are being studied to find out (a) whether energy for photosynthesis passes through the metastable state of chlorophyll, (b) whether pigments other than chlorophyll show initial light-induced reversible changes, and (c) whether kinetic evidence can be obtained for intermediates in the path of oxygen in photosynthesis.

Magnetic Susceptibility of Single Biological Cells (U), RR 005-08-0020. University of Colorado, Boulder, Colorado, Department of Chemistry, Nonr 1147(08), NR 304-435; M. Downing, S. Gill.

To measure the magnetic susceptibility of a single bacterial cell during its life cycle in a suitable nutrient medium, and to observe the effect of a magnetic field on the behavior of the cell during its growth processes.

Study of Radiation Damage (U), RR 005-08-0021. Roswell Park Memorial Institute, Buffalo, New York, New York Department of Health; Nonr 2975(00), NR 304-457; H. C. Box, H. G. Freund.

An attempt is being made to identify the free radicals which are formed in biological materials by ionizing radiation and which are presumed to be responsible for damage to the materials. Simultaneous electron and nuclear resonance absorption will be determined on samples of simple biological compounds--crystalline amino acids, di- and tri- peptides.

Photosynthesis (U), RR 005-08-0022. RIAS, Baltimore, Maryland, Nonr 3025(00), NR 304-462; H. J. Trurnit.

One of the problems still challenging workers in the field of photosynthesis research is the mechanism by which plants convert light energy into chemical energy. This is an attack on the problem by intensive study of the relationship between (a) light absorption and metabolic activity under various environmental conditions, and (b) chloroplant lamellar arrangements, light absorption, and electron transfer.

Investigation of Function of Intracellular Structures by Irradiation with Soft X-Rays (U), RR 005-08-0023. Stanford University, Stanford, California, Biophysics Laboratory; Nonr 225(51), NR 304-471; H. H. Pattee, V. W. Burns.

The functions of subcellular structures will be studied by selectively damaging individual structures in single cells with a micro-beam of low energy X-rays. The effects of radiation are to be followed by observing the structure and behavior of the cell after irradiation and by cytochemical study. The first phase will be the development of a micro-beam X-ray source of about 1 micron (u) diameter with dose rates up to 10^5-10^6 r per second/u^2 and an incident light, phase-contrast optical system for viewing the specimen during irradiation. The second phase will involve various biological studies such as (1) research on the radiosensitivity of cytoplasm and other sub-cellular changes during growth and division, and (2) investigation of the detailed functions of sub-cellular structures such as the nucleolus.

Electron Spin Resonance Studies of Photosynthetic Systems (U), RR 005-08-0024. San Diego State College, San Diego, California, Division of Physical Sciences; Nonr 2984(01), NR 304-473; P. B. Sogo.

This is a study of the photo-induced ESR signals in photosynthetic systems. The first phase of the research is the design and construction of (a) an X-band electron spin resonance spectrometer with very high sensitivity, fast rise time and capable of electron-nuclear double resonance measurements; and (b) associated equipment such as a cryostat and a high intensity monochromatic light system. The second phase of the study is to obtain quantiative measurements such as: (1) the kinetics of the rise and decay of the photo-induced signal; (2) the quantum efficiency for the production of the unpaired electrons; (3) nuclear hyperfine interactions with the unpaired electrons; (4) electron spin resonance saturation of the observed signal. These measurements are to be made as a function of such variables as: (a) the temperature of the sample; (b) the wavelength and intensity of the incident light and (c) the time exposure to the incident light in pulsed light experiments.

Peptide Infra-Red Spectra (U), RR 005-08-0025. Smith College, Northampton, Massachusetts, Department of Physics; Nonr 1594(00), NR 304-476; G. A. Anslow.

This is an investigation of the structure of proteins by (a) identifying by means of infra-red spectroscopy, chemical groups which are hydrogen-bridged in the protein fabric and in protein synthesis; and (b) analyzing X-ray diffraction patterns of native, functioning proteins to determine their atomic and molecular arrangements.

Radiation Induced Free Radicals (U), RR 005-08 0026. Stanford University, Stanford, California, Biophysics Laboratory; Nonr 225(36), NR 304-492; M. Weissbluth.

This research involves the study of free radicals produced by ultra violet, X-rays and electrons in materials of biological interest. Thermoluminescent spectra and EPR signals are to be measured with the intent of studying the electronic energy bands and semiconductivity of these materials. Also, the biological reactivation characteristics of some macromolecules are to be studied and their possible connection with the decay of EPR and TL signals will be investigated.

Electron Microscopy (U), RR 005-08-0027. Stanford University, Stanford, California, Department of Physics; Nonr 225(42), NR 304-493; H. H. Pattee.

Analyses are made of macromolecules and their biologically identifiable fragments using microspectrographic techniques in the optical, ultraviolet, and soft X-ray spectrum. Comparisons are made of these analyses with those that can be made with the electron microscope. An attempt is to be made to achieve an optimum combination of electron and optical techniques for problems of specimen preparation.

Study of the Vibration Receptors in Spiders (U), RR 005-08-0028. Harvard University, Cambridge, Massachusetts, Department of Biology; Nonr 3225(00), NR 301-549; C. Walcott.

The investigator is studying the vibration receptor in spiders. This structurally simple organ also functions as an auditory receptor of wide range and discrimination and displays many other unusual capabilities making it a valuable model for studies of biological transducers that convert sonic energies into nerve impulses. Both behavioral and electrophysiological methods will be employed.

Mechanism of Direction Sense in Animals (U), RR 005-08-0029. University of Milan, Milan, Italy, Department of Physiology; Nonr 3148(00), NR 301-550; T. Gualtierotti.

A new approach to the investigation of direction sense in migratory and homing birds has been provided by study of the cerebellar response to acceleration. This approach is based on the assumption that pathways of sensory receptors from the eyes, ears, skin and muscles converge in the cerebellum where visual and acoustic clues, gravity and acceleration, temperature and other position assessments are integrated. The investigator is making comparative measurements on migratory and non-migratory animals to note the differences in residual electrical activity in the cerebellum in response to rotation, magnetism and light. Experiments in genetic transmission of homing ability are also conducted.

Investigation of Living Systems as Models for Antenna Design (U), RR 005-08-0030. University of Arizona, Tucson, Arizona, Applied Research Laboratory, College of Engineering; Nonr 2173(05), NR 301-578; H. A. Baldwin.

This task is concerned with the investigation of living systems in an attempt to provide insight into electronics design techniques. The investigator is developing electronic models of natural optical and infrared receptors matching as closely as possible their microwave frequencies, band width, gain impedance and efficiency. He is examining such natural antennae as the hairs of the Luna moth and the rods and cones of the human eye to determine their characteristic signal level discrimination, spectral range sensitivity, and variation of integration time as a function of signal amplitude.

Biological Applications of Statistical Methods

(U), RR 005-08-0031. The Catholic University of America, Washington, D. C.; Department of Mathematics; Nonr 2249(05), NR 301-579; E. Lukacs.

This task is concerned with biometry and applications of statistical methods in the biological sciences. The statistician consultant assigned to the program is available to consult with and advise investigators on the planning of biological experiments from which statistical information is sought and on the mathematical interpretation of resulting data.

Behavior and Sensory Physiology of Sharks (U), RR 005-08-0032. University of Miami, Miami, Florida, Marine Laboratory; Nonr 840(19), NR 301-587; W. J. Wisby.

To investigate systematically, in the field as well as in tanks and in pens, the sensitivity and acuity of the sense organs of various species of sharks. Of particular concern at this time is the determination of the range of sensitivity of the auditory system in the perception of low frequency sound. Changes in respiratory rate are used as an indication of reaction.

Significance, Effects and Physics of Non-Thermal RF Fields (U), RR 005-08-0033. New England Institute for Medical Research, Ridgefield, Connecticut; Nonr(G) 008-61, NR 301-602; J. H. Heller.

It is planned to convene a group of experts in fields encompassing biophysics, geophysics, and animal behavior to explore the non-thermal effects and the mechanisms and significance of the effects of radio frequency fields in influencing such phenomena as biological orientation, crystal growth, molecular interactions, and other pattern changes in which they have been observed.

International Biophysics (U), RR 005-08-0034. National Academy of Sciences, Washington, D. C., Division of Biology and Agriculture; Nonr 2300(19), NR 304-480; F. L. Campbell.

The advancement of pure and applied biophysics on an international scale is being promoted by fostering the necessary committees, meetings, conferences, and symposia preparatory to the establishment of an International Union of Biophysics. It is intended that this organization will eventually become a member of the International Council of Scientific Unions.

Substructure of Viruses (U), RR 005-08-0035. University of Pittsburgh, Pittsburgh, Pennsylvania, Division of Natural Sciences, Department of Biophysics; Nonr 624(12), NR 304-489; M. A. Laufer, I. Bendet.

Investigations aimed at elucidating the internal structure of virus particles will be made by studying (a) the physical factors contributing to the birefringence of T_2 bacteriophage gels, (b) the thermodynamics of polymerization of tobacco mosaic virus protein, and (c) the effect of ionizing radiation on the depolymerization of virus nucleic acid.

Mechanism of Ciliary Movement (U), RR 005-08-0036. University of California, Los Angeles, California, Department of Zoology; Nonr 233(65), NR 304-502; T. L. Jahn.

The mechanism of ciliary movement is to be studied by the following approaches: (a) investigation of effect, on protoplasmic streaming and ciliary motion, of a number of metabolic inhibitors and accelerators; (b) investigation of effect of lipoid solvents, detergents, etc., on structure of cilia and cell membranes; (c) investigation of effects of drugs that can affect neurons by changes in polarization; (d) investigation of effects of ions on galvanotaxis (the relation of motion of an organism to the direction of electrical current in the medium).

Biophysical and Biochemical Studies on Electric Organs and Membranes (U), RR 005-08-0037. University of California, Los Angeles, California, Department of Zoology; Nonr 233(66), NR 304-503; B. C. Abbott.

This project consists of: (1) A study of the thermal, electrical, physical and chemical properties of the electric organs in the electric ray Torpedo, electric eel, and other types of similar fishes. Related histological and anatomical measurements are to be made. (2) A study of the effects of the neurotoxin from the small unicellular alga Gymnodinium breve. Various physiological studies will be made using the toxin, including its effects on membrane potentials, membrane impedances and on frog skin ion exchanges. Also, metabolic (thermal and respiratory) studies of muscle tissue under the action of the toxin will be made.

Electro- and Photo-Conductive Properties of Solid Nucleic Acids (U), RR 005-08-0038. Indiana University, Bloomington, Indiana, Department of Chemistry; Nonr 908(17), NR 304-512; W. J. Moore, H. R. Mahler.

This is a systematic investigation of the electro- and photoconductive properties of carefully characterized preparations of desoxyribonucleic acid (DNA), ribonucleic acid (RNA), and simple polymers of their constituents, e.g., polyadenylic or polyuridylic acids. The study will include determination of the presence or absence of photoconductivity and measurement of dark conductivity by electrons and possibly by protons.

Charge Transfer in Biological Materials (U), RR 005-08-0039. Western Reserve University, Cleveland, Ohio, Physics Department; Nonr 1439(08), NR 304-516; J. W. Weinberg.

This research is concerned with measuring the properties of electronic states involving transfer of charge within and between linear highly polymerized molecules of biological interest. Fibers of polynucleotides, polysaccarides and polypeptides including natural and modified DNA, hyaluronic acid and collagen will be used. Monocrystalline powders which are similar to these fibers will be used as controls. Measurements of semiconductivity and photoconductivity (where there is no detectable semiconduction) will be used as the indices of cooperative action among molecules. The conductivity measurements will include (a) direct current conductivity measurements as a function of temperature in the range from room temperature to 200°C and (b) measurement of alternating current

complex conductivity as a function of frequency. The photoconductivity measurements will include measurements of capacitance changes and Q values as the function of variation in illumination intensity and wave length. These measurements will be made on crystals or short fibers closely packed between two pairs of parallel platinum electrodes at right angles to each other. Preliminary exploratory measurements of electron paramagnetic resonance absorption will also be made to remove possible ambiguous interpretation of conductivity measurements and also to resolve conductivity into number of carriers and mobility.

The Effect of Physical Forces on Biological Systems (U), MR 005-08-0020. Naval Medical Research Institute, Bethesda, Maryland, Cdr D. E. Goldman, MSC, USN.

Muscular contraction is the primary biological process being studied under hydrostatic pressure. To understand the influence of elevated pressure, it has been necessary to reexamine the contractile process at normal pressure. Muscular excitation is being studied by microperfusion of isolated myofibrils. It has been found that calcium ions (but not magnesium, sodium, or potassium) elicit the contractile response. Muscular contraction is being studied through the mechanical transients which reflect the working of the contractile element. The isotonic velocity transients have been measured experimentally. Corresponding predicted transients are being worked out for several models on a high speed digitals computer.

The technique previously developed in this laboratory for determining the electrical properties of lobster giant axon membrane gap technique, instead of micropuncture, has been improved to the point where accurate voltage clamp measurements can be obtained. The technique is now being used to study the effects of the ionic environment on the behavior of the axon. Plans are being made to return to studies on the effects of rapid mechanical distortion as a means of investigating membrane structure and as bearing on the behavior of mechano receptors of the body.

Tissue Dose Measurement of Ionizing Radiations from Atomic Weapons (U), MR 005-08-1001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt F. W. Chambers, Jr., MSC, USN.

Much effort has been devoted toward the development of a miniature chemical dosimeter (Trichlorethylene) which contains only a small volume of solution and which would respond in a precise manner to low levels of ionizing radiation in an energy-independent manner. As reported, some success has been achieved with this system when employed in higher radiation intensities. During this reporting period, emphasis was placed upon development of precision atmosphere control, glass cleaning and sealing techniques, and in the search for other types of containers compatible with the trichlorethylene system, all of which might facilitate low level response to gamma and neutron radiations. To the present moment, little success can be demonstrated toward the achievement of the listed goal despite the employment of rigorous and fastidious techniques. Additional investigation is planned for the described system, but other methods of making low level measurements will be investigated.

Medical Problems Related to Ionizing Radiation (U), MR 005-08-1100. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt F. W. Chambers, Jr., MSC, USN, Capt R. B. Williams, Jr., MC, USN, Dr. F. Ellinger, M.D.

Radiation mortality produced by total-body irradiation is studied in a variety of small laboratory animals irradiated under varying exposure conditions for the purpose of (a) obtaining correlation factors for the extrapolation to man of animal data on statistically sound basis, (b) to serve as a baseline for therapeutic studies. Lethal dose studies on mice and guinea pigs are completed. Those on rabbits and action mechanism studies in all three species are in progress.

Recent progress has been made in distinguishing a residual recoverable component of irradiation injury from a residual irrecoverable component, and in distinguishing biological effects upon stem cells in different stages of interphase. Threshold levels for these biological effects that relate to the rate of recovery versus the rate of injury have been demonstrated. It has also been shown that certain rapidly proliferating steady-state tissues essential to life can undergo recovery under continuous irradiation in total doses that have been shown to completely destroy the cells involved when given over a few minutes rather than days. The rate of recovery or interphase time of stem cells may vary from hours to months in different tissues. This results in the demonstrable fact that while one might list the following tissues in decreasing order of sensitivity from a "relatively high dose" of total-body ionizing radiation, namely, the rat small bowel epithelium, bone marrow, skin and testis, the same total dose delivered at a much lower, or decaying dose rates as in a fallout area, would be most likely to produce serious biological effects in just the reverse order, namely, testis, skin, bone marrow, and small intestine.

During this reporting period, nine groups of 12 swine each, and two groups of 2 swine each, were processed and irradiated in the Whole Body Cobalt^{60} Irradiator at controlled radiation levels. Physical responses have been carefully recorded and summarized into monthly intradivisional reports. Pathological studies and other investigations upon these animals are currently under way in the NMRI Department of Pathology.

The application of Victoreen and Sievert miniature type chambers and AdLux film has been pressed during this period of report. Additionally, the 8" Rossi Spherical Proportional Counters and associated equipment have been concentrated upon. At the present time the whole assembly has been made into a portable self-sustained unit complete with vacuum system, manifold, gages and amplifier circuit. A series of test runs has been made in conjunction with the Penco Pulse-Height Analyser located at the U. S. Naval Hospital, in a preliminary effort to measure linear energy transfer of mixed radiation beams.

Fundamental Studies in Radiobiology (U),

MR 005-08-1200. U. S. Naval Radiological Defense Laboratory, San Francisco 24, California; Dr. Edward L. Alpen.

1. Physiological Effects of Sub-lethal Exposure to X or Neutron Radiation: The cumulative incidence of tumors has been found to exceed 85% over the life span of exposed and unexposed animals. Therefore total incidence figures are not meaningful; however, time of onset and distribution of tumors by types were sharply altered by radiation. Renal neoplasms have been observed only in irradiated animals. Tooth growth defects, renal neoplasms, and lens opacification seem to be radiation specific rather than general aging changes. Long range physiological and performance studies are continuing.

2. Studies on Acute Recovery and Residual Injury: The findings on residual injury in rats exposed to multiple 300 or 400 rad doses have been confirmed in dogs receiving repeated exposures. Again the accumulation of residual injury is shown to be a function of the remaining capability of the animal to withstand radiation stress. In the dog, X radiation with repeated exposures of 150 rad is more effective in producing residual injury and eventual death than is neutron irradiation. The incremental damage to the erythroid system has been shown to be also true for the myeloid and megakaryocytic systems. Acute recovery studies in mice, rats, rabbits, and sheep are leading to preliminary conclusions. The acute recovery phenomenon is not a simple exponential decrease of injury as has been postulated but is complicated and often multiphasic. In several species it has been possible to show increased radioresistance at short times after a radiation exposure. The sheep has been shown to recover extremely slowly, and with divided doses it has been found that as little as 10-30% recovery of a single dose may occur in 42 days.

3. Dose Fractionation and Late Effects: Studies have continued on the pathogenesis of one of the principal late lesions following high sub-lethal doses of radiation, namely, nephrosclerosis. This factor is severe enough to be significantly implicated in post-irradiation life span shortening. In mice the lesion has a latent time of 20 weeks after 690 rad of X-rays and is characterized as a progressive glomerular proliferation of large, irregular, pleomorphic cells in the intercapillary spaces. A large population of sheep and burros which have been subjected to sub-lethal doses of X-rays or neutrons has now been accumulated, and studies will continue for some years on the slowly developing post-irradiation pathology. Particular attention is being paid to the late thrombocytopenic difficulty which has been reported by others.

4. Organ Regeneration and Growth as Affected by Radiation: The effects of irradiation on the mitotic process has been approached in a number of ways. Principally the work reported on earlier has led to the finding that repeated resection of the liver of irradiated rats leads to regeneration without loss of the defective mitotic population. Incidences of 85-90% defective mitoses in the first regrowth cycle after radiation are not reduced in subsequent regrowth cycles. In addition the mouse kidney has been shown to have a highly radiosensitive period following a stimulus for compensatory hypertrophy produced by unilateral nephrectomy. X-ray exposure (690 rad) 2 hours after nephrectomy has a profound inhibiting effect on the mitiotic rate in the remaining kidney. Time studies show this period to be short and lead to the conclusion that radiation is influencing some premitotic change in the cell.

5. Critical Organ Studies: The most significant finding during this period is that X radiation in moderate doses produces an outpouring of granulocytes from storage areas into peripheral blood within a few hours. The mechanism for this rapid cellular shift is being studied by autoradiographic means. Studies on in vivo and in vitro gut preparations have shown that doses of X rays which cause bone marrow death do not cause significant loss of sodium and water through the mucosa; however, the electromotive work of the mucosa is very significantly reduced by such doses at 7 days post-irradiation.

6. Bone Marrow Therapy of the Acute Radiation Syndrome: Successful takes of genetically foreign bone marrow (i.e. homologous) have now been obtained in the dog after doses of 900 rad. The necessary conditions for these successful grafts have included intensive pre-exposure treatment with chemotherapeutic drugs, and multiple post-exposure injections of large quantities of foreign marrow. Secondary disease occurs in 20-25 days following the homologous implantation. No dogs have survived this phase. Studies have continued on the post-transplantation chimera, and significantly it has been shown that immunolgically competent cells capable of causing rejection of the graft can be transferred in whole mouse blood.

7. Biochemical Alterations and Metabolism: Contrary to expectation, it has been shown that X irradiation causes an increase in the highly unsaturated fatty acids in liver cell fractions, including mitochondria. Alterations in subcellular structures of the liver were observed by electron microscopy as early as 15 minutes after 300 rad. The hypocalorically reared rat has been shown to have a lowered radioresistance, with its LD_{50} reduced by 80 rad. It characteristically does not develop a post-irradiation anorexia as does the normal rat.

8. Biological Effects of Radioactive Materials: Experiments with Tritium have, in preliminary experiments, shown that skin contact transfer, from surfaces where mechanical removal of the tritium is impossible, can lead to removal of as much as 40% of the attached radioactivity. This transfer is probably through the mechanism of exchange with hydrogen of the skin surface. Equipment for long term exposure of small animals to tritium have been completed and proof tested.

Medical Problems Related to Ionizing Radiation (U), MR 005-08-1300. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Dr. F. Ellinger, M.D., Capt F. W. Chambers, MSC, USN, (Ph.D.)

Development of treatment procedures for victims of exposure to lethal doses of ionizing radiation is effective if administered after radiation. Studies are centered around cell-free spleen extracts and the use of hormones, vitamins,

antibiotics, etc. applied singly or in combinations. Protective effect of cell-free spleen extracts in mice and guinea pigs is established. Preparatory steps for large scale production of spleen extracts, chemical identification and isolation of active principle as well as histological studies of the action mechanism are in progress.

In connection with the development of improved ionization chamber-type instrumentation for radiation dosimetry, further evaluation, using various energy spectra, of machined ionization chambers has been effected. Tests have been made utilizing different body-insulator-antenna combinations, including aluminum, tissue-equivalent plastic, polystyrene, Kel-F and Teflon. Additionally, tests are under way to establish chamber performance when encapsulated in outer envelopes designed to permit both implantation in hard and soft tissues, and variation of gas environments, such as differing tissue-equivalent gas combinations. Further exposures are planned for these chambers so as to permit tissue response evaluation. A report of these investigations has been made to DASA on 13 July 1960.

Work presently in progress on the intestinal syndrome following radiation indicates that in dogs in which 80% of the small intestine is exposed to 3000 r - X-radiation the animal may survive if fed intravenously during the first 10 days following exposure. This finding is interesting inasmuch as it is now considered that irradiation of the intestine is almost equivalent to total body radiation. Our work shows that this is not true. Work planned entails the measurement of ATPase following irradiation of the intestine, changes in total body water following total body radiation, and catechol amine plasma levels following total body radiation.

R005-09 Control and Prevention of Disease

Development and Testing of Sanitary Equipment and Field Sanitation Studies (U), MR 005-09-0010. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; BuMed 17x1319.1813; K. L. Knight, Capt, MSC, USN.

Studies on biology of salt marsh mosquitoes - The laboratory and field studies on the factors regulating selection of oviposition sites are being continued. The phase of this study relating to the role of free and bound moisture in determining the suitability of a site for oviposition has been largely completed and a report is being prepared. Laboratory work on the effect of soluble salts in the ground water on oviposition site selection is being continued. The taxonomic phase of this study is being written up for publication.

An evaluation of a deodorizer product "Timsen-Air" has been accomplished and a report is being prepared. The purpose of this evaluation was to determine if the product has potential value for use in field latrines by the Marine Corps.

Life Cycles of Malaria Parasites as Related to Genetics and Immunity of Hosts (U), MR 005-09-1030. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland; C. G. Huff, Sc. D.

Work being done: 1) Investigations on the fine structure of exoerythrocytic stages of malaria; 2) tissue culture of avian and simian malarial parasites; 3) effects of ultraviolet microbeam upon the interrelations of host cells and their malarial parasites; 4) analysis of factors responsible for susceptibility of mosquitoes to malaria. Nature of work and how it is to be done: All lines of work classify as attempts to better understand the relations between malarial parasites and their hosts, both vertebrate and mosquito. No. 1 above is the morphological approach using the electron microscope; No. 2 employs special methods of tissue culture initiated from infected chick embryo tissues and from the infective forms of simian malaria dissected from mosquitoes, phase contrast microscopy, and time-lapse cinephotomicrography; (3) utilizes the effects of radiation of micro areas of parasite or host cell by means of a special UV microbeam apparatus and time-lapse cinephotomicrography; and (4) employs special techniques of producing parabiotic twins of susceptible and insusceptible mosquitoes and injection of various stages of malarial parasites into susceptible and insusceptible mosquitoes followed by study of the fates of these parasites.

The work under subtask 5 is being continued with studies on the tolerance of larval and pupal stages of Aedes aegypti, Anopheles quarimaculatus, and Culex pipiens to gamma radiation with particular attention to the effects on adult fertility and longevity. The work on Aedes aegypti is about completed and barring any unforeseen developments a report will be prepared soon. The work on Anopheles and Culex continues. Studies on the morphological and physiological effects of varying doses of ionizing radiations on the sporogonous cycle of Plasmodium gallinaceum in A.aegypti were somewhat expanded but they have been completed and submitted for publication and as an NMRI report. In this study, the morphological changes which occur in vivo, as a consequence of the exposure to gamma radiation, have been described in considerable detail, and demonstrated in part in photos which accompany the test. In summary, it has been shown that a certain proportion of the parasites survive exposure to 5,000 r, 10,000 r, and 15,000 r, and complete their development to produce viable sporozoites even though the rate of development may be retarded to a lesser or greater extent. None of the parasites, however, survive exposure to 20,000 r or more. Further, regardless of the amount of radiation that has been administered, vacuole formation around the k-granule of the parasite appears uniformly as the first, and for a time, as the only specific cytological effect resulting from the exposure to radiation. In addition, the Brownian-like movement of the parasite granules which typically occurs in degenerating drug-treated parasties has been found to occur also in parasites exposed to gamma radiation. Other evidences of similarities between drug effect and radiation effect have also been cited.

Bionomics and Control of Human Schistosomes (U), MR 005-09-1031. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; C. G. Huff, Sc. D.

Methodology developed for the analysis of glands and secretions of cercariae while within snail

hosts, newly emerged, and in skin permit their morphological histochemical and physiological comparison as well as the collection of secretion in quantity for antigenic and physico-chemical analysis. Present findings include: mucoid postacetabular gland secretion is deposited only on skin or in India ink-saline; preacetabular gland secretion is stimulated by sebum or vaseline but not by albumin; entry and migration are inhibited by intravital staining of preacetabular glands with purpurin, indicating their involvement in penetration; unstimulated cercariae do not secrete. Physiological comparison of free and penetrated cercariae showed that: water-tolerant, saline-intolerant cercariae became water-intolerant, saline-tolerant schistosomules and cercariae serologically capable of envelope formation in antisera became incapable immediately after penetration. Additionally, envelopes were not formed in vivo and envelope-sheathed cercariae did not penetrate. Electrophoretic fractions of normal and schistosome-infected rabbit serum and of trypanosome-infected rat serum continuously separated permit localization of and physico-chemical and immunological study of the respective antibodies produced.

Bionomics and Control of Human Schistosomiasis (U), MR 005-09-1032. Naval Medical Research Unit No. 2, Box 14, APO 63, San Francisco, California; Cdr R. E. Kuntz, MSC, USN.

During the past year a survey has been completed using intradermal tests as an indication of infection by Schistosoma japonicum, Paragonimus, Clonorchis and Fasciolopsis. A number of persons in Chang Hua Hsien, an area recognized as endemic for zoophilic schistosomiasis, showed positive reactions. Stool specimens from peoples included in the survey are being processed to correlate the actual presence of parasites with dermal reactions and to determine whether autochthonous cases of infection by S. japonicum occur. It is suspected that strong reactors have had contact with bird or other lower animal schistosomes.

Investigations have continued on a cooperative basis with the 406th Medical General Laboratory, Japan, in an endeavor to demonstrate geographic strain differences in S. japonicum that occur in Japan and on Taiwan. Infected snails (Oncomelania) are forwarded regularly to Japan to permit challenging and cross infections of definitive and intermediate hosts with parasites from the two areas. Studies have not progresses sufficiently to warrant conclusions. Additional materials are being forwarded to Walter Reed Institute of Research in Washington, D. C.

Schistosoma and Paragonimus immunity studies are in progress to determine whether a host infected by one species of somatic parasite is influenced by the introduction of another. Although a number of infections and supra infections have been established, hosts have not been examined.

Schistosome susceptibility studies are nearing completion. Ultimately there should be information indicating which hosts are most desirable for experimental schistosomiasis japonica (Taiwan) and the patterns of susceptibility should suggest certain geographic relations of S. japonicum which occur on Taiwan and in Japan.

Studies of the Filarial Infections of Man and Animals (U), MR 005-09-1033. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Cdr L. A. Jachowski, MSC, USN.

The current studies are concentrated on the problem of serological diagnosis of filariasis. Sera from human patients with filarial infections and with symptoms of filarial disease have been tested in complement fixation and slide flocculation tests with antigens prepared from adult heartworms (Dirofilaria immitis). Sera from patients with "filarial disease" are more reactive than those from patients with active infections or without filariasis. Consequently, difficulties are encountered in establishing the sensitivity and specificity of the serological techniques. The working hypothesis is that antibodies are produced to filarial infections, but in active infections these are neutralized by an excess of antigen. Techniques for detecting antigen, rather than antibodies, are under study in dogs naturally infected with D. immitis. Inconclusive evidence suggests that antigens are excreted through the kidneys and can be recovered in the urine. Plans are to collaborate with the clinical Center, NIH, when procedures are ready for human trials.

Bionomics and Control of Human Schistosomes, MR 005-09-1035. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; N. L. Freeman, Lt, MSC, USN, Head, Parasitology Department.

Human bilharziasis is of world wide importance and is a paramount problem in Egypt. A wide variety of parasitological, epidemiological, and pathological studies were conducted under this task. Susceptible laboratory and wild animal hosts were defined and the pathophysiology of the disease elaborated. Molluscicidal effectiveness of over 1500 chemicals was tested against the snail hosts in Egypt including the original studies leading to adoption of sodium pentachlorephenate as an alternative molluscicide in the Middle East. Considerable effort was expended on the study of specific and non-specific antibodies in the blood serum of animals and man infected with S. Hematobium and S. Mansoni. Results were inconclusive as to whether serodiagnosis or true immunity were demonstrable.

The basic ineffectiveness of very low concentrations of molluscicides against snail hosts of Schistosoma in the Middle East was shown contradicting results of uncontrolled field studies which had been reported by some workers in the area.

Work was concluded following the transfer of the principal investigator and death of his successor. The original principal investigator had plans to continue work under a new subtask at NAMRU-1 utilizing antigens and other materials collected while working on this task in Egypt.

Epidemiology, Biology, Pathology, Diagnosis and Prevention of Cholera (U), MR 005-09-1040. Naval Medical Research Unit No. 2, Box 14, APO 63, San Francisco, California; Capt R. A. Phillips, MC, USN.

For the third consecutive year a 19-man team, composed of American and Chinese scientists of NAMRU-2, spent 8 weeks at the Chulalongkorn Hospital in Bangkok, Thailand, in attempts to further elucidate the altered physiology in this

disease. Unfortunately, for our purposes, there were no cases of severe classical cholera, however, the studies conducted this year will constitute material to be used as "controls". Previous studies by NAMRU-2 have shown that cholera produces an isotonic dehydration with excessive K^+ and HCO_3^- losses. We have attempted to replicate this dehydration by perfusing small, large and both intestines with solutions of varying electrolyte and colloid concentrations since the disease cannot be reproduced with regularity in animals by bacteriological means. Perfusion rates of 100 ml/kg/hr were ineffective in producing more than mild dehydration. Sodium pump poisons added to perfusate did not accentuate dehydration. However, by means of peritoneal dialysis it has been found possible to reproduce the isotonic dehydration, the K^+ loss and the acidosis of cholera, thus providing a model for further study of the disease. In severe dehydration one anticipates that water will be lost from all body compartments. On the other hand, it has been repeatedly shown that acidosis effects an increase in muscle cell water. NAMRU-2 studies have demonstrated that cholera produces a voluminous isotonic diarrhea, severe dehydration, acidosis and a loss of 20-30% of available body stores of K^+ in the 3-4 days of diarrhea. Observations on muscle water following severe isotonic dehydration plus acidosis have not been made. For initial rehydration in cholera it is important to know if muscle water has contributed to the diarrheal stool volume. Using techniques described above, muscle water and electrolytes have been determined before and after dehydration and acidosis have been produced. The calculations indicate a significant increase of water in the intracellular phase as the result of a cholera-like dehydration.

The epidemiological studies of cholera in Thailand in January 1960 revealed that Vibrio comma was widely distributed in surface waters of the Bangkok area. Foods from markets, particularly those washed in surface water, were contaminated with V. comma. Forty percent of the diarrheic patients were found to be excreting the organism. A high percentage of contacts and healthy school children were symptomless intermittent excretors of V. comma. Beginning in February there was concurrent decline in number of isolations from all sources with complete disappearance of the organism during July. Severe cholera was not observed in that period. There were no isolations of V. comma from the sources stated periodic samples obtained during the remainder of 1960. An outbreak of gastroenteritis characterized by vomiting and diarrhea occurred during November in Ubon, a town of 25,000, 300 miles east of Bangkok. Studies were performed during the decline of the epidemic. Five hundred persons were hospitalized and it was estimated that at least 15% of the population had been afflicted. An El Tor vibrio was isolated from several patients and from water and food samples. No deaths occurred. The epidemic ended abruptly and the El Tor vibrio is no longer present in the area.

Studies of the Pathogenesis of Shigella Organisms (U), MR 005-09-1100. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Cdr T. M. Floyd, MSC, USN.

Studies of the pathogenesis of enteric organisms have been continued. Sensitization of monkeys by repeated challenge with Shigella has resulted in increased reactions to latter challenge, suggesting that some of the pathology of bacillary dysentery may be allergic in nature. Accompanying immunological responses are being determined. Passage of Shigella on human intestinal epithelial cells did not increase their pathogenicity for monkeys. Enteropathogenic coliforms did not cause overt disease in monkeys. These animals were found to carry most of the the serotypes associated with diarrhea in children. Monkeys were rapidly killed by Shigella when their TCA cycles were interrupted; however symptoms were not related to bacillary dysentery. Many strains of enterics were tested for ability to dilate isolated segments of rabbit small intestine. Recently isolated pathogens were most active, indicating the adaptive nature of the principle involved. Lactic acid is a product of this process but there was poor correlation between amounts present and extent of reactions in the segments. Correlation between in vitro production of lactic acid and ability of strains to dilate segments was also poor. Chromatographic studies on fluid from positive segments have shown the presence of three distinct substances. Identification is in progress. Studies of simian shigellosis and efforts to decrease resistance of monkeys to the experimental infection will be continued. The relationship of reactions in isolated intestinal segments to pathogenicity of enterics, and the mechanisms involved in this reaction, will continue to be studied.

Identification, preservation, cataloging and distribution of enterobacteriaceae is a continuing service function.

Epidemiology, Biology, Pathology, Diagnosis and Prevention of Viral Diseases (U), MR 005-09-1200. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; F. B. Gordon, M.D., Ph. D.

A substrain of Rickettsia prowazekii of increased resistance to chloramphenicol was isolated by serial passage of the Madrid E strain in eggs treated with the antibiotic. In another study with R. prowazekii substrains a consistent association was found to exist between quinoxaline resistance and loss of some virulence for the chick embryo. The newly isolated rickettsialike microorganism, Wolbachia persica, was further characterized by a study of its metabolic activity. Manometric studies carried out with purified preparations in a Warburg respirometer indicated that this micro-organism respires vigorously in the presence of at least three substrates, i.e., glucose, pyruvate, and glutamate. Following the basic characterization of the cytopathogenic dengue-1 virus, derived from a human skin cell carrier culture, the dynamics of virus production of this culture system were studied. The significant finding was a very rapid release of virus from cells which appeared to be controlled mainly by virus concentration of the culture fluid. Extensive attempts to demonstrate hemagglutination with these cultures were unsuccessful. Continued investigation is planned of the cytopathic dengue-1 strain, and of the susceptibility of other kinds of cell

cultures to certain arthropod-borne neurotropic agents. A total of 7 strains of trachoma virus and one of inclusion blennorrhea from various areas of the world have been established in this laboratory for study. Progress has been made in developing a suspending medium to increase the stability of the virus at 35° and studies will continue to provide optimum methods of maintenance and storage. Other continuing studies with the 8 strains include morphologic character of the inclusion in chick entodermal cell cultures, susceptibility of the cell cultures, and sensitivity to selected antibacterial drugs; completion of 10 passages of the Eaton agent of primary atypical pneumonia through chick entodermal cell cultures, with demonstration of the agent by fluorescent microscopy in cooperation with Dr. R. M. Chanock and others at the National Institutes of Health. This finding will continue to be exploited by further passages, and attempts to pass in other cell systems with the objective of finding a system in which specific staining or cytopathic effect of the agent can be observed.

Epidemiology, Biology, Pathology, Diagnosis and Prevention of Viral Diseases (U), MR 005-09-1201. Naval Medical Research Unit No. 2, Box 14, APO 63, San Francisco, California; A. F. Rasmussen, M.D.

A total of 24 strains of trachoma virus have been recovered and are being characterized by mouse toxicity and pathogenicity for Taiwan monkeys. The 24 strains comprise at least 4 distinct groups on the basis of mouse toxin neutralization tests. Chronic infection has resulted in keratitis and pannus in one monkey, thus reproducing the late stages of the human disease experimentally for the first time. A specific complement fixing elementary body antigen, distinct from the common antigen shared with other members of the psittacosis lymphogranuloma venereum group, has been developed. The utility of this antigen has been proved in tests with sera from Egypt, Ethiopia, India and Thailand, as well as Taiwan. Field studies are in progress to test the capacity of formalin inactivated, elementary body vaccine to protect uninfected children of families in which trachoma is prevalent and to alter the course of trachoma in infected children. Efforts to improve the potency of the trachoma vaccine are continuing.

Epidemiology, Biology, Pathology, Diagnosis and Prevention of Viral Diseases (U), MR 005-09-1203. Naval Medical Research Unit No. 4, U. S. Naval Training Center, Great Lakes, Illinois; 10055; Capt L. F. Miller, MC, USN.

Surveillance for adenovirus and influenza in immunized personnel continues with indication of at least partial effectiveness of the vaccines. Search for new viruses continues using a variety of cell lines so far without success. Role of presently known viruses is being determined. To date only the role of influenza and adenovirus has been demonstrated. Multiple infections are being studied for relationship to severity of disease and behavior of multiple agents in the recruit population is being observed. Effect of routine immunizations on respiratory disease rates is being investigated in conjunction with a study of the role of properdin. A collaborative project with the U. S. Naval Hospital on the etiology of viral pneumonias is being continued in conjunction with NIH. A collaborative project with the University of Illinois College of Veterinary Medicine is being planned. Cross sectional and longitudinal epidemiological surveys are continuing in relation to the above studies.

Epidemiology, Biology, Pathology, Diagnosis and Prevention of Viral Diseases (U), MR 005-09-1204. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; BuMed, 17X1319.1813; H. H. Bloom, Lt, MSC, USN.

Specimens collected by Preventive Medicine Unit #2 during a shipboard outbreak of acute diarrhea are being processed for the presence of viral agents. Three different tissue culture lines have been inoculated with rectal swab material. Cytopathic changes have occurred in one cell line from several specimens, suggesting the presence of viral agent. Further investigative work is underway to validate these preliminary findings.

A collaborative study with the Laboratory of Infectious Diseases, National Institute of Allergy and Infectious Diseases, National Institutes of Health, is being actively pursued. Individual throat and rectal swab specimens, and acute-phase and convalescent-phase blood have been collected from approximately 4000 Marine Corps personnel. Two groups of patients are included in the study: (1) men with early acute upper respiratory disease, and (2) an equal number of men free of respiratory disease for at least 10 days prior to admission into the study. The study has yielded data in three areas of the respiratory disease problem in adults: (1) An epidemic of Coe virus occurring during the period 1 September-15 November 1960 at Camp Lejeune provided evidence for the association of an enterovirus with respiratory illness. The Bouma strain of Coe virus, the prototype strain of this epidemic, has been shown to possess a hemagglutinin, thereby facilitating rapid identification and simplifying serologic testing; (2) The parainfluenza viruses, types 1, 2, and 3, were recovered from Marine Corps personnel during the past year. The problem of original isolation from throat swab material with low titers of virus was investigated. Utilization of unfrozen material for inoculum, prolonged incubation of tissue cultures, and equal numbers of tissue culture control tubes resulted in higher recovery rates for this group of viruses; (3) An epidemic of acute upper respiratory disease due to adenovirus which occurred in "post-graduate" recruits during the period February-April 1960 was studied. These recruits were in their 13-20th weeks of training. In addition, the role of adenoviruses in seasoned troop commands was surveyed simultaneously and comparative epidemiological information obtained.

Studies on Beta Hemolytic Streptococcus and other Bacterial Infections in Navy Personnel (U), MR 005-09-1300. Naval Medical Research Unit No. 4, U. S. Naval Training Center, Great Lakes, Illinois; 10055; Capt L. F. Miller, MC, USN.

Mass prophylaxis with benzathine penicillin markedly reduced streptococcal infections and rheumatic fever as in previous years. Erythromycin propionate is being investigated as a suitable

prophylactic in the penicillin sensitive segment of the recruit population. Further data showing the immunological relationship of streptococcal L forms CF antibodies to streptococcal disease has been accumulated and they do not appear to be group A specific. Staphylococcal L forms have been produced both on solid and in liquid media and the differentiation of morphological elements has been accomplished. Effect of mass benzathine penicillin prophylaxis on the emergence or occurrence of penicillin resistant staphylococcus in recruits has been completed and does not indicate a significant hazard to exist.

A Therapeutic Evaluation of Oral Antibiotics in Streptococcus Infections, MR 005-09-1302.1. No funding required; R. A. Mount, Capt, MC, USN.

To date there have been a total of two hundred and ninety-six (296) cases of acute tonsillitis cultured for the study. Of this group, there have been one hundred and thirty (130) group A Streptococcus organisms isolated. These one hundred and thirty (130) patients were placed on one of the three study treatment schedules. Seventy-six (76) of the group A Streptococcus organisms were typeable, as follows: fifty-four (54) type 3; nine (9) type 5; six (6) type 6; three (3) type 1; two (2) type 18; one (1) type 12 and one (1) type 14. There have been twenty-five (25) treatment failures to date (25/130). Twelve (12) of these treatment failures are from those patients receiving the study drug, Ilosone (Propionly Erythromycin Ester, Lilly). In addition, there were ten (10) failures in patients receiving the control drugs, as follows; eight (8) were receiving Ilotycin (Erythromycin, Lilly) and two (2) were receiving V-Cillin-K (Penicillin V Potassium, Lilly). Three (3) failures were from previous one-half gram/day treatment schedules that were discontinued early in the study. At present all treatment schedules are for one gram/day of the oral drug for ten days. There have been approximately forty (40) cases completed with each of the three treatment schedules.

Role of Arthropods in Transmission of Disease, MR 005-09-1402. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; H. Hoogstraal, Ph. D., Head, Medical Zoology Department.

This program has included an extensive investigation into the biology, ecology and taxonomy of vertebrates and their ectoparasites in Egypt as in adjacent countries in Middle East and Africa. Tremendous numbers of specimens and field and experimental data had been assembled. As result of this effort, the many reports published include monographic studies on mammals, reptiles, birds, ticks, fleas, lice and mites. Further examples are reports on ecology distribution, epidemiological relationships, spirochetal and bacterial infections, life histories of parasites and descriptions of new species.

During past year considerable time was devoted by the chief investigator in inaugurating and putting in operation a research program on vertebrates in the kala-azar infected area in Southern Sudan. Satisfactory progress was made in the biological and systematic studies of ticks of the genera Haemaphysalis, Hyalomma, Boophilus, Argas, and Ornithodoros. A preliminary plan of species relationships and host-parasite relations in the tick genus Haemaphysalis was made. This will result in a revision and review of the genus. The phylogenetic aspect of this study was commenced as a background for the study of phylogeny of viruses. Considerable progress was made in the revision of the economically-important genus Hyalomma. Data on distribution, ecology and host-relations of Egyptian Hyalomma ticks have been collated. Extensive series were reared in the laboratory for comparative and crossing studies. Special attention was given to the H. marginatum rufipes complex. A new species of Boophilus from sheep and goats in Jordan was described. This discovery increases the number of species in this cosmopolitan and economically important genus of ticks by 25%. With the arrival of several lots of Argas ticks from different parts of the world the results obtained from comparative studies of their progeny criteria for recognizing this bird parasite was determined. As result, a generic revision on a world-wide basis started, and series of studies on Argas ticks of Western Europe, Africa, Northwestern United States, Peru and Chili were published or are under publication. The bat-infesting Ornithodoros ticks of the world were reviewed and a new species from the Belgian Congo was described. Also, a report on Ornithodoros coniceps from wild swallow nests in India was submitted for publication. Studies on the ticks of Yemen, Libya and Jordan were published or in the last stage of preparation. These are part of the series to supply the F.A.O. of the United Nations with a specific account of the ticks of the countries of North Africa and the Near East. Results of 5 years of effort in studying the bird migration in Egypt were collated and final reports were submitted for publication.

The Role of Arthropods in Transmission of Disease (U), MR 005-09-1406. Naval Medical Research Unit No. 2, Box 14, APO 63, San Francisco, California; Capt H. S. Hurlbut, MSC, USN.

Forty-three presumptive Japanese encephalitis (JE) virus isolations were made from 651 pools of mosquitoes collected on Okinawa by the Entomology Section, U. S. Army Medical Service Group, and shipped to Taipei, Taiwan, by air. The mosquitoes were preserved on dry ice until tested, usually within 2 weeks of the day of collection. The largest number of isolations was made from the September collections when Culex tritaeniorhynchus was most numerous; 20-30% of the pools of this mosquito were positive. Most of the mosquitoes and all of the isolations were from the village of Geoku near the center of the island of Okinawa where sampling was started in March and continued until the middle of November.

Six virus isolations were obtained from 198 pools of mosquitoes collected near Taipei during August, September and October. Five of these are probably JE virus, 3 from C. Tritaeniorhynchus and 2 from C. fatigans. Three presumptive JE virus isolations were made from sentinel suckling mice exposed in the Taipei area during the month of September.

A serological survey in 1959 indicated that about 4% of the Marines converted from negative to positive for JE during the first season of residence on Okinawa. A second group is being tested

during 1960. This work is not yet completed.

Role of Arthropods in Transmission of Disease (U), MR 005-09-1407. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; BuMed, 17X1319.1813; K. L. Knight, Capt, MSC, USN.

All tick studies for 1960 were completed in July and in the period since that time, a report entitled "Detachment of Embedded Adult Amblyomma americanum Ticks with Chemicals" has been prepared and is being processed for printing. A condensed version of this report was presented before the Annual Meetings of the Entomological Society of America at Atlantic City on 1 December 1960.

Based on the techniques developed to date, plans are being developed for an expanded screening program of potential tick detachment agents as soon as adult ticks are again available in the field (April 1961).

Etiology, Epidemiology and Therapeutics of Nongonorrheal Urethritis (U), MR 005-09-1501. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; BuMed, 17X1319.1813; M. C. Shepard, Ph. D.

A new adsorption technique for the primary isolation of T-strain Pleuropneumonialike organisms (PPLO) from cases of non-gonococcal urethritis (NGU), employing strain McCoy or Ep.L. monolayer cell cultures, has been perfected and is undergoing trial.

Studies on the rate of loss of viability of T-strain PPLO in freshly collected clinical material from NGU cases were initiated in an attempt to learn the conditions under which rapid inactivation occurred, and their correction, in PPLO-cell systems.

A collaborative study was established in June 1960, with Dr. D. K. Ford, University of British Columbia, Vancouver, B. C., to confirm the existence of T-strain PPLO in NGU cases in the Vancouver area. The organisms were recovered from 62% of 45 NGU cases. This is the first reported confirmation of our original findings (NMFRL, 1956).

Geomedical Studies of Disease (U), MR 005-09-1601. Naval Medical Research Unit No. 2, Box 14, APO 63, San Francisco, California; Cdr R. E. Kuntz, MSC, USN.

Members of the parasitology department conducted field work in the vicinity of Jesselton, North Borneo, for approximately 5 weeks (August to October). During this period the group examined approximately 1500 animals in an area which had been scarcely touched by investigators in parasitology and/or allied fields. Extensive collection of all categories of parasites were taken. These have been processed and are now in the hands of different recognized parasitologists for study. Museums have expressed keen interest and great appreciation for the vertebrates taken on the expedition to North Borneo.

As part of field activities in North Borneo, stool specimens were obtained from approximately 1,000 persons living in different type localities in the vicinity of Jesselton and in two villages inland. Study materials were obtained from Chinese, Dusuns and Sino-Dusun communities with emphasis on teenage children. The greater part of the collection has been processed. Although it is not anticipated that many unusual parasites will be recorded, these findings along with epidemiological data will provide geomedical information from an area in which the study of intestinal parasites of man has been limited or neglected.

In support of other geomedical investigations, various materials (sera, tissues, etc.,) as well as hosts suspected as reservoirs have been collected for other activities making a study of viruses in this Unit.

Parasites of wild and domestic animals on Taiwan and Offshore Islands: Several thousands of animals examined have provided extensive collections of helminth ectoparasites and blood protozoans from wild and domestic vertebrates. Emphasis has been placed on procurement and examination of animals in areas not previously worked.

Geomedical Studies of Diseases, MR 005-09-1602. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; J. R. Seal, Capt, MC, USN, Commanding Officer.

This task title assigned in 1958 supplants others whose history extends to the establishment of NAMRU-3. The extensive information on medical expenditions and missions, field studies, museum and teaching instruction collaborations cannot be summarized in this brief space but is available in the collected papers of NAMRU-3, 1946-60, available in many Federal libraries.

Major work during the past year has been in connection with S.T. 6 on Kala Azar in the Sudan. A field laboratory at Malakal has been almost completed and stocked. A field team operating for two months during the spring of 1960 collected over 600 rodents and a number of other possible reservoir hosts but did not find Leishmania. Fresh human strains of Leishmania from Kala Azar patients are in culture and antigen for skin testing and immunological studies have been prepared. Teams engaged in intensive search for the reservoir host and vector returned to the field in November 1960. Additional teams for human studies enter the field early in 1961.

In Egypt, rodents and small animals have been collected within a 90 miles perimeter of Cairo and over 1500 animals examined. Three strains of leptospira have been isolated. In 10 percent of 138 Arvicanthus rats and 4.5 percent of 188 Rattus rats positive blood sera in a titer of 1:16 or higher against commercial Q-fever antigen was encountered. Studies for other diseases are continuing. The Commanding Officer investigated facilities for research and for vaccine production related to African Horse Sickness in Turkey with letter reports to the Bureau.

Studies on Leptospirosis, MR 005-09-1702. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; W. J. Brownlow, Jr., Lt, MSC, USN.

Earlier work by McGuire showed that leptospirosis occurred infrequently in man and most animals in Egypt. The finding of antibody to strains of leptospira in 14 of 99 water buffalo blood sera collected from animals being slaughtered at the Cairo abattoir deserved further study.

Blood sera were obtained from 367 buffaloes and 264 dairy cattle at various farms, from 191 buffa-

loes and 124 cows at the Cairo abattoir, and from 185 abattoir workers and 183 farm workers who had close association with bovines because of occupation. Significant level of antibody against L. grippotyphosa, L. autumnalis, and L. malaya were found, one each in three individual farm workers. Leptospiral antibodies were demonstrated in 6.8% of buffalo sera and 3.0% of cattle sera, including serotypes L. icterohemmorrhagae AB, L. icterohemmorrhagiae B, L. autumnalis, L. botaviae, L. canicola, and L. malaya. This confirmed the general paucity of leptospirosis in Egypt and the higher prevalence in water buffaloes than in other mammals so far studied.

Epidemiology, Biology, Pathology, Diagnosis of Diseases of Taiwan (U), MR 005-09-1901. Naval Medical Research Unit No. 2, Box 14, APO 63, San Francisco, California; R. Q. Blackwell, Ph. D.

Blackfoot Studies by Clinical Investigation Department, NAMRU-2. Since 1958 some fifty-nine patients diagnosed as having the so-called "Blackfoot Disease" have been clinically evaluated at the NAMRU-2 wards. Detailed history of disease, family background, economic, dietary and social evaluations have been amassed. This with complete physical examination, roentgenographic studies under standard conditions, and follow-up examinations (including a vascular workup with oscillometry, radiometry, cold pressor tests, exercise tolerance tests) can be correlated with present and future studies by the biochemical department, together with more standard laboratory studies. In cooperation with National Taiwan Medical Hospital, we are collecting pathological material following amputation and/or sympathectomy, in addition to follow-up clinical evaluation in some selected cases. Patients are also being treated (after initial evaluation) with vasodilators and being evaluated for results by the subsequent use of placebos and clinical studies. Preliminary results are not conclusive and emphasis is now being placed upon younger patients. It is hoped some insight may be obtained into this disease process. This not being obtained, at least a thorough clinical evaluation will be made, well documented to complement the extensive biochemical studies, and as a disease study, per se, which would contribute as a review of this local endemic problem and as a unique phenomenon in the overall arteriosclerosis, thromboangitis obliterans controversy.

Epidemiology, Biology, Pathology, Diagnosis and Prevention of Parasitic Diseases (U), MR 005-09-2001. Naval Medical Research Unit No. 2, Box 14, APO 63, San Francisco, California; Cdr R. E. Kuntz, MSC, USN.

Work continues on the preparation of a more precise skin test antigen for detecting paragonimiasis. Recently, increased numbers of adult Paragonimus westermani worms furnished by the Department of Parasitology have allowed acceleration of the study. Basically, antigenic fractions are being isolated from the macerated worms by solution in saline followed by chemical fractional precipitation with buffer solutions. Analysis of the fractions by starch and paper electrophoresis allows comparison with plasma proteins to furnish some notion concerning the types of proteins involved and the complexity of the mixture in each fraction. Agar diffusion (Oudin, et al) techniques using suitable dog, cat, monkey, and human bloods allow assessment of antigenicity of fractions separated. Sufficient quantities of skin test antigen for several hundred tests have been produced during December. Skin tests on sensitized animals are to be made by members of the Departments of Parasitology and Clinical Investigation in the next month; if these tests are promising other tests next will be made on individuals with known Paragonimus infection. Finally, promising fractions will be used in screening tests and compared with other skin tests run on the same individuals.

"Studies on Flagellates and Related Diseases", MR 005-09-2200. Medical Liaison Com-15, Gorgas Memorial Laboratory of Tropical and Preventive Medicine, Post Office Box 2016, Balboa Heights, Panama Canal Zone; LCdr Alan C. Pipkin, MSC, USN, Officer in Charge.

Mammalian cell lines, although capable of supporting growth of hemoflagellates in tissue cultures, have been found to harbor only leishmaniform stages of the test hemoflagellates, Trypanosoma cruzi and Leishmania brasiliensis, such primary explants being apparently incapable of supporting continued cyclic development of these organisms. The developmental studies have been continued, and use is currently being made of trypsinized cell suspensions of 10-13 day old whole chick embryos. In primary explants of such origin, cyclic development (involving actively dividing leishmaniform flagellates which evolve into cyclic forms, escape from the host cells and reinvade other cells anew) has been achieved regularly with T. cruzi. Growth of L. brasiliensis in tissue cultures, a hitherto unreported application of this technique, has been achieved in young and embryonic tissues and macrophages of laboratory rodents, although cyclic development of this species in such preparations has not been yet achieved. Time lapse microcinematographic studies of the intracellular development of T. cruzi are in progress. Another approach to the study of the cyclic development of the hemoflagellates which is getting under way is an attempt to grow L. brasiliensis in tissue cultures of cells taken from the alimentary tract of the arthropod intermediate host, sand flies of Phlebotomus sp. If successful, this could provide a useful source of infectious hemoflagellates for infectivity studies in animals. Another use is being made of tissue cultures in the evaluation of cellular and circulating humoral immune mechanisms in resistance to infection of usually susceptible avian cells to infection with T. cruzi.

R005-10 Protection and Survival of Personnel

Insecticides (U), SR 005-10-603. Communicable Disease Center, U. S. Public Health Service, Savannah, Georgia; Order No. 1700S-659; Dr. H. F. Schoof.

Efficient insect control is essential in the protection of health and morale of personnel as well as the maintenance of material in usable condition. Crowded and humid shipboard conditions pose special difficulties. Spreading insect

resistance to conventional toxicants has presented a perplexing complication. The ultimate goal set has been a treatment which could be applied simply and safely by untrained personnel, while retaining its usefulness for periods of several years.

An experimental resin-toxicant formulation shows real promise in retaining its biological effectiveness for two years (although certain other deficiencies prevent its adoption at this time). Basic formulation studies thus far have shown a marked variation in toxicant efficiency depending on carrier and surface to which applied. The extent of this relationship had not been fully realized earlier. Two new toxicants, DDVP and dimethoate, are showing real promise.

Evaluation of resin-toxicant formulations based on chlorinated hydrocarbons have been completed. Malathion, dieldrin, and DDT have been studied as oil solutions, water-emulsions, and water dispersible powders as applied to bare and painted metal, and bare wood, with major differences being demonstrated. In the case of malathion, the trial use of any of almost thirty additives failed to overcome an early loss of activity on painted surfaces. Preliminary screening of DDVP and dimethoate has given promising results.

Burns, Prevention and Emergency Care of Amphibious Troops (U), MR 005-10-0002. Naval Medical Research Unit No. 4, U. S. Naval Training Center, Great Lakes, Illinois; 10055; Capt L. F. Miller, MC, USN.

Sera from acutely burned patients provided by the Naval Medical School and Dr. S. R. Rosenthal of the University of Illinois inhibited growth of HeLa cells only if the sera were not separated from the clot for several days. Possible adsorption and elution of the "inhibiting factor" from the red cells of burned patients needs further study. Rosenthal has postulated such a mechanism. The HeLa cell technic of Rosenbaum has yielded consistent results between the laboratories of NAMRU-4 and the Naval Medical School.

The presence of a pre-albumin serum component of sera from acutely burned children (fraction which migrated electrophoretically ahead of albumin), observed by Mr. Lytle, Biochemist, was found to be positively correlated with inhibition of HeLa cell growth by such sera.

Burns, Prevention and Emergency Care of Amphibious Troops (U), MR 005-10-0003. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; DASA, 514-60; J. J. Martorano, Cdr, MSC, USN.

Under the general study of the physiology of burns, work is presently directed toward evaluation of existing methods of emergency treatment for severe burns. Special attention is given to a simplification of these methods as they apply to mass casualties and military conditions in which there is likely to be a great disparity between the injured and the medical facilities available to treat them. In this connection, the relative effectiveness of the administration of saline, colloids and whole blood during the first 48 hours of burn was evaluated. Results were in agreement with the findings reported by other laboratories. The effectiveness of saline therapy when compared to plasma was demonstrated.

Development of Armored Garments (U), MR 005-10-0300. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; MarCorps, 17X1319.2717, P.O. 1-0009; C. A. Cole, Jr., Maj, USMC.

(a) Improve body armor and load-carrying systems to obtain better troop acceptability, reduced heat load, and optimum load distribution. (b) Determine the effectiveness of various helmet designs in the prevention of skull and brain injury. (c) Improve helmet shells and suspension systems to decrease skull and brain injury. (d) Develop improved lay-up techniques to increase the ballistic performance of helmets fabricated from flexible materials. (e) Fabricate and incorporate new ballistic materials into body armor, helmets and other protective equipment. (f) Improve armored footgear to achieve greater troop mobility and comfort, to provide better ballistic performance, to reduce surface area in contact with the ground, and to reduce weight. (g) Develop new techniques for the evaluation of protective equipment under attack by fragments and explosives. (h) Continue cooperative effort with troops, physiologists, and psychologists to improve design of protective equipment.

Centrifugal Fogger (U), YR 005-10-103. ERDL; MIPR, R-60-196(AE)-25, Appn:17x1319.2504 RDT&E Bur. Control No. 25/10696; Dr. C. S. Barnhart.

The objective is to develop extreme light weight, high output and easily used and maintained insecticide dispersal equipment for the production of heavy sprays, mists and fog.

Preliminary investigations at ERDL have indicated the feasibility of this development. The initial effort led to the development of a centrifugal machine to put out a mist. This unit consisted of a 3 hp. gasoline engine which drove a propeller and nozzles located on the end of a shaft.

The unit has since been modified and now consists of an electric motor and fuel pump (both standard equipment) with nozzles made of polyethylene tubing. The electric current is obtained from batteries. This unit performs well and will be given extensive tests this Spring. It is lightweight, inexpensive and can be easily mounted on a jeep.

R005-11 Closed Space Environments

Development of Chemical Regenerative Process, SR 005-11-3357. Naval Research Laboratory; C08-04; R. R. Miller.

In chemical regenerative type breathing apparatus oxides of alkali metals are utilized as a carbon dioxide absorbent and a simultanious self-regulating source of oxygen. This type equipment is eminently suited to shipboard and submarine requirements by virtue of inherent lightness, compactness, and minimal maintenance requirements. In the present equipment the heat of the chemical reaction causes a progressive fusing of the chemicals in the canister resulting in a corresponding increase in breathing resistance. This limits the work life of the canister to about 45 minutes and chemical utilization to about 50%. From a physiological

standpoint, the increase in breathing effort entails a similar reduction in the work capability of the wearer.

This task is for the development in canister chemicals which will not fuse. Two approaches are being pursued; the addition of inorganic additives to the presently available oxides, and the development of new oxides. Much of the current effort is involved in the study of the decomposition of calcium peroxide dioxyhydrate to yield calcium superoxide.

Oxygen Breathing Apparatus, SR 005-11-3358. Naval Research Laboratory; C08-04; R. R. Miller.

The Navy standard types of emergency breathing apparatus (OBA types A and B) were developed at the Naval Research Laboratory. Evoluational improvement of these devices is being continued under this project. The laboratory is also developing a 1½ pound escape apparatus designated as the SCOBEA. The device is currently undergoing fleet evaluation by OPDEVFOR. Upon completion of the evaluation the design is to be corrected in accordance with the findings prior to making the device available to the fleet.

Submarine Airline Mask, SR 005-11-3359. Naval Research Laboratory and Contractor; E. A. Ramskill.

This task is for development of an airline mask for use aboard nuclear submarines. The extended periods of wear, requirements of performance, and the environmental circumstances of use anticipated for this device imply problems of comfort and communications not yet fully defined. Initial efforts are being directed toward development of a mask of maximum comfort and simplicity.

Respiratory Mask Communications, SR 005-11-3360. Naval Research Laboratory; R. R. Miller.

This task is for the development and improvement of communication devices in respiratory apparatus. It has been initiated as a result of reports from nuclear submarines of communications difficulties encountered while engaged in operations requiring the use of airline masks. The initial investigations are aimed at improving the speech diaphragm in an effort to circumvent the complications entailed in a built-in microphone and the related adaptations to various communications systems.

R005-12 Naval Medical and Dental Problems

In Vitro Studies of Dental Caries in the Artificial Mouth (U), RR 005-12-0002. University of Alabama, Birmingham, Alabama, Department of Biochemistry, Medical Center; Nonr 3139(00), NR 105-017; W. Pigman.

Basic factors responsible for the initiation and development of tooth decay are being studied in an artificial mouth, a device in which required conditions of the mouth can be reproduced for the study of caries. The factors under investigation are (1) changes in the external surface of the enamel as a result of eruption, maturation, and aging; (2) development of protective layers on the enamel; and (3) surface resistance of enamel to decay. The evaluation of agents and processes which will minimize the process of tooth decay constitutes an important phase of this work.

Experimental Immersion Foot (U), RR 005-12-0003. University of Pennsylvania, Philadelphia, Pennsylvania, Cardiovascular Research Department; Nonr 551(03), NR 105-018; H. Montgomery.

This study deals with the problem of immersion foot, a serious condition affecting limbs following brief or prolonged exposure to cold just short of freezing. Attempts are being made (a) to confirm early observations that a high oxygen concentration reduces the severity of neuromuscular dysfunction; (b) to study the initial damage to and recovery of motor end-plates; (c) to confirm an early observation that primary neuromuscular dysfunction occurs in the end-plate region; and (d) to study the mechanism of edema in chilled and unchilled muscle.

Mechanism of Phosphatase Inhibitors in Caries Prevention (U), RR 005-12-0004. College of Physicians and Surgeons, San Francisco, California, Department of Biochemistry; Nonr 1732(00), NR 105-023; H. M. Leicester.

The long term effects of enzyme (phosphatase) inhibitors in caries prevention were studied. The enzyme inhibitors which were utilized in this study were beryllium, vanadium and fluorine. Attempts were made to make the tooth more resistant to decay by incorporating these inhibitors into the dentin lattice and by determining whether the elements exert individual effects or complement each other in making teeth more resistant to decay.

Mechanism of Calcification in Bones and Teeth (U), RR 005-12-0005. The Jewish Hospital of Brooklyn, Brooklyn, New York, Department of Biochemistry; Nonr 987(01), NR 105-025; A. E. Sobel.

This is a broad research program wherein attempts are being made to uncover more of the critical factors in calcification processes occurring in bone and teeth. For instance, immediate attention is being given to the role of adenosine triphosphate (ATP) as an activator in the calcification process. Physicochemical studies are being made on the rates of mineralization of various types of collagens. A long range program will include the study of (1) organic and inorganic models to obtain a better understanding of the nature of mineralization in bone, teeth, and collagen; (2) the physical state of tooth enamel and dentin; and (3) caries susceptibility in relation to composition of teeth.

Prevention of Tooth Decay (U), RR 005-12-0006. Harvard School of Dental Medicine, Boston, Massachusetts, Department of Oral Medicine; Nonr 1866 (01), NR 105-026; J. H. Shaw.

This study is a part of a major program to study the physiology and biochemistry of oral tissues and the influence of disease states on these tissues. The specific aim is to investigate the constitutional differences between caries-resistant and caries-susceptible rats. Currently studies are being made of saliva with reference to correlating changes in composition and activity of components to caries incidence.

Preservation of Teeth (U), RR 005-12-0007. University of Illinois, College of Dentistry, Chicago,

Illinois, Department of Histology; Nonr 1459(04), NR 105-046; I. Schour, M. Massler.

This study dealt with a method for preserving teeth in young adults by resorting to partial amputation of the pulp. The effects of various blood fractions and various antibiotics on the healing of the amputated pulp were studied histologically and histochemically. The purpose was to determine changes in (1) the blood vessels; (2) the nerve tissues; (3) calcification; and (4) the ground substance, during healing.

Organic Components of Bones and Teeth (U), RR 005-12-0009. Georgetown University, School of Dentistry, Washington, D. C., Department of Biochemistry; Nonr 1531(00), NR 105-050; W. C. Hess.

The primary purpose of this study has been to gain information on the organic composition (proteins, carbohydrates, etc.) of calcified tissues such as teeth and bones in order to better understand the processes of growth, healing of fractures, caries development, and bone abnormalities. Currently, the dynamic aspects of bone metabolism are being considered. This includes an investigation of the metabolic capacity of bone in regard to its ability to utilize glucose, amino acids, and fats as substrates for energy yielding reactions. By knowing the enzyme systems involved in these procedures, it will be possible then to map the enzyme activity pattern in normal and diseased bone.

Hormonal Role in Trauma (U), RR 005-12-0010. Yale University, School of Medicine, New Haven, Connecticut, Department of Surgey; Nonr 609(10), NR 105-057; M. A. Hayes.

Studies are being made to determine and delineate the extent to which endocrine glands are involved in depression or activation of function in the metabolic response to trauma and to evaluate the activity of other endocrines in relation to the adrenocortex as to how the metabolic response of the latter may be modified. Attempts are being made to define exactly the mechanisms in water and electrolyte metabolism during and after traumatic situations, such as operative procedures.

Effects of Trauma on Sodium and Water Metabolism (U), RR 005-12-0011. Tulane University, School of Medicine, New Orleans, Louisiana, Department of Surgery; Nonr 475(07), NR 105-063; J. U. Schlegel.

This task is concerned principally with the study of water and sodium retention following trauma such as is initiated by surgical procedures, thermal injuries, and other debilities. Attention has been paid to the effects of administration of certain osmotic compounds, e.g., urea and mannitol, on water retention following trauma as well as the mechanism of action of such agents. Currently, these studies are being extended to evaluate their effect on renal blood flow. Evaluation is being made of the value of osmotic diuresis in preventing edema formation in burned area of the body.

Thoracic Trauma (U), RR 005-12-0012. State University of New York, College of Medicine, Brooklyn, New York, Department of Medicine; Nonr 2290(00), NR 105-069; H. A. Lyons.

Studies are continuing on the physiology and treatment of impaired breathing resulting from cases of severe injury involving the crushing or puncture of the chest. In particular, the respiratory dynamics and the gas pressures within the pleural cavity and the bronchi are being studied in injuries of this type. The approach involves the use of therapeutic measures which influence changes in intrapleural and endobronchial pressures. These include the administration of varying mixtures of oxygen, helium, and carbon dioxide inhalations, the use of broncho-dilators, and other clinical and surgical procedures.

Preservation of Human Skin (U), RR 005-12-0013. Duke University, School of Medicine, Durham, North Carolina, Department of Surgery; Nonr 1537(00), NR 105-071; N. G. Georgiade.

This is a study wherein determinations are being made of satisfactory methods for the long-term preservation of human skin in the living state. The advisability of using skin homografts as a life-saving temporary dressing for extensively burned patients is being evaluated. Studies of various storage media are continuing in hope that extended storage of skin in the viable state may be achieved. The scope of this work is being extended to include studies of means for preserving corneas and endocrine glands.

Biologic Research with the Color-Translating Ultra-violet Microscope (U), RR 005-12-0016. New England Deaconess Hospital, Boston, Massachusetts, Department of Pathology; Nonr 1299(00), NR 105-083; S. Warren.

The color translating ultra-violet microscope is being used for the comparative study of cellular material obtained from various sources in order to observe histologic and histochemical changes under normal and abnormal conditions. Qualitative analyses are being made of these cell systems on the basis of their ability to absorb ultra-violet radiation.

Combat Head Injury Study (U), RR 005-12-0017. Columbia University, College of Physicians and Surgeons, New York, New York, Department of Neurology; Nonr 2690(00), NR 105-086; W. F. Caveness.

Experimental and clinical investigations are being undertaken in order to provide a better understanding of the reaction to trauma inflicted as a result of combat head injury through established procedures and to record and follow electroencephalographic changes of such injuries. This information should provide a better correlation between the type of head injury and delayed effects directly related to the original injury, for example, epilepsy.

Cartilage Preservation (U), RR 005-12-0018. Medical College of South Carolina, Charleston, South Carolina, Department of Surgery; Nonr 434(02), NR 105-088; R. F. Hagerty.

This is a study of the fate of living and nonliving human cartilage as a graft after long periods of transplantation in the human host. Previous work has shown an indirect correlation between living grafts and their invasion by fibrous tissue. Currently attempts are being made to (1) determine the factors involved in fibrous invasion of cartilage grafts; and (2) devise methods for optimum storage

conditions and preservation to counteract this undesirable characteristic.

Chest Injuries and Defects (U), RR 005-12-0019. Yale University, School of Medicine, New Haven, Connecticut, Department of Pathology; Nonr 609(21), NR 105-090; A. A. Liebow.

Studies of pulmonary anatomy and pathology are continuing along with functional and experimental correlation in order to obtain a better understanding of pulmonary disease and its therapeutic management. Emphasis is being placed on (1) studies of pulmonary circulation and edema; (2) function studies of collateral circulation of lung and heart; and (3) studies of pulmonary embolism. Work with the mechanical heart-lung apparatus is continuing.

Mineral Factors in Caries (U), RR 005-12-0020. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Food Technology; Nonr 1841(32), NR 105-094; R. S. Harris, A. E. Nizel.

This is a broad study of the effects of various mineral components of food, such as phosphorus, on the incidence of dental caries in caries-susceptible animals. Results obtained to date indicate that phosphorus-containing and phosphorus-supplemented diets exert a cariostatic effect. Presently studies are concerned with (1) determining whether the caries-inhibiting effects of phosphorus compounds are local, systemic, or both; (2) establishing how dietary phosphorus affects the chemical and physical structure of teeth; and (3) the development of reliable caries-susceptible strain in the experimental animal under study.

Factors in Diseases of Tooth-Supporting Structures (U), RR 005-12-0021. College of Physicians and Surgeons, School of Dentistry, San Francisco, California, Department of Bacteriology; Nonr 1791 (00), NR 105-096; L. S. Smith.

This study dealt with the relationship between lesions found in the area surrounding the apex of the tooth and the presence of organisms which produce enzymes often associated with pathogenesis and/or invasiveness. Attempts were made to develop a satisfactory technique for experimental investigations in infection and host responses to pulp canals to the bacteria originally isolated from infected human pulp canals.

Preservation of Blood (U), RR 005-12-0022. Protein Foundation, Incorporated, Cambridge, Massachusetts, Blood Preservation Laboratory; Nonr 1852(00), NR 105-112; J. L. Tullis.

Studies are being made to modify and simplify methods of glycerolization and deglycerolization of human red blood cells in an attempt at arriving at the most expedient method for the long-term preservation of red blood cells. Additional studies are directed at observing the post-transfusion survival of such preserved cells after varying periods of storage (from 18 to 36 months). The methods of storage of such preserved cells will be studied in order to arrive at the most simple and facile method which would yield maximum results.

Freezing of Blood (U), RR 005-12-0023. Yale University, School of Medicine, New Haven, Connecticut, Department of Internal Medicine; Nonr 609(18), NR 105-116; J. W. Hollingsworth,

Studies were made on rapid freezing and low temperatures on the preservation and storage of the formed elements of whole blood for transfusion purposes. The studies were directly related to the preservation of red and white blood cells and platelets with the purpose of determining their survival, life span, and physiologic and biochemical activity following transfusion.

Bone Development (U), RR 005-12-0024. George Washington University, School of Medicine, Washington, D. C., Department of Anatomy; Nonr 2945(00), NR 105-118; I. R. Telford, L. E. Church.

Normal and abnormal bone development and growth is being studied by quartz rod illumination, a technique through which it is possible to visualize directly the cellular elements involved. Abnormal development of bone is being studied during the imposition of such physical and chemical forces as fractures, environmental changes, and hormones. The response and activity of bone under such stimuli is currently under study.

Metabolic Disease (U), RR 005-12-0025. University of California, School of Medicine, San Francisco, California, Department of Medicine; Nonr 222(51), NR 105-156; T. L. Althausen, H. A. Harper.

This is a study of the biochemical and physiologic processes governing the metabolic alterations encountered in normal and abnormal conditions of health in Naval personnel. The research undertaken is not limited to any specific disease entity. Investigations are concerned with (1) the study of normal mechanisms that will help to explain the pathologic manifestations; and (2) the study of disturbed metabolic patterns with reference to the normal patterns.

Survival of Transplanted Oral Micro-organisms (U), RR 005-12-0026. College of Physicians and Surgeons, School of Dentistry, San Francisco, California, Department of Bacteriology; Nonr 2534(00), NR 105-157; C. A. Scrivener.

The effectiveness of bacterial antagonists in the control of dental caries was under study. The antagonists consisted of bacteria that were harmless to the host. These were introduced into the mouths of patients in order to determine any protective effect that they may exert against those bacteria associated with dental caries and periodontal disease. The inoculated, protective organisms were maintained in the saliva for prolonged periods of time.

Plastic Artificial Cornea (U), RR 005-12-0027. Massachusetts General Hospital, Boston, Massachusetts, Massachusetts Eye and Ear Infirmary; Nonr 1173(01), NR 105-163; W. Stone, Jr.

The retention of foreign material (plastics) in the cornea of the eye is being studied with the view toward finding an adequate replacement for scarred, opaque corneas in the eyes of humans. Specifically, answers to such problems as growth of the surrounding tissues into the pores of the plastic cornea and prevention of tissue overgrowth are being emphasized. The technique has been successful in the lower classes of experimental

animals. Higher classes of animals are now being studied with the ultimate aim of eventual human application.

Anorganic Bone Grafting (U), RR 005-12-0028. Columbia University, College of Physicians and Surgeons, New York, New York, Department of Surgery; Nonr 266(52), NR 105-166; F. E. Stinchfield, L. A. Hurley.

Anorganic bone had been studied as a source material for bone grafts. The originally proposed objectives of this study have been accomplished essentially.

Effect of Thermal Burns on the Pituitary Gland (U), RR 005-12-0029. University of Texas Medical Branch, Galveston, Texas, Department of Anatomy; Nonr 1598(03), NR 105-167; E. G. Rennels.

In this study major emphasis is being placed on the effects of thermal burns on the ultrastructure of the pituitary cells as seen with the electron microscope. Other stresses are being studied, e.g., cold, hemorrhage, and electric shock, for their effects on the pituitary gland in relation to its secretion of ACTH, - the hormone which stimulates the adrenal glands. Another aspect of this study includes research on the structure and function of pituitary glands that have been grafted from one animal to another.

Air Pollution Toxicity (U), RR 005-12-0030. Huntington Memorial Hospital, Pasadena, California, Institute for Medical Research; Nonr 2402(00), NR 105-172; C. H. Thienes.

The effects of long-term exposure to low concentrations of air contaminants are being studied relative to their influence on the susceptibility to respiratory infections. Ozone is the contaminant that is being used. Simultaneous determinations are being made of the effects of the inhalant on tissues and respiration.

Bovine Embryo Skin Testing (U), RR 005-12-0031. University of Maryland, College Park, Maryland, Department of Veterinary Science, Nonr 2995(00), NR 105-173; C. M. Cotton.

A microbiologic study was carried out on bovine embryo skin for the purpose of determining the presence of brucellosis and leptospirosis in the skin prior to its use as a biologic dressing. In addition, a survey was made of the large number of bacteria isolated from this skin and other bovine tissues. Skins then were rechecked for bacteria after storage, freezing and drying, and after treatment.

Far East Virus Diseases (U), RR 005-12-0033. University of Chicago, Chicago, Illinois, Division of Biological Sciences; Nonr 2121(07), NR 105-175; J. T. Grayston.

The objective of this task was to provide, through field and laboratory studies, essential information on virus diseases and other medical disorders endemic or epidemic in the Far East. This information will be of use in establishing methods for controlling the animal and insect vectors of area diseases. It is hoped ultimately that diagnosis and treatment of endemic diseases will be improved to a point of more effective prevention.

Endocrine Gland Relationship to Dental Caries (U), RR 005-12-0034. Indiana University, School of Dentistry, Indianapolis, Indiana, Department of Biochemistry; Nonr 908(11), NR 105-176; W. G. Shafer, J. C. Muhler.

The specific aim of this study is to clarify the relationships between the endocrine glands (thyroid and gonads), the salivary glands, and experimental dental caries. Attempts are being made to clearly delineate which of the salivary glands is (1) of greatest importance, as an intermediate, in altering the incidence of dental caries; and (2) the most sensitive to dysfunction under the influence of the products of the endocrine glands. Following the establishment of these facts, clarification will be attempted from the standpoint of alterations in salivary gland function. Then, the factors in saliva will be investigated to ascertain which of these become changed so as to result in altered caries experience.

Preservation of Blood (U), RR 005-12-0035. Bryn Mawr Hospital, Bryn Mawr, Pennsylvania, Laboratory of Clinical Pathology; Nonr 2466(00), NR 105-182; M. M. Strumia.

The results of previous work indicated that human red blood cells, modified with sugar solutions (lactose and dextrose in varying concentrations), can be frozen, maintained at low temperature for one week, and transfused without further modification; the survival of such cells was fully comparable to that of normal fresh cells. The aim of this study now is to determine whether long-term storage of blood cells preserved by this method is feasible. The various effects of such storage on the red blood cells are being investigated.

Tolerance of Skin Grafts (U), RR 005-12-0036. State University of New York, College of Medicine at New York, Brooklyn, New York, Department of Pathology; Nonr 1349(02), NR 105-183; S. C. Mohos.

Methods are being sought for reducing antigen-antibody reactions that occur in the body following the application of skin or organ homografts. Studies are being carried out to determine whether such homografts will "take" on animals following hibernation (there is a temporary immunologic tolerance following hibernation). Attempts are being made to establish parabiosis (surgical joining of two animals) between bats and between hamsters following hibernation. Transplants of skin or other organs are being performed in the parabiotic animals and the success of the transplants is determined after the parabions are separated.

Use of Isotopes for X-Raying (U), RR 005-12-0037. Ohio State University Research Foundation, Columbus, Ohio, Department of Physics; Nonr 495(17), NR 105-185; H. D. Spangenberg, M. L. Pool.

Characteristic radiations of radioactive nuclei such as cerium (Ce^{144}), cesium (Cs^{131}), ytterbium (Yb^{169}), and europium (Eu^{155}) isotopes have been studied to find those suitable for compacting into a high intensity, low energy source for clinical radiography. Eu^{155} and Yb^{169} have this property. The current study is dealing with an evaluation of Eu^{155}, free from contaminants.

Tissue Culture Techniques (U), RR 005-12-0038.

The University of Texas Medical Branch, Galveston, Texas, Department of Pathology; Nonr 1598(04), NR 105-189; A. W. B. Cunningham.

This task is a study of the applicability of quantitative tissue culture techniques to the various organs of the body such as heart, kidney, and others. Characteristic functions of the tissue under observation are being measured. Currently brain tissue is being studied. Attempts are being made to identify individual cells or aggregates of cells from various parts of the developing brain which show significant electrical activity in tissue culture.

Diagnosis by Infrared Rays (U), RR 005-12-0040. Columbia University, College of Physicians and Surgeons, New York, New York, Department of Dentistry; Nonr 2648(00), NR 105-193; J. Friedman.

The applicability of an image-converter tube, sensitive in the near infrared, as a clinical diagnostic instrument is the objective of this study. Utilization of this instrument to study the patterns of veins and arteries in the mucous lining of the mouth, under conditions of health and disease, constitutes the major application. Other applications are concerned with blood vessels of other parts of the body such as the retina of the eye.

Energetics of Wound Healing (U), RR 005-12-0041. The University of Texas Medical Branch, Galveston, Texas, Department of Biochemistry; Nonr 1598(05), NR 105-198; T. G. Blocker, Jr., W. W. Nowinski.

Studies are being made of the complete system of anaerobic and aerobic production of energy during the process of wound healing. The energy required by cells for their living processes is derived from the high energy phosphate bond, of which adenosine triphosphate is one of the main sources; the energy uptake of these high energy phosphate bonds is being studied in order to elucidate the energy requirements at different stages of skin granulation during the healing of wounds resulting from burns.

Implantation of Endocrines (U), RR 005-12-0042. New York Medical College, New York, New York, Department of Anatomy; Nonr 2754(01), NR 105-199; E. L. House.

This is a determination of the ideal age combination of donor and host to give the maximum growth and survival time of implants of endocrine tissue, e.g., pancrease, adrenals, etc. Attempts are being made to discover whether there is some general or specific growth-promoting factor in donor tissues of various ages. Changes are being established that occur in blood and lymphatic tissues such as changes in hemoglobin, plasma proteins and others.

Far East Dietary Disorders (U), RR 005-12-0043. Northwestern University, Evanston, Illinois, Department of Biochemistry; Nonr 1228(14), NR 105-200; R. Q. Blackwell.

This task is established to provide important biochemical information on the origin of nutritional diseases epidemic and endemic to Taiwan and the adjacent areas of the Far East. Desired and primary areas of study include diseases connected with nutritional deficiency, exotic diseases of the area, and chemical investigation of food, soil, water and other elements of the environment.

Immunochemistry of Saliva (U), RR 005-12-0044. Columbia University, College of Physicians and Surgeons, New York, New York, Department of Microbiology; Nonr 266(63), NR 105-201; S. A. Ellison.

This study is concerned with the application of various immunochemical and related techniques toward the enumeration, identification, and characterization of the antigenic components of saliva. Attempts are being made to establish normal values and to relate quantitative and qualitative changes to oral disease.

Atmospheric Pollutants (U), RR 005-12-0045. Wayne State University, College of Medicine, Detroit, Michigan, Department of Industrial Medicine; Nonr 2674(00), NR 105-204; A. J. Vorwald.

The aim of this task is to study the effects of inhalation and pulmonary deposition of the atmospheric pollutants. Primarily the studies pertain to the inhalation of fumes, gases, and other noxious products of fuel and propellants.

Dental Cement Properties (U), RR 005-12-0046. U. S. Department of Commerce, National Bureau of Standards, Washington, D. C., Dental Research Section; NAonr 39-59, NR 105-210; G. M. Brauer.

In an attempt to improve the desirable properties of the zinc oxide-eugenol cements (filling material used in dentistry), this study will be concerned with the synthesis and physical properties of isomers and derivatives of eugenol. The first step is to synthesize pure zinc eugenolate and isoeugenolate and other metal chelates and to study their physical properties. Then position isomers of eugenol that are capable of forming chelates will be synthesized to study their physical properties. These compounds will then be tested for setting reactions, hardness, and adhesion when placed in contact with the tooth surface.

Pump Oxygenator (U), RR 005-12-0047. Massachusetts Institute of Technology, Cambridge, Massachusetts, Cryogenic Engineering Laboratory; Nonr 1841 (62), NR 105-211; S. C. Collins.

This research is concerned with the design and testing of an improved pump oxygenator for extracorporeal oxygenation of blood during cardio-vascular and pulmonary surgery. The pump, designed in simplicity, is being evaluated clinically in such problems as severe shock, massive pneumonias, congestive heart failure, pulmonary edema, and others. Improvements in design or mechanics will be made, if necessary, following the application of this "heart lung machine" to the problems cited above.

Bone Graft Substitutes (U), RR 005-12-0048. Georgetown University, School of Dentistry, Washington, D. C., Department of Oral Surgery; Nonr 2836(00), NR 105-212; G. O. Kruger.

The objective of this study is to find a suitable substitute for fresh autogenous bone grafts. The approach to this problem involves two aspects. The first includes a determination of clinical and histologic responses of low-temperature ash (LTA) bone transplants as well as boiled LTA bone

transplants. The second deals with the determination of the precise particle size of this bone that is significant in the healing of bone defects.

Living Cell Preservation (U), RR 005-12-0051. Naval Medical Research Institute, Bethesda, Maryland, Biophysics Division; Project Order No. 770, NR 105-225; H. T. Meryman.

This is a study of the mechanisms involved in freeze- and air-drying preservation of living cells and larger biologic materials. The air-drying technique is being explored for its applicability to the preservation of viability in biologicals and foodstuffs. The freeze-drying method is being studied to learn the relationship between rate of drying, degree of dryness, and vapor pressure requirements for storage.

Caries in Germfree Animals (U), RR 005-12-0052. University of Chicago, Zoller Memorial Dental Clinic, Chicago, Illinois, Department of Bacteriology; Nonr 2121(05), NR 105-242; F. J. Orland.

This study, one of long range, is concerned with the basic mechanisms in tooth decay by utilizing the germfree method of approach. The study is divided into four distinct phases (1) the effects of a cariogenic diet on the teeth of germfree animals as compared to the effects of the same diet on the teeth of conventional laboratory animals; (2) the inoculation of otherwise germfree animals with specific bacteria, previously studied in vivo, to determine their relationship to cariogenesis; (3) the effects of variation of the dietary substrate in the presence of a simplified cariogenic flora; and (4) the effects of both known bacterial flora and known dietary regimen on the teeth while known caries-inhibitors and caries-enhancing substances are present.

Oral Micro-organisms (U), RR 005-12-0053. University of Pennsylvania, School of Dentistry, Philadelphia, Pennsylvania, Department of Microbiology; Nonr 2112(00), NR 105-333; N. B. Williams.

Experimental investigations are being conducted for the purpose of (1) recognizing and evaluating the factors influencing the types and quantity of micro-organisms in the mouth; (2) studying the interrelations among the microbic populations of the oral pharyngeal and nasal cavities and the salivary effects on micro-organisms; (3) surveying the oral microflora and their correlation with oral pathology; and (4) determining the mechanism of deleterious effects of local use of chemotherapeutic and antibiotic agents.

Dental Materials (U), RR 005-12-0054. University of Michigan, School of Dentistry, Ann Arbor, Michigan, Physical Research Laboratory; N6onr 232 (08), NR 105-360; F. A. Peyton.

This is a study of current and new dental materials through physical and chemical means for the purpose of improving the quality of dental restorations. The ultimate aim of this study is to develop the best combinations of dental materials and techniques for the production of more efficient and longer lasting dental restorations.

Medical Advisory Committee (U), RR 005-12-0055. National Academy of Sciences, Washington, D. C., National Research Council, Division of Medical Sciences; MIPR 16-60, NR 105-486; R. K. Cannon.

Information, recommendations, and competent evaluations are being furnished to the Biological Sciences Division, particularly the Medicine and Dentistry Branch, concerning programs in medical, dental, and biologic research.

Function and Morphology of Blood Vessels (U), RR 005-12-0056. Indiana University Medical Center, Indianapolis, Indiana, Department of Surgery; N8onr 733(00), NR 105-829; H. B. Schumaker, Jr.

Long-range studies are being made to observe any changes in strength, function, and durability of the rebuilt blood vessels. The testing of various types of plastic blood vessel grafts will continue. At the same time attempts will be made to develop suitable prostheses for repair of diseased or damaged valves of the heart.

Rapid Photofluorography (U), RR 005-12-0057. The University of Chicago, Chicago, Illinois, Department of Radiology; Nonr 2176(00), NR 105-087; R. D. Moseley, Jr.

This task deals with the development of a method for the rapid diagnosis of disorders of the abdomen and alimentary tract wherein a rapid photofluorograph camera, developed under this contract, is being utilized.

Low-Temperature Preservation of Blood (U), RR 005-12-0058. Linde Company, Research and Development Laboratory, Tonawanda, New York, Division of Biology; Nonr 3003(00), NR 105-208; A. P. Rinfret.

This task is concerned with a practical procedure for freezing, storing, and thawing, of whole blood. To achieve this end, a program is being undertaken of integrated biologic, biophysical, clinical, and engineering research and development for the purpose of studying (a) the thermal characteristics of blood, particularly heat transfer; (b) the effects of various freezing and thawing procedures on the biochemical and physiologic properties of red blood cells; (c) the effects of additives used to facilitate preservation and storage; (d) the influence of storage temperatures; (e) the stability and viability of red blood cells after thawing; (f) clinical evaluation of every known variable in the freezing and thawing of blood; and (g) the design of containers and a freeze-thawing apparatus. This work is continuing. In addition, the pharmacological characterization of a variety of additives such as polyvinylpyrrolidone, glycerol pectate and dextran is being done in order to find the best polymeric additive which will yield 100% survival of the preserved blood. Limited clinical trials in man are being done since the results to date justify a cautious program of clinical evaluation.

Effect of Beta Radiation on the Intermediary Metabolism of Mammalian Skin (U), RR 005-12-0059. The University of Michigan, Research Institute, Ann Arbor, Michigan, Department of Biochemistry; Nonr 1224(35), NR 105-223; I. A. Bernstein.

This task is concerned with the study of the effects of ionizing radiation on the intermediary metabolism of mammalian skin, with learning how radiation might interfere with the availability of

chemical energy which is essential for the metabolic processes which occur in skin. For example, one possibility of aberration of chemical energy is the destruction by radiation of "high energy" compounds like adenosine triphosphate. This and other possibilities are being studied in order to show how radiation interferes with mitosis and nucleic acid synthesis (DNA and RNA), and if so, how can this interference be prevented.

Factors Influencing Establishment of Oral Flora and Their Effects on Oral Tissues (U), RR 005-12-0060. University of Oregon Dental School, Portland, Oregon, Department of Bacteriology; Nonr 3130 (00), NR 105-224; M. L. Snyder.

This study is designed to gain some understanding of organisms present in the oral cavity which act in combination to produce a given effect. If possible, it is hoped to determine the factors influencing the establishment of combinations of microbial flora indigenous to the surface of the teeth and oral mucous membranes and the effects of the flora on these tissues by means of referring activity to the synthesis of mucinous polysaccharides from sucrose. Finally the approach to establishing normal flora involves continuous culture, in some form, with selected pairs of organisms known to be statistically frequent in the selected site to be accepted as "normal."

Pulmonary Function After Thoracic Surgery (U), RR 005-12-0061. State University of New York, Downstate Medical Center, Brooklyn, New York, Department of Medicine; Nonr 3079(00), NR 105-230; H. A. Lyons.

This was a study of pulmonary function in humans who have undergone thoracic surgery. Particular emphasis was placed on the distribution of inspired air before, immediately after, three months and one year after surgery. The objective was to determine the clinical significance of alterations in the bronchial tree and pulmonary blood vessels which occur as a result of surgery.

Transplantation of Cornea (U), RR 005-12-0062. Columbia University, College of Physicians and Surgeons, New York, New York, Department of Anatomy; Nonr 266(71), NR 105-234; G. K. Smelser.

The replacement of constituents of grafted tissue and the relation of host-donor interaction are being studied by the rate of turn-over of isotopically labeled corneal transplants in normal and transplanted corneas of the eye. Comparisons of these rates is being made to reveal whether the corneal grafts are acting only as a "scaffold" or whether the donor tissue persists. At the same time investigations are being made of the relative importance of corneal cells and fibers in evoking a host immune response to the graft.

Bone Marrow Preservation (U), RR 005-12-0063. The San Francisco Institute of Medical Science, San Francisco, California, Department of Surgery; Nonr 3168(00), NR 105-235; V. Richards.

The general objective of this task is the exploration of various methods for the long-term preservation of bone marrow (including its constituent cells) at low temperature. The various elements of marrow will be studied separately at different cooling velocities in order to study the sensitivity of these cells at different ranges of low temperature (from 0° to -195°C). Observations will be made of the viability of the variously preserved bone marrows following autotransplantation and homotransplantation. The ultimate aim of this research is to develop a successful method of long-term preservation of bone marrow for use in the treatment of radiation injury and other disease amenable to the effects of this potential therapeutic agent.

Study of Osteogenesis and Healing of Fractures (U), RR 005-12-0064. Eastman Dental Dispensary, Rochester, New York; Nonr 3140(00), NR 105-240; H. Aduss.

The mechanisms involved in the regeneration of bone, replacement of bone grafts, and bone-forming activity of tissues are still undetermined. In this study some of these mechanisms are being investigated. For example, it is hoped to demonstrate the effect of the enzyme alkaline phosphatase on the healing of fractures when it is used in combination with various osseous and alloplastic materials. Another approach is the study of the effects of chondroitin sulfate on healing when it is present in excessive amounts at fracture and implant sites.

The Immune Reaction and Tolerance Toward Transplanted Tissue (U), RR 005-12-0065. The University of Padua, Padua, Italy, Department of Plastic Surgery; Nonr G-0007-60, NR 105-245; D. Dogo.

One of the major problems which impedes successful transplantation of tissues is that of the immune reaction and the development of tolerance toward the grafted tissue. Those aspects of tolerance being studied are (1) the determination of whether tolerance is due to an irreversible damage induced in formative antibody apparatus or a true change; (2) the possibility of artificially reproducing tolerances; (3) determination of a relationship of tolerance to chromosomal inheritance; and (4) the determination of the biochemical expression of tolerance. Following a study of these phenomena in experimental animals, application of the elaborated principles to humans will be attempted.

Experimental Cold Injury (U), RR 005-12-0066. William James Mills, Jr., Anchorage, Alaska; Nonr 3183(00), NR 105-249; W. J. Mills, Jr.

This task is an experimental and clinical study of cold injury (frostbite). Principally the work includes evaluations of methods of treating frostbite such as rewarming by ultra-high frequency sound. The experimental approach includes a study of changes in local enzyme systems which could be utilized to determine the degree, depth and duration of injury. Radioactive isotopes are being used to study circulatory flow as well as protein absorption in cold injured human extremities.

Periodontal Disease (U), RR 005-12-0067. Health Research, Incorporated, Albany, New York, Department of Biochemistry; Nonr 3266(00), NR 105-251; D. J. Smith.

It is the purpose of this research to investigate the chemical interrelationships of the

components of connective tissue. Particularly, it is hoped to learn the relation between collagen and chondroitin sulfate in tissues from lathyric (poisoned by the sweet pea) animals. In lathyrism there seems to be a metabolic block affecting one or more tissue components which disrupts in some way the normal integrity of connective tissue. This approach may lead to an elucidation of the chemical relation between the fiber and mucopolysaccharide in the tissue ground substance. Since diverse agents can act on the mucopolysaccharide-protein complex and modify these links in the tissue, they may play a role in the genesis of connective tissue disease such as periodontal disease.

Far East Virus Diseases (U), RR 005-12-0068. Dr. A. F. Rasmussen, Jr., Los Angeles, California; Nonr 3214(00), NR 105-252; R. F. Rasmussen.

The objective of this task is to provide, through field and laboratory studies, essential information on diseases and medical disorders endemic or epidemic in the Far East. This information will be of use in establishing methods for controlling the animal and insect vectors of area diseases. It is hoped ultimately that diagnosis and treatment of endemic diseases will be improved to a point of more effective prevention. Current emphasis is being placed on virus diseases and rickettsial diseases.

Problems of Malnutrition in the Middle East and Africa (NAMRU-3 region) (U), RR 005-12-0069. Vanderbilt University, School of Medicine, Nashville, Tennessee, Department of Biochemistry; Nonr 2149 (04), NR 105-254; W. J. Darby, W. N. Pearson.

The purpose of this research is to carry out a broad research program on problems of malnutrition, especially those related to or associated with communicable diseases, occurring in the United Arab Republic, N. Africa, and the Middle East (NAMRU #3, Cairo, Region). The program combines biochemical, clinical, parasitologic, and epidemiologic studies. For example, it is planned to study the relationship of nutrition to the types of anemia present in the general region. Nutritional values of foods of the region are being determined.

Salivary Substances Related to Oral Diseases (U), RR 005-12-0070. Institute of Stomatological Research, Brooks Hospital, Sias Research Laboratories, Brookline, Massachusetts; Nonr 3230(00), NR 105-005; V. F. Lisanti.

The basic concern of this investigation was to determine what enzymes or other substances that occur in saliva could be used as indicators for the presence or absence of oral diseases. The identification and source of these substances were studied in conjunction with the general biochemistry of saliva. Metabolic processes of the tooth enamel were investigated for the purpose of correlating this data with salivary analysis.

Cerebral Regulation of Salivary Function and Its Physiologic Significance (U), RR 005-12-0071. Medical College of Virginia, Richmond, Virginia, Department of Neurologic Science; Nonr 1134(03), NR 105-228; E. C. Hoff.

This task is an integral part of a total study by the investigator on cerebral and higher central nervous regulation of the autonomic function. This particular phase, higher nervous control of salivation, is designed to add further knowledge of cortical regulatory mechanisms of function related to the autonomic nervous system. Precise details are being studied such as localization within the cerebral cortex of salivary function and the nervous pathways which mediate salivation. Determinations are being made of the nature and type of nerve endings and afferent fibers subserving the salivary mechanism from the periphery of the body. The general aim is to determine a more complete basis for understanding the total functions of the cortex and the central nervous system in the integration of the organism as a whole and in the coordinated relationship of autonomic and somatic function.

Studies on Coronary Circulation. MR 005-12-0001. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland; Lt L. H. Edmunds, MC, USNR.

The technique of electronically controlled coronary arteriography has been abandoned at the Naval Hospital, Bethesda, for the diagnosis of ischemic myocardium. Single films of the coronary vessels are insufficient. Plans are being made to use the coronary injector system developed at NMRI with the cine-X-ray equipment recently installed at the Naval Hospital, Bethesda. This technique permits adequate evaluation of the coronary vessels. Under this project experiments in the surgical cure of complete heart block are now in progress. Heart block has been produced in a continuing series of 18 dogs by placing a heavy ligature around the bundle of His just distal to the A.V. node. These animals have been carefully followed to ascertain the fixity of their heart rate. After 2 to 4 months the right thyroid gland of these animals will be inserted as a pedicle graft into the ventricular musculature. Pilot experiments have demonstrated the feasibility of the procedure and have allowed resolution of the technical problems encountered. Each dog will be carefully followed with electrocardiography, arteriography and thyroid function studies. S.T. 3 was approved on 28 Nov 1960 and as yet there is no progress to report.

Studies on the Use of Hypothermia in Surgery (U), MR 005-12-0002. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland; Lt L. H. Edmunds, Jr., MC, USNR.

The work on cardiac arrest was completed and the superiority of cold arrest below 10°C was established. A large study has demonstrated a severe metabolic and function of injury occurring with chemical cardioplegic agents (potassium of acetylcholine) while a relatively minor functional and metabolic injury is associated with cold arrest. A subsequent study established the safe duration of cardiac ischemia at various temperatures. The final study demonstrated compounding of functional injury during successive ischemic periods. In the laboratory the technique for profound cooling to below 10°C for the entire animal was worked out. Subsequently the arterial circulation of the canine brain was completely isolated and perfused. This preparation permits definitive metabolic studies of the perfused and ischemic brain during

profound hypothermia. This work is 75% completed. During the past year 36 clinical open heart surgical cases were performed using equipment and personnel from this department. There were 4 deaths. Under direction of this department, a second extraporeal and thermoregulatory system has been constructed for the Naval Hospital, NNMC. An exhibit has been constructed to demonstrate the NMRI equipment and open heart surgical techniques. This exhibit received enthusiastic reception at two conventions and currently is scheduled to be shown at the Annual Convention of the AMA in New York in June 1961.

Studies on the Treatment of Shock (U), MR 005-12-0101. Naval Medical Field Research Laboratory, Camp Lejeune, N. C.; MarCorps 17X1319.2717, P.O. 1-0009; T. W. Merriam, Jr., Lt, MC, USNR.

Studies carried out previously at this laboratory suggest that myocardial contractility is diminished following 30% BSA thermal burn. During recent months a study was carried out in 18 dogs, demonstrating that a 40% fall in cardiac output occurs within 5 minutes after the burn, and that levarterenol infusion results in a rise in the cardiac output to near normal levels and an elevation of arterial pressure to above normal.

Studies utilizing ventricular function curves have been carried out in 14 dogs. The ventricular function curve is utilized as a measure of myocardial contractility, and it is measured immediately before and 5 minutes after the thermal burn.

The studies performed thus far do not indicate that there is a definite diminution in myocardial function after burn. Further work, which includes the use of an electromagnetic flowmeter for more accurate stroke volume determination, must be done before a definite statement can be made. These studies are to be carried out in the coming months.

Physiological Changes During Total Body Perfusion with a Pump Oxygenator, MR 005-12-0201. Surgical Research Laboratory, U. S. Naval Hospital, St. Albans, New York; C. P. Deal, Jr., Lt, MC, USNR, J. J. Timmes, Capt, MC, USN. Collaborators: K. E. Karlson, M.D., Ph.D., M. J. Trummer, Cdr, MC, USN, H. S. Pollard, Lt, MC, USN.

In the previous annual report twelve clinical open-heart operations were discussed. These included five deaths. During the past year sixteen additional operations were performed using the Dennis oxygenator as modified by our laboratory. These included six patients with inter-atrial septal defect; all of these patients survived and are now alive and well. Two patients had pulmonic valvular stenosis; they are alive and well. One patient had tricuspid insufficiency, who is alive and well. One patient had acquired aortic stenosis; his operation was successful. Four patients had inter-ventricular septal defect; three of these are alive and well. Two patients had Tetralogy of Fallot; of these, one patient survived and today is much improved after a successful operation. The two deaths included a patient with Tetralogy of Fallot in whom an anomalous coronary artery had to be ligated in order to permit the ventriculotomy. This led to a myocardial infarction and his eventual demise. The other fatality occurred in a patient with ventricular septal defect who died five days postoperatively with pneumonia. These results, we feel, are excellent.

The pump has also been used for the isolation-perfusion of an extremity in four patients, in the palliative chemotherapy of selected cases of malignant tumor. None of these patients has shown any deleterious effect from the perfusion itself.

An expanded portion of this task has been the study of the blood pH, oxygen and carbon dioxide content of venous and arterial blood, and serum electrolytes of the patients undergoing total cardiac bypass. Similar studies have been performed in many of the animal perfusions in the laboratory. It is our wish to determine the cause of the metabolic acidosis which occurs during perfusion and to eventually find a preventive for this. During the coming year this portion of our study will be pursued even more vigorously.

During the past year the use of a heat exchanger in the line of the extracorporeal circulation has been perfected in the laboratory and has now been employed clinically in several cases with perfection. With this technic the patient's body temperature can be lowered at a rate of 1-2 degrees per minute, and in one instance the total circulation was stopped for a period of twenty minutes allowing the surgeons a completely bloodless field in which to operate.

Many additional activities have been carried out in conjunction with this project, not the least of which is the frequent presentation of our material to the outlying civilian hospitals. These have been received very well. It is anticipated that an exhibit of this material will be available for the 1961 annual meeting of the American Medical Association in New York.

Investigations of the Etiology, Diagnosis and Treatment of Disease, MR 005-12-0300. Pediatric Service, USNH, NNMC, Bethesda, Maryland; C. R. Boyce, Lt, MC, USN.

Preliminary steps have been taken leading towards the demonstration of cofibrins, released by intraalveolar clotting, in the newborn with hyaline membrane disease. Serum has been extracted to remove proteins and lipids, desalted in a starch column, and various fractions electrophoresed at high voltage and stained with ninhydrin and Salcaguchi reagent. Spots have been demonstrated which correspond to purified bovine cofibrin and which are presumed to represent human cofibrin. Attempts are currently being made to increase the sensitivity of the procedure and staining so that it can be applied to the small quantities of blood which can be drawn from diseased premature infants.

The Tumorcidal Effect of Clorpactin XCB, MR 005-12-0301. Surgical Research Laboratory, U. S. Naval Hospital, St. Albans, New York; C. E. Rogers, Capt, MC, USN. Collaborators: J. J. Timmes, Capt, MC, USN.

This project is still under clinical evaluation by way of the Tumor Registry. Patients who have had Clorpactin XCB used as a wound irrigant are being followed through the Tumor Registry. No definitive data on the decrease of the incidence of local recurrence are available at this time. It is anticipated that these data will not be available until two more years have passed; this would

then give five-year follow-up information.

It is to be noted that reports from various investigators, among those Dr. Warren Cole in Chicago, indicate that they feel Clorpactin is of very little more value than Dakin's Solution or distilled water when used as a tumoricidal irrigant in an operative wound.

Since the continuance of this project requires no material or money and only the same observation which is afforded any patient, it is recommended that this project be continued. It must be borne in mind that at this point there is little hope that Clorpactin XCB will be shown to be an efficacious agent.

Development, Evaluation and Use of Prosthetic Devices for Amputees, MR 005-12-0400. Prosthetic Research Laboratory, U. S. Naval Hospital, Oakland 14, California; Capt Thomas J. Canty, MC, USN.

The task assigned this laboratory consists of four principal interrelated and complementary parts, as follows:

1. Manufacture and fitting artificial limbs and orthopaedic appliances for individual patients and their specific requirements.
2. Conduct of associated research and development program in field of artificial limbs and orthopaedic devices.
3. Conduct School for Orthopaedic Appliance Mechanics.
4. Develop and maintain comprehensive rehabilitation program for amputee and other orthopaedically disabled personnel.

Basic limb and brace materials, manufacturing methods and fitting technics are derived from principles developed here and elsewhere. Components are modified only following adequate study and experimentation where such change accomplishes valid and measurable improvement.

Clinical Aspects of Diseases in the Middle East, MR 005-12-1001. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; J. H. Boyers, Capt, MC, USN, Head, Medical Department.

Since inception of this task major work can be subdivided into the following areas: studies on the etiology, diagnosis, epidemiology, and therapy of endemic and epidemic diseases of the area, various physiological studies, and therapeutic evaluations. During the cholera epidemic of 1947 the value of simple methods for measuring blood specific gravity as an index for needed fluid replacement and of the life saving value of such replacement was demonstrated. Toxicity and usefulness of plasma expanders in other diseases was demonstrated. Brucellosis melitensis was found to be a common disease, its epidemiology and course described and various tehrapeutic regimens evaluated against it, resulting in lowering of the relapse rate from 85% to 15%. As they were discovered, antibiotics have been tested in the prevalent diseases of the area including typhoid fever, typhus, amebiasis, shigellosis, and other fevers. By comparative screening optimum therapeutic regimens have been established. Efforts to use antibiotic prophylaxis against Shigellosis in human populations failed as did monovalent vaccines. A cardiopulmonary laboratory established in 1955 enabled definition of schistosomal cor pulmonale as a disease of the pulmonary arteriolar system not susceptible to therapy after becoming established. It also enabled the training of physicians from the 3 Medical Schools of Egypt in the techniques of study and the establishment of cardiopulmonary laboratories in those schools.

Studies on Metabolism in Health and Diseases (U), MR 005-12-1100. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; LCdr E. M. Neptune, Jr., MC, USN.

Studies on ammonium intoxication have been completed and the final report is ready for processing. The title is "An Experimental Study of Urease Poisoning".

The studies in energy metabolism have been extended into a more detailed scrutiny of the lipid and carbohydrate metabolism of skeletal muscle using the rat diaphragm preparation. By column chromatography the specific chemical constituents of the neutral lipid and phospholipid of muscle are being isolated and measured. The exact sequential pathways and enzymatic steps are being uncovered with a respect to the incorporation of carbon-14 labeled, long-chain fatty acids. An unusual defect in the neutral lipid content of muscle from the nephrotic rat has also been under study as a possible aid towards understanding normal pathways and mechanisms. Concomitantly, studies are underway directed toward glycolysis in muscle homogenate with particular attention to an inhibition of hexokinase by a potent, competing ATPase.

Studies on Metabolism in Health and Diseases (U), MR 005-12-1102. Naval Medical Research Unit No. 4, U. S. Naval Training Center, Great Lakes, Illinois; 10055; Capt L. F. Miller, MC, USN.

Sera from recruits immunized with two influenza vaccines are being fractionated by a modified cellulose column technic to determine whether any differences exist in location of hemagglutination-inhibition (HI) and neutralizing antibodies in sera in which a marked dissociation of HI and neutralization titers was observed.

No correlation was apparent between the antistreptolysin O (ASO titers and gamma globulin levels in the streptococcal group whereas in rheumatic fever a high degree of correlation existed. When streptococcal and adenoviral CF titers were both observed in the same paired sera a positive correlation in both adenoviral CF and ASO titers was found to exist with gamma globulin levels.

Work is continuing on the study of correlation between serum fractions and immunological factors including the relationship of alpha 2 globulins to respiratory illness susceptibility.

Biochemical Alterations in Disease, MR 005-12-1103. Clinical Investigation Center, U. S. Naval Hospital, Oakland, California; Cdr P. D. Doolan, MC, USN.

In 12 oliguric subjects the total body water was measured 16 times with tritiated water. The values varied between 46 and 75% of the body weight, with no low values. Body water was also calculated from the extraction of urea and tritium during hemodialysis. The volumes so calculated increased with the duration of dialysis. When compared with the predialysis control value, the urea values were found to stand in closer agreement than those of

tritium. The close agreement is due to a fortuitous balancing of slow equilibration during extraction with endogenous production of urea in the body.

In 16 anemic uremic patients there was found a significant decrease in reduced glutathione content and stability in those with acute uremia and a significant lowering in reduced glutathione stability in those with chronic uremia. The glucose-6-phosphate dehydrogenase activity, however, was significantly higher than the values obtained in normal subjects. This acquired corpuscular defect is reversible and may be related to the anemia of uremia.

A 3-year-old child has been studied over a 1-year period and found to consistently excrete abnormally large quantities of the keto acids of isoleucine, leucine and valine. The maple-syrup odor, as well as various neurological manifestations, did not appear until she was 16 months old, and have been episodic. She is therefore considered to represent a variant of the disease.

Studies on Metabolism in Health and Diseases, MR 005-12-1104. Surgical Research Laboratory, U. S. Naval Hospital, St. Albans, New York; C. P. Deal, Jr., Lt, MC, USNR, H. S. Pollard, Lt, MC, USN. Collaborators: L. T. Greene, LCdr, MC, USN, K. E. Karlson, M.D., Ph. D.

Defibrillation, a Critical Evaluation of the Electrical Factors Involved:

We have not been able to make any progress on this project because we have not yet been able to buy the necessary equipment. A request for additional funds from BuMed was made last year and was denied. The project still stands in the status of a pilot study.

The information which can be gained from this project is of increasingly vital importance in that it can be applied to resusitation of any patients with acute cardiovascular collapse whether civilians or battle injuries.

Changes in Hepatic Blood Flow with Changes in Cardiac Output:

In the last progress report, thirteen patients had been studied to determine the effects of anesthesia on the liver blood flow. Because of difficulty with instrumentation, we have found it difficult to correlate the liver blood flow with the cardiac output in our operating room. Several attempts have been made to measure liver blood flow and cardiac output simultaneously with dye dilution and radioisotope techniques. We now feel that the best method to determine the cardiac output under these experimental conditions will be the Fick technique, and this should be completed during the coming year.

Cardiopulmonary Function Studies in Relation to Disease, MR 005-12-1200. Clinical Investigation Center, U. S. Naval Hospital, Oakland, California; Cdr P. D. Doolan, MC, USN.

Of a desired 100 patients with emphysema, 44 have been thoroughly studied. On the basis of the clinical and functional studies, the disease has been classified as obstructive, bullous or a combined form. This will provide a superior reference against which prognosis and therapy can be evaluated.

In order to select an animal suitable for experimental studies on the role of the bronchial arteries in the pathogenesis of emphysema, 8 different mammalian species were studied in detail. On the basis of these subgross, thin-slice, latex injection studies, 4 different lung types were identified, with the lungs of the horse bearing the closest resemblance to those of the human.

Thoracotomies have been performed on 10 normal horses and the bronchial artery injected with thorazine. Survival periods ranging up to 3 months have been obtained. In some of the experimental animals, findings identical with those observed in a horse with spontaneous emphysema have been observed. The similarity between equine and human emphysema has been confirmed and the participation of the bronchial arteries in the pathogenesis has been strengthened.

An Integrating Photoelectric Recorder for Paper Electrophoretic and Chromatographic Measurements, MR 005-12-1400. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; J. Sendroy, Jr., Sc. D.

Attempts to make additional measurements by way of obtaining a satisfactory accumulation of data during the past year were largely abortive owing to an inadequacy of funds for the purchase of more recently developed units of instrumentation. Hence, no substantial progress was made in this direction. Such work will be carried out when funds are available. In the meanwhile, additional data will be gathered with the equipment now on hand.

The Study of Molecular Motility and Response to Varying Electric Current as an Aid to Clinical Diagnosis, MR 005-12-1402. Physical Chemistry Research Laboratory, U. S. Naval Medical School and Naval Medical Research Institute, NNMC, Bethesda, Maryland; G. W. Calver, RAdm, MC, USN (Ret). Collaborator: T. G. Ferris, LCdr, MSC, USNR.

Cancerine - Crystallography after electrolysis, steroid and hormone studies on urine specimens.

Free electrophoresis - Protein studies on urine and serum from patients studied in cancerine project. Correlation of abnormal patterns with disease.

Paper electrophoresis - Evaluation, development and adaptation of methods for clinical use in the study of serum proteins, hemoglobins, lipoproteins and glycoproteins as well as other body fluids. Correlation between electrophoresis and other chemical methods. Evaluation of protein electrophoresis, serum hexose and mucoprotein to determine specific patterns in certain diseases to detect early disease states.

Continuous flow electrophoresis - Pure separation of protein components in quantity for differential analysis particularly of value in the abnormal globulin found in the serum of Multiple Myeloma patients.

Starch, agar, and gel electrophoresis - Evaluation of methods as aids in diagnosis, particularly of hemoglobin anomalies.

Comparison of the Hemodynamic Effects of the End-to-Side and Side-to-Side Portacaval Anastamoses, MR 005-12-1404. Surgical Research Laboratory, U. S. Naval Hospital, St. Albans, New York; D. Schufeldt,

Capt, MC, USN. Collaborators: C. P. Deal, Jr., Lt, MC, USNR, H. S. Pollard, Jr., Lt, MC, USN.

Due to transfer of personnel this project was momentarily halted during the early portion of the year. However, it has now been resumed and eight surgical preparations have been completed, seven of whom are living. The first portion of this study will be carried out as soon as ten living preparations are available for study. The second portion of the study will then be undertaken.

Development and Evaluation of Diagnostic Techniques, MR 005-12-1408. Clinical Investigation Center, U. S. Naval Hospital, Oakland, California; Cdr P. D. Doolan, MC, USN.

The pulmonary vascular resistance, as estimated from the vectorcardiographic pattern, is being compared with the results obtained by direct measurement. Twenty-five patients have been studied, with complete data obtained. When sufficient data are available, correlation analyses will be made and if the vectorcardiogram is found to have predictive value, it may be used at times as a substitute for the repeat cardiac catheterizations.

The development of methods for measuring creatinine in small amounts of plasma was completed during the previous period (1959).

Evaluation and Development of Diagnostic Technique, MR 005-12-1410. Orthopedic Service, USNH, NNMC, Bethesda, Maryland; John H. Cheffey, Capt, MC, USN.

A measuring device has been fabricated and 25 disarticulated humeri obtained from the Smithsonian Institution have been X-rayed utilizing the technique under development. These X-rays are being measured to accumulate data for comparison with direct measurements of torion in the specimens.

Study of the Effects and Evaluation of the Use of Radioisotopes and Diagnosis and Treatment, MR 005-12-1502. Radioisotope Branch, Radiology Service, USNH, NNMC, Bethesda, Maryland; E. Richard King, M. D.

Over 350 cases have been studied and correlation of results of scans with clinical findings is continuing. All cases have been re-read at random with the reader having no knowledge of the correlation found in the cases.

A technique for photographic recording has been developed and it has the apparent advantages of economy due to use of less expensive isotopes with longer half-lives. Examination can be performed in 1 hour where old methods required 24 hour scan. Interpretation of results does not require extensive training. Radiation reduction by a factor of 10 is realized by the use of isotopes which are readily excreted. This same technique, using different isotopes can be used for study of the heart, spleen kidneys, large blood vessels, and thyroid. As experience is obtained, this unit may well be of general scanning use in situations where a variety of scanners are not feasible.

The Transit of Digitalis Compounds Across a Semipermeable Membrane, MR 005-12-1504. Surgical Research Laboratory, U. S. Naval Hospital, St. Albans, New York; C. E. Rogers, Capt, MC, USN. Collaborators: M. Mills, Lt, MC, USNR, H. S. Pollard, Lt, MC, USN, J. J. Timmes, Capt, MC, USN, H. T. Randall, M.D.

The first paper on this project is now in the rough stages and is being drafted for publication. Briefly, the conclusions we have reached as a result of the study are:

1) Digitalis can and does cross a semipermeable membrane.

2) When injected into animal or human, the material is so rapidly fixed in the tissues that there is little hope of removing it in the case of digitalis intoxication.

3) Difficulties arising during dialysis of patients who are digitalized are likely due to too rapid a fall in the potassium.

4) When digitalized patients are dialyzed, great care must be exercised to prevent too rapid a reduction in the serum potassium level.

This project has a number of ramifications and extensions and certain of these are now being pursued.

Clinical Evaluation of Drugs and Treatment (U), MR 005-12-1601. Naval Medical Research Unit No. 4, U. S. Naval Training Center, Great Lakes, Illinois; 10055; Capt, L. F. Miller, MC, USN.

Erythromycin propionate (a preparation giving prolonged blood levels) is being evaluated in the recruit population for effectiveness in erradication of Group A hemolytic streptococcal infections. Dosage consists of a single daily dose of 1 gram for 10 days. Negative cultures were obtained during therapy with few exceptions. Within 4 to 11 days, approximately 25% had positive cultures. It was not possible to ascertain whether this represented new acquisitions or activation of residual infection following excretion of the antibiotic.

Detectable blood levels of erythromycin were obtained in 90% of specimens from 10 men sampled 24, 48, and 72 hours after starting the 1 gram daily dose for 10 days. Decay studies of a single dose of 1 gram of erythromycin propionate revealed detectable blood levels in all 4 subjects at 28 hours, 75% at 32 hours, and 50% at 48 hours. All were negative at 72 hours. Side reactions were not noted.

These preliminary observations are promising and are being extended.

Clinical Evaluation of Drugs and Treatment, MR 005-12-1603. Obstetrics and Gynecology, USNH, NNMC, Bethesda, Maryland, T. B. Lebherz, Cdr, MC, USN; Radioisotope Branch, Radiology Service, USNH, NNMC, Bethesda, Maryland, J. S. Burkle, Capt, MC, USN, W. McFarland, Cdr, Mc, USN.

Premature Rupture of Membranes

The original study was completed 12-31-59. Excellent basic statistical data were accomplished from this study and from these data the phase II was devised. The 2nd study on Premature Rupture of the Membranes is a double-blind study utilizing Declomycin and Placebo, was begun on 7-1-60. Eighteen Naval Hospitals are cooperating in this study and the material is being coded on the current obstetrics code sheet at the Statistical Division. Review of the first 3 months was that 1,179 cases of premature rupture of the membranes has occurred, and 8,600 deliveries. 600 cases were considered to be such that they are included in the special study.

No conclusions are available from the present data. It is anticipated this study will be complete on or about 7-1-61.

Adjunctive Chemotherapy Study in Carcinoma of the Ovary

The above subject subtask has been under evaluation as a joint project with over 35 civilian medical centers. No cases were seen at this activity which could be considered to fall into the division set up in the protocol.

Bone Marrow Transplantation Project

7 patients with advanced malignancies have been treated with single dose, total-body radiation at this activity. Four have received infusions of stored autologous marrow, and one received homologous marrow. In two patients, palliation of the basic disease process was satisfactory. The cases receiving autologous marrow gave evidence of hematologic recovery beginning about the third week as compared to controls without marrow in whom recovery is delayed beyond this period if they survive. Studies to date suggest that careful study of hematologic events provides a valuable indicator of the amount of radiation received. This aspect of the study is being compiled for publication.

In a pilot experiment, using six dogs, three were treated with autologous marrow following lethal irradiation. One died before the marrow elements had sufficient time to regenerate. Two survived and the blood elements returned to normal within thirty days. One received autologous marrow by orthotopic implantation, and the return to normal by the blood elements was considerably delayed. No marrow was returned to one dog and it died on the fifth post-radiation day. The sixth dog was not irradiated due to unsatisfactorily curetted marrow for orthotopic transplantation. This portion of the overall bone marrow project has been submitted to and is being supported by DASA. Further work will attempt to devise a label for autologous marrow and attempt to assess the value of preserved marrow.

The Tissue Bank, NMS, furnished support in processing and preservation of the bone marrow used in the pilot experiment. Preservation was for short term only. Studies in long-term preservation will be undertaken as part of the DASA grant.

A Study and Correlation Visual and Convulsive Phenomena in Man and Animals, MR 005-12-2301. Neuropsychiatry Service, USNH, NNMC, Bethesda, Maryland; Robert Cohn, M.D. Consultant: Capt S. V. Thompson, MC, USN.

I. A study of Laminar activity was accomplished by means of microelectrode recordings in the visual cortex of the cat. In this work unit potentials were evoked (ratio of 1:25) by light stimulation in one eye or the other, but not by each in a given electrode position. As the electrode position was displaced deeper into the cortex a reversal was observed; a light stimulus in the previously unresponsive eye, would now evoke unit potentials. II. A case of Reading Epilepsy was reported. The case study was unusual in that the saccadic eyeball movements were precisely measured together with the patient's phonic output (by microphone) to signal the seizure sensation. The importance of the case was that the saccadic eyeball movements ceased for variable intervals prior to the cortical discharge. III. Present research in man pertains to the study of "hidden periods" in the spontaneous EEG. The Periodograms, to date, show a statistically valid correlation between amplitude modulation and the heart pulse activity. It is too early to speculate as to the precise meaning of this relationship. IV. We have high expectation of obtaining in the very near future an averaging response computing system with which to study evoked activity from the intact brain of man and animals. This work should relieve EEG techniques from the limitations of spontaneous activity and allow the study of controlled brain action. V. The relation of spontaneous and evoked activity will be studied in detail by the average response computer and by the projected use of a precise period measurement apparatus.

Chlorambucil as Adjunctive Therapy of Ovarian Carcinoma, MR 005-12-1605. OB-GYN OPD and WARDS; James H. Nelson, Jr., LCdr, MC, USNR.

This study continues and involves the use of Chlorambucil as an adjuvant in the treatment of ovarian carcinoma on a double blind basis. The protocol limits its use to early cases. No new cases have been added during the period this report covers.

Clinical and Experimental Studies in Renal Disease, MR 005-12-1700. Clinical Investigation Center, U. S. Naval Hospital, Oakland, California; Cdr P. D. Doolan, MC, USN.

The evaluation of intermittent peritoneal lavage has been extended to 45 patients in an attempt to further define its place in the management of acute and chronic uremia, as well as in the removal of water and diffusible poisons.

The nitrogen partition of deproteinized plasma has been studied in normal subjects and patients with uremia. In uremia, a small fraction of the nonprotein nitrogen may be unaccounted for. The total alpha amino acid nitrogen is frequently elevated in uremia. The data are being further analyzed to see if it provides further ideas to explore in studying the biochemistry of uremia.

Studies have been initiated on 2 patients with nephrosis and a persisting fasting hyperlipemia with latescence. The effect of 5 mg. of methyl testosterone sub-lingually is being studied both in terms of specific changes in serum lipid fractions and the mechanisms by which these changes are accomplished.

Motivational Factors Relating to Non-Academic Adjustment at U.S.N.A., MR 005-12-2001. Mental Hygiene Unit, Medical Department, U. S. Naval Academy, Annapolis, Maryland; Capt C. S. Mullin, MC, USN, Cdr J. M. Laudenslager, MSC, Lt H. J. Connery, MSC, USN.

Motivational data collected to date from voluntary resignees at USNA have been organized into a booklet entitled "Facts of Life in the Brigade of Midshipmen." This booklet is an enclosure to an official letter dated 1 December 1960 from Lt H. J. Connery, MSC, USN, to Chief, BuPers via official channels, including BuMed. This letter contained specific recommendations for consideration, based on research task findings, to implement current

USNA candidate examination and selection procedures.

From results obtained in the psychiatric screening of candidates for admission to USNA in March 1960, the Personal History Booklet has been revised to further assist the individual examiner in the conduct of candidate psychiatric screening. This new revision will be used in the March 1961 formal physical examinations of candidates seeking admission to the Class of 1965. Instructions to accompany booklet administration will seek to increase the validity of examiners' ratings assigned to candidates following the psychiatric screening.

Research in Military Psychiatry (U), MR 005-12-2003. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; LCdr J. E. Rasmussen, MSC, USN.

An extensive review of the present status and future needs of the psychiatric assessment programs at recruit training activities was completed by a working group of the Surgeon General's Panel in Neuropsychiatry. Coordination of this review and the report to the Surgeon General was effected from NMRI. Extensive reviews of the neuropsychiatric research needs of the Submarine Service have been completed during this year. These reviews, involving members of the Surgeon General's Consultant Panel in Neuropsychiatry as well as personnel from ONR, BuPers, and BuMed, have resulted in a concrete proposal for strengthening neuropsychiatric research in this area. This proposal has been made in the form of a consultants' report. As an aid to furthering the clinical research program of USNH, Bethesda, provisions were made for collaboration in a study being conducted by Dr. Robert Cohn on the correlation of visual and convulsive phenomena in man and animal. The Neurophysiology Branch of NMRI completed sections of 14 cats studied with a micro-electrode technique to localize lesions in the cortical areas of the brain. This work resulted in relatively accurate end-positions of the electrodes. The study was presented by Dr. Cohn at the American Electroencephalography Society Meeting and will be published upon completion of further experimentation.

Validation of Three Modified Screening Procedures in the Psychiatric Assessment of Recruit Aptitude for Service, MR 005-12-2201. U. S. Navy Medical Neuropsychiatric Research Unit, San Diego 52, California; LCdr A. E. McMichael, MSC, USN, John A. Plag.

Experimental samples have been collected for different seasons of the year at two Naval Recruit Training Centers to test the validity of predictions of adjustment to Naval service from brief psychiatric interviews, and from peer, self, and superior's ratings of probable adjustment. Attrition from the Naval service for psychiatric or disciplinary reasons is a criterion of failure in the service; school grades and performance ratings are criteria of successful adjustment. Data are now available upon 8,640 men, including a sample exempted from aptitude board attention.

Perceptual, Motor, Cognitive and Autonomic Functioning During Abnormal EEG Activity, MR 005-12-2304. U. S. Navy Medical Neuropsychiatric Research Unit, San Diego 52, California; L. C. Johnson, Ph. D., Cdr L. K. Cunningham, MC, USN.

Autonomic and cognitive variables, measured simultaneously with cortical activity, under ordinary resting conditions and during the presence of abnormal EEG induced by photic stimulation (or spontaneously occurring) will be recorded in samples of corpsmen, submariners, pilots, and hospitalized patients to help delineate relationships between cortical activity and autonomic functioning and possible importance of organized cortical patterns of activity in cognitive and motor behavior.

Pre-Enlistment Factors Related to Success in Recruit Training, MR 005-12-2502. U. S. Navy Medical Neuropsychiatric Research Unit, San Diego 52, California; MN 32 01 35; John A. Plag.

This study commenced in June of 1957 and had as its purpose (1) the identification of those psychological factors related to the success of Navy recruits in basic training, (2) the development of a valid psychiatric screening questionnaire, and (3) the comparison of objective screening procedures with interview methods. The first of these objectives has been completed, although the findings suggest the need for a second-order analysis and a subsequent revision of the derived Personal History Record. The Personal History Record, one of the products of this investigation, is currently in use at the U. S. Naval Training Center, Great Lakes. The third goal of the investigation is summarized in an article, entitled "Some Considerations of the Value of the Psychiatric Screening Interview," which appeared in the January 1961 issue of the Journal of Clinical Psychology. The final report of the subtask has been completed and is currently in the process of revision.

An Investigation of the Concept of Ego Identity as Related to Character Disorders (U), MR 005-12-2601. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; LCdr J. E. Rasmussen, MSC, USN.

The development and pre-testing of experimental instruments has been completed. The instruments were administered to approximately two thousand recruits at NTC, San Diego. With the aid of the Training Center Psychiatric Unit, 140 subjects were selected for further study, and additional data was obtained on the performance of these men in training and their psychiatric status at the completion of training. Extensive statistical analysis of the data and the first draft of the final report have been completed. The results show highly significant differences in ego identity between recruits displaying evidence of character disorder and those who do not. The data gives added support to Erikson's theory of psychosocial development in terms of construct validity. The results also disclose a rather startling degree of psychopathology among recruits who complete training with a marginally adequate performance. Future plans include a follow-up study of the subjects who completed recruit training. A review of the world literature on character disorder has been completed and a paper is being prepared for publication. A theoretical paper on character disorder was presented at the fall meeting of the American Psychological Association.

Epidemiology, Etiology and Treatment of Dental Caries (U), MR 005-12-5000. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt C. A. Ostrom, DC, USN.

Dietary supplementation with sodium or ammonium phosphate reduced caries severity in the NMRI-D rat 25%, while sodium pyrophosphates or polyphosphates in F1 or sodium molybdate in F1 and F2 generations did not influence caries. Studies are in process to examine the cariostatic influence of other trace elements and combinations. Studies of molybdenum toxicity revealed extensive connective tissue changes resembling osteolathyrism in rats. On diets completely free of sugar, NMRI-D rats through F1 and F2 generations scored 40-50% reductions in caries and marked reduction but not elimination of oral acidogenic flora. Analysis of fasting saliva of these rats demonstrated reducing substances capable of supporting acidogenic micro-organisms. Intent to extend antarctic findings to controlled laboratory investigation was terminated when efforts to adapt the NMRI-D caries-susceptible rat strain to survival in a cold environment failed. The New Zealand field study demonstrated highly significant association between prevalence of dental caries vs ground water and between prevalence of caries vs soil content. Continuing studies will be aimed toward elaboration of these data, analytical work relating soil trace elements and content of those same trace elements in urine, blood and extracted teeth of animals and humans dietarily dependent on those soils. Plans for next year in New Zealand include definitive experiments in lambs and rats. The reported finding that rabbit femur contains isocitric dehydrogenase and aconitase was extended to the rabbit mandible. Highest enzyme activity occurred in the peripheral areas of the ramus. Degradation of TPN was present in epiphyseal-metaphyseal preparations of the rabbit femur; and the characteristics of the enzyme are being studied. Continuing experiments in this area are directed toward further elucidation of the pathways of CHO metabolism in calcified tissues. Several protein complexes isolated from human teeth seemed to include the same fluorescent component, although their methods of preparation were different. Two fluorescent peptides, believed breakdown products of protein matrix, were isolated from human teeth. Isolation and identification of fluorescent components will be continued. Micro-areas of tooth slices will be analyzed for N, Ca and P content, correlated with fluorescence intensity to further test the validity of the assumption that fluorescence intensity is a measure of organic content.

Epidemiology, Etiology and Treatment of Dental Caries, MR 005-12-5001. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; R. R. Perkins, Cdr, DC, USN, Head, Dental Research Department.

The tendency toward increased periodontal disease incidence in individuals who are caries immune (or highly caries resistant) has been frequently noted. Egypt, where several surveys have shown a low caries and high periodontal disease rate, seemed to be an ideal location to study this interesting relationship. Past studies have defined the incidence of caries and periodontal disease in Egyptians, unsuccessfully sought specific infective etiology for periodontal disease, and specifically examined nutritional relationships.

Present studies seek answers to three general questions:

1. Is there a measurable compositional or structural difference in teeth that determines their caries-periodontal disease susceptibility?
2. Are there measurable functional factors in the occlusion that contribute to the dental disease patterns that are observed?
3. Is there a particular "body-type" (i.e., general skeletal and muscular development) which renders the teeth less susceptible to caries but results in an osseous and fibrous integument that is less able to withstand masticatory forces?

Extensive instrumentation was required. Apparatus and techniques for determining both individual tooth and total arch areas of contact during the full masticatory cycle were completed during July. Data on these measurements are now being analyzed. It appears that it is the resolution of forces attendant upon transient areas of contact on the balancing side which are primarily associated with rampant vertical pocket formation.

Apparatus for determining differences in composition (under clinical conditions) was initially completed in late August, however, it is still undergoing additional modification. The first effort was directed toward measuring the electrical resistance and impedance of the enamel.

Resistivity measurements were made with relative simplicity and, it is believed, with a high degree of accuracy. Values in the order of 3.5×10^7 ohms/mm were obtained. Variations between individuals were discernible; but variations between different teeth in the same individual were of equal or greater magnitude--the latter being apparently related to the time at which calcification occurred.

Impedance measurements have been found to be more difficult to obtain for many reasons; however preliminary findings suggest that there are significant differences in the values obtained between caries-free and caries rampant individuals.

Epidemiology, Etiology and Treatment of Dental Caries, MR 005-12-5003. Dental Research Facility, USNTC, Great Lakes, Illinois (transferred from USNTC, Bainbridge, Maryland); R. B. Wolcott.

The relationship of the oral environment to dental caries and factors influencing the state of dental health of young adults has been the principal objective of the studies under this task. The enzyme activity of hyaluronidase demonstrated a relationship to gingival disease and oral hygiene but revealed that no hyaluronic acid-hyaluronidase reaction could be demonstrated to the process of dental caries. Studies of "caries-free" and "caries-rampant" subjects revealed numerous variations in the bacteriological, biochemical and physical character of their saliva. Microscopic appearance of saliva sediment revealed a cytology which appears to influence or, to be influenced, by oral bacteria. The mobility of the protein components of saliva in electrophoresis has led to the identity of these components. In addition, by means of a series of questionnaires, tests, health examinations and dental examinations a relation was made between the dental health of the young

recruits to past dental health experience, home and community environment, education, economic level and state of general health.

Complete removal of teeth of young male adults with high rampancy of caries resulted in a sharply diminished lactobacillus population and acid production. Under phase contrast micrography the presence of salivary corpuscles in saliva sediment showed no relation to caries but demonstrated a direct relation to gingivitis. Certain protein components of saliva, identified by electrophoresis, were found to be related to caries experiences of 36 young males. The study of phagocytosis and agglutination of lactobacilli, which was initiated but not completed, indicated greater phagocytic and agglutination activity among the caries-free group.

New methods have been initiated for the investigation of paper and curtain electrophoretic separation of protein components of various salivary secretions. A study was conducted to determine the morphological differences in teeth of caries susceptible and caries immune male recruits. The immune group possess a significantly greater prevalence of Carabilli cusps, 5 cusped mandibular molars and multi-lingual cusped mandibular premolars.

The susceptible group had a significantly greater prevalence of peg-shaped lateral incisors. An evaluation of 20 other dental features showed no significant differences.

Epidemiology, Etiology and Treatment of Dental Caries, MR 005-12-5004. Dental Research Facility, USNTC, Great Lakes, Illinois; M. A. Mazzarella.

Investigations of various types of therapeutic agents and dentifrices and mouth washes revealed no anti-cariogenic effect. The chemical, cultural and clinical relations of PPLO organisms have been studied and recorded. The PPLO organisms from the oral cavity, as contrasted with strains related from other sources, have not shown any of the usual in vitro biochemical activity. The PPLO organisms showed a higher rate of recovery from the saliva of caries-immune persons. Oral veillonella were found significantly greater in number in both the saliva and plaque of caries-rampant individuals than in the immune.

The effect of full mouth extraction on the incidence and relationship of lactobacilli, Candida albicans, streptococci and staphylococci was studied and reported. The use of lactobacilli or other acidogens as indicators of future decay after full mouth rehabilitation is also under study. This rehabilitation is being accomplished through the use of four temporary restorative materials which are being clinically evaluated in the mouths of various caries-rampant individuals. Bacterial inhibition of parotid saliva from caries-immune and caries-rampant individuals has been studied. It has been found that there is a significantly greater flow rate from the caries-immune patients, and a greater flow rate and increased solid content was reflected by a greater bacterial inhibition than that exhibited by caries-rampant subjects. Attempts to characterize the inhibiting factor have shown a dialyzible and non-dialyzible fraction that must be in combination to exhibit the inhibitory effect. Further studies are being undertaken to identify the factor.

Epidemiology, Etiology and Treatment of Gingival Diseases, MR 005-12-5100. U. S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.; 61751; R. R. Perkins, Cdr, DC, USN, Head, Dental Research Department.

A variety of studies were pursued during the life of this subtask. The incidence of peridontal disease in Egyptians was defined as being similar to that of other natives in the Middle Eastern countries and much more prevalent than in America's or Europe. Superficial information revealed no causative factors in diet but neglect of ordinary dental hygiene is probably a major factor. Endameba gingivalis were found but could not be implicated. The possibility of a spirochete being involved was suggested by some electron microscopy studies but these were terminated before conclusive evidence was deduced.

Other phases were concerned with the study of parotid secretions as a possible lead toward the etiology of both peridontal disease and "idiopathic" parotid hypertrophy. By starch gel electrophoresis it was possible to identify 12 protein components of normal parotid secretion one of which was identified as a singly occurring phosphomonesterase similar to acid phosphotase occurring in human blood.

Epidemiology, Etiology and Treatment of Gingival Disease, MR 005-12-5102. Dental Research Facility, USNTC, Great Lakes, Illinois; I. L. Shklair, Ph. D.

The identification of the chemical constituents and physical properties of parotid secretions of caries-free and caries-active group has revealed further information on enzyme activity, variations of two metals and three cations, and the relation of the caries-activity to certain physical properties of saliva. Little variation in the electrophoretic and chromatographic patterns have been found in the blood of individuals with or without periodontal problems.

The variations in the presence of 17-hydroxycorticoids and parotid secretions in blood has been investigated and may serve as an indicator of stress as manifested by Vincent's infection. The method for determination of the steroids has been improved. A modified anthrone technique was successfully employed in a glucose tolerance test on parotid secretions of caries-active and caries-immune subjects. Plans have been initiated to perform quantitative measurements of carbohydrate in salivary secretions of caries-rampant and caries-immune individuals.

PPLO organisms were not found to be related to any type or degree of gingival conditions, deposits on the teeth or any form of oral hygiene. The oral veillonella populations were found somewhat higher in patients who have ANUG, but the differences were not significant from normal groups.

Hyaluronidase has been demonstrated in saliva and in debris from gingival crevices. Its presence in infected pulps and gingival tissue has been suggested. Work is in progress to demonstrate its presence or absence in these tissues.

Development and Evaluation of Surgical Procedures, MR 005-12-5201. Dental Research Facility, USNTC, Great Lakes, Illinois; I. L. Shklair, Ph. D.

The purpose of this task has been to determine

if non-narcotic analgesic drugs can control pain following minor oral surgery, and to determine the validity of clinical effectiveness of these drugs by questionnaires. This subjective method of testing was applied to 3,320 patients to determine analgesic effectiveness of A.P.C., Aspirin, Apromal, Apamide, N.A.C., Tabcin, and a placebo. All drugs, except Tabcin, showed statistical significance in their analgesic effect when compared with the placebo (which registered an unusually high 77 per cent for relief of pain). No postoperative pain was recorded on tablets used in 32 per cent of the recruits experiencing four or less extractions.

Consideration is being given to evaluating the bioflavinoids and ascorbic acid as therapeutic agents in controlling post-restorative pain in crown and bridge patients.

Another facet of this task studied the effectiveness of various therapeutic agents in producing sterility of carious dentin and infected non-vital root canals. Thioglycollate broth was found to be a more sensitive culture medium than enriched brain heart infusion broth for detection of root canal infection. It was concluded that in routine endodontic procedures more enriched culture media should be used with long periods of incubation to avoid false negative cultures. In addition, Benzylog was found less effective than camphorated-paramonochloraphenal for sterilization of infected root canals.

High speed handpieces and various dental instruments were contaminated with spores of Bacillus globigii and suspended in blood, serum, saliva, dental lubricating oil, and all mixtures of these fluids. Exposure to ethylene oxide gas in a Ben Venue sterilizer for two hours rendered all instruments sterile except the chuck and plunger opening of the handpiece. Silicone immersion at 250 degrees centigrade for five minutes gave complete sterility. Antiformin solution and dilute NaOH were effective cold sterilizing agents but highly corrosive. Iodine (Wescodyne) in aqueous solution with a wetting agent was not effective against the spores of Bacillus globigii, and neither was a solution liberating silver ions (Movidine). The task has been inactive the past year.

Clinical Anesthesia Trials with Carbocaine HCL (U), MR 005-12-5203. U. S. Naval Hospital, Philadelphia 45, Pennsylvania; No funds required; Capt E. A. Gargiulo, DC, USN.

To date 887 cases have been completed. The study clinically is complete and appears to be very favorable.

The study has been based upon clinical trial of carbocaine hydrochloride. This anesthesia was compared with Lidocaine Hydrochloride in equal concentration in all fields of dentistry; i.e., operative, prosthetics, oral surgery, and periodontia.

The duration and profundity in tabulated form is being prepared. There were no reactions noted to either drug.

Estimating the degree of Anesthesia was as follows:

Grade A - Satisfactory Anesthesia.
Grade B - Anesthesia adequate in the opinion of the operator.
Grade C - Anesthesia inadequate and reinjection necessary.

Development and Testing of Prosthetic Procedures, MR 005-12-5207. Dental Research Facility, USNTC, Great Lakes, Illinois; R. B. Wolcott.

The development of a clinical time lapse photographic unit has been accomplished. Because of an inability to obtain a satisfactory camera, the studies which were to be performed with the equipment have been delayed.

Investigation of Changes in Physical Properties of Methyl Methacrylate Induced by Radiation, MR 005-12-5208. Navy Electronics Laboratory, San Diego 52, California; 17x1319.1813 RDT&E, N FY 1961; N. W. Rupp, Capt, DC, USN.

This study was set up to improve by radiation the physical and mechanical properties of methyl methacrylate now used in restorative and prosthetic dental materials. A thorough search of the literature reveals several methods which are theoretically sound. One of these, grafting, is the procedure of choice.

Development and Evaluation of Equipment for Field Use (U), MR 005-12-6001. Naval Medical Field Research Laboratory, Camp Lejeune, North Carolina; MarCorps 17x1319.2717 P.O. 1-0009; E. R. Babcock, Engineer and W. E. Ludwick, Capt, DC, USN.

Proposed changes and revisions to the Dental Technical Field Material Allowance have been considered by the dental members of the Advisory Committee and a report is being prepared. The Field Dental Operative Light (Modified) has been evaluated by the Second and Fourth Dental Companies during field exercises. A report is being prepared. The Dental Prosthetic Repair Kit developed by the Medical Equipment Development Laboratory, Fort Totten, N.Y. was field tested by the Second and Fourth Dental Companies and compared with FSN 6545-918-2750, Dental Supply Set, Emergency Denture Repair, and a report is being prepared.

R005-13 Aviation Medicine

Studies Designed to Study Problems of Stress Due to High Altitude (U), MR 005-13-1002. U. S. Naval School of Aviation Medicine, Research Department, U. S. Naval Aviation Medical Center, Pensacola, Florida; H. J. Schaefer, Ph. D.

The theoretical work on this task pertains to collecting, from literature and through direct contacts with various cosmic ray research teams, all new data on radiation in space, comparing them critically and evaluating them in terms of tissue dosages for a human target. The experimental work pertains to development and testing of a small lightweight radiation monitoring device for manned space capsules. The School's standard emulsion pack is currently flown on all Mercury flights. Other apsects of this task include investigations of hypoxia and hyperoxia, and the effects upon human hearing of pressure differentials produced during rapid ascents and descents.

Human Factors Affecting Operational Performance (U), MR 005-13-1500. Naval Medical Research Institute, National Naval Medical Center, Bethesda

14, Maryland; Capt J. P. Pollard, MC, USN.

Breakthroughs in the design and construction of sub-miniature components has led to notable success in transmission of physiological data enabling remote stations to observe immediate changes in physiological parameters of subjects undergoing varying degrees of stress. Transmission of this data were made in conjunction with the AEC and ONR. Data transmitted and recorded on high altitude STRATO-LAB balloon flights were made in conjunction with ONR. Psycho-physiological data on two scientists in an open balloon gondola to at least 120,000 feet will be transmitted to the Project RAM research flying laboratory for recording. Scientists aboard this flight will wear, for evaluation, pressure suits designed for Astronaut flights. A number of these flights are planned with varying flight profiles. Six parameters of psycho-physiological data were transmitted via single side band from Panama Canal Zone to Bethesda. Further research in transmission components will enable identification, isolation and adaptation of additional psycho-physiological responses to electronic transmission. Modification of apparatus for use on ambulatory patients (heart disease, for example) has been dramatically demonstrated.

Stress Due to High Intensity Noise (U), MR 005-13-2002. Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia 12, Pennsylvania; Emanuel S. Mendelson.

During the past year, basic and applied aspects of cochleo-tympanic reflex registration continued to receive major attention. Technical refinements included cyclic auditory stimulation in time with the subject's heart rate, which has revealed hitherto unregisterable reflex reactions in the least responsive subjects. In addition, tests have been conducted to evaluate the effectiveness of selected acoustic stimuli with which to activate the middle ear muscles intentionally as an ear protective maneuver. A Mobile Field Laboratory has been set up in a walk-in truck for investigating auditory reflex reactions of operational personnel at or near their duty stations. The apparatus assembly used is almost as sensitive as the stationary equipment used in the laboratory, and tests of the facility and of the procedures to be followed are being conducted.

It is planned to continue tests of stimulus-response relationships by the method of cochleo-tympanic reflex recording. As soon as satisfactory standardization has been achieved, arrangements will be made to drive the mobile facility to the AMRL, Fort Knox, Kentucky, in order to coordinate cochleo-tympanic reflex tests with audiometric tests. The purpose of this coordination is to investigate the objective and the psychophysical reactions of subjects in whom the auditory reflex contractions of the middle ear muscles have been activated to protect the ears from gunfire noise.

Stress Due to High Intensity Noise (U), MR 005-13-2005. U. S. Naval School of Aviation Medicine, Neuro-Physiology and Acoustics Laboratory, U. S. Naval Aviation Medical Center, Pensacola, Florida; Dr. H. W. Ades.

Measurement of hearing on various groups after exposure to noise. Electron-microscopic studies of ears of monkeys and guinea pigs after measured doses of high intensity noise. The study of neurophysiological effects and mechanism of prolonged vestibular stimulation is in the planning stage.

Studies for the Development and Evaluation of Standards for Aviation Personnel (U), MR 005-13-3001. U. S. Naval School of Aviation Medicine, Research Department, U. S. Naval Aviation Medical Center, Pensacola, Florida; Capt A. Graybiel, MC.

The development and utilization of high performance aircraft has resulted in increasing demands and stress upon the aviator. Physical standards for the selection and health maintenance of aviation personnel are crucially important. A comprehensive re-evaluation of all standards, especially with reference to emergency mobilization needs, is presently underway. Recently a survey on the physical status of 1,000 aviators was completed and the results are being processed.

Physiological and Psychological Factors in the Selection of Aviation Personnel (U), MR 005-13-3003. U. S. Naval School of Aviation Medicine, Psychology Laboratory, U. S. Naval Aviation Medical Center, Pensacola, Florida; R. K. Ambler, M. S.

The Biographical Inventory was subject to the greatest modification. Continuing improvements in quality control procedures, or secondary selection, were developed and implemented. A research program was begun concurrent with the beginning of the Naval Aviation Observer training program to develop an appropriate selection battery. A pilot study was completed earlier in the year for guidance in launching the NAO research. Procedures were developed and implemented to identify high caliber personnel who are interested in later space endeavors. Presently the orientation of this project is to identify those individuals from naval air training who approximate the Mercury Astronauts in mental and physical capabilities. The reason for so identifying these individuals is to permit more purposive career planning in order that the transition to space duties can be accomplished with maximum effectiveness. Also during this reporting period emphasis has been placed on developing a program of research in the area of psychological stress. Aspects specific to the selection of aviation personnel are concerned with identifying physical and psychological parameters that are significantly associated with later reactions to stressful situations. One early accomplishment in this area was the demonstration that a random selection of naval flight instructors were able to significantly differentiate, on the basis of structured behavioral observations during four indoctrination hops. those students who would later react unfavorably to the stress of flight training.

Pulmonary Physiology (U), MR 005-13-3100. U. S. Naval School of Aviation Medicine, Physiology Laboratory, U. S. Naval Aviation Medical Center, Pensacola, Florida; Dr. R. G. Bartlett, Jr., Ph. D.

Studies are made in a broad program of research in pulmonary function. A relationship between hypocapnia and erythropoiesis in mice has been shown. This observation may be significant in considering

the projected problems of nitrogen-free and carbon dioxide-rich artificial atmospheres. Three new and unique devices for breath moisture recycling, oxygen economy and hyperventilation prevention have been developed and tested. Studies on the effects of liquid oxygen contaminants have shown the usual contaminants to be nontoxic to humans, non-odorous, and nondetectable. However, unidentified contaminants present at very small nontoxic levels sometimes impart an odor to oxygen evolved from LOX.

Studies on Aviation Safety, Escape and Rescue (U), MR 005-13-4001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Capt J. P. Pollard, MC, USN, J. Sendroy, Jr., Sc. D.

Work on subject project was temporarily suspended pending reporting of an experimental psychologist and an aviation physiologist. It is planned to transmit, via telemetry, different psycho-physiological variables in order to identify those parameters which are most sensitive to varying G forces associated with flight maneuvers. These flight profiles will be flown in a side by side aircraft in order to maintain even G forces on subjects. Analysis will be made to determine what correlations, if any, exist between stress situations involving G forces and psycho-physiological changes.

In connection with subtask 2, no further work has been done on the solubility of carbon monoxide. Studies have been continued of the factors which affect the relative affinity constant for carbon monoxide and oxygen in blood. Previously, it had been found that under the conditions of our experiment (complete saturation of hemoglobin with CO and/or O_2), in light from either tungsten or ultraviolet lamps, there was no effect whatsoever on the values previously obtained from the blood of several species in the dark. During the past year, therefore, studies have been made of the individual CO and O_2 saturation curves of the same sample of blood, in total darkness, and by exposure to light. Pending the accumulation of additional data, it may be said that even when the blood is not fully saturated, the effect of light on the dissociation of COHb is not as great as has been assumed. This work is to be continued.

Studies on Aviation Safety, Escape and Rescue (U), MR 005-13-4002. U. S. Naval School of Aviation Medicine, Psychology Laboratory, U. S. Naval Aviation Medical Center, Pensacola, Florida; Ens R. E. Doll, MSC.

The problems of survival during ejection from high performance aircraft at extreme altitudes, following ditching in the sea, or during and following ejection from space capsules on aborted missions are being studied in relation to selection, indoctrination, and training.

Aviation Safety, Escape and Rescue (U), MR 005-13-4004. Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia 12, Pennsylvania; Edwin Hendler, Ph. D.

An evaluation of various types of thermal underwear designed to alleviate the harmful effects of heat and cold stress has been carried on. A formal report concerning the physiological evaluation of open-weave underwear (Valhalla type), worn in conjunction with the MK IV, MK V, and MK VI anti-exposure suits, will be submitted shortly. For the following period, emphasis will be placed on the physiological limitations of the modified MK V anti-exposure suit when worn in dry-cold, immersion-cold, and heat exposures.

A number of limited studies were performed during the past period concerning motor performance restrictions associated with the full pressure suit. Reports on these studies were forwarded by letter to BuWeps. The investigations on the Project Mercury full pressure suit were completed and presented at the 1960 Aerospace Medical Association meeting. Two testing configurations have been installed to facilitate performance testing of occupants of omni-environmental full pressure suits. A laboratory report on the Project Mercury investigation is completed and is soon to be issued.

Development and Evaluation of Methods and Factors Involved in Training (U), MR 005-13-5001. U. S. Naval School of Aviation Medicine, Psychology Laboratory, U. S. Naval Aviation Medical Center, Pensacola, Florida; J. R. Berkshire, M.S.

As the operation of high performance aircraft, missiles, and spacecraft becomes more hazardous, the selection, training, assessment and retention of capable highly motivated pilots becomes both more important and more difficult. An extensive series of studies of human morale, mental and emotional stability, psychomotor functions, and leadership are underway to provide the manpower to participate in these missions.

Problems in Psychophysiology Related to Aviation Medicine (U), MR 005-13-6001. U. S. Naval School of Aviation Medicine, Research Department, U. S. Naval Aviation Medical Center, Pensacola, Florida; Capt A. Gaybiel, MC.

High performance aircraft and spinning spacecraft introduce severe problems of disorientation, motion-sickness and airsickness to the crews of these craft. Studies of the underlying biological and psychological factors are being explored to aid in the maintenance of the health and operational capability of the men.

Problems in Psychophysiology Related to Aviation Medicine (U), MR 005-13-6002. Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania; James D. Hardy, Ph. D.

A number of devices to provide protection of the eyes of aircrews against the blinding flashes of the electromagnetic radiation of special weapons are under development in the military services. Each of these devices requires a finite period time to "close" and shut off the blinding flash from the detonation of a special weapon. The work in progress in this laboratory is an attempt to determine how fast these devices must close in order that the eyes exposed to these high energy flashes are not flash blinded for too long a period of time. Flash blindness for more than five seconds may well be too long for pilots.

At the present time, data is being collected on the recovery of the originally dark adapted eye to

high luminance flashes 30, 120, or 7000 microseconds in duration. These flashes are produced by xenon flash lamp.

Studies in Psychophysiology, Including Sensations and Illusions (U), MR 005-13-6003. Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia 12, Pennsylvania; Sherwin J. Klein, Ph. D., Edwin Hendler, Ph. D.

Research on the enhancement and reduction of muscle tensions, induced by muscular exercise, by means of psychological stressors is continuing. Results indicate that muscle tensions can be increased by as much as 33%, in some instances, in subjects working under psychologically stressful conditions. Experimental evidence for the theoretical performance-arousal curves is being sought through this method.

In order to substantiate the mechanism of temperature sensation proposed from an analysis of skin temperature changes radiometrically measured during exposure of subjects to infrared irradiation, the use of 3 cm. microwaves has been undertaken. Differences in penetrability within the cutaneous tissues between the infrared and 3 cm. microwaves is expected to provide additional information relevant to the mechanism of temperature sensation. A specially designed water calorimeter has been used to measure microwave intensity in the plane of exposure. It is planned to continue the work on temperature sensation by using 10 cm. microwaves. Preliminary experiments using an appropriate energy source have begun.

Studies on the Human Factors Affecting Efficient Communications (U), MR 005-13-7001. U. S. Naval School of Aviation Medicine, Research Department, U. S. Naval Aviation Medical Center, Pensacola, Florida; G. C. Tolhurst, Ph. D.

To explore systematically the effects of continuous and impulse noise exposure upon human hearing, including the effects of noise environments upon the efficiency of voice message transmission and reception whether the message units be subphonemic or connected discourse. Less complex wave forms are also exploited as stimuli. The subjects employed are relatively naive concerning speech and hearing testing (incoming NavCads, MarCads, and A.O.C.'s). Also under study are the actual and simulated acoustic environments that are found both in and out of the military. Techniques for automatic data reduction of the physical parameters of acoustic stimuli are being explored.

Cardiovascular Problems in Aviation Medicine (U), MR 005-13-7004. U. S. Naval School of Aviation Medicine, Research Department, U. S. Naval Aviation Medical Center, Pensacola, Florida; Cdr R. E. Mitchell, MC.

The increased physical physiological, and psychological stresses encountered by pilots in the operation of high performance aircraft, and, perhaps, future spacecraft, seriously affect the cardiovascular system. Studies of the normal and abnormal functioning of this system, together with longitudinal studies of pilots exposed over a long number of years to these stresses are being evaluated to provide information for the maintenance of health and effective performance of present and future pilots and astronauts.

Miscellaneous Tests and Minor Investigations (U), MR 005-13-8003. Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania; James D. Hardy, Ph. D.

Preliminary studies have been carried out on long term exposures of rats to 100% oxygen. At 650 mm of mercury, all animals die within 85 hours. At 250 mm of mercury, the first death occurred in 9 days. Work is underway to further investigate the possible toxic effects of pure oxygen during prolonged exposure at reduced pressures.

R005-14 Submarine and Shipboard Medicine

Field Evaluation of Clothing and Equipment for Submarine Use (U), MR 005-14-0001. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; Cdr Walter F. Mazzone, MSC, USN.

Swimmer's Rescue Suit has been fabricated out of foam rubber, utilizing the wet-suit principle. Tests to date indicate progress. This item has been tested in cold environment (laboratory cold chamber), and during torpedo recovery from a submarine. Buoyancy studies have been completed in the Escape Training Tank. The suit appears to be well adapted for use by underwater swimmers as well as surface swimmers.

Escape and Exposure Suit to be tested after 1 February 1961 in open water. This suit is still being subjected to modifications.

An evaluation of an experimental model of cold/wet weather clothing was completed during this report period. This same clothing is currently under further evaluation aboard the Oceanographic Survey Submarine, ARCHERFISH.

Evaluation of Eye-Protective Equipment for the Naval Service (U), MR 005-14-0100. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; George Moeller, Ph. D.

During 1960 several samples of dark adaptation glasses, jet pilot helmet visors, and flight-deck goggles were evaluated for conformity to specifications. Reports of such evaluations were submitted to BuWeps by letter, or telephone.

A first draft of a general Department of Defense specification for glass and plastic plano lenses was prepared, and specifications for dark adaptation glasses and pilot helmet visors were revised.

Similar work will continue in 1961 with more attention being given to empirical validation and specifications.

Evaluation of Ear-Protective Equipment for the Naval Service (U), MR 005-14-0200. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; J. Donald Harris, Ph. D.

NMRL continues its work of indoctrination and propaganda for the use of the Willson ear muffs in engine rooms and sonar shacks. A continuing evaluation of new devices and ideas for protection of hearing is in operation at this Laboratory.

Psychophysical Studies of Visual and Auditory Factors in Submarine Operation (U), MR 005-14-1001. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; Forrest L. Dimmick, Ph. D., J. Donald Harris, Ph. D.

Psychophysical studies of visual factors in submarine operations have included: The effect of contact lenses on color vision; Accomodation and night-time acuity; Binocular color mixture; Discrimination of visual and auditory patterns; The effect of interruption of dark adaptation; Effect of visual intensity on reaction time; Refractive error and color vision; Retinal distribution of color sensitivity; The shape of the red and green color-zone gradients; Critical-flicker-frequency for monochromatic lights; Effect of background illumination on critical-flicker-frequency; Binocular mixture of disparate brightnesses; Wavelength discrimination; and Saturation discrimination.

Two papers on auditory tracking of loudness variations were published. Work is well along in instrumentation for frequency tracking. A preliminary report has been prepared on the discrimination of frequency intervals, including the musical intervals. Research data are being collected on sensitivity to frequency glissando.

A stereo tape was prepared and is being used to study the so-called "cocktail party effect" (masking) for normal-hearing and particularly, in defective ears.

Human Engineering in Shipboard and Submarine Operation (U), MR 005-14-1100. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; George Moeller, Ph. D.

The Human Engineering Branch was re-activated as of 1 June, and work on this task was recently reinitiated. An annotated bibliography and summary of human engineering research on submarine operations is in preparation. Research has begun on use of the Silverman-Powell Palmar Perspiration Index as a measure of operator effort in task performance. Data from such a measure would supplement measures of performance per se in human engineering evaluations of equipment.

Lighting surveys were made of the red lighting on submarines, and on the U.S.S. RANDOLPH. Lighting surveys were also made of the offices of the DEPCOMSUBLANT and of his Chief of Staff.

Prevention of Deafness Among Submarine Engineroom Personnel (U), MR 005-14-1200. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; J. Donald Harris, Ph. D.

No request for noise surveys were received this year. Information received from such surveys from other activities were added to our data file.

Auditory fatigue subtask is temporarily in abeyance.

Listeners entered a nearby lake to make informal analysis of annoyance and possible damage due to active sonar emission at 5 kc and 3.5 kc at pressures up to 144 db re 1 bar. Informal reports were circulated to interested parties. High energy airborne sonar signals were not investigated during this year due to lack of personnel.

Psychophysiological Evaluation of Personnel for Submarine Duty and Other Underwater Duty (U), MR 005-14-2001. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; George Moeller, Ph. D., Forrest L. Dimmick, Ph. D., J. Donald Harris, Ph. D.

As in past years many Naval personnel were referred to NMRL from Examining centers for intensive tests of color perception. Experience with such referrals has led to planning for a study of the uses and effects of the film "Color Vision Deficiencies" in training of color perception test administrators.

An analytic study of color confusions of color defectives was conducted at NMRL some years ago. When the re-analysis of those data now in progress is completed, it will be published or used as a basis for more systematic study of such confusions.

In the study of optometric problems in the submarine service, a test for astigmatism suitable for routine use with recruits is being studied. A study of the effect on scotopic sensitivity of prolonged exposure to artificial light was carried out aboard the TRITON and these data are being analyzed.

Studies in auditory vigilance have been expanded in scope and are being vigorously pursued.

NMRL continues to administer our six-test auditory battery to all submarine candidates. NMRL now houses a 4-man team from the Bureau of Personnel to pursue validation of these research results.

Psychological Evaluation of Personnel for Submarine Duty (U), MR 005-14-2100. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; Benjamin B. Weybrew, Ph. D.

At present, one research focus is upon improving the current techniques of motivational evaluation of both enlisted and officer volunteers for the Submarine Service. Identification of the factors affecting the maintenance of personal motivation and group morale during prolonged submarine submergence is also being emphasized. A second focus is on delineation experimentally of the somatic processes (in particular, the peripheral indices of autonomic reactivity) which are usefully predictive of individual differences in adjustment to submerged conditions.

Psychological and Psychophysiological Parameters Relevant to the Adjustment of Submariners to Prolonged Periods of Submergence (U), MR 005-14-2200. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; Cdr H. B. Molish, MC, USN.

At present, the research pertinent to this task is focused upon the psychological assessment of the men volunteering for duty aboard the FBM submarines. Aptitude and personality test scores, measures of autonomic nervous system responsivity, and data from psychiatric interviews have been obtained from both the Blue and Gold crews of one FBM submarine. Criterion data with respect to which these predictive indices will be validated are now being collected aboard this submarine during its first deployment period. The results of this research effort should indicate the most valid predictors of optimal adjustment to the conditions

necessitated by the FBM program.

Physiological Factors Affecting Submarine Habitability, MR 005-14-3001. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland; Cdr D. E. Goldman, MSC, USN.

A series of observations have been made on the injurious effects of mechanical vibration on cats, especially with respect to the pathology of the damage. It has been found that the major injuries are to the heart and lungs and to the intestinal mucosa. Functional changes in cardiac and respiratory behavior are seen. In the range from 5 to 20 eps., exposures of over 5 minutes to peak accelerations of 15g produce death within 48 hours in about half of the animals so exposed. Occasional injury is found at exposures as low as 5g.

Two reports are in preparation, one on the normal ECG of the cat and the other on the injuries noted above. Further studies are being carried out to analyze some of the mechanisms involved.

Physiological Factors Affecting Submarine Habitability (U), MR 005-14-3002. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; K. E. Schaefer, M. D., K. G. Wing, M. D., Capt A. G. Nielsen, DC, USN.

Animal studies carried out during 1960 were aimed at completing investigations on: tissue CO_2, electrolyte shifts, and calcium phosphorus metabolism under prolonged exposure to CO_2. Biochemical investigations involving the enzyme, carbonic anhydrase, have been actively pursued. Studies employing fluorescent and phosphorescent techniques have been initiated for evaluation of the function of activated molecular states in the progress of biological energy transfer. To extend our information on the interreaction of atmospheric components or potentially activated biological compounds is our objective.

The effects of various gases in the middle ear of the cat have been investigated. The introduction of various poisons and other substances in the inner ear by use of a wick technique was pursued. Auditory nerve potentials as well as cochlear microphonics were studied with the help of medical students during the summer. A major rearrangement of an experiment for continuing this research has been in progress.

This year's effort has concerned: A study of oral health problems encountered aboard submarines, (a questionnaire was submitted to all Atlantic Force submarines to determine the extent of dental emergencies encountered during a one year period); An evaluation of a portable dental unit (Port-A-Dent) to determine its suitability for use aboard submarines; A study of the causation of pain in oral areas under ambient pressure changes; and as S.T.8, a new study was initiated concerning evaluation of Stannous Fluoride in preventive dentistry.

No requests for evaluation of specific products or items of equipment were received during this report period.

Lt Perlitsh continued the analysis and preparation of his Antarctic data for reports until his release to inactive duty in Aug 1960; Lt Lindsay returned from McMurdo Sound in December and will do similar work with the data he obtained in that area. Extensive work was done on the development of a facial protection device for use in extremely cold temperatures. Five prototypes were sent to Antarctica for testing under actual operating conditions.

A paper was prepared by Dr. Schaefer on "The Use of Amine and other Buffers for CO_2 absorption in Confined Environments."

Physiology of Diving (U), MR 005-14-3100. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; K. E. Schaefer, M.D., G. F. Bond, M.D., R. D. Workman, M.D.

More experiments have been carried out to determine some additional points in the alveolar pathway of CO_2 and O_2 during free dives to 90 feet. Data in the Laboratory previously collected on Tank instructors have been evaluated for the purpose of assessing the adaptation to skin-diving.

Experiments are in progress to evaluate and establish a method of detecting small, poorly ventilated areas in the lung. Control subjects from the Laboratory, six Escape Tank instructors, and 23 patients with various degrees of pulmonary malfunction have cooperated in our efforts to improve and simplify this technique.

Twenty-four adult male white rats were exposed to a simulated depth of 200 feet in a pressure chamber while breathing a 97% helium-3% oxygen mixture for 14 days. Carbon dioxide was removed from the atmosphere by use of lithium hydroxide granules in trays. Decompression to the surface was carried out over 24 hours with stages at 132, 99, 66, and 33 foot depths. The effective oxygen concentration was maintained at 21% during the exposure and subsequent decompression. Biochemical and histopathological studies of animals sacrificed at intervals following the exposure have not revealed any significant differences from the controls.

A similar study was completed exposing 24 adult male white rats and 4 adult guinea pigs to 97% nitrogen-3% oxygen for 14 days. Carbon dioxide absorption and decompression procedures were the same as above. One rat died on the third day due to unknown cause. All other animals survived and showed no change in biochemical or histopathological studies from control animals.

Decompression studies were carried out using goats. A 97% helium-3% oxygen mixture was used for a three-day exposure at 200 feet. Decompression was carried out with 36 hour stages at 84 and 26 feet. One goat of four in this series developed decompression sickness. This animal was successfully treated by recompression to 200 feet for 3 hours on the above gas mixture. Decompression was then accomplished uneventfully with 24 hour stages at 100, 44, and 10 foot levels.

Appliances, Methods, and Procedures for Escape from Submarines (U), MR 005-14-3200. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; George F. Bond, M.D.

Evaluation of data derived from the open-sea 300 foot escape series performed in 1959 led to the conclusion that buoyant ascent could be performed with safety from a depth of 450 feet or deeper.

After careful calculation of decompression problems involved, a proposal for open-sea performance of individual escape from a depth in excess of 400 feet has been presented to COMSUBLANT for consideration and approval. As a direct and immediate result of renewed interest in the problem of deep submarine escape, preparations are now advanced for a series of test procedures to be performed on all operating submarines in the Atlantic and Pacific Forces. Coincidentally, and as a direct result of the 1959 deep escape series, a revision of existing Submarine Escape Bills is to be promulgated. A final model of the submarine exposure suit has been fabricated and is scheduled for open-sea testing to a depth of 250 feet in the near future. This Laboratory is offering consultant and operational assistance in the development and testing of an escape hood, conceived by Lt H. Steinke, USN, Director of Training, Escape Training Tank. Use of this device offers the possibility of free breathing buoyant escape; open-sea testing of this device is scheduled to depths of 300 feet in February 1961.

Human Ecology in Confined Spaces Simulating Conditions of the True Submersible (U), MR 005-14-3300. U. S. Naval Medical Research Laboratory, U. S. Naval Submarine Base-New London, Groton, Connecticut; K. E. Schaefer, M.D., B. B. Weybrew, Ph. D.

The main body of the experimental work planned for this task requires the use of a large climatic chamber. While fabrication of the chamber is in an advanced stage and before its installation (expected early in 1961), we have been conducting experimentation in purified air in a mixing chamber with various levels of ions. Satisfactory experimental conditions have been developed for measuring the physiological effects of these ions.

R005-15 Bioastronautics

Effects of Acceleration on Biological Systems (U), MR 005-15-0002. Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania; James D. Hardy, Ph. D.

Work on the development of a suitable biological instrumentation package for operational use has been continued. A specially designed package for insertion into the Martin Baker seat has been tested operationally in an A3D jet aircraft -- the ranges exceeding 100 miles and altitudes in excess of 40,000 feet. Successful telemetry has been accomplished in the electroencephalograph, electrocardiograph, respiration rate, and three axes of acceleration. The ground monitoring station has been developed for use not only with aircraft but for the study of physiological parameters on the human centrifuge. Work is progressing in the search for suitable sensory systems for the assessment of physiological strain. Preliminary work indicates that measurement of total sweat output by means of electric sensors will offer additional useful information in regard to the state of stress of the pilot. Machine analysis of the electrocardiograph recorded in flight and from the centrifuge shows great promise in evaluating the pilot's state of alertness. Work is now in progress adapting the sensory and telemetry systems to high altitude balloon flights for monitoring and study of physiological changes occurring during such flights.

Stress Due to Acceleration and Deceleration (U), MR 005-15-0003. Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia 12, Pennsylvania; Edwin Hendler, Ph. D.

A survey has been undertaken regarding vetebral injuries suffered by pilots ejecting from naval aircraft using the Martin-Baker escape system. The incidence of injuries for certain types of aircraft has prompted a more detailed consideration of the design and arrangement of components of the system, and of the procedures followed when using the system. In addition, detailed information relating to the nature and extent of the vertebral injuries, including X-rays, is being collected and analyzed. It is planned to continue this work.

Human Tolerance to Acceleration (U), MR 005-15-0005. Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania; James D. Hardy, Ph. D.

In collaboration with the National Aeronautics and Space Administration, the II and III programs of the Mercury vehicle simulations were completed and plans had been made for a IV Mercury program during the early summer of 1961, prior to the planned shots in this series. In the Mercury II simulation and Astronaut training program, the seven Mercury Astronauts were given 141 complete Atlas mission dynamic simulations and several hundred static simulations. The Atlas simulation included the following phases: early morning pre-launch preparations, complete biomedical instrumentation, pressure suit and restraint harness evaluation, instrumentation and communications evaluations and launch acceleration and re-entry acceleration profiles ranging from 8 - 15 G. A new side arm controller and a new instrument panel design and three separate systems of biomedical instrumentation were evaluated. As G tolerance of the Astronauts appeared to be somewhat less than in previous tests, the back angle limits of the Mercury couch were especially studied. It was determined that the loss in acceleration tolerance was due to increased elevation of the head to provide better vision of the instrument panel.

The Mercury III simulation and Astronaut training was concerned principally with the Redstone system and 308 dynamic simulations and 93 static simulations were conducted under realistic conditions of oxygen partial pressure, temperature, sound, communications, acceleration and instrument panel conditions. In addition, the methods of medical and performance monitoring were evaluated and 20 flight surgeons received training in the monitoring system.

Preliminary meetings have been held on the project Dyna Soar and further dynamic testing of this system, as regards the personal equipment of the Astronauts, will be initiated in the early part of 1962.

Protection from Acceleration Stress (U), MR 005-15-0007. Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville,

Pennsylvania; James D. Hardy, Ph. D.

Experimentation on protection which can be afforded by water submersion against the effects of high levels of acceleration has been continued. Thirteen chimpanzees were exposed to positive acceleration up to 31 G for 60 seconds. The animals were anesthetized and mounted in the capsule with an endotracheal tube inserted and ligatured in place by a suture around the trachea. During exposure to the acceleration, the animals were pressurized. Although the capsules were filled with water during the period of acceleration, air bubbles collected in the capsule and in the circulatory system of the animal. Control tests were carried out at 1 G using the same experimental routine but with no centrifugation. Again, emphysema and air embolism resulted. Thus, it is believed that these effects cannot be unequivocally attributed to the effects of acceleration per se. It is planned to expose additional animals to high positive acceleration in the water capsule using an oral nasal face mask thus avoiding the possible difficulties due to tracheotomy and possibly to protect against movement of respiratory gases toward the head under the pressure developed during acceleration.

G x Time Flight Patterns (U), MR 005-15-0100. U. S. Naval School of Aviation Medicine, Acceleration Laboratory, U. S. Naval Aviation Medical Center, Pensacola, Florida; Cdr J. J. Zarriello, MC.

A detailed statistical summary has been presented through four technical reports on six training maneuvers. The average G x time flight patterns, the highest and the lowest individual flight patterns were observed. It was noted that there was an extremely wide range of variations in the various G x time flight patterns. Due to the flight characteristics of the modern jet aircraft, the magnitudes of the G stresses are lower, but the duration of exposures have increased tremendously, particularly in the G patterns obtained on the Immelman and Loop maneuvers. On the basis of this study it was considered most desirable that the program of indoctrination of flight personnel in all phases of acceleration problems be continued in the Naval Air Advanced Training Command. Also in view of the findings, it is believed that careful study should be devoted to the advisability of requiring anti-blackout equipment for flight personnel in the Basic Training Flight Syllabus.

Human Factors Affecting Operational Performance (U), MR 005-15-1003. Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania; James D. Hardy, Ph. D.

The Operator Laboratory of AMAL has been equipped with electrical connections to the large human centrifuge and to the Aeronautical Computer Laboratory. These additional capabilities have been used to support several programs on the human centrifuge by providing the program for acceleration patterns and the performance tasks to be accomplished under acceleration. The Operator Laboratory was found especially useful in the support of Mercury III and will be further used in support of Mercury IV. Performance instrumentation is expected to receive major emphasis by the Operator Laboratory during the next year so that the mapping of human performance parameters in stress environments may be more thoroughly studied. It is anticipated that the Laboratory will also be devoted to studies of the human transfer function as effected by acceleration.

The long term effects of acceleration on humans has been a matter of concern to the laboratory, particularly in the area of possible degredation of mental performance in subjects who have been exposed to acceleration for a period of years. In order to study this problem, a contract was let with Rutgers University to develop a series of tests which may be used in a wide variety of adverse environments to test higher mental function. The tests are being validated first on college students and preliminary testing of human subjects on the AMAL centrifuge is scheduled for early 1961.

Problems in Human Engineering (U), MR 005-15-1004. Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia 12, Pennsylvania; Edwin Hendler, Ph. D.

Anthropometric data on 1190 naval pilots covering 25 variables was collected and analyzed in connection with a program under the joint sponsorship of BuMed and BuWeps. A preliminary application of the data to the design and dimensions of aircrew workspaces was accomplished.

It is planned to apply the data obtained to design criteria of clothing and the determination of aircrew station dimensional requirements.

Stress Due to High Altitude (U), MR 005-15-1006. Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia 12, Pennsylvania; Edwin Hendler, Ph. D.

The full pressure suit as an item of clothing to be worn by both airborne and space vehicle personnel has been examined during the reporting period with respect to its suitability for prolonged wear. Tests have been conducted using various kinds of thermally insulative underwear under different environmental conditions. Physiological measures made in these evaluations have included mean skin temperature, rectal temperature, evaporative and total weight loss. Performance measures made using the full pressure suit in an F9F Operational Flight Trainer have been obtained from a number of subjects and are presently being analyzed and assembled into a report. Efforts to replace the present face seal in the full pressure suit with a neck seal has raised the question of the physiological effect of added dead air space upon the wearer under a variety of conditions requiring physical exertion. Subjects walking at 3.5 mph. on a treadmill set at a grade of 8.6% are subjected to increasing amounts of dead air space, in increments of 100 ml., up to 1 liter. Present indications are that the first significant physiological changes occur during exposure to an added dead space of 300 ml.

It is planned to continue work on all of the subtasks indicated above. Use of the ACEL altitude chamber and related facilities and personnel in connection with Project Mercury environmental trainer tests has precluded planned tests on decompression effects. It is planned in the ensuing period to construct a small decompression chamber which will

enable animal exposures to be made independently of the use of the forementioned facilities. A theoretical analysis involving the dynamic factors in explosive decompression is planned to be made in the next reporting period. Physiological and performance data to be collected from personnel wearing the full pressure suit will be associated with environmental conditions and situations resembling those anticipated in space and orbital flight. Special emphasis will be placed on problems relating to nutrition and waste disposal, and suitable instrumentation assemblies for this purpose are now being constructed.

Effects of Environment on Aviation Medicine Problems (U), MR 005-15-2001. U. S. Naval School of Aviation Medicine, Research Department, U. S. Naval Aviation Medical Center, Pensacola, Florida; D. E. Beischer, Ph. D.

Environmental conditions of atmospheric and space flight determine the survival of living matter exposed to radiation, extremes of temperature and pressure, and other hazards. Problems of the adequate provision of oxygen, removal of carbon dioxide and body wastes, food and water supply, are being evaluated through logically designed experiments conducted under simulated high altitude or extra-terrestrial conditions.

Effects of Environment on Aviation Medicine Problems (U), MR 005-15-2002. Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania; James D. Hardy, Ph. D.

Presently available data indicate that physiologic temperature regulation contain elements of three of the basic control actions, namely, on-off control, proportional control and rate control. Reset or integral control appears to be minimal. The solutions of the heat flow and regulatory equations have been obtained using a simplified heat flow model, and these solutions have been compared to the experimental data in a steady state and in a dynamic state involving the transfer of man from a warm room to a cold room. The agreement between the calculated and experimental values of rectal temperature, average body temperature, skin temperature, heat loss, heat production, vaporization, and peripheral thermal conductance have been within the experimental range of error.

Work has also been carried on in the area of temperature regulation by producing electrolytic lesions in the forebrain of cats. Ten animals were tested for shivering during periods of cooling and warming after production of brain damage. Shivering resumed in one animal but stopped after enlargement of the lesion. Seven other cats did not stop shivering when lesions of comparable size were made several millimeters lateral to the effective area. Unilateral lesions often suffice to stop the shivering if the lesions were placed within 1/2 mm of the mid-line in the area of the anterior commissure. A volume of tissue, common to all lesions that effectively stop shivering, extended approximately 1/2 mm from the mid-line on one side and divided the anterior commissure and upper third of the preoptic region. Additional work is planned on animals which will be operated on and allowed to completely recover from the immediate effects of the operation.

Miscellaneous Problems Involved in Aviation Medicine (U), MR 005-15-2003. Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia 12, Pennsylvania; Edwin Hendler, Ph. D.

During the past year, several electrophysiological monitoring assemblies have been undergoing evaluation. Various levels of stressors have been quantitatively investigated with those appearing most significant being integrated into a statistical design. A laboratory report is being prepared covering the effects of acute brachial venous impediment and static muscular tension as might be experienced while wearing various protective or safety devices in today's high-performance aircraft. Future work will entail a continuation of this effort and an attempt to delineate some of the basic variables involved in hypo- and hyper-environmental stresses and their effects on peripheral circulation.

R005-99 Other Biological Sciences

Comparative Nutrition of Invertebrates (U), RR 005-99-0002. University of Illinois, Urbana, Illinois, Department of Entomology; Nonr 1834(07), NR 107-082; G. S. Fraenkel.

The investigator is engaged in a study of various aspects of chemical factors in the physiology of insects and marine invertebrates. Primarily, this research concerns the functions of carnitine, a recently identified vitamin apparently universally distributed in biological material. Ancillary studies include the functions of secondary plant substances in attracting and repelling insects, and examinations of physiological adaptations of marine invertebrates to heat and desiccation.

Influences of Micro-environments Upon Embryo Growth in Plants (U), RR 005-99-0004. University of Virginia, Charlottesville, Virginia, Department of Biology; Nonr 474(02), NR 107-114; J. Rappaport.

This investigation was designed to identify and characterize the substances influencing the abnormal growth and development of living tissues. The Jimson weed Datura was used in the experiments because of the large amount of genetic data available concerning this plant.

Arctic Field Investigations (U), RR 005-99-0005. Arctic Institute of North America, Washington, D. C.; Nonr 1138(03), NR 107-180; R. C. Faylor.

The field investigations being conducted by the Arctic Institute of North America in the Arctic and Antarctic represent many branches of the biological sciences, and, in composite, are designed to present as completely as possible a picture of normal and extreme polar conditions including seasonal and geographical distribution of plants and animals, particularly those of survival value on land and at sea, as well as habitability and adaptability studies applicable to human survival and well being.

Water Economy and Salt Metabolish in Marine Birds (U), RR 005-99-0007. Duke University, Durham, North Carolina, Department of Zoology; Nonr 1181(08), NR 107-315; K. Schmidt-Nielsen.

It has been discovered that some animals are able to utilize highly saline water to maintain their water balance. Such marine birds as gulls, auks, petrels, cormorants, etc., remain out of reach of fresh drinking water for months at a time. During these periods they drink only sea water. This task is designed to investigate the mechanism of water use and salt elimination from the body fluids, using sea birds as biological models. Special attention will be focused on the newly discovered extra renal excretory mechanism whereby hypertonic salt solutions are eliminated through an excretory gland located in the nose when the balanced osmotic pressures in the body are disrupted by the ingestion of excess salt.

Biological Investigation in Pacific Areas (U), RR 005-99-0008. National Research Council, Washington, D. C., Pacific Science Board; N7onr 291(57), NR 107-321; H. J. Coolidge.

This task represents a series of individual research projects in the Pacific Islands on various subjects of Naval interest including pest control, hydrobiological hazards and environmental stresses peculiar to the Pacific Area. Currently, special activity toward organizing and analyzing the ecological and taxonomic material and coordinating the field research conducted under this and related contracts will be undertaken.

Pharmacology and Chemistry of Venomous Fishes (U), RR 005-99-0009. University of Southern California, Los Angeles, California, Department of Pharmacology; Nonr 2255(00), NR 107-342; P. R. Saunders.

The objectives of this investigation are the study of the pharmacological actions and chemical nature of the venoms of a number of fishes which are capable of inflicting serious and sometimes fatal wounds. Basic pharmacological activity of the venoms are being defined and the chemical properties of the active components determined. Particular attention is being given to the study of the mechanisms of production of the decrease in blood pressure which is characteristic of all of the venoms.

The Role of the Chemical Senses in Orientation (U), RR 005-99-0010. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Biology; Nonr 2514(00), NR 107-353; V. G. Dethier.

Whereas many terrestrial animals employ visual and auditory senses in order to orient within their environment, aquatic organisms and many terrestrial invertebrates rely for orientation chiefly upon information derived through the chemical senses. Orientation by means of chemical cues is especially highly developed in flying insects which respond to food and sexual odors and in insects which produce and follow chemical traits on the ground. The proper understanding of these modes of orientation depends upon a thorough understanding of chemosensory physiology and behavior patterns which operate by means of chemical senses. This research is designed to study the chemosensory physiology and behavior patterns which operate by means of chemical stimulation in insects. The investigations fall into three categories (a) trail following in non-social terrestrial insects, (b) physiology of the orientation behavior of certain insects, (c) the bearing of sensory adaptation, summation and inhibition on orientation behavior.

Biologically Active Steroid Glycosides from Holothurians (U), RR 005-99-0011. New York Zoological Society, New York, New York, New York Aquarium; Nonr 2266(00), NR 107-354; R. F. Nigrelli.

Investigations were made into the chemical composition and properties, and biological activity of the steroid glycoside Holothurin, produced by the sea cucumber. Holothurin was expected to be of value as a toxic, repellent substance in the prevention of fouling and the repelling of obnoxious animals. Its activity in regeneration in the sea cucumber suggested a value also as an antitumorous agent.

Nature and Biological Action of Fish Poison (U), RR 005-99-0014. University of Hawaii, Honolulu, Hawaii, Marine Laboratory; Nonr 2289(00), NR 107-405; A. H. Banner.

This task is a study of the ecology and feeding habits of poisonous fish, with the aim of discovering the source of the poison, and its chemical and biological characteristics. The investigator is examining poisonous fish species and their habitual food to trace the source of the toxin and to determine if it is ingested intact by the immune fish in the form of poisonous plankton, or if it is produced in the tissue of the fish regardless of their choice of food.

Pharmacology of the Venom of Weever Fishes (U), RR 005-99-0016. College of Medical Evangelists, Los Angeles, California, Laboratory of Neurological Research; Nonr 2571(00), NR 107-433; F. E. Russell.

This task is a study of the pharmacological activity of an unusual and chemically unknown poison occurring in the weever fish. This venom is considered one of the most virulent toxins known. It differs chemically and pharmacologically from that of the stingray, sculpin, and other venomous fishes. Studies indicate that it exhibits an extremely potent parasympathetic activity, a property quite unusual in marine animals' venoms.

Control of Bird Pests on Midway Island Air-Strip (U), RR 005-99-0017. Pennsylvania State University, University Park, Pennsylvania, Department of Zoology; Nonr 656(18), NR 107-464; H. Frings.

This study is aimed at the control of birds on Midway Island. Aircraft using this air station are endangered by the large bird population comprised principally of albatrosses and terns. Dr. Frings has been investigating the feasibility of acoustic and other control methods.

Water Economy and Salt Metabolism of Desert Vertebrates (U), RR 005-99-0018. University of California, Los Angeles, California, Department of Zoology; Nonr 233(61), NR 107-485; G. A. Bartholomew.

This is an analysis of the role of the saline water in the water economy of various vertebrates living in the deserts of the southwestern United States, on the desert islands of the Gulf of

California and on the essentially waterless islands off the coast of California and Baja California. The ability of terrestrial vertebrates to use the sea as a source of water has long been a matter of both physiological and ecological interest but remarkably little data is available for birds and mammals which do not obtain their food from the sea. The investigator hopes to correlate the different capabilities for using sea water with morphological and histological characteristics of the excretory systems, the digestive tracts and cloacas of the animals under study.

Comparative Studies in Prolonged and Deep Diving (U), RR 005-99-0019. University of California, La Jolla, California, Scripps Institution of Oceanography; Nonr 2216(09), NR 107-493; P. F. Scholander.

This is a study of the circulatory, respiratory and calorigenic processes occurring in animals during prolonged diving. Bradycardia, circulatory bypass of muscles and other organs, lactic acid formation and "flushout" in muscles, and other events connected with diving are examined in detail. Oxygen debt in relation to energy metabolism and metabolic conditions contributing to susceptibility to gas embolism is also studied. Crocodiles and sea turtles are used in testing because of their ability to remain submerged for hours.

Body Temperature Regulation and Breeding Behavior of Pelagic Birds (U), RR 005-99-0021. University of California, Los Angeles, California, Department of Zoology; Nonr 2807(00), NR 107-516; T. H. Howell, G. A. Bartholomew.

This was a study of the physiological and behavioral adaptation of young birds and adults to a stress environment, tropical heat. Sea birds were chosen for study because they nest in exposed locations where the young are subjected to considerable environmental stress.

Marine Biology Studies from Arctic Drift Stations (U), RR 005-99-0022. University of Southern California, Los Angeles, California, Department of Biology; Nonr 228(19), NR 107-567; J. L. Mohr.

The investigator is conducting studies of the floating and anchored fauna and flora of the Arctic Basin. Emphasis is on selected areas of the deep basin and along the continental shelf near Point Barrow. Collections are being made from three drifting ice islands. Fresh samples are examined at once for general identification, and on site ecological information is gathered. Preserved specimens are analyzed at a land-based laboratory for more detailed classification and for semi-quantitative chemical analyses of tissue fat and protein reserve during the year.

Biochemistry of Physiological Action Principles in Echinoderms (U), RR 005-99-0023. Mount Sinai Hospital, New York, New York, Department of Chemistry; Nonr 3128(00), NR 107-543; H. Sobotka.

This investigation is aimed at the isolation of the biologically active principles in echinoderms, the determination of their chemical structures and their pharmacological activity. Of especial interest is Holothurin, a complex substance produced by certain sea cucumbers.

R006 PSYCHOLOGICAL SCIENCES

R006-01 Sensory Mechanisms

Visual Adaptation at Various Levels of Illumination (U), RR 006-01-0001. Florida State University, Tallahassee, Florida, Department of Psychology; Nonr 558(00), NR 140-036; H. D. Baker.

Four related visual problems are being investigated under this task (1) the basis of the transient threshold rise before dark adaptation; (2) the relationship between retinal neural discharge (electroretinogram-ERG) and psychophysical threshold changes in the early stages of dark adaptation; (3) the effect of electrically induced discharge rate upon threshold sensitivity for light; and (4) binocular and monocular shifts under conditions of constant adaptation.

Electrophysiological Studies of Chemoreceptors (U), RR 006-01-0002. Florida State University, Tallahassee, Florida, Department of Psychology; Nonr 589(00), NR 140-038; L. M. Beidler.

This is a basic research investigation concerning human taste sensitivity. The research program includes three major areas (1) comparative analysis of the sodium and potassium content of red blood cells and taste response to these substances; (2) the correlation of electrophysiological data with that obtained through psychophysical means, and; (3) electrophysiological recording of taste response from the chorda tympani nerve of human subjects.

Photochemistry of Visual Retinal Pigments (U), RR 006-01-0004. University of Rochester, Rochester, New York, Department of Biology; Nonr 1190(00), NR 140-074; J. C. Peskin.

Chemical changes occurring in the eye in response to light constituted the major part of this research program. It included analysis of the building up and breaking down of the photochemical elements required for the initiation of visual sensation. Particular research attention was directed toward the determination of the rates of absorption of light by retinine as influenced by intensity and wavelength.

Psychophysiology of Vision (U), RR 006-01-0005. Rockefeller Institute for Medical Research, New York, New York; Nonr 1442(00), NR 140-093; H. K. Hartline.

This is a comprehensive research investigation dealing with the visual system. Investigations include the response of individual rods and cones of the retina, the nerve network from the retina to the optic track and the activity of specific fibers of the optic nerve in response to light stimulation.

Psychophysiology of Vision (U), RR 006-01-0007. Lehigh University, Bethlehem, Pennsylvania, Department of Psychology; Nonr 610(02), NR 140-095; N. B. Gross.

A systematic investigation of the functional relationships existing in the auditory areas of the brain is the goal of this task. Research will be conducted to investigate the relationships between ipsilateral and contralateral auditory areas

in response to tonal stimulation, spontaneous activity and lesions of connecting fibers between the two hemispheres.

An Analysis of Tactual Stimuli (U), RR 006-01-0008. Florida State University, Tallahassee, Florida, Department of Psychology; Nonr 1827(00), NR 140-097; D. R. Kenshalo.

This is an investigation of the mechanism of tactual sensitivity. Such variables as area of stimulation, degree of pressure, and acceleration of tissue displacement are being investigated as they relate to frequency of neural impulse. The primary interest in this research is the phenomena of tactual adaptation, in which neural discharge ceases in the presence of continuing stimulation. The hypothesis of tissue movement as the adequate stimulus for the sense of touch is being evaluated. Additional investigations will be undertaken concerned with pain and the factors which influence sensitivity and adaptation to painful stimuli.

Antomy of the Auditory System (U), RR 006-01-0009. University of Oregon, Portland, Oregon, Medical School; Nonr 1779(01), NR 140-103; A. R. Tunturi.

The primary areas of investigation under this task are the distribution and response of nerve fibers from the inner ear to the cortex, the pattern of cortical response following varied acoustical stimulation, cortical response in relation to masking effects, differential influence of monaural versus binaural stimulation, interaction between the primary and secondary auditory cortical areas, and other relationships between acoustic stimulation and central neural response.

Response of the Accommodation Mechanism (U), RR 006-01-0010. Ohio State University, Columbus, Ohio, Research Foundation; Nonr 495(09), NR 140-105; G. Westheimer.

This task is designed to investigate the accommodation mechanism of the human eye. The general goal is to differentiate between peripheral and central mechanisms in bringing about visual accommodation. Studies are being conducted to determine the effect upon accommodation of such factors as: degree of field structure, temporal intervals of target presentation, spatial intervals between targets, distance of target, illumination variables of the field, adaptation state of the eye, wavelength of light and other factors known to be of significance to visual accommodation.

An analysis of Cochlear Wave Motion (U), RR 006-01-0011. State University of Iowa, Iowa City, Iowa, Department of Otolaryngology and Maxillofacial Surgery; Nonr 1893(00), NR 140-112; J. Tonndorf.

The purpose of this task is to investigate the cochlear wave motion in the human ear. This will be accomplished by means of high speed photography of the traveling wave in a mechanical model of the cochlea. The photographic records obtained will be evaluated to determine the factors associated with the wave build-up, its perpetuation along the cochlear membrane and its cessation following stimulation.

Armed Forces-NRC Committees on Vision and Audition (U), RR 006-01-0012. National Academy of Sciences, National Research Council, Washington, D. C.; Nonr 2300(05), NR 140-113; G. Finch.

The Armed Forces-NRC Committees on Vision and Audition have been established under a secretariat function of NRC primarily to assist the Armed Forces in the solution of their problems related to these sensory modalities. This is accomplished through collaboration between civilian scientists in the fields of vision and audition and representatives of the military services. The major activities of the Committees are to stimulate, supervise, coordinate, and promote the utilization of research in these areas.

Visual Adaptation (U), RR 006-01-0013. University of Wisconsin, Madison, Wisconsin, Department of Psychology; Nonr 2433(00), NR 140-119; F. A. Mote.

This is an equipment loan contract for the purposes of investigating certain factors relating to visual adaptation and the means of preserving dark adaptation under conditions of varied light stimulation. The effects of light flashes (simulating gun flashes, beacons and search lights) on the ability to see in the dark, or the extent to which such stimuli destroy dark adaptation, have been subject to study. Similar investigations will be continued utilizing very brief but intense visual stimuli. Further work will be undertaken concerning the effect of specific wavelengths of light on the adaptation of the human eye.

Threshold Quanta and Color Sensitivity (U), RR 006-01-0014. Fordham University, New York, New York, Department of Psychology; Nonr 2508(00), NR 140-121; R. T. Zegers.

This was an investigation of human color vision as a function of monochromatic quanta light stimulation. Threshold measurements were obtained for the perception of specific hues as a function of the wavelength of light and the number of quanta required for sensation. Quanta counts were made of the stimulating light energy with correction for absorption due to ocular media, macular pigment, and the efficiency of absorption by the photochemical substance.

Relationship Between Hue, Intensity and Critical Flicker Frequency (U), RR 006-01-0015. Fordham University, New York, New York, Department of Psychology; Nonr 880(03), NR 140-124; R. T. Zegers.

The relationship between hue, intensity and critical flicker frequency is investigated. The effect of flash rate on the brightness of various hues is being determined through the visual spectrum from 400-700 millimicrons, at 10 millimicron intervals. Flash rate is varied from 20 to 60 cycles per second. Particular emphasis during the initial period of this research has been concerned with the effect of hue upon the critical flicker fusion frequency at the two extremes of the visible spectrum.

Retinal Sensitivity during Photopic Adaptation (U), RR 006-01-0017. Eye Research Foundation, Bethesda, Maryland, Department of Biophysics; Nonr 2570(00), NR 140-130; R. H. Peckham.

Investigations are being continued concerning

human response to repetitive visual stimuli under conditions of varied brightness, contrast, light-dark ratio and wave form. These data will be evaluated in terms of evidence for neural integration at various levels of the visual system. The basic goal of the research will be to determine relationships between visual perception under varied conditions and the neurophysiological basis underlying the perception. Experimentation will be initiated utilizing various phylogenetic levels, including man, to trace the neural activity throughout the visual system from the retina to the occipital cortex.

Relations Between Sensory Scales, Psychophysical Discrimination and Reaction Time (U), RR 006-01-0019. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Psychology; Nonr 551 (37), NR 140-142; E. Galanter.

The primary task of this research program is to conduct experimental studies to determine the relationship between intensity of physical stimuli, the level of sensation and the latency of response. In addition, individual differences will be determined for various stimulus conditions and the extent to which learning contributes to sensory discrimination will be investigated. These experimental data will be used to test the validity of different theoretical models of human sensory discrimination.

Temporal Sensory Integration (U), RR 006-01-0020. Syracuse University, Syracuse, New York, Bioacoustics Laboratory; Nonr 669(13), NR 140-145; J. J. Zwislocki.

The general purpose of this research is to further develop and verify a theory of temporal integration, i.e., the mechanism by which stimuli occurring over a period of time are summated to bring about a response proportional to the total energy. Preliminary experimentation utilizing auditory stimuli at threshold level will be expanded to include suprathreshold measures. Concurrently, experimentation will be undertaken to evaluate the extent to which the response to vibratory stimulation conforms to the temporal integration theory.

Physiological Acoustics (U), RR 006-01-0021. Central Institute for the Deaf, St. Louis, Missouri; N6onr 272(03), NR 140-170; H. Davis.

The immediate objective is to investigate the mechanism of excitation of auditory nerve impulses by acoustic energy. A secondary objective is to investigate other mechanically stimulated sense organs, such as the labyrinth, tactual receptors and muscle spindles, to test the generality of models and hypotheses developed from the study of the cochlea.

Fundamental Chemical Processes in the Eye (U), RR 006-01-0022. Harvard University, Cambridge, Massachusetts, Biological Laboratories; Nonr 1866 (38), NR 140-277; G. Wald.

This task is concerned with the mechanism by which light energy is converted to neural impulses. The major direction of the research is toward the analysis and synthesis of the photochemical elements existing in the rods and cones of the eye. The rate and direction of chemical reaction is evaluated as a function of stimulation by specific wavelengths and intensities of light. Supplemental studies are designed to correlate the visual activity in various unique animal species with the chemical composition of the light sensitive elements.

Sound Conduction in the Ear (U), RR 006-01-0023. Princeton University, Princeton, New Jersey, Department of Psychology; Nonr 1858(18), NR 140-322; E. G. Wever.

An investigation of the nature of sound conduction in the ear, with special emphasis on the clarification of the fundamental processes involved in normal and abnormal hearing, is the subject matter of this task. This investigation includes the functions of the middle ear apparatus in converting airborne pressure waves to mechanical energy, the effects of over stimulation, and the process of distortion in the normal and defective ear.

Study of the Electrical Activity of the Human Retina (U), RR 006-01-0024. Brown University, Providence, Rhode Island, Department of Psychology; Nonr 562(21), NR 140-359; L. A. Riggs.

This task consists of a series of investigations concerning the electrical activity of the human retina and the influence of eye movements on visual acuity and discrimination. Measures of electrical activity (ERG electroretinogram) are obtained by means of corneal surface electrodes. Research will be initiated to determine the specific sources and tissue activity which contribute to the total ERG response. Further research will be conducted regarding the correlation between eye movements, both "stopped" and continuous tracking movements, and the electrical response.

Cutaneous Mediation of Vibratory Forces (U), RR 006-01-0025. University of Virginia, Charlottesville, Virginia, Psychological Laboratory; Nonr 474(06), NR 140-598; F. A. Geldard.

A study of the response characteristics of the human skin to mechanical and electrical stimulation in order to determine the feasibility of using vibrational patterns on the skin surface as an auxiliary method of communication.

Psychophysiology of Chemoreception (U), RR 006-01-0026. Brown University, Providence, Rhode Island, Department of Psychology; Nonr 562(23), NR 140-721; C. Pfaffmann.

This research program undertakes a comprehensive analysis of the sense of taste. The work includes investigations of the receptor elements and their response to various taste stimuli, the neural pathways from the tongue to the brain, the cortical areas associated with the sense of taste and the factors which influence taste sensitivity, food preferences and aversions. The primary effort during the coming year will be an elaboration of the research dealing with the cortical effects of taste stimulation.

Effect of Noise on Inner Ear Cells (U), RR 006-01-0027. University of Goteborg, Goteborg, Sweden, Medical School; N62558-2631, NR 140-154; H. Engstrom.

A determination of the point at which irreversible damage occurs to the hair cells of the inner

ear as a function of exposure to high intensity noise is the subject matter of this task. Animals will be exposed to controlled sound stimulation of varied frequency and intensity. Histologic and electron microscopic analysis will be conducted to determine the extent to which sensory hair cells of the inner ear are permanently damaged and attempts will be made to relate the area of tissue damage to the characteristics of the stimulus spectrum.

Frequency Content of Electrophysiological Mechanisms (U), RR 006-01-0028. University of Amsterdam, Amsterdam, The Netherlands, Medical Physics Laboratory; N62558-2701, NR 140-156; L. H. van der Tweel.

This investigation is directed toward a comprehensive analysis of signal characteristics generated in electrophysiological measurement. Spontaneous as well as induced activity will be considered and subjected to Fourier analysis. Primary emphasis will be placed upon signals obtained from the visual system and those derived from skeletal muscular activity.

Biophysics of the Visual Process (U), RR 006-01-0029. University of California, Berkeley, California, School of Optometry; Nonr 222(82), NR 140-159; G. Westheimer.

This research will concern itself with the study of various aspects of the visual process using techniques of physics, physiology and psychology. Particular attention will be given to the process of image formation within the eye. It will be attempted to study the light distribution on the retina, the mechanics of defocussing and the various modes of image-formation.

R006-02 Neural and Perceptual Processes

Visual and Stereoscopic Acuity for Moving Objects (U), RR 006-02-0001. Kresge Eye Institute, Detroit, Michigan; Nonr 2963(00), NR 142-023; E. J. Ludvigh.

An analysis will be made of the visual direction sense to determine the manner in which accuracy of visual target location is influenced by separation of reference stimuli, contrast, brightness, size of targets and other variables. Investigations will be continued concerning the dynamics of vertical turning movements of the eyes.

Visual and Other Factors in Human Space Orientation (U), RR 006-02-0002. State University of New York, New York, New York, Medical Center; Nonr 1175(00), NR 142-073; H. A. Witkin.

This task is determining those factors which account for individual differences in perception. This is to be accomplished through continuous longitudinal studies of perceptual development as well as cross sectional studies of various age groups. Periodic measurements have been, and will continue to be made upon a group of individuals within the age range of 18-20 years. From these data the development changes in perception are being charted. Similarities and differences in perceptual response of various clinical groups are also being studied.

Visual Perception of Space and Motion (U), RR 006-02-0003. Cornell University, Ithaca, New York, Department of Psychology; Nonr 401(14), NR 142-087; J. J. Gibson.

This is an investigation of those variables determining the perception of movement, position, shape and surface texture of objects in space. This task has two major facets (1) the individual's perception of his own movement and orientation in space by means of external stimulus cues; and (2) the perceptual phenomena associated with the determination of velocity, size, shape and distance of moving targets. Particular attention will be directed to the problem of the kinds of perception induced by conjunctive and disjunctive motions of optical stimuli.

Effects of Perceptual Isolation on the Human Subjects (U), RR 006-02-0004. Harvard University Medical School, Cambridge, Massachusetts; Nonr 1866(29), NR 142-115; P. Solomon.

It is the purpose of this task to measure and evaluate the psychological and physiological changes that take place in an individual isolated from normal environmental stimuli. Pre-test data concerning the physiological and psychological status of the individual will be compared with measures obtained while the subject is in the stress situation and following his period of confinement. The stimulus field will be systematically varied to determine the type and amount of stimulation required for an individual to maintain reality contact in a restricted environment. In addition, blind and deaf subjects are included in the experimental program.

The Effects of Varied Sensory Input Central Neural Response (U), RR 006-02-0005. Harvard University, Cambridge, Massachusetts, Department of Psychiatry; Nonr 1866(41), NR 142-127; F. R. Ervin and J. H. Mendelson.

The electrophysiologic and metabolic activities of the central nervous system under conditions of sensory deprivation and varied sensory input is the subject matter of this research task. Overt behavioral data will be correlated with EEG recordings obtained from depth and surface electrodes in adult human subjects. In addition, biochemical studies of the changes in adenosinetriphosphate (ATP) concentration as a function of varied external and direct electrical stimulation will be undertaken in animals.

Controlled Light and Dark Phase Illumination (U), RR 006-02-0006. Tufts University, Medford, Massachusetts, Institute for Applied Experimental Psychology; Nonr 494(18), NR 142-140; J. A. Hanson.

The primary goal of this task is the determination of those factors influencing dark adaptation and resulting visual acuity. Primary emphasis is given to stimulation by very brief light exposures separated by dark intervals and the consequent changes in adaptation. An attempt will be made to develop an illumination system which will provide "light phases" of intensities and durations which have minimal effects upon subsequent visual sensitivity. In addition, studies will be undertaken to investigate dynamic visual acuity in a situation

in which free head movement is permitted and target velocity and exposure time are systematically varied.

Voice Communications (U), RR 006-02-0007. Harvard University, Cambridge, Massachusetts, Psycho-Acoustic Laboratory; Nonr 1866(15), NR 142-201; S. S. Stevens.

This is a comprehensive research program conducted by the Psycho-Acoustic Laboratory of Harvard University. This research covers the general field of psychological and physiological acoustics, with special emphasis on problems related to speech, hearing and communications. Investigations will be undertaken concerning the effectiveness of voice communication equipment, personnel noise protective devices, and the psycho-physiological nature of the auditory process.

Visual Perception (U), RR 006-02-0008. Columbia University, New York, New York, Department of Psychology; Nonr 266(46), NR 142-404; C. H. Graham.

This is a comprehensive research program in the field of vision. Investigations vary over a considerable range but are primarily concerned with visual discriminations, as represented in the following (1) target detectability under varied color contrast; (2) color transformation; (3) form or shape discrimination under varied exposure conditions; (4) bisection of visual distance; (5) quantum requirements in vision; (6) the initiation of other research investigations deemed of importance to the progress of visual sciences and of significance to military personnel safety and performance efficiency.

Spatial Orientation (U), RR 006-02-0009. Tulane University, New Orleans, Louisiana, Department of Psychology; Nonr 2400(00), NR 142-455; C. W. Mann.

This was a research program in the broad area of disorientation in space. Particular attention was directed toward the relationship between the visual and labyrinthine senses in maintaining orientation. The primary variables investigated were (1) the extent to which human subjects can perceive body tilt, in the absence of visual cues, and adaptation to a tilted body position; (2) the accuracy with which subjects can determine the relative position of objects in space while tilted or rotated from the normal body position; (3) the determination of absolute and discrimination threshold for body displacement; and (4) evaluation of the relationship between visual nystagmus and velocity of rotation.

Electrophysiology of the Cerebral Cortex (U), RR 006-02-0010. Washington University, St. Louis, Missouri, School of Medicine, Department of Neuropsychiatry; Nonr 816(03), NR 144-041; G. H. Bishop.

Investigations of the relationship between the structure and function of nerve cells will be undertaken. Particular attention will be given to the neural connections between the thalamus and cortex. Individual neurone response will be measured as a function of varied stimulation. The relationship between fiber size, distribution, and cortical activity will be subject to study. Neurohistological investigations will be conducted utilizing the electron microscope. Increased emphasis will be directed toward the comparative evaluation of neural structure in varied species as well as the changes in structure and function during growth periods of single species.

The Roles of the Autonomic and Central Nervous Systems in Human Behavior (U), RR 006-02-0011. Indiana University, Bloomington, Indiana, Department of Psychology; Nonr 908(03), NR 144-071; R. C. Davis.

This task supported the research of seven professional personnel whose activities were devoted to a series of investigations concerning autonomic and skeletal muscle response to varied environmental conditions and human task requirements. The research program included (1) measures of somatic response during sensory isolation and noise stress; (2) the influence of heavy physical exertion over prolonged periods on the individual's autonomic activity and response to sensory stimuli; (3) techniques for simultaneous recording of the electrogastrogram and other somatic variables; and (4) experimentation utilizing four channel tape recording of EMG potentials under varied environmental and task conditions.

Brain Organization and Behavior (U), RR 006-02-0013. University of California, Los Angeles, California, School of Medicine, Department of Physiology and Psychology; Nonr 233(32), NR 144-102; D. B. Lindsley.

Research under this task includes: Studies of the influence of electrical stimulation of the brain; the effect of self-stimulation via implanted electrodes; the action of certain tranquilizing drugs upon learned behavior; the effects of repetitive photic and auditory stimulation upon the sensory areas of the cortex; the pattern of brain discharge arising from emotional activity; and other investigations concerned with the relationship between brain organization and behavior.

Motor Unit Electrical Activity of Human Extraocular Muscles (U), RR 006-02-0014. The San Francisco Institute of Medical Sciences, San Francisco, California, Department of Surgery (Ophthalmology); Nonr 3009(00), NR 144-108; A. Jampolsky.

The extraocular muscle system and the pattern of human eye motility is the subject matter of this investigation. By means of microelectrodes implanted in the control muscles of the eye, response measurements are obtained while the subject is fully conscious and capable of tracking, reading and other visual tasks. The research to be undertaken during the coming year will include investigations of (1) proprioception in extraocular muscles; (2) fusional vergence movements of the eyes; (3) nature of tracking movements of the eye; (4) electromyograms in neuro-ophthalmological disease, and (5) continuation of research initiated during the past year.

The Effects of Common Centrally Acting Drugs (U), RR 006-02-0016. University of Kansas, Lawrence, Kansas, Department of Pharmacology; Nonr 583(09), NR 144-123; D. G. Wenzel.

The effects of various centrally acting drugs on complex human psychomotor performance are being

investigated. The variables to be examined are (1) the physiological system primarily affected by specific drugs (2) side effects in systems other than those to which the drug is directed (3) the influence of varied dosage, (4) the extent to which drugs may enhance performance (5) the duration of this enhancement and (6) the extent to which drugs may be used to maintain normal performance and to delay work decrement for extended periods. Particular attention will be directed toward establishing valid experimental procedures for behavioral effects of drug administration.

Reticular Stimulation and Conditioned Behavior (U), RR 006-02-0017. University of California, Los Angeles, California, Medical Center, Department of Pharmacology; Nonr 233(57), NR 144-129; B. B. Brown.

The facilatory or inhibitory effect of electrical stimulation of the brain on the acquisition and retention of learned behavior is the subject matter of this task. In addition, studies are being conducted concerning the influence of various centrally acting drugs on learned behavior and the interaction of these drugs with electrical stimulation.

Comparative Learning (U), RR 006-02-0018. Bryn Mawr College, Bryn Mawr, Pennsylvania, Department of Psychology; Nonr 2829(01), NR 144-132; M. E. Bitterman.

The comparative psychology of the learning process is the subject matter of this task. Selected animal species will be trained to react in a prescribed manner in controlled stimulus situations. The improvement in performance as a function of practice will be objectively measured. Comparative studies of the learning process in the different species will be conducted with particular reference to the relationship between the complexity of the animal nervous system and learning characteristics.

Human EEG Activity and Performance (U), RR 006-02-0019. Langley Porter Neuropsychiatric Institute, San Francisco, California, Department of Mental Hygiene; Nonr 2931(00), NR 144-134; E. Callaway and C. L. Yeager.

Variation in human electroencephalographic (EEG) activity are being correlated with changes resulting from drug administration, fatigue, emotional disorders and other independent variables. The initial phases have been concerned with the relationship of the alpha rhythm to afferent stimulus thresholds and motor response.

Drugs and Stress (U), RR 006-02-0020. Washington University, St. Louis, Missouri, Medical School, Department of Neuropsychiatry; Nonr 816(13), NR 144-135; J. A. Stern.

The relationship between sympathetic nervous system activity and resistance to psychological and physiological stress will be investigated. Various drugs will be administered to induce sympathetic activity and performance measures obtained under various stressful environmental conditions. In addition, research will be conducted to determine the influence of "psychic energizers" upon tolerance to stress.

Drug Enhancement of Performance (U), RR 006-02-0021. Stanford Research Institute, Menlo Park, California, Department of Biological Sciences; Nonr 2993(00), NR 144-137; N. Plotnikoff.

The objective of this research program is twofold (1) to provide professional staff and facilities for comprehensive analysis of diverse research tasks in terms of their relevance to drugs and human performance, and (2) to conduct experimentation required to provide information where gaps exist in present knowledge of drugs and performance.

Effects of Drugs on Somatic Activity and Human Response (U), RR 006-02-0022. Indiana University, Bloomington, Indiana, Department of Psychology; Nonr 908(15), NR 144-138; R. C. Davis.

The objective in view is making comparisons of patterns of physiological activity in resting conditions and during task performance when the individual is (1) in a normal state, (2) under tranquilizing drugs, and (3) under activating drugs. Simultaneous channel recording will provide a picture of major physiological systems under these conditions of drugs and performance. Research emphasis during the coming year will be concerned with varied drug dosage, increasing the number of drugs evaluated, and comparison studies with substances of known physiological response characteristics.

Mechanisms Underlying the Placebo Effect (U), RR 006-02-0023. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Psychology; Nonr 551(38), NR 144-143; E. Eisman.

This research was directed toward two independent but related problems. The first problem concerned the mechanisms underlying the placebo phenomena. The second concerned the nature of pain, its measurement and the relationship between pain threshold and analgesia. Investigations were undertaken to determine the influence of certain drugs and placebos on the perception of pain. Procedures were established to obtain reliable thresholds for pain stimuli. Variation in these thresholds were measured as a function of certain analgesic and tranquilizing drugs. These effects were compared with pain threshold variation using placebos.

Analysis of Biological Information Systems (U), RR 006-02-0024. Yale University, New Haven, Connecticut, School of Medicine, Department of Neurology; Nonr 609(39), NR 144-144; L. Stark.

The application of principles of cybernetics and information theory to an analysis of human behavior and biological systems is the primary purpose of this research. Visual tracking behavior will be investigated as a function of simple and complex input signals and in particular those mechanisms which permit the subject to adapt or adjust his behavior in such a way as to predict and accurately follow input signals. Data derived from these experiments will be utilized to construct a synthetic model of human motor coordination which accounts for the organization of the neural system which will allow anticipatory behavior at a simple neuro-muscular level. This work is being continued under NR 144-157.

Neural Mechanisms of Sensory Discrimination (U), RR 006-02-0025. University of Chicago, Chicago, Illinois, Department of Psychology; Nonr 2121(06), NR 144-608; W. D. Neff.

The primary purpose of this research is to conduct a series of experiments to investigate the cortical and subcortical neural mechanisms underlying the ability to discriminate stimuli in different sense modalities. Comparison of frequency, intensity, duration and temporal pattern discrimination will be made following subcortical and cortical lesions utilizing auditory, visual and tactual stimuli.

Effects of High Intensity Flashes of Light on Visual Perception (U), RR 006-02-0027. University of Pennsylvania, Philadelphia, Pennsylvania, Medical School; Nonr 551(39), NR 142-146; J. L. Brown.

The objective of this experimental program is determination of relationships between light flashes and subsequent return of functional perception.

Stimulus Analyzing Mechanisms (U), RR 006-02-0028. Oxford University, Oxford, England, Institute of Experimental Psychology; N62558-2453, NR 142-147; N. S. Sutherland.

The primary aim of this task is to uncover the detailed stimulus analyzing mechanisms responsible for the discrimination of visual patterns in man and animal. Initially an attempt will be made to specify these mechanisms in terms of a general mathematical model which will hypothesize the characteristics a mechanism would have to possess in order to provide the output observed, in this case perceptual discrimination, from a controlled visual input. A second step in this research will be to relate neurological and behavioral data to the established model in an attempt to describe the stimulus analyzing mechanism in physiological terms as an arrangement of nerve fibers having certain properties related to input and output.

Evolution of Perceptual Frames of Reference (U), RR 006-02-0029. Kansas State University, Manhattan, Kansas, Department of Psychology; Nonr 3290 (01), NR 142-155; W. Bevan.

All psychophysical judgments of stimulus duration, intensity, brightness, etc., are made in terms of the individual's frame of reference, previous experience or personal standards. This experimentation will not only provide information concerning present judgments but will also systematically study the gradual evolution of perceptual judgment to its present status. Such information will allow the prediction of changes in stimulus discrimination under varied conditions and durations of exposure.

Loudness Scales and Judgment (U), RR 006-02-0030. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Psychology; Nonr 551 (41), NR 142-161; J. Beck and W. A. Shaw.

This task attempts to discover basic information concerning the relationships between loudness scales and similarity judgments. The general problem is to investigate whether the similarity judgments one makes for the loudness of auditory signals can be accounted for, via a formula, by a single underlying loudness scale.

Development of a Stress Sensitive Test (U), RR 006-02-0031. Human Factors Research, Incorporated, Los Angeles, California; Nonr 3135(00), NR 144-152; W. Harris.

The development, standardization and validation of a perceptual discrimination test which will reliably measure individual variability in performance efficiency as a function of various type psychological and physiological stressors is the goal of this task.

Analysis of Biological Information Systems (U), RR 006-02-0032. Massachusetts Institute of Technology, Cambridge, Massachusetts, Electronic Systems Laboratory; Nonr 1841(70), NR 144-157; L. Stark.

The application of cybernetics and information theory to an analysis of human behavior and biological systems is the primary purpose of this research. Visual tracking behavior will be investigated as a function of simple and complex input signals and in particular those mechanisms which permit the subject to adjust or adapt his behavior in such a way as to follow input signals accurately. Data derived from these experiments will be utilized to construct a model of human motor coordination which accounts for the neural organization that allows anticipatory behavior at a simple neuro-muscular level. Additional studies will be undertaken concerning automatic reading and interpretation of human electroencephalograph records.

Effect of Air Ions on Behavior (U), RR 006-02-0033. General Electric Company, Ithaca, New York, Light Military Electronics Department; Nonr 3303 (00), NR 144-158; A. H. Frey.

This research program is concerned with determining the effect of varied concentrations of atmospheric ions, of both positive and negative charge, on human behavior. The initial stages of the research will be directed toward (1) the identification of a sensitive and reliable behavioral measure of ion effects; and (2) the development of techniques to experimentally control interacting variables, i.e., distance of source from subject, temperature, humidity, mobility of the ion, barometric pressure, extraneous particles in the air, etc.

R006-03 Motor Mechanisms

Display, Control, and Transmission of Information (U), RR 006-03-0001. Johns Hopkins University, Baltimore, Maryland, Department of Psychology; Nonr 248(55), NR 145-089; A. Chapanis.

The input, transmission, display, recognition and control of information as utilized in military communication and detection systems is the content of this research program. Experimental investigations are being conducted regarding man-machine interactions, problems of information reception, judgment and decision making and applied research in systems analysis and procedures. Research interest in the near future will be concerned with intermittent photic stimuli of alternating durations, multiple coded visual displays, the interrelatedness of display information as it influences performance, and the timing of sequentially

presented information so as to facilitate performance efficiency.

Human Performance in Aided Tracking Systems (U), RR 006-03-0003. Columbia University, New York, New York, Engineering Center; Nonr 266(42), NR 145-110; J. M. Notterman.

The primary purpose of this task was the study of kinesthetic feedback ("feel" of controls) as it influenced tracking performance. Systematic variation in kinesthetic feedback was introduced by changing the inertia, pressure or damping characteristics of the control device, or by varying the amount and rate of control displacement required to produce a given displacement of the object being controlled.

Perceptual and Physiological Response During Auditory Stress (U), RR 006-03-0004. Hofstra College, Hempstead, New York, Department of Psychology; Nonr 2252(01), NR 145-114; R. Plutchik.

Investigations are being conducted to determine those aspects of auditory stimuli, i.e., frequency, intensity and temporal intervals between stimuli, which serve to establish a stress or tension state within the organism. The influence of high intensity intermittent sounds are being determined using both behavioral and physiological measures. Changes in the efficiency of skilled tracking performance and fluctuations in heart rate, EEG patterns, skin temperature and other physiological indices are being analyzed as a function of variation in sound stimuli and other controlled environmental conditions.

A Continuous Biometric Measure of Response (U), RR 006-03-0005. Princeton University, Princeton, New Jersey, Department of Psychology; Nonr 1858 (19), NR 145-116; J. M. Notterman.

An evaluation of the similarities and differences between servosystem theory and organic behavior theory is the goal of this research. Traditional laboratory experiments concerned with discrimination, avoidance conditioning, reinforcement, transfer, etc., will be conducted within the framework of servosystem theory, i.e., a continuous feedback system in which the inputs (stimuli) are determined not only by changes in external physical energy but also by the outputs (responses) of the organism. Data will be evaluated in terms of the applicability of behavioral information to further refinement and modification of servosystems as well as the applicability of servosystem theory to problems or organismic behavior.

An Investigation of Certain Means of Sound Attenuation at the Ear (U), RR 006-03-0007. Syracuse University, Research Institute, Syracuse, New York, Special Education Department; Nonr 669(11), NR 145-125; J. J. Zwislocki.

The utilization of a resonator system for increasing the sound attenuation of ear protective devices was the area of investigation under this task. The physical characteristics of size, shape and composition of the resonating chamber were varied to determine the appropriate combination that would satisfactorily attenuate sound intensities and frequencies encountered by military personnel working in high level noise fields. In addition, various methods for supporting the ear protective device in such a way that it will not interfere with other equipment or clothing, will not hinder the performance of assigned duties, and will permit wearing for extended periods with ease and comfort were investigated.

Motor and Autonomic Response (U), RR 006-03-0009. Creedmoor State Hospital, Queens Village, New York, Experimental Psychology Laboratory; Nonr 2850(00), NR 145-133; M. Kaplan.

Determination of the course of concurrent autonomic and motor responses occurring during the acquisition and extinction of various sensory discriminations is the subject matter of this task. Current activity is directed toward the development of satisfactory measuring and recording equipment and the design of appropriate discrimination tasks.

Aircrew Visual Aids (U), RR 006-03-0010. Marks Polarized Corporation, Whitestone, Long Island, New York; Nonr 2923(00), NR 145-136; A. M. Marks.

It was the purpose of this task to investigate the basic approach of utilizing a solid state electro-optic shutter which is compatible with the human visual requirement in certain air warfare techniques. Basic research was undertaken to develop an optic shutter which would be activated by photic energy, and which by means of polarization, light transmission characteristics would be restricted or enhanced in accordance with human requirements in fields of varying brightness.

Low Frequency Vibration Effects on Human Performance (U), RR 006-03-0011. Boeing Airplane Company, Wichita, Kansas, Human Factors Staff; Nonr 2994(00), NR 145-139; J. E. Beaupeurt.

The objective of this program is to determine the capabilities and limitations of the human performing tasks simulating aircrew duties while being subjected to vibrations of various frequencies and amplitudes. This research is based on a need for human performance data to minimize performance decrements resulting from turbulent air during low altitude, high speed flight, and other conditions of vibration.

Complex Perceptual Motor Skills (U), RR 006-03-0012. Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota, Aeronautical Division; Nonr 3011(00), NR 145-141; J. W. Senders.

This study investigated the effects of correlated display inputs and control outputs on various psychomotor tracking tasks. Correlation between visual displays ranged from zero to identity. Efficiency of human tracking performance was measured as a function of degree of correlation.

Voice Communication (U), RR 006-03-0013. Ohio State University, Research Foundation, Columbus, Ohio, Department of Speech; Nonr 495(18), NR 145-993; J. W. Black.

The development of valid and reliable intelligibility tests is the goal of this task. Multiple-choice word lists will be constructed and analyzed in terms of phonetic elements of the stimulus words and subject responses. An attempt will be made to measure the contribution of various phonemes and their variants to the determination of response

choice. Studies will also be undertaken to compare vocal and visual phonemes as to their relative contribution to word discrimination. A separate study will be undertaken to quantify the pauses and delays that contribute to the rhythm of continuous speech and the extent to which this varies in relation to intelligibility, aesthetic properties of speech and to certain speech disorders.

Electro-optical Trigger System (U), RR 006-03-0014. Edgerton, Germeshausen and Grier, Incorporated, Boston, Massachusetts, Engineering Department; Nonr 3184(00), NR 145-148; F. E. Barstow.

The purpose of this task was to develop and fabricate crystal pulser equipment for use with electro-optical systems designed to protect personnel from flash blindness. Changes in light intensity act as the stimuli for the triggering action of the equipment which modify the electrical field of the lens system so as to increase or decrease light transmission qualities. The research and development program was concerned with the light levels required for response of the system, the speed of action in response to various light intensities, and other practical considerations of weight, size, voltage required, etc.

Restriction of Visual Radiation (U), RR 006-03-0015. Isomet Corporation, Palisades Park, New Jersey; Nonr 3122(00), NR 145-149; W. Ruderman.

An electro-optical crystal shutter will be constructed to determine its feasibility for personnel protection against atomic flash. The shutter system will be activated by photic energy and have a response time of 50 microseconds or less and possess transmission characteristics in accordance with human visual requirements in fields of varying brightness. Major effort in the current program will be directed toward increasing the field of view and the transmission characteristics of the shutter in the open position.

Integration of Eye Protective Assembly (U), RR 006-03-0016. Omnitech, Incorporated, Quinebaug, Connecticut; Nonr 3177(00), NR 145-150; L. Laliberte.

A retrofit visor assembly will be constructed which can be attached to the present APH-5 helmet and of such design that it will integrate with helmet and oxygen mask. When positioned before the eyes the visor assembly will provide an efficient light seal and will act as a carrier or frame for light-restrictive devices. It is also the purpose of this task to evaluate the integrated devices for ophthalmic characteristics.

R006-04 Psychological Traits

High-level Aptitudes (U), RR 006-04-0001. University of Southern California, Los Angeles, California, Psychological Laboratory; Nonr 228(20), NR 150-044; J. P. Guilford.

In recent years widespread interest has developed in the so-called higher level abilities not measured by the usual psychometric devices. This is the area that this task explores -- the definition and measurement of such abilities as reasoning, planning, evaluation, and creative thinking. Its purpose is to isolate the factors that make up high-level aptitudes and to explore the extent to which each factor relates to success in occupations where high-level skills are required.

Experimental Analyses of Problem Solving Behavior (U), RR 006-04-0002. New York University, New York, New York, Department of Psychology; Nonr 285 (30), NR 150-064; H. H. Kendler.

The fundamental aim of the task is to understand the basic processes that operate in a problem solving situation. A pretheoretical model that assumes that habit competition and habit chaining are fundamental psychological principles that operate in problem solving behavior is being tested in a variety of experimental situations: concept formation tasks, arithmetical reasoning, etc. Specific attention is being paid to the interaction of learning, perceptual, and language variables.

Psychological Problems (U), RR 006-04-0003. Princeton University, Princeton, New Jersey, Department of Psychology; Nonr 1858(15), NR 150-088; H. Gulliksen.

Mathematical models in the areas of test construction, psychological scaling theory, learning theory, and factor analysis are developed under this program of basic psychometric research. The fundamental aim of the task is to increase the precision of scientific description of human behavior. It involves a continuing series of investigations and experiments to test the mathematical models or statistical procedures developed.

Psychological Studies of Problem Solving (U), RR 006-04-0004. Yale University, New Haven, Connecticut, Department of Industrial Administration; Nonr 609(20), NR 150-166; D. W. Taylor.

This approach to the analysis of human problem solving skill involves both field studies and experimentation. The research is aimed at determining the effects of such variables as intelligence, sex, special abilities and attitudes upon achievement in problem solving. A secondary purpose of the task is aimed at the possibility of training individuals in problem solving and related skills.

Development of a Theory of Problem Solving (U), RR 006-04-0005. Bethany College, Bethany, West Virginia, Department of Psychology; Nonr 2315(00), NR 150-181; W. S. Ray.

An attempt to develop a theory of problem solving behavior and to describe it in mathematical terms. Data were collected through laboratory experimentation. A mathematical model of a "search" mechanism was developed and experimentally verified.

Abilities Underlying Human Tracking Behavior (U), RR 006-04-0008. Matrix Corporation, Arlington, Virginia; Nonr 3065(00), NR 150-214; J. F. Parker.

Through the use of factor-analytic techniques, the skills involved in complex tracking tasks are being identified and measured. The component abilities and aptitudes identified are similar to those required for missile delivery in a number of missile systems.

The Process of Concept Invention (U), RR 006-04-0009. University of Illinois, Urbana, Illinois,

College of Education; Nonr 1834(33), NR 150-220; L. J. Cronbach.

Most psychological experiments in cognitive learning involve the use of tasks in which the subject "discovers" an arbitrary concept provided by the experimenter. This task will explore the use of a task for concept formation research which will require that the subject "invent" rather than discover a concept or generalization thus providing a measurement technique more closely related to the natural situation.

Symposium on Vigilance (U), RR 006-04-0010. Human Factors Research, Incorporated, Los Angeles, California; Nonr 3301(00), NR 150-225; D. N. Buckner.

The performance of human observers during prolonged vigils has been the subject of considerable applied and theoretical research over the past several years. A symposium, aimed at coordinating research efforts in this area, summarizing the present state of knowledge, and identifying critical research areas will be conducted.

R006-05 Selection Methods and Performance Criteria

Techniques in Multiple and Differential Prediction (U), RR 006-05-0001. University of Washington, Seattle, Washington, Department of Psychology; Nonr 477(08), NR 151-143; P. Horst.

There are many situations in which a number of jobs are open to a job candidate after initial selection. The new Naval recruit or the entering college student is typical. Through techniques under study it will be possible to determine from scores on a single battery of tests what the chances of success are in all the jobs open to the candidate. Two general types of problems relating to tests are being investigated (1) the selection of a set of predictor variables from a larger set which will provide optimal differential prediction; and (2) the determination of optimal test length for maximum differential prediction.

Occupational Ability Patterns in Personnel Classification (U), RR 006-05-0002. Harvard University, Cambridge, Massachusetts, Department of Education; Nonr 1866(31), NR 151-159; D. V. Tiedeman.

A basic investigation of factors relating to career development, this task is concerned with methods for predicting educational or vocational choices, the relevance of theories of self-concept and identity for careers, and the development of an adequate model for predicting sequence of choices.

Problems in Psychological Test Development (U), RR 006-05-0003. Educational Testing Service, Princeton, New Jersey; Nonr 2214(00), NR 151-174; J. W. French.

New tests and new item types are in constant demand for the selection and classification of personnel. The development of these frequently requires basic information about the ways in which people learn, solve problems or carry out involved and intricate tasks. A concomitant need is for new methods of psychological measurement and statistical techniques for handling test data. It is at these basic problems that this research is aimed -- to study learning and other complex intellectual functions and to conduct psychometric research and test development as these relate to the over-all problem of personnel selection and classification.

Tests of Special Abilities (U), RR 006-05-0005. Educational Testing Service, Princeton, New Jersey; Nonr 2338(00), NR 151-182; N. Frederiksen.

Concerned with some of the fundamental problems involved in the development and application of selection and classification procedures, this task undertook research on and development of tests for special abilities. The investigators are working with such skill areas as report-writing ability, knowledge of current affairs, interpretation of data, reading comprehension, and aptitude tests in foreign languages.

Human Talent Identification, Development and Utilization (U), RR 006-05-0006. American Institute for Research, Pittsburgh, Pennsylvania; Nonr 2596(00), NR 151-191; J. C. Flanagan.

A program of research on the identification, development and utilization of human talents was conducted on a nationwide scale and a planning study conducted to determine its feasibility. A study was conducted to determine the interrelationships of measurable aptitudes or talents with environmental factors.

Mental Test Theory and Methods (U), RR 006-05-0008. Educational Testing Service, Princeton, New Jersey; Nonr 2752(00), NR 151-201; F. M. Lord.

Mental test theory and methodology are being developed in a series of continuing studies. The approach involves the formulation of hypotheses in the form of mathematical or statistical models representing mental test data in compact, manageable form and the testing of the hypotheses through empirical research.

Evaluation of Personnel Selection Systems (U), RR 006-05-0009. Psychological Service of Pittsburgh, Pennsylvania; Nonr 2810(00), NR 151-203; R. C. Hackman.

The variety of systems for the selection of personnel that exist or are under development is being subjected to critical evaluation. A criterion model has been developed for this purpose.

Selection of Programmers (U), RR 006-05-0010. The Psychological Corporation, New York, New York; Nonr 2983(00), NR 151-212; C. R. Langmuir.

The Bureau of Naval Personnel as part of its in-service personnel research program is undertaking a project on the selection of programmers for complex computer systems. As an assist to this project, research is being undertaken aimed at investigating the applicability of a logical analysis device to the problem of programmer selection.

Interest Patterns of Enlisted Personnel (U), RR 006-05-0011. University of Minnesota, Minneapolis, Minnesota, Department of Psychology; Nonr 710(17), NR 151-248; K. E. Clark.

A Vocational Interest Inventory is being developed which will provide an objective and quantitative measure of the interest of enlisted naval

personnel. Special scoring keys have been developed for different Navy rates and the relationship of scores to re-enlistment, disciplinary offenses, and other behavior is being studied. Improved scoring methods are currently under investigation.

Naval Billets for New Weapons (U), RR 006-05-0012. The Clifton Corporation, Washington, D. C.; Nonr 2476(00), NR 152-187; C. T. Clifton.

As new weapons systems are introduced into the Fleet, manpower requirements, both qualitative and quantitative, must be reassessed. This task provided techniques for matching personnel qualifications with the new requirements imposed by the advent of new weapons or related developments. It provided such end products as personnel staffing guides, duty assignment listings, billet descriptions, classification codes, rating qualifications and the like.

The Impact of New Developments upon Personnel Systems (U), RR 006-05-0013. American Institute for Research, Pittsburgh, Pennsylvania; Nonr 2872 (00), NR 152-208; R. L. Krumm.

This task conceives of personnel procedures of the Navy in systems terms. Its goal is to increase the flexibility of the "system"; i.e., to enhance its capability for handling future problems. A mathematical model of a personnel system has been developed. This model is expected to predict future personnel supply and future requirements. It should also delineate specific personnel programs to bring about a match between supply and demand. A feasibility study of the model utilizing current requirements data and historical supply information is to be conducted.

Electronics Personnel Research (U), RR 006-05-0015. University of Southern California, Los Angeles, California, Electronics Personnel Research Group; Nonr 228(02), NR 153-093; J. W. Rigney.

A broad program of research on personnel and training problems as they relate to electronics personnel. The basic data of the study are being collected by shipboard observation of electronics personnel, including electronics technicians, electronics material officers, sonarmen, radarmen, fire control technicians, and radiomen. Collateral research includes a study of group performance in the Combat Information Center, investigations in the area of electronics maintenance, a series of problems involving the optimal training techniques for tasks in which complex information displays are used, personnel research in the area of computer programming and maintenance, and automated tutoring devices.

Post Training Performance (U), RR 006-05-0017. Applied Psychological Services, Wayne, Pennsylvania; Nonr 2279(00), NR 153-177; A. I. Siegel.

Criterion measures provide the standards against which training methods, selection devices, and other personnel procedures are evaluated. This task is developing criteria of on-the-job proficiency for selected aviation rates for the purpose of making comparative evaluations of the proficiency of aviation technicians trained under varying conditions. Fundamental research in the criterion area is also conducted.

Measures of Physical Proficiency (U), RR 006-05-0018. Yale University, New Haven, Connecticut, Department of Industrial Administration; Nonr 609(32), NR 153-192; E. A. Fleishman.

The development of physical proficiency is an important aspect of military and civil educational programs. Factor analytic techniques are employed to determine the nature of physical proficiency and more adequate measures of this complex combination of characteristics are being developed.

Methods of Human Performance Evaluation (U), RR 006-05-0019. Human Sciences Research, Incorporated, Arlington, Virginia; Nonr 2525(00), NR 153-196; M. D. Havron.

A synthesis of system research methodology aimed at the systematic review and integration of the methods of human performance evaluation employed in studies of complex man-machine systems. Through such a synthesis, the task is attempting to broaden research methodology in the systems area and to increase its applicability and usefulness across diverse disciplinary approaches.

Human Factor Problems in Antisubmarine Warfare (U), RR 006-05-0020. Human Factors Research, Incorporated, Los Angeles, California; Nonr 2649(00), NR 153-199; R. R. Mackie.

This is a broad program of research aimed at increasing knowledge pertaining to human performances in antisubmarine warfare; i.e., of research on the human factor in ASW operations. Examples of the range of research areas covered include the maintenance of alertness, the classification of sonar targets, the effective operation of ASW teams, the development of proficiency tests and training principles and materials, basic psychophysical research on the discrimination of stimuli, human factors in the design of new equipment, and applications to non-surface sonar.

Factors Influencing the Judgment of Human Performance (U), RR 006-05-0021. Human Factors Research, Incorporated, Los Angeles, California; Nonr 1241(00), NR 153-625; D. N. Buckner.

A study of the basic processes involved in the making of performance judgments, this task is developing an experimental model aimed at identifying factors influencing the judgment of performance. The general approach is to observe judgmental behavior under controlled conditions and to systematically vary the value of factors relevant to the judgment process.

Survey of Emotional Breakdown Among Scientists (U), RR 006-05-0022. The Mount Sinai Hospital, New York, New York, Department of Psychiatry; Nonr(G) 00015-60, NR 151-222; M. R. Saperstein.

Although reliable statistics are unavailable, American scientific effort no doubt suffers through the attrition caused by the incapacitation of scientists from emotional breakdown. As a first step in a larger planned program, a preliminary survey of the incidence and causes of emotional disturbances among scientists will be undertaken.

Worker-oriented Job Variables (U), RR 006-05-0023. Purdue Research Foundation, Lafayette, Indiana; Nonr 1100(19), NR 152-224; E. J. McCormick.

In an attempt to clarify the nature of job interrelationships, an exploratory study of worker-oriented job variables will be undertaken. A terminology which will reliably describe such variables will be developed and arranged in checklist form and experiments conducted to determine the extent to which such procedures can be applied to worker and job analyses.

Evaluation of ASW Training (U), RR 006-05-0024. Human Sciences Research, Incorporated, Arlington, Virginia; Nonr 3126(00), NR 153-217; M. D. Havron.

A procedure for the evaluation of operators in a selected portion of a fleet ASW mission is being developed. The approach involves (a) the observation of fleet exercises to identify and describe tasks critical to mission accomplishment, (b) the development of criterion measures for the evaluation of these tasks, and (c) the application of the developed procedures in fleet exercises.

R006-06 Learning and Training

Factors Influencing the Learning and Retention of Verbal Materials (U), RR 006-06-0001. Northwestern University, Evanston, Illinois, Department of Psychology; Nonr 1228(15), NR 154-057; B. J. Underwood.

Research under this task is aimed at specifying the conditions under which people learn and retain verbal materials. Through controlled experimentation, systematic explorations are being conducted into the effect of such factors as meaningfulness of material, method of presentation, speed of learning, and interference from previously learned material upon the learning and forgetting of verbal materials. Both simple rote learning and complex concept formation are included.

Team Training for Guided Missile Operations (U), RR 006-06-0002. American Institute for Research, Pittsburgh, Pennsylvania; Nonr 2551(00), NR 154-079; R. Glaser.

The program of research being conducted under this contract has been directed at arriving at a systematic understanding of team performance, identifying the factors that influence team proficiency, and developing training procedures which can be applied in Navy operations. The approach includes both field studies, particularly in guided missile operations, and more recently in a team training laboratory setting.

Factors Influencing Clinical Judgment (U), RR 006-06-0003. Northwestern University, Evanston, Illinois, Department of Psychology; Nonr 1228(18), NR 154-091; W. A. Hunt.

The success of psychiatric screening of military personnel depends to a large extent on the accuracy of the examiner's clinical judgment, which plays an important role in the form of interview impressions and individual clinical diagnoses. A series of experiments designed to investigate the nature of the judgmental process is being undertaken, including the determination of the reliability and validity of clinical judgment, a survey of past research in the general field of psychiatric screening, and research aimed at determining the relation of learning to judgment.

Research on Human Learning (U), RR 006-06-0004. University of Connecticut, Storrs, Connecticut, Department of Psychology; Nonr 631(00), NR 154-099; W. A. Bousfield.

The primary objective of this research is to extend psychological theory in the field of human learning. The research is concerned with the processes that underlie verbal learning, attempting, for example, to determine the principles that people utilize when learning a series of words that enable them to recall the list or that cause systematic changes in what is retained over a period of time. Another area of endeavor is the testing of hypotheses in proprioceptive conditioning. The task consists of a continuing series of basic studies in these general areas.

Motivation and Performance in Learning and Conditioning (U), RR 006-06-0005. State University of Iowa, Iowa City, Iowa, Department of Psychology; Nonr 1509(04), NR 154-107; K. W. Spence.

Aimed at the clarification of the role of motivation in learning and performance, this task is approaching its objective through the utilization of experimental situations involving a variety of learning tasks. The tasks include simple reaction time, classical conditioning, learning pairs of associated words, and complex motor learning. Motivation is varied by introducing different levels of anxiety in the subjects, varying the amount of instructions given prior to the task; and by manipulating the degree of success or failure experienced by the subjects working at the task.

Effectiveness in Technical Training (U), RR 006-06-0006. Washington University, St. Louis, Missouri, Department of Psychology; Nonr 816(02), NR 154-135; P. H. DuBois.

The general aim of the research conducted by Washington University in collaboration with the Naval Air Training Command is the evaluation of the effects of selected methods and conditions of training upon student gain in proficiency. It is a systematic study of the conditions affecting the learning and retention of the complicated activities taught at Air Technical Training Schools.

Learning of Meaningful Material (U), RR 006-06-0007. New York University, New York, New York, Department of Psychology; Nonr 285(47), NR 154-161; C. N. Cofer.

The processes involved in learning, retaining, and recalling meaningful material are probably quite different from those involved in learning and remembering non-meaningful materials, such as nonsense syllables. The research is on the former processes--those involved in the assimilation and integration of meaningful materials into the residue of past learnings and memory and the processes involved in their recall.

Transfer of Training (U), RR 006-06-0008. Vanderbilt University, Nashville, Tennessee, Department of Psychology; Nonr 2149(01), NR 154-170; S. C. Ericksen.

Transfer of learning or training is the phenomenon in which a mental or motor function is

improved through the practice of some kindred function. The success of almost all training is dependent upon the sophisticated application of sound principles of transfer. This task has a twofold purpose (1) to translate what has been discovered about transfer of training to principles applicable to Navy training problems, and (2) to conduct research in transfer of training to extend knowledge in this area.

Psychological Processes in Language Communication (U), RR 006-06-0009. Arizona State University, Tempe, Arizona, Department of Psychology; Nonr 2794 (02), NR 154-179; A. W. Staats.

Language is the fundamental communication technique and forms the basis for education and most interaction among people. This task is investigating some of the basic psychological processes underlying language communication. A series of laboratory experiments are underway which are exploring the ways in which meaning becomes associated with words through conditioning.

New Techniques in Training Research (U), RR 006-06-0011. Dunlap and Associates, Incorporated, Stamford, Connecticut; Nonr 2490(00), NR 154-188; J. Dunlap.

The results of training research, in addition to providing specific recommendations for a given training problem, frequently include the development of a new research technique or methodology capable of application in another situation. This task surveyed recent published and unpublished training research and compiled such methodological innovations, indicating the use for which such methods were designed and their potential uses in wider research applications.

Training Problem Solving Behavior (U), RR 006-06-0012. University of California, Los Angeles, California, Department of Psychology; Nonr 233(50), NR 154-189; I. Maltzman.

One of the factors that comprise skill in problem solving is the ability to produce uncommon or original responses to the problem situation. A series of experiments are being conducted to evaluate a promising procedure for training individuals in this skill.

Reinforcement in Paired-Associates Learning (U), RR 006-06-0014. University of Massachusetts, Amherst, Massachusetts, Department of Psychology; Nonr 2691(00), NR 154-195; A. E. Goss.

Controlled laboratory experimentation is employed to determine the role of percentage of reinforcement in paired-associates learning. This is a basic study of human learning aimed at clarifying the type of learning that takes place when subjects, after being exposed to pairs of words or syllables, are required to respond with the second word or syllable when the first is presented alone.

Limits of Effective Learning (U), RR 006-06-0016. University of Florida, Gainesville, Florida, Department of Psychology; Nonr 580(07), NR 154-202; W. B. Webb.

The limits of effective learning are being determined through experimentation with the rate at which students can accept materials to be learned. The effect of such variables as motivation, psychological saturation, and type of materials presented are also being assessed.

Officer Leadership and Training Procedures (U), RR 006-06-0017. American Institute for Research, Pittsburgh, Pennsylvania; Nonr 2838(00), NR 154-204; J. C. Flanagan.

A series of situational problems aimed at assessing Navy petty officer leadership skills is being developed. Based on past research in the areas of group structure, team proficiency, and commissioned officer leadership research, the procedures developed will serve a training function and as a criterion against which to evaluate different training methods.

Techniques in the Evaluation of Training (U), RR 006-06-0018. Personnel Research and Development Corporation, Cleveland, Ohio; Nonr 2834(00), NR 154-205; E. K. Taylor.

Only on occasion has training research been directed to the empirical determination of the efficacy of curricula and the emphasis on their subordinate parts. The major objective of this research is to explore a variety of correlational relationships which hypothetically should provide information regarding the appropriateness of the proportion of time allotted to each element of the curriculum.

Training Research Symposium (U), RR 006-06-0019. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Psychology; Nonr 624(09), NR 154-206; R. Glaser.

An analysis of past and current research programs in the area of training has been conducted through the medium of a symposium. A report integrating the knowledge resulting from several years of research effort by military and university agencies will be prepared and distributed.

Factors Underlying Disciplinary Offenses (U), RR 006-06-0020. Courtney and Company, Philadelphia, Pennsylvania; Nonr 2845(00), NR 154-207; D. Courtney.

The variables affecting the incidence of disciplinary and related offenses in the Naval service were identified and isolated. Recommendations were provided for immediate action that can be taken on the problems associated with such offenses and a research design prepared for the systematic collection of data relating to the problem of delinquent behavior.

Verbal Learning and Individual Differences (U), RR 006-06-0021. Montana State University, Missoula, Montana, Department of Psychology; Nonr 2960(00), NR 154-210; C. E. Noble.

Man is essentially a verbal animal and his ability to think and reason depends largely on verbal processes. In this program of basic research in verbal learning an attempt will be made to integrate approaches to the understanding of verbal behavior which in the past has been thought of as separate endeavors. A series of experiments will be conducted aimed at identifying the role of individual differences in verbal learning.

Variables in Human Operant Behavior (U), RR 006-06-0022. I. T. T. Laboratories, Nutley, New Jersey; Nonr 2973(00), NR 154-211; D. E. Page.

In classical learning experimentation, human response is measured and controlled in terms of the stimulus which elicits it. However, much of human behavior is 'operant' in character, that is, responses cannot be correlated with any known stimuli. The study of operant behavior is thus hampered by lack of control and measurement parameters. This task will utilize a tracking situation to analyze responses on the basis of the elements of duration and intensity, providing parameters intrinsic to the response and independent of the stimulus.

Transfer of Training between Sense Modes (U), RR 006-06-0023. University of Florida, Gainesville, Florida, Department of Psychology; Nonr 580(09), NR 154-213; H. Kimmel.

As part of a program of basic research in transfer of training, this task will undertake to determine the interaction of visual and auditory elements of a compound stimulus in the conditioning of a galvanic skin response. The approach is experimental and will utilize classical conditioning techniques.

Variables in Transfer of Training (U), RR 006-06-0024. Electric Boat Division, General Dynamics Corporation, Groton, Connecticut; Nonr 3075(00), NR 154-215; D. Goldstein.

Three variables affecting the transfer of training in complex tasks will be studied through controlled laboratory experimentation. These include: (1) retention of transfer effects, (2) guidance received during training, and (3) task difficulty.

Factors in Automated Instruction (U), RR 006-06-0025. American Institute for Research, Pittsburgh, Pennsylvania; Nonr 3077(00), NR 154-216; L. J. Briggs.

In recent years there has been a rapid increase in the development of automated tutoring devices, also called teaching machines, which appear to have promise for increasing the effectiveness of individual and group instruction. In a series of laboratory experiments and theoretical analyses, this task is attempting to define the operation of some of the psychological variables involved in the use of such devices. The research is directed at the determination of the optimal nature of response modes and feedback characteristics for use in automated instruction.

Statistical Behavior Theory (U), RR 006-06-0026. University of Indiana, Bloomington, Indiana, Department of Psychology; Nonr 908(16), NR 154-218; W. K. Estes.

Aimed at the development of a statistical behavior theory, this task will involve the development of mathematical models of human learning, the empirical testing of predictions from the models, and the extension of a statistical behavior theory through the integration of research findings.

Symposium on Human Learning (U), RR 006-06-0027. University of Michigan, Ann Arbor, Michigan, Department of Psychology; Nonr 1224(37), NR 154-219; A. W. Melton.

An analysis of past and current research in human learning, specifically in the concept formation process, will be conducted through the medium of a symposium. Reports, possibly in book form, will be prepared which will integrate research findings and provide a current picture of the status of research in this area.

Symposium on Multivariate Experimental Design (U), RR 006-06-0028. University of Illinois, Urbana, Illinois, Department of Psychology; Nonr(G) 0008-60, NR 154-221; R. B. Cattell.

The technique of multivariate analysis has been used in psychological testing for some time. This procedure has, however, considerable promise for use in experimentation where complex groupings of variables are being considered. A symposium has been conducted aimed at the refinement of multivariate experimental methods and designs for wider application in psychological research.

Studies of S-R and R-S Learning (U), RR 006-06-0029. North Carolina State College, Raleigh, North Carolina, Department of Psychology; Nonr 486(08), NR 154-223; S. E. Newman.

A series of laboratory experiments will be conducted to test hypotheses from a theory of S-R and R-S learning. The theory takes the phenomenon of "backward learning" into account; i.e., the response to a stimulus properties which can elicit the original stimulus.

R006-07 Individual Effectiveness

Decision Making in Situations Involving Risk (U), RR 006-07-0002. Stanford University, Stanford, California, Applied Mathematics and Statistics Laboratory; Nonr 225(17), NR 171-034; P. Suppes.

Mathematical models are being developed for application to choice between two valued objects, group learning situations, conformity behavior and economic decision making. The experiments on choice are approached from the standpoint of developing scales of preference. Mathematical learning models originated by Estes and Suppes are being applied to both game situations and to conformity to a majority group judgment. The sampling theory basic to these models is also being extended to economic situations.

Perceptual Factors Related to Emotional Stress (U), RR 006-07-0006. Texas A. and M. College, College Station, Texas, Basic Division; Nonr 2119 (01), NR 171-054; W. C. Bonney.

Problems under investigation concern relationships between social behavior and responses to changes in serially presented stimulus objects. The effects studied are partially a function of change in object characteristics, for example, sudden or inappropriate alteration of color, and partly a function of perceiver characteristics such as emotional stability. Tests of adaptation to serially presented objects are being correlated with a number of personality characteristics.

Verbal Patterns as Predictors of Group Behavior (U), RR 006-07-0007. Princeton University,

Princeton, New Jersey, Department of Psychology; Nonr 1858(12), NR 171-055; H. M. Schroder.

The adjustment of an individual to group situations can take the form of one of a number of different kinds of processes. Each of these processes attempts to resolve some disparity or contradiction in the social situation. An example of such a disparity is disagreement between critical remarks made to a person and his beliefs about himself. In this experiment adjustments of four kinds are being studied. These are processes tending to (1) maintain satisfactory self evaluation; (2) maintain consistency of information; (3) maintain friendly relations with others; and (4) maintain control over others.

Group Effect on Tension Patterns and Motivation (U), RR 006-07-0009. New York University, New York, New York, Research Center for Human Relations; Nonr 285(28), NR 171-061; M. Horwitz.

According to psychological theory, an individual's efficiency is reduced by those of his behavioral responses which are inhibited in their expression but remain covertly active. For example, if a worker dislikes his supervision and can freely express this feeling, he should be more productive than when repressing this attitude. In the present experimental task devised for testing such hypotheses, the subject performs monotonous muscular work under varying degrees of freedom to express his attitude toward the task. Effect of repressed feeling is measured in terms of decision time, muscle tension and errors in performance.

Interpersonal Perception in Therapeutic Counseling (U), RR 006-07-0010. University of Illinois, Urbana, Illinois, Department of Psychology; Nonr 1834(11), NR 171-064; J. McV. Hunt.

The psychotherapeutic relationship provides a good medium for the study of interpersonal perception, since this perceptual process occurring between counselor and client is of crucial importance to the outcome of counseling. Measures of the client's perception of himself and others during the early stage of therapy are being analyzed to answer a number of questions basic to the theory of personality measurement. These questions involve such problems as identification of possible mathematical artifacts, determination of factors common to perception of self and others, and measurement of factors important for progress in therapy.

Effect of Pre-Problem Set and Group Pressure on Problem Solving (U), RR 006-07-0011. University of Virginia, Charlottesville, Virginia, Department of Neurology and Psychiatry; Nonr 474(08), NR 171-143; A. J. Bachrach.

The verbal interaction of groups can be manipulated experimentally by providing the members with "artificial histories" in which the individual is rewarded for certain verbal responses such as agreeing with or attempting to influence other members. In this experiment such histories are used for the purpose of studying the development of various types of behavior including conformity, deviance and leadership.

Accuracy in Interpersonal Perception (U), RR 006-07-0012. University of Utah, Salt Lake City, Utah, Department of Psychology; Nonr 1288(04), NR 171-146; V. B. Cline.

Factors are being determined which lead to correct or incorrect judgments of other persons' characteristics. Sound films have been prepared, depicting brief standardized interviews with persons of varied social backgrounds. The hypotheses being tested are whether or not subjects, based on observing filmed situations, can predict other behavior in similar and differing situations. Particular emphasis is placed on determining the personality characteristics associated with ability to predict accurately. Accuracy of groups as compared with individual judgments is also being studied.

Cognitive Organization and Attitude Change (U), RR 006-07-0013. Yale University, New Haven, Connecticut, Department of Psychology; Nonr 609(27), NR 171-147; M. J. Rosenberg.

Three groups of hypotheses, relating to a theory of the emotional and intellectual elements in attitude change, are being tested. Thus an individual's change of belief about an object is studied as a function of (1) his shift from positive to negative feeling toward it (or vice versa); (2) his desire to maintain consistency among his beliefs; and (3) the degree of organization of his personality. Particular emphasis is placed on measurement of consistency and integration as general personality traits leading to "resistance to persuasion".

Interpersonal Attraction and Hostility (U), RR 006-07-0014. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Psychology; Nonr 551(27), NR 171-199; A. Pepitone.

Individuals have many experiences classifiable as personal devaluations arising from disagreements, criticism, expressions of dislike, etc. The response to the person making such negative communications may range all the way from hostility to friendliness. Type of response depends on characteristics of the stimulus (imputation of low intellectual status, insufficient praise, status of the communicator) and of the devalued person (guilt feeling, self evaluation, confidence). Specified combinations of these factors are hypothesized to result in different degrees of anxiety, hostility, acceptance of criticism, and even attraction toward a rejecting person. A series of experiments is being performed to test these hypotheses and develop a theory of accommodation to personnel devaluation.

Behavioral Changes Under Psychological Stress (U), RR 006-07-0016. University of Rochester, Rochester, New York, Department of Psychology; Nonr 668(12), NR 171-342; V. Nowlis.

Basic human motivations which are important in group behavior under stress are being investigated. Attitude changes under different degrees of arousal of these motivations are measured. The structure of attitude change is analyzed to determine which types of beliefs change most readily as a result of emotion-arousing communications. Problems investigated include structure of attitude change as a function of fear, guilt, hostility, and pleasant moods.

The Dynamics of Social Influence (U), RR 006-07-

0017. University of California, Los Angeles, California, Department of Psychology; Nonr 233(54), NR 171-350; B. H. Raven.

The process of interpersonal influence involves the combined operation of variables such as the degree of power to reward or punish, the legitimacy of power, the source of power, and the degree of public compliance produced. For testing hypotheses relating these variables, the research plan combines results of previous work on influence with the theory of cognitive "dissonance" which predicts a person's attitude changes following perception of incongruities in his own behavior. Reward, punishment or group pressure is used to produce conflict in individuals concerning their beliefs.

Established Reference Scales and Reactions of Individuals (U), RR 006-07-0018. University of Oklahoma, Norman, Oklahoma, Department of Psychology; Nonr 982(09), NR 171-449; M. Sherif.

Standards used by individuals in evaluating social situations may differ according to prior experience as members of different groups. In order to determine how experience of the familiar thus enters into perception of the unfamiliar, the investigation studies the range of relevant prior experiences defining the individual's conception of the "usual" in space, time, etc. Such individual reference scales are also studied as they enter into the interaction of different groups.

Social and Personality Factors in Attitude Change (U), RR 006-07-0019. University of Colorado, Boulder, Colorado, Department of Psychology; Nonr 1147(07), NR 171-465; O. J. Harvey.

In adapting to new information which contradicts former beliefs an individual may alter his belief system to assimilate effectively the new material, or he may distort the new information until it agrees with his already existing beliefs. The strength of the tendency to use one of these processes rather than the other may be expected to vary in different people as a function of certain social and personality characteristics. The latter includes tendency to rigidity of thought, degree of self esteem, preference for exploratory behavior, etc. Experimental methods of producing discrepancy between belief and information have been developed for both stress and non-stress conditions. Social background characteristics and personality traits of individuals are measured and correlated with flexibility of attitude change in experimental situations.

Group Expectancies and Leadership (U), RR 006-07-0020. Washington University, St. Louis, Missouri, Department of Psychology; Nonr 816(12), NR 171-488; M. Bunch.

It is hypothesized that attainment of high position in a problem solving group is a function both of task competence and of conformity to certain group expectations. To achieve and continue leadership an individual may have to maintain a certain ratio between his degree of task competence and his degree of non-conformity. Thus a highly competent individual could afford more non-conformity without loss of position than could a less competent person. Various hypotheses generated by this conception of leadership emergence are being tested.

Measurement of Elements of Achievement Motivation (U), RR 006-07-0021. Amherst College, Amherst, Massachusetts, Department of Psychology; Nonr 2309(02), NR 171-531; R. C. Birney.

Study of the need for achievement has indicated that it may be a fundamental and general human tendency. Experiment has also suggested that measurement of the achievement motive may be more precise if broken into two parts: the hope for success and the fear of failure. In the present experiment, fear of failure is being analyzed and a scoring procedure for it is being developed.

The Role of Positive Motivation in Individual and Interpersonal Effectiveness (U), RR 006-07-0022. Vanderbilt University, Nashville, Tennessee, University Counseling Center; Nonr 2149(03), NR 171-609; C. E. Izard.

The effect of positive motivation on group interaction is being investigated. Positive motivation is taken as any motive characterized by friendly acceptance of other persons. An index of positive motivation toward others is being constructed. Relationships are being determined between positive motivation and social perception, interpersonal attraction, and group productivity.

Social and Psychological Factors in the Behavior Disorders (U), RR 006-07-0023. Georgetown University, Washington, D. C., Department of Psychiatry; Nonr 1530(07), NR 171-235; J. H. Rohrer.

An investigation is being made of factors in psychological development which tend to result in problem behavior in the late adolescent years, roughly from age 16 to 21. The social cultural development of each subject is studied through interview and projective testing and compared for groups of young males varying from "psychiatric suspects" to men of outstandingly good adjustment. Factors making for good and bad adjustment are being identified and will be utilized for the improvement of character training methods.

New Techniques of Analysis of Psychotic Behavior (U), RR 006-07-0024. Harvard University, Cambridge, Massachusetts, Harvard Medical School; Nonr 3119(00), NR 171-422; O. R. Lindsley.

A technique developed on animals and children is being applied to psychotic patients, for eliciting simple responses which reveal and possibly improve various perceptual and motivational processes. After imposing a repetitive task such as putting counters into a candy vending machine, the experimenter manipulates rewards in such a way that certain perceptual patterns must be learned. Observations on learning and motivational level can thus be made and used for both diagnostic and therapeutic purposes.

R006-08 Group Effectiveness

Consulting and Advisory Services (U), RR 006-08-0001. Smithsonian Institution, Washington, D. C.; Nonr 1354(02), NR 170-032; L. Carmichael.

Consultant services are provided to the Psychological Sciences Division. As needed, conferences on psychological problems are arranged. Expert assistance for short periods of time is also

provided, when performance of some special project is required as a supplement to the research program.

Group Problem Solving and Interaction (U), RR 006-08-0002. Yale University, New Haven, Connecticut, Department of Sociology; Nonr 609(16), NR 170-044; O. K. Moore.

This program on group problem solving draws from the fields of engineering, mathematics and logic, and linguistics as well as sociology and social psychology. The theoretical approach derives from such areas as information theory, automata theory, theory of cognitive processes, semantics, and game theory. The central problem is to use various tools such as logical analysis, linguistic analysis, and computer programming, to elucidate the processes used by experimental groups to solve various logical problems. In particular, reasons for the deviation of groups from the most economical and efficient solutions are being determined.

Perceptual and Structural Factors in Group Behavior (U), RR 006-08-0003. University of North Carolina, Chapel Hill, North Carolina, Institute for Research in Social Sciences; Nonr 855(04), NR 170-046; J. M. Thibaut.

Relations between perception and communicative behavior during social interaction are being investigated. Conformity to group opinions is being studied as a function of such factors as desire to maintain group membership, absorption in the group task, public commitments to a certain opinion, and possibility of loss of status position. Social perception is being measured in various interaction settings. One hypothesis is that the same behavior will be differently evaluated according to its degree of personal relevance for the perceiver. Particular emphasis is placed on experiments stemming from a theory of the relationship between communication and the type of group control exercised. Arbitrary use of power is compared in its effects with power operating according to ascertainable rules.

Productivity and Cohesiveness in Culturally Heterogeneous Groups (U), RR 006-08-0004. New York University, New York, New York, Department of Psychology; Nonr 285(24), NR 170-050; I. Katz.

Culturally heterogeneous groups tend to develop subgroupings which interfere with smooth cooperative interaction. It should be possible to determine the principles governing the dissolution of such disruptive subgroupings with consequent increase in productivity and cohesiveness. Experiments are therefore being conducted on small problem-solving groups, to determine the effect of certain work conditions on productivity and interaction of members. The conditions being tested for group-unifying properties are those which increase interdependence of co-workers or decrease anxiety in subgroups which have less prestige.

Group Efficiency and Group Process in Problem Solving (U), RR 006-08-0005. Columbia University, New York, New York, Teachers College; Nonr 266(43), NR 170-058; H. Solomon and I. Lorge.

Group problem solving process and efficiency are being analyzed and related to size groups and type of problem. Particular attention is paid to the relative efficiency of the group and the individual. Mathematical models of group problem solution are in process of development. Problems used relate to field tactics, human relations, military strategy, personnel assignment, morale, and high policy. Hypotheses tested center around the problem of the extent of which a group is benefited through the addition of more members.

Group Equilibrium (U), RR 006-08-0006. Rutgers University, New Brunswick, New Jersey, Department of Psychology; Nonr 404(10), NR 170-093; F. K. Berrien.

A group is considered to be in equilibrium when the pattern of motivational activities of the members remains in stable balance while operating smoothly toward both group productivity and members' personal satisfaction. It is hypothesized that groups subjected to influences tending to disrupt their equilibrium will be able to maintain productivity and morale through adjustments in their work-related beliefs and attitudes. A number of experiments are therefore being performed to compare the adjustments of groups disrupted and not disrupted by stressful conditions.

Intergroup Communication Under Conditions of Cooperation and Competition (U), RR 006-08-0009. Educational Testing Service, Princeton, New Jersey; Nonr 3054(00), NR 170-247; J. Hemphill.

Problems of the interaction of groups as units are investigated. Pairs of groups are placed in a mutual problem situation and incentives toward cooperation or competition are systematically varied. Resulting interaction is analyzed in terms of amount and formality of inter-group structure and patterns of communication.

The Effects of Changes in Communication Patterns (U), RR 006-08-0010. Boston University, Boston, Massachusetts, Department of Psychology; Nonr 492 (05), NR 170-255; R. Chin.

Problem solving groups were arranged according to any one of three precisely defined communication patterns. By comparison of groups subjected to these patterns in different sequences, it was possible to determine effects of sequences on efficiency, leadership, morale, and organization. Effects of continued practice within these communication patterns and results of permitting teams to develop their own patterns were also studied. On the basis of these results a model predicting the influence of previous experience on the communication systems of problem solving groups was developed.

Mathematical Models for n-Person Decision and Communication Processes (U), RR 006-08-0011. University of California, Los Angeles, California, Department of Psychology; Nonr 233(58), NR 170-282; R. C. Atkinson, E. C. Carterette.

Statistical learning theory and information theory have now reached the point where they can be applied to n-person social situations in which each person makes a series of choices depending not only on his actions but on those of the other members of his group. A mathematical model, developed for predicting choice behavior in a two-person

situation, is being extended to apply to three-person situations containing coalition structures. Accuracy of communication in three-person groups is also studied from the standpoint of information theory.

Structure-in-Interaction in the Performance of Group Tasks (U), RR 006-08-0012. Educational Testing Service, Princeton, New Jersey; Nonr 2959(00), NR 170-297; J. K. Hemphill.

A theory of leadership and group interaction has been developed, containing as a basic concept "structure-in-interaction." According to this concept, for an individual to work effectively in a group, there must be a noticeable consistency in the behavior of others and members must deliberately pattern their own activities in order that their behavior can be predicted. Experiments on small group problem solving are in progress, to determine the effect of changes in structure-in-interaction on group efficiency, especially those induced by leadership acts.

Research on Group Performance (U), RR 006-08-0013. University of Michigan, Ann Arbor, Michigan, Research Center for Group Dynamics; Nonr 1224(34), NR 170-309; D. Cartwright, R. B. Zajonc.

The efficiency of group performance is affected by at least two large classes of variables: abilities of individual members and the way in which the group task is divided and assigned to members. Different distributions of task elements may be optimal for different configurations of group member abilities. Resulting problems attacked are (1) the extent to which the individual's performance is affected by the fact that he is working in a group; (2) the method by which knowledge of individual skills can be used for predicting and producing gains in the group product.

Originality in Group Productivity (U), RR 006-08-0014. Ohio State University, Columbus, Ohio, Department of Psychology; Nonr 495(15), NR 170-396; H. B. Pepinsky.

Individual contributions to group productivity are being studied to determine conditions which foster originality in group members. Particular emphasis is placed on methods of utilizing individuals whose attitudes and abilities are different from those of the average group member and who show some independence of thought. Conditions conducive to the development of various kinds of constructively independent behavior are experimentally created and their effect on group productivity measured.

Communication Processes in Task Oriented Groups (U), RR 006-08-0015. Tufts University, Medford, Massachusetts, Institute for Applied Experimental Psychology; Nonr 494(15), NR 170-408; T. B. Roby.

The performance of a small problem solving group can be seen as requiring three fundamental processes (1) obtaining information relating to task objectives; (2) evaluating the results of various proposed plans of action; (3) carrying out the plan of action decided upon. The first of these processes may be regarded as the most crucial phase and also the process most likely to be generalizable over a number of situations. This process of obtaining information has therefore been chosen for particular emphasis. It has been broken down into five aspects. For each of these, the group communication pattern most suitable for successful performance will be determined.

Interaction Patterns in Group Behavior (U), RR 006-08-0016. Washington University, St. Louis, Missouri, Social Sciences Institute; Nonr 816(11), NR 170-424; R. deCharms.

Interaction is being studied as a function of group structure and of member's motivations. The first type of experiment concerns such problems as attitudinal elements in coalition formation, leadership in autocratic structure, effects of ambiguous reward on group equilibrium, and machine simulation of group behavior. The second series of experiments includes analysis of the affiliation and achievement motives and their interaction, and effects of vicarious expression of hostility.

Leadership and Organizational Behavior (U), RR 006-08-0017. Tulane University, New Orleans, Louisiana, Department of Psychology; Nonr 475(08), NR 170-478; G. J. Palmer.

A number of hypotheses derived from a theory of leadership are being tested through the use of a management game in which three competing teams attempt to maximize their profits under realistic business conditions. Problems include determination of relationships between the level and heterogeneity of ability of a group and the type of leadership developed, the type of task most successfully handled, and the changes in structure over time.

Perceptual Variables and Communication Efficiency (U), RR 006-08-0018. University of Delaware, Newark, Delaware, Fels Group Dynamics Center; Nonr 2285(02), NR 170-508; J. Lanzetta.

One group of experimental problems centers around the vividness with which an individual is perceived. Perceptibility is studied as a function of certain visual or auditory cues, and as a condition underlying the number and types of communications directed to a person. A second approach to perception-communication problems is the comparison of interaction in "closed" groups having stable membership and "open" groups having a shifting composition. Factors involved in the absorption of newcomers and utilization of old members are studied.

Group Process Under Different Conditions of Success and Failure (U), RR 006-08-0019. Harvard University, Cambridge, Massachusetts, Department of Psychology, Harvard Medical School; Nonr 1866(43), NR 170-518; D. Shapiro, P. H. Leiderman.

In the role of leader of an experimental group the experimenter can, by creating suitable conditions of success or failure, cast certain individuals in specific roles such as "favorite" or "scapegoat"; thus he can learn how such behavior develops and disappears. Experiments of this type will be performed and, in addition, it will be hypothesized that effects of success and failure conditions will be a function of the ease with which group members can observe and communicate with each other. Effects of various degrees of sensory isolation of group members will therefore be tested.

Bases and Effects of Systems of Communication (U), RR 006-08-0020. Duke University, Durham, North Carolina, Department of Sociology; Nonr 1181 (11), NR 177-470; K. W. Back.

Communication can be analyzed according to its form or its content. Previous experiments indicate that messages similar in content but different in form may change the attitude but not the actions of the recipient, while messages differing in content but not form may lead to the actions desired by the communicator. These hypotheses and others based on a theory of the relationship between communication and its social setting are being tested through experiments on small groups.

Group Factors Influencing Creativity (U), RR 006-08-0021. University of Illinois, Urbana, Illinois, Department of Psychology; Nonr 1834(36), NR 177-472; F. E. Fiedler.

In the development of novel ideas through group interaction, important factors are the ease of intermember communication, the likeness of group members, and individuals' previous experience in problem solving. Effects of these factors will be determined in a series of experiments. One hypothesis is that members' similarity of outlook will facilitate communication but reduce originality of solution. Other hypotheses relate to the manner in which prior experience in group or individual problem solving may influence creativity.

Mathematical Methods in Small Group Processes (U), RR 006-08-0022. Stanford University, Stanford, California, Department of Statistics; Nonr 225(55), NR 170-367; H. Solomon.

A symposium will be held to work on mathematical methods as applied to group processes. Participants will be persons currently making the most promising contributions to the subject. The purpose is to facilitate an exchange of ideas between mathematically sophisticated investigators and quantitatively minded group behavior scientists, in order to make progress in bridging the gap between mathematics and group behavior research. Topics included will be treatments of conformity behavior, cooperation, two-person interaction, group learning and attitude change.

Factors Producing Defensive Behavior in Groups (U), RR 006-08-0023. National Training Laboratories, National Education Association, Washington, D. C.; Nonr 3088(00), NR 170-411; J. R. Gibb.

Small discussion groups are being studied to identify factors which threaten the confidence and self-esteem of members and thus produce defensive behavior. Defensive behavior is considered to include inflexible responses aimed at preserving self-esteem rather than advancing the problem solving of the group. Relationships are being determined between defensive behavior and such basic determiners as homogeneity of the group, members' freedom to play desired roles, and adherence to group standards. An analysis will be made of the fundamental nature of defensive behavior and its relationship to productivity.

R006-09 Engineering Psychology

Editorial Service for Human Engineering Guide to Equipment Design (U), RR 006-09-0001. McGraw-Hill Book Company, Incorporated, Technical Writing Service, New York, New York; Nonr 2161(00), NR 196-004; C. T. Morgan.

This task is to provide editorial service for the organizing, standardizing, collating, eliminating of duplication, indexing, and rewriting of materials prepared for the Joint Services Human Engineering Guide to Equipment Design.

Human Engineering Information and Analysis Service (U), RR 006-09-0003. Tufts University, Medford, Massachusetts, Institute for Applied Experimental Psychology; Nonr 494(13), NR 196-008; P. G. Ronco.

This task provides research required to develop an information and analysis service in the area of human engineering designed to meet the needs of individuals responsible for the development of equipment operated by military personnel. Critical features of the task include systematic searching, coding and analysis of current literature pertinent to human engineering by competent subject matter experts.

An Electro-Mechanical Model for Predicting Systems Effectiveness (U), RR 006-09-0004. Applied Psychological Services, Wayne, Pennsylvania, Nonr 2492(00), NR 196-010; A. I. Siegel.

During the early design stages of a man-machine system, the problem exists of predicting where the system may overload the human operator during various operational phases and conditions. The electromechanical model being developed under this task will provide precise quantitative information about these areas where the operator is likely to become overloaded. Previous research has shown that the use of the model is feasible, and it has been applied successfully to two operational man-machine systems drawn from Naval aviation.

Effect of Redundancy in Information Displays (U), RR 006-09-0005. University of California, Los Angeles, California, Department of Engineering; Nonr 233(49), NR 196-011; J. Lyman.

Certain displays are designed to present information to the human operator during complex tasks. As the operator learns the task and as he becomes more familiar with the displays being used, he finds that informational cues available to him early in the learning process are no longer needed as learning progresses. Thus, there is the question of whether the same display design that aided in training will necessarily be useful in the operational situation. Explicit information becomes implicit after training has "programmed" it into the operator. If better displays are to be designed, one must know the functional relationship between the amount of displayed information made redundant by training and the amount of information the operator needs and uses.

Visual Factors in Photointerpretation (U), RR 006-09-0009. Tufts University, Medford, Massachusetts, Institute for Applied Experimental Psychology; Nonr 494(17), NR 196-015; M. N. Crook.

The problem of photointerpretation has become increasingly more important as photographic

equipment has been improved and reconnaissance aircraft fly higher. The visual problems pertaining to photointerpretation are being examined, including such factors as ambient illumination, special illumination on the work, and visual fatigue. Exploratory research will be conducted to solve some of the lighting problems in an effort to increase efficiency and reduce fatigue of the interpreter.

Developing and Testing the Effectiveness of the Predictor Display (U), RR 006-09-0010. Dunlap and Associates, Incorporated, Stamford, Connecticut; Nonr 2822(00), NR 196-017; J. H. Ely.

The effectiveness of a predictor instrument in manual control systems was tested. The predictor display is a new concept to give the operator of a control system information about the future of the variable he is controlling. It does this by use of a special computing device capable of extrapolating present conditions into the future.

Space Requirements of the Moving Operator (U), RR 006-09-0011. Rowland and Company, Haddonfield, New Jersey, Nonr 2856(00), NR 196-018; G. E. Rowland.

A program was conducted to identify the work space requirements of the human moving operator. Dynamic anthropometrical measures were taken of men engaged in daily work activities under normal work conditions. Such measures would fill in gaps and add to the mass of data which has been collected on the static nude body in standard anthropometric postures. Measures were taken also of operator performance as a function of time. This research has provided handbook type data on the dynamic capabilities of the human operator which may be applied to the design of man-machine systems.

Study of the Human Element in Future Anti-Ballistic Missile Systems (U), RR 006-09-0012. Convair, A Division of General Dynamics Corporation, San Diego, California; Nonr 2953(00), NR 196-019; W. E. Woodson.

The purpose is to investigate the best use of the man as an integral part of a system designed for high speed, automatic defense against ballistic missiles. This is an analytical study to determine the man's functions in the system, and to state the informational requirements needed for him to perform these functions most effectively. With these requirements outlined, general principles of man-machine integration can be worked out which may be used by the design engineer. In cases where there is missing information, this will be supplied through a program of research which will involve theoretical consideration of the man's capabilities with respect to monitoring, decision making, data handling, and maintaining equipments.

Control of Human Operator Performance Through Machine Design (U), RR 006-09-0013. University of Pittsburgh, Pittsburgh, Pennsylvania, Department of Psychology; Nonr 624(11), NR 196-020; R. Glaser.

This is an analytical and experimental study directed toward the problem of appropriate allocation of systems functions to the man and to the machine in a man-machine system. The approach taken is that of studying the ways equipment can be designed to control or aid the performance of the human operator, and thus improve system performance. Investigations are being made of techniques for machine-aiding human performance in specific areas, such as tracking, monitoring, and maintaining equipment. Part of the results will be in the form of a report written for human factors and design engineers which can be used as a source of ideas in system design and development, and as the specification of procedures for identifying machine-aiding possibilities in a man-machine system.

Use of Additive Color Photography for Photointerpretation (U), RR 006-09-0014. Dunlap and Associates, Incorporated, Santa Monica, California; Nonr 3137(00), NR 196-021; J. W. Wulfeck.

A system for additive three-color photography and projection will be investigated for possible use in photointerpretation. The following questions will be answered (1) does the availability of full color photoreconnaissance data actually enhance the speed or accuracy of photointerpretation beyond that achieved with black and white materials; and (2) does the possibility of examining photoreconnaissance data under special selected or exaggerated wavelength conditions for restricted color content enhance speed and accuracy of photointerpretation beyond that achieved with black and white material, or beyond that achieved with full color?

Psychological Research on Information Display, Design, and Use (U), RR 006-09-5350. U. S. Naval Research Laboratory, Washington, D. C.; Y02-03; J. R. Hayes.

Studies are conducted to determine the basic factors which govern complex decision making and problem solving.

Psychological Research in Target Tracking (U), RR 006-09-5351. U. S. Naval Research Laboratory, Washington, D. C.; Y02-01; R. Chernikoff, J. Sweeney, H. Birmingham.

It is the purpose of this task to develop information and understanding concerning the interaction of machine and human operator, where the human is part of a continuous control system, with the objective of improving the performance of such systems. Included is basic research in target tracking, and in areas where the human is controlling a vehicle (helicopter, submarine, aircraft, etc.). The research generally is basic, rather than specific to any one system or vehicle.

Cold Weather Effect on Human Operators (U), SR 006-09-0521. Contractor, Contract, and Principal Investigator, to be assigned.

Increasing naval activities in the Arctic region place added stress on personnel engaged in assigned duties incident to shipboard, underwater swimmer, amphibious, and beach operations. Optimum effectiveness and efficiency in the performance of such operations and the use of Bureau of Ships equipment can be more assured by complete knowledge of the effects of short and long range cold exposure on the physical limitations of military personnel.

Operator Sensory Characteristics and Information Handling Capacity (U), SR 006-09-0523. Navy Electronics Laboratory; Allotment No. 170; Mr. C. White.

The performance of shipboard personnel is limited by their capacity for receiving, assimilating, processing, and transmitting information perceived or made available to them by vision, audition, and touch. Knowledge regarding these limitations and their correlations with human decision-making processes will provide a more adequate basis for the design of equipment and instruments, its arrangement and installation on ships, and the selection of the form or manner in which the output of such equipment should be presented or transmitted to operations personnel.

Studies have been made of form perception, with regard to the factors necessary for a perception of simultaneity when a form is broken down into various parts and then presented to an observer sequentially. These studies lead to an understanding of the way the nervous system deals with information and are directly applicable to problems of symbolic display. Aspects of increased detection capabilities using time-compressed visual displacement also have been studied. This work has been reported.

Vision Research (U), SR 006-09-0525. University of California, Visibility Laboratory, NObs 72092, Dr. J. H. Taylor; Navy Electronics Laboratory, Allotment No. 170, Dr. A. Morris.

The search, detection, recognition, and classification of various objects or targets by direct observation is a continuing military requirement. Greater efficiency and reliability could be obtained in the performance of military personnel in these duties through the development of better basic information or visual thresholds and perceptual responses of observers.

Previous works on contrast threshold determinations was extended to cover the cases of large targets (over 6^{o} visual angle) under high luminance, and large targets under low luminance (such as in dense fogs or in turbid water); also the development of improved analytical methods for the determination of threshold contrasts of visual targets.

Human Factors in Equipment Maintenance, SR 006-09-0560. Human Factors Research, Incorporated; NObs 78911; Mr. E. L. Parker.

The complexity of modern electronic equipment on ships presents problems in operation and maintenance, and in the shipboard manning requirements necessary to obtain optimum performance of the equipment.

The personnel aptitudes, skills, and knowledge required to maintain shipboard electronics equipment at peak performance will be determined; the limits of design complexity that are possible while maintaining peak equipment performance using trained Navy personnel will be determined; and the design characteristics and personnel selection and training practices that would enhance the quality of maintenance of shipboard electronic equipment will be determined. For the purposes of these studies, the SPS-29 air search radar and the SQS-23 sonar were chosen as typical items of complex equipment which will be used presently and in the near future.

Auditory Presentation of Information (U), SR 006-09-5741. Navy Electronics Laboratory; R. S. Gales.

Improvement in auditory warning, signalling, and communications systems, and performance under conditions of noise such as in the vicinity of rockets and jet aircraft is required in order to obtain high personnel performance and avoid loss of hearing. These objectives require the development of techniques and equipment for maximizing aural reception of information, including research on electronic methods of enhancing the transmission and reception of speech signals and the study of hearing acuity and perceptual processes involved in the utilization of auditory information under adverse environmental conditions.

Instrumentation was completed for studies comparing pure tones and bands of noise as producers of hearing loss. Inter-comparisons of various types of intelligibility tests were simplified by controlled tests with various speech material, including standard Navy phrascology.

R007 MATERIALS SCIENCES

R007-01 Metals and Alloys

Plastic Deformation and Creep of Metals and Alloys (U), RR 007-01-0001. University of California, Berkeley, California, Division of Mineral Technology; Nonr 222(49), NR 031-048; J. E. Dorn.

To decide experimentally between various suggested theories or mechanisms of plastic deformation and creep of metals and alloys, the creep rates and activation energies for creep of both polycrystalline and single crystal materials are being studied over a wide range of temperatures and stresses. Investigations which are being pursued presently include (a) activation energies for creep of high-purity copper single crystals in simple shear; (b) effect of alloying on the activation energies for creep of Cu single crystals; (c) effect of stress on the creep rate of aluminum single crystals in both the cross-slip region and in the region where Peierls processes are operative; (d) comparison of the activation energies for creep of ordered vs. random solid solution alloys of the same composition at low temperatures; (e) study of the creep behavior of substitutional solid solution alloys under conditions where strain ageing or dislocation locking may occur.

Fracture of Metals (U), RR 007-01-0002. Case Institute of Technology, Cleveland, Ohio, Metals Research Laboratory; Nonr 1141(04), NR 031-049; W. M. Baldwin, Jr.

This task was devoted to a study of the factors which control or affect the ductility and fracture of metals. The work proceeded along two main directions: (a) an investigation of the effects of hydrogen on the ductility of group VB elements--vanadium, niobium and tantalum, (b) an investigation of the nature of a new type of brittleness which was found in quenched carbon steels at temperatures between the blue brittle range and the low temperature brittleness range.

Relationships between Metallurgical Structure and Properties (U), RR 007-01-0003. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1841(35), NR 031-142; M. Cohen, B. L. Averbach.

A broad, comprehensive study is now in progress to investigate the role which lattice imperfections play in the heterogeneous nucleation of solid-state reactions and to determine the influence of the metallurgical fine structure and lattice imperfections or the mechanical properties of both pure metals and alloy phases.

Specific investigations consist of: A study of the influence of heterogeneous nucleation sites on the martensitic transformation in iron-nickel-carbon alloys. Nucleation sites are introduced in iron-nickel-carbon austenites on heating by means of the reverse transformation, martensite-to-austenite, and the influence of these nucleation sites on the subsequent martensitic transformation on cooling is observed. The imperfections or nucleation sites introduced by the reverse transformation are being studied by X-ray and metallographic techniques. Electrical resistivity and precision density measurements will also be used to investigate the nature of these imperfections and attempts will be made to observe the nucleation sites directly using thin-foil electron microscopy.

Current studies are aimed to determine (a) the influence of "quenched-in" vacancies on the transformation kinetics of iron-nickel-carbon alloys; (b) a study of the imperfection structure and mechanical properties of the resulting martensites; (c) a study of the effect of quenched-in vacancies on the early stages of decomposition of gold-nickel alloys; (d) the influence of lattice defects introduced by neutron irradiation on the early stages of deformation of copper and aluminum single crystals and on the fracture mechanisms at low temperatures; (e) the influence of neutron irradiation on the nucleation of martensitic and other reaction products in Cu-Al alloys; (f) nucleation studies in thin iron-nickel-carbon alloy foils.

Kinetics of Reactions in the Solid State (U), RR 007-01-0004. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Metals Research Laboratory; Nonr 760(08), NR 031-184; G. M. Pound.

This task is a study of the kinetics of basic solid state processes in metallic systems. Two general areas are encompassed: nucleation (solid-solid and vapor-solid), and diffusion. The following particular topics are currently being studied, or are planned: (a) kinetics of the alpha-beta transformation in Sn; the effect on nucleation rate of time, temperature, impurities and particle size. Similar studies of Fe, Zr and Ti, to test the validity of the current theoretical concepts of solid-solid nucleation, (b) kinetics of crystal nucleation from vapor onto solid substrates--Ag and An on LiF and NaCl. Condensation is to be observed by direct transmission microscopy, using a Knudsen cell--collimator to provide a vapor beam, (c) rate of approach to equilibrium of the surface composition of solid-vapor couples (Cu-Zn and Cu-Ni). Surface diffusion of Zn to grain boundaries, (d) diffusion in Fe-Cr alloys, measurement of diffusion coefficients and activation energies, (e) measurements of grain boundary grooving angle and microcreep of Al-Ag alloys, to determine Gibbs adsorption and verify the Gibbs adsorption equation.

Factors Affecting the Strength of Metals (U), RR 007-01-0005. University of California, Berkeley, California, Division of Mineral Technology; Nonr 222(52), NR 031-255; E. R. Parker, J. Washburn.

A basic study of the mechanism of plastic deformation of metals is being undertaken in order to determine the precise manner in which plastic flow leads to strain hardening and ultimately to fracture. The research program is effectively divided into two parts, the first dealing with pre-yield phenomena and the mechanism of yielding and the second dealing primarily with fracture. To provide a clearer picture of the strengthening effect due to subgrain or dislocation boundaries, a detailed study of the pre-yield stress-strain behavior of zinc and LiF crystals is being carried out. Similar experiments are being performed on alloy crystals in order to check current theories of solid solution hardening.

Fracture studies, specifically the fracture nucleation problem in fatigue is being investigated, using both polycrystalline and single crystal

specimens of hexagonal-close-packed metals, such as zinc. Cleavage failures in body-centered-cubic and ionic crystals (LiF, MgO) are being studied in order to determine whether dislocations piled up against barriers are capable of initiating the cleavage crack. The origin and nature of high temperature intergranular fractures and stress-corrosion cracking are also being investigated.

Study of Order-Disorder in Alloys (U), RR 007-01-0006. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Physics; Nonr 1841(36), NR 031-282; B. E. Warren.

An X-ray diffraction study of order-disorder phenomena in alloys is being undertaken in order to provide a more precise physical picture of the ordered or partially ordered state. Among the problems under investigation are the following: (a) the nature and origin of the "satellite" reflections which have been observed about certain superlattice lines in ordered non-stoichiometric Cu-Au alloys; (b) the nature of the short-range order which exists above the critical ordering temperature in Cu_3Au; (c) the magnitude and relative importance of multiple scattering as a source of additional diffuse scattering in powder patterns.

Emphasis will now be given to the order-disorder phenomena as an experimental tool to study the nature of cold work in metals and alloys. Using an ordering alloy, instead of an element, an improved X-ray transmission technique for measuring short range order will be utilized to permit a more accurate determination of diffuse intensities and scattering effects. Measuring the fine structure reflections in an alloy, particularly sensitive to cold work, is contemplated, which should yield important information on the basic processes of deformation.

Mechanism of Fatigue and Fracture of Ductile Metals (U), RR 007-01-0007. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1841(25), NR 031-356; W. Backofen.

This task involves a detailed study of the structural changes which occur in metals under the application of alternating or fluctuating stresses, the ultimate objective being to elucidate the basic mechanisms for the initiation of fatigue cracks and for their subsequent propagation. At present, work is currently proceeding or planned in the following areas: (a) a study of the slip-band topography and the kinetics of slip-band extrusion and intrusion in copper single crystals as a function of alloying temperature and crystal orientation; direct metallographic examination, taper-section metallography and electron micrographic techniques are being employed, (b) the influence of grain boundaries on fatigue crack initiation; aluminum bicrystals with controlled boundary structure and orientations are being grown for this purpose, (c) a study of the propagation of fatigue cracks along slip bands in copper single crystals, (d) a study of the temperature dependence of the strain hardening during fatigue and correlation of the fatigue hardening characteristics with observed structural changes, (e) the effect of surface adherent films on the fatigue process.

Ductile-Brittle Transition in Iron and Steel (U), RR 007-01-0008. Columbia University, New York, New York, Department of Metallurgy; Nonr 266(07), NR 031-427; M. Gensamer.

This task is a study of mechanical properties and fracture of metals, with particular emphasis on brittle fracture of iron and steels. A major objective is the fundamental understanding of the ductile-to-brittle transition which occurs in a characteristic, narrow range of temperature. Tensile testing of smooth, rather than notched bars is employed in order that the stresses, strains and strain rate are as nearly uniform as possible throughout an appreciable volume of material. This permits more meaningful measurements of resistances to flow, twinning and fracture, and of ductility, than can be made with notched bars. Tests will be carried out at temperatures as low as $4^{\circ}K$. The separate roles of the slip and twinning modes of deformation in fracturing processes are being studied in relation to significant features of the material such as grain size. Single crystals of iron of ultra high purity will be used. Evidences of dislocation distributions and motions are sought so that observed mechanical behavior may be described in terms of dislocation processes.

Characteristics of Phase Transformations in Alloys (U), RR 007-01-0009. Case Institute of Technology, Cleveland, Ohio, Department of Metallurgical Engineering; Nonr 763(01), NR 031-471; R. F. Hehemann.

This task is a study of the behavior of interfaces between new phases and the parent phases from which the new phases form and grow in solid alloys. In general, following nucleation of the new phase, the progress of the transformation from the parent phase to the new phase is controlled by processes occurring at the interface, and/or by diffusion. Many studies have been made of thermodynamic and crystallographic features of solid state transformations, but relatively few studies have been made of the movements of phase interfaces during transformation.

Specifically, measurements will be made of interface propagation rates by direct observation, using high temperature microscopy and polarized light to distinguish the interfaces. Typical reactions to be studied include the bainite transformation in steels, the slow isothermal growth of martensite in an Fe-23% Ni-3% Mn alloys and the transformation occurring in Cu base alloys typified by Cu-Ga. In addition to composition and reaction temperature and the controlled variables will include plastic deformation prior to transformation and also mechanical stressing during transformation to determine their effects on the behavior of interfaces. The ultimate objective is to determine the basic rate-controlling processes governing interface movements in different systems, and to develop a general theory of the growth of new phases from unstable phases in solids.

X-ray Study of the Fine Structure of Metals (U), RR 007-01-0010. Rutgers University, New Brunswick, New Jersey, Materials Research Laboratory; Nonr 404(09), NR 031-494; S. Weissmann.

This task is a study of lattice defects associated with recrystallization, precipitation

hardening, and creep phenomena in metals and alloys. A specially developed X-ray method which combines X-ray and electron transmission microscopy and diffraction analysis is being used to study the fine structural changes and to elucidate the basic related mechanisms of structure and mechanical properties. The above method, effectively used in the past in the study of recrystallization and grain growth of Al, will be used for Cu, W and Mo. Analogue computer methods of analysis of X-ray diffraction "line" profiles are being applied to elucidate changes taking place during plastic deformation and precipitation hardening.

This will be carried out by the divergent beam method of X-ray diffraction analysis aimed to yield clear and informative back-reflection patterns. It has been used for study of precipitation hardening in Al-Cu and Ag-Al single crystals. In addition to the above, electron transmission microscopy will be used in complementary studies of thin metal foils.

Precipitation hardening will be studied on the following systems: Cu-Ni-Fe, Cu-Ni-Co, Ni-Si, Ni-Cr-Si, Ni-Cr-Al, Ni-Cr-Ti, Ni-Al, and Au-Pt.

Studies of creep in Al and its alloys, including age-hardenable alloys, are aimed at clarifying the relationship between substructure and macro-mechanical behavior, particularly in the "steady state" secondary stage and the terminal tertiary stage.

Kinetics of Order-Disorder Transitions (U), RR 007-01-0011. University of Notre Dame, Notre Dame, Indiana, Metallurgy Department; N7onr 439(08), NR 031-501; G. C. Kuczynski.

The kinetics of order-disorder transformations in alloys of the AB_3 and AB type are being studied by resistometric, dilatometric, X-ray and metallographic techniques. One of the major variables under investigation is the effect of the disordering temperature on the subsequent rate of approach to order at lower temperatures. The peculiar transitions which have been shown to occur within the disordered region in alloys such as $AuCu_3$ are being investigated in detail.

Particular emphasis will be placed on examining antiphase domain boundaries and interphases in AB_3 f.c.c. alloys. The approach used is to study the effect of small deformations upon ordering and disordering, using $AuCu_3$ single crystals. A careful X-ray analysis will be made of the rate of line broadening of the super lattice due to deformation and correlating it to observed temperature effects on ordering. The characteristics of antiphase domains will be studied by both thermodynamic as well as statistical mechanical methods.

Influence of Cyrstal Boundaries on the Plastic Deformation of Metals (U), RR 007-01-0012. Harvard University, Cambridge, Massachusetts, Division of Engineering and Applied Physics; Nonr 1866(27), NR 031-503; B. Chalmers.

The mechanisms by which crystal or grain boundaries affect the mechanical behavior of metals are being investigated by studying the stress-strain characteristics of aluminum bicrystals of varying relative orientations. In the specimens now being examined, the relative orientation of the crystals is chosen so than an incompatibility arises for simple slip at the grain boundary. The effects of polygon and substructure boundaries (produced by deformation and annealing) on the plastic flow of aluminum single crystals are also being investigated in order to gain a better understanding of multiple slip hardening. Etch-pit techniques are also being used to study the condensation of vacancies at particular sites on the surface of single crystals while cooling from high temperatures.

Calorimetric Studies of Solid State Phenomena (U), RR 007-01-0014. Illinois Institute of Technology, Chicago, Illinois, Department of Metallurgy; Nonr 1406(03), NR 031-510; P. Gordon.

A calorimetric study is being made of the energy changes associated with the annealing of cold-worked metals. Specific problems currently under investigation include (a) determination of the stored energy of deformation of high purity copper which has been prestrained in tension and then given further amounts of (reverse) deformation in compression, (b) measurement of the stored energy changes resulting from fatigue following static deformation, (c) a study of the rate of energy release during the annealing of explosively deformed copper, (d) measurement of the driving energy for the recrystallization of zone-refined aluminum as a function of prior deformation and impurity contents, (e) measurement of the energy changes associated with grain growth in zone-refined aluminum, from which the average grain boundary energy can be evaluated.

Early Stages of Plastic Deformation (U), RR 007-01-0015. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Metallurgical Engineering; Nonr 551(20), NR 031-520; N. Brown.

The primary objective of this task is to determine the nature of yielding in metals under stress. Since macroscopic yielding is generally preceded by a small amount of plastic strain, this prior microstrain sets the stage for macroscopic yielding and thus must be studied if the transition from elastic to plastic behavior is to be understood. In addition, since the microstrain region is concerned with a relatively small number of dislocation movements, it offers the best opportunity for obtaining quantitative information about the forces acting on individual dislocations. To test the hypothesis that impurity locking (carbon) determines the stress necessary to move dislocations, an attempt will be made, using high purity iron, to measure the stress to move dislocations, which are free of impurity locking.

Using the two most important tools for understanding plastic behavior, i.e. (1) precision stress-strain equipment which permits measurement of microstrains, and (2) an electron microscope for making direct observations of dislocations in foils, research will be directed to the problems of the force to move a dislocation in iron, the effect of subgrain boundaries and the effect of a dispersed phase in impeding the motion of dislocations.

The bulk properties of iron that contains carbon particles as a dispersed phase will be studied. Such a synthetic alloy might permit a quantitative understanding of the effect of a dispersed phase since the dispersion would be of a uniform size and shape.

Plasticity, Recovery and Recrystallization of

Metals (U), RR 007-01-0016. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Metallurgical Engineering; Nonr 551(19), NR 031-528; R. Maddin.

This task is a fundamental study of the factors which influence the mechanical properties of metals and alloys, with particular emphasis on the crystallographic aspects of plastic deformation and on the effects of quenching, ageing and annealing. Currently the following studies are underway: (a) the crystallography of the deformation of molybdenum-rhenium alloys (which have extraordinary ductility), (b) the effects of quenching and ageing on the mechanical properties of low-impurity molybdenum, (c) the role of quenched-in vacancies in precipitation phenomena in copper-beryllium and nickel-beryllium.

Simultaneously, the above studies will be extended to include the following: (a) crystallography of deformation of other binary refractory alloys as functions of their compositions; (b) effects of quenching and ageing on other metals, such as W, Ta, Nb, V, Cr and Fe, and the temperature dependence of mechanical properties of such quenched (or irradiated) metals. It is also proposed to use transmission electron microscopy to study the effect of relative orientation of sub-boundaries in impeding dislocation movements, and to measure stacking fault energies.

Transformation Studies of Titanium-Hydrogen Alloys (U), RR 007-01-0017. University of Tennessee, Knoxville, Tennessee, Metallurgy Division; Nonr 811(06), NR 031-532; E. E. Stansbury.

The purpose of this task was to investigate the mechanism and kinetics of phase transformations in titanium-hydrogen alloys. High purity titanium-hydrogen alloys were prepared and the characteristics of transformations, the effect of cooling on the rate of decomposition of the beta phase, and the nature of a possible martensite reaction during rapid quenching were investigated by metallographic, dilatometric, and calorimetric methods, resistivity measurements, hydrogen vapor pressure measurements, and X-ray analysis.

Transformation Studies on High Strength Titanium Alloys (U), RR 007-01-0018. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1841(02), NR 031-550; B. L. Averbach, M. B. Bever.

Studied phase transformations in high-strength titanium alloys as a function of thermal and mechanical treatments and correlated the strength properties of the alloys with their structural characteristics. The age-hardening reaction in Ti-6 Al-4V alloys were investigated by metallographic, X-ray, dilatometric and other methods, to determine the kinetics of the decomposition of the beta phase and the influence of heat treatment upon mechanical properties. The influence of plastic deformation on the nature and kinetics of the transformations was examined including the effects of specific interstitials such as oxygen and carbon.

Anomalous Electron Emission from Metal Surfaces (U), RR 007-01-0019. William Marsh Rice Institute, Houston, Texas, Department of Mechanical Engineering; Nonr 2116(02), NR 031-562; F. R. Brotzen.

The nature of the electron emission which is observed from metallic surfaces when the metal is cold worked--the so-called Kramer effect--is being studied in order to establish possible correlations with the mechanical behavior. By deforming aluminum specimens in tension and simultaneously observing the electron emission from the specimen surface, the exact state of deformation at which emission occurs is being determined. The effect of strain rate, specimen purity and prior thermal treatment on the emission rate during deformation and during subsequent annealing is being studied.

The nature of the lattice defects or interactions responsible for the emission effect is also being investigated by simultaneously observing the changes in electrical resistivity and emission during plastic deformation at low temperatures. Thus attempts are made to correlate the emission process with complex mechanical phenomena.

Effect of Particle Dispersion on the Behavior of Metals (U), RR 007-01-0021. Stanford University, Stanford, California, Department of Metallurgical Engineering; Nonr 225(34), NR 031-577; R. A. Huggins.

The objective of this task is to study the effects of finely dispersed second phase particles on the annealing response and mechanical properties of metals. The principle objective is to advance fundamental understanding of the mechanisms of these effects, namely the interactions of the dispersed particles with vacancies, dislocations, low-angle boundaries and grain boundaries. Silver and dilute alloys of silver with Mg, Pb and Zn are internally oxidized to provide suitable dispersions of oxides. These alloys will be subjected to deformation and to various annealing treatments and will be examined by metallographic and X-ray diffraction techniques. These methods of examination will be supplemented by electrical resistivity measurements and by electron microscopy.

Flow and Fracture of Solids at Very High Loading Rates (U), RR 007-01-0022. Harvard University, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1866(35), NR 031-586; B. Chalmers.

This task was devoted to a study of the flow and fracture of metals under short duration or impulsive loads, such as are produced when an explosive charge is detonated in contact with a body. The fracture behavior of aluminum and other metals in both polycrystalline and single crystal form was investigated under shock loading conditions. Using techniques which permit the time of application of the tensile load to be varied, information was obtained concerning (a) the early stages of fracture, (b) the rate of crack propagation, and (c) the energy for fracture.

Irradiation Aging of Supersaturated Solid Solutions (U), RR 007-01-0023. Materials Research Corporation, Yonkers, New York; Nonr 2498(00), NR 031-599; C. T. Murray.

A study is being made of the mechanism of irradiation aging in binary alloy systems. Changes in various physical properties, e.g. hardness, electrical resistivity, produced by neutron irradiation of solution-treated Cu-Be and Cu-Ti alloy single crystals are being determined and a comparison is

being made with similar fundamental studies of aging reactions based on solution anneal temperatures, quench rate and composition and to interrelate the effects of irradiation and cold work on subsequent low temperature aging. Results of these studies will be interpreted chiefly on the basis of changes in X-ray diffraction line patterns, both as a function of irradiation aging and thermal aging, utilizing low angle scattering techniques.

Structure of Liquid Metals and Alloys (U), RR 007-01-0024. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1841(48), NR 031-603; B. L. Averbach.

To undertake research on the structure of liquids with particular emphasis on comparison of short range ordering on the solid and liquid state. The structure of pure metals (Au, Cu, Au and Fe) will be investigated first followed by an exploration of selected alloy systems of Cu-Au, Ni-Au, Au-Ag and a number of iron alloys. Studies will be carried out near and above melting point. Combined X-ray and neutron diffraction techniques will be utilized to measure the extent of short range or local ordering.

To maintain suitable angular contact with the liquid surface, special adaptations will be made for a geiger counter-spectrometer for X-ray diffraction measurements. The neutron diffraction phase of this program will be carried out in close collaboration with the Physics Department in the Massachusetts Institute of Technology nuclear reactor facility.

Equipment for X-ray spectrometer analysis and neutron diffraction has been designed and built and experimental work is being undertaken. The changes in short range order in gold and gold-nickel alloys as a function of temperature, just above and below the melting point will be investigated first. The data will be compared with previous measurements of order in solid material at lower temperature.

Structure and Properties of Metallic Solutions (U), RR 007-01-0025. University of Chicago, Chicago, Illinois, Institute for the Study of Metals; Nonr 2121(11), NR 031-604; C. S. Barrett, O. J. Kleppa, P. C. Mangelsdorf.

This task is concerned with a fundmaental investigation of the thermodynamic, transport, and structural properties of metals and metallic solutions. Both solid and liquid solutions are being investigated.

Various thermodynamic properties of metallic solutions are being determined by direct measurement. These include the volume change on mixing in binary alloy systems, the excess partial molar entropies of the components in liquid alloys, etc. In a general way, the influence of valence electron concentration (and short-range order) on the thermodynamic properties of liquid alloy systems is being explored. High temperature calorimetric techniques are also being used to study the heat effects associated with metallurgical and chemical reactions in both the liquid and solid state.

The transport of both mass and electrical charge in liquid metal alloys is being studied by making parallel determinations of the chemical diffusion coefficients, electrolytic migration rates and electrical resistivities of alloys at various temperatures and compositions. Because of the theoretical simplicity of the alkali metals, emphasis is now being placed on a study of the transport properties of potassium alloys.

Various studies of the crystallography of metallic solutions are being carried out using refined X-ray diffraction techniques. At present, precision determinations of the structure and lattice parameter of high-purity zone refined bismuth are being made at temperatures from 4°K to room temperature. These measurements will be extended to other Group V semi-metals (As, Sb, Bi) and their alloys. Data of this type are needed in order to substantiate a theoretical model of the electron band structure of the Group V elements which has recently been developed.

X-Ray Study of Crystal Imperfections (U), RR 007-01-0026. Harvard University, Cambridge, Massachusetts, Division of Engineering and Applied Physics; Nonr 1866(39), NR 031-605; A. R. Lang.

Newly-developed X-ray diffraction techniques were used to study the point-by-point distribution of imperfections--mainly dislocations--in both artificially grown and natural crystals. Work was aimed at obtaining a precise understanding of the diffraction effects associated with individual imperfections such as dislocations in crystals. On the experimental side, the dislocation structure of various crystals, particularly silicon, diamond, calcite and aluminum were studied. Attempts were made to produce low-dislocation density, strain-free single crystals or aluminum so that the initial stages of dislocation multiplication during deformation could be investigated.

Short-Range Order and Clustering Phenomena in Solid Solutions (U), RR 007-01-0027. University of Minnesota, Minneapolis, Minnesota, Department of Metallurgy; Nonr 710(29), NR 031-607; J. M. Sivertsen.

An investigation of short-range ordering and clustering phenomena in a number of binary alloy systems is being carried out using diffuse X-ray scattering, small angle X-ray scattering, acoustical and magnetic techniques. The alloy systems being studied include Au-Ni, Ag-Li, Cu-In, Ag-In, Au-Fe and Ag-Mn.

To determine whether the property changes observed during the low-temperature aging of Au-Ni alloys are associated with changes in the degree of short range order or to the formation of Ni-rich clusters, the X-ray studies are being supplemented by internal friction measurements and by following the kinetics of transformation using magnetic methods. Short-range order, pre-precipitation effects and reversion processes in the Ag-Li, Cu-In and Au-In systems are being studied in similar fashion. Since the presence of stacking faults and the variation in the stacking fault energy with composition may play some role in pre-precipitation phenomena, it is also proposed to study stacking fault formation in the silver-base and gold-base alloys.

A program is also being initiated to study the effects of irradiation on the elastic and anelastic behavior of crystalline solids, particularly NaCl and copper. The immediate purpose of these experiments is to test recently developed theories of dislocation damping phenomena.

Research on the correlation between local

ordering and magnetic properties is also being initiated. Ordered alloys such as Cu-Pa, Cu-Pt, Fe-Pt, etc., will be investigated to determine whether the magnetic properties of alloys in various states of order can provide information about the processes underlying magnetic phenomena in solid solutions. Magnetic susceptibility measurements will also be used to study the precipitation of Fe or Ni in semiconductors (e.g. Ge and Si).

Precipitation Effects in Semiconductors (U), RR 007-01-0028. University of Minnesota, Minneapolis, Minnesota, Department of Metallurgy; Nonr 710(27), NR 031-608; R. A. Swalin.

The major effort under this task is concerned with the study of nucleation or precipitation processes in solids, specifically semiconducting solids such as silicon and germanium. Primary emphasis has been placed on a detailed study of the role which point defects, i.e. vacancies, play in the precipitation of lithium from silicon and germanium. Oxygen-vacancy complexes have been shown to be important as nucleation catalysts and current work is aimed at obtaining more quantitative information about the role of oxygen in the nucleation process, particularly with regard to the role of defect complexes involving oxygen. Gamma ray bombardment will be used to introduce vacancies into the semiconducting crystals. Investigation of the precipitation of elements having different chemical properties from lithium (e.g. Ni, Au or Si) is also planned to arrive at a more general picture of the precipitation process in germanium and silicon.

Another phase is concerned with the study of the nature of the activated state in the diffusion process. Experiments are being planned to study thermal diffusion of impurities (e.g. Li) in germanium and lithium.

The ion-bombardment etching studies have been discontinued because of lack of success.

Fundamental Studies on Nuclear Engineering Materials (U), RR 007-01-0029. California Institute of Technology, Pasadena, California, Department of Mechanical Engineering; Nonr 220(30), NR 031-610; P. Duwez.

To undertake a broad long-range program to study the fundamental nature, properties and reactions of metals, pertaining to nuclear engineering. In addition, the nature and kinetics of allotropic transformations in metals generally, subject to high heating rates and temperature gradients, are being investigated.

Much use will be made of the new technique, developed under this contract, by which liquid alloys can be quenched to room temperature or below at rates which suppress or prevent the normal processes of nucleation and growth of equilibrium phases. Metastable structures with unusual properties are thus produced. The following investigations are underway.

a. Effects of Radiation on Crystalline Solids: As the first phase of this general research area, the effect of electron irradiation on the structure of alloys is being studied. A 2-Mev electron accelerator will be used as the radiation source. Foils, about 10-15 microns thick, of metastable alloys produced by the above mentioned quenching techniques will be the initial materials investigated.

b. Alloy Systems and Non-Metallic High Temperature Materials: Kinetics of phase transformation, radiation effects on martensite type diffusionless transformation, ordering reactions, fine structure of solid solution alloys, etc. The metals Zr, Nb, U and Th, having interesting electron structures, will be explored separately and through alloying interaction with rare earth metals. Attention will be given also to potentially promising refractory compounds, with emphasis on interdiffusion reactions in oxides, carbides, nitrides, etc. Current attention is being devoted to the kinetics of transformation in uranium and its alloys, utilizing techniques for rapid heating through the allotropic transformation temperature.

c. Interactions of Liquid Metals with Solids: The structure and properties of liquid metals and corrosion mechanisms induced by liquid metals will be studied. This will include diffusion reactions in liquid metals and between liquid-solid metals. Part (c) will be closely coordinated with related programs of other agencies and the AEC. Some alloys (such as Au-Ge) can be quenched fast enough from the molten state to retain a quasi-liquid structure. Such alloys can, therefore, be studied in the solid state, although their structure is similar to that existing in the liquid state. This greatly simplifies the experimental approach to the study of the structure of liquid alloys and X-ray diffraction studies of metastable liquid alloys (in the solid state) are now underway.

Grain Boundary Self-Diffusion in Metals (U), RR 007-01-0030. University of Oklahoma, Norman, Oklahoma, Research Institute, Department of Metallurgical Engineering; Nonr 982(04), NR 031-611; W. R. Upthegrove.

This task is a study of the phenomena of diffusion along grain boundaries in metals and alloys; specifically, to improve our understanding of the structures of grain boundaries in terms of arrays of dislocations, vacancies, substitutionals and interstitials. In the current phase of the program grain boundary self-diffusion measurements are made on bicrystals of lead. The grain boundary between the two crystals in each specimen will be either a symmetrical twist or a symmetrical tilt boundary, and the crystals will have various particular relative orientations. The kinetics of grain boundary diffusion will be studied by radioactive Pb^{210} and autoradiography. The data obtained will be analyzed in terms of current theories of grain boundary diffusion using computer procedures for numerical analysis.

An investigation will also be made of the influence of impurities on grain boundary diffusion in lead containing controlled amounts of tin. This will provide a critical test of a conjectured relationship between the migration of grain boundaries and self-diffusion along grain boundaries.

Interactions Between Impurities and Dislocations (U), RR 007-01-0031. Columbia University, New York, New York, School of Mines; Nonr 266(61), NR 031-612; D. N. Beshers.

Under this task it is proposed to further investigate the interactions between impurities and dislocations in body-centered-cubic metals, the structure of the dislocation care, and finally the nature of precipitation phenomenon in iron. To accomplish this, heavy reliance will be placed upon (1) internal friction measurements, (2) correlation between the lower yield stress and temperature as well as grain size, and (3) electrical resistivity measurements.

Physical Change Resulting from Imperfections in Solids (U), RR 007-01-0032. Northwestern University, Evanston, Illinois, Department of Metallurgy; Nonr 1228(12), NR 031-613; J. W. Kauffman.

The purpose of this research is to study the relationship between lattice imperfections and the physical properties of crystalline solids. The physical properties involved are (1) electrical resistivity, (2) mechanical properties, and (3) volume change.

Research on the migration and coagulation of defects which occur during the quenching process will continue.

Experiments on the effect of alloyed elements on the formation and migration of vacancies will continue. Preliminary studies indicate that the addition of trace amounts of copper to gold results in an increase in the quenched-in resistivity. Further work will include other solute elements in varying concentrations in order to systematically study the various effects of alloying. For more concentrated alloys, the method of volume change will be used. Anelasticity and creep studies will be carried on along with volume change measurements experimental work. In addition, additional theoretical research is needed in order to describe these processes. Existing calculations, involving random distribution of defects, can lead to large errors. Work is under way which makes use of the fact that vacancy concentrations should be treated as a function of spatial coordinates and time.

Structure and Properties of Solid Solutions (U), RR 007-01-0034. Northwestern University, Evanston, Illinois, Department of Metallurgy; Nonr 1228(11), NR 031-618; M. E. Fine.

The principal purpose of this research is to study the sources of solid solution hardening.

The work in Cu base Al alloys on short-range order hardening will continue. In addition, a study of the hardening effects due to changes in dislocation density produced by alloying will be initiated. Gold alloys will be used to minimize contamination effects. Flow stress, critical resolved shear stress, and internal friction will be measured as function of alloying content and temperature. Atomic misfit and valency will also be investigated as variables. Since the amplitude dependent part of the internal friction is sensitive to dislocation population and distance between pinning points along dislocations, its change with temperature will help ascertain whether solute atoms pin dislocations or merely increase the density of dislocations.

Plasticity studies will be conducted on Cu base Al alloys in order to better understand the stress-strain relations after initial yielding. Flow stress will be investigated as a function of (a) amount of deformation, (b) strain rate, (c) atomic % al, (d) strain aging effects.

Properties of Dislocations in Body-Centered-Cubic Metals (U), RR 007-01-0035. Colorado School of Mines Research Foundation, Golden, Colorado, Department of Metallurgical Engineering; Nonr 2580(02), NR 031-619; D. W. Bainbridge.

The influence of elastic anisotropy on the nature and properties of dislocations in body-centered-cubic metals was investigated. The treatment of dislocations in anisotropic materials (Eshelby theory) was applied to several real systems including the metals molybdenum, tantalum and iron. The strain energy associated with dislocations in these metals were computed for all reasonable orientations and Burgers vectors; estimates of the critical shear stress to move these dislocations through an otherwise perfect crystalline lattice were obtained.

Heat Capacity of Liquid Alloys (U), RR 007-01-0036. University of California, Berkeley, California, Department of Engineering; Nonr 222(63), NR 031-621; R. Hultgren.

The principle objective of this task is aimed toward a fundamental understanding of thermodynamic reactions in liquid alloys by measuring their heat capacity. Concurrently, studies will be carried out on the interactions between atoms in the liquid state, structure of liquids, and other factors which may influence the accurate determination of heat capacities.

Heat capacities of different compositions of suitable low-melting alloys will be determined by a modified Liquid Tin Solution Calorimeter which permits accurate (+0.0003°C) temperature measurements. Temperature range will extend upward from the liquidus to the highest ones possible in this apparatus. This calorimeter will also be used for heats of formation measurements.

Heat capacity measurements on high purity tin, indium and bismuth have been completed, showing that the heat capacity of the liquid phase decreases with increasing temperature. Future work will consist of rechecking the results on liquid tin and the study of the effect of alloying on liquid heat capacities. Alloys of lead-tin (endothermic), bismuth-indium (exothermic) and bismuth-tin ($H = 0$) will be used in these studies.

Nuclear Magnetic Resonance Study of Metals and Alloys (U), RR 007-01-0037. General Electric Company, Schenectady, New York, Research Laboratories; Nonr 2615(00), NR 031-623; M. B. Webb.

The techniques of nuclear magnetic resonance were used to obtain fundamental information concerning the electronic structure of alloy systems. A study was made of the variation of the Knight Shift with composition in several alpha-phase alloys of the monovalent metals (e.g., alkali metals). The data so obtained were used to test two recent theoretical treatments of the band structure of monovalent metals and alloys, one based on the free electron model and one which depends entirely on deviations from the free electron model.

Mechanism of Solid Solution Hardening (U), RR 007-01-0038. The Franklin Institute, Philadelphia, Pennsylvania, Laboratories for Research and

Development; Nonr 2608(00), NR 031-624; B. H. Kear.

The object of the investigation is to obtain a better understanding of the striking difference in mechanical properties exhibited by ordered and disordered Cu_3Au crystals. These differences should be interpretable in terms of differences in the nature of and the interactions between dislocations in these two states of the material. To establish the nature of the dislocations in these alloys electron microscopy and diffraction are being employed on thin films. To study the interactions between dislocations slip line observations are being made on crystals plastically deformed in compression in special orientations.

Lattice Stability of Metallic Phases (U), RR 007-01-0040. Manufacturing Laboratories, Incorporated, Cambridge, Massachusetts; Nonr 2600(00), NR 031-627; L. Kaufman.

This task is concerned with the theoretical and experimental research on the relative stabilities of face-centered cubic, body-centered-cubic and hexagonal closed packed structure in metallic systems. Such data are of value in correlating the electronic and thermal properties of metals, predicting phase relationships in complex alloy systems, predicting phase transformations in metals, estimating the propensity for stacking fault formation during mechanical deformation, studying the mechanism of phase transformations in metallic system. Known and experimentally determined thermodynamic data, physical properties and alloy behavior are being utilized to calculate the free energy difference between two crystallographic forms of a metal as a function of temperature. At $0^{o}K$, this free energy difference corresponds to the difference in cohesive energy between the two lattices and hence gives a measure of relative stabilities of the two structures.

The relative lattice stabilities of phases in Ti, Zr, Cu, Ag and Zn have been determined, and predictions as to the effect of pressure on phase transformations in several iron base alloys have been experimentally verified.

The research is now being concentrated on the relative stability of f.c.c., b.c.c., and h.c.p. structures in the transitions metals, Fe, Ni, Co, and Cr. De bye temperature measurements, as a function of composition, are being determined in several alloy systems to yield additional independent data on free energy differences between various crystallographic forms. High pressure (100,000 atmospheres) studies with iron and zinc will be undertaken to look for the occurrence of transitions predicted by theoretical analysis.

Elastic Damping and Coercivity of Iron (U), RR 007-01-0042. Battelle Memorial Institute, Columbus, Ohio, Nonr 2606(00), NR 031-629; R. E. Maringer.

A study is being made of the interactions which occur between impurities and ferromagnetic domain walls in iron. Toward this end, the damping capacity of high-purity iron containing known concentrations of carbon and/or nitrogen is being measured as a function of temperature both in the presence and absence of a static magnetic field. The time- and temperature-dependent changes in magnetic induction following the application of an a-c field are also being studied. The work with pure iron-carbon or iron-nitrogen alloys will be extended to substitutional alloy systems such as iron-nickel. The effect of grain size on the magneto-elastic damping and magnetic relaxation characteristics of iron will also be investigated. It is planned in this study to examine specimens having a wide range of grain sizes, including single crystals and whiskers. To obtain information concerning the effect of lattice vacancies, the damping and magnetic properties of quenched specimens of high-purity zone-melted iron will be measured; these data will be compared with those obtained on quenched and aged and with well annealed specimens.

Perspective in Metallurgical Research (U), RR 007-01-0043. National Academy of Sciences, National Research Council, Washington, D. C.; Nonr 2300(14), NR 031-630; L. Jordan.

The objective of this task is the assessment of the current state of the science in metallurgy. A number of small study groups have been established to analyze several fields of metallurgical research with the aim of providing information concerning the current knowledge in these fields, the outstanding problems which require concentrated research effort, and promising approaches for undertaking such research. The following metallurgical fields have been selected for initial exploration: Deformation and Fracture; Phase Transformations and Solid State Reactions; Alloy Theory; Diffusion and Mass Transport; Surface Phenomena (including Corrosion); Magnetic Behavior of Metals and Alloys; Radiation Damage; Structure and Properties of Liquid Metals; Chemistry and Constitution of Metallurgical Systems; New Research Techniques and Instrumentation.

The findings and conclusions of these study groups will be made available to the scientific community by means of working-level seminars, open symposia and publication in book form. The National Academy of Sciences, which has administrative control of this program, during the forthcoming renewal period will assemble and edit the reports and recommendations of the various panel groups and assist in preparation of these studies in book form.

Effect of Pressure on Transformations and Constitution of Metal Systems (U), RR 007-01-0044. University of California, Los Angeles, California, Department of Geophysics; Nonr 233(53), NR 031-631; G. C. Kennedy.

A study will be made of the effect of hydrostatic pressures in the range from 50,000 to 100,000 atmospheres, on phase transformations in metals and on solid solubility limits in alloy systems. The effect of pressure on the alpha-gamma transformation in pure iron is being studied in order to obtain a more precise determination of the pressure-temperature relationships. Phase transformations in other pure metals will also be investigated at high pressures. The effect of pressure on second-order transitions such as magnetic transformations in ferromagnetic on antiferromagnetic materials will likewise be investigated. Studies on the influence of high pressure on transformations in oxide systems will be undertaken later in the program. Throughout the course of this work effort

will be devoted to the development and improvement of (a) equipment for achieving high pressures at elevated temperatures (e.g. 100,000 ats. at 2000°C) and (b) instrumentation for examining substances at high pressures and temperatures.

Measurements on the pressure coefficient of melting of metals are being made and work will begin on materials of high compressive stress. The feasibility of making carbon bonded diamond aggregates will receive special attention because of their potential in enabling the construction of apparatus capable of reaching pressures and temperatures much above those currently available.

Intergranular Fracture of Metals at Elevated Temperatures (U), RR 007-01-0045. Sylvania Electric Products, Incorporated, Bayside, Long Island, New York; Nonr 2613(00), NR 031-632; L. Siegle.

The relationship between void formation during diffusion and grain boundary cracking during creep at elevated temperatures is being studied. Particular attention is being given to the effects which trace impurities have on the incidence of grain boundary cracking, and attempts are also being made to determine the role played by the diffusion of lattice vacancies in the grain boundary fracture process.

An evaluation of the influence of both dissolved and undissolved impurities on grain boundary cracking in nickel and copper is currently in progress. These investigations are being extended to titanium and zirconium of normal purity in order to confirm the absence of grain boundary cracking in these materials at elevated temperatures. Creep experiments will be carried out at higher temperatures than have been employed thus far and a thorough study of the structures of these metals will be made in order to detect the presence or absence of grain boundary sliding. A critical test of the vacancy diffusion hypothesis for grain boundary cracking may also be obtained by studying the incidence of cracking in specimens in which diffusion and creep are occurring simultaneously.

Formation of Intermediate Alloy Phases by Diffusion Processes (U), RR 007-01-0046. Stanford University, Stanford, California, Department of Metallurgical Engineering; Nonr 225(43), NR 031-636; V. Macres.

The objectives of this task are to construct an electron probe microanalyzer and to use this equipment in the study of the kinetics of intermetallic phase formation during diffusion processes in simple binary metal systems. Primary emphasis will be placed on the determination of the compositional gradients in the diffusion zone for the copper-cadmium system and on the establishment of their dependence on time and temperature variables. Subsequently, the effect of pressure on the characteristics of intermetallic phase formation will be investigated.

Effect of Surface Environment on Flow and Fracture Characteristics of Solids (U), RR 007-01-0048. New York University, New York, New York, Mechanical Engineering; Nonr 285(43), NR 031-648; I. Cadoff.

This study relates to the plastic deformation and fracture of solid and liquid coated solids. Torsional stress-strain measurements are carried out supplemented by direct observations of dislocation movements in crystals. Initial experiments are carried out on alkali halides (LiF, NaCl) and silver halide (AgCl) single crystals for a more direct observation of dislocation movements. Attempts will be made to observe the generation and motion of dislocations under torsional loading conditions and to determine the effect of solid and liquid coatings on the ease of dislocation flow through the surface. The nature of dislocation pile-ups and the movement of dislocations from the pile-ups at various temperatures, strain rates, etc. will also be determined for both coated and uncoated specimens. The formation of microcracks at the surface and in the interior of the crystals and the stabilization or healing of the surface microcracks by liquid coatings will also be investigated.

The influence of solid and liquid coatings on the strain-hardening and fracture characteristics will be studied. Eventually the studies on halide crystals will be extended to pure metals e.g. Cu, Al, Zn and to semiconductors such as silicon and germanium.

Effect of Pressure on Melting of Metals (U), RR 007-01-0049. University of Oklahoma Research Institute, Norman, Oklahoma, Department of Physics; Nonr 982(05), NR 031-651; S. E. Babb, Jr.

The effect of pressure on the melting points of metals and other pure substances is being investigated in the range up to about 12,000 atmospheres. Relatively low melting metals, such as magnesium and cadmium, as well as metals which melt above 1000°C are being studied. Because of geophysical interest, the melting of iron and certain iron-nickel alloys under pressure will be examined. The related problem of polymorphism in metal systems at elevated temperatures and pressures is also receiving attention. Phase transformations during the course of the work are being studied to map out or complete the pressure-temperature phase equilibria.

Effect of Adsorbed Films on Bulk Properties of Solids (U), RR 007-01-0050. Columbia University, New York, New York, School of Mines; Nonr 266(64), NR 031-652; J. H. Schulman.

A study is being made of the effect of adsorbed surface films on the bulk properties of both dense and porous solids. In this connection, the creep rates of copper, aluminum and iron wires are being measured in different gaseous environments and after selective adsorption on the metal surface of various chemical species from aqueous solution. The influence of grain size in relation to the wire diameter is also being investigated. Analogous experiments are being carried out to determine the effect of adsorbed films on the frictional characteristics and fatigue behavior of various pure metals. An attempt is also being made to measure directly the change in the bulk modulus of porous silica bodies on changing the surface energy of the solid through quantitative adsorption of both polar and non-polar gases.

Application of Physical Acoustics to Metallurgical Problems (U), RR 007-01-0051. Yale University, New Haven, Connecticut, Department of Metallurgy; Nonr 609(35), NR 031-665; R. B. Gordon.

This task is concerned with the use of the high frequency techniques of physical acoustics for the study of certain metallurgical problems. Initially the research program will emphasize the following two phases:

a. The use of high frequency attenuation (internal friction) techniques for the study of the hydrogen embrittlement of iron. Previous research had revealed that the interference of solute atoms with the free motion of dislocations plays a large role in the brittle behavior of body-centered-cubic metals and that hydrogen, nitrogen and carbon are of particular interest in the case of iron. The aim of this research will be to study dislocation damping effects in iron as influenced by carbon and nitrogen and subsequently the influence of dissolved hydrogen upon these effects as a consequence of its interaction with other solutes at dislocations. Ultrasonic pulse techniques and megacycle range frequencies will be employed. Close control of the hydrogen content of the iron will be maintained by making the measurements while the sample is in a cathodic charging bath.

b. The use of acoustic scattering and attenuation techniques to study the kinetics of phase separation of liquid metals (separation of a single liquid phase into two immiscible liquids) with particular emphasis on the early stage of phase nucleation and growth. Acoustic transmission coefficient measurements will be used to deduce information about the nature of the solid-liquid interface.

Crystal Growth and Properties of Small Crystals (U), RR 007-01-0052. University of Virginia, Charlottesville, Virginia, Department of Physics; Nonr 474(05), NR 031-666; N. Cabrera, J. W. Mitchell.

This task is devoted to a study of (a) the growth and evaporation of crystals and (b) the mechanical and physical properties of small crystals such as whiskers.

The theory of crystal growth is being examined from several points of view. A kinematical treatment of the flow of steps on crystal faces is being applied to various problems such as the growth of crystals from the vapor phase or from solution. The role which impurities play in the advance of steps on growing crystal surfaces is also being analyzed. Experimentally, the conditions necessary for the growth of whiskers and thin platelets, both from the vapor phase and by chemical reduction, are being studied. The influence of impurities on the growth process is also being investigated.

The dislocation structure and mechanical properties of metal whiskers are being studied, as a function of whisker diameter. Information concerning the dislocation structure is being derived from X-ray diffraction studies from the elastic properties and creep behavior and from internal friction measurements on whiskers. Measurements of piezoresistance effects as well as the contribution of surface effects to the resistance in copper, zinc, and other metallic whiskers are being examined; both the elastic and plastic behavior of whiskers will be studied in this manner.

Deformation Characteristics of Thin Foils and Composites (U), RR 007-01-0053. The Franklin Institute, Philadelphia, Pennsylvania, Physics of Metals Branch; Nonr 2992(00), NR 031-667; H. G. F. Wilsdorf.

This program falls into two broad categories: (1) a fundamental study of the deformation characteristics of thin metal foils, which it is hoped will lead to an understanding of the extraordinary mechanical strength of such materials; (2) a more applied program to investigate the feasibility of utilizing the high strength of thin foils in synthesizing composite materials for structural applications.

The fundamental program involves a study of the deformation characteristics of metal foils no thicker than 200 Å which have been prepared in various ways, i.e. by electrolytic thinning, by evaporation plus subsequent heat-treatment, etc. The technique of transmission electron microscopy is being used to permit direct observation of dislocations and other lattice defects responsible for the plastic properties of these foils. Information will thus be obtained using also electron diffraction techniques, concerning (a) dislocation patterns in the undeformed materials; (b) the origin of dislocations during deformation; (c) interactions between dislocations; (d) interactions of dislocations with obstacles such as sub-boundaries, impurity clusters and precipitation; (e) the mode of fracture. Initially studies will be on foils of high purity Al and Al-Cu alloys.

Structure of Single Crystals (U), RR 007-01-0054. Brown University, Providence, Rhode Island, Metals Research Laboratory; Nonr 562(27), NR 031-675; C. Elbaum.

The objective of this task is to gain a better understanding of the origin of dislocations and lineage boundaries in crystalline solids grown from the melt. In order to obtain more knowledge of the factors influencing the formation and elimination of these types of imperfections, the structure of single cyrstals will be investigated as a function of thickness and growth conditions. Techniques have been developed for growing single crystals of any desired thickness, e.g. down to 0.1 mm. The density and distribution of dislocations and lineage boundaries in such crystals will be studied by means of recently developed, high-sensitivity X-ray diffraction techniques.

For the immediate future emphasis will be placed upon determining the role of condensing lattice vacancies and impurity segregations on the formation of dislocations.

Measurement of Absolute Surface Free Energies of Solids (U), RR 007-01-0055. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Metallurgical Engineering Department; Nonr 760(19), NR 031-676; P. G. Shewmon.

Under this task, an experimental study is being undertaken of the feasibility of a new technique for the measurement of the absolute surface free energies of solids. The technique involves the contacting of a metal surface with a light-weight wedge and observing the initially established equilibrium contact angle and the changes in groove depth and width around the wedge as a function of time at temperature. The wedge must consist of

a material which is not "wet" by the metal whose surface energy is to be determined. The analysis of the situation is similar to that for grain boundary grooving. The initial phase of the study will be to determine the surface tension of silver, so as to study the feasibility, accuracy and reproductibility of the wedge technique. Clean single crystals at temperatures near the melting point will be investigated. Successful development of the technique will lead to future studies of surface energies of other metal systems; surface concentration of solute atoms; high temperature adsorption at grain boundaries; and orientation effects.

Small Angle Boundary Motion in Single Crystals (U), RR 007-01-0056. California Institute of Technology, Pasadena, California, Division of Engineering; Nonr 220(37), NR 031-677; T. Vreeland, Jr.

The objective of this task is to study the relationships which exist between stress and dislocation velocity to obtain an increased understanding of the dynamic motion of dislocations. The particular experimental approach involves the study of the stress-induced motion of small angle tilt boundaries in high purity zinc-single crystals. Shock tube loading systems and stress pulse techniques will be employed. Dislocation displacements and dislocation motion will be followed by means of etch pit observations. The nature of the drag force acting on the motion of high velocity dislocations will be investigated by determining the influence of known amount of impurities on tilt boundary displacements.

Diffraction Studies on the Structure of Liquids (U), RR 007-01-0059. California Institute of Technology, Pasadena, California, Department of Chemistry and Chemical Engineering; Nonr 220(40), NR 031-626; C. J. Pings.

To conduct a fundamental study on the structure of liquid metals with the aid of advanced X-ray and neutron diffraction techniques. The principal objective of this program is oriented toward a more complete understanding of the nature of the liquid state and of phase transitions.

The major emphasis will be on the study of liquid systems in the vicinity of liquid-solid phase boundaries. A system will be selected which exhibits desirable undercooling characteristics in the unstable region of the liquid phase. Initially, only basic phenomena will be studied rather than specific substances utilizing simple atomic and molecular structures. Various other techniques, e.g. nuclear magnetic resonance, thermal relaxation, etc., will be used as supplemental tools to obtain supporting data on the microscopic behavior of liquids in non-equilibrium states.

Equipment Grants for Material Sciences (U), RR 007-01-0060. California Institute of Technology, Pasadena, California; Nonr(G) 00016-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0061. University of California, Los Angeles, California; Nonr(G) 00029-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0062. University of Colorado, Boulder, Colorado; Nonr(G) 00023-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0063. The University of Florida, Gainesville, Florida; Nonr(G) 00019-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0066. Harvard University, Cambridge, Massachusetts; Nonr(G) 00024-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0067. Indiana University, Bloomington, Indiana, Research Division; Nonr(G) 00030-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0068. University of Kentucky, Lexington, Kentucky; Nonr(G) 00027-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0069. Massachusetts Institute of Technology, Cambridge, Massachusetts; Nonr(G) 00028-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0070. University of Notre Dame de Lac, Notre Dame, Indiana; Nonr(G) 00025-60, NR 031-695.

Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0071. The University of Oklahoma, Norman, Oklahoma, Research Institute; Nonr(G) 00020-60, NR 031-695.

Procurement of vital scientific equipment needed

to support and strengthen basic research in material sciences now being sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0072. Polytechnic Institute of Brooklyn, Brooklyn, New York; Nonr(G) 00021-60, NR 031-695.
Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0073. Stanford University, Stanford, California; Nonr(G) 00018-60, NR 031-695.
Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0074. The University of Texas, Austin, Texas; Nonr(G) 00017-60, NR 031-695.
Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0075. University of Utah, Salt Lake City, Utah; Nonr(G) 00026-60, NR 031-695.
Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0076. University of Virginia, Charlottesville, Virginia; Nonr(G) 00022-60, NR 031-695.
Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

Equipment Grants for Material Sciences (U), RR 007-01-0077. Yale University, New Haven, Connecticut; Nonr(G) 00014-60, NR 031-695.
Procurement of vital scientific equipment needed to support and strengthen basic research in material sciences now sponsored by ONR and related DOD activities.

High Temperature Materials Research (U), RR 007-01-5400. U. S. Naval Research Laboratory, Washington, D. C.; C05-08; R. R. Miller.
The work on this task is concerned in the present phase with the evaluation of high temperature thermocouple combinations. In some of the physical property measurements, an accurate temperature difference between two points must be known. Thermocouples more stable and dependable to 2000°C will be required. Following the selection of the best couple for a particular temperature range, it will be used to determine temperatures and temperature difference in physical property measurements on materials.

Properties of High Temperature Heat Transfer Liquids (U), RR 007-01-5402. U. S. Naval Research Laboratory, Washington, D. C.; C05-11; R. R. Miller.
Description classified.

Titanium Base Alloys (U), RR 007-01-5403. U. S. Naval Research Laboratory, Washington 25, D. C.; M01-01; R. W. Huber, W. A. Reaves, Jr., E. J. Chapin.
This investigation was aimed at developing information and procedures for the production of titanium and titanium alloy components prepared by cast-weld techniques suitable for Naval application. The castability phase included studies such as: a thermocouple system for measuring temperatures of molten titanium; the manner in which titanium solidifies and the effects on casting design; the effects of pouring temperatures on selected mold materials and on the physical and mechanical properties of cast metal.

Deoxidation of Reactive and Refractory Metals with Selected Reducing Agents (U), RR 007-01-5404. U. S. Naval Research Laboratory, Washington, D. C.; M01-04; I. R. Lane, Jr., E. J. Chapin.
This is an investigation aimed at developing cold ductility in reactive and refractory metals contaminated with deleterious amounts of oxygen by deoxidation with selected powerful reducing agents.

Properties of Iron Alloys (U), RR 007-01-5405. U. S. Naval Research Laboratory, Washington, D. C.; M01-05; J. E. Srawley.
Studies of fracture resistance of sheet steels and other alloys with very high ratios of yield strength to density. Fracture strength is measured by tensile tests of specimens provided with cracks of controlled size, position, and orientation. The influences of composition, processing, heat treatment, thickness, temperature, and loading rate are considered. Fracture surface features, microstructure, and crystal structure are studied with the objective of relating fracture characteristics to structure through the prevailing concepts of the defect solid state. Macro-phenomenological fracture mechanics concepts as a basis for engineering structural design are tested experimentally.

Gases in Steel (U), RR 007-01-5406. U. S. Naval Research Laboratory, Washington, D. C.; M01-08; B. F. Brown.
A delayed fracture test was devised for evaluating hydrogen embrittlement of high strength steel, and this was employed to ascertain the requirements for baking out the embrittlement caused by cadmium plating or chromium plating. New electroplating solutions were developed which deposit cadmium without embrittling the steel. Current work has shown that NaCl solutions drastically reduce low-cycle fatigue life, that standard cathodic protection methods can prevent this, but that in some materials excessive "over protection" leads to premature fracture.

Metallurgy and Ceramics (U), RR 007-01-5407. U. S. Naval Research Laboratory, Washington, D. C.; M01-09; M. R. Achter.
The mechanisms of flow and fracture of metals at temperatures in the recovery and recrystallization range are studied in terms of the fundamental processes of structural alterations taking place. Attention is concentrated on the influence of

environment on these basic mechanisms. Equipment has been constructed and put into service to measure creep, fatigue and rupture properties in vacuum and controlled gaseous environments. Unusual effects of atmosphere have been observed and explained in terms of the fundamental reactions of metals and gases.

Basic Studies of the Metallic State (U), RR 007-01-5408. U. S. Naval Research Laboratory, Washington, D. C.; M01-10; A. I. Schindler.

The electrical, magnetic, and plastic properties of metals, alloys, and intermetallic compounds, are studied from a basic point of view. To understand these properties, quantum mechanical principles are employed. Frequently it is necessary to carry out preliminary experiments in order to modify oversimplified theories so that they may be applicable to the more complex materials. Increasing military exploitation of new materials necessitates such a program of research designed to develop a clearer understanding of these materials.. With emphasis on future use of nuclear facilities, it is necessary to consider radiation as a normal operating environment, and radiation damage effects will be studied.

Radiation Damage of Metals (U), RR 007-01-5409. U. S. Naval Research Laboratory, Washington, D. C.; M01-14; L. E. Steele, J. R. Hawthorne.

Investigations of the effects of nuclear radiation on the mechanical properties of metals commonly used in structural components of nuclear reactors have indicated important changes which may affect the safety of the reactor during operation.

Preliminary studies have shown that notch ductility of steels is seriously reduced after exposure to a nuclear environment similar to that of power reactors. Other mechanical properties are affected, but to a lesser extent. The degree of change depends to some extent upon the type of steel and its metallurgical history, but is determined chiefly by the physical and nuclear environmental conditions during irradiation of the metal. The objective of this project is to study the effects of nuclear radiation on various metals in view of these factors and to determine which materials are least affected by nuclear exposure. The possibilities and techniques of post irradiations recovery of properties are also being studied in the hope of minimizing radiation damage by thermal treatments.

Metallurgy of High Temperature Heat Transfer Systems (U), RR 007-01-5411. U. S. Naval Research Laboratory, Washington, D. C.; M01-12; B. F. Brown, S. W. Strauss.

Liquid metal solvents and solutes are selected on the basis of relative atomic size, relative electronegativity, and electronic structure in order to design critical experiments to detect interactions in liquid solutions and to develop models of the state of aggregation by use of densitometry. Density is determined by the direct Archimedean method modified to nullify surface tension effects (by use of twin suspensions) and the significance of the density data is interpreted by calculation of partial molar volumes as a function of composition and temperature.

Principles of Casting Metals (U), RR 007-01-5412. U. S. Naval Research Laboratory, Washington, D. C.; M02-03; E. A. Lange.

The aim of this task is to establish scientific information required for the technology of melting and casting of metals. This involves continuing research concerned with melting practices, gating and risering systems, mold media, and solidification mechanisms to improve the physical properties, mechanical properties, dimensional qualities, and reliability of castings. Also, exploratory studies are conducted concerning low-cycle fatigue with the aim of developing a method for defining and evaluating the mechanical systems involved in specimens, models, and full size structures and of determining the mechanical and metallurgical changes under known mechanical systems.

Metallurgical Studies of Cast Metals (U), RR 007-01-5413. U. S. Naval Research Laboratory, Washington, D. C.; M02-06; R. A. Meussner, G. Sandoz.

The addition of a small amount of sodium to aluminum-silicon alloys during melting produces a remarkable change in the solidification characteristics, the resulting microstructure, and thereby the mechanical properties of the material. The changes in the solidification characteristics were studied by thermal analysis and controlled solidification experiments, the structural changes by special metallographic techniques and by electron microscopy and X-ray diffraction of extracted phases.

The results have shown that the nucleation and growth of the silicon phase dominates the eutectic transformation in the modified alloys as well as in the untreated binary material. Although the 6° to 8°C depression of the eutectic temperature is reproducible, this effect is nonreversible. Thus the modified structure is produced under metastable conditions. The extreme stability of this non-equilibrium state was demonstrated experimentally.

The amount, composition, distribution, and morphology of carbides are known to control the properties of many ferrous materials, but there is only limited knowledge of the properties of the carbides themselves; therefore, studies of the thermal stability and mechanical properties of alloy cementite and other carbides were carried out.

The results show that iron carbide alloyed with about 15 percent aluminum is thermally stable, oxidation resistant at 2000°F, and is quite soft and ductile relative to orthorhombic cementite. Ternary ferrous alloys containing more than 50 percent of the carbide are ductile and are also oxidation resistant at 2000°F. Ternary iron-aluminum-carbon alloys containing nearly 100 percent of the carbide are oxidation resistant but not ductile, probably because of non-ductile films at the grain boundaries.

Fundamental Study of Weld Joint Behavior (U), RR 007-01-5414. U. S. Naval Research Laboratory, Washington, D. C.; M03-01; P. P. Puzak.

This task was established to investigate factors which determine the performance of weldments and particularly to investigate the initiation and propagation of fractures in weldments and machinery components as related to Naval structures.

Controlled conditions of temperature, strain rate, and stress geometry are correlated with mechanical properties of the various weld zones and materials for the determination of factors which predispose failure.

Magnetic Phenomena (U), RR 007-01-5416. U. S. Naval Research Laboratory, Washington, D. C.; P02-01; M. A. Garstens.

Equipment for both laboratory and military applications frequently depends on a basic understanding of magnetic phenomena. The powerful techniques of electron and nuclear magnetic resonance have been used to study these phenomena and thereby to learn more about the structure of matter. The program in double resonance has continued with emphasis on the "double effect" (which is of importance in the operation of rf analogs of the maser) in charred sucrose as a function of amount of adsorbed water vapor and partial pressure of oxygen. The spin echo technique has been applied to a study of self-diffusion in phosphorous. An investigation of nuclear resonance in antiferromagnetics has been initiated. Work in electron spin resonance has continued on sucrose chars and on paramagnetic ions in cyrstals.

Ferromagnetism, RR 007-01-5417. U. S. Naval Research Laboratory, Washington, D. C.; P02-02; G. T. Rado.

In order to gain a general understanding of the mechanism of magnetization and to survey the magnetic properties of ferromagnetic materials, careful and reliable experimental data on various basic quantities are needed. These quantities include saturation magnetization, magnetocrystalline anisotropy, magnetostriction, exchange stiffness, relaxation frequencies, spectroscopic splitting factors, and crystalline electric field parameters. Recent studies of anisotropy have opened the way toward obtaining magnetic oxides whose anisotropy can be specified in advance. Further advances in understanding the resonance line widths of ferrites and garnets have been achieved.

Physical Metallurgy of Refractory Metals (U), RR 007-01-5418. U. S. Naval Research Laboratory, Washington, D. C.; M01-16; B. F. Brown, G. Sandoz, R. A. Meussner.

The refractory metals and alloys upon which advances in high temperature capabilities will depend are presently unusable because of inadequacies in strength, oxidation resistance, or toughness. The current emphasis is upon (a) improving the reliability of the zinc coating for protecting columbium alloys against oxidation, (b) endeavoring to increase the temperature capabilities of this type coating, (c) fully defining the fundamentals of this protection mechanism, and (d) exploring alternate ways of protecting columbium in the range 2000° - 2500°F.

Investigation of Refractory Metals Processing (U), RR 007-01-5419. U. S. Naval Research Laboratory, Washington, D. C.; M01-17; R. W. Huber, I. R. Lane, Jr., W. A. Reaves, Jr., E. J. Chapin.

Columbium will be alloyed with such elements as may be useful in promoting or improving the effectiveness of protective coatings.

Columbium and tantalum will be alloyed with such elements as may provide elevated temperature strength by solution and by precipitation strengthening.

Refractory metals including columbium, molybdenum, tantalum, and tungsten will be investigated to develop alloys for high temperature environmental applications. Areas of study include high vacuum arc melting and casting, electron beam melting, fabrication by hot working procedures, and the determination of properties.

Metals and Alloys, WR 007-01-001. NOL, White Oak; RRMA 02 008/212; RRMA-41.

To develop the wide variety of functional materials required in electronic, electrical, magnetics, and acoustical equipment. To improve the capabilities of current materials, and to develop new materials with performance characteristics superior to those of any currently known materials. Included are the metals and alloys required for ballistic protection of weapons systems and personnel.

A series of investigations on specific types of materials is in progress. Current emphasis is on magnetic materials development and on study of the effects of environmental conditions on the properties of currently available materials.

Metallurgical Mechanisms (U), SR 007-01-0850. David Taylor Model Basin, 10169/61.2411, A. R. Willner (735); Lehigh University, NObs 78589, Dr. R. Stout; Rensselaer Polytechnic Institute, NObs 78813, Dr. E. Nippes; Battelle Memorial Institute, NObs 78540, P. J. Rieppel.

A program was initiated to study the effects of transformation products, impurities and composition variation on the mechanical properties of high yield steels. Study has been concentrated on HY80 in attempt to resolve fabrication problems through insight to metallurgical mechanisms; however, study will not be limited to HY80.

Contracts have been initiated with Lehigh, Rensselaer, and Battelle. Most of the material has been procured and experimental work is being conducted. A program at DTMB for study of both high and low chemistry HY80 at the 80 ksi level is nearing completion. Effects of varying percentages of tempered isothermal products and tempered martensite on the mechanical properties of the steel have been determined experimentally. Effects of chemistry, impurities and austenitic grain size on toughness have been investigated.

Work at Battelle concerns the determination of the basic mechanisms responsible in the cracking of restraint weldments. Preliminary work indicates that liquation is responsible for hot crack initiation. Grain boundry composition is being determined. Some laboratory size heats have been prepared in which controlled variation of composition is made to study effects of each element on mechanical properties and weldability.

Mechanical Properties of Iron-Base Alloys (U), SR 007-01-0852. NEES, 10101/61.2411, R. Niederberger; MATLAB, Welding Development Section, 10171/61.2411, I. Stern (Code 984).

Requirements for deep submergence, ultra-high pressures, and weight limitations in submarine hulls, pressure vessels and certain machinery

components are necessitating new design concepts involving much greater stresses and strains, including plastic deformation. These new design concepts require a knowledge of the more "unusual" properties of structural materials. Extensive experience and investigation has confirmed the necessity for using the explosion bulge test as a criterion for investigations of welded joints intended for use in Naval Ships.

As a result of the explosion bulge test being accepted as a standard and valuable test, a site has been established at the Naval Ammunition Depot, Earle, Red Bank, New Jersey under management of MATLAB. During this report period numerous explosion tests were conducted at Naval Weapons Laboratory, Dahlgren; however, tests have now been discontinued at this laboratory.

Tensile and impact properties of HY80 extrusions (T-Bars) which had been cold bent to the circular configuration of submarine frames were determined. The objective was to determine the magnitude and importance of the Baushinger effect resulting from the cold bending operation.

A contract was completed with Republic Steel and delivery was recently made on a series of experimental steels based on HY80 composition with five purity levels with regard to sulfur, phosphorus, gas and tramp elements.

Work is underway to correlate weldability, mechanical properties, time-temperature-transformation characteristics, and microstructure to impurity level. It is anticipated that greater control of impurities will result in an alloy with a markedly improved combination of weldability, ductility and strength level for structural applications.

Another area of current investigation concerns mechanical properties, including strain cycling at normal and elevated temperature, as affected by various heat treatments that lead to temper embrittlement. The primary interest is in heavy-plate materials, such as A-302 steel, which are used for pressure vessels containing nuclear reactors; however, hull steels such as HY100 are also included in the study.

Explosion bulge tests have been scheduled for various 2" thick welded assemblies in HY80 steel which have been fabricated at the Material Laboratory in connection with studies of the weldability of heavy sections of HY80. In addition, tests have been scheduled for heat treatable HY80 weldments and weldments in HY80 castings.

Steel Processing and Fabrication (U), SR 007-01-0853. NEES, 10101/61.2411, R. Gross; MATLAB, 10171, I. Schwartz (Code 981), S. Goldspiel (Code 982); DTMB, 10169, A. Willner (Code 735); Westinghouse Research Laboratory, NObs 78823, J. Heuschkel.

Work hereunder is directed toward increased realization of the mechanical properties of steel through controlling the effects of processing and fabricating techniques. The quantitative effect of cold bend forming of structural steel known as the Baushinger effect, the effect of normalizing on notch-toughness properties of various steels, the effect of inclusions and lattice vacancies on weldability, ductility and strength of structural steels, etc., are to be investigated. Such information will be applicable to the improvement of present ship steels and to the development of new steels of increased fabricability and better able to meet service requirements.

During this report period an investigation was completed to determine loss of mechanical properties in HY80 steel at 80 ksi and 100 ksi yield strength levels caused by the Baushinger effect. Various stress relief treatments to overcome the Baushinger effect were investigated. Westinghouse was established as the prime contractor on a project aimed at development of a weldable 150,000 psi yield strength material. A literature survey of previous, related developments has been subcontracted to Battelle Memorial Institute. Plans were completed which will enable award of a contract for procurement of experimental steels based on HY80 composition, but treated with columbium and rare earths.

A report is in preparation on a study of the Baushinger effect on structural steel. Arrangements are being made to initiate a coordinated program between NEES, MATLAB, DTMB, Battelle Memorial Institute, Babcock & Wilcox Company, Westinghouse Research Laboratory, Lehigh University, and Rensselaer Polytechnic Institute for investigation of the improvement in weldability of HY80 plate attainable through rare earth and columbium additions. Production size heats of steel will be obtained and work will involve tensile, impact, drop weight and explosion bulge properties, weldability studies, hot ductility experiments, study of isothermal transformation characteristics, and macro and micro constituents. Exploratory work is underway in development of base line properties of a 150,000 psi yield strength material for pressure hull application. Data are being developed on low and high chemistry HY80, STS, T-1, QT35, and various commercial electrodes which will serve as future comparison and provide guidelines in the contemplated development of a new material. In addition a comprehensive study of heat flow and thermal cycles encountered in the ar. welding process is being conducted. These data will be applied in improved welding processes. The literature study underway at Battelle will provide a history of the related developments previously recorded.

Ultra-High Strength Iron Alloys (U), SR 007-01-0854. NEES, 10101/61.2411, M. Gross; DTMB, 10169/61.2411, A. Willner (Code 735).

This task involves investigation of metallurgical and welding characteristics and mechanical properties of ultra-high strength iron base alloys (140 KIPS and higher) to determine their suitability for use in ships structures and machinery. Emphasis is placed on the effects of impurities and interstitials and the types of melting practices on the properties of the alloys and weldments of same. The various hardening mechanisms are investigated. Changes in phase transformation temperatures and time temperature transformation characteristics for hardening mechanisms are correlated with impurity and interstitial contents.

Laboratory size heats of an HY80 base steel with four different purity levels has been purchased from the Republic Steel Corporation. Meetings with International Nickel Company have laid ground work for investigation of an ultra-high strength Fe/Ni alloy by Navy laboratories when

the material is available.

Weldability of Metals and Alloys (U), SR 007-01-0855. U. S. Naval Research Laboratory, PO-1-0001, P. Puzak; MATLAB, 10171/61.2411, I. Stern; NEES, 10101/61.2411, H. Siegel; Babcock and Wilcox Company, NObs 84169, R. Wylie; Battelle Memorial Institute, NObs 72425, P. Rieppel.

Information relative to the various factors which influence weldability is essential in fabricating structures with acceptable properties. Research is performed to accomplish the following objectives: (1) Develop weld fabrication procedures, parameters, and tests; (2) Develop welding wires and electrodes; and (3) Determine the effects of variables in the mechanical properties and metallurgical characteristics of the weld and base metals. Generally, work under this task is concerned with known welding processes, and the application of those processes.

Fatigue of Iron Base Alloys (U), SR 007-01-0856. MATLAB, 10171/61.2411, L. Stern, H. Cordaino; University of Illinois, NObs 77137, Professor Muncy; NEES, 10101/61.2411, R. Gross.

Plastic strain fatigue, and low-cycle high stress fatigue studies are made of iron base alloys used in ship structures. The plastic strain fatigue studies are aimed at understanding the phenomena involved under conditions of plastic loading such as are encountered at stress concentrations in large structures. The low-cycle high stress fatigue work is aimed at providing statistically sound data that can be correlated with tests of large scale structures, thus providing an economical and quick method for obtaining design data. Large and small specimens of the base metals and of various welded configurations are tested.

Radiation Damage of Metals (U), SR 007-01-0858. U. S. Naval Research Laboratory; PO-1-0001; L. Steele, J. Hawthorne.

With the advent of nuclear power in submarines and surface craft, it became necessary to study the effects of neutron irradiation on weld and base metal properties. Specimens of A212B, A302B, A201, HY80, and T-1 are prepared and inserted in suitable reactor facilities and irradiated for various times and flux densities. Irradiated specimens are tested for mechanical properties using hardness, tensile, charpy, and drop-weight tests to determine changes in properties resulting from irradiation exposure. Post-irradiation heat treatments are conducted to study possibilities of recovery of mechanical properties through annealing.

Drop weight and charpy-V impact tests were conducted on irradiated samples of each of the materials listed above. A definite correlation between results of the two tests was noted in samples irradiated in 20 different reactor experiments. A plot of the results indicated a definite upward shift in transition temperature. This was true of all results plotted irregardless of type, thickness or degree of irradiation. The results of HY-80, however, had not been plotted.

Effects of annealing on impact properties of irradiated samples were studied. Good recovery of impact properties was noted in samples which were irradiated at temperatures below 400°F. At higher irradiation temperatures, recovery through annealing is less pronounced.

Development of Iron Base Castings (U), SR 007-01-0859. U. S. Naval Research Laboratory, contract not issued, E. Lange; MATLAB, 10171, S. Goldspiel.

New ways are constantly sought to reduce shipbuilding costs, yet to maintain or improve the quality of structures. A great potential savings is at hand if high strength steel castings can be developed to replace components now being fabricated by forging and/or machining. Developmental work is required to realize the full potential of castings in submarine and other critical applications. Production of HY80 castings by shell mold and sand casting techniques is under consideration.

Pioneer work with the shell mold process resulted in the development of a procedure for producing 30" P.T. Boat propellers of 410 CRES. Some work has been done in applying the SM process to turbine blades. The necessary tolerances have not been achieved, however. Large HY80 submarine hull insert castings (approx. 1000#) have been produced by the General Steel Castings Company. One such casting, produced in a sand mold, survived underwater explosion testing.

Cast HY80 plate specimens produced by General Steel Castings are presently undergoing explosion bulge tests. Very limited work is being done in shell mold development. A specification covering HY80 castings for submarine application is in preparation by the Bureau.

Aluminum and Magnesium Alloys (U), SR 007-01-0701. NEES, 10101/61.2411, F. Sutton; MATLAB Welding Development Section, 10171/61.2411, I. L. Stern (984).

This task is designed to develop information on lightweight alloys suitable for use in Naval construction. Emphasis is placed on aluminum alloys because of increased interest in their use for shipboard machinery and structures, including submarine hulls, and because of availability, low cost, and high strength to weight ratio.

The static and fatigue properties of butt welds in aluminum alloys in current use have been determined by MATLAB and compared with equivalent base plate properties. Recommended values for static joint properties in these alloys have been reported. Explosion bulge specimens have been prepared for and subjected to tests by the Naval Research Laboratory. Marine atmosphere corrosion and stress-corrosion properties of a series of aluminum alloys for flight deck and jet-exhaust deflector applications have been determined by EES. These alloys were prepared by Cornell Aeronautical Laboratory. Major progress was made on a long-time marine corrosion and stress-corrosion exposure program on a series of commercial and experimental aluminum alloys of the high-strength non-heat-treatment variety. These were prepared by Kaiser and Alcoa, and were being tested over a 50-year span after both natural and artificial aging treatments.

Copper Alloys (U), SR 007-01-0702. MATLAB Casting Development and Foundry Control Section, S. Goldspiel (982); NEES, 10101/61.2411, J. L. Basil, L. Williams; Armour Research Foundation, NObs 77020, D. Simcue.

Copper alloys are widely used in the Navy; however, there exists a lack of basic information which is needed before alloy developments and applications can proceed on a rational rather than empirical basis. This lack of information extends into areas, such as fatigue, corrosion fatigue, stress-corrosion, notch properties, effects of plastic strain, fracture, etc. The objective of this task is to work on problems of this type within selected areas, and to develop, test, and evaluate improved Cu-base alloys for marine service with considerations of (a) higher strength, (b) fabricability, (c) strategic element content, (d) heat treatment, (e) corrosion resistance, and (f) as applicable, pressure tightness and cavitation erosion resistance.

Two areas of investigation were active during this reporting period. One of these was a major effort culminating in the marine exposure of approximately 1600 specimens representing all the cast and wrought copper-base alloys, in various treatments and tempers, that would be of interest in Naval applications. About 62 alloys and treatments were involved. These were exposed at various stress levels to determine stress-corrosion tendencies. Half of the specimens were removed in November 1960 (after one year exposure) and visual, microscopic and residual tensile property examinations were started. The remaining specimens were left in test for a second year of exposure.

Analysis of results from these exposure tests should provide a significant fund of information toward the intelligent use of copper alloys in marine environments.

The other active copper-alloy investigation was based on previous observations which indicated that a marked increase in sea-water corrosion-erosion resistance might be obtained if about 1.5% aluminum were added to copper-nickel alloys. This idea was followed up by having special condenser tubes manufactured from aluminum-bearing 90-10 and 70-30 copper-nickel alloys. Model condensers containing these and conventional tubes were put in test during this reporting period. Water velocities up to 20 ft/sec. were employed, in the expectation that at least a 50% increase in maximum design water velocity would prove feasible for Navy condensers, thereby reducing weight and space requirements. Preliminary examinations after several months of operation have shown the aluminum-bearing tubes to be definitely superior; however, much longer exposure times will be required before the test can be terminated for final destructive examination. The mechanical properties of the tubes have been determined and reported.

Nickel and Cobalt Alloys (U), SR 007-01-0703. NEES; 10101/61.2411; P. Sacharov, M. R. Gross.

Numerous material problems involving special corrosion, wear or magnetic characteristics in addition to good mechanical properties are often solved by the use of nickel or cobalt alloys. Examples are nuclear plant equipment, unprotected outboard shafting, submarine sea-connection fittings and bolts, etc. However, there is little information on some of the properties which influence behavior at high design stresses, under notch and high impact conditions, and in certain specialty applications. The objective of this task is to develop the types of information needed to allow safe use of these alloys in modern ship and machinery design.

One minor assignment was completed during this reporting period. This was an investigation of the corrosion resistance of Hastelloy cladding on steel, which showed that corrosion resistance was not impaired when the material was subjected to the heating cycles common to the fabrication and heat treatment of steel.

Titanium Alloys (U), SR 007-01-0704. David Taylor Model Basin, 10169/61.2411, A. R. Willner (735); MATLAB Welding Development Section, I. L. Stern (984).

Theoretical calculations indicate that on a strength-weight basis titanium alloys of 120,000 psi yield strength and higher can advantageously be used for the hulls of deep-diving submarines. The fabricability, weldability, notch toughness, and other properties of these alloys need to be investigated to allow determinations of the practicability and economics of their use.

Literature on the properties of titanium alloys has been reviewed. Compressive yield, charpy impact, NRL drop-weight, TMB fracture impact, notch-tensile and explosion bulge tests have been conducted on specimens from nine plates of titanium.

Creep studies are underway. Attempts are being made to correlate explosion-bulge and drop-weight tests with fracture impact and notch-tensile tests. Development of welding techniques is underway. Effects of transformation products on notch sensitivity is under study.

High Temp Electronic Metals (U), SR 007-01-0705. Engelhard Industries (H. A. Wilson Division), NObs 77085, V. Mooradian; Westinghouse Electric Company, NObs 77041, S. Rosecians.

Development of guided missiles and high speed aircraft as well as nuclear powered propulsion systems have brought about a need for materials for electronic components such that the components will function at high temperatures. For the particular application the target was 500°C for 3000 hours operation while maintaining a minimum tensile strength of 100,000 psi, and a maximum resistivity of 9 micro-ohm cm. The program was designed to meet current requirements, and was monitored by the Bureau of Ships for the Bureau of Naval Weapons and the Air Force.

The contracts with Engelhard and Westinghouse were completed during this report period. Several commercially available materials were evaluated as well as special materials. Tensile strength target requirements were met by some of the commercial materials e.g. Inconel 718. A special alloy of Mo-0.5% Ti cold worked 85% was found to meet all of the target requirements except for resistivity. This latter alloy, however, was subject to oxidation at 500°C and exhibited brittleness. Numerous copper-palladium alloys were able to meet minimum requirements, however, exhibited brittle characteristics at elevated temperatures.

Miscellaneous Metals, and Special Characteristics of Metals Including Wear, Fretting (U), SR 007-01-0706. NEES, 10101, W. Smith; Ampco Metal, Incorporated, NObs 77015, R. Maersch.

This task includes development and evaluation of miscellaneous non-ferrous metals and alloys not classified elsewhere. Work on lead, solder, manganese alloys, etc., is included. In addition, the special problems of metal and non-metallic wear, such as in journals, bearings and gears is considered with and without lubrication.

Studies were completed during this report period to establish load ratings for various combinations of gear and pinion alloys including various bronzes and steels at different hardnesses. The effects of microstructure, microhardness and corrosion susceptibility of constituents and alloys have been evaluated in an attempt to assess basic causes for wear of metals under various conditions of loading and lubrication.

Materials for Special Chemical Environments (U), SR 007-01-0707. NEES; 10101; R. Niederberger.

The need for handling special materials aboard ship requires development and evaluation of alloys and metals with unusual characteristics. Special fuels and oxidizer such as concentrated H_2O_2 when handled in bulk have created serious material problems both from the standpoint of contamination and deterioration of the container. Many material problems in regard to fuel cells have to be considered, such as compatibility of materials with electrolytes, electrodes, and reaction products and catalyst materials.

A final report on metallurgical factors affecting usefulness of aluminum alloys and stainless steels for systems handling concentrated hydrogen peroxide was issued.

Investigations of the many materials problems associated with fuel cells of the regenerative types, two stage magnesium oxygen type and hydrocarbon type as well as others will be initiated. Catalyst development will be considered.

Gas Turbine Materials (U), SR 007-01-0811. NEES; 10101; L. Williams.

The project was initiated to develop and evaluate alloys suitable for gas turbine service. The current requirements are 10,000 hours service at 1550°F under a design stress of 20,000 psi. Developmental approach was through minor compositional variations of a Cr-Ni-Mo alloy and stainless steel, and minor additions of Cb, W, Ti, B, and Al. Effect of melting practice on mechanical properties was also considered.

The project has been inactive during this report period. During the previous period, contract NObs 77019 with Cornell Aeronautical Laboratory to investigate effects of minor composition changes and minor additions on the mechanical properties of Cr-Ni-Mo alloys was completed. Stress rupture properties of dispersion strengthened austenitic stainless steel were investigated and reported.

It is planned to investigate the optimum proportion of nickel to chromium in very-low-carbon iron-nickel-chromium alloys, also the effects of varying amounts of W, Mo, V and others in improving high temperature properties.

Metals for High Temperature Service, SR 007-01-0812. NEES, 10101, L. Williams; BUSTDS, 1700S-591, L. Wyman; BUSTDS, 1700S-553, H. Logan.

A need exists for development of improved high temperature material particularly for application to lighter weight higher pressure steam piping, to high temperature bolting, and to superheater tube supports.

A project was active at BUSTDS during this report period. High temperature corrosion tests were conducted on a 60/40 Cr-Ni base alloy having Ti additions varying from 1 to 5%. The effectiveness of the various compositions in resisting corrosion due to sodium vanadate in the ash of residual fuel oils was reported.

Studies of the role of titanium in hindering oil ash corrosion of this type is continuing.

It is proposed to investigate the effects of melting practice on the mechanical properties of the 60/40 Cr-Ni alloy. It is believed a more ductile material capable of being fabricated by extrusion and forging processes can be developed.

Residual Stresses (U), SR 007-01-0851. NEES, W. L. Williams; MATLAB, H. V. Cordiano.

This program was initiated at NEES to obtain data and develop procedures wherein residual stress patterns, either inherent or applied, could be used to improve the performance of machinery components used aboard ship.

This program has been inactive since last report period at which time load carrying capacity under rolling contact and fatigue strength of nitrided gears was reported.

A program is under consideration to study residual stresses in structural shapes. It is proposed to evaluate the Baushinger Effect by means of measuring strain/load relationships in structural shapes such as T-Bars and H-Bars and scaled submarine hull sections.

Non-Magentic Metals (U), SR 007-01-0711. NEES, 10101/61.2411, F. Sutton, M. R. Gross; American Steel and Wire Division, U. S. Steel Corporation, NObs 76310, H. Bernstein.

This task was set up to develop and evaluate alloys and prototype parts of nonmagnetic or feebly magnetic metals (permeability of 2 or less in weak fields) that could be used under essentially the same conditions as magnetic metals. The principal use of these materials would be for nonmagnetic minesweeper applications. The task is being terminated in Fiscal Year 1961.

(1) Completed and reported an investigation which demonstrated that an Inconel steam generating coil, from a nonmagnetic auxiliary minesweeper boiler, suffered no serious deterioration during extended operation at NBTL. The previous use of stainless steels for this application had led to serious stress-corrosion cracking and ultimate boiler breakdown within 1000 hours of operation.
(2) Completed and reported on tensile and magnetic permeability tests of nonmagnetic "Tenelon" alloy wires and wire ropes made under Contract NObs 76310. The material was satisfactory for the intended service trials in minesweeping applications.

Sonar Transducer Magnets (U), SR 007-01-0717. Naval Ordnance Laboratory; 10175/61.2411; John F. Haben.

To improve sonar it is necessary to develop or improve a magnetic core material for a high power, broad band, variable reluctance sonic transducer.

Such a core material should have a high flux density at low bias magnetizing forces with a high incremental permeability and a low incremental core loss. Accordingly a program was started to study areas for possible improvement. These were (1) standardize test procedures between NEL and NOL, especially to assure reproducibility of incremental core lose data; (2) investigate the supermender cores and translate its potential for use in the variable reluctance transducer; (3) investigate other high saturation materials (including Hyperco) for suitability and (4) develop improved methods of fabricating, insulating, bonding and mounting of the transducer cores.

Techniques were developed which will allow use of supermender (50 Fe - 50 Co alloy) in a configuration suitable for a variable reluctance sonic transducer. Use of this material will allow a 25% improvement over presently used silicon iron core material.

R007-02 Ceramics and Related Inorganic Solids

Defect Structure and Properties of Corundum (U), RR 007-02-0001. University of Utah, Salt Lake City, Utah, Department of Physics; Nonr 1288(03), NR 032-168; P. Gibbs.

A comprehensive study of the imperfection structure and the properties of defects in corundum (alpha-Al_2O_3) is being carried out. The dislocation structure of as-received, deformed and heat-treated corundum single crystals is being investigated by dislocation etching techniques. To obtain additional information concerning the defect structure, and to establish the relationships between the imperfection structure and the electrical, mechanical, optical and surface properties, studies have also been undertaken on the electrical conductivity, photoconductivity, dielectric loss, internal friction, creep, optical properties and ion emission of both pure and doped Al_2O_3 single crystals. The growth and properties of macroscopic crystals, as well as whiskers and thin films of corundum are also being studied.

Solid State Reactions in Ceramic Systems (U), RR 007-02-0003. University of California, Berkeley, California, Division of Mineral Technology; Nonr 222(68), NR 032-314; J. A. Pask.

The techniques of high-temperature X-ray diffraction and thermogravimetric analysis were used to study the mechanism and kinetics of solid state reactions such as the reactions between alumina and magnesium fluoride and between aluminum fluoride and titanium dioxide. The reaction, potassium carbonate and ferric oxide to form K_2O Fe_2O_3 was also investigated by means of the weight loss method, with emphasis on the effects of particle size and shape of the reactants on the reaction kinetics. The study of the solid state reaction between $BaCO_3$ and TiO_2 to form barium titanate ($BaTiO_3$) has been completed.

Structure and Properties of Glasses (U), RR 007-02-0004. Rutgers University, New Brunswick, New Jersey, School of Ceramics; Nonr 404(15), NR 032-319; H. T. Smyth.

An attempt has been made to develop a mathematical theory which relates the physical properties of glasses to their atomic or ionic constitution and structure. In its present state of development, the theory allows certain predictions to be made regarding the effects of the concentration and size of modifying ions on the visco-elastic behavior of simple glasses, and on their elastic (Poisson's ratio), stress-optical, dielectric and infrared absorption properties. These predictions have been tested experimentally.

Structure and Properties of Metal Borides (U), RR 007-02-0006. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Physics; Nonr 839(12), NR 032-414; B. Post.

A comprehensive study of the crystallography of the isostructural borides of the transition and nontransition metals is in progress. Electrical and thermoelectric properties, as well as crystal structure, are being determined. Work is continuing on the determination of the structure of the new tetragonal form of boron.

A parallel effort is being devoted to the rare earth borides and a group of compounds have been prepared of the composition MB_x (where x = 4, 5 or 12) in order to determine their structure and physical properties.

Plastic Deformation and Fracture of Inorganic Solids (U), RR 007-02-0008. Materials Research Corporation, Yonkers, New York; Nonr 2432(00), NR 032-427; E. S. Machlin, G. T. Murray.

A study is being made of the factors which control or determine the flow and fracture characteristics of brittle inorganic solids. At present an attempt is being made to determine the source of the limiting resistance to dislocation motion and crack propagation in rock salt type structures. Single crystals of MgO are being purified by solid state electrolysis and the yield stress, flow stress and elongation are being measured as a function of temperature and purity. Similar measurements are being made on both vacancy hardened and annealed crystals and on crystals which are subjected to an applied voltage during the tests.

Sintering Phenomena in Ceramic Systems (U), RR 007-02-0009. University of Notre Dame, Notre Dame, Indiana, Department of Metallurgy; Nonr 1623(06), NR 032-429; G. C. Kuczynski.

This task involves a fundamental study of the phenomenon of sintering in ceramic systems. Information is being sought on the kinetics and mechanism of sintering and on the detailed nature of the diffusion processes which occur during sintering. For this purpose the theoretical and experimental techniques previously developed by the chief investigator will be employed.

Mechanical and Thermoelectric Behavior of Inorganic Solids (U), RR 007-02-0010. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Department of Physics; Nonr 760(16), NR 032-437; R. Smoluchowski.

The stress-strain behavior and mechanical properties of various non-metallic solids are being investigated in relation to the defect structures of these materials as deduced from X-ray studies, etch pit and dislocation decoration techniques,

optical absorption and precision density determinations. In the alkali halides, relationships are being sought between the mechanical behavior and the lattice binding energy and/or the ratio of cationic and anionic radii. The annealing kinetics of lattice defects introduced by plastic deformation at both high temperatures (vacancies only) and low temperatures (vacancies and interstitials) are also being studied. The electronic nature of the dislocations in alkali halides and its influence on the mechanical properties will also be investigated by studying the mechanical behavior of crystals while subjected to ionizing radiation. The thermoelectric power of silver halides and alkali halides is also being examined theoretically.

Thermoelectric Properties of Semi-conducting Compounds (U), RR 007-02-0011. General Mills, Incorporated, Minneapolis, Minnesota, Mechanical Division; Nonr 1589(14), NR 032-439; H. Soonpaa.

To evaluate the potentialities and limitations of bismuth tellurium sulfide (Bi_2Te_2S) as a thermoelectric material for power generating or Peltier cooling devices, a study is being made of the electrical and thermal properties of this material. Thermal and electrical conductivities of melt-grown single crystals are being measured as a function of temperature both parallel and perpendicular to the (0001) cleavage planes. Based on the results obtained with stoichiometric crystals, methods will be sought for decreasing the lattice thermal conductivity and thus raising the figure of merit of the material.

Crystal Chemistry at Elevated Pressures (U), RR 007-02-0012. Pennsylvania State University, University Park, Pennsylvania, Department of Geophysics and Geochemistry; Nonr 656(20), NR 032-441; R. Roy.

This task is devoted to a study of the crystal chemistry of inorganic solids at high pressures and temperatures. A systematic investigation of the crystal structures, compositions and stabilities of the phases which exist in simple oxide, sulfide and halide systems involving highly-charged cations is now in progress. The effects of pressure on the size and polarizability of the constituent ions is being investigated. A study of any reversible polymorphic changes which may occur in these systems at elevated temperatures and pressures has also been undertaken. Continued attempts are also being made to develop new or improved high pressure apparatus (up to 150,000 atm. at 600°C). Techniques for determining certain properties of materials (e.g., electrical conductivity, crystal structure) under the actual pressure-temperature conditions imposed are also under development.

Diffusion in Semiconducting Compounds (U), RR 007-02-0013. Yale University, New Haven, Connecticut, Department of Metallurgy; Nonr 609(34), NR 032-444; J. B. Wagner, Jr.

The diffusion of both lead and sulfur in single crystals of lead sulfide is being studied using tracer techniques. One aspect of this work is concerned with diffusion under conditions of controlled stoichiometry. The second aspect is related to diffusion under conditions of controlled valency through additions of mono- and tri-valent cations.

Mechanism of Growth and Properties of Oxide Whiskers (U), RR 007-02-0014. Horizons, Incorporated, Cleveland, Ohio; Nonr 2619(00), NR 032-446; C. G. Harman.

This task has involved a study of the factors affecting the growth of Al_2O_3 whiskers from the vapor phase, an investigation of the factors which control the growth of ZrO_2 and SiO_2 fibers from colloidal suspensions, and a determination of certain physical and mechanical properties of these whiskers and fibers. Among the properties evaluated were creep behavior at elevated temperatures, polygonization characteristics and elastic strain prior to fracture as a function of whisker diameter. As a direct result of this work, a technique was developed for reproducibly forming alumina whiskers of tensile strength up to 3,000,000 psi.

Preparation and Properties of Oxide Single Crystals (U), RR 007-02-0015. Stanford Research Institute, Menlo Park, California, Department of Chemistry; Nonr 2620(00), NR 032-447; F. A. Halden.

The main objectives of this task are to develop techniques for the preparation of high-purity single crystals of refractory non-metallic materials (i.e. oxides, silicides, borides, nitrides, etc.) and to evaluate some of the chemical, structural and physical properties of these crystals.

Crystals are being grown by a modified Verneuil technique using a double arc image furnace as a heat source. Attempts are being made to establish the optimum conditions (i.e. temperature gradient, heat flux, furnace atmosphere, powder feed rate, purity of feed powder, etc.) for growing crystals of controlled purity, stoichiometry and structural perfection.

Deformation and Fracture of Cermets and Ionic Solids (U), RR 007-02-0016. Minneapolis-Honeywell Regulator Company, Hopkins, Minnesota, Research Center; Nonr 2456(00), NR 032-451; C. H. Li, T. L. Johnston, R. J. Stokes.

A study is being made of the inter-relationships between plastic flow and fracture in magnesium oxide single crystals and related ionic compounds. The stresses required to activate slip dislocation sources and to move dislocations through the lattice are being evaluated. Also the factors governing the deformation and fracture of dispersed phase systems, such as cermets, are being investigated.

Transport Properties of Refractory Metal Oxides (U), RR 007-02-0017. Northwestern University, Evanston, Illinois, Department of Metallurgy; Nonr 1228(16), NR 032-459; E. Greener, M. E. Fine.

The defect structures and transport processes which occur in refractory metal oxides are being investigated by X-ray and acoustic relaxation techniques, and by electrical measurements of various types. Among the oxides studies are those of vanadium, niobium, tantalum, molybdenum, and tungsten.

An attempt is being made to establish the limits of the homogeneous single phase fields for the thermodynamically stable oxides and to determine the nature of the defect structure from measurements of the X-ray lattice parameters and density as a function of composition. The transport numbers of electrons and ions are being determined by DC electrolysis experiments. The electrical

conductivity is being measured as a function of temperature to determine the electronic energy levels and activation energies for electronic or ionic transport.

Thermoelectric Properties of Ionic Crystals (U), RR 007-02-0018. Dartmouth College, Hanover, New Hampshire, Department of Physics; Nonr 2799(00), NR 032-460; R. W. Christy.

Measurements are being made of the thermoelectric power of AgBr doped with Ag_2S in concentrations up to 0.1% at temperatures between room temperature and 400°C. The results are analyzed with the aid of the theory developed by Liddiard and Howard; this analysis is expected to yield information concerning the temperature dependence of the heat of transport and heat of formation of vacancies as well as the association of defects with impurities. The thermoelectric power of alkali halide single crystals (NaCl, KCl and KBr) which have been electrolytrically colored will also be measured at temperatures between room temperature and roughly 300°C; these measurements are being made as a function of the F-center concentration, as determined from optical absorption data, and should give important information about the thermal ionization of F-centers.

Effects of Plastic Deformation on the Electrical Properties of Semiconductors (U), RR 007-02-0019. Battelle Memorial Institute, Columbus, Ohio; Nonr 1870(00), NR 032-462; A. C. Beer.

A detailed study of the influence of plastic deformation and subsequent annealing on the electrical characteristics of indium antimonide is being carried out. The changes in etch pit or dislocation density produced by deformation are being determined and the effects of subsequent annealing treatments on the electrical characteristics and etch pit density are also being investigated. Similar experiments are being performed on crystals which are subjected to fatigue (i.e. reversed bending) and torsional deformation.

High Temperature Physical Properties of Ceramic Materials (U), RR 007-02-0020. Alfred University, Alfred, New York, Department of Ceramics Engineering; Nonr 2407(00), NR 032-022; W. B. Crandall.

The purpose of this work is to study the nature of high temperature heat transfer in ceramic materials by measuring the surface heat transfer coefficient, Biot's modulus and thermal diffusivity at several temperatures up to 2000°C on Al_2O_3, BeO, MgO, and TiO_2. Thermal diffusivity is being determined by a method based on measurements of internal friction and by other methods.

Properties of Materials at High Temperatures and Pressures (U), RR 007-02-0021. Harvard University, Cambridge, Massachusetts, Department of Metallurgy; Nonr 2496(00), NR 032-400; F. Birch.

This task involves exploratory work on the behavior of solids at high pressures and high temperatures. In particular, changes in the physical behavior, structure and properties of materials subjected to high pressures and temperatures will be evaluated. The possibility that polymorphic transitions may be induced in certain materials by high pressures and temperatures will also be investigated. Attempts will be made to synthesize new materials which either do not exist in nature or are found in only minute quantities.

High Temperature Thermodynamic and Crystallographic Properties of Oxides and Borides (U), RR 007-02-0022. University of Kansas, Lawrence, Kansas, Department of Chemistry; Nonr 2760(00), NR 032-452; P. W. Gilles.

The crystallographic, physical and thermodynamic properties of various intermediate phases in a number of refractory metal-oxygen and metal-boron systems were investigated. This study included the oxides of titanium, molybdenum and tantalum and tantalum borides. Powder diffraction and single crystal X-ray techniques were used for the Crystallographic studies. Heats and entropies of vaporization and other thermodynamic properties were derived from vapor pressure measurements which were carried out by the Knudsen effusion or Langmuir techniques.

Nuclear Magnetic Resonance Study of the Structure of Glass (U), RR 007-02-0023. Brown University, Providence, Rhode Island, Department of Physics; Nonr 562(26), NR 032-463; P. J. Bray.

Nuclear magnetic resonance techniques are being used to study the structure of glasses and to obtain fundamental information concerning the type of chemical binding and degree of order in the glass network. The resonances from a large number of atomic nuclei will be investigated in both binary and ternary glasses of various compositions. From the splittings of these resonances by electric quadropole effects, specific information about the bonding and positions of the atoms in the glass structure is being derived.

Plasticity and Fracture of Ceramics (U), RR 007-02-0024. Northwestern University, Evanston, Illinois, Department of Metallurgy; Nonr 1228(17), NR 032-464; J. O. Brittain.

The objective of this task is to study the plasticity and structure of ceramics as influenced by the interaction of dislocations with other imperfections, i.e., other dislocations or point defects such as solute atoms, vacancies, etc. Experimentation is directed toward the determination of such properties as creep, grain boundary sliding and fracture, yielding and strain aging characteristics, delay time for the initiation of plastic flow and internal friction in ceramic materials. The determination of the relationship between these properties and structure is a major objective of this experimental program.

Ceramics/Inorganic Solids (U), WR 007-02-001. Naval Ordnance Laboratory, White Oak; 07 212; RRMA-33.

To develop and expand the capabilities of ceramics and related inorganic solids in such areas as high temperature refractory compounds and coatings, radome and infrared materials, semi-conductors, radiation detection systems, thermo-electric materials, dielectric and magnetic materials.

Research will be pursued to further define the dependency of properties on composition and body structure, and other fundamental phenomena. various compositions and combinations will be explored,

developed and evaluated. Manufacturing techniques and processes will be developed and evaluated.

Previous development work has resulted in the utilization of materials such as alumina for radome and structural applications. Past evaluations indicate advantage may be gained by improving purity and/or structural configurations of material now in use. Novel processing and controls have also imparted material improvements to the product. An examination of dense ceramic coatings having superior rain erosion resistance has been undertaken. Preliminary models of radomes constructed with dense outer skins and foamed cores have been produced. A series of infrared window materials have been evaluated to establish transmission, absorption, reflection and emission characteristics.

Refractories (U), SR 007-02-0980. Naval Boiler and Turbine Laboratory; Mr. J.F. Kelly, Mr. R. Burt.

Refractory materials are being reduced in quantity but not eliminated in naval marine boilers of modern design. The present trend is toward high temperature resistant materials of unique characteristics.

Ceramics (U), SR 007-02-0981. Contractor, Contract and Principal Investigator, to be determined.

Lack of adequate impact resistance has prevented use of dense polycrystalline ceramic materials in many high temperature applications beyond the temperature use limit of metals or alloys. Additional fundamental knowledge is needed concerning the attributes of ductility and crystal structure defects in dense ceramic materials.

R007-03 Organic, Polymeric and Fibrous Materials

Tropical Woods (U), RR 007-03-0001. Yale University, New Haven, Connecticut, School of Forestry; Nonr 609(13), NR 330-001; G. A. Garratt.

A broad program of physical and chemical research on wood is conducted, utilizing the unique collection of Tropical American woods which was accumulated in the earlier phases of the task. Each academic year, thesis topics are selected by predoctoral candidates. Currently the topics being investigated include toxicity of wood extractives, properties of wood fibers, experimental veneer cutting.

Resilience of Textiles (U), RR 007-03-0002. Textile Research Institute, Princeton, New Jersey; Nonr 090(01), NR 330-005; J. H. Dillon.

This contract provides support for the Institute's studies on the relationship of the molecular structure of textile fibers to the properties of the fabrics made therefrom. The current program includes the effects of temperature changes on the X-ray diffraction patterns of stressed and unstressed filaments, the response of crimped fibers to dynamic strains, and the resilience of woven fabrics as a function of yarn and fiber properties.

Wool in Navy Fabrics (U), RR 007-03-0003. Fabric Research Laboratories, Incorporated, Dedham, Massachusetts; Nonr 1422(00), NR 330-035; W. J. Hamburger.

A systematic experimental investigation of the properties and characteristics of yarns and fabrics made from blends of wool with other fibers. Nylon and viscose rayon are used as the admixture fibers because these two are not only in wide use as blendents, but represent extremes in fiber characteristics.

Organic--Polymeric--Fibrous Materials, WR 007-03-001. Naval Air Material Center, RRMA 03 015/200, RRMA-3; Naval Ordnance Laboratory, White Oak, RRMA 03 071/212, RRMA-34; National Bureau of Standards, 19-61-8002-Weps, RRMA-3.

This task is directed toward the synthesis, development and evaluation of new and improved elastomers and textiles having substantially better performance capabilities than existing materials; also the isolation and definition of new polymers having merit for compounding superior plastics and adhesives, as well as elastomers and textiles.

The approach embraces supporting research on polymers and polymerization processes, developmental effort predicated on pertinent new scientific findings, and evaluation of new materials bearing on task objectives.

As a result of past development work, some promising new approaches for development of high temperature elastomers have been devised. Supporting research has partially explored the possibilities of inorganic composities as an approach to the high temperature (1000°F) elastomer problem and several sub-tasks have been undertaken on new polymer systems and polymerization techniques.

Cordage Fibers (U), SR 007-03-1011. Material Laboratory, Boston Naval Shipyard; 10283 RDT&E 61.2411; L. J. Sheehan.

Since September 1958, the Navy has been converting steadily from manila rope to nylon rope, especially in sizes ranging from 1½ miles circumference up through 9 inches circumference.

Service tests conducted by COMSERVLANT indicate the feasibility of utilizing nylon in lieu of manila rope for purposes such as jigger tackle, riding lines, saddle whips, highlines, guess warp, etc.

The Laboratory has been authorized to conduct exploratory studies and tests of propylene fiber and yarn and evaluation of polypropylene ropes of linear, branched, and cross-linked polymers.

For deep mooring operations, it is proposed to study effects of marine organisms on fiber and rope finishes and the effects produced therefrom.

Techniques and Mfg. Wood Products--Characteristics (U), SR 007-03-1004. Puget Sound Naval Shipyard, 10292 RDTE 61.2411, Wm. Miles, Rollo England; U.S.F.S. Dept. Agric. For. Prod. Laboratory, 1700S-669-60, J. A. Liska; Washington State Inst. of Tech., NObs 78267, Dr. Ben Jayne; New York State College of Forestry, NObs 78605, Dr. Richard Pentany.

Structural wood laminates and marine plywoods for ships and boats have been developed in lieu of scarce solid timbers for many Navy applications. Development research in characteristics of materials, improved fabrication and testing techniques have been carried on to expand the process to new materials and to reduce costs.

Laminating properties of additional species and treated woods have been evaluated and specification requirements ascertained for selected woods and treatments having special characteristics adapted to ship and boat use. Fatigue properties of laminated red oak in dry, wet and cyclic exposure disclosed this species to be equal to white oak in strength. Characteristics of molded composite plywood construction show that strong light weight corrosion and rot proof materials can be developed for use as hydrofoils and small boat hulls. Boat hull plywood from veneers treated with preservative before bonding have been produced in the laboratory, and in one commercial production, (British).

Studies to develop mechanical design criteria for curved and straight wood laminates are continuing. Laminating properties of white oak treated with decay, fire and marine borer resistant preservatives were determined. A reliable nondestructive short test for scarf joints in wood laminates was determined. A specification for plywood made from pretreated veneers was developed on the basis of production and laboratory testing techniques. Such plywood has a bond essentially equivalent to that obtained with untreated veneers.

Shipbuilding Woods--Physical, Mechanical, Chemical Characteristics (U), SR 007-03-1005. U.S.F.S., Dept. Agric. For. Prod. Laboratory, 1700S-669-60, Dr. Herb Fleisher.

Testing and evaluation of foreign and domestic woods has provided basis for greater availability and reduced cost of these materials for ship and boat use. Steam bending characteristics and improved bending techniques were developed as a basis for revised specifications and standards. Weight data for submerged wood hull materials are being determined as a basis for better design and service performance.

Application techniques and specifications for readily available woods suitable for marine use were developed. Moisture content gradient in wood is being determined from both field survey and laboratory tests under typical exposure conditions for Navy craft, i.e., fully submerged, water on one side only, well ventilated, poorly ventilated, sealed end grain, painted surfaces, to ascertain methods of improving performance.

Data are being analized and will be reflected in appropriate manuals, and standards.

Modification of Natural Wood Properties to Improve Characteristics for Shipbldg (U), SR 007-03-1006. U.S.F.S., Dept. Agric. For. Prod. Laboratory, 1700S-669-60, Dr. R. M. Lindgren; NAVSHIPYD Puget Sound Mat. Laboratory, 10292 RDTE 61.2411, Wm. Miles, Rollo England; Wm. F. Calpp Laboratories, NObs 78875, Dr. A. P. Richards.

Decking materials as well as new marine borer, decay, and fire retardant treatments have been evaluated at several test sites.

Evaluation of materials on decking test panel continued, also new marine borer, decay, and fire retardant treatments at several test sites. Tributyl tin oxide preservative treatments have shown promise as both marine borer and decay inhibitors in initial exposure tests.

New test specimens representing various woods, treatments, materials and fastenings are being evaluated. Fire retardant characteristics are also being sought thru testing. Exposure of potential combination treatments is continuing.

Characteristics of Wood Structures for Marine Use (U), SR 007-03-1007. NAVSHIPYD Puget Sound, 10292 RDTE 60.2401, Wm. Miles, Rollo England; Forest Products Laboratory, 1700S/669-60, Fred Werren.

Structural panel deck for wood hull ships developed. Laminated white oak high strength fully closed ring constructed and tested. Outline of a wood ship and boat manual on fasteners prepared. System of wood block decking available commercially adapted for use on submerged LSD ship deck and trial installation specifications developed.

System of treated wood block decking available commercially for land (factory floor) installation, adapted thru minor modifications for use on submerged LSD ship deck; trial installation specifications developed.

Modification of structural panel deck developed for use in minesweeper hulls.

Development of High Polymers (U), SR 007-03-1000. Material Laboratory, New York Naval Shipyard, 10171 RDT&E 61.2411, B. B. Simms; Material Laboratory, New York Naval Shipyard, 10171 RDT&E 61.2411, C. K. Chatten; U. S. Rubber Research Center, Wayne, New Jersey, NObs 84025, Dr. Clide I. Carr; Reaction Motors, Thiokol Chemical Corporation, NObs 78416, Dr. Marvin M. Fain.

It is generally recognized that metal-modified polymers offer potential thermal stability at temperature ranges above 500°F. Thermal stability is also imparted to certain polymers by the inclusion of so-called "high temperature anti-oxidants," as studied by the U. S. Rubber Research Center. Investigations have indicated that polymers are affected by certain polar liquids and high pressure gases. These volume changes and changes in strengths of the polymers are noted. Certain packing and seal applications make necessary the development of materials with improved surface lubricity.

Lead modified silicone elastomer materials have been prepared which show stability in the 600-700°F range. The materials prepared to date are non-elastomeric. The U. S. Rubber Research Center has made crosslinked polyethylene and ethylene-propylene rubber quite stable to atmospheric oxygen by the addition of combinations of antimony oxide and organic halides. Tests at the New York Naval Shipyard indicate that certain fluorocarbon elastomers may be compounded to reduce the swelling effects of high pressure oxygen, air and polar liquids. Graft polymerization techniques by Quantum Incorporated on an in-house basis, indicates that the coefficient of friction of natural rubber may be considerably reduced by the attachment of fluoro-carbon groups to the surface of vulcanized elastomers. The Reaction Motors Division of the Thiokol Chemical Corporation has prepared a number of boron chemicals which have good high temperature and reasonably good electrical properties as monomers.

Structural Plastics (U), SR 007-03-1008.

Material Laboratory, New York Naval Shipyard, 10171 RDTE61.2411, Mr. R. R. Winans, Mr. A. R. Allison; Boston Naval Shipyard, 10283 RDTE60.2401, Mr. B. H. Tytell; Puget Sound Naval Shipyard, 10292 RDTE61.2411, Mr. W. Park; Norfolk Naval Shipyard, 10288 RDTE60.2401, Mr. W. Francis.

Reinforced plastics have found wide acceptance as structural materials for naval use. Emphasis on weight reduction, particularly in connection with deep submergence and hydrofoil applications, has created a demand for more versatile, dependable, higher strength vs weight and higher modulus vs weight materials. These materials are needed to meet increasingly severe operational requirements for which conventional materials of construction are proving marginal or inadequate.

New types of reinforcements and resin modifers have been evaluated. Techniques for curing large G.R.P. structures using ultraviolet radiation have been developed. Means for minimizing erosion of glass reinforced plastic have been suggested. Integral anti-foul gel-coats show promise but require further investigation.

Basic studies are being conducted on mechanisms of failure in glass reinforced plastic laminates. Emphasis is on high strength, filament wound materials for use in deep submergence structures. Test methods are being investigated. Optimum materials are being developed and studies are being conducted to determine performance characteristics. Study of the erosion resistance of glass reinforced plastic is continuing. Reinforced plastic coatings for protection of aluminum from sea-water corrosion are being subjected to long-term immersion tests. Lightweight sandwich panels are being evaluated in comparison to panels of equal weight constructed of wood, aluminum and steel.

Structural Plastics Design (U), SR 007-03-1009. New York Naval Shipyard (Material Laboratory), 10171 RDTE 61.2411, Mr. R. R. Winans; Forest Products Laboratory, 17005-635-60 Amend 3, Mr. K. Boller; Philadelphia Naval Shipyard, 10290 RDTE 61.2411, Mr. C. Furtaw.

There has been increasing interest in the use of reinforced plastics in naval applications. Since these are comparatively new materials it is necessary to develop information on design characteristics, design procedures and design limitations. This information must also be compiled into a form suitable for use by the naval architect and engineer.

The Material Laboratory has investigated shear properties of reinforced plastic panels made of two different materials. Experimental results have been obtained from buckling of these square panels and correlation made with mechanical properties of the laminates. Data on fasteners and joining techniques have been collected into a "Design Manual for Joining Structural Plastics". Short term "Prot" tests have been completed at the Forest Products Laboratory and checked for correlation with long-term loading test results.

The Philadelphia Naval Shipyard is gathering all available design data and is revising and simplifying the preliminary "Design Manual for Glass Reinforced Plastics" to make it more useful to the marine designer. Long-term loading tests are continuing. Studies are being continued to acquire new knowledge in the areas of fatigue of structural connections, pull-through strength of fasteners, watertightness of joints, and use of adhesives for joining. The scope of the fastener design manual will be increased as new knowledge is developed.

Structural Plastics--Quality Control, SR 007-03-1010. New York Naval Shipyard, Material Laboratory, 10171 RDTE 60.2401, Mr. R. R. Winans, Mr. A. R. Allison; Forest Products Laboratory, 1700S-635-59 Amend 3, Mr. J. M. Black.

Glass reinforced plastic materials have been assuming a larger role in Naval applications each year. These materials are being used in an increasing number of engineered structures which require materials having specified strength characteristics and uniform, dependable quality. Workmanship has been found to be an extremely important factor in obtaining acceptable reinforced plastic products. Thus, quality control and inspection procedures were established in a Bureau inspection manual for reinforced plastics. Destructive test techniques are completely inadequate and, also, too costly for assuring the quality of large glass reinforced plastic structures. The Bureau has, therefore, sponsored work for some time, on non-destructive test methods. Numerous methods such as dielectric measurements, beta and gamma backscatter techniques, sonic tapping, dye penetrants, ultrasonics, and light (infrared, ultraviolet, and white) have been investigated. To date most of the methods studied have drawbacks which limit their field use.

The Bureau's reinforced plastic inspection manual was revised and has been readily accepted by industry. A surface gauge for reinforced plastics has been developed.

The Bureau is currently endeavoring to develop a means for obtaining greater dependability in in-process quality control and for final inspections. Investigations of new automated fabrication techniques and equipment is continuing. Automatic continuous filament winding processes which can be used to fabricate high strength laminates will be investigated more fully. Automation should provide the means for obtaining greater dependability in in-process inspection. Ultrasonic techniques are being further evaluated for non-destructive testing. A new surface roughness gauge is also being developed.

Foam Plastics (U), SR 007-03-1013. Material Laboratory, New York Naval Shipyard, 10171 RDT&E 61.2411, R. R. Winans; Industrial Test Laboratory, Philadelphia Naval Shipyard, 80290/RDN59.91, J. Alpert.

There exists a need for cheaper and more efficient insulation. New materials with lower "k" factors, lighter weight and lower installed costs are necessary for such insulation.

The development of materials with high strength to weight ratio, good impact resistance and low cost installation capabilities are needed to get the reduction in weight and cost and improvement in design desired in structural applications.

New materials are required to remedy the following deficiencies of the preformed polystyrene currently used for flotation: (I) - incomplete void filling due to inaccessible areas - (II) high cost of installation and (III) lack of resistance to

gasoline and diesel oils.

Polyurethane and polyethylene semi and rigid foams have been evaluated for thermal conductivity and other physical properties. Results indicate these materials may be useful for thermal insulation applications below 200°F where fire retardance is not mandatory. The polyurethane foams appear very promising and are being service evaluated in submarine refrigerator spaces.

The physical and mechanical properties of polyurethane and polystyrene foams have been evaluated. The polyurethanes are especially suited for sandwich construction by virtue of their high strength to weight ratio. They are now specified for use as sandwich cores in boat construction and for filling submarine structural voids such as transition cones, stabilizers and diving planes. Tests on urethane foams and other foams in underwater explosion protection systems have been successful.

Materials and techniques for making a large scale installation of rigid, low density polyurethane foam in a Liberty Ship were investigated. Results of the study indicated that halocarbon blown urethanes had satisfactory buoyancy and mechanical properties, and, in addition, could be installed at lower costs than pre-molded blocks of polystyrene foam.

Submarine Periscope Bearings & Seals (U), SR 007-03-3820. NAVENGRXSTA; 72002; R. Ward.

Low torque, tight-sealing seals are required that are capable of sealing an axial keyway existing in some submarine periscopes.

Conventional periscope seals and packings were investigated to establish a reference level. Several new seal designs were tested with little if any improvement.

An Electric Boat seal design modified in accordance with U. S. Naval Engineering Experiment Station recommendations is currently undergoing evaluation tests. Present plans are to install this seal in an active ship upon completion of the evaluation tests.

R007-04 Composite Materials

Composite Materials, WR 007-04-001. Forest Products Laboratory, 09 881, RRMA-3; NOL White Oak, 09 212, RRMA-3; NWL Dahlgren, 09 210, RRMA-32; National Bureau of Standards, 09 050, RRMA-3.

This task is directed toward the development of superior structural sandwich systems, reinforced materials, transparent and other composites, and more effective utilization thereof to serve a broad range of applications in Naval weapons including the structural electronic, propulsion and optical fields.

The approach encompasses the elements of supporting research, fundamental materials studies, development including component materials as well as composites produced therefrom and methods therefore, evaluation, and the development and accumulation of design data.

As a result of past development work, composite constructions with improved strength/weight ratios, greater heat resistance and improved durability have been made available for use in aircraft and guided missiles. The various types of sandwich construction comprise one of the most thoroughly exploited classes of composite materials. Other developments are based on the use of fibrous reinforcements glass fibers reinforced plastics being one important type. Significant advances have been made in the structural properties of glass fibers and techniques for procuring superior fiber based composites. Contributions to a better understanding of the fundamentals of composites have been made. Improved transparent composites have been evolved.

Flame Resistance and Toxicity of Plastics (U), SR 007-04-1016. United States Testing Company, NObs 78898; Bureau of Mines, Central Experiment Station, 1700S-579, L. B. Berger.

The close confinement of electrical and electronic equipment aboard submarines and other vessels has increased, and a great interest exists in burning properties and the toxicity of gases emitted by burning dielectric and insulating plastics. The arc ignition method of determining flammability of plastics developed by the Bureau of Mines several years ago has been used for several years to determine the flammability and toxicity of burning plastic materials. Many plastics have been evaluated since the Bureau of Mines started its work in 1945.

The Bureau of Mines has tested the flammability and toxic characteristics of a large number of plastic materials in the form of molding compounds and laminates which represent all of the important chemical polymer types. This information has been used as a guide in selecting dielectric and electrical material aboard naval ships.

Contractual arrangements have been made with the United States Testing Company to acquire testing equipment for the performance of flammability and toxicity tests formerly run by the Bureau of Mines. The test equipment will be quite similar to that developed by the Bureau of Mines so that continuity will be maintained with comparable results. This work at the Bureau of Mines has been concluded.

It is planned to continue this work so that new and improved polymer types may be examined. This will consist of the examination of polymers in qualification testing as well as the evaluation of experimental materials.

Insulation For Thermoelectric Generators (U), SR 007-04-1049. Material Laboratory, New York Naval Shipyard, H. K. Graves; Contractor to be selected.

Problems arising from the development of thermoelectric generators point to the need of an electrical insulation material for thermocouples which will permit the flow of heat. The material must be thin (a few thousandths of an inch), preferably secured to the surface of the hot plate or the module, and capable of resisting abrasion by the motion of the components under pressure. The maximum ambient of the insulation material for presently designed units is 600°C. This temperature will probably increase to greater than 1000°C in the next few years, due to demands for greater efficiency and performances.

It is planned to initiate work assignments at the New York Naval Shipyard Material Laboratory to develop and use test equipment for evaluating electrical insulating materials for thermoelectric generators. In addition, it is planned to secure a contract with a private laboratory or organization

to develop thermally conductive electrical insulation for this purpose. It is intended that materials originating from the contract will be tested at the New York Naval Shipyard Material Laboratory as required.

Embedding Dielectrics (U), SR 007-04-1050. Material Laboratory, New York Naval Shipyard, 10171 RDT&E 61.2411, H. K. Graves; Hughes Aircraft Company, NObs 84027, R. G. Brault; Synthetic Mica Company, NObs 78714, F. A. Barr & J. P. McCarthy.

Electronic circuits and electrical and electronic components must be protected from ambients such as high humidity, corrosion, vibration and shock. As a consequence, embedment of circuits and components has gained increased acceptance as a means of accomplishing this and aiding reliability. With the advent of missiles, high speed aircraft and the crowding together of components, temperature requirements of insulating materials has been vastly increased and, currently, materials are required which must perform satisfactorily at 500°C.

The embedding compound specification, MIL-I-16923, developed by the Material Laboratory, has been successfully used to discriminate between the many commercially available low temperature compounds. In preparing an engineering manual, the Material Laboratory has developed new methods for determining important handling characteristics not covered in MIL-I-16923. Tentative methods for evaluating pot life, gel time, flow, adhesion to metals, corrosion and shrinkage stresses in castings during cure have been developed. Hughes Aircraft Company has made significant progress with polysiloxane embedding materials. This achievement is based on the use of disylilbenzene as a cross-linking agent. The Synthetic Mica Company has developed an embedding system based on the bonding of particles of synthetic mica with phosphates.

High Temperature Liquid Dielectrics (U), SR 007-04-1051. Monsanto Chemical Company, NObs 78294, Mr. Lucius Gilman; Material Laboratory, New York Naval Shipyard, 10171 RDT&E 61.2411, Mr. H. K. Graves.

The unusually high thermal conditions in missiles and high speed aircraft have made it necessary to develop liquid dielectrics stable electrically and chemically at high temperatures. Work has been underway since 1958 to develop and test liquid chemicals for use in capacitors and transformers.

The Monsanto Chemical Company has synthesized a large number of liquid materials, primarily for use in capacitors. The two best candidates found in the investigation were Benzylated O-terphenyl and tetrakis (O-biphenyl) silicate.

The Material Laboratory has developed test methods and high temperature equipment to evaluate various types of liquid dielectrics. Successful measurements for insulation resistance, dielectric breakdown, dissipation factor, dielectric constant, and cubical coefficient of expansion have been made at temperatures approaching 500°C on a large number of chemical compounds.

The Monsanto Chemical Company is attempting to purify materials developed in the course of the contract so that improved electrical properties will be attained. The Material Laboratory is testing contractors' compounds and others to determine high temperature electrical properties on commercial and experimental dielectric liquids at high temperatures.

High Temperature Capacitor Dielectric Materials (U), SR 007-04-1052. General Electric Company, NObs 77070, E. C. Henry; Clevite Corporation, NObs 78108, John Koenig.

Capacitor ceramic materials are needed which will exhibit a dielectric constant of greater than 15 (preferably greater than 50) electrical resistivity greater than 10" ohm-cm, an electrical Q of 1000 or greater and an R. C. product of 5 megohm-microfarads at a minimum operating temperature of 275°C. Various ceramic materials containing Zerconium Oxide and Tin Oxide in combination with rare earth oxides have been considered candidates for such a material.

The General Electric Company has prepared a large number of materials for electrical studies. Of these, the best two compositions were equivalent to $3S_RO$, ZTa_2O_5,Z_RO_2 and $3S_RO$, $2Ta_2O_5$,SnO_2. With the exception of Q values, these materials meet the electrical properties at temperatures of 350°C. The most promising results were found with the former material. When tested for 60 hours at 300-350°C, these materials showed dielectric constants greater than 80. The Clevite Corporation has prepared capacitor materials similar to the above. The materials can be described as equivalent to $(Ba_{.97}La_{.02})$ $Z_R O_3$ $Ba_{.99}(Z_{R.98}$ $Nb_{.02})O_3$ and $La(Al_{.96}$ $Si_{.03})$ O_3. The former stood the life test successfully.

The work at the Clevite Corporation is being concluded with the completion of life testing of previously prepared dielectric ceramics. The contract mentioned above with General Electric Company has been concluded.

High Temperature Magnet Wire (U), SR 007-04-1053. Anaconda Wire & Cable Company; NObs 78320; W. W. Pendleton.

A need has existed for magnet wire which will operate satisfactorily for an extended period at temperatures ranging from -75°C to 500°C.

Magnet wire capable of 500°C service with desirable electrical properties. In addition, a specification has been developed by the Anaconda Wire and Cable Company to cover this type of magnet wire.

Methods and Slot Cell Dielectrics (U), SR 007-04-1055. New York Naval Shipyard Material Laboratory, 10171 RDT&E 61.2411, H. K. Graves.

In recent years considerable emphasis has been placed on electrical equipments which can operate at high temperatures, in smaller places, and with greater efficiency. There is a need for continuing development for new dielectrics for naval applications such as Teflon tubing and pressure sensitive tapes. There is an additional need for new methods to simplify specifications, reduce costs of testing and eliminate qualification testing.

Test work in the laboratory has resulted in the development of specifications to cover very low temperature vinyl tubing, flexible polytetrafluoroethylene tubing and slot cell insulations of the polyester type, mica paper and mica flake for applications having ambient temperatures up to 200°C.

Work is under way to investigate two types of Class F insulation thin wall polytetrafluoroethy-

lene tubing and pressure sensitive tapes.

Deck Coverings (U), SR 007-04-1056. Material Laboratory, New York Naval Shipyard; 10171 RDT&E 60.2401; A. W. Cizek, Jr.

There is a need to develop improved underlayment and nonslip deck covering materials for use in wet spaces aboard ship and on aircraft carrier flight decks.

Nonslip materials: Investigation of various materials indicated three suitable for decking and ladder tread resurfacing over wood and aluminum.

Linoleum and plastic tile: A test method has been developed to ensure that linoleum and plastic tile cements possess adequate initial adhesion.

Insulating underlayment: Laboratory test results were satisfactory on two materials, each consisting of mailable magnesite, granulated cork, and magnesium chloride solution; one other magnesite and a vinyl sponge were unsatisfactory in service.

Aircraft carrier flight deck coverings: An epoxy type flight deck compound was satisfactory in laboratory and service tests and is now in use. It gives better adhesion to wood than the standard material.

Thermal Insulation (U), SR 007-04-1057. U. S. Naval Engineering Experiment Station; Mr. R. Plate.

Recent submarine developments and resulting shipboard machinery items have introduced the need for thermal insulation with unusual properties not immediately available in conventional materials. Machinery and piping components should be provided with insulation that is extremely light in weight yet resistant to high impact shock and other adverse environmental factors.

Exploratory work has been accomplished in high temperature binders for small size samples of lightweight fibrous glass insulation for temperatures up to 500°F. An insulating system was developed under Contract NObs 77065 with Cincinnati University consisting of built-up layers of 1.3 mils thick aluminum alloy laminated with 0.2 mils diameter fibrous glass matt. This system has a thermal conductivity value of 0.42 Btu/hr/sq.ft - °F-/inch at a mean of 600°F.

Packing and Gaskets (U), SR 007-04-1058. U. S. Naval Engineering Experiment Station; Mr. J. F. Post, Mr. R. F. Stone.

Trouble-free submarine operation at intermediate depths presents a variety of problems in sealing of hull openings. Particularly critical is the need for a full-load or backup packing seal for main propulsion shaft. A failure of the mechanical seals may lead to catastrophic leakage if a backup packing type seal is not available.

Cable penetration, periscope tubes, and remote control openings will present new problems of leakage and extrusion at intermediate depths.

Problems continue to arise in the field of packing and gaskets for inboard equipment. The use of phosphate ester hydraulic fluids with present packing and gasket materials indicate the need of further study of compatibility of the fluid with materials used in the system.

Need for cryogenic liquid storage and transfer may demand a new series of sealing materials.

An automatic adjusting flax-and-rubber channel packing was developed and evaluated. The packing showed promise, operating satisfactorily between 15 through 200 psi pressure without gland adjustment.

Fifteen packings of various types were evaluated for naval hydraulic systems using phosphate ester fluid at 180°F and 3000 psi and found suitable for ram and valve stem service, for valve stem service and cup packing service.

R007-05 Structural Materials

Studies of Fracture Strength (U), RR 007-05-5450. U. S. Naval Research Laboratory, Washington 25, D. C.; Foro 3; H. L. Smith, H. A. Kies, G. R. Irwin, I. Wolock.

Work on this task has resulted in a new concept of fracture mechanics centered around a modified Griffith theory. Through applications of this concept one arrives at a fracture strength measurement and analysis procedure for avoiding crack propagation failures. This study is assisting in the analysis of several important problems such as: blow-out of transparent plastic canopies, structural failure of commercial and military aircraft, bursting of large turbine-generator rotors, and failures due to crack propagation in rocket-engine vessels such as the Polaris missile. At the present time refinements are being made which will assist in a better understanding of the role of certain parameters or features which are essential to measurements of fracture strength.

Plastic Flowing (U), RR 007-05-5451. U. S. Naval Research Laboratory, Code 6210; F01 04; J. M. Krafft, A. M. Sullivan.

This research relates to all aspects of plastic flowing in metals as influenced by composition, microstructure and conditions of testing. It is expected to provide a fundamental explanation of plastic flow processes and also to elucidate their role in the evaluation of material resistance to disturbances such as extending cracks and projectile penetration.

Critical analyses of machines used for dynamic testing have led to an improved understanding of testing machines generally (1) (2). The relationship between rate controlled processes observed in yield initiation, lower yield, and general plastic flow have been interpreted using the principals of plasticity mechanics.* The micromechanisms leading to the observed behavior have also been given consistant interpretation.

*Included in 62F01-10 in studies of yield delay time.

Structural Materials (U), WR 007-05-001. Naval Air Material Center; 10 200; RRMA-2.

This task is directed primarily toward the development, test and evaluation of new and improved metals, alloys and non-metallic structural materials required for the broad range of structural application encountered in Bureau of Naval Weapons vehicles and equipment. Strength and fabricability are primary requisites of materials in this category.

A series of specific materials development, test and evaluation investigations is being undertaken

to accomplish the necessary advancement in material capabilities. Current emphasis is being placed on development of beryllium, vanadium and titanium alloys and on ultra high strength steels.

Improved non ferrous alloys, including aluminum, titanium and beryllium have been developed which, in their respective fields, provide distinct advantages in terms of higher strength at room and/or elevated temperatures. Weldable titanium alloys displaying good creep strength and stability at temperatures up to 1200°F have been developed and are being evaluated. Berryllium is being investigated both as a high modulus, light weight material and as a filament strengthener in composite materials and ductile beryllium wire has been developed.

Survey of ABS Steels (U), SR 007-05-1996. Material Laboratory, New York Naval Shipyard; Allot. 10171; Mr. E. Imbembo.

The objective is to evaluate steels presently being supplied under ABS specifications for ship construction and those involved in cooperative work with other SSC investigators.

Charpy V-notch tests have been performed on samples of ABS steels furnished by commercial shipyards throughout the country. Work on 132 samples received before revision of ABS rules in 1956 indicated a great improvement in the transition temperature characteristics as compared to World War II steels. Results on steels made to the new rules (after Jan 1956) indicate further improvement. Experimental work is complete and final report is in preparation.

In addition Charpy V-notch, Van der Veen and Drop Weight tests are being performed on steels furnished from other SSC projects.

Metallurgical Structure (U), SR 007-05-1997. Massachusetts Institute of Technology; NObs 78541; Prof. Morris Cohen.

The objective is to determine the influence of metallurgical structure on the brittle behavior of ship steel.

The transition temperature of high purity iron single crystals deformed in slow tension has been measured both in the as-grown and annealed condition and after prestraining and annealing. While prestrains of 3% markedly raised the transition temperature, a prestrain of 10% had no further effect. Fracture surfaces of both single crystals and bi-crystals have been examined metallographically to determine the point of origin of cleavage. In single crystals, cleavage originates at twins, while in bi-crystals cleavage originates either at twins or at the grain boundary, more often at the latter. In prestrained and in prestrained and annealed crystals, some fractures originate at the surface.

Experiments have begun which will determine more completely the effect of prestrain on the transition temperature. Special emphasis will be placed on prestrains less than 3% and greater than 10%. Techniques for studying twins with the electron microscope, and a method for following the formation of microcracks by means of differential density measurements are under development. In addition, a study has been undertaken to examine and separate effects of cold work, microcracks, aging, and recovery on the deformation and fracture of Steel E above and below the ductility transition.

Mill Rolling Practice (U), SR 007-05-1998. Massachusetts Institute of Technology; NObs 72386; Dr. W. A. Backofen.

The objective is to determine the relationship of mill-rolling practice to metallurgical structure and properties of ship plate.

Normal-rolled and controlled-rolled plates from the same heat have been made available. Charpy V-notch and Van der Veen tests are being performed on the steels. The gross structure of the plate and conditions of anisotropy are being examined. In particular, grain size, inclusions and macro and micro fissuring are being studied to determine their relationship to fracturing. Future plans include extension of the metallographic study of fissuring by turning to electron microscopy; investigation of special plates rolled according to different controlled schedules; and consideration of a more systematic study of the temperature and time dependence of deformation, recovery, recrystallization, etc., in steel under conditions that characterize practical rolling.

Metallurgical Variables & Drop Weight Test (U), SR 007-05-1999. Battelle Memorial Institute; NObs 77113; Mr. F. W. Boulger.

The objective is to compare the influence of manganese, carbon, and other elements on behavior under different kinds of current tests, with particular emphasis on the NRL drop-weight test.

A series of seven semikilled and seven aluminum-killed laboratory steels, rolled to 5/8 inch plate at a finishing temperature of 1850°F, having comparable grain sizes and ranging in carbon content from 0.11 to 0.32 percent and from 0.30 to 1.31 percent in manganese, with a range in tensile strength from about 49,000 to 78,000 psi were subjected to Charpy V-notch and drop-weight tests. The available data indicate that: (1) an increase of 0.10 percent carbon raises the NDT 13°F; (2) an increase of 0.10 percent manganese lowers the NDT 2.7°F; and (3) aluminum deoxidation and the usual increase in silicon content lower the NDT 14°F.

Long Time Creep Of Prestressed Concrete I Section Beams (U), YR 007-05-001. NCEL; Appn:17X1319. 2514 RDT&E, Bu. Control No. 10601; S. L. Bugg.

The objective is to determine long-time creep and shrinkage of prestressed concrete I-beams under loads of various magnitude.

Tests have been under way for seven years on twenty-two 42' concrete I-beams under loads varying from dead load only to dead load plus 1.5 live loads. Measurements of strains and deflection on the beams listed above has been completed.

The first draft of the report is scheduled for the last quarter of FY 1961. Publication of the final report is scheduled for early FY 1962. Upon receipt of the final report, it is planned to terminate the task.

Prestressed Concrete To Rigid Frame Laboratory Building (U), YR 007-05-002. NCEL; Appn:17X1319. 2514 RDT&E, Bu. Control No. 10601; R. A. Breckenridge.

The objective is to determine statis strains,

long time creep, and seismic strains of prestressed, rigid frame building. The end product desired is criteria for design of prestressed concrete structures.

Data has been collected for seven years from two 100' span bents and selected roof panels of a rigid frame prestressed laboratory building. Quarterly reports have been forwarded to BuDocks. Additional seismic instrumentation was installed in the building in FY 59.

During FY 62 it is planned to take, reduce, compile and plot quarterly readings and send quarterly reports of data to BuDocks.

Prestressed Concrete Hollow Box Beams (U), YR-007-05-003. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; R. A. Breckenridge.

The objective is to determine the shrinkage and creep of long prestressed concrete hollow box beams. The end product desired is criteria for the design of prestressed concrete members.

Tests have been underway for five years on eight 42' prestressed concrete hollow box beams under loadings of various amounts. Quarterly readings are taken and the data reduced and analyzed.

It is planned to continue measurements on beams until all significant creep has occurred.

Fiber Glass Reinforcement (U), YR 007-05-005. Princeton University; NBy 8996, Appn:17X1319, 2504 RDT&E, Bu. Control No. 10696; N. J. Sollenberger.

The objective is to investigate the feasibility of using fiber glass rods as a substitute for the high tensile strength steel normally used in prestressed concrete construction.

A number of methods of anchoring the fiber glass rods were investigated, including clamped anchorages of the flat plate and Serrated jaw types, cemented metal tubes and wire sockets. The most satisfactory method found consisted simply of coating the rods with plastic and dusting with sharp sand before the plastic sets. Industry has commercially produced rods having an ultimate strength of about 170,000 psi.

In FY 61 fatigue tests to determine the percentage of the ultimate strength of a fiber glass rod which may be used as a safe working stress were conducted, creep tests of fiber glass rods subjected to a tensile stress of 50% of their ultimate strength were run, and a limited number of exposure tests to compare those reinforced with fiber glass and those reinforced with steel wire tendons were started.

Future effort will be directed toward accomplishing the objective given above following a comprehensive review of the work to date.

Investigation of Hydrophobic Cement (U), YR-007-05-006. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; D. F. Griffin.

The objective is to develop a method of rendering cement resistant to the effects of moisture during transit and storage.

The Laboratory is investigating the use of oleic acid as a means of rendering portland cement resistant to deterioration normally caused by adverse humid storage conditions. Contract NBy 3111 to produce oleic acid-treated cement incorporating tri-n-butyl phosphate as an additive was closed out because it was discovered that chemical reactions deactivated the tri-n-butyl phosphate as an air-detraining agent. Technical Note N-303, covering this portion of the project, was completed and transmitted to BuDocks in July 1957. Laboratory tests have been continued to discover a satisfactory air-detraining agent that will remain inert when mixed with dry cement. Tests of grindability of cement clinker with varying amount oleic acid are complete. Tests to determine the optimum amount of oleic acid for adequate protection of cement are continuing. Two Russian books on Hydrophobic Cement have been acquired by the Laboratory and have been translated. Explorations to discover a satisfactory air-detraining additive continued without success. Exposure tests of cement treated with oleic acid in varying amounts were continued both to completely evaluate the efficacy of oleic acid as a means of rendering portland cement resistant to sack hardening and to determine the optimum amount of oleic acid required for this purpose.

Coral Concrete (U), YR-007-05-007. NCEL; Appn: 17X1319.94 RDN, Bu. Control No. 80601; W. R. Lorman.

The objective is to develop principal criteria regarding general physical properties of coralline materials employed as concrete aggregate and to establish suitable information concerning the mix design and fabrication of coral concrete which will be of better quality than that produced heretofore.

Long Term Tests Of Concrete Exposed To Sea Water (U), YR 007-05-008. Shipyard, Portsmouth, New Hampshire; Appn:17X1319.64 RDN, Bu. Control No. 80204.

The objective is to provide support for a program of long-term tests of the deterioration of concrete piles exposed to sea water.

Study Of Epoxy Resins (U), YR 007-05-010. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; R. L. Alumbaugh.

The objective is to investigate epoxy resin formulations as a general class of material for use as: caulking compound, crack filler, sealer, and adhesive, in connection with concrete construction and masonry.

A study was conducted on the various methods available for testing materials to determine their performance characteristics. Representative materials were procured and classified according to type. Concrete and mortar test blocks were prepared in accordance with MIL-P-442. These blocks were coated with epoxy sealer or damproofing coatings as well as a few standard sealer coatings which will be utilized as comparative controls. The coated blocks are being used in weathering water absorption studies in order to determine their comparative performance as sealer coatings.

Study Of Creep In Concrete (U), YR 007-05-011. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; J. R. Keeton.

The objective is to determine the rate, magnitude and nature of deformation attributable solely to creep in concrete subjected to sustained compressive stresses in the higher stress ranges.

Salt Water Concrete (U), YR 007-05-012. NCEL;

Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; C. H. Scholer.

The objective is to develop information on the use of salt or brackish water in concrete.

Professor Scholer visited certain islands in the Pacific Ocean Area and conducted an examination and study of the present conditions and service record of certain structures built of Portland cement coral concrete in which the mixing water was either brackish water or sea water. This study indicated serious corrosion problems, one produced by buried steel electrical conduit and, to a less extent, by reinforcing.

In FY 1961, Professor Scholer, under Contract NBy 3198, made studies at Portsmouth Naval Shipyard and at the Corps of Engineers Treat Island, Maine site. Tests at NCEL utilizing 2" discs and a wet cup method were conducted to find a satisfactory method of measuring corrosion of steel embedded in concrete.

Work in FY 62 may be with Professor Scholer for European studies of salt water concrete problems. NCEL will concentrate on corrosion of steel embedded in salt water concrete or in concrete exposed to marine environments.

Wet Mix Analysis (U), YR 007-05-013. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; W. R. Lorman.

The objective is to develop a practical procedure for quality of concrete from tests made during the mixing stage.

Initial effort was directed to the establishment of an approach toward solution of the problem. A thorough literature survey was undertaken. In addition, the project engineer visited various concrete laboratories to discuss the task. The test method envisioned should be such that it can readily be performed by inspection personnel. It must also be accomplished in a short time, approximately five minutes or less, so that a batch of concrete can be rejected at once if it does not meet specification requirements.

To date, no satisfactory test procedures have been found. Several methods have been suggested, but all appear to be too sophisticated or time-consuming for field use.

Future effort will be directed toward modification of available test apparatus and development of new techniques.

Permeability Of Coral Concrete (U), YR 007-05-014. NCEL.

The objective is to determine under what conditions coral concrete, capable of inhibiting corrosion of metal therein, can be made.

Deterioration of coral concrete structures has been attributed to: salt laden moisture penetrating into the steel reinforcement, insufficient concrete cover over the metal, certain chemical reactions caused by sea water in the mix or aggregate and concrete of poor quality.

It is planned to make a comprehensive study of existing information dealing with permeability and durability of concrete. The causes and effect of spalling of concrete will be investigated. If these studies so indicate, a laboratory program to find ways of preventing moisture migration to embedded metal is planned. Integral water-proofing and cathodic protection will be considered.

R007-06 High Temperature Materials

Molybdenum and Tungsten Base Alloys (U), RR 007-06-0001. Climax Molybdenum Company, Detroit, Michigan; Nonr 2390(00), NR 039-002; M. Semchyshen, G. A. Timmons.

To undertake a broad investigation and development program of molybdenum- and tungsten-base alloys. The following specific studies are currently under way or will be carried out: (a) Molybdenum-Tungsten Alloys. A systematic investigation of the behavior of a number of selected binary alloys with respect to casting techniques, deoxidation practice, and primary working methods. Initially three binary Mo-W alloys (containing 35, 67 and 85 w/o tungsten respectively) have been selected for a general screening study and the determination of the principal mechanical properties. (b) Tungsten Base Alloys. This program is aimed toward the development of moly-free tungsten alloys. A series of tungsten alloys will be prepared, containing initially varying amounts of either Ti, Zr or Hf in conjunction with carbon or boron; the extent of solution strengthening obtainable (similar to Mo-base alloys) through alloying in the presence of a dispersed carbide phase will be closely studied. Mechanical properties (hardness, tensile strength, creep-rupture, etc.) will be determined at room temperature, 1800°F, and 2400°F.

The development effort on Mo-base alloys will continue in addition to (a) and (b). The particular effects of boron additions (vs carbon during previous studies) as another dispersed phase of strengthening quality is being explored.

Ductility of Molybdenum-Rhenium and Related Refractory Alloys (U), RR 007-06-0002. Battelle Memorial Institute, Columbus, Ohio; Nonr 1512(00), NR 039-003; R. I. Jaffee.

Molybdenum-Rhenium alloys containing about 35 atomic percent rhenium exhibit an unusual and highly desired combination of properties, namely good high temperature strength, excellent room temperature ductility and good workability. An explanation for the outstanding ductility of these alloys was sought together with related studies to see if other additions to Mo exhibit a similar effect. One mechanism explored was based on the suggestion that Re alters the chemistry and surface tension relationship in such a way that oxides no longer appear at the grain boundaries thereby preventing brittle inter-granular fracture.

Specifically, this program was aimed at determining (chiefly with an electron microprobe) the composition and structure of the O_2-containing phase of Mo-Re alloys, their plastic deformation behavior using high purity single crystal, and the effects of alloying elements on twinning and oxide distribution. The influence of interstitial elements (mainly O_2) in their relationship to Re and other substitute elements affecting the strength of grain-boundaries received particular attention. The mechanism of an observed decrease of O_2 solubility in rhenium alloys was explored further through the addition of small amounts of elements which have been shown to lower the hardness of

Molybdenum; these included Co, Ni, Al, Fe, Cr and Si. The effectiveness of these additions individually or in alloy combination were studied.

Properties of Niobates and Oxidation of Niobium Base Alloys (U), RR 007-06-0003. Ohio State University, Columbus, Ohio, Department of Metallurgy; N6onr 22528, NR 039-005; R. Speiser, J. W. Spretnak.

The structure, stability and physico-chemical properties (i.e. density, thermal expansion characteristics, volatility, etc.) of binary, ternary and quaternary niobates have been investigated at elevated temperatures. The data obtained are useful as a basis of selection of (a) niobium-base alloy compositions which form self-regenerative, protective oxide scales and (b) alloy compositions which, when used as coating materials, will protect more reactive metals such as molybdenum, tungsten and their alloys against oxidation at elevated temperatures.

Specific investigations, based on initial results obtained with certain Nb-Binary alloys, have been carried out on the oxidation behavior and mechanism of oxidation of Nb-Zr-Ti ternary alloys at 1000-1400°C; particularly the principal effects of Ti-additions. These ternary alloys have shown, thus far, remarkable oxidation resistance above 1000°C and nonspalling behavior of the oxide upon cooling. The effects of various volatile oxides, e.g. WO_3, MoO_2, etc., on the oxidation rate of Nb-Zr-Ti including the nature and properties of the protective oxides have been carefully studied. The results from these and related oxidation studies have been systematically extended to the investigation of other Nb-ternary alloys.

Metallurgy at High Temperature (U), RR 007-06-0004. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1841(28), NR 039-007; N. J. Grant.

This research program was aimed at determining the factors which influence the deformation and fracture behavior of metals and alloys at elevated temperatures. In particular, the relationships which exist between the composition, structure, etc. of heat-resistant alloys and their strength properties at high temperatures were investigated. The following specific studies were carried out: (a) the effects of solid solution and second phase strengthening of metals at elevated temperatures. A series of Ni-base binary alloys of both the solid solution and two-phase type was evaluated; specifically, the mechanism of alloy strengthening as influenced by alloy composition, solubility limits, etc., was investigated. As a corallary, the cause for observed second phase weakening (resulting in interphase cracking) was investigated; (b) the deformation and fracture behavior of pure Ni under conditions of high temperature and varying strain rates. In particular, the role of cold work and substructure size on the properties of nickel were emphasized; (c) the mechanism and mode of interaction between local strain hardening and annealing effects, influencing deformation behavior and recovery during creep. Resistance measurements and creep behavior were simultaneously recorded to obtain evidence regarding the first sites of deformation in creep, i.e., grain boundaries or grains. Aluminum and aluminum alloys were used in these studies.

Relation Between Structure And Properties Of Cermets (U), RR 007-06-0005. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1841(24), NR 039-008; J. T. Norton.

The purpose of this task was to study the structure of cermets as influenced by the methods of preparation and heat treatment and the effect of the resulting microstructures upon mechanical properties. This program, now complete, was aimed toward a better understanding of the effects of the binder metal composition and other variables which influence the surface energy of the hard constituent of the metal matrix and thus the microstructure. The experimental aspects (involving WC and various binder metals) were aimed to study the effective solution mechanisms and kinetics of reactions of crystalline phases during liquid phase sintering.

A limited effort was devoted to the important study of grain boundary diffusion. This involved the selection of a bi-crystal of known orientation which was subjected to the diffusion of a second element under controlled conditions. Diffusion rates and composition gradients were determined with the aid of a modified electron microbeam analyzer.

Strength Of Two Phase Alloys (U), RR 007-06-0006. Brown University, Providence, Rhode Island, Division of Engineering; Nonr 562(19), NR 039-028; J. Gurland.

The objective of this task was to determine the extent to which the strength properties of two-phase alloys are influenced by the properties of the dispersed phase. The work was conveniently divided into two parts: (a) a theoretical survey of the factors affecting the mechanical behavior of two phase alloys which arise as a result of the introduction of a second phase, (1) the inherent physical and mechanical properties and structural variables of the constituent phases (2) the interaction between phases, i.e., plastic constraint offered by the dispersed phase, the roles of thermal stresses and interphase boundaries and stress concentrations; (b) an experimental study of the deformation of two phase alloys. Specifically the effect of the second phase on the physical properties (i.e., yield strength, strain hardening capacity, fracture strength) of the composite alloy was studied. Work on the deformation behavior of WC-Coalloys was extended to other hardening constituents, to examine their interaction with a ductile matrix, using silver or any of the refractory metals. Physical and mechanical property determinations, including stress distribution, were carried out by X-ray diffraction and metallographic techniques.

Investigation Of The Me-Zr-Ti-O Phase Diagrams (U), RR 007-06-0007. University of Cincinnati, Cincinnati, Ohio, Department of Metallurgy; Nonr 2168(02), NR 039-032; M. Hoch.

The purpose of this task is the investigation of the Me-Zr-Ti and the Me-Zr-Ti-O alloy phase diagrams (in which Me can be e.g. molybdenum,

niobium, or another transition metal) and the oxidation resistance of such alloys. Presently, the Mo-Zr-Ti and Nb-Zr-Ti system is being investigated. The ternary phase diagram for the temperature range of 700-1500°C is being calculated from the known binary diagrams to determine the region of phase boundaries. From the general shape of the ternary diagrams, the quaternary Mo-Ti-Zr-O system is being established from both experimental data and theoretical calculations. The interaction between oxides of molybdenum and niobium and Ti-Zr-O, and the possibility of forming a ternary mixed oxide, is receiving particular attention. Promising alloy compositions will undergo a critical oxidation evaluation which will include a determination of the nature of the oxide scales.

Low Temperature Brittleness of Refractory Metals (U), RR 007-06-0008. General Electric Company, Schenectady, New York, Research Laboratories; Nonr 2614(00), NR 039-051; J. R. Low.

An experimental and theoretical investigation of the low temperature brittleness of refractory body-centered-cubic metals, particularly tungsten, is currently under way. Special emphasis is being placed on the effect of impurities on the gross physical properties and on the effect of grain size on the macroscopic ductility.

Ultra-high purity tungsten single crystals are being prepared by a floating-zone electron bombardment melting technique. Known quantities of interstitial impurities are being added and the proportional limit, yield strength and ductility are being determined as a function of the impurity content. Using the so-called scratch-bend technique, the dislocation mobility in suitably-treated tungsten crystals at room temperature, a study will also be made of the influence of atmosphere pinning on dislocation behavior.

Strain anneal techniques are being used to obtain polycrystalline samples having various grain sizes from initially pure single crystal specimens. The effect of grain size on the macroscopic ductility will then be studied to determine whether the ductility improves with decreasing grain size as is the case for iron. It is planned to extend this work also.

The Structure And Effects Of A Dispersed Phase On The Creep Behavior Of Metals (U), RR 007-06-0009. University of Michigan, Research Institute, Ann Arbor, Michigan, Chemical & Metallurgical Engineering; Nonr 1224(29), NR 039-065; R. A. Flinn.

This task, now completed, related to the mechanism and kinetics of creep in dispersion hardened alloys. High purity Ni-Cr-Al alloys were used as a model, in which the structure and the principal strengthening effects of a dispersed phase, of the composition Ni_3X (X being the variable from pure Cr to pure Al) were critically analyzed; this particularly in the absence of other precipitates, e.g. carbides, nitrides, borides, etc. The principle aim in this study was to establish a correlation between the composition (including size and distribution) of the precipitated phase and its effect upon elevated temperature strength properties.

High Temperature Properties And Alloying Of The Platinum-Group Metals (U), RR 007-06-0010. Battelle Memorial Institute, Columbus, Ohio; Nonr 2547(00), NR 039-067; R. I. Jaffee.

The purpose of this task is to investigate the high temperature properties and alloying behavior of the platinum-group metals and alloys. Studies are being directed in particular toward the metals osmium, iridium, rhodium and ruthenium to determine their high temperature strength, deformation behavior and resistance to oxidation. The following specific studies are under way or will be initiated: (a) fabrication of Ruthenium and Osmium--including an evaluation of electron beam zone-refining techniques, (b) mechanical properties of the Platinum-Group Metals--determination of room and elevated temperature strength properties and ductile-brittle transition behavior, (c) modes of deformation using Single Crystals, (d) physical properties of Platinum-Group Metals--i.e., of melting points, emissivity, vapor pressures, etc., (e) oxidation behavior of Platinum-Group Metals--the identification of oxidation products formed, and (f) alloying behavior--metallurgical structure, mechanical properties, fabricability and oxidation behavior of alloys of the Platinum-Group Metals are being screened. Promising alloys will be subject to more detailed investigation, in which both solute and interstitial elements will be included.

Thermodynamic Properties Of Titanium And Other Compounds (U), RR 007-06-0012. Department of Commerce, U. S. Bureau of Mines, Berkeley, California; NAonr 174-53, NR 039-073; K. K. Kelley.

Low-temperature heat capacities and entropies of various titanium halides are being determined at temperatures down to 50°K; the compounds being studied include $TiCl_2$, $TiCl_3$, $TiBr_2$, $TiBr_3$, $TiBr_4$, TiI_2, TiI_3 and TiI_4. The high-temperature heat content or enthalpy of these same substances is being determined at temperatures up to about 1800° K. The pure halides used in this work were prepared by the National Bureau of Standards under this task. In addition, the above measurements are being carried out on a series of high temperature and rare metal compounds, e.g., columbium, tantalum, germanium, gallium, etc., including some in the rare earth group.

High Temperature Materials, WR 007-06-001. Alloyd Research Corporation, Nuclear Corporation, Aeroprojects, Incorporated, Massachusetts Institute of Technology, Armour Research Foundation, Climax Molybdenum Corporation, Battelle Memorial Institute, Carborundum Corporation, Syracuse University, New England Matts Laboratory, Wah Chang Corporation, Lockheed Aircraft Corporation, Southern Research Institute, Fansteel Metallurgical Corporation, Westinghouse Electric Company, Universal Cyclops Steel Corporation, Sylvania Electric Company, The Martin Company, University of California, General Electric Corporation; RRMA-22.

This task is directed toward development and evaluation of the new and inorganic materials required primarily for those applications in propulsion systems and auxiliary equipment in which temperatures in excess of about 1500°F are encountered. A series of specific materials development, test and evaluation investigations is being undertaken to accomplish the necessary advancement in

material capabilities. Current emphasis is being placed on development of refractory metals and on exploitation of the dispersion hardening mechanism.

R007-08 Corrosion, Deterioration and Protection

Fundamental Corrosion Studies (U), RR 007-08-0001. Ohio State University, Columbus, Ohio, Department of Metallurgical Engineering; Nonr 495(11), NR 036-006; M. G. Fontana.

This task is concerned with research on the mechanism of stress corrosion cracking and with the nature and mechanism of passivity and passivation treatments. In the study of stress corrosion cracking attention is being concentrated on the effects of structure and composition on the initiation and propagation of cracks; measurement of cracking rates; measurement of energy absorption and plastic strain ahead of the advancing crack; and the role of solid corrosion products and "wedging action" in promoting cracking. Stainless steels are the primary alloy systems under investigation. Related studies on the structure dependence of stainless steels to hydrogen embrittlement also are under way. Investigation of electrode surface reactions and polarization studies are being pursued to provide better insight into the nature of passivity of pure iron and nickel. The iron-nickel alloy system is now being examined with future attention to the iron-chromium and iron-nickel-chromium systems.

Passivity and Corrosion Studies (U), RR 007-08-0002. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Metallurgy; Nonr 1841(09), NR 036-007; H. H. Uhlig.

The purpose of this task has been the study of the relationships between corrosion behavior and the electron structure of metals, with particular emphasis on passivity and passivation phenomena. More recently, an equal emphasis has been aimed at the investigation of the stress-corrosion cracking of austenitic stainless steels and other alloy systems. Studies on the mechanism of inhibitor action are being continued with attention to the effects of benzoates, cinnamates and gluconates. Inhibiting mechanism of chromates, molybdates, tungstates and nitrates have been previously investigated. Research on the effects of electron configuration in chromium alloy systems has been completed and is being extended to the copper-nickel system in which the role of special electron donor elements, e.g. Sn, Al, Zn, will be considered.

In the stress corrosion cracking research, particular attention is being directed toward the effects of interstitial elements (e.g. C, O, N) and heat treatments to clarify the important factors responsible for the formation of crack sensitive paths. The relation between surface energy effects and stress corrosion cracking susceptibility also is being investigated.

Adsorption Studies and Corrosion Reactions (U), RR 007-08-0003. University of Texas, Austin, Texas, Department of Chemistry; Nonr 375(02), NR 036-008; N. Hackerman.

This task is aimed at explaining the chemical inhibition of metal surface reactions and of the passivity of metals. Current emphasis is being placed on passivity in ferrous systems, the nature of the passive film and the effect of ions in solution upon its breakdown. In this connection, leakage currents through the electrical double layer of passivated electrodes and the effect of radiation on passivation are being explored and studies of the relation between molecular structure, adsorption and inhibition are being pursued. A study is also being made of the mechanism of the reaction of iron and steel with NH_3NO_3 solutions where the presence of stress produces rapid reaction of metal which is inert in the annealed state.

Influence of Environment on Failure of Metals (U), RR 007-08-0004. Yale University, New Haven, Connecticut, Department of Metallurgy; Nonr 609(28), NR 036-009; W. D. Robertson.

This task is concerned with the mechanism of structural failure of metals and alloys when exposed to active chemical environments. Since previous work on this contract has demonstrated that the mechanisms of failure in metal or alloy single crystals are often closely associated with the structural state produced by prior plastic deformation, much of the current research is being devoted to a study of the relationship between the structure of deformed crystals and failure processes, i.e. stress-corrosion cracking.

Currently, the crystallographic mechanism of martensite transformation in the austenitic stainless steels and the mechanisms of delayed fracture and embrittlement of iron by hydrogen are being explored. Precipitation phenomena in the system LiF-MgF_2 are also being studied as an aid in the interpretation of precipitation phenomena previously observed in the aluminum-copper system.

Chemical Properties of Large Metal Crystals (U), RR 007-08-0005. University of Virginia, Charlottesville, Virginia, Department of Chemistry; Nonr 474(01), NR 036-010; A. T. Gwathmey.

This task involves a study of the chemical behavior of metal crystal surfaces, with particular emphasis on the correlation between the chemical activity or reactivity of different crystallographic faces and the surface structure. The role which crystal imperfections at the surface play in such processes as corrosion, catalysis, and oxidation is also being investigated. Electron micrographic, metallographic, and X-ray and electron diffraction techniques are being employed to study the structure of metal surfaces both before and after exposure to various chemical environments. Experimental emphasis will be placed on determining with the microscope the nature of the exact points at which the processes of oxidation, corrosion, and catalysis first begin to take place. The topography of the surfaces will be studied with the electron microscope, and the structures will be studied with X-ray and electron diffraction. The study of the influence of electronic structure of transition metal alloys (i.e. with partially filed "d" orbitals) will be continued.

Chemical Behavior of Subgrain Boundaries (U), RR 007-08-0006. University of Illinois, Urbana, Illinois, Department of Mining and Metallurgical Engineering; Nonr 1834(25), NR 036-024; M. Metzger.

The areas of research delineated in this contract are threefold: (a) a detailed study is made of the relation between the susceptibility to corrosion and the grain boundary structure of the material under investigation. The study is conducted as a function of the grain boundary orientation, the orientation difference between grains and the intrinsic structure of the boundary itself; (b) a study of the rupture of surface films by plastic deformation with emphasis on mechanisms of initiation and propagation of stress corrosion cracking; (c) a study to relate the rate of crack propagation in austenitic stainless steel to the applied stress. For this latter work, sheet specimens in uniaxial tension will be investigated.

Electrochemistry of Hydrogen Evolution and Stress Corrosion Reactions (U), RR 007-08-0007. University of Pennsylvania, Philadelphia, Pennsylvania, Department of Chemistry; Nonr 551(22), NR 036-028; J. O'M. Bockris.

This task is a study of the electrochemistry and kinetics involved in the fundamental processes of hydrogen evolution at the surfaces of metals immersed in electrolytes. More precise knowledge of those factors is essential to the understanding and control of the phenomenon of hydrogen embrittlement which may result from electroplating or from corrosion of certain metals. One important factor is the steady state concentration of atomic hydrogen on the metal surface.

Several original methods for measuring this concentration are now being studied: (1) methods of varying the rate of permeation (of H_2 through a metal membrane) with current density, (2) determination of the concentration of H_2 in the metal, but very close to the surface.

The permeation rate measurement method will also be applied to study corrosion inhibitors, viz. capillary active organic molecules which adsorb on iron.

Corrosion of Metal Single Crystals & Bicrystals of Misorientation (U), RR 007-08-0008. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Department of Metallurgical Engineering; Nonr 760(14), NR 036-029; H. W. Paxton.

This task is a study of the corrosion behavior of single crystals, and of grain boundaries in bicrystals, of low-impurity stainless steels. Stress corrosion phenomena are being studied as well as the corrosion of unstressed crystals. This approach is aimed to determine the relationship of corrosive attack to specific microstructural features, particularly the role of grain boundaries as compared with that of the grain themselves.

With regard to corrosion without applied stress, a detailed investigation is planned covering the following variables: composition of the steel, corrodent composition, applied potential, grain size and orientation, heat-treatment, and pre-oxidation.

In order to clarify observations of stress corrosion cracking, a study is being made of the effects of strain rate and temperature on the flow stress of Fe-Ni-Cr alloys in the absence of an aggressive environment. The purpose is to determine whether purely mechanical propagation of cracks might occur periodically during the stress corrosion test. This will provide a test of a theory that has been proposed and also provide a basis for further discriminating stress corrosion experiments.

Structure and Properties of Surfaces (U), RR 007-08-0009. Cornell University, Ithaca, New York, Department of Engineering Physics; Nonr 401(31), NR 036-035; T. Rhodin.

A basic, comprehensive study of the behavior and properties of metal surfaces is being undertaken to obtain a better understanding of corrosion and surface reactions in general. The oxidation rates of high-purity magnesium single crystals are being determined as a function of gas pressure (oxygen and others), crystallographic orientation, and impurity concentration. This work will be extended to additional metals such as Al, Cu, Zn, Cr, Nb, Ti, W, and Mo.

Electron diffraction and electron micrographic techniques are being used to examine the structure of metal films and the relation between such structures and their physical, electrical, and magnetic properties. Film structures and defect density will be related to the mechanism of nucleation and crystal growth particularly for the earliest stages of metal-gas reactions.

Measurements will be made of gas adsorption or description and the growth or evaporation of thin films of oxides and other layers formed by chemical reactions on metal substrates on the assumption that a good understanding of the early stages of evaporation or oxidation is of prime importance in the subsequent microscopic behavior of the surface. The rates and extent of these processes will be interpreted in terms of surface structures and surface concentration of impurity atoms. Carefully prepared single crystals either pure or doped will be used.

Mechanism of Stress-Corrosion Embrittlement (U), RR 007-08-0010. Armour Research Foundation, Chicago, Illinois; Nonr 2602(00), NR 036-037; W. Rostoker, H. I. Francis.

The purpose of this task is to study various embrittlement phenomena involving both deformation and chemical processes which are effective in the fundamental mechanism of stress corrosion cracking. The common behavior pattern of embrittlement by hydrogen, liquid metals and stress corrosion cracking in exhibiting delayed failure implies that a similar mechanism for the formation and propagation of cracks may be effective in each case. One such proposed mechanism involves the reduction of surface energy (which facilitates the propagation of an initiated crack and the formation of new surfaces) by the adsorption of ions in the crack surfaces.

The following studies involving stainless steel and other metals are being undertaken: (a) the effects of various ion species on the reduction of surface energy and their influence on fracture stress, this is to be carried out by systematically introducing and replacing selected ion species; (b) the influence of adsorbed films and effects of wetting on fracture strength relative to grain size; (c) the relationship of environment on delayed failure and reduced fracture strength of stainless steel (including also other alloys e.g. Mg-6% Al).

The above program is broadly aimed to seek a rational understanding of the mechanism of crack propagation in normally ductile alloys.

The Nature and Location of Corrosion Fatigue Attack (U), RR 007-08-0011. University of California, Berkeley, California, Department of Engineering; Nonr 222(67), NR 036-041; I. Cornet.

The purpose of this task is to clarify the role of the environment on the nucleation and propagation of fatigue cracks. Recent advances in the understanding of the initiation and growth of cracks during cyclic stressing of metals now permit a more sophisticated approach concerning the influence of environment in accelerating fatigue cracking and the relationships between the structural features of fatigue deformation and surface corrosion processes. Dislocation theory concepts of fatigue damage will be involved insofar as possible, to explain corrosion fatigue mechanisms. The fatigue behavior of orientation is being investigated in aqueous chloride solutions and will be compared with the "dry" fatigue behavior. Particular emphasis is being placed upon the initial sites of corrosion fatigue attack and relative importance of the environment in the crack nucleation and propagation stages.

High Temperature Reactions Between Condensed Phases and Gases (U), RR 007-08-0012. University of California, Berkeley, California, Department of Mineral Technology; Nonr 222(32), NR 036-043; A. W. Searcy.

The kinetics of the reactions between metals and various gases at low pressures are being investigated at temperatures which are sufficiently high so that only gaseous reaction products are formed. Metal wires will be heated to various temperatures in a system containing a gas at a fixed low pressure and the extent of the reaction between the metal and the gas phase will be determined by measuring the decrease in weight of the wire as a function of time. The number of gas molecules involved in the formation reaction will be studied as a function of gas pressure at fixed temperatures.

Currently, this program is aimed to determine the reaction kinetics between tungsten and O_2 (above 2000°C) and will be extended later to include other metals (e.g. Mo, Pt, Re) with regard to their behavior characteristics in O_2, N_2 or other gaseous environments. A smaller effort will involve the dissociation reaction of certain high-melting phosphates and oxides that evaporate as constant boiling mixtures; the results of the latter will be analyzed in terms of entropy changes and other energies of reaction.

Relation of Composition, Microstructure & Electrochemical Changes to Stress-Corrosion Cracking (U), RR 007-08-0013. Westinghouse Electric Corporation, Research Laboratories, Pittsburgh, Pennsylvania; Nonr 2868(00), NR 036-044; D. van Rooyen.

This task comprises one phase of a comprehensive investigation aimed at elucidating the detailed mechanism of stress corrosion cracking in stainless steels by coordinated studies involving surface growths, electrochemistry reaction kinetics and metallurgical aspects of the phenomenon. One of the features of this coordinated attack is the use of well characterized materials, either specially prepared pure alloys or pedigreed commercial materials. Specifically, studies will be carried out on the effects of alloying elements such as Mo, Ti, N, C and Mn on highly pure 16 Cr--20 Ni steel.

Electrochemical potential measurements are made in order to follow the process of initiation of cracks. Polarization by an applied potential is also utilized to study both initiation and propagation of cracks. Bimetal couples (e.g. nickel bonded to stainless steel) are used to study comparative resistance of different alloys to crack propagation. Transmission electron microscopy will be used to study the relationship of microstructure to crack patterns. Observations to date are consistent with an electro-chemical explanation of stress corrosion crack propagation and the ultimate objective is a thorough understanding of the electro-chemistry of the various stress corrosion phenomena.

Kinetics of Crystal Dissolution (U), RR 007-08-0014. Carnegie Institute of Technology, Pittsburgh, Pennsylvania, Department of Metallurgical Engineering; Nonr 760(17), NR 036-046; J. P. Hirth.

Quantitative measurements are being made of the growth and dissolution rates from single crystals and polycrystals as a function of time, temperature, crystal orientation, undersaturation and degree of crystal perfection. The experimental results are being compared with predictions of a general theory of crystal growth and dissolution which is under continuing development. Dissolution studies are currently being carried out on lithium fluoride single crystals in water or acid solutions. This work will shortly be extended to metal-solution systems. It is hoped that these measurements will enable the rate controlling step in the dissolution process and the detailed dissolution mechanism to be identified.

Parallel studies of the condensation of metal vapor on clean metal surfaces are also in progress. The condensation coefficient for silver vapor deposited on silver is being determined as a function of the degree of super-saturation in order to check certain theoretical predictions.

Prevention of Deterioration Center (U), RR 007-08-0015. National Academy of Sciences, Washington, D. C.; Nonr 2300(17), NR 331-002; C. J. Wessel.

The Prevention of Deterioration Center has been operated by the National Research Council since 1945 for the Armed Services as a center for the collection, coordination, exchange, and dissemination of information on the deterioration of materials and methods of prevention. Contact is maintained with research and development activities concerned with the prevention of deterioration of materials operated by and for the government, particularly in the Army, Navy, and Air Force. The Center provides consulting services to all agencies of the Department of Defense and acts as an intermediary in relations with industry. Incidental to these services, the Center issues a series of Prevention of Deterioration Abstracts, a set of Handbooks, and reports requested for special needs.

Oxidation-Inhibitors in Oils (U), RR 007-08-5500. U. S. Naval Research Laboratory, Washington 25, D. C.; CO2-02; H. Ravner.

There is an increasing military need for stable lubricants capable of operation at temperatures in excess of 500°F. At these temperatures even the better fluids available require antioxidants. Research is being conducted to improve the high-temperature stability of two such classes of fluids--fluoroesters and silicones. It has been found that in the presence of certain metals, and their salts, the stability of fluoresters is enhanced. The reaction of certain metal salts and chelates with silicones likewise enhances their high-temperature oxidation stability. The modes of action of these antioxidants are being studied. Their suitability for other fluids will be investigated.

Friction and Wear Phenomena (U), RR 007-08-5501. U. S. Naval Research Laboratory, Washington 25, D. C.; C02-03; W. A. Zisman.

The objectives of this task are to clarify the basic mechanisms in friction and wear phenomena and to support the development of lubricant and lubricant additives designed to meet the more stringent requirements of modern military equipment. The materials investigated are mainly new synthetic oils, chemical addition agents or solids whose possible utility in lubrication is of interest.

Synthesis of Fluorine-Containing Organic Compounds (U), RR 007-08-5502. U. S. Naval Research Laboratory, Washington, D. C.; C02-17; J. G. O'Rear.

Research has been directed toward the synthesis of fluorine containing compounds of interest as lubricants, surfactants, dielectric liquids and additives. A variety of organo-fluoro compounds have been synthesized and studied as dielectrics, surfactants, and oil additives. These studies have led to promising candidates in each of these areas.

Tropicalization of Materials (U), RR 007-08-5503. U. S. Naval Research Laboratory, Washington 25, D. C.; C03-01; J. M. Leonard.

This study has several phases related in some way to the microbiological deterioration of materials. Two types of surface chemistry investigations are pursued, viz., the analysis of fungal spore surfaces by microelectrophoresis, and studies of biochemically important proteins through the film balance and related techniques. Studies on the chemistry of toxic agents, the physiology of fungi are included. From time to time, laboratory evaluations of the resistance of materials to biological attack are performed.

Tropical Exposure Site (Panama) (U), RR 007-08-5504. U. S. Naval Research Laboratory, Washington 25, D. C.; C03-02; J. M. Leonard.

Completed work has afforded some basis for calibrating accelerated laboratory climatic tests and it has pointed out several deficiencies of electronic component design. About thirty separate weathering experiments on various materials and manufactured items are in progress. The number is expected to increase somewhat in the next year. The tropical woods exposure program has revealed a great many vulnerable species; some anomalies in the observations, however, preclude any firm conclusions of positive resistance to biological attack. Instrumentation work of the Scientist-in-Charge is directed toward some projected sea experiments.

Marine Borer Control (U), RR 007-08-5505. U. S. Naval Research Laboratory, Washington 25, D. C.; C03-04; T. R. Price.

During the course of this work the following discoveries were made: (1) all fractions of creosote provide some degree of protection to wood against marine borers; (2) the protection afforded by the distillation fraction increases with increasing boiling point; (3) the high boiling residue of creosote functions both as wood preservative and as a means of holding the lower boiling constituents in the wood; (4) the tar acids and bases in creosote have little or no significance in relation to the effectiveness of creosote as a marine wood preservative; (5) the incorporation of resins into creosote can increase resistance to leaching and bring about some improvement in its resistance to Limnoria attack; (6) nitration of creosote produces a superior preservative which is limited in usefulness because of its extreme viscosity; (7) trialkyl tin esters and halides show promise as potential marine wood preservatives.

Canal Zone Corrosion Laboratory (U), RR 007-08-5506. U. S. Naval Research Laboratory, Washington 25, D. C.; C03-11; A. L. Alexander.

The major effort is directed toward the accumulation of quantitative data on the corrosion rates of most common metals in the tropics. These data are required for specification of new materials of construction to be used in these areas and in allaying corrosion processes in existing structures. More recently a study has been added to determine the natural resistance of the commercially available timbers in the Canal Zone to attack by marine borers, termites and fungi.

Fluorescent Paints (U), RR 007-08-5507. U. S. Naval Research Laboratory, Washington 25, D. C.; C03-12; J. E. Cowling.

This task is a study of fluorescent paints with the object of arriving at formulations having maximum weather stability. In addition to formulation studies this work involves the development of reliable methods of instrumentation, particularly with regard to color, for the specification of fluorescent paints. Specifications Mil-P-21563 and Mil-P-21600 are the outgrowth of accomplishments to date.

New Aircraft Finishes (U), RR 007-08-5508. U. S. Naval Research Laboratory, Washington 25, D. C.; C02-14; J. E. Cowling.

Studies have been carried out, and are continuing, with the object of determining what types of polymers best withstand intense ultraviolet radiation in high vacuum. Formulation studies have been undertaken to determine what types of pigmentation are necessary to properly control the spectral absorption and emission characteristics of these coatings. Film-forming polymers such as silicones, methacrylates, urea formaldehyde and others have been irradiated with intense ultraviolet energy at low pressures (approx. 1×10^{-3} to 1×10^{-5} mm Hg). The physical and optical

properties are evaluated following this exposure.

Considerable effort has been applied to the design of suitable high vacuum equipment for these studies. This equipment now is on hand and in operation. The results of studies thus far completed indicate that phenyl-silicone resins are among the most stable in a "simulated" space environment. Results further indicate that in the absence of a normal oxygen-bearing atmosphere (air) some polymers may be relatively more stable to UV radiation than in the presence of air. In most instances there has been significantly less weight loss in a coating irradicated by intense UV energy in a vacuum than when similarly irradiated in air.

Corrosion Mechanisms (U), RR 007-08-5509. U. S. Naval Research Laboratory, Washington 25, D. C.; M04-01; M. C. Bloom.

This task is concerned with Corrosion Mechanisms, major attention being given to steel systems under conditions pertinent to steam power generation. The key to corrosion prevention is the development of a protective film. In the case of steel under the conditions of interest, the structure of this film has been determined. It is the spinel structure and studies are being concentrated on the mechanism of its formation, stabilization and breakdown.

Cathodic Protection Studies (U), RR 007-08-5510. U. S. Naval Research Laboratory, Washington 25, D. C.; M04-02; L. J. Waldron.

Electrochemical potentials are measured periodically on hulls of active ships under various types of cathodic protection, and these hulls are inspected and photographed upon drydocking in order to evaluate the relative effectiveness of various cathodic protection systems. Various anode types are set up against an "infinite sink" and the relative protective current outputs are compared. Specimens of structural alloys are stressed statically and dynamically in 3% NaCl solution in the laboratory and the effect of various levels of cathodic protection on fracture behavior is studied.

Corrosion Deterioration and Protection, WR 007-08-001. Naval Air Material Center; RRMA 05 010/200; RRMA-5.

To provide increasingly superior methods, materials, processes and techniques for protection against corrosion, erosion, deterioration, biological fouling and damage that will afford an evolutionary advancement in the art of protecting the weapons systems and components under the cognizance of the Bureau of Naval Weapons, and to provide laboratory support for the development program.

A series of specific materials development, test and evaluation investigations is being undertaken to accomplish the necessary advancement in materials capabilities. Current emphasis is being placed on improved scuff-resistant finishes; high temperature-resistant coatings; collision-avoidance by visual means; rain-erosion resistant finish; radar attenuation coatings; anti-fouling paint; photo-chromic coatings; improved barrier and VCI-impregnated packaging materials; preservative compounds; impact recorders; strippable coatings and controlled emissivity coatings. Materials will be formulated and exposed to the environments involved. Subsequent evaluations under service conditions will be conducted.

Protective Clothing Materials Against Missile Fuels (U), SR 007-08-1102. Material Laboratory, New York Naval Shipyard; 10171 RDT&E, 60.2401; B. B. Sims.

This task was to develop protective clothing materials for personnel against corrosive and toxic effects of rocket and missile fuels and oxidizers.

The best material developed to date was a butyl rubber-resin blend and this material was satisfactory for splash or short term protection for currently used fuels and oxidizers.

Oxidizers for Special Fuels, SR 007-08-0607. Material Laboratory, New York Naval Shipyard; 10171 RDT&EN, 61.2411; E. Haas.

There is need in the field to check accuracy of detection equipment used to monitor ppm of mixed amine fuels (MAF) and inhibited red fuming nitric acid (IRFNA) in air.

Method has been developed for passing air containing known concentrations in ppm of MAF through a filter paper soaked in a solution which is specific in chemical reaction with MAF to form gray coloring. Degree of color is dependent on MAF concentration.

Specialized Analytical Techniques, SR 007-08-0608. Material Laboratory, New York Naval Shipyard; 10171 RDT&EN, 61.2411; W. Miller.

A need was indicated in the field for a quick method for alloy steel identification when such identification had been lost.

Prototype chemical spot-testing kit developed. Plans and requirements for electro-chemical spot-testing kit completed.

Finishing effort being completed in fabrication of prototype electro-chemical spot-testing kit.

Ion Exchange--Shipboard Applications (U), SR 007-08-0609. Nalco Chemical Company, Chicago, Illinois; NObs 77046; S. Adkins.

High flow rates had been shown practical in a number of applications, but data were lacking concerning possible application in shipboard nuclear plants with high operating temperatures and stringent halide limits.

Some of the available data show promise of giving basis for reducing design size of demineralizer.

The effect of the operating temperature at these flow rates are being studied critically.

Shark Repellents (U), SR 007-08-0610. Cornell University, Ithaca, N. Y., Requisition--EN24/634A-19460, Dr. Perry Gilbert; Lerner Marine Biology Laboratories, Bimini, British West Indies, Requisition--EN24/634A-19460, Dr. James Oliver.

The repellent procured under Specification MIL-S-2785 had been found to be unreliable in that erratic performance was reported. Any such failures obviously can not be tolerated with survival gear.

A survey has been completed compiling all currently available data concerning the distribution of various shark species.

Listings are being made of all reported shark attacks together with data as to the prevailing conditions. Studies are being made of shark behavior under natural conditions and of their physiology with respect to their ability to see and smell. Finally, their reaction to various chemical stimuli is being investigated in an approach to developing basic leads to efficient repellents.

Analysis Industrial Gases--Quantitative Impurities, SR 007-08-0622. Shipyard Laboratory, Philadelphia Naval Shipyard; 10290 RDT&EN, 60.2411; J. Sherman.

An investigation was made to determine feasibility of developing analytical procedures for spectrographic analysis of impurities in inert gases.

Chemical Cleaning (U), SR 007-08-0614. U. S. Naval Boiler and Turbine Laboratory, Philadelphia Naval Shipyard, 10176 RDT&EN, 61.2411, Mr. S. Greenberg; Wyandotte Chemicals Corporation, Wyandotte, Michigan, NObs 72059, NObs 84149, Dr. L. R. Bacon.

This program was established to develop improved procedures for use by ships force and by shipyards and contractors in the chemical cleaning of boilers.

Both laboratory and full scale trial applications have proven that sulfamic acid-citric acid mixtures are definitely superior to the sodium bisulfate-citric acid mixture in boiler descaling efficiency. Diethythiourea additions in a concentration of 5% of the dry formulation reduce corrosion rate to a satisfactory level and prevent redeposition of copper. Tests have established that the hydrochloric acid boiler descaling procedure used by contractors and shipyards can be considerably improved. Diethylthiourea additions to the hydrochloric acid solutions will prevent copper deposition. The water rinsing procedure will be deleted and a mild acid solution (pH1.5) will be substituted. A mixture of monosodium and disodium phosphates and sodium nitrite prevents after rusting and will be substituted for the soda ash neutralization procedure now specified. A fireside cleaning additive formulation was standardized for shipboard use. Special injection devices were designed and fabricated for the injection of the additive into the boiler furnace.

Chemical Cleaning (U), SR 007-08-0615. Chemical Laboratory, Boston Naval Shipyard; 10283 RDT&EN, 61.2411; Mr. B. Rozene.

This program was established to develop improved formulations and procedures for cleaning tanks and piping systems.

In December 1960 a procedure employing 10% Hydrogen Peroxide solutions was successfully used in cleaning boiler fireside super-heater sections on the USS WILLIS ALEE (DL-4). After further refinement of this procedure instructions for its use will be issued to Fleet Activities.

Tests for improvement of the procedure using 10% Hydrogen Peroxide solutions for removal of fireside deposits are continuing. Formulations for use in spray cleaning of fuel tanks are being evaluated.

Chemical Cleaning, SR 007-08-0616. U. S. Naval Engineering Experiment Station; 10101 RDT&EN, 61.2411; H. Messinger.

Improved procedures were needed to produce steel surfaces satisfactory for receiving coatings following chemical descaling.

Test indicated that 1% by weight additions of sodium chloride to sulfuric acid pickling solution reduced acid attack of medium-tensile, high-tensile, and special treatment steels by as much as 85% compared with the unsalted solution.

Chemical Cleaning (U), SR 007-08-0617. U. S. Naval Engineering Experiment Station, 10101 RDT&EN, 61.2411, H. Messinger; Chemical Laboratory, Boston Naval Shipyard, 10283 RDT&EN, 612411, B. Rozene; U. S. Naval Supply Research and Development Facility, Bayonne, 10372 RDT&EN, 61.2411, S. Stambler.

Because of recent significant advances in the field of laundry chemicals a test program was initiated to improve products or establish new products to make Navy laundry operations more efficient. Improved methods for disposal of oil slicks resulting from accidental spillages on harbor waters were needed.

Developed powdered compound for use in descaling evaporators. Developed analytical test procedures to control quality of this compound. Developed solvent-emulsifier in solution as a single phase liquid for use in emulsifying and dispersing oil slicks from harbor waters. Developed improved all-purpose laundry detergent by incorporating sodium tripolyphosphate into the formulation.

Chemical formulation for use in removal of calcium sulfate scale from electric heating elements in vapor compression stills are being investigated. The use of foaming agents in conjunction with acid solutions in descaling tanks and voids is being investigated. Use of foaming agents may greatly decrease the volume of chemical formulations required to fill a tank or void.

Organic Coatings (U), SR 007-08-1201. Paint Laboratory, Mare Island Naval Shipyard, AL 10286 RDT&E, 61.2411, J. R. Saroyan; Material Laboratory, New York Naval Shipyard, A. Cizek; Naval Engineering Experiment Station, AL 10101 RDT&E, 61.2411, F. Lovell; Miami Marine Research and Test Station, NObs 84004, Alexander C. Frue.

The work is divisible into three areas of effort; paints, calking and sealing compounds, and rust preventives.

In regard to paints, the work is centered at Mare Island. It includes efforts to correct deficiencies in the performance of present systems for shipbottoms, exterior hull and decks, interior, and tank surfaces. It involves the laboratory screening for potential use of the newest of available ingredient materials, such as epoxy, polyurethane and silicone resins. The contract with Alexander C. Frue (now Miami Marine Research and Test Station) provides a facility for year-round evaluation of experimental shipbottom paint systems at Miami Beach where fouling attachment is always severe. Work at the Material Laboratory on metal repair and hull streamlining compounds was temporarily discontinued due to lack of funds but is proposed for resumption if funds permit. Work on corrosion preventive compounds at the Engineering Experiment station is concerned with

development of corrosion preventive compounds.

Inorganic Coatings (U), SR 007-08-1202. NEES; 10101 RDT&E, 61.2411; J. L. Basil.

There are numerous shipboard applications for inorganic coatings, particularly metallic coatings, wherein protection from corrosion or wear, or the reclamation of worn machinery, is desired. The purpose of this task is to investigate selected problems within this general area.

Three active assignments have been brought to successful conclusion during this reporting period: (1) A long-term marine atmosphere exposure program of metallic coatings, including those applicable to electronic equipment. This covered coatings of lead, lead-10% tin, tin, zinc, cadmium, gold and rhodium. Variables included base metal, coating thickness, undercoatings, supplementary chemical treatments, and effects of dissimilar metal couples in the vicinity of fasteners. (2) A long-term sea water exposure program on a wide variety of metallic and nonmetallic galvanize repair compounds to be used where galvanizing is destroyed in the vicinity of welds. Comparisons were also made between behavior in the natural marine atmosphere and in the artificial salt-fog cabinet. (3) An investigation of surface pre-stress treatments (shot peening and nitriding) for steel prior to chromium plating, as a means to overcome the deleterious effects of the plating on fatigue resistance. Plated shafting, including crankshafts, with superior resistance to fatigue and journal wear has been proven.

Inorganic Dielectric Coatings for 650°C. (U), SR 007-08-3263. MATLAB Electrical Insulation Section, Code 995, H. K. Graves; Westinghouse Electric Corporation, NObs 77059, Mr. R. B. Grekila.

Electrical insulating coating materials for high temperature applications are a new class of materials of predominantly inorganic composition. Rapid technological advances in development of high-speed aircraft, missiles, submarines and thermoelectric devices resulted in electronic and electrical systems operating at temperatures up to 650°C. Success of this equipment is highly dependent on the thermal stability of the electrical insulating coating material which protects elements of the system. Solid state converters employing thermoelectric principles, (a new concept of energy conversion) with non moving, noiseless parts require electrical insulating coatings which can operate at 650°C, or perhaps 1000°C in the near future. Consequently, the development of electrical insulating, coating materials of mainly inorganic origin is required to provide electronic and electric equipment such as transformers, capacitors, and solid state converters, with the capability of withstanding the extremes encountered in the new technology.

Work in the development of these materials is currently in the research stage. Commercial developments have been discussed with manufacturers' research and development groups and extremely limited study has been made at this laboratory to determine possible Naval applications pertinent to the design of equipments such as thermoelectric power generators.

Marine Corrosion (U), SR 007-08-0718. NEES, 10101 61.2411, J. L. Basil; International Nickel Company, NObs 84016; Kaiser Aluminum and Chemical Corporation, NObs 72433, T. A. Lowe.

The Navy has numerous material and equipment problems in which various types of marine corrosion are of a critical nature. The study of marine corrosion of various base materials and fasteners, including clad fasteners, is the objective of this task.

Specimens of beryllium sheet were prepared from material obtained from the Air Force Sheet Rolling Program and evaluated under various conditions of exposure (aeration, velocity, crevice attack, stress-corrosion, etc.). It was found that the corrosion properties of beryllium were poor. Under a second assignment, specimens were prepared of aluminum and steel plate with various fasteners and two kinds of vinyl insulation. This was reported during a previous period. The specimens are now undergoing marine atmosphere corrosion tests. Under a third assignment, the corrosion-erosion characteristics of a wide variety of alloys are being determined at high sea water velocities. Special equipment was constructed to expose specimens in water moving up to 135 ft/sec. (80 knots). Approximately ten 30-day runs with six specimens per run, have been completed. These have included carbon and low-alloy steels, stainless steels, and alloys of aluminum, copper, nickel and titanium. A progress report was issued.

Condenser Materials (U), SR 007-08-4190. NEES; 10101; J. L. Basil.

An extensive investigation of condenser and heat exchanger materials has been carried out at NEES for several years. Much useful information has been obtained on the mechanical and corrosion properties of many alloys under a variety of conditions. The work on this task was previously carried out under SF 013-08-15, but the task was transferred to SR 007-08-06 in Fiscal Year 1962. Only a few minor phases remain to be completed, and these will be accomplished prior to Fiscal Year 1963.

The following items were accomplished during this reporting period: (1) Completed and reported a 6-year operational test of a Type A Ross jacket water cooler which demonstrated that this type of cooler would perform satisfactorily without the need of protective zinc anodes. (2) Completed and reported a hot sea-water corrosion test of special triple-tube fittings for use in heat exchangers of Badger vapor compression distilling units. (3) Initiated sea water tests of model condensers containing tubes with rolled-on corrugations. These corrugations result in greater heat transfer capacity, and would permit the design of smaller and lighter condensers than is possible with conventional tubes. However, these corrugations cause water turbulence inside the tubes. The purpose of the investigation is to determine whether the water turbulence will result in corrosion-erosion damage to the tubes.

Cathodic Protection Studies (U), SR 007-08-1203. U. S. Naval Research Laboratory, Code 6325, L. Waldron; Material Laboratory, New York, Code 973, W. L. Miller; Magna Products, Incorporated, NObs

77071; University of Illinois, NObs 77012; Boston College, NObs 77040; Boston Naval Shipyard, B. B. Rozene.

Cathodic protection is specified for protection of the underwater surfaces of the Reserve Fleet and for certain ships of the Active Fleet. It has been determined that appreciable savings in maintenance is possible through its use. Certain additional basic information and developmental work are needed to take best advantage of economic gains possible. Also other related aspects of effects of cathodic protection need to be explored.

Seven types of metals used as propeller, shaft and hull construction materials were studied using up to date methods and concepts for possible hydrogen embrittlement as a result of cathodic protection applications. None of the metals were affected except stainless steel (410) and aluminum-nickel-bronze, which showed considerable hydrogen uptake. Theoretical analysis of current distribution from anodes using model analogues show that practical considerations used in the past have been adequate for size of dielectric shields to prevent paint damage in vicinity of anodes. Corrosion probes for exterior hull of ships, interior hull sections, pipes, condensers and heat exchangers have been designed. These probes utilize the electrical resistance method to detect and continually measure corrosion under actual operating conditions. Laboratory evaluations have shown that an improved design, inert anode performed satisfactorily under simulated current loading and flowing sea water. Beneficial effects of small additions of aluminum and cadmium to zinc anodes was confirmed by laboratory tests.

Surface Preparation of Metals (U), SR 007-08-1204. Material Laboratory, New York, Chemistry Section; Code 973, W. L. Miller.

Surface preparation is extremely important in determining the service life and cost of a coating. The Bureau has specified acid pickling, grit blasting and a few chemical treatments over the last 20 years. Little change has been made in many of these procedures since their inception. This work will review critically the existing practices, along with industrial and other sponsored research and development and inventions in the field, and initiate investigations which appear to offer promise of improvement or reduction in cost. Areas offering possibilities are: acid cleaning using uninhibited low concentrated acid; high and low pressure water sprays with and without added chemicals (includes oil and grease removal, rust and scale removal, and inhibition of surface) rust removing and inhibiting pastes; selection of proper type coating for the type of surface achieved; techniques that can be readily duplicated to depict suitable surfaces; and ultrasonics.

Water Treatment--Potable (U), SR 007-08-0611. No contractor.

Laboratory tests had shown promise in a system based on release of minute concentrations of silver.

Three trial installations have been operating successfully for several months to several years on a seaplane tender, a submarine, and a destroyer.

Boiler Water Treatment Chemicals and Tests (U), SR 007-08-0613. U. S. Naval Engineering Experiment Station, Annapolis, Maryland, 10101 RDT&EN, 61.2411, Mr. H. Messinger; U. S. Naval Boiler and Turbine Laboratory, Naval Base, Philadelphia, Pennsylvania, 10176 RDT&EN, 61.2411, Mr. S. Greenberg; U. S. Naval Research Laboratory, Washington, D. C., 10173 RDT&EN, 61.2411, Dr. M. Bloom; Midwest Research Institute, Kansas City, Missouri, NObs 77056, Dr. B. W. Beadle; The LaMottee Chemical Products Company, Chestertown, Maryland, NObs 78532, Mr. W. R. Kenny.

The watersides of shipboard boilers, distilling plants, internal combustion engines, cooling systems and other water and steam systems are subject to scaling, contamination and/or deterioration. These problems are aggravated since shipboard water systems involve sea water cooling or water derived from sea water. The purpose of this task is to develop effective water treatments and processes and the necessary complementary chemical tests.

Fire Prevention--Ships, Firefighting Chemicals, SR 007-08-0605. Material Laboratory, New York Naval Shipyard; 10171 RDT&EN, 61.2411; H. Lacks.

Mechanical foam liquid is subject to many conditions of use and storage. Deterioration of the foam liquid has been reported and confirmed to some degree. Studies were initiated to determine causes and affects of deterioration. Increase in uses of light metal alloys effected studies for investigation of extinguishing agents for fires involving these alloys.

Progress is being made on development of a laboratory bench test to predict stability and performance of foam liquid. Progress is continuing in developing test procedures and test methods for evaluating potential of fire extinguishing agents for magnesium alloy fires.

In the mechanical foam liquid deterioration studies, work is being done in determination of effect of accelerated aging on bacteriological properties, chemical analysis of sediments of deteriorated liquids, and development of a bench test to predict foam liquid stability. Effort is continuing in development of criteria for evaluating extinguishing agents for light metal alloy fires.

Marine Corrosion Studies (U), SR 007-08-2822. New York Naval Shipyard; SR 007 08 11; W. Miller.

To reduce corrosion and corrosion costs, new and improved corrosion preventive measures, including materials and methods of surface preparation are necessary, particularly for inaccessible areas, i.e. well decks, bilges, undersuperstructure.

Determine major corrosion problems and areas aboard ship with view to recommending suitable protective measures.

Study and evaluate various chemical and mechanical surface treatments prior to coating application: effect of various acidic cleaners on variety of metals.

Investigations of specialized coatings for unusual corrosive conditions.

Study and evaluate foreign flag methods of corrosion prevention and shipboard maintenance.

Investigate and evaluate unanticipated corrosive conditions and deterioration.

Marine Coatings (U), SR 007-08-2823. Naval

Shipyard, PTSMTH, C. Lewis; Naval Shipyard, MARE, J. Saroyan; Naval Shipyard, NORVA, W. Francis; Naval Shipyard, LBEACH, V. Brennan; Forces Afloat; Commercial contractors.

(1) Naval Shipyard, MARE, 9190(371/373-32577) of 14 September 1960 (Tanks); (2) BuShips Notice 9190 Ser 633E-2719 of 30 November 1960 (Appendages); (3) BuShips Notice 9190 Ser 633P-2533 of 13 October 1960 (Underwater areas); (4) BuShips Notice 9190 Ser 633P-1692 of 9 August 1960 (Deck coating).

Tank Coatings--Suitable resistant tank coatings are required for protecting surfaces during exposure to salt water, fresh water and aviation fuel. In addition coatings are needed for protecting feed water tanks and launcer flasks on nuclear propelled and Polaris ships that will not contaminate the system, will resist high temperatures and air flow.

Work is continuing to develop coatings and methods of application that will reduce application and maintenance costs. Materials being investigated include 100% solids epoxy resins (applied by hot spray, internal mix spray guns and conventional spray equipment) and polyurethanes which may permit application at lower temperatures and require shorter curing periods.

Underwater Coatings--Investigation of new methods of surface preparation and application equipment, and modified antifouling and anticorrosive coatings are required to reduce cost of coating application and improve performance of antifouling and anticorrosive coatings. Improved coatings for surfaces such as propulsion shafting, hydrofoils, boot-topping and other appendages to obtain corrosion and erosion protection between overhauls are required. The problem of satisfactory antifouling protection in tropical waters has not been completely resolved. The use of other toxic materials such as mercurials will be investigated. Improved formulations of black antifouling are needed and will be evaluated. Coatings with improved adhesion to aluminum brass, bronze and other non-ferrous metals are also required accomplishments. Service tests are being continued.

Interior Coatings--Although presently specified interior paints provide satisfactory service in most instances, maintenance is still considered excessive in areas such as wet spaces and bilges. Solvent free paints are required for nuclear submarines to eliminate hydrocarbon contaminants. Epoxy paints offer promise in the first area and newly developed emulsion paints require service tests in submarines. Increasing use of phosphate ester hydraulic fluids (cellulube) has emphasized the need for coatings resistant to this material, which will attack currently specified paints.

Exterior Coatings--Suitable coatings are required for exterior topside surfaces to provide improved performance and reduce maintenance by ship's force in active fleet. Forces afloat have also indicated a desire for exterior paints with higher gloss and better gloss retention. Problems relating to surface preparation and compatibility require resolution. Improved maintenance primers are needed for surfaces where optimum preparation by ships force is not practicable.

Deep Sea Corrosion (U), SR 007-08-2829. Stanford Research Institute; Magna Products Company; International Nickel Company or Cleveland Pneumatic Industries.

This work will determine the factors which affect the rate of corrosion of metals submerged at great depths and the measures necessary to arrest such corrosion. Examples are deep sea anchoring devices, and submarine operations at great depths. Such factors to explore will be oxygen concentration, salt concentration, temperature, composition of bottom.

Corrosion Study With 14th ND (U), YR 007-08-001. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; C. V. Brouillette.

The objective is to provide information concerning the corrosion of metals and alloys and the effectiveness of protective coatings exposed to marine atmospheres.

The initial efforts involved the determination of the corrosion resistance of metals and alloys immersed in sea water. Sixteen types of metals were tested in the harbor waters of Port Hueneme, California. Subsequent to this, atmospheric corrosion racks for testing coating systems were designed, fabricated and erected at NCEL and Kwajalein. Another atmospheric corrosion test rack was erected at Kaneohe Station. Coating systems are first given preliminary tests at NCEL. Only those coating systems which appear superior as a result of these tests are used in the preparation of coated test panels for evaluation at the two Pacific stations. To date, 44 coating systems have been placed under atmospheric exposure at the three test locations.

Six coating systems were placed on the exposure racks at Port Hueneme, Kaneohe and Kwajalein during the second quarter of FY 1961. It is planned to continue this task indefinitely for use in obtaining corrosion data on protective coatings, metals, alloys, and possible other construction materials. This data, collected simultaneously from three corrosion sites having varying degrees of severity, will have considerably more reliability than the data from one site alone.

Underground Corrosion Control (U), YR 007-08-003. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; R. J. Zablodil.

The objective is to determine the most effective materials and methods for protecting against corrosion, and insulating where required, underground structures and piping which because of pressure, temperature, structural strength, or economic requirements are fabricated from steel.

The task was initiated mainly because no known insulating and protecting material for underground steam distribution systems is completely reliable. The main cause for buried pipe failure is corrosion caused by soil water penetration through the pipe covering. NCEL will investigate and evaluate new, untried, materials which appear to have suitable characteristics for protecting and insulating underground hot piping. The task will include an evaluation of cellular glass insulation, HH-I-551 and a similar type of new high temperature insulation, "Foamsil."

NCEL is completing an investigation of existing

underground piping installations utilizing "Foamglas." Arrangements will be made by NCEL to field test underground piping protected with "Foamglas" and "Foamsil" at a Naval Station convenient to the Laboratory.

Corrosion Resistant Pipe And Tubing (U), YR 007-08-004. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601 and Bu. Control No. 10605; R. J. Zablodil, Dr. H. Hochman.

The objective is to determine the most suitable pipe materials or types of coated pipe which can be substituted at an economical advantage for presently specified systems including piping that is subjected to corrosive environments.

This task was initiated because of the many inquiries from field activities requesting assistance on piping corrosion problems. The nature of the problems submitted can be categorized as general and specific. Problems submitted of a general nature involve internal corrosion of steam condensate lines and external corrosion of piping in shore environments. Problems of a more specific nature are those related to accelerated external corrosion in extremely corrosive tropical atmospheres as well as those involving accelerated internal corrosion of pipes conveying highly corrosive waters.

NCEL is making a literature search in the field of corrosion resistant materials with emphasis on plastics to determine applicability to pipe systems presently unsatisfactory to the Navy. Following determination of failure trends, NCEL will submit a report and proposed test procedure for Bureau comment. In addition, the Laboratory is assisting the 12ND DPWO in setting up and monitoring an in-service test installation of plastic pipe in a steam condensate return line system.

Moisture Control in Wood Buildings (U), YR 007-08-201. Southern Forest Experiment Station, New Orleans, Louisiana, Appn:17X1319.2514 RDT&E, Bu. Control No. 25/10696, Dr. A. F. Verrall; Forest Products Laboratory, Madison, Wisconsin, Appn: 17X1319.2514 RDT&E, Bu. Control No. 25/10696, Dr. R. M. Lindgren.

The objective is to develop guidelines, specifications and procedures for the most effective and economical moisture control in wooden navy structures to control decay.

The most authoritative investigations are being conducted by the Forest Products Laboratory, Madison, Wisconsin, and the Southern Forest Experiment Station, Forest Service, New Orleans, Louisiana.

A wide range of long term investigations are being made to prevent decay in wooden buildings at Naval Installations. They include the effect of roof overhang and eaves gutters on siding wetting; water repellent treatment of siding in-place; in-place preservative treatment and gel type preservatives. These studies are being conducted under various climatic conditions.

Test And Evaluation Of Paints (U), YR 007-08-301. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; C. V. Brouillette, A. DeMarco.

The objective is to evaluate currently available and promising new commercial paints and compare them to paints currently specified in TP-Pw-30. End product desired is a report comparing new products with those currently specified in TP-Pw-30. The report will include sufficient information to write material specifications on products that are superior to those currently used. Presently available paints and pretreatments do not adequately protect such material, equipment and structures during periods of use or storage.

Spectrographic Analysis of Paints (U), YR 007-08-302. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; R. D. Hitchcock, J. Crilly.

The objective is to determine the feasibility of using infrared spectrophotometric analysis of paint vehicles as a means of inspection and identification.

This task was assigned to NCEL on 4 April 1956. The CEC 21-103A Mass Spectrometer, previously installed at the Laboratory, has been modified for high-mass analysis; a hi-resolution analyzer and heated gas-introduction system have been added. Mass spectra of certain paint vehicles indicate that it will probably be possible to control instrument parameters so that identification of these vehicles by means of their fragmentation patterns will be practicable. Work on infrared methods has been directed mainly toward developing methods of sample preparation for the identification of paint vehicles. Analysis of data from the Beckman IR3 Spectrophotometer has shown that sample films on KBr discs can be reproduced so that deviations from an average value of absorbance are less than 3 percent. An interim report, TN-326 of December 1957, describes a method of identification of paint nonvolatile vehicle by infrared spectrophotometry. Preliminary indications are that infrared is quite feasible and the time and cost considerably reduced over currently used chemical analysis.

Protettive Coatings Steel Piling (U), YR 007-08-401. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; R. L. Alumbaugh.

The objective is to evaluate various coatings in order to determine which coating offers maximum protection to steel piling.

The initial phase of this task was carried out at NCEL in the Fall of 1951 with an investigation of the early deterioration of a bituminous coating applied to marine piling at Guantanamo Bay, Cuba. The conclusion reached was that the premature deterioration was due to improper application of the bituminous coating. Active testing was initiated at NCEL on 23 December 1952. Test specimens were first fabricated from 2-1/2 inch angle iron, ten feet in length. Later, flat bar stock steel panels 1/4" by 4" by 10' were substituted for the angle iron panels. The panels were sandblasted to a gray matte surface, coated according to the recommended systems and suspended from the corrosion test dock so that the bottom third of the panel was continuously submerged, the middle third in the tidal zone, and the top third of the panel was continuously exposed to the atmosphere. Thirty-four coating systems were evaluated on the angle irons and seventy-two coatings on the 1/4" by 4" panels. Subsequent to these tests, twenty-three protective coating systems, including several of the best as determined by the previous tests were applied to steel sheet and H-piles which were driven in the

harbor at Port Hueneme. The coatings were evaluated after six months and the best eight coatings are presently being tested on driven sheet and H-piles at Port Hueneme and Guam.

Floating Coatings (U), YR 007-08-402. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; C. V. Brouillette.

The objective is to determine the most effective materials and application techniques for preventing deterioration of ballast compartments of Floating Drydocks.

Coating Water Storage Tanks (U), YR 007-08-403. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; Dr. H. Hochman.

The objective is to find or develop the most effective materials and methods for coating or lining steel water tanks, 24 inches diameter and larger, to protect the tank from interior corrosion.

A number of problems concerning severe interior corrosion of water tanks were submitted to the Bureau from field activities. These problems frequently involve corrosion in the interior of medium and large warm and hot water storage tanks. All these activities have attempted remedial action using specification and nonspecification coating materials. The 11ND Public Works Office Testing Laboratory has had success with siliceous linings and will cooperate with NCEL in further developing and evaluating this material.

Protection of Mooring Buoys (U), YR 007-08-404. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601.

The objective is to find or develop a suitable method for protecting mooring buoys against corrosion. The following efforts support this objective.

a. Protective Coatings for Mooring Buoys--The objective is to find or develop a satisfactory material which will give a white or light colored protective coating to the portion of a mooring buoy which is above the water line.

All present known protective coatings discolor very quickly (one month average) making the buoy difficult to see during the night and inclement weather. In addition to the above water line protective coatings do not last longer than one year.

b. Cathodic Protection for Standard Fleet Moorings--The objective is to investigate the feasibility of protecting fleet moorings against corrosion by the use of cathodic protection.

Non-Specification Preservation (U), YR 007-08-406. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; J. M. Stephenson.

The objective is to determine preservative methods and types of materials which are most effective for the outdoor storage of vehicles and equipment without cyclic preservation and with a minimum requirement for depreservation at reactivation time. In addition, to determine the lubricating and engine performance properties of oils and greases which are found to be superior preservatives.

Existing methods of long term storage require cyclic inspection to monitor the condition of the stores and when necessary, represerve areas where original preservatives have weakened. There are on the market many types of preservatives that may preclude cyclic inspection. Some serve dual purpose of being a lubricant as well as a preservative. Those appearing to have merit were purchased in order to determine by test whether or not they could satisfy the objectives of the task. An outdoor storage site was established and stocked with test equipment. This equipment includes five TD-9 International Tractors, three M38A1 Willys Jeeps, and twenty-four 55 gpm salt water pumps. Originally seventeen different preservatives (not covered by Military specifications) were applied to various areas of this test equipment to determine whether or not the preservatives would afford protection against rust and deterioration.

Revision of Engine Preservation Specification (U), YR 007-08-407. NCEL, Appn:17X1319.94 RDN, Allot No. 25/80696, J. B. Crilly; Villanova University, NBy 4712, Dr. G. N. Quam.

The objective of this task is the preparation of a strict specification covering the best of the available engine preservative oils. The most effective application methods for these oils will also be determined.

Current specification preservatives have comparatively short periods of effectiveness, are either subject to run-off or require an extensive depreservation operation, and are frequently inconsistent in performance.

Villanova is presently investigating the feasibility of preserving engines in the field by adding chemical corrosion inhibitors to standard lubricating oils, prior to placing the vehicle in storage. Preliminary laboratory tests on the Villanova Cycling Machine, a preservative testing apparatus, have proven very successful. Action to modify the existing, or to write a new preservative oil specification, will be delayed pending resolution of this new approach.

Fire Protective Coating Against CW (U), YR 007-08-408. NCEL, Appn:17X1319.2514 RDT&E, Bu. Control No. 10601, R. L. Alumbaugh; ERDL, Appn: 17X1319.2514 RDT&E, Bu. Control No. 10601, H. Miller.

The objective is to develop fire retardant paints and impregnates to improve the defensive position of the Naval Shore Establishment against CW agents. End products desired are paints and impregnates that afford a high degree of fire retardance with a one coat application; that can be applied with regular paint equipment and cost no more than standard maintenance paints; and that are equal in performance to standard paints.

Masonry Coatings (U), YR 007-08-409. Contractor, Contract and Principal Investigator, to be determined.

The objective is to find or develop suitable coating materials which will effectively waterproof masonry surfaces.

Many types of paints and coatings have been used in the field to waterproof masonry construction but none proved to be satisfactory for

extreme conditions. Water entering a masonry structure corrodes steel reinforcing and causes wood and insulation to deteriorate.

It is planned to have NCEL conduct the task. A preliminary literature and field survey will be made. Depending on the results of this survey, materials will be procured and field tested in severe environments.

Coating Material For The Prevention Of Ice-Snow (U), YR 007-08-410. Contractor, Contract and Principal Investigator, to be determined.

The objective of this task is to develop or obtain some material that could be applied, either by spraying or painting, to power lines, RF transmission lines, insulators, micro-wave dishes, antennas and other electrical installations, which would prevent the formation of ice on the surfaces of these items.

The development of such a material would reduce maintenance on the type of structures involved. Communication and power outages would be reduced. The need for costly preventative measures such as Radomes and heating systems would be drastically reduced.

Vehicle Protection Corrosion Environment (U), YR 007-08-411. Contractor, Contract and Principal Investigator, to be determined.

The objective is to establish preservation procedures for automotive equipment operating in areas having humid and/or salt ladden atmospheres.

Automotive equipment located in tropical and subtropical areas, especially those adjacent to the sea shore, are subjected to severely corrosive conditions. Condensation caused by day-night cyclic temperature changes in humid air, forms and collects on the body, frame and other components of vehicles contributing to rapid corrosion. In addition, it has been established that at relative humidities over 60%, a microscopic film of water often forms on steel surfaces. In the presence of salts carried to the vehicle by sea spray, winds and dust, this moisture becomes highly corrosive. Metal deterioration is a constant process requiring continuous costly maintenance, repairs and replacements.

It is expected that NCEL will be assigned the task. It is intended to investigate a number of protective coatings for use on exterior, interior, exposed and concealed metal surfaces. Based on existing information and possibly additional laboratory tests, a number of vehicles will be coated and field tested.

Pre-Gel Preservative Tests (U), YR 007-08-412. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; A. P. DeMarco.

The objective is to devise and conduct laboratory tests to determine the relation between dropping points of pre-gel type preservatives, as determined by ASTM method D566-42, and actual run-off and drop-off action under variable conditions of time, temperature, and coating thickness.

The dropping point temperature of a pre-gel preservative material such as "Eureka" or "Yosemmite" is an indication of its resistance to soften and lose bond at elevated temperatures. However, the Bureau is not aware of any previous attempt to correlate the dropping point with what actually occurs under field conditions on horizontal and vertical coated surfaces. The rate of run-off from vertical surfaces and drop-off from horizontal surfaces is probably a function of the physical characteristics of the material (dropping point, viscosity), and coating thickness, temperature, time, and the surface condition. It is expected that results of this task may be used as a performance type test requirement in future procurement specifications to supplement or replace the presently specified dropping point test.

Cathodic Protection (U), YR 007-08-901. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; A. E. Hanna.

The objective was to study the cathodic protection of the inactive floating drydocks at Long Beach, consisting of one AFDL-12, seven sections of an AFDB-4, and three YR barges. Also to participate in the annual inspection of the YFD-70 at San Francisco, to determine the results of using zinc annodes to protect the inside of tanks. Follow the development in the art of electroyltic descaling as it pertains to the inside of tanks.

The use of galvanic anodes, magnesium and zinc, has been investigated on the AFDL-20, located at Port Hueneme, for four years. It is essential to use resistance control for magnesium to limit the cathodic potential to a value compatible with the paint coating and to obtain a realistic anode life. Zinc will inherently maintain a safe potential but will require more anode surface area and must be used in a low resistance electrolyte.

A preliminary study of 21 coating systems for use with cathodic protection in sea water was conducted for one year. The results emphasized the need for close potential control and the use of coatings with good aldali and hydrogen blistering resistance.

600 Volt Cable Sheaths (U), YR 007-08-902. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; A. Hanna.

The objective is to find a suitable insulating sheath material which is resistant to the deteriorating effects of oil base corrosion inhibitors for use as an electrical insulating cover on 600 volt cables used on the cathodic protection system in the ballast tanks of floating drydocks.

The task was assigned to NCEL in July 1959 because the usual polyvinyl and polychloroprene type cable sheaths are adversely affected by oil base corrosion inhibitors. Malfunctioning and replacement of cables has been necessary. Nineteen cable manufacturers and vendors were contacted to obtain their recommendations for a cable which could endure the proposed use. Four do not make a cable which they would recommend for the conditions indicated. From the balance, six different jacket-insulation systems were suggested, and quantities of these have been tested.

Lithium Chloride Inhibitors (U), YR 007-08-903. NCEL; Appn:17X1319.2514 RDT&E, Bu. Control No. 10601; C. V. Brouillette.

The objective is to determine suitable container materials and/or corrosion inhibitors compatible

with water solutions of lithium chloride for use in fire extinguishers at low ambient temperatures.

Because of the highly corrosive action of Lithium Chloride solutions, which because of their low freezing temperatures are used in hand fire extinguishers in polar regions, NCEL was requested to find or develop suitable corrosion inhibitors or compatible metals for containers. Work was started in February 1956. After a considerable number of metals and inhibitors were tested it was found that lead lined brass fire extinguishers containing 24% LiCl solution and inhibited with dichromateoxalic acid were best suited for the purpose. Because the tests were conducted at elevated temperatures to accelerate the corrosive action, NCEL is conducting additional tests to confirm the original finds.

Gaskets Study (U), YR 007-08-904. Naval Shipyard New York (Materials Laboratory); Appn:17X1319.2504 RDT&E, Bu. Control No. 10611; C. K. Chatten.

The objective is to determine suitable gasket materials of high electrical resistance to insulate steam and condensate piping at appropriate locations to isolate cathodic protection circuits. Flange gaskets presently used as electrical insulators for cathodically protected underground steam and condensate piping have a short service life because of the high temperatures.

Teflon as a Preservative for Automotive Equipment (U), YR 007-08-906. NCEL; Appn:17X1319.2504 RDT&E, Bu. Control No. 10601; H. R. Joerding.

The objective is to determine the suitability of a Teflon film as a preservative for corrodible surfaces of equipment and machinery.

Long-term open storage of equipment causes serious corrosion on the working surfaces of the components such as engines, transmissions, differentials, etc.

A jeep was coated internally and externally with Teflon. After 2 years outside exposure at Port Hueneme, California it was determined that Teflon was unsatisfactory for surfaces exposed to the atmosphere but excellently preserved internal parts. As a result it is proposed to test the jeep's engine to determine if the Teflon still on the internal parts has any adverse effects on engine performance.

R007-09 Fabrication and Processing Techniques

Fabrication and Processing Techniques, WR 007-09-001. Massachusetts Inst. of Technology, Southern Research Inst., Solar Aircraft Corp., Sciaky Corp., Aeroprojects, Stanford Research Institute, Chromalloy Corp.; RRMA-23.

This task is directed toward the development and evaluation of new or improved fabrication and processing techniques required for the processing of metallic and non-metallic materials used in the broad range of applications encountered in Bureau of Naval Weapons vehicles and equipment. Several projects investigating the use of ultrasonic and plasmatron welding are in progress to provide improved methods for joining materials. Explosive forming is also being studied as a cheaper and more versatile method for fabrication of materials. A number of projects concerned with the development of improved protective coating materials and techniques are underway. An extensive program for study of the fabrication characteristics of high strength heat treatable titanium sheet alloys is also being undertaken.

Textile Treatments and Materials (U), SR 007-09-1150. Naval Supply Research and Development Facility, Bayonne; 10372 RDT&E, 61.2411; A. Siegfried.

1. Ship service tests of a fluorescent-dyed rayon sharkskin signal flag showed poor durability. CNO desired further development work be expedited to produce a flag meeting the Fleet requirements.
2. In view of the lightweightness, easy handability of nylon-vinyl laminates, many shipyards have been using these materials for coverings in lieu of canvas.
3. CNO has requested the development of life preservers capable of withstanding emergency ascents from open-sea depths of 100 feet or more.
4. Submarine Forces have requested the development of hydrophobic textiles to relieve the workload on driers and washers aboard ship.

Threaded Fasteners (U), SR 007-09-0857. David Taylor Model Basin, 10169/61.2411, R. B. Allnut (Code 721); Almay Research and Testing Corporation, Nonr 3291(00)(X), H. S. Brenner.

The use of screw-threaded fasteners is governed by a miscellaneous assortment of manuals, technical instructions, and other bits of information published in various trade journals and in the technical literature. Preparation of a logical guide which sets up for the designer all the conditions necessary for joining structures together by means of mechanical fasterners is the objective of this project.

A literature study has been conducted. A contract has been negociated for preparation of portions of a handbook. These portions include evaluation and test metho's for fasteners and the performance and characteristics of locking devices.

Fabrication Characteristics of Rivets (U), SR 007-09-0885. Puget Sound Naval Shipyard; R. N. Bondy.

For the development of optimum fastening systems of steel and aluminum joints, an investigation is being conducted jointly between Kaiser Aluminum and Chemical Corporation and Puget Sound Naval Shipyard. The shipyard phase included a study of the forming and driving cycle characteristics of rivets and Huck type fasteners. The shipyard has prepared a report on the evaluation of relative costs, ease of application, tools and skills required, difficulties encountered, difference in time and reproducability of results. Fabricated bi-metal specimens have been forwarded to Kaiser Aluminum and Chemical Corporation for corrosion testing.

Adhesive Bonding of Pipes (U), SR 007-09-0886. Quantum, Incorporated; NObs 77166.

The purpose of the investigation was to establish the feasibility and potential of adhesive bonding of pipes, and to establish a definite "State of Art" for bonding procedures and bonding strengths.

The project has been completed and reported.

Various adhesives, joint configurations, and surface preparations were investigated. Joints were fabricated in 90-10 and 70-30 copper-nickel tubing. Tensile, hydrostatic and fatigue tests were conducted. A fabrication manual was prepared reflecting the best procedures determined by the investigation.

Welding and Cutting Processes (U), SR 007-09-0875. Battelle Memorial Institute, NObs 78839, P. Rieppel; NAVSHIPYD MARE, 10286/61.2411, L. Robbins; NAVSHIPYD CHASN, 10286/61.2411.

New ways are sought to improve ship fabrication and to reduce costs. The object herein is the improvement of present conventional welding processes --either expanding their use to new applications or improving quality and economics in the present application--and developing new processes such as submerged - arc and electro-slag welding for ship construction applications.

An important accomplishment during the past report period has been the perfecting of a submerged - arc welding process at the Mare Island Naval Shipyard and subsequent use of the process in production work for fabricating both butt and tee joints in submarine hulls.

A project at Battelle has consisted of extensive studies to develop electrodes, fluxes and procedures for submerged-arc welding HY80. Commercial wires and experimental fluxes were used to determine the effect of flux composition on weld deposit mechanical properties. Welds having yield strengths of 80,000 psi or higher, notch-bar values of 30 ft.-lb at -100F and 80 ft-lb at 80F have been made. One-inch-thick HY80 explosion bulge weldments were made and tested. On the basis of this test, the welds were not considered entirely suitable for submarine application.

Principles of Casting Metals (U), SR 007-09-0898. U. S. Naval Research Laboratory; PO 1 0001; E. A. Lange.

The aim is to establish scientific information required for the technology of melting and casting of metals. This involves continuing research concerned with melting practices, gating and risering systems, mold media, and solidification mechanisms to improve the physical properties, mechanical properties, dimensional qualities, and reliability of castings

The effect of vacuum stream degassing on the chemical composition of high-strength aluminum alloys containing a critical amount of magnesium, 0.3%, and trace amounts of sodium was determined. Exploratory work concerning low cycle fatigue and the design of specialized equipment for examination of fatigue failures and evaluation of extent of fatigue damage has been conducted.

Work is underway on the vacuum stream degassing process for refining molten metals, and risering of high-strength aluminum alloys with radiographic inspection techniques as a sub-phase.

Flaw Detection (U), SR 007-09-1985. Naval Ordnance Laboratory, From Coast Guard, Mr. E. Criscuolo; Navy Radiological Defense Laboratory, Allot. 10178,. Mr. K. F. Sinclair.

A manual to guide field workers in the techniques involved in the use of four selected gamma-ray sources for detecting flaws in welded structure has been completed.

An investigation of a radiographic flaw-detection technique using source and film located on the same side of the plate proved unsatisfactory and project was terminated.

Work on a filmless radiographic method utilizing conventional radiation sources and back scattered radiation is continuing. A systematic examination of gross scattered intensity as a function of geometry is underway. Further examination of the application of pulse-height analysis to the problem is also being investigated, as well as a study of various detection schemes.

Design Detail Handbook (U), SR 007-09-1986. Prof. A. D'Arcangelo; NObs 74584; Prof. A. D'Arcangelo.

A design detail handbook that will serve as a guide for the design and fabrication of structural details in ships is being prepared.

The handbook will include among other items, details on: appendage and fitting connections to main hull, bracket and end connections, foundations, hatch corners and coamings, intermittant welds, joining of plates and shapes of different thickness, reinforcements around openings, riveting on a welding ship, sub-assemblies, superstructure and deck deckhouse connections, weld joint details, welding or joining of thick plates and shapes and welding sequence.

Residual Stress Patterns (U), SR 007-09-1987. Battelle Memorial Institute; NObs 77028; Mr. D. C. Martin.

The objective is to determine if hydrogen-induced cracking can be used to study residual-stress patterns in weldments in steel.

Systematic crack patterns were produced in weldments made with SAE 4340 steel plate heat treated to a high strength level. In lower strength steels, systematic crack patterns were not obtained. A mathematical analysis has been made of two simple cases which correspond to a butt joint and a circular-groove weld. Fundamental equations were obtained which could be used to predict the crack pattern which would be obtained.

Future research is being undertaken to obtain a more thorough understanding of the phenomena encountered in the hydrogen-cracking technique. Investigations of the stress-corrosion cracking technique also are being conducted.

R007-10 Methods of Analysis, Inspection and Tests

Methods of Analysis, Inspection and Test, WR 007-10-001. Air Material Laboratory, RRMA 04 011/200, RRMA-12; Naval Research Laboratory, RRMA 33 020/566, RRMA-12; NAS Alameda, RRMA 04 025/010, RRMA-12.

To provide new and improved methods of evaluation, test, and analysis in order to facilitate and promote maximum efficiency and reliability in the utilization of materials for Naval weapons systems. Also, to provide laboratory support for programs for the development of methods of analysis,

inspection and test.

Concentrating on areas of weakness, refine existing, methods of analysis, inspection, and test, or devise new methods, as appropriate. Screen and evaluate pertinent test and inspection devices. Establish specific test, evaluation, and development investigations on various phases of pertinent programs, to provide essential exploratory and confirmatory data.

New and improved methods of analysing, inspecting, and testing materials are being developed on a continuing basis for consideration as standards and incorporation in specifications.

Spectrographic Analysis (U), SR 007-10-0700. Philadelphia Naval Shipyard; 10290/61.2411; Dr. J. Sherman.

The objective is to establish a general procedure for critical analysis by means of X-ray spectrography with all possible extensions to minute sample size, low concentrations and full allowance for difficulties introduced by the inter-element or matrix effect.

Work has commenced aimed at minimizing preliminary calibration and standardization procedure. The applicability of instrumental analysis in the determination of impurities, doping levels, and homogeneity in semi-conductors has been examined.

This work will be continued and extended to materials for thermoelectric power generation. Anticipated application of present work will be to a few critical analyses of any possible composition rather than the mass production of similar analyses, as in inspection procedures.

Evaluation of Bearing Materials, SR 007-10-3821. NAVENGRXSTA; W. V. Smith.

Test procedures for determining wear and physical characteristics of plastic bearings using water as a lubricant have been established, a QPL test has been developed, and a specification invoking these requirements has been issued.

The wear and frictional characteristics of propeller shafting and shaft sleeve material subjected to abrasive contaminated water lubrication on bench wear testing machines was evaluated.

Journal and bearing materials under various conditions of lubrication were also evaluated.

Develop Non-destructive Babbitt Bond Test, SR 007-10-3822. NAVENGRXSTA; W. V. Smith.

An exhaustive study of methods of developing a non-destructive babbitt to bearing shell bond test has produced negative results. Therefore, lacking an immediate acceptable non-destructive test to include in the preparation of a standard babitting technique, development of a standard babbitt bond test of a destructive nature cannot be avoided. The development of a standard specimen and a standard non-destructive test to measure the quality of bond between babbitt and bearing shell is still required.

Fatigue Life of Rolling Bearings (U), SR 007-10-3823. NAVENGRXSTA; 720006; R. L. Ward.

The development of proper methods to test the load-life-fatigue characteristics of rolling bearings is required to enable the procurement of bearings that will give reliable operation. A proposed industrial test plan was found to be less sensitive than the Navy's existing method. The U. S. Naval Engineering Experiment Station has a new test plan which is considered to be superior to existing plans. Procurement of large lots of typical samples has commenced to enable the evaluation and comparison of these various methods.

A large lot of bearings from a qualified supplier's single production run was procured for testing under the various testing methods discussed above. The test equipment was overhauled and modernized and sample bearings tested under three different methods and under two different temperature conditions.

A parallel effort was also initiated to develop, design and build test machines to enable the establishment of the ultimate life of needle bearings. Sample lots of thin outer shell, full complement bearings, thin outer shell, cage bearings and cage type needle bearings were subjected to tests. Evaluation of the test procedures and results is nearing completion.

Techniques for Bonding Bearing Rubber to Propulsion Shafts, SR 007-10-3824. NAVSHIPYD MARE; 50286RDT&EN, 60.2401 OPEVAL; R. Morris.

The purpose of this subtask is to explore and develop a method of bonding rubber and synthetic rubber like materials to propulsion shafting, outboard of the stern tube stuffing box, for the purpose of acting as a stern tube and strut bearing wearing material.

Testing has determined that an acceptable bond can be produced between both steel and aluminum bronze propeller shafts and rubber journals.

Mare Island Naval Shipyard has manufactured bearing assemblies to be evaluated in an MSO 421 class ship. One of the aluminum bronze shafts on the test ship will have bearing journals of rubber running in bearing shells of gun metal. The other shaft will have rubbe journals running in a nickel copper silicon alloy ("S" Monel) bearing shells.

Develop High Load - Low Speed Bearings, SR 007-10-3825. NAVSHIPYD MARE, F. Braghetta; NAVSHIPYD PTSMH, M. Clay; NAVENGRXSTA ANNA, R. L. Ward.

The purpose of this subtask is to explore and develop a method of using the comparatively new materials such as Teflon, Delrin and Lexan as bearing materials for use in sea water lubricated high load, low speed bearings, such as for submarine diving plane bearings.

The unusual physical characteristics of some of the above type materials wherein the static coefficient of friction is equal to the dynamic, and the promise of these materials as boundry lubricants in the presence of sea water has prompted the implementation of this program.

Various Teflon products have been tested with promising results. Delrin has been applied on the SSN571 and is presently being evaluated. Results to date are very promising.

Develop Bearing Materials for High Temperature Operation, SR 007-10-3832. NAVENGRXSTA; W. V. Smith.

Rolling contact fatigue which normally limits

the life of all rolling contact bearings is greatly accelerated when lubrication is sharply altered to such media as water, liquid metals or oil at elevated temperatures. In as much as rolling contact bearings are continually being designed into components requiring higher and higher bearing temperatures, suitable bearing materials must be developed.

Test equipment was designed and developed which enabled compression loading of contact rollers submerged in various lubricating media. Rolling contact and hot hardness tests have indicated that welding and seizure of rolling components are cause of failure of standard rolling contact bearings operated in molten metals. Test results to date show that in general, the ferrous materials below 40 Rc exhibit a tendency to pick up on hardened SAE spindle whereas those of 45 Rc scored the spindle. Tests on non-ferrous materials have shown that aluminum alloy 14S has been run satisfactorily while subjected to a load of 50 psi and NAK at 250°F. Sliding contact tests have been made in NAK at temperatures up to and including 500°F. Aluminum base alloys continue to show the highest resistance to pick-up of the materials tested to date. Contact roller tests on various tool steel rollers were made in NAK at 250°F. None of the materials tested have shown any improvement over SAE52100 steel. Various other tests have been made using 52100, 18-4-1, 14 ST materials in 2190 T, and NAK at various temperatures with varying degrees of success.

Investigate Bearing Performance with Explosion Resistant Lubricants, SR 007-10-3833. NAVENGRXSTA; W. V. Smith.

Explosions on aircraft carrier catapults resulting from the use of explosive type hydraulic fluid has led to a prime requirement for development of a suitable non-explosive synthetic lubricant.

Various synthetic non-explosive lubricants have been developed and tested by various commercial firms such as Cellanese and Monsanto with varying degrees of success. Since the non-explosive lubricant tests conducted to date indicate that they do not have the lubricating characteristics necessary with conventional materials, materials that will run with these non-explosive lubricants will be developed.

Gas Lubricated Bearings, Development of Technology for, SR 007-10-3834. ONR (Franklin Institute), Nonr 2342(00), W. Shuggart, D. Fuller; ONR (General Electric Co.), Nonr 2844(00), B. Sternlicht.

Experimental, theoretical and commercial information all indicate that gas-lubricated bearings have significant advantages over liquid and grease-lubricated types in certain applications. Specially noteworthy is the avoidance of contamination by liquid lubricants of the gas surrounding the rotating system, their ability to operate over a wide range of pressures and temperatures, their suitability for use in nuclear radiation fields. In particular cases their simplicity, quietness, reliability, low friction and long life offer special benefits.

Recent work of various manufactures and laboratories toward establishing a technology for hydrodynamic (self-acting) and hydrostatic (externally-pressurized) gas bearing design has been reported. Many of these advances have been made by Franklin Institute and General Electric Company. Another result of this contract has been to indirectly stimulate research by private industry. Various Government agencies, including the Bureau of Ships, financially contribute to and participate in ONR contracts, Nonr 2342(00) and Nonr 2844(00). Much of the theoretical knowledge needed in this area has resulted from this project.

Interaction of Brg. Matls. Mech. Attributes and Lube as a Limiting Perf. on R. C. Brgs., SR 007-10-3835. NAVENGRXSTA; W. V. Smith.

Satisfactory rolling contact bearing operation is dependent on many variables including type and quantity of lubricant, degree of balance of equipment, limiting speeds, etc. Present day applications are becoming marginal for grease lubrication due to high "DN" values which is the diameter of the bearing in millimeters times the speed in RPM. Rule of thumb limits grease lubrication to applications whose "DN" does not exceed 200,000. Oil lubrication complicated the design and introduces undesirable sealing problems. Attempts to use grease lubrication in applications with "DN" values above 200,000 have been both successful and unsuccessful. This indicates that other factors such as degree of balance, type and quantity of lubricant, position of bearing (whether it is a radial or thrust load carrier), vibration, etc., have an effect on bearing performance in high "DN" applications.

Radiography of Metals (Ferrous and Nonferrous) (U), SR 007-10-0890. Material Laboratory, Casting Development and Foundry, Control Section; 10171/61.2411; Code 982, S. Goldspiel.

The objective is to develop standards for the non-destructive testing of ferrous and nonferrous castings in order to safeguard against service failures due to hidden defects. In this connection, the objective of this project is to develop reference radiography and correlation of mechanical properties with radiographic indications for (a) Aluminum castings up to 6 inches thick, (b) bronze castings up to 6 inches thick, and (c) Steel castings up to 12" and above (if possible). In performing the above project work, advantage is being taken of cooperative efforts between the Bureau of Ships and the American Society for Testing Materials, through the Material Laboratory representation on cognizant ASTM Task Forces, to effect overall expedition and economics in the projects. However, the work is also designed to supplement corresponding work of ASTM by meeting special needs of the Navy, e.g. determination of significance to deterioration of properties of castings when different grades and types of discontinuities are involved.

The Material Laboratory has been assisting ASTM Task Force A of Committee E-7 Sub II in development of reference radiographs for 3" steel castings, for Co-60, 1000 KVP X-rays and Betatron sources, which have been completed and are scheduled for submission for Committee action when editorial material, now in preparation, has been completed. Work on 6" reference steel radiographs is in the planning stage.

Ultrasonic Testing (U), SR 007-10-0891. Naval

Ordnance Laboratory, 10175/61.2411, E. Criscuolo; Material Laboratory, 10171, I. Schwartz (981); Armour Research Foundation, Not Processed; Curtis-Wright Corporation, NObs 72375; International Inspection, Incorporated, Not Processed.

Techniques developed for transmission of sound energy in solids require improved instrumentation for application to flaw detection in metals. Basic ideas heretofore uninvestigated require development for best utilization of sound energy in accomplishing flaw detection in various structures including weld joint configurations.

A prototype model of an ultrasonic unit for inspection of propulsion shafting has been built and has undergone testing at a Naval shipyard. The equipment was found to be unsatisfactory. Revision action by the contractor is pending. Sonic inspection apparatus commercially produced by various manufacturers has been obtained by the Naval Ordnance Laboratory. Test weld configurations have been prepared.

Evaluation of commercial equipment is underway at NOL employing the prepared joint configurations. Sonic findings are being compared with radiographic and visual findings. Documents are being processed for initiation of research on the following basic concepts: (1) Polarized sonic energy; single and/or variable frequencies, (2) Intermodulation of sound energy beams of differing frequency, (3) Continuously variable frequency surface waves.

R007-11 Radiation Resistant Materials

Radiation Resistant Materials, WR 007-11-001. Naval Air Material Center; 15-200; RRMA-32.

To determine the effects of nuclear radiation on the various materials used in the construction of weapons systems and components.

The ability of various materials to withstand the effects of radiation will be determined. The shielding and absorption characteristics of various materials under various conditions of radiation will also be determined.

Materials have been found which are satisfactory for use in a radiation environment, provided the life expectancy under radiation is considered. These materials are replaced when the established life period has expired. For example, a grease is replaced after a definite time under radiation. Also, new materials are being developed which will withstand radiation for a longer period of time without deterioration.

Radiation Effects on Organic Materials (U), SR 007-11-0546. U. S. Naval Radiological Defense Laboratory; Allotment 50178/RDT&E 61.2411; R. S. Alger.

To determine the mechanism by which ionizing radiations change the electrical, mechanical, and optical properties of polymer materials.

Electron paramagnetic resonance techniques are used to identify the radicals produced by ionizing radiation and their interactions with the parent atom at low temperatures. Irradiated alcohols, ketones, ethers and paraffins have been studied. Samples of $CH_3CH_2CH_2OH$, $CH_3CH_2CD_2OH$, $CH_3CD_2CH_2OH$ and $CD_3CH_2CH_2OH$ were irradiated with either 2 million peak or 50 KVP X-rays and examined for EPR hf structure, some at 77°K and others at 4°K. The results show that a hydrogen atom is preferentially removed from the carbon next to the OH(C_1) and the unpaired electron interacts with the remaining hydrogens on C_1 and C_2. If D is substituted on C_1 some of the radicals are produced by a loss of hydrogen from C_2.

Similar studies are underway with emphasis on hydrocarbons of the alicyclic and ring type. Compounds of fluorine with Group III, IV and VI elements are also being studied.

Material Classification Code 988.

Radiation Effects on Electronic Parts (U), SR 007-11-0547. Admiral Corporation; NObsr 77612; Mr. E. R. Pfaff.

To develop type CPM08 capacitors of Specification MIL-C-14157 which will be resistant to gamma radiation at a maximum rate of 10^5r/hr with voltage and temperature superimposed.

Capacitor units impregnated with a series of different liquids and solids have been irradiated at 10^5r/hr with 2000 volts pulsed applied at 135°C. Monoisopropylbiphenyl liquid gave the best results. The Mylar and Mylar-paper components were embrittled in the tests, the indications being that the Mylar is being damaged by hydrolytic degradation rather than gamma damage.

Capacitors using isocyanate treated Mylar and filtered monoisopropylbiphenyl liquid are being tested. Similar units using synthetic mica paper are being prepared for tests.

Effects of Space Radiation (U), SR 007-11-0549. Contractor not assigned, (Naval Research Laboratory and U. S. Naval Radiological Defense Laboratory both under consideration).

For applications involving manned satellites or unmanned communication satellites of interest to the Bureau to define the radiation field of the Van Allen belts and its effects on mammalian tissues, materials, and electronic components and circuits of interest to the Navy.

Radiation Effects on Magnetic Materials (U), SR 007-11-0550. U. S. Naval Ordnance Laboratory, White Oak, Maryland; Allotment 10175/RDT&E 60.2401; D. J. Gordon.

To obtain information on the capabilities of permanent magnets in electromagnetic flowmeters to operate at high temperatures and in radiation up to 10^{19} - 10^{21} nvt.

Earlier NOL work had established that soft (core) materials with coercive forces below 0.5 oersted suffer severe degradation in magnetic properties when subjected to radiation up to 10^{17} nvt (epicadmium). Soft materials with coercive forces above 0.5 oersted and all hard (permanent magnet) materials have been found to be radiation resistant at least up to $3x10^{17}$ nvt (epicadmium).

NOL magnets are being irradiated in the highest flux (10^{13}nv) holes of the CP-5 reactor at Argonne National Laboratory (ANL) and are being compared with magnets subjected to equivalent high temperatures without irradiation. Complete results are not available but preliminary results indicate Alnico II, V and XII magnets are resistant to radiation up to $5x10^{20}$ nvt (epicadmium) at 325°C.

Materials Classification Code 988.

Effects of Fallout Radiation on Circuits (U), SR 007-11-0051. U. S. Naval Radiological Defense Laboratory; Allotment 50178/RDT&E 61.2411; H. Zagorites.

To make a detailed study of electronic performance of critical military systems in predicted fallout radiation environments; to establish analytical, simulation, and testing methods for the design and evaluation of such systems which must function reliably in these environments; to provide solutions to individual problems defined in the study; to implement efforts to make available components and engineering data needed in future design for this environment.

Data from Operation HARDTACK indicated that high-level fallout radiation (ranging between 10^4 and 10^6 r/hr) has deleterious effects on the performance of certain critical electronic circuits. These effects affect circuit performance during the time of exposure, which may last from several minutes to several hours. In recent work at NRDL it was found that some germanium transistors and diodes exhibited an increase in leakage current as large as a factor of 100 or more when exposed for several minutes to gamma radiation at an intensity of 800,000 r/hr. A significant increase in current gain of the transistors was noted immediately after irradiation.

Arrangements are being made with the San Francisco Naval Shipyard to obtain equipment and information to be used in a theoretical analysis of Navy circuitry most likely to be adversely affected by fallout radiation. The areas of investigation include: (1) missile launch and guidance circuits, (2) The Navy Tactical Data System (NDTS), (3) Communication Circuitry, (4) Infra-red Equipment. Trouble spots will be identified. Concurrently further tests on transistors to establish statistically significant data for each type are in progress. A breadboard data acquisition system is now being used in the tests pending purchase of a faster and more accurate system.

Radiation Effects on Thermoelectric Materials (U), SR 007-11-0555. U. S. Naval Radiological Defense Laboratory; Allotment 50178/RDT&E, 61.2411; R. S. Alger.

To determine the effects of nuclear radiations upon such properties of thermoelectric materials as are significant in the direct conversion of thermal energy to electric power by these materials. The work complements similar research being supported by Code 1500 of the Bureau of Ships at the Knolls Atomic Power Laboratory and by the Atomic Energy Commission at Westinghouse Atomic Power Department.

Repeat measurements of the Seebeck coefficient and electrical resistance of bismuth telluride will be made as a function of electron irradiation and temperature upon completion of current studies to improve experimental techniques. These include: (1) improvement of test apparatus in order to measure resistivity as a function of temperature within a reproducibility of 5% over the range from room temperature to 300°C, (2) measure and control the temperature gradient existing in a sample during measurement of the Seebeck coefficient so as to measure temperature differences of 1 to 10°C to within 0.1°C., (3) improve sample fabrication; in its first test run a new machine successfully sliced a wafer of Bi_2Te_3 less than 0.45 mm in thickness.

Radiation Effects on Elastomers (U), SR 007-11-0556. U. S. Naval Radiological Defense Laboratory; Allotment 50178/RDT&E 61.2411; L. H. Gevantman.

To investigate radiation chemical effects important to the development of highly radiation resistant elastomers.

(1) The additive, N-cyclohexyl - N^1 - phenyl - p - phenylenediamine, can significantly mitigate the predominant chain cleaving damage in stretched rubber and the predominant cross linking damage in unstretched rubber.

(2) A quick and useful method for measuring radiation damage in polyurethane elastomers was examined by using the relationship between the extent of cross-linking and the degree of swelling in a solvent. A linear relationship was found to exist between radiation dose and cross-linking using three different solvents. Changes in cross-linking were observable for doses as low as 10^6 rads.

(3) Compression set measurements have been completed on small cylinders of rubbers containing anti-rads which were subjected to 10^7, 10^8, and 10^9r in a nitrogen atmosphere. The results showed a dependence of radiation resistance with initial cross-linking, and this was accounted for in evaluation of the anti-rads. Although several anti-rads were effective up to a dose of 10^8r, none were able to protect at a dose of 10^9r.

R007-12 Energy Conversion Materials

Thermoelectric Materials-Properties Measurement, SR 007-12-0800. U. S. Naval Research Laboratory; 10700 RDT&E, 61.2411, Mr. P. H. Egli; U. S. Naval Engineering Exp. Station, 10101 RDT&E, 61.2411, Mr. M. R. Gross; National Bureau of Standards, PR 342B-11068, Mr. D. R. Flynn.

At the Naval Research Laboratory, the Crystal Branch has designed and constructed: (a) a comparator apparatus for accelerated high temperature thermal conductivity approximation to permit rapid screening of thermoelectric materials; (b) a calorimetric type thermal conductivity apparatus for precise measurements on small specimens (¼" x ¼" x ½") at elevated temperatures; (c) thermal expansion apparatus; (d) differential thermal analysis (d.t.a.) apparatus for use in conjunction with (b) and (c) above. This group is also setting up a program whereby various homogeneous thermal conductivity reference materials Al_2O_3, MgO, PbTe, Ingot Iron, Sapphire) are being distributed to government and contractors' laboratories to permit comparison of the validity and accuracy of techniques and equipment.

The Energy Conversion Branch at Naval Research Laboratory is setting up a measurements laboratory for lower temperature work. They are constructing equipment for measuring electrical conductivity, Peltier coefficient, Seebeck voltage and later, a rapid method for measuring thermal conductivity. They have designed and constructed a Peltier apparatus to act as either heater or refrigerator. With this, they have determined how actual measurements (Peltier effect, Seebeck effect, Thomson

effect, Coefficient of Performance) over a wide range of operating conditions match theoretical predictions on which they are basing apparatus design. A report is in publication covering this work.

At the U. S. Naval Engineering Experiment Station and the NRL Crystal Branch high temperature devices have been duplicated and will be used for routine evaluation of thermoelectric materials from contractors, government laboratories, and industrial sources. At the Engineering Experiment Station an efficiency meter and apparatus for measuring Seebeck coefficient and electrical resistivity to 1100°C. are also being constructed.

At the National Bureau of Standards new precise techniques for high temperature thermal conductivity measurement are being studied. Equipment employing a modified "cut-bar" absolute method for testing up to 600°C. has been completed; alterations thereto for testing at up to 1200°C. are in progress.

Solid Thermoelectric Materials For Use Below 800°C, SR 007-12-0801. Battelle Memorial Institute, NObs 77034, Dr. T. S. Shilliday; Radio Corporation of America, RCA Laboratories Division, NObs 77057, Dr. Fred D. Rosi; Transitron Electronic Corporation, NObs 78345, Dr. E. M. Brown; Westinghouse Electric Corporation, NObs 78365, Dr. R. R. Heikes; Merck Sharp and Dohme, NObs 78503, Dr. P. I. Pollack; Chrysler Corporation, NObs 78664, Dr. C. R. Lewis; Tyco, Incorporated.

This category of materials includes the conventional broad-band wide-gap compound semiconductors which, as a group, have already shown promise for thermoelectric power generation and Peltier refrigeration and air conditioning. The work covers both the development of new materials not previously investigated and improvement of presently known compounds by alloying, doping, and improved preparation techniques.

Solid Thermoelectric Materials For Use Above 800°C, SR 007-12-0802. Union Carbide Corporation, Parma Research Laboratory, NObs 77066, Dr. R. G. Breckenridge; University of Pittsburgh, Department of Metallurgical Engineering, NObs 77068, Dr. J. A. Berger; General Atomic Division of General Dynamics Corporation, NObs 77144, Dr. P. H. Miller, Jr.; Research Chemicals Division of Nuclear Corporation of America, NObs 84088, Dr. E. V. Kleber; Titanium Alloy Manufacturing, Division of National Lead Company, NObs 78326, Dr. S. F. Urban; Westinghouse Electric Corporation, NObs 78365, Dr. R. R. Heikes.

In order that thermoelectricity be practical for widespread military applications it has become increasingly obvious that materials with good conversion efficiencies at temperatures up to 1200°C. or higher are necessary. Conventional broad-band semiconductors are restricted to an upper limit of thermal stability of 800°C. Such very high temperature requirements introduce formidable problems of thermal stability, mechanical properties, chemical diffusion, and joining and contacting.

Liquid Thermoelectric Materials, SR 007-12-0803. Stanford Research Institute, NObs 77017, Dr. Clinton M. Kelley; Ohio State University, Research Foundation, NObs 78254, Dr. T. S. Shevlin.

Stanford Research Institute work on Cu_2S has indicated an interesting anomaly. Seebeck coefficient increases linearly from 50 uv/°C to 370 uv/°C at 1050°C. From 1050° to the melting point (1125°C) it increases sharply to 500 uv/°C. There is no corresponding break in the electrical resistivity vs temperature curve. No thermal conductivity data has yet been acquired.

The Ohio State University Research Foundation contract was executed in January 1960. It will deal with solid, solid-liquid, and liquid semiconductor systems, particularly the latter. Systems to be included are vanadates, tungstates, chromates, and simple oxides.

Thin Film Thermoelectric Materials, SR 007-12-0804. U. S. Naval Research Laboratory; 10700 RDT&E, 61.2411; P. H. Egli.

Work has recently been initiated at the Naval Research Laboratory to study the possibility of utilization of thin film techniques for thermoelectric applications. For such applications, thin films have two unique features. First, they offer possibilities for packaging thermoelectric configurations in large area, light weight units since they lend themselves to sandwich type stacking arrangements for connection either in parallel or in series. Also, they can be produced as homogeneous mixtures of components in chemical compositions which can not be obtained in bulk solids. By evaporation, sputtering, pyrolysis or related techniques it is possible to deposit an intimate mixture of materials which acts effectively as an alloy though the constituents would not be mutually soluble in the bulk solid. Properties may thus be obtained in films which could not be achieved in crystals.

Thermoelectric Materials Environmental Studies, SR 007-12-0805. U. S. Naval Radiological Defense Laboratory, 30178 RDT&E, 61.91, R. S. Alger; U. S. Naval Engineering Experiment Station, 10101 RDT&E, 61.2411, Mr. R. Gross.

The objective of this task is to evaluate the manner in which thermoelectric materials behave in various service environments. The environmental conditions most needing exploration include: (1) high energy radiation fields; (2) thermal shock and thermal fatigue; (3) mechanical shock; (4) chemical reaction with service atmospheres. Among properties to be monitored are: (1) impurity segretation and diffusion, both with the thermoelements and at junctions and contacts; (2) aging, grain growth, and recrystallization at operating temperatures over extended periods of time; (3) evaporation and chemical deposition.

At the Radiological Defense Laboratory, thermoelectric materials are being collected and preliminary laboratory experimentation is being conducted on a few selected materials, notably Bi_2Te_3. Samples have been subjected to beams of a 2 Mev beta radiation from a Van de Graaff generator. Plans are to conduct in-pile tests and pre- and post-irradiation tests in conjunction with high intensity monochromatic radiation. At the Engineering Experiment Station three units for evaluating the effect of thermal gradients on possible degradation

after prolonged simulated service exposure are being constructed. These will be capable of handling 27 specimens. Methods for evaluating mechanical properties of elements and junctions are being developed. Specimens are being collected and aging, diffusion, etc. studies will be inaugerated.

Thermoelectric Materials Fabrication, SR 007-12-0806. Contractor, Contract and Principal Investigator, to be determined.

In keeping with the Bureau of Ships Design Division's plans for imminent construction of submarine refrigeration and air conditioning systems prototypes, there is need for new and improved techniques for fabricating thermoelectric semiconductors into thermoelements and thermocouples. The objective of this task is to develop such techniques. This will include studies of: powder metallurgy techniques for large scale production of thermoelectric semiconductors; joining and contacting problems; segmented couples; co-extrusion of metal clad thermoelements; production of special configurations such as washer shaped thermoelements.

Plasma Diode Materials, SR 007-12-0807. Contractor, Contract and Principal Investigator, to be determined.

The thermionic plasma diode, particularly when considered in conjunction with the nuclear reactor fuel element as a heat source, is quite attractive as a potential silent direct energy conversion system. The plasma thermocouple, using cesium vapor to overcome space charge effects and high cathode ("emitter") temperatures is being studied at several laboratories. Early models have shown conversion efficiencies of 13%, with efficiencies of 20% predicted for the near future and values of 35 to 40% theoretically possible. These models have demonstrated the highest specific power output per unit volume of any direct conversion device. Because of the high temperatures involved (2000°C) and corrosivity of cesium vapor, materials are a limiting factor on efficiency and service life. Extensive materials research is necessary before the plasma diode can be used in practical working devices or large power applications. The Materials Development Branch has drawn up a proposed program of research in cathode materials.

Fuel Cells (U), SR 007-12-0809. Naval Research Laboratory, Washington 25, D. C.; Allotment; Dr. J. C. White.

This work was initiated very recently. While theoretical efficiences approaching 100% are possible in the conversion of fuel to electrical energy in a fuel cell, trial and error methods thus far have not yielded an economically competitive cell. It is now obvious that the development of useful cells that are both practical and economical will depend on a fundamental understanding of the electrochemistry of applicable electrode systems.

The effort in this study is directed primarily towards a determination of the mechanisms of the electrode reactions of possible systems with emphasis on the kinetics of such reactions. This effort includes any oxidizing or reducing electrode reactions which have any possibility of being used in a continuous fashion. It is further expected that the effort will be limited to the fundamentals of any specific system and leave the actual engineering development of promising systems to other groups. Thus far, the work has been devoted to the development of an electrochemical system which can operate under closely controlled conditions in a known atmosphere. This is entailing the building of a vacuum tight gas purification train and electrolytic cell system.

R008 ELECTRONIC SCIENCES

R008-01 Electromagnetic Wave Propagation and Radiation

Aircraft Electromagnetic Interference and Propagation Techniques (U), WR 008-01-001. Naval Air Test Center; Naval Air Development Center.

To provide low drag (preferably zero-drag) antenna designs to meet new rigorous operational requirements established for aircraft and electronic systems. To provide Radomes and Irdomes to keep pace with ever increasing requirements with respect to electrical characteristics, heat, stability, rain erosion and drag. To provide information necessary to permit aircraft electronic installations which will suffer no degradation in performance due to man-made or natural interference. To improve protection against lightning damage.

Specific problem areas are investigated thru sub-tasks to provide laboratory solutions. When these are firmed the weapon system contractor is encouraged or required to use the results.

Several new antenna designs (flush-mounted and low drag) have been developed. Protection from lightning damage to aircraft has proven feasible in laboratory tests particularly with respect to radomes, which are exceedingly vulnerable. The injection molding of slip (alumina oxide) for improved manufacturing of radomes has proven feasible as well as rain erosion coating of plastic radomes with ceramic skins. Most of the antenna research has been carried on thru weapon system contracts with only token effort on strictly antenna research under this project. Emphasis on Interference Reduction has been thru attempts to release available information in form of usable specifications.

Electromagnetic Wave Propagation, WR 008-01-002. Applied Physics Laboratory; NOrd 7386; W. Avery.

To support BuWeps long-range plans for future generation missile programs by insuring, through supporting research, that propagation characteristics are known on a timely basis to optimize new versions of existing weapon systems and to translate future design concepts into hardware. This task supports Operational Requirement SR 10701.

In the development of new concepts for future missiles much supporting research emphasis must fall on studies of the propagation of electromagnetic waves through various media. Problems arise which require knowledge of reflection and scattering phenomena occurring at the boundaries between media of different properties. The approach will be both analytical and theoretical.

Three general problems have been studied; the

transmission media in space communication, statistical models for radar terrain return and polarization and depression-angle dependence of radar terrain return. The results of these studies have been published in publications of the Institute of Radio Engineers.

European Propagation Studies (U), SR 008-01-7028. U. S. Naval Research Laboratory, Washington 25, D. C.; NRL Prob S-1888; Mr. Wm. E. Garner.

The objective of this task is to obtain atmospheric noise and VLF signal Field strengths in this area. Stations have been operating for varying periods of time at Hammerferst, Bodo and Stavanger, Norway, Rome, Italy and Haifa, Israel. The Northern Stations in particular will give much needed information on propagation conditions over paths which include considerable ice covered regions. Another station is planned to record Cutler VLF transmitter when it becomes operational.

Stanford VLF Project (U), SR 008-01-7029. Stanford Electronics Laboratory, Palo Alto, California; NOnr 225(27); Dr. R. A. Helliwell.

Whistler Mode type of VLF propagation measurements being continued on NSS at Greenbank, W. Va., Ushuaia, Argentine and Byrd Station, Antarctica and on NPG at Stanford and on NPM in New Zealand.

Cutler Coverage-Perth (U), SR 008-01-7030. Stanford Research Institute, Menlo Park, California; 687H 18906; Mr. A. L. Whitson.

By making suitable measurements of Signal Wavefront characteristics (angle) of arrival, amplitude, polarization, etc.) at the antipode of Cutler, Maine, it is possible to describe the path loss and propagation characteristics of every conceivable path eminating from the VLF Cutler station. This task covers the development of the necessary equipment. Installation and operation of same at Perth, Australia for a period of one year.

Microwave Propagation (U), SR 008-01-7031. U. S. Navy Electronics Laboratory; Allot No. 10170 RDT&E 2411 (M 1-3); R. U. F. Hopkins.

This problem was established in September 1959, and is a continuation and broadening in scope of work done under former Problem M1-1, Tropospheric Propagation. During 1959-1960 a multiple station beyond-the-horizon microwave tropospheric scattering system was operated simultaneously with refractive index measurements in the scattering region. Measurements were made at X, L and S bands at 94 and 190 miles using narrow beam antennas and pulsed transmitters. Beamswinging experiments showed beam broadening and provided estimates of aperture-to-medium coupling loss. Power spectra and correlation functions of the microwave signals and of refractive index fluctuations were obtained and compared with predictions of various theories of turbulence. Data analysis was completed and a report of the results is being published. During July-August 1960 a cooperative experiment (Tradewinds III) with NRL verified the existence of trans-oceanic ducts. Measurements of 220 and 445 Mc signals were made over a 2200 mile Hawaii/San Diego path under favorable meteorological conditions. A report on this work is being prepared.

The trans-oceanic duct radio propagation data obtained over the Hawaii-San Diego path during July-August 1960 is being correlated with meteorological data obtained simultaneously. The results will be reported during FY'61.

A 60 foot parabolic antenna suitable for use at frequencies from X-band to 400 Mc is under procurement. This dish will be mounted on a special alt-az pedestal on Point Loma for microwave propagation experiments. Auxiliary mechanical and electronic equipment is being designed by the Laboratory or procured for this purpose.

Prop Studies over 10KMCS (U), SR 008-01-7032. Contractor, Contract and Principal Investigator, to be determined.

This task will cover research on Electromagnetic Wave Propagation and absorption at frequencies above 10KMCS as equipment from task 7033 become available. The task results will be useful in the analysis of such systems as "Earshot" in which the benefit to be derived depends upon the characteristics of a component of the earths atmosphere.

SHF Field Strength Instrumentation (U), SR 008-01-7033. Contractor, Contract and Principal Investigator, to be determined.

The object of this task is the development of portable, reliable and precise field strength and radio-meteorological measuring equipment needed by other tasks. Wide band equipment is lacking for the S, X, K and above K bands and equipment development awaits parts and tube development.

Panoramic Field Intensity Equipment (U), SR 008-01-7035. Motorola Incorporated, Phoenix, Arizona, NObsr 77543, Mr. J. E. Kirch; Shock Test, U. S. Navy Electronics Laboratory, San Diego, California, T2 17, Mr. J. L. Eitel (Code 2543).

Production schedule delayed due to failure of development units to meet specifications and give reliable performances.

This task covers the design and development of five (5) AN/URM-126 (XN-1) Panoramic field intensity meters (50 cycles-100 KC) for use on NRL Problem S-1888 and other related VLF data collection programs.

Contract amended 9/9/60 by Amendment No. 5 to increase quantity of panoramic equipments to twelve (12) and to design and develop quantity twelve (12) VLF (10-30 KC) fixed channel receivers for same purpose.

ELF/Atmospheric Noise Measuring Equipment (U), SR 008-01-7036. NBS Boulder Laboratories; 1700R-691-61; Mr. Wm. Crichlow.

Modification of NBS Boulder ARN-2 noise recording equipment to cover frequency band 50 cps - 500 KC in 200 cycle steps to record spectrum noise and signal energy levels. Project just starting.

Wideband Field Intensity Tape Recorder (U), SR 008-01-7037. Contractor, Contract and Principal Investigator, to be determined.

A broad band antenna coupler, preamplifier and magnetic tape recorder are required for evaluation of this approach to recording atmospheric noise and signals in the field to permit extensive analysis

in the laboratory to obtain reliable noise distribution information. The equipment should cover the frequency range of a few cycles to 30KC with at least a 40db dynamic range.

Ionospheric Propagation (U), SR 008-01-7039. U. S. Navy Electronics Laboratory; (M2-3) Allot No. 10170; Dr. C. A. Potter.

Analysis of Arctic VLF Field strength data obtained from airborne measurements was performed and a report is in press. Theoretical work on ionospheric structure was concentrated on electron density profiles produced by various mechanisms such as photo-detachment and cosmic radiation. A near-vertical incidence VLF D-layer sounder facility was constructed in the Arizona desert in 1960 to study D-layer fine-structure and turbulence as seen by VLF systems. A special narrow band receiving system was also designed and placed in operation to measure very weak VLF signals. A modification of this system provides a phase-sensitive device for studying the effects of solar flares on VLF propagation.

High Frequency Propagation Prediction Systems (U), SR 008-01-7040. NBS Boulder Laboratories, Boulder, Colorado; 1700R-692-61; Mr. D. W. Patterson.

Preparation of IBM 7090 computer program to provide optimum working frequency predictions equivalent to those published in DNC-14().

Correlation study to establish mathematical relationship between natural Geophysical phenomena, communication quality and optimum working frequencies for any specific area to area communication path in the Naval Communication System.

Design and development of specialized equipment for determining and recording various propagation and geophysical parameters required for inclusion in the Propagation Prediction System.

Design and development of equipment which will automatically interpret and convert propagation and geophysical information into digital or other appropriate forms to be included in the Prediction system.

Engineering and Operational evaluation of H.F. Propagation Prediction system.

Deep Space Nuclear Detonation Detection (U), SR 008-01-7041. U. S. Navy Electronics Laboratory; M4-1, ARPA Order 164-61, Project Code 8200, Dr. C. A. Potter.

This task covers the theoretical analysis of the mechanism of energy transfer to the D-layer of the Ionosphere from Nuclear detonations in space to determine the effects on the phase of VLF signals propagating over links of various distances and locations. Measurements will be made of the D-layer characteristics by diurnal monitoring of phase fluctuations from phase stable transmitters and by using NEL VLF Arizona transmitter with both fast time response and correlation receiving systems. This work sponsored by ARPA.

Study of Angles of Arrival at H.F. (U), SR 008-01-7042. Contractor, Contract and Principal Investigator, to be determined.

Study vertical and azmithal angles of arrival of H.F. radio signals as well as their characteristic polarization over a number of radio paths. Circular polarization as well as vertical and horizontal should be considered. Intelligence transmittal - fade rates etc. should also be considered.

R008-02 Physical Properties of Solids, Liquids, and Gases

Solid State Electronics (U), RR 008-02-0001. Harvard University, Cambridge, Massachusetts, Division of Applied Science; Nonr 1866(16), NR 372-012; N. Bloembergen.

The broad objectives of this task are (a) to conduct research in solid state and electron physics, including microwave and radio frequency spectroscopy of solids; (b) to study certain aspects of communication theory and circuits, including microwave circuits and active circuits.

Electron Spins in Solids (U), RR 008-02-0002. Harvard University, Cambridge, Massachusetts, Division of Engineering and Applied Physics; Nonr 1866(28), NR 372-013; N. Bloembergen.

This task is devoted to investigations of paramagnetism in solids, and to related relaxation and resonance phenomena which may have application in electron devices.

Alloy Thermoelectric Power (U), RR 008-02-0004. Massachusetts Institute of Technology, Cambridge, Massachusetts, Research Laboratory of Electronics; Nonr 1841(51), NR 372-044; D. White.

This task studies electrical and thermodynamic properties of solid solutions of binary compounds for the purpose of determining their characteristics as thermoelectric power sources. Energy-band structures and thermal conductivities as functions of alloy proportion are studied.

Basic Cathode Research (U), RR 008-02-0005. University of Missouri, Columbus, Missouri, Physics Department; Nonr 2296(01), NR 372-081; E. B. Hensley.

This task is concerned with an experimental study in the field of Solid State and Surface Physics, to provide basic understanding of the electrical properties of selected materials suitable for use as cathodes of vacuum tubes. This understanding is achieved through the use of X-ray, electron diffraction, optical, infrared absorption, luminescence, photo and thermal emission, and tracer techniques. The end product of the study should be an understanding of the electronic structure of the selected materials. Emphasis is being placed on the study of BaO, MgO, SrO and BaSrO, i.e., oxide cathode materials.

Columbia Radiation Laboratory (U), RR 008-02-0006. Columbia University, New York, New York, Physics Department; MIPR 8-60-ONR, NR 372-101; P. Kusch.

This task is a coordinated effort to perform basic research in those fields of physical electronics which utilize techniques involving micro and millimeter waves. Complementing this effort, research is conducted on components required for

generation, propagation and detection of those waves. Specifically, this task includes (1) fundamental research on (a) microwave spectroscopy of gases, (b) millimeter wave sources such as Cerenkov radiation, molecular beam oscillators, and silicon harmonic generators, (c) paramagnetic resonance, (d) super-conductivity, (e) properties of metasable states of hydrogen and helium; and (2) applied research in magnetrons to obtain millimeter wave magnetrons of improved power, tuning, lifetime and stability characteristics.

Ionic Plasma Theory (U), RR 008-02-0007. Yale University, New Haven, Connecticut, Physics Department; Nonr 609(22), NR 372-133; H. Margenau.

This task is devoted to improvement of the atomistic theory of electromagnetic properties of ionized gases and plasmas. Particular topics include (a) cyclotron resonance in ionized gases, (b) scattering of electromagnetic waves by plasma oscillations, (c) contribution of electron-ion and of electron-electron collisions to the microwave conductivity of a plasma.

Electrical Discharges (U), RR 008-02-0008. New York University, New York, New York, College of Engineering; Nonr 285(34), NR 372-141; L. H. Fisher.

The task is concerned with establishing the fundamental mechanism of electrical discharges and arcs. The purpose of the investigations, principally experimental, is to determine the formative time lags of arcs in air, selected gases, and vacuum with uniform and non-uniform electric fields and as a function of electrode separation.

Low Frequency MASER (U), RR 008-02-0009. New York University, New York, New York, Physics Department; Nonr 285(35), NR 372-142; Y. Beers.

Modern optical and microwave spectroscopy has served as a tool for investigation of frequencies, locations and breadth of quantized emission and absorption lines which arise from energy level jumps in atomic and molecular systems. Some of these energy levels arise from differences in kinetic energy of rotation of light molecules, as HDO and D_2O. This task is an investigation of the intensities of lines absorbed or emitted by these molecules in the ultra-high-frequency radio spectrum region to study possible adaptation of gases of such molecular composition into stable oscillators exploiting their quantized frequency jumps.

Surface State Studies (U), RR 008-02-0010. University of Illinois, Urbana, Illinois, Department of Electrical Engineering; Nonr 1834(17), NR 372-161; J. Bardeen.

This task is a study of the fundamental properties of semiconductor surfaces. Principal interest centers upon (a) experimental determination of the physical location, energy levels, and densities of the electronic states associated with etched germanium and silicon surfaces; (b) determination of the relationship between these atomistic electrical properties of the semiconductor and imperfections (such as dislocations and foreign atoms) at the surface.

Field Emission (U), RR 008-02-0011. Linfield Research Institute, McMinnville, Oregon; Nonr 2341(00), NR 372-171; W. P. Dyke.

The principal purposes of the task are to (a) identify and describe the properties of field-emission cathodes and related temperature-field cathodes; (b) develop methods of operation of stable, reproducible field and T-F emitters having both desirable electrical properties and long life, under practical operating conditions; and (c) apply field emission to novel electrical devices.

Microwave-Quanta Detectors (U), RR 008-02-0012. University of Maryland, College Park, Maryland, Electrical Engineering Department; Nonr 595(11), NR 372-180; J. Weber.

This task is devoted to a generalization of the optical pumping technique in which microwave resonance is supposed to occur between Zeeman levels of the optically excited rather than the ground state. The investigation is concentrating on low spontaneous emission noise characteristics of Maser-like devices.

Random Processes (U), RR 008-02-0013. Northwestern University, Evanston, Illinois, Physics Department; Nonr 1228(13), NR 372-190; A. J. F. Siegert.

The broad objectives of this task are to conduct research on statistical physical phenomena, such as various forms of noise and phase transitions. This involves research on generalized random processes and classical and quantum statistical mechanics.

Artificial Dielectrics (U), RR 008-02-0014. University of Southern California, Los Angeles, California, Engineering Center; Nonr 228(16), NR 372-561; Z. Kaprielian.

This task concerns itself with the study of artificial dielectrics for microwaves. Emphasis of this research is placed on experimental and theoretical investigations of artificial dielectrics having (a) dispersive properties, (b) unity indices of refraction, and (c) applicability as crystallographic models.

Semiconductor Mechanisms (U), RR 008-02-0015. Loyola University, New Orleans, Louisiana, Physics Department; Nonr 2816(00), NR 327-711; F. A. Benedetto.

This research provides experimental evidence of the mechanism of electrical conductivity of lead telluride and lead selenide. Selected electrical properties are measured as a function of temperature. The following measurements are being completed for PbTe and PbSe for the 1.5°K ambient temperature range: (a) resistivity and thermo-electric power vs temperature; (b) Hall coefficient as a function of magnetic field strength as well as temperature; (c) other cyogenics measurements. This contract provides equipment which is on hand at Loyola University as a result of termination of task NR 372-710, to permit continued use in semiconductor research.

Cathode Surface Studies (U), RR 008-02-0016. University of Notre Dame du Lac, South Bend, Indiana, Physics Department; Nonr 1623(01), NR 372-731;

E. A. Coomes.

The object is to develop fundamental information concerning the surfaces of oxide cathodes and the relation between surface state and emission characteristics of cathodes in general. Major effort is being directed to (a) detailed study of the kinetics of SrO on Mo; (b) kinetics of Sr vs. SrO on W and Mo to ascertain activation energies for basic tungstate formation; (c) detailed study of work function lowering and surface states; (d) the kinetics of KCl on W with photoexcitation.

Microwave Spectroscopy (U), RR 008-02-0017. Georgia Institute of Technology, Atlanta, Georgia, Engineering Experimental Station; Nonr 991(07), NR 372-781; M. W. Long.

This task is devoted to improving the sensitivity of microwave detectors to small changes in large signal levels and to a study of molecular spectra. This work is carried out in frequency range from 4 to 16 KMc/sec.

Research Laboratory of Electronics (U), RR 008-02-0018. Massachusetts Institute of Technology, Cambridge, Massachusetts; MIPR 24-60 ONR, NR 375-042, NR 372-000; J. B. Weisner.

This task has several major aims, namely, (a) to conduct investigations in modern electrical circuit theory and techniques; (b) to perform theoretical and experimental research in gaseous discharges, electron ballistics and vacuum tubes; (c) to investigate the structure of matter, as relating to the field of electronics; and (d) to perform theoretical and experimental research in statistical communications theory and information theory applied to bio-processes and electro-neurology, as well as related fields.

Theoretical and experimental investigations of statistical methods in network analysis and synthesis, as well as information theory, are directed at improving circuit design methods and applications. This part of the task embraces research in human communications links, correlation methods in detection of signals in the presence of noise, transistor circuitry design, and the use of ferrites in networks.

Recombination and avalanche phenomena studies, microwave spectroscopy, nuclear, ferromagnetic and paramagnetic resonances are part of (b) above. Structure of matter, emphasizing tools for study, as X-ray diffraction and low-temperature experiments, constitute an important part of the work of this laboratory of physical electronics. Traveling wave, backward-wave, thermionic, cold-cathode, thyratron-type magnetrons and other types of tubes are also studied.

Tunnel Emission (U), RR 008-02-0019. California Institute of Technology, Pasadena, California, Electrical Engineering Department; Nonr 220(42), NR 372-263; C. A. Mead.

This task studies the properties and characteristics of solid state surface and near-surfaces for the purpose of understanding the physical electronics involved in motion of electrons and ions through and out of solid state emitters.

R008-03 Electronic Materials and Components

Wide-Band Klystrons (U), RR 008-03-0001. Massachusetts Institute of Technology, Cambridge, Massachusetts, Electrical Engineering Department; Nonr 1841(49), NR 373-043A; L. Smullin.

Operational effectiveness of modern air defense, air-traffic-control, guided missile, navigation and other electronic systems is drastically reduced when these systems are jammed or partially jammed by interferring radiation. It is the purpose of this task to aid in development of jamming systems, by conducting basic and applied research in microwave tubes having application to such systems.

Columbia Radiation Laboratory (U), RR 008-03-0002. Columbia University, New York, New York, Columbia Radiation Laboratory; MIPR 8-60-ONR, NR 372-101, NR 373-000; P. Kusch.

This task is a coordinated effort to perform basic research in those fields of physical electronics which utilize techniques involving micro and millimeter waves. Complementing this effort, research is conducted on components required for generation, propagation and detection of those waves. Specifically, this task includes (1) fundamental research on (a) microwave spectroscopy of gases, (b) millimeter wave sources such as Cerenkov radiation, molecular beam oscillators, and silicon harmonic generators, (c) paramagnetic resonance, (d) superconductivity, (e) properties of metastable states of hydrogen and helium; and (2) applied research in magnetrons to obtain millimeter wave magnetrons of improved power, tuning, lifetime and stability characteristics.

Barkhausen Oscillators (U), RR 008-03-0003. Oki Electric Company, Ltd., Tokyo, Japan, Science and Engineering Department; Nonr 2932(00), NR 373-201; S. Mito.

This is a study of a wide variety of millimeter wave and microwave radio tubes of the Barkhausen triode and traveling wave magnetron type. Such tubes are generators of radio frequency energy for spectroscopic research as well as for electronic systems application.

Velocity Modulated Tubes (U), RR 008-03-0004. California Institute of Technology, Pasadena, California, Electrical Engineering Department; Nonr 220(13), NR 373-262; L. M. Field.

The purpose of this task is to investigate electron beam interactions with various structures and electron phenomena within the beam itself. Four major studies of the task are as follows (a) Noise: Theoretical analysis of noise generation in traveling-wave tube amplifiers, as well as the development of low noise amplifiers for operation at approximately 1400 mc/s; (b) Beam-Circuit Interaction: Both large-signal and small-signal analysis of M-type carcinotrons and magnetron type amplifiers with theoretical studies supplemented by experiments; (c) Plasma Physics: Microwave generation processes in plasma are studied with particular interest in radio astronomy applications; (d) Growing Space Waves in Electron Beams: Emphasis is placed on unstable flow conditions.

Basic Electronics Research (U), RR 008-03-0005. Stanford University, Stanford, California, Stanford Electronics Laboratory; Nonr 225(24), NR 373-360; W. R. Rambo.

This task involves investigations in several areas of physical electronics as follows: (a) microwave tubes and electron and ion devices, (b) network and information theory.

In the area of microwave tubes and electron and ion devices, studies in low-noise microwave tubes, parametric amplifiers, crossed-field devices, electron beam research, and plasmas are emphasized.

The work in solid state electronics includes research on (a) devices such as maser and parametric diodes, (b) circuit studies in connection with transistors, and (c) studies of related phenomena, as diffusion in silicon, the Hall effect, avalanche effect in transistors, and noise.

Microwave Tubes (U), RR 008-03-0006. Stanford University, Stanford, California, Microwave Research Laboratory; Nonr 222(48), NR 373-361; E. L. Ginzton.

The purpose of this task is to investigate high power microwave tubes and circuits with emphasis on increased band-width and to study large signal effects in such systems with the aim of improved performance and finally to pursue research directed to the generation of millimeter and sub-millimeter radiation. Associated areas of research are investigations in the use of ferrites as active circuit elements for harmonic generation at high power levels, possible use of plasmas as variable-parameter propagating structures and millimeter wave generation using parametric principles.

Microwave Devices (U), RR 008-03-0007. Stanford University, Stanford, California, Electronic Research Laboratory; Nonr 225(40), NR 373-370; D. A. Watkins.

This task involved fundamental studies, design and prototype fabrication of a series of modern microwave electronics devices, such as paramagnetic and ferromagnetic amplifiers and oscillators, as well as parametric amplifiers and other devices having characteristics and properties based on use of time-varying and non-linear elements.

High Power Klystrons (U), RR 008-03-0008. Watkins-Johnson Company, Palo Alto, California; Nonr 3020(00), NR 373-430; D. A. Watkins.

This is a study to extend obtainable power, duty-cycle and lifetime performance characteristics of high-power microwave klystron tubes.

Electron Beams (U), RR 008-03-0009. University of Colorado, Boulder, Colorado, Engineering Experiment Station; Nonr 1147(06), NR 373-572; J. C. Twombly.

The purpose of this task is to study, experimentally and theoretically, the behavior of confined, drifting electron beams in the vicinity of critical perveance. Emphasis is placed on (a) verification of critical perveance figures for a solid cylindrical electron beam injected concentrically into a hollow cylindrical conductor; (b) amplification of shot noise and, possibly, coherent signals by a supercritical perveance beam; (c) extent to which beam cross-section is altered by space-charge forces in supercritical perveance beams; (d) influence on supercritical beam behavior of added conductors placed within drift space sheath.

Semiconductor Devices (U), RR 008-03-0010. University of California, Berkeley, California, Electrical Engineering Department; Nonr 222(57), NR 373-612; A. C. English.

This task involves studies of stability, photo and electrical effects in semiconductor devices under high temperatures. Along with studies on devices will be investigations of crystal properties such as imperfections and impurities.

Millimeter Wave Devices (U), RR 008-03-0011. University of Utah, Salt Lake City, Utah, Electrical Engineering Department; Nonr 1288(05), NR 373-740; R. W. Grow.

This task studies, by theory and experiment, new means for generation of electro-magnetic energy in the millimeter wavelength region. Among techniques being investigated are use of charged-particle plasmas and cyclotron-resonance devices with parameters such as to expect generation of coherent millimeter-wavelength radiation.

Research Laboratory of Electronics (U), RR 008-03-0013. Massachusetts Institute of Technology, Cambridge, Massachusetts, Research Laboratory of Electronics; MIPR 24-60-ONR, NR 375-042, NR 373-000; J. B. Weisner, P. Elias, B. N. Fano, H. J. Zimmerman.

This task has several major aims, namely (a) to conduct investigations in modern electrical circuit theory and techniques; (b) to perform theoretical and experimental research in gaseous discharges, electron ballistics and vacuum tubes; and (c) to investigate the structure of matter, as relating to the field of electronics.

Theoretical and experimental investigations of statistical methods in network analysis and synthesis, as well as information theory, are directed at improving circuit design methods and applications. This part of the task embraces research in human communications links, correlation methods in detection of signals in the presence of noise, transistor circuitry design and the use of ferrites in networks.

Recombination and avalanche phenomena studies, microwave spectroscopy, nuclear, ferromagnetic and paramagnetic resonances are part of (b) above. Structure of matter, emphasizing tools for study, as X-ray diffraction and low-temperature experiments, constitute an important part of the work of this laboratory of physical electronics. Traveling wave, backward-wave, thermionic, cold-cathode, thyratron-type magnetrons and other types of tubes are also studied.

Ion-Beam Deposition (U), RR 008-03-0014. Varo Manufacturing Company, Garland, Texas; Nonr 3167 (00), NR 373-471; F. Granger, Jr.

This is a study in the use of ion beam formation, control and use to deposit conducting material on bases for the purpose of enabling fabrication of micro-dimensional electronic components. Study of appropriate beam ballistics as well as design of the ion beam gun are goals of this research.

Solid State Devices (U), RR 008-03-0015. ITT Laboratories, Nutley, New Jersey; Nonr 3358(00), NR 373-804; L. M. Vallese.

This task investigates the application of recent network synthesis methods to the evolution of transistorized amplifiers and other modern solid state devices.

Microwave Tube Research (U), RR 008-03-5650. U. S. Naval Research Laboratory, Washington, D. C.; RO8-03; H. D. Arnett, W. J. Graham, R. P. Little.

Exploration of new electronic methods of generation and amplification of microwave energy particularly at millimeter wavelengths.

Storage Tube Research (U), RR 008-03-5651. U. S. Naval Research Laboratory, Washington, D. C.; RO8-04; F. H. Harris, G. L. Stambach, T. E. Hanley.

To investigate and devise methods of storage of electrical signals. New and more effective methods of storage and display are sought, and the basic factors (such as theoretical limits of resolution and the uniformity of the secondary emission ratio) which control the design and fabrication of storage tubes are being investigated. Operational limits such as resolution, persistence and uniformity are being measured.

Cathode Research (U), RR 008-03-5652. U. S. Naval Research Laboratory, Washington, D. C.; RO8-05; G. A. Haas, J. T. Jensen, Jr.

Basic research on electron tube cathodes with the objectives of increasing electron emission and providing more reliable tube life.

Instruments and Measurements (U), RR 008-03-5654. U. S. Naval Research Laboratory, Washington, D. C.; RO8-14; E. Toth, H. F. Hastings.

Phase 1 - Continued cooperation with the Naval Observatory in the development of techniques and instrumentation for precise and constant frequency transmissions by Naval Radio Stations.

Phase 2 - Further investigation of wide band spectrum analyzers will be conducted to devise techniques which will permit more rapid sweep and still maintain maximum resolution.

Phase 3 - NRL participation will continue in the operation of the Electronic Test Equipment Coordination Group, OSD(R&E), the Joint Test Equipment Subpanel (MCEB) and Study Group VII, CCIR.

Phase 4 - Study will be made of all signal generating, power and impedence measuring equipments, to determine how well present equipments or those under development satisfy the requirements of the Navy and to ascertain the gaps existing for which new instrumentation is needed.

Components and Material Studies (U), RR 008-03-5655. U. S. Naval Research Laboratory, Washington, D. C.; RO8-15; E. Toth, D. A. Venn.

The program is directed to provide greater understanding of the physical differences between natural and synthetic quartz. Development of better growth techniques, which produce a raw crystal more easily fabricated into resonators having less aging effect, will lead to greater reliability of equipment in frequency and better r-f spectrum utilization. The present phase of the investigation employs optical techniques and low temperature environments to determine the effects of x-irradiation and thermal annealing on quartz samples.

Electronic Digital Computer (U), RR 008-03-5656. U. S. Naval Research Laboratory, Washington, D. C.; RO8-30; A. B. Bligh.

A program of logical design modifications of the NAREC Computer is being continued. Consultative services are being furnished to the group now operating and maintaining the NAREC.

Solid State Electronics (U), RR 008-03-5657. U. S. Naval Research Laboratory, Washington, D. C.; RO8-33; Albert Brodzinsky.

The theory of p-n junction is being extended to include large signal effects including inductive behavior. This work is being checked out by fabrication of experimental diodes and being put to use in the design of high-Q solid state selective circuits.

The thin semiconductor film program is being extended to the experimental fabrication of multilayer devices, to further crystallization studies and to the study of other materials.

A specially designed furnace for growth of semiconducting intermetallic compounds has been designed and is being evaluated for growing single crystals.

The measurement of liquid nitrogen performance of microwave detectors is being carried out.

A microwave detector operating on the avalanche effect has been designed and tested.

Low Noise Amplification (U), RR 008-03-5658. U. S. Naval Research Laboratory, Washington, D. C.; RO8-35; Albert Brodzinsky.

Work has been started on the development of a low noise X-band parametric amplifier in which it is hoped to obtain significant noise reduction by utilization of the idler changer for signal purposes. In this case, the amplifier operates in a quasi-degenerate mode so that the pump supply is approximately twice the signal frequency which maximizes the efficiency of the amplifier for a given signal frequency.

Electro Magnetic Ceramic Materials (U), RR 008-03-5663. U. S. Naval Research Laboratory, Washington, D. C.; MO5-01; Paul H. Egli.

This task involves fabrication of polycrystalline bodies and study of the properties of materials at high temperatures. Emphasis on fabrication concerns ferrites and garnets for microwave rotators. Ferrites with unusually low losses at high power have been achieved in simple shapes and efforts are in progress to extend the techniques to other shapes and to other chemical systems. Work is starting on fabrication of high temperature materials by hot pressing, with the materials intended primarily for evaluation as thermoelectric generators. Study of high temperature properties includes differential thermal analysis, thermal expansion and thermal conductivity. Sensitive apparatus for differential thermal analysis have made this a powerful analytical tool, particularly for study of phase transformations and determinations of stoichiometry. Apparatus for thermal conductivity includes a

highly successful rapid comparator device and a precision calorimeter intended for small specimens.

Infrared Detector Materials (U), RR 008-03-5664. U. S. Naval Research Laboratory, Washington, D. C.; P01-03; R. F. Wallis.

Infrared detectors are needed in a variety of applications for the detection of low intensity radiation in wavelength regions where there are windows in the atmosphere and in the far infrared. The study of noise in infrared detector materials has been continued. An experimental investigation of the electrical noise in indium-doped germanium in the pre-breakdown region revealed a shot-type noise associated with the current in excess of ohmic current. The construction of an indium-doped germanium infrared detector has been started which should be sensitive out to 100 microns. The resolvent formalism has been applied to the theory of irreversible processes and has led to a much simplified theory.

Physical Investigation of Non-Metallic Solids, RR 008-03-5665. U. S. Naval Research Laboratory, Washington, D. C.; P03-03; Paul H. Egli.

Work in progress includes (1) a study of lead manganese active calcium silicates for use as persistent transparent luminescent films. (2) A study of deformation of ADP crystals for possible application as wide aperture electro-optic shutters. (3) A study of breakdown processes in crystals using etching techniques to provide information of electronic and mechanical processes that occur in crystals at high fields. (4) A study of conduction and relaxation phenomena in dielectric crystals to provide information on the influence of crystals imperfections on conduction processes in low fields. (5) Preparation of the quarterly status report on Thermoelectricity to provide information on recent developments in materials research and thermoelectric device applications. (6) A study of the special properties of certain metallic whiskers that show an unusual color invariance effect in polarized light. This effect discovered at NRL will be investigated as part of the work on thin films.

Physical Properties of Semiconductors, RR 008-03-5666. U. S. Naval Research Laboratory, Washington, D. C.; P01-04; R. F. Wallis.

Additional studies of magneto-optic phenomena in semiconductors have been carried out. Evidence was obtained concerning the energy dependence of the effective g-factor of conduction electrons in InSb. The effective masses of conduction electrons in InSb, InAs, InP and GaAs were measured using infrared cyclotron resonance and infrared Faraday rotation. The effective mass of light holes in InSb was measured using infrared cyclotron resonance. The infrared Voight effect was observed for the first time in semiconductors and was used to measure the conduction electron effective masses of InSb and InAs.

Calculations were continued on the Zeeman splitting of the optical absorption lines of acceptor impurities in germanium. A theoretical calculation of the conduction band structure of InSb in an external magnetic field gave good agreement with the details of the infrared cyclotron resonance results.

The infrared lattice vibration spectra of compound semiconductors are being measured at low temperatures to determine precise values of the effective charges and dispersion frequencies.

Calculations have been made of the influence of quartic anharmonic terms on the temperature dependence of the infrared lattice vibration spectra of ionic crystals. The quartic terms appear to be important at temperatures near the melting point. The nature of surface elastic waves in cubic crystals has been investigated theoretically as a function of the three elastic constants.

Radiation Effects in Dielectric Solids, RR 008-03-5667. U. S. Naval Research Laboratory, Washington, D. C.; P03-01; C. C. Klick.

It has been shown that the color centers formed in Al_2O_3 are due to displaces atoms with a displacement energy of 50 or 90 electron volts if the ions are aluminum or oxygen respectively. TiO_2 shows no radiation damage. In alkali halides the production of colloids is related to the presence of traces of hydroxyl ion. A solid state Bragg-Gray chamber has been developed using Mylar as the detecting element and a radically different design has been proposed for a free air chamber. Steps have been taken to improve the uniformity in sensitivity of CdS crystals as radiation detectors.

Physical Properties of Dielectric Solids, RR 008-03-5668. U. S. Naval Research Laboratory, Washington, D. C.; P03-02; C. C. Klick.

The main color center-the F-center-in the cesium halides has been found to consist of at least five bands in contrast to the single band typical of the sodium chloride type alkali halides. A mechanism has been described for low temperature coloration in alkali halides which avoids many of the difficulties of the Varley proposal. It has been shown that local modes and lattice modes of vibration around an impurity are of nearly equal importance in interactions with electronic transitions and some of the more common generalizations about lattice vibrations in ionic solids are shown to be not of general validity. Some evidence has been obtained which seems to show that the electron spin resonance of small metallic colloid particles is dependent on the colloid size.

Structure and Composition of Radiation Sensitive Materials (U), RR 008-03-5669. U. S. Naval Research Laboratory, Washington, D. C.; P03-04; C. C. Klick.

Ca_2:Mn has been prepared in a practical radiation monitoring thermoluminescent dosimeter which can be substituted for the film badge. Its dose range is from 10^{-2}R to $2x10^5$R. A small device of the same material has been explored for medical use in vivo. The phosphor itself has been improved. Scintillating glass of high efficiency has been developed which has sufficiently good working properties so that it can be drawn into fibers. Sprayed luminescent films of Zn_2SiO_4:Mn, Zn_2SiO_4:Ti, and $CdSiO_3$:Mn have been prepared.

High Pressure Research, RR 008-03-5670. U. S. Naval Research Laboratory, Washington, D. C.; P03-06; R. L. Dolecek.

High pressure research on molecular and electronic configurations in solids will yield new knowledge and opportunities for solid state applications. The permitted energy states for electrons in lattices and in molecules are dependent in large measure on the crystalline structure of the material. This structure is subject to perturbation and even control by the application of sufficiently high pressures so that fundamental concepts and phenomena of crystal physics, luminescence and the role of impurities, defects and discontinuities in the lattice can be studied. A theoretical model for describing the effect of pressure on the luminescent spectra of phosphors has been developed and is being compared with available experimental data. This study has revealed the need for experimental information on the effect of pressure on the emission spectra of phosphors. Laboratory equipment and apparatus for obtaining the required data is under design. It is expected that the experimental program can be brought to fruition during the coming year.

Electronic Materials and Components, WR 008-03-005. Melpar, Incorporated, NOW 60-0362-c(002), C. Feldman; Melpar, Incorporated, NOW 61-0415-c(010), E. Deitz; Lear, Incorporated, NOW 61-0468-c(056), J. Pittman.

To support BuWeps immediate and long-range plans for missile systems by insuring through supporting research that new electronic materials and components are available on a timely basis to optimize new versions of existing weapons systems and to translate future missile design concept into hardware. This project supports Operational Requirement SR 10701.

Theoretical and experimental investigations will be carried out on: Thin film molecular circuits utilizing charge carriers at specific locations within, at the surface and between layers of solid state materials to form complete electronic circuits; the analysis and measuring of the movement of ions in solution as a means of determining acceleration; the feasibility of using piezoelectric and magnetic pickoffs in conjunction with a rotary device of two fluids with different densities.

Results show the feasibility of producing germanium la ers with surface sensitive properties similar to the pyrolytic and vacuum deposition techniques. Other indications show possibilities of obtaining threshold sensitivities of 10^{-7} g's by the development of an accelerometer using electrochemical and electro-osmotic transducer principals.

Electro-Magnetic Ceramics Materials (U), SR 008-03-8055. Naval Research Laboratory; NRL M05-01; Dr. Paul Egli.

This task is to produce new and improved ceramic materials for a variety of electronic applications. The scope of the work will include ferroelectric materials, ferromagnetic materials, high temperature semiconductors and insulators. Emphasis will be placed on materials for applications as high temperature circuit components, thermoelectric elements, microwave components and sonar transducer elements. The investigation includes the chemistry of high temperature reactions, the mechanism of sintering, the effect of fabrication techniques and the measurement of basic properties.

Semiconductor Reliability (U), SR 008-03-9345. Naval Material Laboratory, 5032-B-28.21, R. Martin; Naval Material Laboratory, 5032-B-28.27, R. Martin; National Bureau of Standards, PO No. 995/701, G. Conrad; Remington-Rand Univac, NObsr 72660, G. Kasky; ARINC, NObsr 81304, W. Von Alven; Naval Material Laboratory, 5032-B-28.0.2, R. Martin; one contractor not assigned.

The prime objective of this semiconductor reliability task is to provide evidence to both the user and the manufacturer of equipment that a population of semiconductor devices will be capable of performing its intended function under the environmental and operating conditions present when there is need for its use at some point in the future and for the period of time intended.

To satisfy this prime objective, this reliability task must encompass, but not all inclusively, the following:

1) Determination of catastrophic failure rates.
2) Determination of deterioration rates.
3) Determination of parameter variation as a function of time and various environmental and operational conditions.
4) Development of accelerated life tests methods and procedures.
5) Development of techniques for prediction of expected life.
6) Establishment of acceptable aging and standard testing methods and procedures.

The accomplishment of this task shall include extensive performance testing of semiconductor devices and, in addition to the data collected from the above, the collection of reliability data generated through out industry, applying statistical processes in the experimental design of the projects, analysis of the data obtained, and dissimination of the results by means of handbooks, reports, etc.

High Temperature Semiconductor Devices (U), SR 008-03-9346. Texas Instruments, Inc., NObsr 77532, M. E. Jones; one contractor not assigned.

A need exists for high temperature transistors, diodes, and other semiconductor devices capable of operation above 200 degrees C for use in airborne electronic equipment and missile applications. The availability of higher temperature devices will permit the location of electronic equipment near the surface of high speed aircraft and missiles, thus eliminating heavy cooling equipment now required. Even in applications at lower temperatures, the high temperature tolerance of these devices will permit higher power ratings, smaller cases, greater packing densities in electronic circuitry, thereby reducing weight and volume in electronic equipment.

This task provides for device technology, development and evaluation of gallium arsenide, silicon carbide, and other compound semiconductors which show exceptional promise for high temperature operation.

Transistor Device Development (U), SR 008-03-9347. Motorola, NObsr 81185, A. B. Phillips; RCA, NObsr 81322, R. L. Sherwood; Raytheon, NObsr 72787, J. M. Lavine; one contractor not assigned.

A need exists for the development of transistors capable of operation at higher power, frequency and voltage levels. The upper frequency limit of

transistors is now in the neighborhood of 4000 MC. The maximum power levels are on the order of 300 - 1000 watts, and are in the low audio frequency range. Computer transistors are currently capable of switching 3/4 of an ampere in the 250 millimicroseconds. Success in this effort would make possible improved systems for electronic countermeasures, radar, sonar missile and communications applications.

This task provides for the development and evaluation of transistors for power, switching and amplifier service which are beyond the power, frequency and voltage capabilities of existing types.

Solid State Switches (U), SR 008-03-9348. Contractor not assigned.

A need exists for the further development of special solid state devices which are currently replacing or supplementing their electron tube counterparts in many applications. These devices are replacing thyratrons, ignitrons, relays, switches, pulsed modulator tubes, TR tubes and many others. One category of devices, three terminal solid-state thyratrons, includes the silicon controlled rectifier, thyristor, trinistor and trigistor. Lower-power units can be used in bistable circuits, memory circuits, ring counters and signal switching or gating circuits. High power units can be used in practically all applications presently employing gas thyratrons. Many new applications in the high power range are possible because of improved characteristics of solid-state units such as lower conducting voltage drop, faster switching speed, faster recovery time, higher peak-current capability and absence of filaments.

This task provides for the development and evaluation of special solid-state devices including two-terminal PNPN solid-state switches, three-terminal solid-state thyratrons, photodiodes, solid-state T-R switches, and hall generator devices.

Solid State Devices for Amplification (U), SR 008-03-9349. Microwave Associates, Inc., NObsr 77621, A. Uhler, Jr.; General Telephone and Electronics Laboratory, PR 691A2-19208, P. H. Keck; Hughes Aircraft Company, PR 691A2-19210, R. Zuleeg; Naval Material Laboratory, 1102-B-29.14, P. Giordano; one contractor not assigned.

A need exists for improved solid state devices such as parametric amplifier (varactor) diodes, tunnel diodes, and transistors especially designed for low noise detection and amplification. Great advancements are being made by using tunnel and parametric diodes in low noise amplifiers to increase radar and communications ranges by large factors, however, noise continues to be the limiting factor so that its reduction continues to be an objective of major importance. A new mode of operation (parametric) makes it possible to extend the useful frequency range of certain types of transistors into the microwave region. A single semiconductor device operating from batteries can give amplification or harmonic power well beyond its maximum frequency of oscillation. This task provides for the development and evaluation of diodes and amplifiers of lower noise figures and at still higher frequencies of operation, and device and circuit studies on the parametric mode of transistor operation.

Tunnel Diode R & D (U), SR 008-03-9350. General Electric Company, NObsr 81320, C. S. Kim; Naval Material Laboratory, 1102-B-31.3, R. E. Martin; one contractor not assigned.

The potential applications in switching, oscillating, and amplifier service at very high frequencies have made the Tunnel Diode the object of widespread interest. There is evidence to indicate that the Tunnel Diode is relatively resistant to nuclear radiation.

This task provides for the investigation, development and evaluation of Tunnel Diodes in the following areas:

1) Improving uniformity, developing new packaging techniques, and extending the useful power and frequency range.
2) Investigation to establish new methods of high doping of semiconductors and the formation of junctions in very degenerate materials.
3) Investigation of high doping of compound semiconductor materials for Tunnel Diode use.

Solid State Diodes and Rectifiers (U), SR 008-03-9351. Contractor not assigned.

The computer field is requiring diodes which are much faster than any presently available and diodes which are several orders of magnitude smaller in size and higher in reliability. To accomplish the first of these requirements, devices are being developed using mesa construction and having abrupt junctions. These devices are capable of switching speeds up to 4 n sec. To fulfill the second requirement, diodes with passive surfaces are being developed. New types of voltage reference (zener) diodes have been developed with stabilities approaching that of standard cells. Many power systems now being developed for the military require this extreme stability and accuracy in their reference elements. There is a great need for primary microwave standards for calibration and correlation of microwave mixers and holders. At present, three of the more important bands (S, X & K) are lacking in standards and standards of several other bands have a definite need for improvement.

Nuclear Radiation Resistant Semiconductor Materials and Devices (U), SR 008-03-9352. Contractor not assigned.

A need exists for semiconductor devices capable of withstanding nuclear radiation. Limited device capability, in terms of zero permanent nuclear radiation damage and minimum transient effects now exist. It appears that contemporary circuits utilizing semiconductor devices will operate only to an integrated neutron flux of 10^{12}, however it is possible to extend the range, at least for some circuits to 10^{14} or even to 10^{16} in a few circuits by circuit re-development.

Cooling of Semiconductor Devices (U), SR 008-03-9353. Contractor not assigned.

A need exists for the development of thermoelectric coolers for use with semiconductor devices. Particularly apt uses would be cooling of transistors, since the sustained heat load is small and the gas or liquid cooling systems presently

used are bulky and troublesome. Thermoelectric coolers are compact, provide silent operation with no moving parts, and provide a controllable cooling rate.

This task provides for the development and evaluation of improved methods of removing heat from semiconductor devices which will extend the power levels and frequency ranges of existing devices. It is expected that this program would serve a dual purpose, developing a cooling device and a technology which would be readily applicable to other military requirements.

Transistor and Related Solid State Material Research (U), SR 008-03-9354. Stanford Research Institute, NObsr 72772, F. Halden; one contractor not assigned.

To study elemental and compound semiconductors (i.e., silicon, germanium, silicon carbide, III-V compounds, and new materials) in relation to their chemistry, purification, imperfections, dislocations, and physical properties, in order to develop materials of the highest possible perfection for use in semiconductor devices.

This task provides for investigation in the following areas: (1) The basic study of silicon and its application to transistors and related devices, silicon imperfections, and diffusion; (2) Basic studies of III-V compound conductors and their application to high temperature transistors and related devices; (3) Basic studies of silicon carbide and its application to high temperature transistors and related devices; (4) Basic studies of other compound semiconductors aimed at determining high temperature potentialities; (5) Study of the low temperature properties of semiconductors; (6) Study of carrier lifetime and solid-state diffusion processes from the standpoint of application to the development of semiconductor and/or solid-state devices; (7) Silicon crystal perfection study centered on the mechanism of crystal imperfections and the formation of dislocations; (8) Investigation of new group II-VI compounds for the purpose of their characterization for diode and transistor applications; (9) Materials research in CdS to obtain very pure, single-crystal material for solar generators and rectifiers; (10) Materials research in AlSb, emphasizing the processing of single-crystal material for use in semiconductor devices; and (11) Physical, chemical and metallurgical studies directed toward the preparation of very pure semiconductor materials.

Solid-State Surface Studies (U), SR 008-03-9355. Contractor not assigned.

The study of surface phenomena, which will be the true limiting factors in transistor and integrated circuit development. Included are physical and chemical research on clean surfaces, study of surfaces in relation to environment, and study of solid-state interfaces.

This task provides for investigation in the following areas: (1) Investigation of the basic properties of germanium and silicon surfaces; (2) Study of surface stability in order to gain information needed to stabilize transistors with respect to environment; (3) Investigation of the Hall effect and magnetoresistance in semiconductor surfaces in order to obtain information on electronic states and mobility of carriers; (4) Study of germanium and PbS surface properties and related noise mechanisms; (5) Research on processing methods and procedures to assure initially clean surfaces, and to reduce deterioration of device characteristics during life; (6) Research on the mechanisms of surface phenomena and on the surface recombination processes of intermetallic compounds; (7) Study of semiconductor surface effects in the region of a junction.

Microelectronics Techniques Research and Development (U), SR 008-03-9356. a) Naval Research Laboratory, Code 5260, Prob. No. S-1942, G. Abraham; b) Commercial-Unassigned, PR 691A2-19207; c) Unassigned.

The Navy requires major advances in the functional capability, reliability, and weight-size reduction of its complex electronic equipments. The most promising approaches to the problem of obtaining a high density of electronic circuitry with low weight, greater capability and reliability is through the use of functional, integrated, molecular or multilayer deposited film structures built on substrates of semiconductor materials.

This task provides for investigation, development and evaluation of novel and promising techniques leading to the fabrication of active microelectronic devices and/or structures.

Nuvistor Development (U), SR 008-03-9366. Radio Corporation of America; NObsr 81478; W. J. Helwig.

Design and development of a line of small (Approximately 1/2 prototype size) ceramic-metal envelope Nuvistor Tubes to include a medium mu triode, tetrode and pentode. These tubes shall be concentric cylindrical cantilever electrode construction, having a maximum heater power of one-half watt and other electrical characteristics approximating those of the Nuvistor prototype. These tubes will be suitable for general purpose RF applications. Potential advantages are: (1) low power consumption; (2) ability to give reasonable performance at low values of plate voltage; (3) small size; and (4) inherent ruggedness.

Linear Variable Amplifier (U), SR 008-03-9367. Westinghouse Electric Co.; NObsr 81509; H. Shabanowitz.

Design and develop a low noise, linear, variable gain RF amplifier tube (s) with a greater linear dynamic range (signal handling capacity) as a necessary prerequisite in overcoming the deleterious effects of cross-modulation, intermodulation, and overload. It is recognized that no single tube development will alleviate the interference problem over the entire radio communication frequency range. This initial development should be concentrated for applications up to 400 mc.

Ceramic Stacked Tubes in Glass Envelopes (U), SR 008-03-9368.

Evaluation of the capabilities of the stacked mount developed by Sylvania in connection with their ceramic tube program. This is to be done by designing, developing and producing in glass envelopes a limited sample quantity of tubes having electrical characteristics similar to the following five (5) types.

(1) SR2145 - double diode
(2) SR2359 - dual cathode high mu double triode
(3) SR2360 - semi-remote cutoff RF pentode
(4) SR2361 - single triode
(5) SR2362 - audio voltage amplifier pentode

When taken together with existing Armed Forces programs a useful complement of nine (9) types will be available for incorporation into equipment. This availability will allow an extension evaluation to be made of the advantages of this (Technique - Method) of construction.

Quick Warm-up-time Tube, SR 008-03-9369. Raytheon Company; NObsr 77535; Norman Linson.

Design and development of a quick warm-up-time tube using as a vehicle a simple planar stacked ceramic triode tube employing a ceramic sandwich heater-cathode structure. Quick warm-up-time being defined as the plate current value being 90% of the steady state plate current value five(s) seconds after the application of heater and element voltages.

The work accomplished to date has been confined to: a study of the mechanism of cathode warm-up; design and evaluation of a prototype heater-cathode structure; and fabrication of laboratory samples for analysis. At the present time prototype tube models are being assembled for testing of emission, leakage, and life. Sealing and environmental testing of the package will also be done.

Low Power Pulse Tubes Applications Information (U), SR 008-03-9370. ARINC.

Within the last two years, tube manufacturers have designed and developed Low Power Miniature and Subminiature Tubes specifically tested and rated for pulse applications. Although many general purpose tube types have been used in the past for pulse applications, there is still no specification assurance for proper operation of pulse tubes in the positive-grid region, and little if any overall applications information.

This task will compile and evaluate data for pulse tubes currently being used in missiles, radar, and other vitally important applications. Such data would include product variability information in the positive-grid region; collection of pulse emission behavior over 500 and 1,000 hour life tests; and the generation of suggested deviating curves for pulse applications.

Heaterless Electron Tube (U), SR 008-03-9371. Commercial.

The ever increasing need for miniaturization and reliability in equipment results in the production of high dissipative power densities within electronic equipment which leads to heating of the individual components and tubes. To obtain reliable operation with the presently available components and tubes available today, it is necessary in compactly assembled systems to provide means for removing the heat generated. This requirement does not exist if the components and tubes themselves are capable of operating at the elevated temperature that otherwise can develop in the absence of cooling.

This project is the design and development of heaterless cathode tubes which will operate and provide satisfactory performance in high temperature environment and be compatible for use with micro-sized modular components. It is expected that the reliable features of high temperature electron tube performance can be obtained with total power efficiencies approaching those realized with transistor circuits.

Application Handbooks for Low Power Electron Tubes, SR 008-03-9374. ARINC Research Incorporated, work order unassigned.

This task will provide for the continuing revision of the techniques for applying MIL-STD-200 preferred tubes correctly in military equipment. This information, when linked with Military Specifications, provides design and maintenance personnel with a single source of applications and specifications information.

Investigation of Effects of Combined Environments on Electron Devices, SR 008-03-9376. Naval Material Laboratory; 5032-B-5.12; R. E. Martin.

Recent developments in weapon systems have resulted in tubes and components being subjected to very severe environmental conditions, involving in many cases combinations of high temperature and severe mechanical excitation. Thus far, while there has been some exploratory work in this field, no definitive experimental work resulting in realistic specifications and test methods for evaluating electron tubes under these conditions has been undertaken.

This task will undertake the appropriate theoretical studies and experimental work to accomplish the following:

a. Investigate the properties of typical low power and small transmitting tubes when subjected to combined environments of high temperature, high acceleration (vibration and shock) and other factors as appropriate.

b. Determine, insofar as practicable, the actual amplitude of these combined environments as they exist in typical weapons systems, and develop equipment and techniques necessary to evaluate the resistance of electron devices to these environments.

c. High level acoustic noise environments will be investigated in accordance with MIL-STD-446.

Low Power Tubes; Evaluation and Techniques (U), SR 008-03-9377. MAT LAB; M. Abelman.

The cathode follower circuit is widely used in many critical applications where a low impedance source is desired in signal amplification and transmission. Performance of specific tube types as cathode followers is non-existent. With the development of a subminiature and miniature cathode follower tube under NObsr 81552 there will be an urgent and definite need for test methods and performance data to provide the circuit designer with appropriate technical information. This task will be concerned with the development of test methods, techniques and circuitry to evaluate tubes as cathode followers; and development of application notes.

Recent trends in low power tube developments has witnessed the emergence of new concepts in tube design. Two typical examples are the RCA Nuvistor

(A15133) and the General Electric Compactrons. Such new tube types possess characteristics of potential importance to military applications such as miniaturization and ruggedness.

Various types of radar, sonar and communication systems require almost immediate operation of the electronic equipment. In some instances, equipment operation must be available within 0.5 second upon demand. Difficulty in equipment operation has been encountered due to the use of present techniques in achieving rapid warm-up by "hot shotting" or by applying voltages in excess of the maximum tube ratings. To provide faster warm-up, present trends in tube design is to employ a variety of emitters (cathodes) based on new principles. These emitters have exhibited extreme fast starting. Based on prototypes, several tubes employing the new principles, have been developed and are expected to show great improvement in operation and reliability of the various electronic systems. This task will provide evaluation of fast warm-up tubes; operation in typical circuits and development of objective military specifications. Specifically, it shall provide for the selection and procurement of typical tubes possessing designed fast warm-up characteristics; development of techniques and circuitry to permit rapid, direct measurement of tube operation; conduct experimental work to study reliability factors and correlation of static and dynamic characteristics with typical circuit applications; prepare objective military specifications.

Interaction Structures (U), SR 008-03-9385. a) Litton Industries (U), NObsr 77568, Paul Crapuchettes; b) Sperry Gyroscope (U), NObsr 77590, C. C. Wang; c) Commercial (U), Principal Investigator, undetermined; d) Commercial (U), Principal Investigator, undetermined.

Microwave Interaction Structures of all kinds must be substantially improved with respect to peak and average powers, bandwidth, efficiency, heat dissipation, and size and weight. Frequency ranges must be extended.

	Present Best
Peak Power (Representative)	10MW (S-band)
Average Power (Representative)	10-20KW (S-band)
Bandwidth	5-10% (all bands)
Efficiency	15-70% (all bands)
Heat transfer	100-150°C (Ambient)
Size and weight reduction	
Frequency range	75,000 MC/S

	Anticipated Minimum
Peak Power (Representative)	50-100 MW (S-band)
Average Power (Representative)	100-1000KW (S-band)
Bandwidth	20-30% (all bands)
Efficiency	50-85% (all bands)
Heat transfer	500°C (Ambient)
Size and weight reduction	20% minimum
Frequency range	100,000 plus MC/S

The purpose of this task is to explore techniques to permit effecting the above parameters for both propagating and non-propagating structures.

Microwave Duplexing Techniques (U), SR 008-03-9386. a) Microwave Associates (U), NObsr 77585, L. Gould; b) Microwave Associates (U), NObsr 77586, L. Gould; c) Microwave Associates (U), NObsr 81205, L. Gould; d) Commercial (U), Principal Investigator undetermined; e) Commercial (U), Principal Investigator undetermined.

Present electronic system plans, both short range (2-5 yrs) and long range (5-10 yrs), will require progress beyond the present state-of-the-art in microwave dynamic duplexing techniques. These techniques include both electronic switching and phase control.

Data Processing, particularly in the "billboard" type antenna equipments must be at least an order of magnitude more rapid in rate and capable of phase-frequency or phase-phase type scanning. Pulse widths and pulse repetition rates, in some cases simultaneously, will be substantially increased. Pulse width requirements are expected to increase from present day 10μs to 60μs and more in the future, particularly in pulse compression systems. Pulse repetition rates are expected to increase from present several hundred to future 20,000 and higher.

Satellite communication systems are now proposed to utilize 250μs pulses at 2,000 pps.

Power Levels are expected to increase, for example, from 10 MW to 50 or 100 MW at "S" band and from 1-2 MW to 5-10 MW at "X" band.

Control of phase stability to 0.1 degrees or less per ampere in microwave oscillators and amplifiers will be required. Present capabilities run from .1 degree to 9-10 degrees.

Noise and Frequency Stability (U), SR 008-03-9387. a) Westinghouse Electric Corporation, NObsr 77640, W. Hayter; b) Microwave Electronic Tube Company, NObsr 81242, L. Roberts; c) Commercial, Principal Investigator, undetermined; d) Commercial, Principal Investigator, undetermined.

The problems of noise and frequency stability in microwave tubes appear to be closely related. Fixed frequency, narrow band devices when optimized for frequency stability usually show greatly improved noise characteristics. It is the intent of this task to investigate the present "barriers" of noise (both AM and FM) and frequency stability with a view to not only improving fixed frequency devices but to project this improvement into broad-band dynamically tuned devices as well.

Millimeter Wave Amplifiers (U), SR 008-03-9389. Hughes Aircraft Company (U), NObsr 81198, Dr. M. R. Currie; Microwave Associates (U), NObsr 81206, Dr. G. St. John; Commercial (U), Principal Investigator, undetermined.

The need for millimeter wave tubes is constantly increasing, particularly for communications. In addition to overcrowding in the lower frequencies (X-band and below), the tendency to place more dependence on radar and communication leads to the need for development of point to point, highly directive, secure and jam-proof communications. Such systems, which critically depend on microwave tube generators and amplifiers, are likely to be developed or improved only through the expenditure of considerable funds in supporting research for these microwave tube devices. These tubes when developed, can be utilized in high resolution radar systems

such as for battle-field or terrain surveillance, separation of target clusters, etc. If reasonable powers can be generated at these mm frequencies, small lightweight radars capable of extreme accuracy to several hundred miles should be feasible. Appropriate improvement in communication systems will also result.

Parallel Operation of Microwave Power Sources (U), SR 008-03-9394. a) U. S. NOTS, China Lake, California, Dr. J. R. Hechtel; b) Commercial, Principal Investigator, undetermined.

The obtaining of super power microwave energy can logically be divided into two aspects: (1) full power from a single tube source; (2) full power from a multiple tube source. Each approach has considerable merit. Aspect (1) could simplify power generation equipment but require more complex power distribution systems. Aspect (2) would make the generation somewhat more complex but would greatly simplify the power distribution system. Aspect (2) has the further advantage of permitting the utilization of a number of already existing lower power devices to produce the desired high power levels. It is the intent of this task to explore aspect (2).

Research conducted at NOTS, China Lake, over the past several years by Dr. J. R. Hechtel has produced a theoretical design for a "low voltage" high power, electrostatically focussed linear beam device. Phase I under this subtask will sponsor the fabrication and evaluation of sample tubes based upon this design. The design should, if successful, lead to power outputs between 10 and 20 megawatts. Phase II when activitated will involve parallel operation of this device. In theory, approximately 20 of these basic tubes, radiating from a common cathode, will provide 300 to 400 megawatts of power through parallel operation.

Microwave Tube Evaluation (U), SR 008-03-9395. a) Material Laboratory: 1. Klystron Tubes for Missile Application; 1102-B-13.2.14; J. Adelsberg. 2. Duplexer and Klystron AN/SPS-13; 1102-B-13.0.3; N. Cooper. 3. Specification Evaluation for type 7417; 1102-B-13.1.7; M. Siegman. 4. Measurement Techniques for Amplitron; 1102-B-13.3.3; M. Siegman. 5. Measurement Techniques for Jammer Tubes; 1102-B. b) Tubes and Materials; Principal Investigator to be determined.

It is the intent of this project to utilize the facilities of Material Laboratory to evaluate microwave tubes on a need basis to determine their qualities of performance and design to insure that reliable operation will result when such tubes are operated in systems.

High Power Hard Tube Modulator (U), SR 008-03-9405. Machlett Laboratories, Incorporated; NObsr 77593; H. Langer.

The objectives of the project are to investigate the limitations of hard tube pulse modulator for use in radar systems using high power transmitting tubes or microwave devices. The areas of investigations includes: High voltage "Hold-off" in the region of 200 KV; High current density (10 amps/cm^2 or greater); Long pulse duration (200 microseconds or greater) and the design of a tube capable of switching 35 megawatts of power.

Additional studies have been made after the first year effort on Gas analysis, cathode processing, and improved electrode geometry required to exploit cathode current density of 10 amps/cm^2, and the various methods required to realize the high voltage "Hold-off" objective.

Results of studies made to date on the initially designed tubes indicates after 1000 hours of life that the internal gas pressure (5×10^{-7} mm of Hg) and high voltage (20 - 30 KV) does not cause significant liberation of gas or cause ion bombardment producing cathode poisoning.

Result of electrode geometry and high voltage consideration studies indicate that shielded grid configuration is most desirable for high voltage pulse tubes using oxide cathodes. Sample tubes with 30-cm^2 cathode area has been shown to be capable of 300 amperes peak cathode current. High voltage hold-off as a function of spacing between electrodes was found to follow a 3/4 power law up to 100 KV. High voltage testing has been conducted under pulse condition up to 100 KV.

Cathode current density up to 7 amps/cm^2 has been evaluated up to several hundred hours. Long pulse duration tests showed that with "proper aging" (long operation at high current density and short pulses), current density of 4-5 amp/cm^2 could be drawn for 200 microseconds pulse with negligible droop.

Gas analysis studies will be continued along with further investigation of high current density and long pulse duration.

Evaluation of 12.5 MW Ceramic Hydrogen Thyratron (U), SR 008-03-9410. Naval Material Laboratory; Problem 1102-B-32.23; Mr. M. Adleman.

The evaluation of a 12.5 megawatt hydrogen thyratron, type 7322, to determine the tube's capability for use in radar set AN/SPS-40 and the use of this tube as a possible substitute for tubes type 5948 and 5949 presently being used in radar sets AN/TPS-28 and AN/MPS-28.

The tube type 7322 is a ceramic hydrogen thyratron-similar in electrical characteristics to an existing glass tube, but represents a tremendous reduction in size and weight by 4 orders of magnitude, plus improvements in life and ruggedization.

Tubes and mounting devices have been received by the Laboratory. Modulator equipment has been received and is in the process of modification. Information is being received from equipment manufacturers on the application of the tube in various prototype military equipments.

High Temperature, High Current Tube for Voltage Regulation (U), SR 008-03-9413. Tung-Sol, Incorporated; NObsr 81287; Frederick Peters.

This project is for the development of a series voltage regulator tube using metal-ceramic sealing techniques for voltage regulator service. A definite demand exists for voltage regulator tubes that can operate at the 350 degree C - level to meet present systems requirements, and also the extension of operation of such tubes to 500 degrees C operation when the need arises.

The required characteristics needing investigation for series regulator services are high current and low tube drop. A lower tube drop is necessary because it not only permits lower input voltage from the rectifier, but also reduces the internal

dissipation, which is a product of the tube drop and load current.

The benefits of using ceramics for this project should result in a tube with greater performance and longer life resulting from: higher out-gassing temperature, less stringent cooling requirements, increased ruggedness, and resistance to shock, vibration and radiation damage.

Power and Gas Tube Reliability (U), SR 008-03-9414. Unassigned--not funded.

The objective of this project is to establish a power and gas tube reliability program; such a program is to be based on the most commonly used tubes which have an indicated short life according to Navy failure report data.

It is the intention of such a program to select those tubes that have a high rate of failure and subject them to analysis to determine the specific deficiencies. Upon the determination of the causes, steps are taken to have the specific tube or tubes redesigned and evaluated by commercial contractor, with the objective being the establishment of a line of reliable transmitting or gas tubes.

Very High Power Tube Application Notes (U), SR 008-03-9415. Naval Material Laboratory; Problem 1102-B-32.22; Mr. M. Adleman.

The objective of the work under this problem is to develop a set of application notes for use with equipment applications using Super Power Negative-grid tubes.

Since power tubes are often incorrectly used above or below their rated limit, either by design or improper maintenance procedure, it became necessary that instruction notes be used as a guide. This is especially required in the application of expensive tubes now being used, such as tube type 6952 and other types being designed into long range, low frequency radars.

Visits have been made to tube manufacturers to discuss the many problems inherent in the application of super power tubes--such as the unusual features of cooling and the protective circuits that are required for satisfactory application of tubes of super power design.

Evaluation of A2572 for Battle Announcing Equipment (U), SR 008-03-9417. Naval Material Laboratory; Problem 1102-B-32.20, Part I and Part II; Mr. M. Adleman.

The work under this project is to cover two phases.

Phase I--This work is to determine the suitability of tube type 7650 (A2572) for use in Battle Announcing Equipment without forced air cooling. As such, the tube should be capable of operating in a class AB Audio Amplifier with a minimum of 500 watts of power output and a complete absence of forced air cooling.

Phase II--Upon completion of Phase I, further investigations and evaluations are to be performed on various methods of adequately cooling external anode power tubes without the use of forced air or liquid cooling. Such investigations will include, but will not be limited to the following areas of exploration: - the anode thermally and electrically grounded; convecting member connected to the anode; and conduction cooling by the use of beryllia ceramics.

Evaluation of Tube Type 3D21B for AN/ARN-21 (U), SR 008-03-9418. Naval Material Laboratory; Problem 1102-B-32.21; Mr. M. Adleman.

An evaluation of a refined tube type 3D21B for use in AN/ARN-21 TACAN equipment. Approximately 20% of all failures in the airborne TACAN equipment have been attributed to the malfunctioning of the 3D21B due to the mechanical characteristics and the instability of the electrical characteristics.

A quantity of 500 tubes were produced under contract NObsr 72526 with Bendix Aviation Corporation.

The tubes are presently undergoing evaluation at the Laboratory and, in addition, samples of tubes are being distributed to TACAN manufacturer and various fleet Air Squadrons for evaluation against the presently used 3D21B's.

Preliminary results received from field evaluation of the improved 3D21B indicates that the tube is an improvement over the existing tube type from the standpoint of a reduction of mechanical and arcing failures; prevalent in Aircraft installation.

Evaluation of Tubes 6569, 6697 for AN/BQQ-1 (U), SR 008-03-9419. Naval Material Laboratory; Contract unassigned.

An evaluation of tubes type 6569 and 6697 to determine the tubes' capability of meeting the operating conditions of the AN/BQQ-1 sonar.

In sonar applications, signals are transmitted in pulses where a duty cycle of one in ten with a ten second duration is typical. In operations of this type the limiting factor is not the average power dissipated by the various electrodes, but the actual temperature rise of the electrode while the pulse is on.

Evaluation of X-643F for Sonar AN/SQS-4 (U), SR 008-03-9420. Naval Material Laboratory; Contract unassigned.

It is the intention of this project to conduct an evaluation of tube type X-643F for use as an immediate substitute for tube type 4PR60A used in AN/SQS-4 sonar.

The X-643F is a ruggedized version of the present 4PR60A. It is expected that this tube may give more reliable performance as a power amplifier for sonar type application because of its higher temperature rating and the elimination of the presently existing leakage problem.

This project is intended to be the first approach to a solution of the high failure rate of the presently used 4PR60A tubes in sonar set AN/SQS-4.

Ceramic Power Tubes for Sonar Systems (U), SR 008-03-9421. Naval Material Laboratory; Contract unassigned.

The evaluation of ceramic power tubes for use in present or anticipated Sonar Systems using long pulse techniques.

There is and always has been a definite lack of tubes especially designed for Sonar Types of application due to the relatively small demand for such tubes for other than ASW programs. As a result, all presently used tubes are on a "make do" basis. This has led to high tube failure rates, maintenance

problems and low performance.

Electron tubes using ceramic-metal type of construction can, by virtue of their mechanical strength and ability to operate at higher temperature than glass-metal types, be used to advantage in sonar type application.

High Vacuum Switch Tube Evaluation (U), SR 008-03-9422. Naval Material Laboratory; Problem No. 1102-B-32.26; Mr. M. Adleman.

A tube evaluation program to determine, based on present equipment requirements which now exist or may be reasonably expected to exist, power tubes suitable for hard tube modulator service. Such tubes are to be selected and evaluated in terms of peak and average power pulse width, and duty cycle and for single or multiple pulses.

Initially, the evaluation would cover tubes capable of switching powers from 350 kilowatts to 1 megawatt. This is desired since present developments in the field of radar design techniques indicate a more precise and flexible method of switching power is needed other than that afforded by line type (hydrogen thyratron) modulators - such as the use of very short pulses in rapid succession as would be needed to provide coded signals.

Evaluation of Ceramic Thyratrons (U), SR 008-03-9424. Naval Material Laboratory and commercial; Problem No. 1102-B-32.28; Mr. M. Adleman.

This project is for the procurement and evaluation of two types of a miniaturized ceramic hydrogen thyratron as a ruggedized replacement for 4035; 5022; 5949; 1258 or 3C45 presently used, or as a new design type for military equipment. These ceramic to metal hydrogen thyratrons are reported to be capable of operating at high power levels, high repetitive rates and high temperature. Special features are reported to be low cathode input power, low trigger drive requirement, fast warm up and low jitter, and rapid recovery time to permit operation at pulse repetition rates in excess of 50,000 pulses per second. The tubes require no forced cooling for operation up to 125 degrees C per ambient, and capable of environmental tests of 500 g shock and 2,000 cycles vibration at 10 g.

It is believed that the use of such tubes in newly designed equipment should result in more reliable operation and longer life.

Series Regulator Tubes for High Currents (U), SR 008-03-9425. Commercial; work order unassigned.

The design and development of a single or dual, medium or high MU, power triode for series regulator service.

Depending on the current level desired, from 2 to 70 tubes in parallel are presently required of existing tubes for "Passing Tube" service. A tube for series regulator service is called a passing tube in view of the fact that the initial function is a diode for passing of high DC currents. It's secondary function is regulating the voltage of the high current by the valve action of a grid.

At present, the best available type (6336A) is good only up to .5 amps. It is proposed to design and develop a tube which will reduce substantially the number of tubes required for use as "passing tubes" for series regulator service. Such a tube should have: low plate resistance to permit passage of high currents; high plate dissipation; high perveance, compactness, reliability, uniformity, and absence of grid current either from gas, leakage or grid emission.

Power Tube Structural Research (U), SR 008-03-9442. Commercial; work contract not assigned.

It is the intention of this project to develop a new technology for all classes of power tubes to improve such performance characteristics as power density, efficiency, linearity, operation in environments of high ambient temperatures, shock, and vibration.

To date, most of the power tube design has been merely a scaling up or down of designs evolved years ago. Some improvement in technology such as use of ceramics, rigid frames for grid supports, coaxial and stacked construction to use electrodes and insulators as an integral part of the vacuum envelope, and multiple and parallel tubes in one envelope have been made - but work is not keeping pace with present systems requirements.

Future systems requirements such as super-power high-duty cycle radar modulators, high power intermediate and final stage amplifiers, very linear single sideband amplifiers, compact missile and space equipment, electronic tuning and antenna switching at high power cannot be met reliably per the present state of the art.

Development of "Crowbar Tubes" (U), SR 008-03-9443. Commercial; work contract unassigned; U/A.

The objective of this project is the development of "Crowbar Tubes" for use as protective devices for very high power tubes (5 megawatts and above) and their associated circuitry. The advancing state of the art of high power tubes will require microsecond-response fault detection and protective circuits to minimize flash-arc damage to very expensive power tubes as well as its associated circuitry.

Most high power tubes are subjected to a phenomenon known as the "Rocky Point" effect. The phenomenon occurs as an internal flash-arc without prior warning. The triggering sources of these internal arcs ranges from cosmic rays to line voltage transients. Such arcs, unless protected against, are in most cases destructive to both tubes and its associated circuitry depending upon the magnitude of current flowing.

Presently used devices (gas tubes and ignitrons) are limited in some respects to: voltage and power handling capability, size, pulse lengths, temperature, and mechanical arrangements.

Emphasis will be directed but not limited to developing new devices such as: pure tungsten filament rectifiers, current limiting triodes, spark gaps etc.

AGET SECRETARIAT (U), SR 008-03-9455. New York University; DA-36-039-sc-64632; Col. H. Serig.

To provide a Secretariat for the Advisory Group on Electron Tubes of the Director, Defense Research and Engineering of the Secretary of Defense, including furnishing a central compilation and data reference on electron tube and semiconductor device research and development, underway in government and industry.

This task represents Navy Share in tri-service

program administered under a Signal Corps contract.

Research on Storage Tube Assemblies (U), SR 008-03-9456. Naval Research Laboratory; S-1849; F. H. Harris.

This task covers a program of applied research on storage surfaces, storage assemblies and electron paths, and study of problems of ionic effects on storage tubes. The results will be information leading to solution of problems in design and development of storage tubes, which presently limit the performance of these devices with respect to resolution, uniformity, storage time capability, and life.

Secondary emission ratios of insulators of low bombardment energies have been determined and curves published for the use of storage tube designers.

Information leading to better control of paths of electrons near the surface of both metals and insulators has been obtained through development of a special tube for measurement of contact potentials, which can be observed by a television type monitoring of surface potentials on clean copper.

Results of these accomplishments have been disseminated to storage tube designers.

Electroluminescent Panel Display (U), SR 008-03-9457. Westinghouse; NObsr 72782; Dr. E. A. Sack.

This task covers study and investigation towards design and development of a solid state display panel consisting of 2048 x 2048 individual cells, as required for OPCON Center usage including Sea Surveillance, Subic and NTDS systems to provide a graphic presentation of stored information continuously sampled by a switch in dimensions approximating six feet square, bright enough to be viewed by groups under normal ambient light and with resolution capacity sufficient to distinguish alphanumeric characters.

The supporting research objectives to be emphasized in this task are:

(1) Study of half tones for the development of optimum gray scale levels and control characteristics of the screen for half tones

(2) Study of "layering" techniques to permit the screen to be fabricated by "printed circuit" types of evaporated materials in lieu of the component assembling methods used in the experimental model

(3) Addition of multi-color presentations.

Field Emitter Semiconductor and Device Studies (U), SR 008-03-9458. Linfield Research Institute; NObsr 72697; Dr. Walter Dyke.

Investigation of field emission from various crystal semiconductors and study of electronic devices which exploit to advantage the field emission properties. The feasibility of using semiconductor materials as electron sources was determined obtaining J-I graphs and J-E plots and comparing data with the theories of Margulis and Stratton, on which much of the work was based. Analysis of the data is included in the final report. Electron micrographs were obtained which showed profiles so that applied field and emitted current density values can be determined and correlated for the various surfaces.

In the device area field emission microwave amplifiers were developed to the stage where feasibility was demonstrated under a concurrent Navy project using results based on studies under this task. Electrostatic beam forming techniques suited to single and multiple needed field emission cathodes were investigated to develop high transmission guns that yield collimated or focused electron beams of high current density.

Research and Development of a Color Storage Tube (U), SR 008-03-9459. Hughes Aircraft; NObsr 81199; John Koda, L. S. Yaggy, R. D. Ketchpel.

Research and development of a two-color direct view storage tube shall be conducted. The design objectives shall be a tube 10 inches in diameter and a maximum of 20 inches long, with a useful screen diameter a minimum of 7 inches.

The resolution shall approximate 80 lines per inch; the brightness shall approximate 60 seconds per volt of storage characteristic range. It is proposed to accomplish this by a simplified color-storage mask assembly which is expected to result in much brighter tubes than was feasible in earlier attempts to design three-color storage tubes using "shadow mask" color TV screens.

Addition of more than one color to display tubes is needed to provide a new dimension for presenting large quantities of information available from advanced radars and sonars. The data are often so complex that delays in interpretation result from indistinguishability between categories of targets. Since there are no available color phosphors with the required persistence characteristics, the storage tube approach appears most promising toward attainment of multicolor display.

The first experimental model sealed off tube has been made, and shows promise of meeting the required performance characteristics.

Image Amplifier Storage Tube (U), SR 008-03-9460. ITT Laboratories, Fort Wayne, Indiana; NObsr 72783; R. W. Hunter.

Design and development of a projection storage tube for use with a Schmidt projection system in military applications for radar displays in control centers have been completed, and a sample tube is ready for submission for evaluation. The face of the tube is 7 inches in diameter, and it is anticipated that the tube will be capable of producing a display 50 inches in diameter at a brightness of 15 foot lamberts on a diffused reflecting screen when used with a Schmidt optical system when the mean throw distance between the Schmidt system and the display tube is 84 inches.

Final samples have been completed and are being shipped to the Material Laboratory for test and evaluation.

Transparent Phosphor for Cathode Ray Tubes (U), SR 008-03-9461. Naval Research Laboratory; S-1887; T. E. Hanley.

Studies are being conducted along the lines of the development of means by which cathode ray tubes may be improved in resolution, contrast and brightness of display, and use of "windshield" type tubes. The factors being studied are:

(1) The means by which long persistent phosphors may be deposited as transparent films as has been accomplished with shorter persistence phosphors.

(2) Basic studies of the cathodoluminescence of

vycor glass.

(3) The synthesis of meltable glasses with cathodoluminescent properties, based on the information gained by the studies on vycor glass.

(4) Experimentation with the decay properties of glass by the addition of selected activators and trapping agents in order to enhance the persistence of the luminescence of glass phosphors.

The purpose of the research laboratory studies is to investigate new principles on which can be based design and development of improved cathode ray tubes at industrial laboratories.

Transparent Phosphor Long Persistence (U), SR 008-03-9462. Westinghouse Electric Corporation; NObsr 77582; R. J. Kurtz, W. A. Thornton.

In the research and development of a transparent phosphor which will approximate the persistence of P7 and have good contrast ratio, and which can be deposited on soft glass, the most encouraging results have been obtained with manganese-activated potassium magnesium fluorides, and zinc borates activated by manganese and nickel. It is anticipated that further experimentation in synthesis of these two phosphor powders will lead to materials possessing higher build up and brightness ratios. Development of acceptable phosphor films of the ABF_3 type by a two-step process shows promise at this time.

Transparent film phosphors, being without grains to reflect light offer possibilities of non-reflecting properties to greatly improve target detectability in high light ambient situations. The removal of the phosphor-grain limitation on particle spot size will also lead towards achieving very high resolution on cathode ray tubes, on which the electron beam optics have already proved capable of forming spots smaller than phosphor grains for settled or deposited phosphors.

Development of 12" and 21" APSEL Charactron Shaped Beam Tubes (U), SR 008-03-9465. Stromberg-Carlson Company; NObsr 77560; Mr. Dan Haflinger.

The task covers the development of character display tubes using the "Aperture Selection" principle for use in the Navy Tactical Data System, covering requirements for tubes which will present a combination of line PPI radar and also symbolic identification of targets. Successful development of these tubes should result in increased speed and accuracy of recognition of symbols by observers because of improvement in legibility, and also elimination of separate consoles now used to display each of the two types of information. Two types of tubes are being developed - a 12-inch electrostatic deflection version and a 21-inch version with magnetic deflection.

The development of the 12-inch tube has been completed, and samples were tested at NEL. The results showed that the aperture selection tubes were incapable of satisfying the operational requirements of the NTDS consoles primarily because of low light output. (NTDS contract is NObsr 77624.) Work on the NObsr 77560 contract was temporarily suspended in favor of working on NObsr 77624 to obtain a tube that will meet the demands of the fast (four-mile) radar sweep and eight-microsecond character unblank times. Final samples of the charactron will be delivered on the contract NObsr 77560.

Causes and Prevention of Electron Tube Deterioration (U), SR 008-03-9466. Radio Corporation of America, NObsr 77637, Dr. N. E. Freedman; Briggs Associates, NObsr 77530, Mr. T. H. Briggs; General Electric Company, NObsr 81225, Mr. J. C. Hickel.

Electrical wearout mechanisms whereby chemical and physical changes proceed in an interdependent kinetic pattern limit tube life and reliability. Based on data results from this task, it is hoped to achieve greatly increased assurance of stability of tube characteristics well beyond life test periods. Gaps in knowledge of why tubes wear out and how deterioration factors can be overcome are being filled.

High Temperature Storage Tube (U), SR 008-03-9467. Radio Corporation of America; NObsr 77644; R. P. Stone.

The aim of this program is the development of a practical direct view storage tube with stringent electrical performance specifications for use under severe environmental conditions. The initial effort on tube fabrication used a design employing writing between the secondary emission crossovers. In the application for which this tube is being developed a complete raster must be written before any intelligence is usable, thus alternate writing and viewing may be used. Four coaxial gun systems have been evaluated, and two have been selected as the most promising. They are the coaxial write-flood gun systems with long and short magnetic focus and deflection. Six phosphors were evaluated as a function of temperature in a sealed-off tube. Initial test results on P11 phosphor are encouraging.

A sample tube embodying the most promising design has been made, and has been shipped to the Material Laboratory for evaluation.

Multi-beam Tube Tracking Studies (U), SR 008-03-9468. General Electric; NObsr 77536; M. E. Russell.

Tracking of targets and missiles by displays presented on cathode ray tubes, whereby speed and accuracy of displayed information becomes increasingly important, is extensively used in Naval equipment. Since most of these tubes contain from two to five separate electron beams, the problem of precision alignment of each beam and accuracy of tracking of the beams with one another have presented difficulties beyond solution within the present knowledge of electron optical design and cathode ray tube construction. Supporting research to forward the art was, therefore, undertaken by this task, to be conducted in three phases: (1) theoretical calculations, (2) experimental models to verify theory, and (3) fabrication of final samples for service evaluation.

High Temperature Tube Techniques for Photomaterials (U), SR 008-03-9470. Westinghouse Electric Corporation; NObsr 77556; H. A. Stahl, Z. Szepesi.

To conduct studies and investigation on high temperature photoelectric techniques and materials toward making available means of sensing light useful in pickup devices operating in environments up to 120 degrees C. Two approaches may be pursued, i.e., studies of photoemissive techniques and

materials leading toward their application in photomultiplier type of pickup tube, and studies of photoconductive techniques and materials leading to applications in vidicon type pickup tubes. The prime objective of either or both approaches is supporting research to make possible high temperature pickup devices responsive to low-level visible light (1 ft. lambert approx.) such as emitted by cathode ray phosphor screens (which may be assumed to have compatible spectral outputs) and within present limitations under elevated temperature conditions due to thermal effects of noise and dark current.

Pick-Up Tubes for Use at High Temperature (U), SR 008-03-9471. Contractor not assigned.

To design and develop a slow-scan ruggedized "vidicon" type photoconductive camera pickup tube which will operate at high ambient temperature. This vidicon is to serve as the "readout" function from a display presented by the high temperature direct-view storage tube now being developed for advanced guidance systems having broad potential application to guidance of aircraft and missiles.

To design and develop an end-on 10-stage multiplier phototube with S-11 response, with a small diameter, and which will operate at high ambient temperatures.

Cold Cathode High Emission Cathode for Power Tubes (U), SR 008-03-9472. Nuclear Corporation of America; NObsr 77591; Dr. N. Sclar.

Study of concept of novel cold-cathode emitter, designated "COCAT", by selection and use of a suitable semiconductor material with large energy gap as the cathode, with the objective being to obtain an emission density comparable to or greater than that obtainable using a hot cathode, leading to a new class of electron tubes of a vacuum solid-state type with whose efficiency and techniques may afford solutions to problems encountered in conventional tubes. This investigation will include preparation of materials of desired compositions, binary compounds of Group IV types of polynary materials, incorporation of selected impurities and defects of controlled quantity and types. It will also include laying a basic foundation for fuller interpretation of the fundamental solid-state mechanisms of behavior of COCAT materials and determination of general rules for selection of materials for such emitters.

Formed Structure Electron Guns for Cathode Ray Tubes (U), SR 008-03-9474. Stromberg-Carlson; NObsr 81208; Mr. B. Gear.

The scope of the work is the investigation and development of novel fabrication techniques for electron guns in cathode ray tubes and other types using beam forming elements. Approaches under consideration are (1) formation of tube elements directly on the interior of glass bulbs and/or necks; (2) forming tube elements from machinable or moldable materials; (3) use of high resistive films to perform certain functions. It is expected that completely new fabrication techniques for cathode ray tubes and similar structure tubes using electron beams, will make available more compact, simplified structures with high precision and stability in military environments, such as are required for missile guidance control in aircraft and signal analysis purposes.

The first 5-inch tube for the machined glass-bonded mica gun made in two pieces has been completed. Samples are being constructed as called for under Phase II of the contract, and will be ready for testing soon.

Work has been started on the gun to be formed in one piece. Initial guns will be machined to develop the special techniques necessary for inserting apertures into a complete cylinder and for forming the conducting elements.

Study of Electrophotoluminescent Phosphors (U), SR 008-03-9475. Philco Corporation, NObsr 81189, Dr. M. E. Lasser; one contractor unassigned.

Study and investigation of the phenomena of electrophotoluminescence in phosphors toward practical application in display devices whereby the brightness can be quenched by control voltages in the order of 1 or 2 volts. Solid state display panels now under development require controls in the order of 200 to 300 volts d.c. with the accompanying power supplies, amplifiers and structural requirements. Elimination of the high voltage drive will result in simplified display panels of lower cost, using miniaturized components such as transistors.

The "electroquench" effect was discovered during basic research being carried out in Philco Laboratories where it was found that very low fields across such a phospher will suppress optically-induced fluorescent emission with very good definition.

To date, the changes in the cadmium sulfide evaporation, namely, better control of evaporation rate, uniformity of evaporation pattern, and uniformity of evaporation charge have done much to contribute to the reproducibility of quenching characteristics of completed cells. The elimination of shorting defects now allows the measurement of electrical and optical characteristics so that effects of phosphor film processing conditions and a study of contacts can be pursued.

Successful achieving of the quenched principle will lead to development of a display using EQ phosphors.

Alpha-Numeric Printer Tubes (U), SR 008-03-9476. Litton Industries; NObsr 81181; Norman Fyler.

Conduct a research and development program that will result in the design and construction of an electronic printer cathode ray tube to accomplish the following: (a) the rapid and direct printing of alpha-numeric characters on a dielectric sheet or base, such as paper, by establishing an electrostatic charge image which is developed by the adherence of pigment dust and fixed by a fusion process; (b) the direct selection from a choice of 64 characters with a 6-channel, 2 condition input signal; (c) the utilization of a mosaic target scanning; (d) the positioning of characters along a line by electronic scanning techniques; (e) the accommodation of a vertical index by the step advance of dielectric sheet or base with a minimum of friction.

Data processing means are outstripping the speed of methods for displaying information. This task is expected to furnish a hard copy of projectable

slide of information from data shown at a considerable faster rate than has hitherto been accomplished. This is made possible by elimination of steps of beam-to-light, and light-to-photographic plate conversion by making possible direct printing for a CRT beam thru the tube face.

Test and Evaluation of Special Tubes (U), SR 008-03-9478. (a) Material Laboratory, Prob. No. 1102-B-24.11, Milton Adelman; (b) Contractor unassigned - commercial, PR 691A-19224.

The purpose of the project is to procure and evaluate samples of new indicator tubes, developed both commercially and under Navy contracts to determine the suitability of these tubes for use in the design of new Navy radar and sonar indicator equipments. This project shall cover such items as:

a. New commercially developed cathode ray tubes with low drive characteristics for use in transistorized equipments;

b. Direct view storage tubes developed under Navy contracts to determine applicability for use in Navy equipment, development of testing procedures, and establishing limits for parameters and methods;

c. Experimental models of commercially developed storage tubes, both direct view and electrical output types;

d. Flat cathode ray tubes - monochrome model.

Ultra High Vacuum Processing Techniques for Electron Tubes (U), SR 008-03-9479. Stanford Research Institute; Lester Feinstein.

To satisfy the increasing need for improved tube reliability and performance the present state of the art of tube technology must be extended into the area of investigating effects of fabricating tubes with pressures in the range of 10^{-10} to 10^{-12} mmHg with a study of effects on tube life, performance and reliability. Such an investigation will provide information on effect of pressure on tube failure phenomena such as cathode deterioration, arcing leakage, surface contaminations and changes in tube characteristics.

The problem of achieving ultra-high vacuum electron tubes can be approached by several avenues to be studied individually, concurrently or in sequence, with results applied to the overall problem. These include (1) vacuum system design; (2) study of vapor pressures and evaporation rate of materials; (3) gas absorption, diffusion and permeation studies; (4) cleaning methods, tube assembling and processing techniques; (5) tube testing.

It is anticipated that this program will not only involve considerable experimenting with vacuum components, but will also involve tracer and mass spectrometer techniques to study migration of gases and solids as well as vacuum metallurgical work to provide metals having the required grade of purity for ultra-high vacuum tubes.

Cathode Ray Tubes for Three-Dimensional Display (U), SR 008-03-9483. Contractor unassigned.

The objective is to provide display tubes capable of presenting true three-dimensional data with dimensions scaled to the original volume from which the data originates. The proper presentation of information derived simultaneously from such sources as omni-range surveillance radars, radar mapping and computer generated environments has established the requirements for design of more comprehensive display systems to reduce the accumulated positional and environmental data to a form in which instantaneous response to acquired information is possible. Investigations have been carried out by qualified and experienced physicists and engineers, from which they have reached conclusions that three-dimensional, multicolor displays are feasible to simplify in great measure the data displays situation. Two immediately practicable ways to achieve this are proposed, both of which overcome the problems of the previously suggested stacked panel by employing a single panel of controlled luminance and actually moving the plane either rotationally or rectilinearly to realize a third dimension.

Long-Persistent Color Phosphors (U), SR 008-03-9485. Contractor not assigned.

To develop at least two additional phosphors which will have long persistent colors that contrast with the present yellow orange long-persistent characteristics. The new phosphors would be used to present a radar display in more than one color to give color differentiation to different types of signals. The color difference would make possible the discrimination of target from noise, moving targets identified over land masses, multiple target discrimination, such as IFF, navigational beacons, identification of varying heights by color codes, and various simultaneous displays not now usable because of lack of ability to distinguish between them.

MIRRECHON Electrical Output Storage Tube (U), SR 008-03-9486. Contractor not assigned.

This storage tube uses the principle of reflective storage grid control of a scanning reading beam. The amount of beam reflected is controlled by the amount of the negative potential placed on the insulator by a "writing" beam. Since the beam does not land on the insulator, the potential pattern can be retained through multiplicities of reading, such as 20,000 copies over a ten minute period without loss of half-tone capabilities or resolution. Such capabilities have been shown in the laboratory, but technical problems in construction of screen material and beams must be overcome by engineering development. The tube show promise of providing simultaneous and independent writing, reading, and erasing, which is beyond capability of any current design of storage tubes.

The AN/SQS-26 and future surface ship equipments will employ complex search methods requiring displays utilizing storage tubes, including storage and readout times of 175 seconds and longer. Selective erasure is also a highly desirable feature. No known storage tubes of such performance characteristics are presently available.

New Materials for Electron Tubes (U), SR 008-03-9487. Contractor not assigned.

Conduct applied research leading to evolution of new materials for electron tubes, particularly those for use under adverse military environments. Examples of materials in which existing deficiencies may be overcome or hitherto unattainable performance

achieved are:

a. Wire materials for leads of miniature and subminiature tubes to replace the current requirement for all nickel, which is chronically in short supply and subject to breakage during fabrication, increasing cost of procurement, and chance of unreliable operation in fleet.

b. Base potting encapsulant materials with higher dielectric strength, lower electrical leakage, improved thermal expansion and thermal conductivity characteristics than presently available for tube construction. A whole new category of expoxy resin systems possess some remarkable properties which should be investigated for their applicability to electron tube encapsulation.

c. Solid state bonding of metals similar to that of pressure welding used in metal working as a replacement for brazing or soldering.

"Cool Cathode" Approach to Long Life Reliable Tubes (U), SR 008-03-9488. Contractor unassigned.

There exists a wealth of accumulated evidence which proves that electron tube life and reliability can be improved by an order of magnitude if the operating temperatures of their oxide cathodes were reduced by as little as 100 to 150 degrees C. below their present operating point of 800 to 900 degrees C.

Although it is within technical feasibility to design tubes that will perform satisfactorily at these lowered operating temperatures, the technological processes required for production on a large scale are prohibitively expensive (e.g. such tubes are produced in very limited quantities and excessive cost per tube for burial in submarine cables by commercial communication companies).

The objective of this task is to study oxide cathode operation with a view towards evolving new materials and processing controls which would make practical quantity production of electron tubes with thermionic oxide-type cathodes optimized for best performance at relatively "cool" temperatures.

Thermoplastic Printout Techniques (U), SR 008-03-9490. Contractor unassigned.

Conduct a research and development program leading to a cathode ray tube which will accomplish direct electronic printing at high speed on thermoplastic recording tape. Electrons from a high intensity, high definition beam can produce a charge pattern on a dielectric surface through a mosaic consisting of fine metallic wires penetrating a vacuum-tight glass face plate of a cathode ray tube. To date densities of 62,500 wires per square inch have been attained. A thermoplastic tape has been developed which may be charged within a vacuum by a cathode ray tube electron beam according to a pattern which causes a pattern of indentation or ripples to be made by heating and cooling the tape. By this means extremely high recording density (as much as 40 million bits per square inch) has been achieved on an experimental basis. However, the difficulties encountered due to the amount of tape which can be processed in a vacuum enclosure, and the insertion and withdrawal from a vacuum impose serious limitations on the applicability of the thermoplastic tape for military uses. Adaptation of the electronic printing principle external to the vacuum would make the device suitable for use in data recording and display for radar and command centers.

General Tubes Research (U), SR 008-03-9491. Naval Research Laboratory; S-1956; Dr. Sidney T. Smith.

This task covers study, investigation, consultative and advisory services in various categories of electron tubes, in the following specific areas of research:

a. Consultative Services on Tube Technique Problems.

b. High Ambient Temperature Receiving Tubes.

c. Noise in Crossed Electric and Magnetic Fields.

d. Linear RF Amplifier Tube.

e. Cold Cathode Magnetron.

Field Enhancement of Cathodoluminescence (U), SR 008-03-9493. Contractor unassigned.

Develop means of using in cathode ray tube structures known phenomena relating to brightness enhancement, storage, and persistence effects produced by the application of electric fields to cathode ray tube screens. Improvement of efficiency or energy conversion by amplification of luminescence should be reflected in performance of cathode ray displays by producing much higher light output for given power input. This would permit operation in higher ambient light environments, reduction in beam current providing increased resolution, lowering of accelerating voltages to provide improved deflection sensitivity and improved useful life of phosphor screen and cathode.

The approaches to be undertaken would extend previously published work in transparent phosphors to overcome the breakdown encountered in earlier efforts to field enhancement with powder screens, and investigating possibility of enhancement by use of materials with selected conductivity properties with study of possible phosphor injection control by application of techniques known in semi-conductor laboratories.

Solid State Self Scan Display Panel (U), SR 008-03-9494. Contractor unassigned.

Study new concept of solid state video display panel capable of random access to display oscilloscope-type patterns and capable of scanning itself to present a raster-type panel. This novel display means is based on a combination of an electroluminescent phosphor layer in contact with a flat piezoelectric ceramic panel which excites and controls, point by point, the light output of the electroluminescent phosphor layer. Evidence of the technical feasibility of the basic design has been demonstrated. An R & D program is required to complete the basic investigations and to develop and bring to technical fruition a device which offers a new means of electronically displaying fast changing analog information by means of purely solid state techniques.

Study of Storage Tube Writing Techniques (U), SR 008-03-9495. Contractor unassigned.

Study of writing techniques in order to achieve more uniform writing of storage surfaces plus capability to erase and write selectively or re-establish

storage potential to written level with a single electron gun. This task covers development of a method of equilibrium writing between the two cross-overs of the secondary emission curve by collector modulation. It is anticipated this will make possible a storage tube for use in the "black writing" mode--that is a black picture on a white background, greatly improving its capability for viewing target displays in a high ambient light and offering much sharper resolution and contrast than when writing normally bright traces on a white background.

Improved Scan Conversion Storage Tubes (U), SR 008-03-9496. Contractor unassigned.

Scan conversion devices to convert slow scan PPI traces into a raster display for brightness enchancement in high ambient conditions, or to convert and store video for readout at slower rates for narrow bandwidth transmission have been limited in performance by technical deficiencies in the state of the art. This task covers studies of basic physical principles and techniques to overcome the present limitations exhibited by electrical storage tubes with particular respect to the parameters of resolution, uniformity, signal-to-noise ratio, and ability to withstand severe military environments.

Radiation Effects on Parts and Materials (U), SR 008-03-9525. No Contractor, Contract, or Principal Investigator.

This task covers the development of electronic parts and materials which will operate satisfactorily while subject to nuclear radiation.

The phenomenon to be exploited will depend upon the specific electronic component that is required to be developed.

The methods to be used will depend upon the specific electronic component to be developed, however, the initial phases of the developments will be based on information determined by the evaluation of existing electronic components by various Air Force and Bureau of Weapons contractors such as: General Electric, General Dynamics, Martin Aircraft Company, etc.

High Temperature Transformers with New Configuration for Use in Missiles and Aircraft (U), SR 008-03-9526. Raytheon Manufacturing Company; NObsr 72761; Mr. F. Kilham.

This task covers the exploration of new insulation systems for the purpose of developing transformers capable of operating for 2,000 hrs. at ambients of 250°C and 500°C respectively.

This will be based upon the use of new insulation systems primarily the use of a gas for the dielectric in conjunction with mica and other inorganic layer insulation wire insulations.

Using stand test coils (wire, layer insulation), as well as case material etc. and all other components of a transformer will be evaluated at the specified temperatures for the times indicated. Using these results, a line of prototype transformers will be constructed and evaluated re. the environmental requirements. These prototypes include a high power pulse, audio, high voltage and high current transformer.

Transformers capable of operating at ambient of 250°C (350°C coil temp) have been completed and the 500°C (600°C coil temp) units have been fabricated and are currently undergoing evaluation.

High Temperature Rectilinear Potentiometer (U), SR 008-03-9528. PR Mallory and Company, Incorporated; NObsr 72742; Mr. James Kaufman.

This task provides the research and development necessary, including basic investigation of the characteristic of the metal film, to develop a rectilinear potentiometer capable of operation at 430°C and meeting specific design objectives. This device is being developed for BuWeps for use in new missile systems such as the Super Talo, etc.

The tests of the developed resistors indicate that all the design objectives were not met on their entirety. The following objectives were met; termination resistance, flim resistance, linearity and resolution. Noise requirements were met in twelve samples at 430°C but the noise was high (0.25 ohms) at room temperature. Film wear above 1,000,000 cycles of rotation increases producing a resistance change from 1 to 5%. Test results show that the resistor is capable of performing well at 430°C if the rotation is limited to less than 1 million cycles. A compromise was made while adjusting the contact pressure to cover the range of temperature of 25°C to 430°C and still meet the requirements of the specification.

High Temperature Pulse Forming Network (U), SR 008-03-9531. Sprague Electric Company; NObsr 77598; Mr. R. L. Lord.

This task covers the research and development of a pulse forming network capable of 2000 hours operation at a temperature of 150°C.

This will be based upon the use of an impregnant which will retard the development of corona and will not decompose into combustible materials and gases. The insulation system will have to be one in which hydrogen is not evolved as a product of decomposition.

Perflurocarbon and perflurochlorocarbon liquids are being evaluated to determine products resulting from electrical breakdown and subsequent arcing. When a choice of liquid impregnant has been made it will be used in the construction of 10 developmental models of high temperature pulse forming networks evaluated for corona free operation in any position at 50,000 feet maximum altitude.

Several impregnants have been evaluated from which perfluro-tri-n-butyl amine and triflurovinyl chloride polymer have been found suitable. Test capacitors have been designed and fabricated for accelerated life testing and standard capacitor tests. The impregnants found suitable in arc-over tests have been used in the test capacitors in conjunction with mica paper and the work will be evaluated in the near future. No further funding anticipated.

High Temperature Miniature Connectors (U), SR 008-03-9532. Cannon Electric Company; NObsr 72798; R. Duncan.

This task covers the exploration of new insert materials (insulators), contact, and shell materials for the purpose of developing connectors capable of operating at ambients of 500°C.

Connector development will be based upon the use of new insert materials primarily the use of experimental silicone molding compounds of Dow Corning in lieu of alumina and the use of dry lubricants for the coupling ring in lieu of liquid lubricants. This task will provide the research and development necessary to furnish high temperature connectors conforming to Bureau of Ships specifications.

Multicontact connectors were developed which will operate satisfactorily at 500°C. The connectors are available with 10 No. 16, 12 No. 20, 19 No. 16, 32 No. 20, 48 No. 16 and 55 No. 20 contacts. The connectors will withstand vibration of 30 gr from 10-3000 cycles.

High Temperature RF Connector (U), SR 008-03-9533. Contractor unassigned.

This program covers the design and development of a high temperature (500°C) RF connector.

Successful completion of this program will entail an investigation into high temperature, conductive materials which can be machined; sealing techniques and high temperature spring materials. Such materials as inconel, fused silica and stainless steel will be considered.

The electrical design of suitable connectors is available. It will therefore be necessary to piece parts in the form factor and to the tolerance evolved by calculation. Also techniques for suitable assembly of a connector to a cable will be devised.

High Temperature Parts (U), SR 008-03-9535. Material Laboratory; 4960-V-102; Mr. G. Neuschaefer.

This task will be the test and evaluation of high temperature parts and materials developed either commercially or under government sponsorship.

The tests and evaluations are intended to determine if these parts can maintain these mechanical and electrical characteristics at the specified elevated environment.

Parts and materials developed under other contracts as well as commercially developed parts are forwarded to the Laboratory where specified are conducted to determine performance characteristics.

Under the problem established at the Material Laboratory to date most of the commercially developed parts have been procured by the Laboratory. In all areas that parts have been received, tests are underway. These include high temperature relays, resistors, switches, capacitors, and transformers.

High Temperature Conformal Coating (U), SR 008-03-9537. Rubber and Silicon Products Company, Incorporated; NObsr 77597; J. Schrecber.

Develop a conformal coating for printed wiring which will operate at 250°C.

The ability to polymerize various silicone oils and modified silicone resins into a thin continuous coating.

Various silicone resins, silicone oils and epoxy silicone combinations will be investigated and evaluated on printed wiring boards fabricated of various materials.

Various modified silicone compounds on teflon glass laummates have satisfactory insulation resistance when subject to Method 106 of MIL-STD-202, thermal shock, immersion, and limited thermal aging of 250°C. The coatings are stripable and have a rough surface. Problems concerning the oxidation of the copper pattern at 250°C remains a problem. Thermal aging at 125, 155 and 200°C will be investigated to determine the affect of the reduced temperature on copper oxidation.

High Temperature Blower Unit (U), SR 008-03-9538. Eastern Air Devices, Incorporated; NObsr 77537; Mr. S. A. Davis.

This task is intended to develop two small 400 cycle induction type blowers capable of operating over the temperature range of -55 to 200°C and meet the stringent environmental conditions specified for Bureau of Weapons electronic equipment.

Based upon the investigation of wire, high temp. insulation, lubricants and bearings, the most efficient cooling device will be designed. Using these results prototype blower units will be constructed and evaluated to the specified environmental requirements.

Investigation of high temp. materials for phase I (small) blower and development of configuration is complete. Investigation is underway on determination of the proper lubricant and bearings. The phase one blower is undergoing lift test. To date phase one blower has completed more than 1800 of the required 2,500 hours of life at 200°C. Phase II of present task, calling for 70,000 ft. operation, is now underway. The engineering and research design decisions and written instructions to drafting for design are completed.

High Temperature Parts Guide (U), SR 008-03-9539. Contractor unassigned.

Short term temperature part evaluation at Material Laboratory has shown that low temperature parts may be operated at higher temperatures with reduced life. The intent of this task is to develop a set of guide lines (which would improve part reliability) which could be used industry-wide to establish voltage and power ratings in such parts as resistors, capacitors, transformers, fuses, terminal boards, etc. This development has been requested by Bureau of Weapons (BuAer ltr Ser AER-AV-4422 (0797) dtd 20 Jan 1958 to BuShips) to establish realistic ratings for parts to be used in missiles and aircraft.

Magnetic Switching Devices (U), SR 008-03-9542. Naval Ordnance Laboratory; NOL 60921; H. Irons.

Development of all-magnetic disital devices such as shift registers (devices which do not require diodes and transistors) which will operate at very low power levels and will switch very rapidly (1 miroseconc or less).

The ability to advance magnetized regions in a wore (Magnetic material) along the wire by activating a suitable array of solennoids along the wire in the proper time sequence.

Twisted permallory wire under tension, unstressed permallory wire and nickel-iron plated copper wire will be investigated as to their applicability to all magnetic digital devices such as shift registers. Shift registers will be fabricated and evaluated for speed of operation, complexity and

reliability.

The work was discontinued in view of the effect of the earths' magnetic field on the device and the slow switching time of such devices which makes it unsuitable for Bureau of Ships computers.

Hi-Temperature Binder for Magnetic Cores (U), SR 008-03-9543. Westinghouse Materials, Engineering Ceramics Section; NObsr 77578; Mr. R. B. Grekila.

The object of this task is the development of an inorganic binder for "C" and torroidal cores suitable for operation over the temperature range from -55°C to ± 500°C.

This will be based upon the study and applications of ceramic coatings and glass including the processes involved in the application of these coatings to the magnetic ribbon to provide electrical insulation and mechanical strength in construction of wound cores.

It is intended that a roller type of winding line shall be used to apply various ceramic coatings to a number of units constructed of 2 and 4 mil oriented steel, 2 and 4 mil 12% (or higher) aluminum, 2 and 4 mil 35% (or higher) cobalt iron, and 4 mil 3.5% (or higher) silicon steel. The samples shall be fabricated and tested to insure a minimum 2560 hour life at 500°C while providing adequate mechanical strength and no degradation of the electrical properties of the cores.

High Temperature Transformer Using the Wafer Coil Technique (350°C) (U), SR 008-03-9544. Sylvania Electric Products, Incorporated; NObsr 77550; Mr. A. Zack.

This task cover(s) the design and development of transformers for high temperature applications (350° to 600°C) using the wafer coil technique. This included analytical and experimental approaches as well as the production of prototype units and the contract was allowed to terminate at the conclusion of the 350°C phase.

This was based upon the exploitation of new insulation systems and techniques in the "wafer" coil configuration. Investigation of high temperature welding and encapsulation was required.

Using the wafer coil technique, foil conductors as well as oxide dielectrics and encapsulants for case material were investigated. Hermetically sealed metallic cases were the final design for all types. Aluminum oxide powder was the potting material for the final design. Aluminum foil with isomica insulation was used in the final design for all transformers.

Using results from prorotype models that successfully completed 350°C life test, as well as other environmental requirements, twelve each filament, audio, and pulse transformers were produced and shipped to the Bureau of Ships. With delivery of final report.

High Power High Temperature Magnetic Modulator (U), SR 008-03-9545. Westinghouse Electronics Division; NObsr 77638; Mr. J. Horner.

This task covers the development of a 3 megawatt magnetic modulator for use in Navy electronic equipment. This modulator shall produce a pulse of 0.25 microseconds duration at points of minus 3db with rise and fall times of 5 percent. The modulator occupy a volume no greater than 2 cubic feet, weigh no more than 100 pounds, and be capable of operation throughout the temperature range from 55°C to 85°C.

This will be based on the use of solid state switching devices, particularly silicon controlled rectifiers as well as on the use of new rectangular loop core materials (magnetic materials) to reduce jitters and enable use on MTI.

The project will be posed as a mathematical problem using computer analysis techniques, and as a circuit problem using "breadboard" techniques. The study of electrical and magnetic circuits will form the basis for construction of the fixed model.

The switching circuit, and jitter compensation circuits have been developed and tested. The final manufacturing drawings have been completed, and final fabrication and testing of the modulator will soon be complete.

Overload and Overvoltage Protection of Transistor Circuitry (U), SR 008-03-9547. Battelle Memorial Institute; NObsr 77579.

To determine the feasibility of protecting transistors and transistor circuitry against electrical surges.

Based upon evaluation of specific transistor, verify the thermal analog to ascertain the causes of failure of transistors due to transient conditions.

To contact manufacturers and user of transistors and equipment designers to obtain information on the failure criteria of transistors. To determine important transistor characteristics affected by surges and derive parameters around which protective devices should be designed.

Determination of transistor junction temperature rise produced by various conditions of transient overload is being accomplished through the use of a transistor thermal analog. In attempting to verify the analog results, however, using transistors, the high mortality rate has led to attempts to perfect methods of protecting transistors under test. Worthwhile analog results await these developments.

Heat Dissipating Electron Tube Shields (U), SR 008-03-9548. Henry and Miller Industries; NObsr 77575.

To develop subminature, minature and other electron tube shields with high heat dissipating ability coupled with superior electrical shielding ability.

Thermally and electrically conductive metals.

Determine the ability of current tube shields to electrically shield the electron tube from stray electric fields in the frequency range 500KC to 300MC. Design and develop shields incorporating twice the electrical shielding capabilities as well as high thermal conductivity.

The contractor has developed prototypes and submitted some data showing these shields to be thermally superior to existing shields.

Radiation Resistant Capacitors (U), SR 008-03-9549. Admiral Corporation; NObsr 77612; Mr. E. R. Pfaff.

This task covers the development of type CPM08 capacitors of specification MIL-C-14157 (High reliability capacitor spec) capable of withstanding a specified nuclear environment.

Superimposition of the nuclear environment upon the voltage and temperature environment predetermined to cause 75% failures will establish the degree of degradation caused by the addition of the nuclear equipment. Dielectric paper and impregnant will be investigated.

To reduce the number of variables involved in this investigation all capacitors are being supplied by Sangamo Electric Company and the capacitors are fabricated from the same rolls of paper, cut and handled by the same people on the same machines. When the degradation parameters are determined, investigation will be conducted on the materials affected (i.e., metal container, dielectric material, impregnant, etc.).

Materials used in fabricating the high reliability capacitor have been subjected to the specified gamma radiation to determine their usefulness. Additional materials will be tested prior to assembling a unit which will be subjected to the radiation tests.

High K Energy Storage Capacitor (U), SR 008-03-9550. Erie Technical Ceramics, Division of Erie Resistor Corp.; NObsr 77554; Mr. L. J. Ruffner.

This task covers the development of capacitors utilizing high-grade ceramic as the dielectric with large energy storage per unit volume.

Material studies and fabrication techniques have been investigated to determine an optimum process for fabricating capacitors with a charge storage per unit volume equal to or greater than that obtainable in conventional aluminum foil electrolytic capacitors with reduced volume and improved shelf life.

Material selection was based on empirical results obtained by means of ternary chemical systems employing barium titanate, barium zirconate, magnesium zirconate, cadmium titanate barium carbonate, antimony tri oxide, tin dioxide, zinc oxide, and lead titanate, as well as fluoride-modified titarates of some elements.

Samples of capacitors have been fabricated, utilizing the assembly and encapsulating techniques and the ceramic composition ultimately developed under the contract. These samples are currently undergoing test, the results of which will be reported upon completion. No further funding is anticipated.

Precision Variable Resistor (U), SR 008-03-9552. Weston Instruments; NObsr 77548; Mr. T. K. Lakshmanan.

This project covers the development of several types of metal-film precision potentiometers of conventional design but superior operating characteristics to presently available film or wirewound types; Phase II covers the study of a solid state physics approach to the development of a variable precision potentiometer which shall contain no moving parts and meet the requirements of the contract specification.

Roller contact has been substituted by finger contacts of Paliney #7 alloy. Graphite roller contacts were investigated but results were not good. Final design of housing will be half the size of first samples. Film hardness has been increased by using etched pyrex underlay. Final production samples are under tests against the requirements of the specification. Tests show noise reduction and lower resistance wear in the final samples. It is expected that units meet the requirements.

Design and Development of a Flexible Coaxial-transmission Line (U), SR 008-03-9554. Andrew Corporation; NObsr 81413; Mr. E. Book.

As a basis for present work - A means of bridging shipboard expansion joints with rigid coaxial transmission line has been required. Previous method was to subricate a "U" secontn consisting of minimum of 4 additional elbows adding attenuation and reflection to the system.

A flexible section employing a trombone arrangement while still maintaining pressurization has been planned and built.

Variable Resistor Noise Study (U), SR 008-03-9555. National Bureau of Standards, Washington, D.C.; BuShips/1700R-556; Mr. G. T. Conrad.

This project covers the development of noise measurement techniques, and the measurement of noise in fixed and variable composition resistors under varying conditions of temperature, voltage, and rotational life. A description of the noise measurement technique will provide for use in MIL-STD-202.

This will be based upon the necessity to establish acceptable noise levels for inclusion in resistor specifications and the study of interference effects of resistor noise in selected low-level circuits.

Based on a study of noise characteristics of various sample composition resistors empirical data will be compiled from which a scientific correlation of variables will be made in order to arrive at a set of dimensionless numbers which will describe noise levels and noise characteristics of fixed and variable composition resistors.

A standard test method for fixed resistors has been established and is presently being added to MIL-STD-202. Work is continuing to accomplish the same for variable composition resistors.

Tensor Permeability Investigation (U), SR 008-03-9556. National Bureau of Standards, Boulder, Colorado; 1700-668-60; J. R. Kalke.

Determination of the permeability tensors and dielectric constant band frequencies of commercially available and experimental microwave ferrite. Investigate the feasibility of obtaining a mathematic expression for these tensors properties in bounded regions.

The relationship between the intrinsic properties of microwave ferrite and the transmission line properties of the materials.

The permeability tensors are determined by the standard cavity technique.

The permeability tensors and dielectric constant of 17 ferrites have been determined at 9200MC. S band and L band equipment has been constructed and checked for accuracy. Initial measurements have been made at S and L band. The information when complete will provide a tensor plot to be used in the design of microwave devices.

Ferrite Material Development (U), SR 008-03-9559. Motorola Inc.; NObsr 77618; Dr. D. Fresh.

Development of ferromagnetic materials suitable for all types of applications in microwave devices. This will include materials suitable for use in

phase shifters in fixed array antennas, materials suitable for application in circulators, limiters, switches, etc. This effort will be directed toward the development of those materials required for the development of the devices to enable the construction of systems now under study by the Radar Branch. Improved performance with temperature (higher curie temperature) is particularly desired.

High Capacity, High Voltage, Solid Electrolytic Capacitor (U), SR 008-03-9560. Philco Corporation; NObsr 72770; Dr. Maurice Francombe.

This project covers the study of the behavior of electrolytic capacitors and the development of a capacitance of the order of 0.1 to 1.0 farad per gram. Increased voltage and temperature capabilities are expected to result. This will result in a smaller cheaper (compared to tantalum) capacitor.

This will be based upon the correlation between the anodic leakage current, the elimination of the direction of easy flow in the solid - electrolyte type capacitor and the development of a procedure to deposit silicon in vapor form onto porous carbon. Methods will be developed to oxidize porous silicon carbide.

Material studies will be undertaken aimed at controlling precisely some physical properties of silicon carbide which are curtailed for this purpose. Methods will be developed to fabricate the SIO2 dielectric film and the finished devices will be encapsulated.

Silicon carbide foam samples initially received from Carborundum Co. revealed that the samples were too impure to work with. The material will be replaced with purer silicon powder.

Non-Metallic Ferromagnetic Materials (U), SR 008-03-9562. Naval Research Laboratory; S-1876; J. Murray.

Develop techniques for producing high purity polycrystalline and single crystal yttrium iron garnets and ferrites suitable for use in phase shifters for fixed electrically scanning arrays at "X", "S" and 200-400 mc frequency bands.

The techniques and knowledge developed in producing high purity barium titanate polycrystalline material. The ability of yttrium iron garnets and ferrites to produce a phase shift in microwave energy propagated through it.

Techniques such as the flame fusion, floating zone and hydro thermal will be used in producing high purity YIG single crystals. Techniques and controls similar to those used in producing polycrystalline barium titanate will be used.

Techniques are continuing to be developed to improve the reproducibility of ferrite materials based on rigid control of the processing investigation of the various techniques for producing single crystal YIG have been conducted and YIG crystals are being evaluated physically and electrically.

Miniature, Expendable, Elapsed Time Indicator (U), SR 008-03-9561. Nuclear Development Corp. of America; NObsr 81367.

This project covers the elapsed time indicators to be used, principally, in Navy transmitters to record the time of actual transmission of intelligence. Information required to study allocation of channels by CNC. In addition, this device would satisfy the requirement of the Darnell report (PSMR-1 (vols I and II)) for a cheap device to enable the acquisition of accurate life data on electronic part failures.

Recently, some commercial development has resulted in the use of the principle of deposition of copper from an anode to a cathode through the medium of an electrolyte. If the current flow between anode and cathode is kept constant, this process proceeds in proportion to time. It is proposed to study this and other like systems.

The system offering the best probability of success will be utilized in the fabrication of prototype elapsed time indicators.

To date the electrolyte and electrode composition have been finalized as has the mechanical configuration of the indicating tube.

Ruggedized, Sealed, Scale Change Roentgen Rate Meter (U), SR 008-03-9563. Weston Instruments; NObsr 77566.

To develop a sealed, ruggedized, adjustable scale, 3-1/2 inch, 50 microampere roentgen-rate meter the scales of which are 0 to 0.5, 0 to 50 to 50 and 0 to 500. Requirements furnished by Code 685 due to high failure rate of meter on PDR/27.

To render the roentgen rate meter relatively impervious to shock, trembling and vibration and to develop a seal for the range change shaft.

Emphasis is placed on the design of a gear train sufficiently rugged in order to resist damage while effecting smooth changing of scales.

Models have been developed and shipped to Material Laboratory for test. Contract has been amended to enable production of other models for reliability testing by the contractor.

Component Part Reliability Study (U), SR 008-03-9564. Material Laboratory, NYK; 4960-F-100.

Determine the cause of field failures of electronic component - parts and provide recommendations concerning corrective action.

Electronic component - parts which have failed in service are forwarded to the Material Laboratory. The cause of failure of parts which are considered to have an excessive failure rate is investigated and corrective action is recommended. The action recommended can be any of the following: part design change, specification change or use of different part.

A summary of the results of the parts analysis to approximately Jan 1959 were published as NAVSHIPS 93455. Analysis is continuing on high failure parts.

Antenna Applied Research (U), SR 008-03-9565. Naval Research Laboratory; NRL No. R09-02; M. Kales.

This project covers a basic study of radar frequency propagation characteristics of ferrite-loaded transmission lines. This information will be applied to a study of optimum material development as a supporting test.

This project should yield components and design data which would be applicable to R.F. components, of value to the radar and communication art. This would principally cover isolators, circulators, switches and phase shifters.

To date, work at NRL has resulted in a study of ferrite phase-shift characteristics which yielded improved materials for this purpose, and the

development of numerous microwave devices including the Y- or junction type circulator. NRL Report 5297 covers the development of a strip transmission line phase shifter for "S" band. In addition this group due to its unique position, acts as a consultant to this Bureau for antenna and associated microwave devices.

Capacitor Dielectric for Use as Capacitor Impregnants (U), SR 008-03-9566. Naval Research Laboratory; NE 110,000, ST 17.25, Prob. No. S-1877; Mr. J. B. Romans, Dr. C. R. Singletery.

This project covers the development of new dielectric liquids having higher dielectric constants and lower loss characteristics over a wider temperature range than materials presently available.

A study of the relation of molecular structure to dipole moment, dielectric constant and dielectric loss will provide the guidance for the synthesis of new materials.

Earlier work at NRL revealed the superiority of certain fluorine containing compounds as liquid dielectrics. On the basis of the generalizations obtained, specific candidate materials will be synthesized and their characteristics determined. The most promising materials will be further evaluated by studying the operating characteristics and life expectancy of capacitors impregnated with these compounds.

New liquids having dielectric constants as high as 10 have been prepared. The behavior of the new dielectric liquids in the presence of gamma radiation has been studied. Results indicate that the fluorine-substituted compounds studied offer no advantages over pentachlorodiphenyl in this respect. An impregnant is being prepared to use and test in type CP05 capacitors.

Ferrite Power Limiter (U), SR 008-03-9567. Hughes Aircraft Company; NObsr 77605; T. S. Hartwick.

Initial experiments with ferrite devices demonstrated that ferrite loaded waveguide and coaxial devices exhibited a nonlinear characteristics with power above a threshold level. The threshold levels and altenuation vs power characteristics were interesting enough to warrant investigation of these devices for possible application as protective elements for receivers or to control elements for receivers or to control the output of BWO.

As a result of progress to date and based upon an up-to-date knowledge of the non linear properties of ferrite material it is now possible to predict the threshold level of and the leakage spike thru the ferrite. It has been established that simple ferrite limiters are suitable for receiver protection in normal high power systems. However, in application where the power levels are low or where the decay time of TR tubes is excessive, ferrite limiters do have application. It has also been established that the reaction time of a secondary limiter using diodes is short enough to induce the leakage spike to a usable level.

Work is continuing on the diode secondary limiter characteristics

Design and Development of Magnetostructive Delay Line for I.F.F. (U), SR 008-03-9568. Ferranti Electric Incorporated; NObsr 77545; Mr. W. Harwood.

A method of providing finely spaced tops has been devised which can easily be contained in the 1x1x10 space.

Development of low loss transducers and thermally insensitive delay media and testing of same.

Multi-coaxial Cable Connector (U), SR 008-03-9572. Amphenol Borg Electronics; NObsr 81119 (FBM).

The objective of this program is the development of a series of RF connectors suitable for use with coaxial cable RG-264/U (multi-coaxial cable).

The contractor proposes to employ techniques used in other AN connectors to provide the desired connectors.

New contact arrangements will be devised for use with, if possible, existing shells or bodies. Each design will be assembled to a length of cable and evaluated in accordance with established specification requirements.

A series of connectors for a multi-coaxial cable have been developed. These connectors are now being phased into submarine electronic systems.

Magnetic Testing Laboratory (U), SR 008-03-9573. National Bureau of Standards, Boulder, Colorado; 1700-R-646-59; J. R. Dalke.

To establish a facility for the development of standard test methods for ferromagnetic materials, which will enable test results from varied organizations to be correlated.

The test methods will be developed in cooperation with the various industrial organizations, trade associations and technical societies. NBS will assemble the necessary equipment and conduct the necessary tests to check out the methods.

NBS is in the process of fabricating and assembling various pieces of test equipment which will cover the frequency spectrum from DC to 15000 MC. Test methods for determination of static properties, reversible magnetostriction, temperature coefficient of permeability, total loss and complex initial permeability are under development. Preliminary design of a torque magnetometer underway. Improvement of the quasistatic by-steresisloapplotter is continuing. The accuracy of the permittemeters and measurement of tensor permeability at S band is being determined. An L band cavity for determining tensors of permeability is being constructed.

High Cap Range Trimmer and/or Tuning Cap (U), SR 008-03-9574. Contractor, Contract, and Principal Investigator not assigned.

This project will cover the development of high capacity range trimmer and/or a tuning capacitor. The development will consist of two phases, one concerned with glass as the dielectric, the other phase concerned with quartz as the dielectric.

This will be based upon the use of glass or quartz as the dielectric material in order to accomplish the task requirement (i.e., high temp operation, high Q, high capacity to volume ratio, improved temperature coefficient, and improved stability).

Based upon the techniques evolved for the existing trimmer capacitors an investigation will be made as to the feasibility of reducing the wall thickness of the dielectric by new methods of construction to

increase the capacitance per unit volume.

Development of Miniature Trimmer Cap with Adjustable T.C. (U), SR 008-03-9575. Radio Condenser Company; NObsr 81173; E. J. Caron.

This project covers the design and development of a series of high temperature, t.c. trimmer capacitors with the t.c. variable between 2000 to +2000 ppm/oc.

This will be based upon the use of glass or quartz as the dielectric material in order to accomplish the task requirements (i.e., high temp operation, high Q, high capacity to volume ratio, improved temperature coefficient, improved stability and retraceability).

Several approaches have been evaluated. All the approaches include the use of a limited sensing element to perform the desired function. Both spiral and contilever action of the limited were involved.

Several samples have been constructed to evaluate the construction. Fringe capacity effects must be reduced.

Infinite Resolution, Long Life, Wirewound Precision Potent Potentiometer (U), SR 008-03-9576. Contractor not assigned.

This project covers the development of a linear function wirewound, precision potentiometer of long life (several million rotations), low noise and infinite resolution. Existing requirements in radar and display equipment require that low noise components of this type be developed.

A mechanical design will be utilized which permits the contract assembly to slide along the length of resistance wire rather than across windings on a card or mandril.

The mechanical design feature provides a potentiometer resolution which is equal to the resolution of the wire, and is essentially infinite. This feature should greatly reduce contact noise between the contract and the resistance wire, as well as wear on the wire (since stress will be uniform and continuous).

Capacitors Based Upon Thin Films of Barium-Strontium-Titanate (U), SR 008-03-9577. Philco Corporation, Research Division; NObsr 81203; Dr. B. Nicholson.

This project covers the feasibility of vacuum deposition of single crystal barium-strontium-titanate dielectric films in forms suitable for use as capacitors. A study will also be made of the properties of different compositions within the system $BaTcO_3$ - $SrTcO_3$ and of other mixed oxide systems which exhibit feroelectric paraelectric transitions with a change of composition.

This will be based on the deposition of a thin film onto metal, glass, or ceramic substrate.

Vacuum deposition barium-strontium-titanate films will be appraised (by means of X-ray or electron diffraction methods, optional studies, chemical analysis, and permittivity/temperature measurements), the compositional control homogeneity and texture of the films produced. Special emphasis will be placed on thickness and on reproducibility of textural characteristics.

Techniques and apparatus were developed for the vacuum deposition work and with the measurement of the properties of film specimens, eleven films were prepared on tantalum substrates. The crystalline structure of these films are not yet positively determined. Experiments were made to determine the effect of anodization of film properties.

Single Crystal Garnets (U), SR 008-03-9578. Texas Instruments, Incorporated; NObsr 77571; T. Ramsey.

Develop techniques to produce high purity single crystal rare earth garnets of suitable size to be used in phase shifting at the UGF, S and X band frequencies. Single crystals (due to reproducibility) are required for device applications.

The ability of various rare earth garnets to shift the phase of microwave energy propagated through it.

A variation of the floating zone techniques for producing single crystals will be used. The variation does not use a seed crystal. The heat is applied by R.F. energy which is coupled to a susceptor and not directly coupled to the polycrystalline garnet rod.

Yttrium iron garnet single crystals of 3/8" in diameter and 3/8" long have been produced. Also single crystals of the following rare earth garnets have been grown, SmIG, GdIG and ErIG.

UHF and "S" Band Ferrites (U), SR 008-03-9580. Motorola Incorporated; NObsr 77618; D. Fresh.

Development of ferrite materials suitable for reciprocal phase shifters which operate at frequencies of 200-400 MCS and 3000 MCS. The materials will be required to fabricate devices for use in "UHF" and "L" band now being considered.

The ability of a ferrite material to shift the phase of microwave energy that is propagated through it.

Investigate, fabricate and evaluate ferrite materials of the following systems: yttrium iron-gadolinium iron garnet aluminates, yttrium iron garnet aluminate and nickel-cobalt-manganese ferrite aluminate.

High power measurements at 3.00 MC indicate the yttrium iron garnet aluminates are non-linear with a threshold value of less than 10KW. The following ferrite system is being investigated (LiFe) $1-\frac{a}{2}$ Ti $1-A\ O_4$, $NiFe_2$ - X Al X O_4, $LiFe_{2,5}$ AlXO4. No material has been developed that shows any appreciable improvement over magnesium manganese ferrite aluminate at 300 MC.

Low Frequency Broadband Ferrite Devices (U), SR 008-03-9581. Electronics Communication, Incorporated; NObsr 77602; G. Bauhler.

This program covers the investigation of various techniques for the design of ferrite devices which exhibit suitable, broadband low frequency characteristics.

The contractor is to investigate the effect of loading various forms of transmission lines with major emphasis on the four wire or polyphase wire configuration which when ferrite loaded exhibits a certain amount of rotation of the propagated wave.

Various materials, form factors and transmission line configurations will be employed in the evaluation of components across a frequency band of 100 to 1500 mc/sec.

Tests have shown that large field rotation is not possible at frequencies below 600 mc/sec in a four-wire system. Reasonable results have been obtained at low frequencies (100-500 mc) with strip line isolators.

Basic design criteria in the form of curves have been developed which permit the design of stripline broadband circulators in the frequency of 150 to 900 MC without extensive experimentation. It has been established that at very low frequencies, i.e., 150MC, a three port device provide greater isolation than a standard two part isolator.

L and S-Band Phase Shifters (U), SR 008-03-9583. Western Electric Company (Bell Telephone Laboratory); NObsr 77570; W. Von Aulock.

Develop a reciprical phase shifter for operation at "L" and "S" Band in a fixed scanning antenna array. The phase shifter should be capable of operation without requiring a controlled temperature environment. The requirements for such systems as the SPS-33 have been incorporated into this development.

The ability of a ferrite to shift the phase of microwave energy propagated through it and thereby making it possible to fabricate an electronically scanning fixed antenna array suitable for a variable frequency radar.

The newer ferrite material will be evaluated in various phase shifter configuration. Techniques for magnetic temperature compensation will be investigated. Methods for reducing the size and power requirements will be investigated.

A coaxial "S" band phase shifter has been developed and the prototype model has been fabricated and will be submitted approximately 1 January 1961 for Bureau evaluation.

Low Frequency Microwave Ferrite Application (U), SR 008-03-9584. Chu Associates; NObsr 72586, NObsr 81386; I. M. Faigen.

The objective of this program is an investigation of the feasibility of using ferrite devices at UHF frequencies and experimental verification of the findings. This requires the development and fabrication of laboratory models of the necessary hardware items.

The effect of waves propagated through a section of ferrite loaded transmission line which has been magnetized either transversely or longitudinally.

Using a standard test setup which is suitable for rapid sample changes, a large number of test samples will be evaluated. The microwave properties of these ferrite samples at UHF frequencies will be tabulated and used as a guide in the selection of suitable material for component design.

The feasibility of using ferrites at UHF frequencies has been demonstrated and the construction of an initial reciprocal phase shifter has been completed. The nature of the contract has been changed from a feasibility program to a hardware program. A multi-mode stripline phase shifter has been constructed. Studies are underway to investigate the power handling capabilities and thermal stability of the model.

High Stability Variable Capacitor (U), SR 008-03-9585. Radio Condenser Corporation; NObsr 72751; Mr. E. J. Caron.

This project covers the design and development of twelve (12) capacitors impervious to microphonics when used with oscillator and amplifier circuits that are subjected to mechanical vibration. A second phase requires a reduction in physical size and temperature coefficient while withstanding the same microphonics.

This project will depend upon the determination of the mechanical stresses involved and methods to prevent or minimize them.

Plate spring, plate thickness, plate diameter and material will all be investigated to determine the optimum selection for accomplishment of this project. A judicious selection of materials and mechanical configurations are required for this work.

The capacitor for Phase I have been developed with a maximum frequency deviation of 600 to 700 cycles. The Phase II effort is directed to fabrication of a preliminary version of a 4 gang capacitor. By plate shaping the compensating plate and serrating it, a resulting overall low TC is anticipated over most of the tuning range.

Development of Advanced Components for Microwave Scanning Techniques "L" Band (U), SR 008-03-9586. Hughes Aircraft Company; NObsr 81378.

This project is for the development of bi-stable (digital operation) techniques to coaxial and stripline phase shifting devices for use at "L" band frequencies. Increased speed, reduced average switch power and increased reliability are the objectives of this technique as applied to scanning devices for use at this frequency.

The magnetic remembrance in square loop magnetic ferrite materials.

Square loop magnetic ferrite will be used to complete the magnetic circuit which includes the microwave ferrite. Pulse power is applied to the coil on the square loop material and the magnetic remembrance of this material supplies the magnetic field required to vary the phase shift in the microwave ferrite.

High Power Solid State Duplexer Limiter (U), SR 008-03-9587. Motorola; NObsr 81244; N. Sakiotes.

This program covers the study of techniques and the design and development of a high power, L Band, solid state duplexer-limiter.

The effect of ferrite loading on the electric and magnetic fields within a transmission line which have been discussed in many papers will be the major area of consideration in this program insofar as the duplexer is concerned. The non linear properties of ferrite under high power will be used in the development of the limiter.

The program will entail the investigation of various types of circulators, i.e. field displacement coaxial line types, four wire types and strip line differential phase shift types; to determine which is most suitable for use as a high power compact duplexer. Limiting attenuators or limiting couplers will be considered for the passive limiter.

Mechanical Scanning Device for Fixed Antenna Arrays (U), SR 008-03-9588. Scanwell Incorporated; NObsr 81265; C. Watts.

This project covers exploration of electro-

mechanical phase shifting methods for scanning fixed antenna arrays.

It is expected that this project will result in a mechanical phase shifter capable of shifting phase (over 360° range) within one millisecond. Such a device would prevent complete dependency upon ferrite devices for phase shifting. The obvious advantage of a mechanical phase shifter is that power, frequency and temperature characteristics which limit ferrite device performance will not be inherent.

It is expected that this project will utilize a foreshortened coaxial element as the principle delay element. The element would be such that the inner conductor would be capable of being mechanically displaced within the fixed outer conductor; such displacement being accomplished by electromechanical means. External fins on the inner conductor and internal fins on the outer conductor serve as the necessary delay parameters.

All mathematical calculations necessary to prove feasibility and to establish the design parameters have been completed. The first prototype for evaluation purposes is being constructed.

Solid State Ceramic Transformer (U), SR 008-03-9590. General Electric HMEF, Syracuse, New York; NObsr 81369; Dr. S. W. Tehon.

This project will provide the necessary research and development to develop ferroelectric ceramic power transformers, having a power density of approximately ten (10) watts per cubic inch, for general use in Navy electronic equipment.

The piezoelectric properties of ceramic and glass will be investigated and used to develop a line of power transformers. Such characteristics of the material in transformer configuration as efficiency with frequency power density and range of temperature operation will be evaluated. The frequencies of 10, 40 and 100 KC at input voltages of 10-150 and with output voltage of 100-1000 at output power levels of 2 to 20 watts will be investigated.

Sample transformers will be constructed and evaluated. Each of the above parameters will be related to the material properties to enable optimum transformer design.

The contract is in its second quarter. Thus far about 16 ceramic compositions have been evaluated. The low power level evaluation has been interpreted and the higher power level units are being fabricated.

Design and Development of an Automatic RF Connector Test Set (U), SR 008-03-9591. Polytechnic Research and Development Company, Incorporated; NObsr 81373; Mr. L. Nadler.

In order to reduce the cost while raising the quality of RF connectors it is necessary to produce performance specifications for connectors instead of the design specifications now in existence. A rapid and inexpensive means of measuring VSWR is necessary before such a performance specification can become operational. This task proposes to supply this means in the form of a test set.

An RF bridge has been developed which will provide measurement of reflection coefficient over a wide frequency range.

Testing of test set and providing matches coaxial terminations and loads for connectors series to be tested.

Development of Min. Blower (U), SR 008-03-9592. IMC Magnetics Corporation; NObsr 81526; Mr. A. H. Mankin.

This project covers the design and development of a cooling device capable of delivering 50 CFM at a static pressure of .5 in water when the input frequency is varied from 50 CPS to 400 CPS to meet requirements of RF synthesizer C-464.

An attempt will be made at more efficient motor (miniature) design with a minimum of slipping of the synchronous field and temperature rise at 400 CPS. Consideration also will be given to switching of the number of field poles.

It is expected that this project will perfect the design of the two pole induction motor and reduce the slip at 400 CPS. The temperature rise shall be kept at a minimum in order to achieve 10,000 hours life.

The double cage motor is being investigated. To date, a sample model is being fabricated for test and evaluation. Tests have been run on the R.F. synthesizer, O-464, to determine the necessary requirements.

Non-Ferrite Techniques for Phase Shifters (U), SR 008-03-9594. Microwave Associates; NObsr 81470; Dr. L. Gould.

To investigate new and novel techniques of phase shifting without using ferrite materials or solely mechanical techniques. Such investigation for projected systems is required.

This program will encompass a detail study of various phase shifting techniques such as delay lines, diodes, slow wave structures etc., which show promise of substantially advancing the electrical scanning art. Recent advances in the application of diodes in waveguide structures requires investigation concerning optimum configuration, proper handling capabilities, etc.

Studies have been conducted on diodes to determine the optimum circuit configuration and the effect of Bias and High Power on diode characteristics.

Work will continue in the present direction to establish the most suitable configuration for a diode shifter and to determine the ultimate limits of operation.

Springless Longlife Polarized Relay (U), SR 008-03-9595. Space Components, Incorporated; NObsr 81446.

Develop a miniature polarized sensitive relay without the use of armature or contact springs. Repeated failures of existing relays (contact spring failures) has established need for long life relay.

Study of the application of flux-piping and magnefloat contact principle to relay design.

Investigate various configurations to give the most efficient, trouble-free operation consistent with minimum size. Determine the operating range of the chosen configuration in order to compare with the required operating range of a specific type of polarized relay. Develop polarized, sensitive relay and determine compliance with requirements of the contract.

Evaluation of Printed Conductors (U), SR 008-03-9596. Material Laboratory, NYNS; Lab Proj. 5315; W. Hand.

Determine the reliability of various printed wiring terminations (eyelets; plated thru and others) used for terminating component leads and terminals.

Determine the electrical continuity of a test pattern including eyelets, after repeated soldering and unsoldering of leads inserted in the eyelets and thermal cycling. Determine the strength of the lead-eyelet termination, the eyelet foil bond and foil-laminate band after repeated soldering and unsoldering of leads inserted in the eyelets.

The evaluation is complete and based on the results fullel flanged eyelets are considered a suitable interfarial connection on epoxy glass boards but a questionable connection on paper phioolic boards if the boards must withstand thermal cycling.

Serpentine Waveguide Fabrication Techniques (U), SR 008-03-9597. Contractor not assigned; 691B2-19115.

The objective of this program is the investigation of techniques and materials which will result in a substantial reduction in the weight of waveguide runs.

It is expected that this program will result in a material and fabrication technique which will be used in the manufacture of serpentine waveguide runs which are substantially lighter than types using standard metal guides.

This program will entail the study of materials such as plastic waveguide metal clad plastic waveguide, and various clad foams. It will also involve studies on fabrication techniques which show promise.

Resistive Devices (U), SR 008-03-9598. Contractor not assigned; P.R. 691B2-19114.

A continued review and evaluation is required for resistive type devices and techniques which will fulfill the present and future requirements dictated by Naval electronic equipment. The devices must be capable of providing the required stability and operating life, in a volume to resistance configuration satisfactory for the specific application. Consideration will be given but not limited to such technologies as film, single crystals etc. in addition to the standard types of construction e.g., metal film, wire, carbon slug and carbon film. Methods of sealing, extreme conditions or range of heat, vibration, shelf life, moisture and stability will be considered. Coverage is the voltage range from 1/100 watt to 150 watts as well frequency range coverage from D.C. to 10mc/sec.

Inductive Devices (U), SR 008-03-9599. Westinghouse, NObsr 77578; Contractor not assigned, P.R. 691B-19191.

A continual review and evaluation is required for inductive type devices and techniques which will fulfill the present and future requirements dictated by Naval electronic equipment. The devices must be capable of providing the required stability and operating life in a volume to function (e.g., inductive, impedance transformation, suming, differentiating etc.) satisfactory for the specific application. Consideration will be given but not limited to such technologies as film, single crystal (for piezoelectric filters and transformers) in addition to the standard metallic and air cored types of construction. Methods of sealing extreme conditions of range of temperature, shelf life, moisture and stability will be considered. Transformers in the KVA range from 0 to 20 and with a frequency range from 55 to 2 KC/sec (power) and 50 mc/sec (I.F. A.F etc.) will be considered.

Capacitive Parts (U), SR 008-03-9600. Philco, NObsr 72770; Dr. Maurice Francombe; Contractor not assigned, P.R. 691B2-19160.

Satisfactory electronic equipment operation is dependent on the fullest characterization of the electronic parts. A continued review and evaluation is required for capacitive type devices and techniques which will fulfill the present and future requirements dictated by Naval electronic equipment. The devices must be capable of providing the required stability and operation life, in a volume to capacitance configuration satisfactory for the specific application. Consideration will be given but not limited to such technologies as organic, inorganic film, single crystals etc. in addition to the standard dielectric materials e.g., organic films (paper, paper plastic, plastic - teflon mylar, polystylene etc.) inorganic (oxides, single crystal ceramic etc.) methods of sealing, extreme conditions or range of temperature, vibration, shelf life and life, moisture and stability shall be considered. Capacitors in the voltage range from 0 to 50KV with capacitance values from 0 to 1,000 mfj in rolled, stacked etc. structures, capable of operating over the frequency range from D.C. to 10 mc/sec will be included.

Reliability of Electronic Parts (U), SR 008-03-9601. Material Laboratory, NYK; 4960-F-100; Mr. H. Strsbel.

Satisfactory electronic equipment operation is dependent on the fullest characterization of electronic parts as well as careful application. The existing electronic part specification do not have a quantative measure of life equated against a set of known conditions (failure rate in percent per 1000 hr for a specified life test). To establish this measure of acceptable reliability level will require considerable investigation and test. Continued investigation of failed electronic parts will be required to assure proper coverage and direction.

A detailed study is being made to determine whether MIL-STD-242 parts should be dealt with, or whether a specific line of parts (separate specifications) should be developed with specified failure rates. An investigation will be made to determine the feasibility of developing a method for establishing failure rate with a short life test time and small sample size.

Miniature Transmission Lines (U), SR 008-03-9602. Contractor not assigned.

The objective of this program is the investigation and development of new and novel means of propagating electromagnetic energy which are suitable for and commensurate with the requirements of advanced systems. Special emphasis will be placed upon size reduction (at a specified frequency).

This program will of necessity entail the development of a new technique(s) or the combination of existing techniques to achieve the goals of the program. At present every known mode of transmission has inherent short comings which must be overcome before said system may be used. These initiations included but are not limited to power handling capability, loss, size, weight, field radiation and cost.

Evaluate Miniature and Selected Parts (U), SR 008-03-9603. Contractor not assigned, P.R. 691B-19124; Material Laboratory, 691B2A-788.

Selected (usually miniature) parts will be used as prototypes to determine where development is required. In addition, surveys and evaluations will be made from time to time, to ascertain what specific developments are required. These developments will be carried on under the task for the specific type of device. An example of such a survey is NAVSHIPS #93440 which has recently been published on miniature parts, and is now being used as a basis of an evaluation program on these small parts.

Very High Power R.F. Components (U), SR 008-03-9604. 691B2-19166, 691B2-19165, 691B2-19220; Dr. Gould, Dr. Oliver.

Continuing difficulties encountered with high power (peak power levels of 3-5 megawatts) radar systems in the "UHF", "L" and "S" band region have made it necessary to continue the investigation and development of very high power transmission line components. An effort is being made to obtain a more thorough understanding of this breakdown mechanism in a transmission line when a high energy pulsed wave is transmitted - concurrent with the above, the state of art of high power tube development has progressed at such a rate that tubes with peak power outputs of 15 megawatts (average power of 45KW) at "S" band (approximately 3 KMC/mc) and band widths of 10% minimum will be available within 1 to 2 years. Power sources for super powers of 20 MWPK and 12 KWAV, at 30 MWPK and 20 KWAV and at 50 MWPK and 1000 KWAV are either under development or being considered.

Magnetic Logic Elements (U), SR 008-03-9605. Contractor not assigned.

Development of magnetic logic elements which will be suitable for computer applications. The elements should switch rapidly (50 megacycles or faster).

The ability to transfer information by magnetic paths. Exploitation of the phenomenon would eliminate wired coupling loops and numerous connections which are a high failure rate item in computers.

The multiaperture and the thin film approaches will be investigation of the use of long strips of magnetic material with numerous molded apertures.

Foamed Tantalum Capacitor (U), SR 008-03-9606. Contractor not assigned, P.R. 691B2-19160.

This project covers the development of a solid electrolytic capacitor with high orders of capacitance and low leakage currents. This capacitor would have a very high capacitance to volume ratio (reduction in size from 25 to 60% over existing types). Another phase covers the development of a 100V solid tantalum capacitor utilizing existing technology.

Foamed tantalum. Refinement of the existing technique is required to produce a high purity foamed material. In addition, development will be required to determine and control pore size of the material as well as the development of a technique of electrolyte introduction.

Foamed tantalum will result in a material with a large surface area compared to wire or foil tantalum. The foamed tantalum would be formed in the best manner to result in a small leakage current. (Probably a combination of the thermal and the anodic oxide formation process.)

Study of Non-Film Resistive Techniques (U), SR 008-03-9607. Contractor not assigned, W.O. 691B2-19161.

This project covers the study of techniques which may be utilized to produce non-film resistors. Presently available techniques such as wire, carbon or films are not being considered in this project. Present film types exhibit failures when subjected to a transient voltage pulse, e.g., tube failure.

The possibility of using silicon germanium, etc., as a resistor (elimination of spiral and thin film) material to develop a rugged precision resistor will be explored.

Single crystals of solid-state materials will be investigated to determine their ability to function as a resistor device. Various methods and types of controlled impurities will be studied to determine their effectiveness to achieve a non-film resistor.

Study of New Transformer Techniques (U), SR 008-03-9608. Contractor, Contract, and Principal Investigator not assigned.

This project covers a study to determine new methods of impedance transformation. Present methods consist of lumped or distributed constants occupying considerable space. Methods to determine new techniques for summing, difference and impedance matching will be studied.

Various phenomonea including, but not limited to magnetic striction piezoelectric and ferroelectric will be studied to determine if these techniques can be employed in the development of miniature devices.

Strongly ferroelectric materials of barium titanate composition, lead titanate-lead zirconate solid solutions, and modifications of lead metaniobate will be fabricated and studied to determine their ability to perform the stated function. Other materials with the phenomonea listed under (2) will be treated in a similar manner.

Miniature Inductive Parts (U), SR 008-03-9609. W.O. 691B-19191.

This project covers the development of miniature inductive parts compatible for printed circuit use. Small inductors (high inductance to volume ratio) wire wound and deposited film types will be investigated.

A study of inductive films in the form of flat spirals and small wire sizes on high permeability torrodial cores will be undertaken to reevaluate form factor, inductance to volume ratio, production difficulties, etc.

A good conductor such as silver or aluminum

evaporated through a suitable mesh will result in a flat spiral or inductor. The film can be stacked to achieve higher inductance values than are attained in a single pattern. A ten-term spiral of 0.21 inches diameter can result in an inductance of 0.786 microhenries. Inductors will be fabricated and evaluated to determine optimum inductance to volume ratio, production difficulties, form factor, etc. Also, investigation will be made to see if core material (ferrite) increased in can be accomplished.

Miniature High Range Resistor (U), SR 008-03-9610. Contractor to be assigned; P.R. 691B2-19114; Principal Investigator to be assigned.

This project covers the development of stable miniature high resistance range resistors with low values of temperature coefficient. The configuration (cubic) will be suitable for high density packaging on printed boards.

Thin films deposited and stacked to give maximum resistance per unit volume. Technique will involve the development of a technique where the film pattern will be deposited in such a way as to eliminate the need for spiralling.

Suitable resistive filing will be deposited and stacked to produce a monolithic-type structure. Since the films are extremely thin, many layers can be built up and deposited in such a manner as to make internal connections resulting in large values of resistance per unit volume. Development of a suitable film with precision parameters (i.e., t.o., tolerance, stability, etc.) will be attempted. Existing film technology will be employed and modified as required.

Miniature Electromechanical Devices (U), SR 008-03-9611. Electrical Testing Laboratories Inc., NObsr 81586, R. S. Smith; Contractor unassigned (connector R&D), P.R. 19219; Contractor unassigned (Digital voltmeter), P.R. 19113.

Develop and evaluate miniature electromechanical devices such as switches, connectors, relays, circuit breakers, etc., which will be compatible with unitized equipment techniques.

Miniaturization in order to obtain a greater parts density, less weight and less volume.

(a) Evaluation of crimp, snap-in contact connectors to determine suitable high contact density connector.

(b) Development of crimp, snap-in control, edge board printed wiring connector which will have an increase density of contact while maintaining serviceability.

(c) On the digital voltmeter, the instantaneous field theory conversion of voltage to distance will be exploited.

Printed wiring and crimp snap-in contact techniques will be investigated in the development and evaluation of switches and connectors. A voltage to distance converts approach will be used in the digital voltmeter. A solid state approach will be investigated in the development of relay, circuit breakers, etc.

R. F. Component and Waveguide Evaluation (U), SR 008-03-9612. Material Laboratory; ST 9612; I. Birnbaum.

The basic objective of this program is the evaluation of all R. F. components, which are of specific interest to the Bureau of Ships from either a specification or application point of view. These components include components developed under Bureau R&D contracts and commercially available items.

Insofar as possible, standard test procedures will be used to evaluate the component in question. Where special test procedures are required they shall be in accordance with applicable specifications or shall be devised at the time the tests are conducted.

Low Frequency High Temperature Crystals (U), SR 008-03-9613. Bliley Electric Company, NObsr 72532, J. M. Wolfskill; Material Laboratory, Proj. No. 4960-40.3-4 Part 5, R. S. Cotton.

This project is to develop designs and techniques for crystal units capable of meeting the more stringent requirements inherent to modern compact equipment and to supersonic aircraft and missiles.

Prototype units developed on this project are being used to establish practical temperature and frequency stability limits for high temperature application and to gain knowledge of the resistance to shock and vibration characteristics of such units.

Units designed for operation up to 125°C have been evaluated and a tentative specification prepared.

Temperature controlled type units for operation at 200°C and non-temperature controlled type for operation over the temperature range of -60° to +200°C have been delivered to Mat. Lab for evaluation and to determine realistic limits of the state of the art. These units are in the frequency range of 80 KC to 500 KC.

Thermal Design of Assemblies (U), SR 008-03-9614. Pneumafil Corporation; NObsr 81377; E. Nagel.

Develop standard thermal design techniques applicable to modular plug-in assemblies. Provide efficient thermal paths to intermediate and final sinks, to transfer heat across connector. Provide reliable operation of standard assemblies in a variety of environments. Develop integrated thermal system for modular equipment, providing heat path from source to sink.

Thermal design mechanisms have been evaluated on an individual assembly-type basis. Such evaluation indicates need for standard techniques of thermal design applicable to modular assemblies operating under a variety of conditions. Under the current contract; thermal deficiencies of some existing assemblies have been investigated; a thermal test chamber for assemblies has been constructed.

Standard Functional Assemblies (U), SR 008-03-9615. Walter Kidde & Company, Inc.; NObsr 81323; Neil Diepeveen.

Determination of designs for general usage, functional assemblies. Complete physical and electrical descriptions for each assembly will be prepared so that procurement specifications can be written.

Assembly designs will be based on the use of new materials, parts and semi-conductor devices selected generally from the preferred lists.

The results of previous work (see "Progress") will be extended to include other functions, such as digital circuits or I.F. amplifiers. Improvements to functions already included will also be considered in terms of parts, materials, and packaging techniques. The results of Task 9622, (Reliability of Transistorized Assemblies) will be applied to improve the existing transistorized functional assemblies.

Power Supply Assemblies (U), SR 008-03-9616. Kin Tel division of COHU Electronics, NObsr 81132, Dr. P. Kofitz; Contractor not assigned, 691B-19192.

To further supplement the functional assembly program, designs for general usage low voltage transistorized power supply assemblies will be determined. Power supplies will be sectionalized into functional units such as power source, rectifier-filter, amplifier, regulator. Each unit will be packaged as an assembly and designed so that various groupings will fulfill the range of output voltages and currents required for transistorized equipment.

Prototype supplies, representative of the total family, will be constructed and packaged to meet environmental requirements and tested in accordance with MIL-E-22436.

Fault Location Techniques (U), SR 008-03-9617. National Bureau of Standards; 1700R-648-59; G. J. Rogers.

To develop simple fault location techniques and circuitry to permit equipment failures to be traced quickly and easily to the particular functional unit involved. The techniques will be based on unitized equipment construction.

Various approaches will be explored. Modifications to the general usage assemblies will be developed to provide a simple unequivocal measurement of assembly performance, using either internal fault monitoring devices or common types of external test equipment.

The 20 types of standard functional assemblies (designed under Nobsr 72538) will be studied to define for each function a single measurement which would indicate overall assembly performance. Such indication may be qualitative rather than quantitative. This group of standard assemblies includes amplifiers, mixers and oscillators, operating at audio, video, and radio frequencies; therefore, a variety of circuit techniques will be necessary.

Controlled Environment (U), SR 008-03-9618. General Electronics Labs., Inc.; NObsr 77546; William Grim.

Develop system for controlling immediate environment of shipboard electronic equipment thru use of fresh water supplied by shipboard central system. Also determine applicability of MIL-W-21965 (general water cooling spec.) for general shipboard electronic use. Study means for preventing water leaks, study heat-exchanger techniques and explore possibility of enhancement of electronic performance.

An equipment was chosen that was early in the design stages, so that a proper thermal design procedure could be applied. Original plans called for air cooling. This contract will result in a water-cooled version of AN/SLQ-4 (XN) countermeasures set.

Requirements of the water cooling spec. MIL-W-21965 have been applied to the design of the water cooled version of the AN/SLQ-4. The necessary heat-exchangers have been designed; parts layout is quite similar to the air cooled version.

Thermoelectric Techniques (U), SR 008-03-9620. Whirlpool Corporation, NObsr 77617, Art Martz; Texas Instruments, Inc., NObsr 81204, Ray Marlow.

This is a general project to apply thermoelectric cooling techniques to various electronic devices. Areas are sought where the characteristics of a thermoelectric cooler can be profitably applied. Thermoelectric techniques are developed to serve these applications.

Under NObsr 77617 a quartz crystal chamber was developed using thermoelectric cooling and heating. Internal temperature is maintained at $25^{\circ} \pm .5^{\circ}C$ as ambient varies from -30° to $85^{\circ}C$. This device is intended for use in frequency standards; further efforts are under SS294-001 Task 9215.

Under NObsr 81204 the use of thermoelectric cooling for transistors and diodes is being studied. This use is divided into three categories: (1) cold surface, where one or more conventional transistors are mounted on a thermoelectrically cooled surface; (2) internal cooling, where the thermoelectric cooler reaches inside the transistor case to extract heat from the junction where it is actually dissipated; (3) integral cooling similar to number 2 with the cooling device electrically in series with the diode to be cooled, thus using a common power supply. The first method will undergo initial development; the latter 2 methods will be investigated for applicability.

Cryogenic Application to Electronics (U), SR 008-03-9621. Contractor not assigned.

Study the feasibility of applying cryogenic techniques to general classes of shipboard electronic equipment and devices. Benefits from operating various parts and assemblies in a cryogenic environment will be sought. Problems of circuit functioning and fabrication will be studied, and techniques developed. Prototypes of parts and assemblies will be constructed; their operation studied.

Brief in-house survey has indicated that cryogenic state-of-art is premature for this effort. This project is planned for implementation when apparatus for producing cryogenic environment is smaller, less cumbersome, less expensive; and when ship-board system appears practical.

Reliability of Transistorized Assemblies (U), SR 008-03-9622. Vitro Laboratories, Inc.; NObsr 77531; F. M. Medley.

Determination of the primary design factors affecting the long-term performance of transistorized circuits, and development of design methods for long-life transistorized assemblies.

The stability and manufacturing variations of transistor parameters are recognized as limiting factors in reliable assembly design, but little information is available to correlate these factors with assembly performance. Various circuit design techniques, to compensate for the expected variations of parameters, will be studied.

Circuits will be selected from those designed

under NObsr 72538, and breadboard models will be constructed for aging tests. Actual performance will be compared to calculated performance, considering variations in part and transistor characteristics caused by aging, temperature changes, changes in operating point, and initial variations in production tolerances.

Repair of Unitized Equipment (U), SR 008-03-9623. Material Laboratory, New York Naval Shipyard; 1101-S-124; T. E. McDuffie.

To develop repair procedures for functional assemblies which will be compatible to shipboard repair facilities.

This study is based on the use of repairable replaceable functional assemblies. For each such assembly designed under NObsr 72538, test points will be located to permit isolation of equipment failure without additional circuitry. Also, for each assembly, repair procedures will be developed to permit isolation of the specific failed part after the assembly has been removed from the equipment and brought to the test bench for repair.

The video amplifier unit of the AN/SPS-28 radar equipment has been redesigned using seven assemblies (including three of the standard types developed under NObsr 72538). Each assembly will be provided with test points to facilitate measurement of performance. This equipment will be used as a model to study test points and monitoring devices.

Microcircuitry Techniques (U), SR 008-03-9624. Westinghouse Electric Corporation, Electronics Division, NObsr 81380, Dr. Gene Strull; Contractor not assigned, 691B3-19173.

To evaluate and develop new techniques of assembly construction for possible application to shipboard assemblies. Recent developments in assembly techniques offer potential savings in size and cost of shipboard equipment.

Complete functional assemblies will be fabricated within single blocks of Silicon if feasible. Under some circumstances it is more reasonable to break the functions into more than one block or to use film deposition for certain elements. Therefore, a hybrid technique may evolve for certain electronic functions.

Three specific amplifier assemblies have been selected as the basis for the initial phase of this project. These amplifiers are required in large quantity and in a restricted space for use with two types of electroluminescent display systems. Major problem areas are expected to be in interconnections, voltage gradients, and temperature rise, because of the relatively large power and voltages required.

Equipment Application of Peltier Cooling (U), SR 008-03-9627. Contractor not assigned.

Investigate means of improving operating characteristics of shipboard electronic equipment thru cooling of specific parts of assemblies. Thermoelectric techniques will be used for spot and small area cooling. It is felt that certain parts may operate with a lower noise figure, thus suggesting possibilities of better signal-to-noise ratios in receiver front-ends (for example) by reducing temperatures of certain parts by orders of 25 to 100°C below usual operating temperatures. Beneficial areas in equipment will be sought; techniques for cooling by thermoelectric devices will be developed. Representative equipment to demonstrate improvement in performance will be constructed (or modified).

Preliminary technical discussions on probable areas for improvement have been held. Preliminary investigations were carried on at USNUSL--results are pending.

High Dissipation Water Cooling (U), SR 008-03-9628. Contractor not assigned (Commercial).

Develop most advantageous methods of water cooling high powered electronic equipment. It is considered that shipboard electronic systems dissipating (in the order of) 100 KW and more will present special problems of heat removal to maintain reliable and efficient operation. Such problems will be sought, studied, and methods developed for transferring heat to the shipboard central water system which provides fresh water at 35°C for cooling purposes. The general water cooling spec. MIL-W-21965 will be applied and revised as necessary to provide for the special high dissipation techniques.

It is planned to implement this project after some initial experience is gained with shipboard operation of high power equipment.

Development of Radiac Parts (U), SR 008-03-9630. Contractor, Contract and Principal Investigator not assigned.

This project covers the development of components specifically intended for application in radiac equipments, where the small size, low current and high voltage are the prime considerations.

Depends upon the specific application. In general the requirements evolved during the equipment development or deficiencies uncovered during field usage will be used as the basis "to characterize" the component to be developed. This technique has previously been used to develop capacitors, roentgen rate meter, etc.

Microelectronic Assembly Techniques (U), SR 008-03-9631. Trionics, Inc.; NObsr 85160; Mr. T. Newkirk.

Provide suitable assembly techniques for the construction of microelectronic shipboard systems.

Recent effort has done much to perfect methods of fabricating electronic systems that are more reliable, smaller and lighter than conventional systems. Three general approaches, have evolved, all based on the use of solid-state devices as the active elements: (1) repackage parts as economically as possible from the space and weight viewpoint, (2) fabricate all parts as thin films, (3) utilize the active element material for the passive functions.

The Bureau of Ships Panel on Microelectronics recommended supporting a moderate program contributing both to short-range hybrid schemes and longer-range methods based primarily on semiconductor technology. Further the Panel recommended supporting techniques not being sufficiently exploited, novel and promising approaches to current techniques, and selected groups with unusual talent but inadequate support working in more conventional areas.

Microelectronics Research (U), SR 008-03-9632. Navy Electronics Laboratory; 170/RDT&EN; Mr. Walter Mitchel (Code 2840).

Evaluation of present and future microelectronic techniques to determine:

(a) Limitations and potential capabilities compared to conventional techniques.

(b) Requirements for redesign or new design to realize the full potential of the techniques.

(c) Operating problems-such as reliability, maintdinability, heat dissipation, etc.

(d) Cost and payoffs expected from the use of microelectronics.

Evaluate the use of microelectronic techniques for the design and construction of future shipboard electronic equipment.

(a) Determine what types of equipments are capable of being microminiaturized in total or in part.

(b) Quantitatively determine what equipments offer the greatest economic advantages when such factors as improved mission capability, maintenance, logistics, procurement are considered.

Provide technical support for the Bureau of Ships and the Navy Electronics Laboratory in the general field of microelectronics.

Electro-Mechanical Devices (U), SR 008-03-9633. Contractor not assigned.

A continued review and evaluation is required for electromechanical type devices and techniques which will fulfill the present and future requirements dictated by Naval Electronic equipment. The devices must be capable of providing the required stability and operating life in a volume to function (e.g., indicating, switching, connecting; rotating, etc.) satisfactory for the specific application. Consideration will be given but not limited to such technologies as film (for indicating instruments) metals (connections) organics and inorganic materials for (motors and insulators). Methods of sealing, extreme conditions of range of temperature, shelf life, moisture and stability, will be considered. The following parts within the characteristic ranges specified will be covered.

(a) Blower motors (60 and 400 cy with h.p. rating from 1/10 to 1/2).

(b) Indicating instruments (for D.C., 60,400 cy as well as high frequency; lapsed time inductors.

(c) Strain Insulators (all sizes, consisting of organic and inorganic material).

(d) Relays (all types, including choppers).

(e) Connectors (all types, e.g., AN, tube sockets, compersion, etc.).

(f) Switches (all types).

(g) Miscellaneous (small pieces, e.g., tube chips, etc.).

Microelectronic Techniques (U), SR 008-03-9635. New York Naval Shipyard (Material Laboratory).

The possibility of using microelectronic systems on ships is fast becoming a reality. However the acceptance of microelectronic systems will bring forth many new problems. For example, the ability to predict reliability in military equipment is based on many year's experience with parts; much of this data will not be valid when systems are fabricated from thin films or in semiconductor materials. Repair and maintenance procedures will have to be modified because of the physical size of microelectronic assemblies; data regarding support of replaceable items will have to be developed, failure analysis will require new knowledge and approaches, new concepts of packaging will have to be developed. The military is becoming accustomed to having these data available on new equipments, lack of such data will not be tolerated since performance requirements are more stringent than ever. It is imperative that as much of these data as possible be accumulated before widespread use of microelectronic systems is a fact.

Microelectronic Parts (U), SR 008-03-9636. Contractor not assigned.

This project covers the research, development and necessary investigation of existing and developed technologies to provide the required functional elements for Naval electronic equipment. These microelectronic parts may consist of a simple or complex function although the completed unit would be a complete entity for circuit use, e.g., resistor, capacitor, etc.

Parametric Amplifiers (U), SR 008-03-9726. Contractor, Contract and Principal Investigator not assigned.

Extraordinary demands are now being placed on systems for guidance, reconnaissance, communications and space exploration. Range of performance is an important element. Range and resolution can be enhanced by increasing the transmitted power or by using more effectively the low level reflected or transmitted signal received from transmitters of present power levels. The outstanding requirement of amplifiers used to amplify the lower level returned signal is that of a low noise factor. Depending on application, other parameters take on importance. Applications such as troposcatter communications, satellite communications and radio astronomy will emphasize some parameters while radar and navigational systems will emphasize others. However, all these categories of systems will place high priority on greater sensitivity of the receiver.

R008-04 Radio Astronomy and Astrophysical Studies

Radio Star Astronomy (U), RR 008-04-0002. University of Illinois, Urbana, Illinois, Astronomy Department; Nonr 1834(22), NR 370-163; G. C. McVittie.

The purpose of this task is to obtain accurate positions, flux densities, and information about the spectra of radio sources located outside our galaxy. These studies will be accomplished by use of a large fixed parabolic cylindrical antenna collector, which has sufficient amplitude gain and resolution to observe radiations coming from radio stars located far beyond the range attainable with optical telescopes.

Radio Stars (U), RR 008-04-0003. University of Manchester, Manchester, England, Jodrell Bank Experimental Station; N6 2558-2096, NR 370-220; A. C. B. Lovell.

The task is to measure the occurrence, intensity and distribution of those radiations in the radio portion of the electromagnetic spectrum which emanate from sun, stars, and regions of extra-terrestrial space. Observation of these radiations,

which may be detected by suitable receiving antenna arrays connected to radiometer devices or microwave receivers, will yield much new information on characteristics of the ionosphere, in addition to an increased understanding of the nature of the universe.

Radio Interferometry (U), RR 008-04-0004. California Institute of Technology, Pasadena, California, Division of Radio Physics; Nonr 220(19), NR 370-265; J. G. Bolton.

The task is measuring the occurrence, intensity and distribution of those radiations in the radio portion of the electromagnetic spectrum which emanate from sun, stars and regions of extra-terrestrial space. Observations of these radiations, which may be detected by suitable receiving antenna arrays connected to radiometer devices or microwave receivers, will yield much new information on characteristics of the ionosphere, in addition to an increased understanding of the nature of the universe.

Solar Astronomy (U), RR 008-04-0005. Cornell University, Ithaca, New York, Electrical Engineering Department; Nonr 401(27), NR 370-321; T. Gold.

This task continues to study characteristics of the solar flux, as well as emissions from interesting sources, as the Crab Nebula. Polarization, intensity, burst characteristics and "solar winds" are studied at various frequencies of emission.

Radio Astronomy References (U), RR 008-04-0006. Cornell University, Ithaca, New York, Electrical Engineering Department; Nonr 401(22), NR 370-322; M. S. Carpenter.

This task concerned itself with the preparation of a bibliography in the field of world-wide radio astronomical research. It involved searching of the literature and the abstracting, classifying and indexing of references.

Solar Radio Astronomy (U), RR 008-04-0007. University of Michigan, Ann Arbor, Michigan, Astronomy Department; Nonr 1224(16), NR 370-390; F. Haddock.

The broad purpose of this task is to operate equipment to record the radio frequency spectrum of the sun and planets, and of galactic and extra-galactic radio sources over as wide a frequency range as possible. The emphasis is to be placed on the shorter wavelengths (about 3 centimeters). Observations are to be closely correlated with optical measurements made at the McMath-Hulbert Observatory.

Radio Star Astrophysics (U), RR 008-04-0008. University of California, Berkeley, California, Department of Astronomy; Nonr 222(66), NR 370-613; H. Weaver.

The purpose of this task in radio astrophysics is to study hydrogen and other gas concentrations around galactic stars, and to understand the role of these gases in stellar birth and evolution. These studies are accomplished by use of a large parabolic antenna collector and sensitive receivers of sufficient amplitude gain and resolution to observe radiations coming from excited gases and thermal sources in radio stars.

Galactic Astronomy (U), RR 008-04-0009. Carnegie Institution of Washington, Washington, D. C.; Nonr 3021(00), NR 370-620; M. A. Tuve.

The purpose of this task in radio astrophysics is to study hydrogen and other gas concentrations around galactic stars, and to understand the role of these gases in stellar birth and evolution. These studies are accomplished by use of a large parabolic antenna collector and sensitive receivers of sufficient gain and resolution to observe radiations coming from excited gases and thermal sources in radio stars.

Millimeter Wave Astronomy (U), RR 008-04-0010. University of California, Berkeley, California, Electrical Engineering Department; Nonr 222(54), NR 370-720; S. Silver.

This is a study of solar radiation in the millimeter wave region of the electromagnetic spectrum, including absorption effects of the earth's atmosphere, especially that caused by ozone layers in the higher regions.

R008-05 Antenna Theory and Information Theory

Solid State Electronics (U), RR 008-05-0001. Harvard University, Cambridge, Massachusetts, Division of Applied Science; Nonr 1866(16), NR 372-012, NR 375-000; H. Brooks.

The broad objectives of this task are:

(a) To conduct research in solid state and electron physics, including microwave and radio frequency spectroscopy of solids.

(b) To study certain aspects of communication theory and circuits, including microwave circuits and active circuits.

Columbia Radiation Laboratory (U), RR 008-05-0002. Columbia University, New York, New York, Physics Department; MIPR 8-60-ONR, NR 372-101, NR 375-000; P. Kusch.

This task is a coordinated effort to perform basic research in those fields of physical electronics which utilize techniques involving micro and millimeter waves. Complementing this effort, research is conducted on components required for generation, propagation and detection of those waves. Specifically, this task includes (1) fundamental research on (a) microwave spectroscopy of gases, (b) millimeter wave source such as Cerenkov radiation, molecular beam oscillators, and silicon harmonic generators, (c) paramagnetic resonance, (d) superconductivity, (e) properties of metastable stakes of hydrogen and helium; and (2) applied research in magnetrons to obtain millimeter wave magnetrons of improved power, tuning, lifetime and stability characteristics.

Basic Electronics Research (U), RR 008-05-0003. Stanford University, Stanford, California; Nonr 225 (24), NR 373-360, NR 375-000; W. R. Rambo, J. Linvill.

This task involves investigations in several areas of physical electronics as follows (a) microwave tubes and electron and ion devices, (b) solid state electronics (c) radio propagation studies, and (d) network and information theory.

In the case of microwave tubes and electron and ion devices, studies in low-noise microwave tubes, parametric amplifiers, crossed-field devices, electron beam research, and plasmas.

The work in solid state electronics includes research on (a) devices such as masers, and parametric diodes, (b) circuit studies in connection with transistors, and (c) studies of related phenomena, as diffusion in silicon, the Hall effect, avalanche effect in transistors, and noise.

Transistor Analysis (U), RR 008-05-0004. Harvard University, Cambridge, Massachusetts; Nonr 1866(40), NR 375-017; H. Brooks, J. Narud.

This task studied, by theory and experiment, electrical representations and circuit properties of non-linear circuit elements, as transistors, ferrite rotators, regenerative oscillators and diodes. Rules of similitude of various families of circuits which use the non-linear elements, were deduced, and equivalence in circuit description of the non-linear elements to combinations of vacuum tube parameters was established.

Research Laboratory of Electronics (U), RR 008-05-0005. Massachusetts Institute of Technology, Cambridge, Massachusetts, Electrical Engineering Department; MIPR 24-60-ONR, NR 375-042; J. B. Wiesner, P. Elias, R. M. Fano, H. J. Zimmerman.

This task has several major aims, namely, (a) to conduct investigations in modern electrical circuit theory and techniques and (b) to perform theoretical and experimental research in statistical communications theory and information theory applied to bio-processes and electro-neurology, as well as related fields.

Theoretical and experimental investigations of statistical methods in network analysis and synthesis, as well as information theory, are directed at improving circuit design methods and applications. This part of the task embraces research in human communications links, correlation methods in detection of signals in the presence of noise, transistor circuitry design and the use of ferrites in networks.

Nonlinear Electrodynamics (U), RR 008-05-0006. Polytechnic Institute of Brooklyn, Brooklyn, New York, Microwave Research Laboratory; MIPR 10-60-ONR, NR 375-214; N. Marcuvitz.

This task concerns itself with study and experiment in the properties of circuit elements which have non-linear characteristics. Such elements include iron-cored inductors, ferroelectronics, magnetic amplifiers, and a family of ferrite and gyrator devices.

Sea Reflections (U), RR 008-05-0008. Polytechnic Institute of Brooklyn, Brooklyn, New York, Microwave Research Institute; Nonr 839(28), NR 375-216; N. Marcuvitz.

This task is to study detection of disturbances at the surface of the sea, by measurements of reflected electromagnetic energy in the air above the sea. It involves not only the physical properties of the air-sea water interface, but also, capabilities of the instrumentation. This latter, in turn, may be analyzed by statistical methods in which disturbances associated with the sea surface may be correlated with cause for those disturbances.

Magnetic Amplifiers (U), RR 008-05-0009. Carnegie Institute of Technology, Pittsburg, Pennsylvania, Electrical Engineering Department; Nonr 760(09), NR 375-272; E. M. Williams.

This task is devoted mainly to study and experiment in the fields of magnetic amplifiers, semiconductor devices, cryogenic switching elements, and synthesis in electronic circuits. Analysis of magnetic amplifiers is being extended to include effects of feedbacks involving frequency dependent elements. Techniques previously developed under this task are being applied to analysis of more general "parametric" devices such as "parametric oscillator".

Noise Mechanisms (U), RR 008-05-0010. Stanford University, Stanford, California, Stanford Electronic Laboratories; Nonr 225(44), NR 375-865; J. Linvill, N. M. Abramson.

The development of new types of solid state devices, particularly parametric amplifiers, brings the need for a critical evaluation of noise-producing mechanisms in these devices, and a study of these mechanisms to learn methods for coping with undesired noises.

Microwave Antenna Basic Research (U), RR 008-05-5700. U. S. Naval Research Laboratory, Washington 25, D. C.; R08-37; R. M. Brown.

Perform research of theoretical and experimental nature to develop new and improved microwave antennas, antenna components, and antenna instrumentation. Develop new and improved methods, techniques, equipments and systems to support and further the research and development antenna program.

R008-99 Other Electronic Sciences

Low Frequency Generator (U), RR 008-99-0001. Ling Electronics, Inc., Culver City, California, Engineering Department; Nonr 2939(00), NR 374-410; J. A. Ross.

This task resulted in availability of an electromagnetic generator, which provides high peak power alternating current in the 200 to 500 cycles per second range, for use in driving sonar transducers or for conducting experiments in electromagnetic wave transmission and propagation.

R009 ENGINEERING MECHANICS

R009-01 Hydrodynamics

Hydrodynamics of Turbomachines (Fuel Pumps) (U), RR 009-01-0001. California Institute of Technology, Pasadena, California, Division of Engineering; Nonr 220(24), NR 062-010; A. J. Acosta.

This project is devoted to experimental and theoretical investigation of cavitating flows and cavitation processes such as occur in hydraulic rotating machinery, when the liquids handled are highly volatile (e.g., rocket fuels and cryogenic liquids) or when low pressures or high rotative speeds are required. Current interest centers on

two aspects of cavitation: the external fluid dynamics of the cavity-flow and its relationship to such variables as VANE geometry, etc.; and the internal processes that give rise to the region of cavitation and vapor formation.

Ship Motions in Waves (U), RR 009-01-0002. Stevens Institute of Technology, Hoboken, New Jersey, Davidson Laboratory; Nonr 263(10), NR 062-012; E. V. Lewis.

Analytical and experimental investigations are being conducted on ship motions in waves, in order to make possible the development of ships of superior seaworthiness. Current emphasis is on (a) further study of the analytical calculation of ship motions in regular waves with six degrees of freedom; (b) systematic studies of the effect of variations in hull characteristics on behavior in regular waves by the use of an analog computer; (c) theoretical investigation of ship motions in head seas, taking into account more completely the distortion of waves by the ship; and (d) specific investigation of particular problems or developments for improvements in ship form revealed during the course of the 1959-60 work. This will involve further work on hulls for sub- or super-cricital operation.

Supercavitating Flows (U), RR 009-01-0003. University of Minnesota, Minneapolis, Minnesota, St. Anthony Falls Hydraulic Laboratory; Nonr 710(24), NR 062-052; L. G. Straub.

Supercavitating flows are being investigated experimentally in a free-jet water tunnel capable of producing cavitating numbers approaching zero. Current emphasis is on (1) investigating the sound field associated with supercavitating flows involving both ventilated and nonventilated cavities; (2) studying unsteady supercavitating flow; and (3) investigating pressure distribution on ventilated, supercavitating lifting bodies in connection with lift, drag and moment measurements.

Jets and Turbulence (U), RR 009-01-0004. State University of Iowa, Iowa City, Iowa, Iowa Institute of Hydraulic Research; Nonr 1509(03), NR 062-053; H. Rouse.

This project constitutes a broad program of experimental and theoretical investigations in hydromechanics. Current activities concern the following areas, namely (1) annular jet studies; (2) axisymmetric gravity waves; (3) instrumentation for experimental hydrodynamic research; and (4) jet cavitation. Work on item one began last year and is being continued. Specifically, a precise annular jet with interchangeable mouthpieces is being used to study (a) ratio of area of jet flow to nozzle base area, (b) jet angle, and (c) angle of tilt of nozzle over land and water, moving and stationary. In addition, altitude ratio and jet momentum effects for an annular jet moving over water are being studied. The gravity waves program includes a study of energy components for the waves for various conditions. Instrumentation work includes development of turbulence data analyzing equipment and use of hot-film anemometers in salt water.

Special Problems in Hydrodynamics (U), RR 009-01-0005. California Institute of Technology, Pasadena, California, Division of Engineering; Nonr 220(28), NR 062-059; M. S. Plesset.

Theoretical and experimental studies of complex and important hydrodynamic phenomena are being conducted. Currently emphasis is centered upon chemical and physical effects in cavitation damage and the fluid mechanics of two-phase media. More specifically, cavitation damage experiments are being run in various liquids, with and without cathodic currents, on small metal samples having different chemical activity. X-ray analysis of the damaged areas is being done to shed more light on the nature of the damage, also, theoretical studies are being made to extend the theory covering propagation of acoustic and shock waves in liquids containing gas bubbles from the case where the wave lengths are long compared to bubble radii to the case where wave lengths are of the same size or less than the bubble radii. Another problem to be investigated concerns an analysis of the ship wave problem.

Interaction of Waves with Floating Bodies (U), RR 009-01-0006. Massachusetts Institute of Technology, Cambridge, Massachusetts, Hydrodynamics Laboratory; Nonr 1841(44), NR 062-068; A. T. Ippen.

The objective of this task is a comprehensive examination, both mathematical and experimental, of the interaction of floating bodies and waves, and the determination of the relations of body and wave parameters for which a maximum degree of damping results. By damping is meant a reduction in wave height due to reflection or dissipation or both. Present emphasis in on (a) experimental investigation of configurations other than circular cylinders to ascertain the configuration having the best wave damping characteristics and yet still be suitable for engineering applications and (b) experimental investigation of the effect of various mooring schemes for floating breakwaters on wave damping of the breakwater. The theoretical studies of wave damping of half submerged cylinders in deep and shallow water of uniform depth will be continued and extended where possible to the experimental cases previously mentioned.

Unsteady Viscous Flows and Magnetohydrodynamic Propulsion (U), RR 009-01-0007. Massachusetts Institute of Technology, Cambridge, Massachusetts, Mathematics Department; Nonr 1841(12), NR 062-156; C. C. Lin.

Theoretical investigations of unsteady fluid phenomena are being carried out with current emphasis on both linear and non-linear effects on the stability of the laminar boundary layer, the transition from laminar to turbulent flow, and the stability of magnetohydrodynamic viscous flows. The program has recently been expanded to include the stability of viscous flows involving free surfaces and liquid films, problems of magnetohydrodynamic propulsion, and the motion of liquid helium.

Theoretical Fluid Dynamics (U), RR 009-01-0008. New York University, New York, New York, Institute of Mathematical Sciences; Nonr 285(06), NR 062-160; J. J. Stoker.

A broad program of fundamental studies in theoretical fluid dynamics is conducted under this

project. At present major emphasis is given to the problem of ship motions in a seaway and problems concerning internal waves, e.g. modification of internal waves in passing barriers or cliffs in the sea, and amplitudes of internal waves in small desnity gradients. This work is closely coordinated with similar work by Professor Keller at the same institution.

Cavitation Phenomena (U), RR 009-01-0009. California Institute of Technology, Pasadena, California, Hydrodynamics Laboratory; Nonr 2182(00), NR 062-166; A. T. Ellis.

Special laboratory equipment developed under Contract Nonr 220(08) for the investigation of the hydromechanics of cavitation damage will be used to continue this investigation. Particular emphasis will continue to be placed on the damage produced by fixed type cavitation. Several series of measurements have been made to determine the variation in intensity with flow velocity, and these investigations will continue. The effect of size of geometrically similar guiding surfaces will also be investigated.

Forced Mixing in Boundary Layers (U), RR 009-01-0010. National Bureau of Standards, Washington, D. C., Fluid Mechanics Section; NAonr 31-59, NR 062-167; G. B. Schubauer.

This task involves studies of (a) the effect of forced mixing on turbulent boundary layers developing in regions of rising pressures and (b) practical methods by which effective forced mixing may be caused. The objective of these studies is the development of simple devices or techniques for preventing the separation of turbulent boundary layers with a minimum of drag penalty imposed by the devices or techniques themselves. Current emphasis concerns a continued theoretical and experimental study of methods of achieving forced mixing, e.g., boundary layer suction, boundary layer blowing, use of fixed devices of various geometries, combination of these, and any other promising techniques.

Fundamental Problems in Hydromechanics (U), RR 009-01-0011. National Bureau of Standards, Washington, D. C., Fluid Mechanics Section; NAonr 32-60, NR 062-171; G. B. Schubauer, G. H. Keulegan.

Major emphasis is being given to the following problems. First, the behavior of internal waves in density gradients will be studied from two aspects. The waves generated by a wave maker in density gradient fluids and the waves created by a towed body in a density gradient will be simultaneously investigated in two channels. The second problem comprises a study of the effects of independently produced subsurface turbulence on surface waves. Other problems being studied on a lower priority basis include studies of mechanisms of generation of cavitation bubbles from free convected and surface bound nuclei under action of pressure fluctuations, and fundamental studies of wave damping of screen assemblages. As time and personal requirements permit, other problems studied in the past under this contract will be given further study.

Homogeneous Turbulence and Sea Surface Studies (U), RR 009-01-0012. University of Michigan, Ann Arbor, Michigan, Department of Aeronautical and Astronautical Engineering; Nonr 1224(02), NR 062-175; M. S. Uberoi.

Fundamental experimental studies are being made to test or suggest hypotheses which yield a determinate set of equations on the statistical theory of turbulence. Specifically, considerable attention is paid to the return to nonisotropy of axisymmetric homogeneous turbulence leaving a flow contraction in which isotropy has been nearly achieved. New electronic equipment will be utilized to measure energy transfer from one scale of motion to another for this case. The measurements will be made with sophisticated hot-wire anemometry in a low-speed, low-turbulence wind tunnel.

In addition, the measurement of the "two-dimensional" spectrum of sea surface roughness by analysis of the photographic plate of the sea surface with a parallel slit light source will be investigated.

Special Problems in Fluid Mechanics (U), RR 009-01-0014. Brown University, Providence, Rhode Island, Division of Applied Mathematics; Nonr 562 (07), NR 062-179; R. E. Meyer.

This task is concerned with theoretical studies of various problems in fluid mechanics. During the current period the following areas are being investigated (a) extension and completion of calculations describing the development of an underwater explosion from a spherical charge. Preliminary results have already been published; (b) mathematical description of the distortion of a plane explosive wave moving transverse to the ocean density gradient; (c) a study of the recently obtained first-order theory of the radial spreading of gravity waves on shallow water to determine the implications to basic shallow water theory and the relation to linearized deep-water waves; (d) isotropic turbulence theory--specifically, to study the relationship between normal distribution transfer theory and Kraichnan's theory for times other than first order; and (e) flow stability between opposite rotating cylinders. Specifically, an inviscid approximation study of the convective and oscillatory modes of instability.

Hydrodynamics of Naval Architecture (U), RR 009-01-0015. University of California, Berkeley, California, Department of Naval Architecture; Nonr 222 (30), NR 062-181; H. A. Schade, J. V. Wehausen.

Experimental and theoretical studies of fundamental problems in naval hydrodynamics are being conducted. These include problems in the design and operation of ships, water-based aircraft and underwater ordnance. Currently a variety of problems are being investigated including ship hydrodynamics, turbulent boundary layers, and the general theory of water waves.

Ship Hydrodynamics (U), RR 009-01-0016. State University of Iowa, Iowa City, Iowa, Iowa Institute of Hydraulic Research; Nonr 1611(01), NR 062-183; H. Rouse.

Interdependent theoretical and experimental investigations of fundamental problems in ship hydromechanics are being conducted. Emphasis is placed on research designed to develop rational methods

of predicting the forces and moments acting on ships and submerged bodies and on their components and of determining the velocity field about such bodies. Current emphasis is being placed on research on ship rolling, wave making of certain shapes, effect of a free surface on flow separation on a body, and viscous drag of ship models.

Surface Roughness Effects (U), RR 009-01-0017. University of Maryland, College Park, Maryland, Institute of Applied Mathematics and Fluid Dynamics; Nonr 595(07), NR 062-188; F. R. Hama.

The effect of surface roughness on turbulent shear flows is being studied experimentally with particular emphasis on the incremental frictional resistance due to roughness. A critical summary of data and literature on the subject has been finished. The experimental investigation initially concerns two-dimensional roughness of variable size and spacing covering one wall of a 50' long, 5' wide air channel of a variable height (2, 4 or 6 inches). More general and realistic types of roughness will be investigated as understanding of the simplest types grow.

Viscous Flow Stability (U), RR 009-01-0019. Rensselaer Polytechnic Institute, Troy, New York, Mathematics Department; Nonr 591(08), NR 062-190; R. C. DiPrima.

The emphasis of this task has changed from supercavitation theory to viscous flow stability theory. The stability work was begun under another task and is now being accomplished under this task. Currently viscous flow stability between rotating cylinders is being studied to determine effects of the following (a) angular coordinate dependent disturbance velocities; (b) axial velocity components; and (c) radial temperature gradients. In addition, the energy associated with rotationally symmetric disturbances will be studied. Non-linear aspects associated with the above problems will be included in the investigations.

Ventilated Hydrofoils (U), RR 009-01-0020. University of Minnesota, Minneapolis, Minnesota, St. Anthony Falls Hydraulic Laboratory; Nonr 710(04), NR 062-192; L. G. Straub.

Under this task, experimental studies of ventilated submerged hydrofoils are being carried out. Tulin-Burkhart profiles and other sections are being investigated to determine the air demand as a function of cavitation number, submergence, aspect ratio, and any other parameter found to be important. In addition, lift and drag data are being obtained.

Propeller Theory (U), RR 009-01-0021. Hamburgische Schiffbau Versuchsanstalt, Hamburg, Germany; N62558-2223, NR 062-197; H. W. Lerbs.

Theoretical and experimental studies of the hydrodynamics of ship propellers are being carried out. Current emphasis is devoted to studying the effect of propeller geometry on fluctuations of thrust, torque, bending moments and cross forces in a non-homogeneous wake.

Hydraulic Breakwaters (U), RR 009-01-0022. University of California, Berkeley, California, Department of Mechanical Engineering; Nonr 222(46), NR 062-198; J. W. Johnson, R. L. Wiegel.

The characteristics of water currents and the methods of generating them for the attenuation of surface waves are being studied. Effort is directed towards optimizing systems for attenuating waves involving water currents with particular emphasis on steep shallow water waves. The 8 ft. by 6 ft. by 200 ft. wave tank, the 54 ft. by 2-1/2 ft. by 150 ft. model basin, and the 1 ft. by 3 ft. by 60 ft. wave tank are being used for this study. Current emphasis is directed toward determination of the scale effect using models of different sizes.

Waves generated by wind blowing over the water surface will be used to measure the power spectrum with the breakwater off; then with the breakwater operative. By this means one can determine the effect of the breakwater on different ranges of the frequency spectrum of the waves.

Wave Phenomena and Magnetic Field Effects on Conducting-Fluid Convection (U), RR 009-01-0023. Harvard University, Cambridge, Massachusetts, Department of Engineering and Applied Physics; Nonr 1866(20), NR 062-199; G. F. Carrier.

Analytical research in hydrodynamics is being conducted with current emphasis on various aspects of magnetohydrodynamics including the following problems (a) theoretical analysis of the flow of a conducting fluid in the presence of a magnetic field on the neighborhood of the entrance of a pipe; (b) theoretical magnetic field to compare with experimental results in the literature; and (c) wind generated equatorial currents on a rotating earth.

Turbulent Diffusion (U), RR 009-01-0025. Johns Hopkins University, Baltimore, Maryland, Mechanical Engineering Department; Nonr 248(38), NR 062-201; S. Corrsin.

Theoretical and experimental investigations of diffusion and mixing in homogeneous turbulent flows are being pursued from a very basic viewpoint. Also, a mathematical and analog computer study will be made of simple non-linear stochastic differential equations which provide foundations for study of the non-linear stochastic field problem of turbulence.

Water Exit Phenomena (U), RR 009-01-0026. University of Illinois, Urbana, Illinois, Department of Theoretical and Applied Mechanics; Nonr 1834(10), NR 062-202; J. M. Robertson.

Basic studies have been carried out of hydrodynamic phenomena involved in the exit of bodies from water. These studies were primarily experimental. Initial emphasis was placed on attempts to obtain a quantitative understanding of accelerations experienced by bodies passing from denser into lighter fluids.

Ship Wave Computations (U), RR 009-01-0027. U. S. Naval Weapons Laboratory, Dahlgren, Virginia, Comp. and Ext. Ballistics Laboratory; P.O. 10501-704, NR 062-203; A. V. Hershey.

Theoretical research on non-linear aspects of ship waves is being carried out, with primary emphasis on utilization of numerical methods designed to take advantage of available high speed computing machines, and in particular, the Naval Ordnance Research Computer (NORC). The problem of a wave-making ship proceeding in smooth water is to be solved to the approximation that boundary conditions on

the ship are satisfied exactly but boundary conditions on the water surface only approximately. Effects of finite water depth will be taken into account.

Current work concerns (1) exploratory analysis to increase further the speed of computation by development of techniques for interpolation; (2) completion of a program for the calculation of pressure distribution and wave resistance for a ship of arbitrary shape; and (3) computation of wave patterns for actual ships.

Ship Seaworthiness (U), RR 009-01-0028. Institut fur Schiffbau der Universitat Hamburg, Hamburg, Germany; N62558-2237, NR 062-204; G. P. Weinblum.

Theoretical and experimental studies of ship seaworthiness are being conducted with present emphasis on the roll of ships in a regular seaway. Included are studies of roll periods and damping in calm water, and non-linear effects for forced rolling, as occurs in a seaway. Tank tests are being planned to check recent theoretical analyses of special states of roll in a regular sea.

Boundary Layer Noise Transmission (U), RR 009-01-0029. Bolt, Beranek and Newman, Incorporated, Cambridge, Massachusetts; Nonr 2321(00), NR 062-205; I. Dyer.

The problem of the transmission of pressure fluctuations in a boundary layer through an elastic structure is being studied. Particular emphasis is placed on systems where the motions in the fluid surrounding the structure are strongly coupled to the motion of the structure. The overall aim of these studies is (1) to provide estimates of boundary layer transmission for several elastic system models; (2) to highlight areas of required experimental research; and (3) to explore possible methods of achieving boundary layer noise control. Current emphasis will be placed on some of the following investigations in the field of hydrodynamic noise (1) noise transmission from boundary layer turbulence into a cylindrical space; (2) improvements in the analytical form assumed for boundary layer turbulence; (3) correlation of transmitted boundary layer noise within rectangular space; (4) effect on boundary layer turbulence of yielding surfaces; and (5) the coupling of energy from a moving fluid to a surface that can vibrate.

Hydrodynamic Self-Noise (U), RR 009-01-0030. New York University, New York, New York, Institute of Mathematical Sciences, Division of Electromagnetic Research; Nonr 285(33), NR 062-206; R. Kraichnan.

Theoretical research on the statistical picture of turbulence is being conducted in order to better understand and predict the hydrodynamic self-noise associated with it. Included in the studies is the exceedingly difficult problem of determining the true structure of the turbulent and velocity fluctuations.

Water Exit Hydrodynamics (U), RR 009-01-0031. Allied Research Associates, Incorporated, Boston, Massachusetts; Nonr 2343(00), NR 062-207; T. Goodman.

Theoretical studies of the launching of airborne missiles from underwater and of hydrodynamic phenomena involved in the water exit of such bodies are being carried out. Current activities concern the following (a) determination of the apparent masses of bodies of revolution with appendages; (b) derivation of a method of determining the apparent masses of bodies which deviate slightly from regular bodies of revolution whose apparent masses are known; (c) detailed calculations of the submarine response (particularly roll response) to waves to include effect of appendages and the effect of damping induced by internal Gyros; (d) continuation of the study of the optimum submarine heading including the effects of submarine forward motion, directional properties of currents and shears, and the effects of a confused sea; (e) using results of (a) and (b) above, calculation of the effect of the appendages and the flat platform on the apparent masses of an SSBN submarine; (f) an analysis of the forces due to waves on an SSBN submarine using the apparent masses calculated in (e); (g) numerical calculations of the wave response of an SSBN submarine, and the effect of this submarine response on the missile response at the surface; (h) recalculation of the missile responses previously reported.

Ship Motion Theory (U), RR 009-01-0032. Hamburgische Schiffbau-Versuchsanstalt, Hamburg, Germany; N62558-1745, NR 062-208; O. Grim.

Theoretical research on ship motions will be carried out. The effect of forward speed on those forces which influence the oscillatory motion of a ship in head seas will be determined, as will be the additional resistance caused either by oscillatory motion or by waves. The solution of difficult three-dimensional boundary value problems is involved.

Boiling Heat Transfer and Two-Phase Flow (U), RR 009-01-0033. Massachusetts Institute of Technology, Cambridge, Massachusetts, Heat Transfer Laboratory; Nonr 1841(39), NR 062-209; W. M. Rohsenow.

Research under this task is the investigation of interrelationships among the various factors involved in boiling heat transfer, for the purpose of determining a mechanism or mechanisms which correlate quantitative measurements made experimentally under various conditions of interest and importance. The study employs a closely integrated program of analysis and experiment and concentrates particularly on the phenomena of nucleation, two-phase flow and peak flux or burnout.

Current investigations are concerned with various aspects of burnout in vertical tubes, two-phase flow entrance effects, and the effect of surface conditions on the boiling heat transfer process.

Wave Resistance of Ships (U), RR 009-01-0034. Technical Research Group, Incorporated, Syosset, New York; Nonr 2427(00), NR 062-210; J. Kotik.

This task is concerned with theoretical studies of ships of minimum wave making resistance. Current efforts involve completing some simple three-dimensional studies such as the case of constant volume and constant wetted area and the case of intermediate generality where the ships are defined in terms of affine cross sections. A new problem to be studied (concerned with the

representation of bodies, especially surface-piercing bodies, by singularity distributions) is intended to investigate the effect of the free surface on the shape of the body generated by a dipole distribution extending up to the free surface, and to consider other corrections which may be important near the keel and corrections for fullness.

Viscous Effects on Wave Drag (U), RR 009-01-0035. C. Wigley, London, England; N62558-1772, NR 062-211; C. Wigley.

The effects of viscosity on the wave drag of surface ships and models are being calculated, with emphasis on the case of low ship's speeds, by a semiempirical theory devised by the contractor. Constants in a formular for the correction to measured wave resistance for these effects are being determined by comparison with existing experimental results. The correction equations are being applied to real ship forms. The results are also being compared with results obtained by boundary layer theory.

In addition, this task now covers the collection and editing of some 61 hydrodynamic papers of Sir Thomas Havelock in form ready for composition by a publisher.

Supercavitating Hydrofoils Impact and Stability (U), RR 009-01-0036. Stevens Institute of Technology, Hoboken, New Jersey, Davidson Laboratory; Nonr 263(20), NR 062-212; D. Savitsky.

This is a theoretical and experimental research task which is intended to contribute to a basic understanding of, and provide design information on, the hydrodynamic behavior of hydrofoil systems, planning forms and hydroskis when piercing the free water surface. Currently, effort is being directed toward (a) a basic analytical study of the force characteristics of surface piercing, fully ventilated supercavitating hydrofoils; and (b) an experimental study of the forces acting on a freely oscillating surface piercing hydrofoil.

Journal of Fluid Mechanics (U), RR 009-01-0037. American Branch of Cambridge, University Press, New York, New York; Nonr 2548(00), NR 062-213; F. R. Mansbridge.

One-hundred and eighty-seven subscriptions to the Journal of Fluid Mechanics will be purchased and the issues distributed to libraries and key personnel of Naval bureaus, laboratories, research and training establishments, and analogous Air Force establishments. This will make the fluid mechanics research published in this important and rather unique Journal readily accessible to Navy's and Air Force's scientific personnel and make possible the Journal's financial self-sufficiency by 1961.

Supercavitating Foil Boat (U), RR 009-01-0038. Dynamic Developments, Incorporated, Babylon, New York; Nonr 2695(00), NR 062-214; W. P. Carl.

Analytical work of Tulin-Burkart and of Johnson indicate that foils operating in full cavity maintain useful lift/drag ratio at high speed. Laboratory controlled experiment verifies the practicability of extending the speed range of hydrofoil supported craft. It is the purpose of this project to build and operate a foil system to determine for the first time the operational feasibility of high speed foil craft in the fully cavitating range.

Wake Studies (U), RR 009-01-0041. State University of Iowa, Iowa City, Iowa, Iowa Institute of Hydraulic Research; Nonr 1611(03), NR 062-217; H. Rouse.

Interdependent theoretical and experimental investigations of fundamental problems in hydrodynamics are being conducted. Current emphasis is on towing tank studies of ship model wakes and wind tunnel studies of momentumless wakes.

Investigation of Flow Noise (U), RR 009-01-0043. Pennsylvania State University, University Park, Pennsylvania, Ordnance Research Laboratory; Req. 00014-1-000083, NR 062-219; E. J. Skudrzyk.

This task is concerned with an experimental and theoretical study of hydrodynamic noise such as roughness noise and turbulent boundary layer noises. The current objective is the abatement of flow noise in torpedoes and submarines. Specifically the program is concerned with practical methods for reducing flow noise in transducer arrays and obtaining a better understanding of the spatial distribution of the pressure fluctuations on a solid boundary. The latter is being accomplished by correlating flow noise spectra with hydrophone geometries.

Hydrodynamic Forces Acting on Supercavitating Hydrofoils with Generalized Oscillatory Motions (U), RR 009-01-0044. Stevens Institute of Technology, Hoboken, New Jersey, Davidson Laboratory; Nonr 263(29), NR 062-220; M. Martin.

The objective of this task was to evaluate the hydrodynamic forces acting on supercavitating hydrofoils in generalized oscillatory motions, i.e., with the arbitrary chordwise distribution of vertical velocity, thereby allowing determination of the forces due to deformations of the chord and to the effect of waves.

Surface and Internal Waves (U), RR 009-01-0045. New York University, New York, New York, Institute for Mathematical Sciences; Nonr 285(45), NR 062-221; J. Keller.

This task is a theoretical investigation of surface and internal waves, including an analysis of the effect of the motion of a submerged body on the ocean surface wave spectrum and a computation of the decay of internal waves in a density gradient due to viscous effects.

Ships of Minimum Wave Resistance (U), RR 009-01-0046. Stevens Institute of Technology, Hoboken, New Jersey, Davidson Laboratory; Nonr 263(31), NR 062-222; J. P. Breslin.

The primary objective of this task is to obtain experimental data on ships designed for minimum wave resistance to compare agreement between computed and measured wave resistance. Initially tests were run on a ship, similar to the destroyer class, designed with the aid of Weinblum's tables, with the lines modified to compensate for boundary layer displacement thickness. Calculation assistance is provided by the NORC computer facility at NWL under NR 062-203.

Supercavitating or Ventilated Propeller Feasibility Study (U), RR 009-01-0047. Gibbs and Cox, Incorporated, New York, New York; Nonr 2800(00), NR 062-223; W. Bachman.

The present knowledge of high speed propellers is based entirely on model tests and small scale applications. The advantage to be gain from their use and difficulties which may be encountered can only be determined from a period of operating experience with a full-scale application. Since the DD692 class is marginally attractive, it was considered desirable to make studies to indicate more fully the feasibility of testing available theory through an experimental application. A more complete understanding of overall weight advantage in ships machinery through high speed propellers was needed. It was considered also important to study the design of these propellers to see to what extent presently available ship speeds may require ventilation. The prupose of the work pursued in this project was to determine more certainly the validity of existing theory of high speed propeller design through study of an existing DD692 long-hull destroyer and to perform the basic investigations and calculations necessary to indicate feasibility of an experimental installation.

Ventilated Propellers (U), RR 009-01-0048. U. S. Naval Ordnance Test Station, China Lake, California, Propulsion Division; PO 1-0055, NR 062-224; J. W. Hicks.

The objective of this task is to provide experimental data on the performance and noise characteristics of a ventilated propeller mounted on a torpedo test vehicle. The propeller has been designed using the Tulin supercavitating foil theory. During the tests, the propeller is ventilated using varying quantities of exhaust gas from the torpedo power plant. The tests are providing information covering relative noise characteristics and propeller efficiencies for the supercavitating propeller with ventilating gas flow rates varying from zero to the maximum permissible by the test vehicles power plant.

Supercavitating Hydrofoils (U), RR 009-01-0049. Max-Planck Institut für Strömungsforschung, Göttingen, Germany; N62558-2196, NR 062-225; H. Reichardt.

This task comprises a theoretical and experimental study of the lift and drag forces, pitching moments and cavity dimensions on supercavitating sweptback and delta hydrofoils in two- and three-dimensional flow. The foils studied will vary in camber, aspect ratio, sweepback, and thickness.

Air Lubricated Boundary Layer (U), RR 009-01-0050. Hydro-og Aerodynamisk Laboratorium, Lyngby, Denmark; N62558-2197, NR 062-226; C. Prohaska.

The object of this task was to conduct an experimental investigation of an invention of Mr. K. Gram of Copenhagen, Denmark pertaining to the stabilization of air boundary layers on ship bottoms in order to achieve drag reduction. Experiments were run in a new 240 metter long x 12 meters wide x 5.5 meters deep towing basin using a wood tanker model having a transparent bottom. Tests were run at different drafts, speeds, trim conditions and air rates supplied to the air film. Pressure distributions across the bottom, air film thickness, drag with and without air films were measured and the resultant wave patterns photographed.

Practical Ship Forms of Minimum Wave Resistance (U), RR 009-01-0051. Skipsmodelltanken, Trondheim, Norway; N62558-2235, NR 062-227; J. K. Lunde.

Under this task model studies are being performed on practical ship forms of minimum wave resistance at a speed corresponding to a Froude number of 1/2. The initial phase was primarily concerned with choosing the proper hull forms based on a compromise between the available theory, its limitations, and practical construction techniques. In the second phase, a basic model was constructed and redesigned after tests were performed to measure trim and sinkage at Froude Number of 0.5. In the third phase the redesigned models are being constructed and tested. Resistance experiments in smooth water are being performed and the models compared with forms of Taylor's Standard Series. All models are being designed to accommodate supercavitating propellers.

Effects of Viscous Damping and Basin Geometry on Amplitude of Resonant Oscillations in Harbors (U), RR 009-01-0052. Massachusetts Institute of Technology, Cambridge, Massachusetts, Hydrodynamics Laboratory; Nonr 1841(59), NR 062-228; A. T. Ippen.

This task comprises a theoretical and experimental investigation of the motion induced within harbors by waves incident upon the harbor entrance. Initially a harbor of circular plan form is being studied. Theoretical calculations are being made of the amplitude of the harbor waves in terms of incident wave amplitudes at the harbor entrance. The effect of the harbor entrance width for the various resonant conditions are included in these calculations. Experiments are being conducted to check these calculations. Viscous effects will be experimentally investigated also. Various techniques for decoupling the resonant waves from the incident waves are to be studied.

Relationship Between Fluid Motion and Sound (U), RR 009-01-0053. University of California, Los Angeles, California, Institute of Industrial Cooperation, Department of Engineering; Nonr 233(62), NR 062-229; A. Powell.

The principal objective of this task is to provide a better understanding of the relationship between various fluid flow and sound phenomena. The primary interest involves phenomena in which the fluid motion generates sound, e.g., jet and wake noise, aeolian tones, etc. The other major interest involves pheonomena in which the fluid motion is affected by acoustic disturbances, e.g., sensitive jets, edge tones, etc. The major effort is experimental investigations of fundamental problems in these areas although adequate theoretical work is being done to keep a proper balance. Typical of the types of problems are: studies of the details of flow about edges and the correlation with the sound field; studies of stability limits and instability coefficients for real laminar jets and the correlation with the acoustic field; and studies of the correlation between turbulent flow in wakes and jets and the generated sound field.

Free Surface Flow, Cavity Flow and Propulsion (U), RR 009-01-0054. California Institute of Technology, Pasadena, California, Division of Engineering; Nonr 220(35), NR 062-230; T. Y. Wu.

Theoretical studies of important hydrodynamic problems are being conducted. Current emphasis is on the following three problems: Unsteady cavity flow theory, theory of fish propulsion, and free surface flows. Various potential models which yield good flow approximations in the proximity of supercavitating bodies will be investigated and compared. Necessary assumptions introduced to facilitate solutions of water waves or supercavitating flows involving free surface effects will be studied. Several phases of the mechanism of fish propulsion are being studied. Included are the problem of the flow field produced by wavy motion of a slender body, and the flow configuration around different kinds of fish under sudden maximum acceleration.

Study of Annular Nozzle Proximity to Free Water Surface (U), RR 009-01-0055. University of California, Berkeley, California, Institute of Engineering Research, Department of Engineering; Nonr 222(71), NR 062-231; J. W. Johnson, J. V. Wehausen.

The object of this task is to conduct a theoretical and experimental investigation of a vertical annular jet in proximity to a water surface. Tests are being conducted for stationary and moving jets (plane of motion parallel to the plane of the water surface) over smooth water and water with waves. Some of the most important features of the investigation are to study the stability and wave-making characteristics of the jet. Thrust augmentation, drag, and pitching moment measurements are being done. This work will complement related work under NR 062-053.

Oscillating Hydrofoils (U), RR 009-01-0056. Versuchsanstalt fur Wasserbau und Schiffbau, Berlin, Germany; N62558-2236, NR 062-232; S. Schuster.

This task comprises a theoretical and experimental study of surface-piercing, v-shaped hydrofoils oscillating near a free surface. The current emphasis concerns theoretical studies of idealized hydrofoils (flatplates) and dihedral foils. Specifically, the pressure distribution about these foils will be determined as affected by speed, wave length of unsteady motion and submergence depth.

Design and Construction of Supercavitating Propeller for One-Ton Hydrofoil Boat (U), RR 009-01-0057. David Taylor Model Basin, Washington, D. C., Ship Powering Division; Allot. #526, NR 062-233; W. B. Morgan.

Under this task, a supercavitating propeller was designed and fabricated for use on the one-ton supercavitating hydrofoil boat being designed, constructed and tested under another task.

Pressure Fluctuations in a Turbulent Boundary Layer (U), RR 009-01-0058. University of Michigan, Ann Arbor, Michigan, Aeronautical Engineering Department; Nonr 1224(30), NR 062-234; W. W. Willmarth.

An experimental investigation of the pressure fluctuations in the turbulent boundary layer is being conducted under this task. The boundary layer on the side walls of a 5' x 7' cross section x 27' long test section of a low turbulence level wind tunnel is being used. Boundary layers varying in thickness from 0.9" to 4" are being studied. The pressure fluctuations will be correlated with wall pressures and the boundary layer velocity fluctuation.

Ventilated Foils (U), RR 009-01-0059. Dynamic Developments, Incorporated, Babylon, New York; Nonr 2852(00), NR 062-235; W. P. Carl.

This task comprises an experimental program designed to provide a large quantity of data at a minimum expenditure of time and money for various lift and/or auxiliary lift devices for use on hydrofoil supported craft. The data are useful in optimizing practical designs for actual applications. The tests are being performed on the Dynamic Developments pendulum facility. Currently the effort concerns the following: construction and test of two hydrofoil and strut configurations to obtain lift, drag, side load and pitching moment as affected by immersion, and flap deflection, angles of attack and yaw, velocity and water temperature. The two foil sections are a thin delta hydrofoil and a delta foil having a cambered parabolic cross section.

Hydromagnetic Towing Tank (U), RR 009-01-0060. California Institute of Technology, Pasadena, California, Aeronautical Engineering Department; Nonr 220(36), NR 062-236; H. Liepmann.

Under this task a hydromagnetic towing tank has been constructed and is to be used on another task for the measurement of forces on bodies moving through a liquid conductor in an axial magnetic field. The tank consists of a cylindrical, mercury filled column surrounded by a large coil. A sting mounted model, instrumented for appropriate measurements, is driven through the column along the axis of the column.

Non-Uniform Cavity Flow Theory (U), RR 009-01-0062. Institut voor Toegepaste Wiskunde, Delft, Netherlands, Technische Hogeschool; N62558-2269, NR 062-238; R. Timman.

The objective of this research is the establishment of a linearized theory for cavity flow about hydrofoils in non-uniform motion. Several hypotheses concerning simplifications in the linear theory will be tested by investigating several special cases including (a) non-steady motion of a partially-cavitated wing of arbitrary shape; and (b) non-steady motion of a supercavitating wing of arbitrary shape.

Variable Pitch Supercavitating Propeller (U), RR 009-01-0064. David Taylor Model Basin, Washington, D. C., Hydromechanics Laboratory; PO 501-726, NR 062-240; K. Schoenherr.

Development of the supercavitating propeller depended on the experimental verification of theoretical designs. The Royal Swedish Navy requested cooperation in the design of apropeller for their variable pitch mechanism fitted to a 40 knot boat. This project provided for the design of a supercavitating propeller for experimental verification

in one of the few existing vehicles suitable for such work.

Boundary Layer Control (U), RR 009-01-0065. U. S. Rubber Company, Wayne, New Jersey, Research and Development Department; Nonr 3121(00), NR 062-241; L. M. White.

This task is concerned with laminar boundary layer stabilization by means of distributed damping of turbulent vibrations afforded by compliant rubber coatings. Specifically, theoretical and experimental studies are being made of several types of rubber coatings applied to flat plates with regard to their ability to delay laminar-to turbulent boundary layer transition and/or to result in a reduction in drag.

Cross Waves (U), RR 009-01-0066. Massachusetts Institute of Technology, Cambridge, Massachusetts, Hydrodynamics Laboratory; Nonr 1841(65), NR 062-242; A. T. Ippen.

Under this task the non-linear problem of cross waves is being investigated theoretically and experimentally. The problem of cross wave generation in a standing wave tank has already been treated theoretically by one of the principal investigators. An experimental program is being conducted to substantiate the theory and to provide a clearer understanding of this phenomena. Further work on the theory is also underway. Another problem being studied experimentally and theoretically is the generation of standing cross waves in a traveling wave tank.

Rheo-Electric Analogies Study of Supercavitating Hydrofoils (U), RR 009-01-0067. Bureau D' Analyse et de Recherche Appliquees, Paris, France; N62558-2545, NR 062-243; L. Malavard.

This task includes the use of a simple, rapid, inexpensive experimental technique to verify and extend the theoretical work of Tulin on supercavitating flows. The principle of the technique is based on the fact that the equations describing the distribution of electrical potential in a conductor in which current is flowing are identical to the equations describing fluid flow through a geometrically similar shape. The current objectives are to (a) complete the development of this technique for this particular application; (b) to determine new supercavitating hydrofoils in two-dimensional flow; (c) to extend the linear theory to ring or annular hydrofoils; and (d) to extend the development of the basic technique to enable one to solve three-dimensional flow problems for supercavitating hydrofoils.

Research on Vertical Axis Propellers (U), RR 009-01-0068. Netherlands Ship Model Basin, Wageningen, Netherlands; N62558-2630, NR 062-244; J. D. van Manen.

Although the Cycloidal Propeller was invented by Kirsten at Washington State University in 1920, its development and commercial success has been almost completely German. The complex mathematics and hydrodynamics of design have not been formalized in the open literature; thus, this task will provide needed knowledge in design methods by carrying out research on a systematic series of vertical axis propellers. The effect of the number of blades, blade area and ducts will be examined.

Surface Wave Phenomena (U), RR 009-01-0069. Johns Hopkins University, Baltimore, Maryland, Division of Mechanical Engineering; Nonr 248(56), NR 062-245; O. M. Phillips.

This task comprises theoretical and experimental studies designed to improve the basic understanding of processes involving surface waves. Included are such problems as: the development of the spectrum of wind-generated waves and wave-wave interactions in traveling swell. Other problems under consideration are: the generation of surface waves by subsurface turbulence; and the relation between the wave spectra and the statistical properties of horizontal motions of fluid particles in a random, three-dimensional wave field.

Supercavitating Foil Boat (U), RR 009-01-0070. U. S. Maritime Administration, Washington, D. C., Office of Research and Development; NAonr 4-61, NR 062-246; R. P. Godwin.

This project will provide design and supporting experiment to make possible the construction of an advanced supercavitating 80-knot hydrofoil craft with seagoing ability.

Model Tests of 300-ton, 50-knot Hydrofoil Craft (U), RR 009-01-072. Skipsmodelltanken, Trondheim, Norway; N62558-2596, NR 062-248; J. K. Lunde.

This is an experimental model study of a 300-ton, 50-knot hydrofoil craft. The first experiments will be carried out in still water with a model carrying a surface-piercing foil forward and a fully submerged foil aft. Still water resistance and take-off characteristics will be measured. Studies will also be made of transverse and longitudinal stability at different speeds and with varying heeling and trimming moments. Further the turning and heeling moments during turning maneuvers will be examined.

Minimum Wave Drag Forms (U), RR 009-01-0073. Technical Research Group, Incorporated, Syosset, New York; Nonr 3150(00), NR 062-249; J. Kotik.

This task is concerned with experimental work on models of minimum wave drag forms. The objectives are (1) to measure the wave drag of an optimum form and compare it with the calculated wave drag; (2) measure the total drag and compare it with the total drag of forms having the same length, volume, etc.; and (3) to do these things in a range of Froude numbers containing the Froude number at which the form is designed to be optimum. Several models, each with different vertical distributions, will be designed and tested.

Summer Study on Theory of Ship Motions (U), RR 009-01-0074. Technical Research Group, Incorporated, Syosset, New York; Nonr 3175(00), NR 062-250; J. Kotik.

This task provided support for a group of 7 or 8 experts in ship motion theory who assembled for approximately one month to discuss ship motion theory with the aim of summarizing the present state-of-the-art and for the recommendation of future areas of fruitful endeavor.

Fluid Dynamic Lift (U), RR 009-01-0075. Dr. S.

F. Hoerner, Midland Park, New Jersey; Nonr 3196(00), NR 062-251; S. F. Hoerner.

This project is expected to produce an up-to-date engineering treatise on fluid dynamic lift.

Hydrofoil Flutter and Flapped Hydrofoils (U), RR 009-01-0076. CONVAIR, San Diego, California; Nonr 3180(00), NR 062-252; R. H. Oversmith.

This task comprises two phases of the study of hydrofoils. Phase one concerns an experimental and analytical study to provide fundamental data for the design of hydrofoils incorporating trailing edge flaps for subcavitating operation in smooth water. Suitable hydrofoil section and flap configurations are being determined and tested with various flap chords and flap spans. Suitable measurements are being taken to indicate the extent to which airfoil data may be used in the design of flapped hydrofoils, e.g., measurements of lift, drag, pitching moment of flapped foils and lift, drag, and hinge moment of flaps alone.

Lateral Stability and Motions of a Hydrofoil Craft in Smooth Water (U), RR 009-01-0077. Technical Research Group, Incorporated, Syosset, New York; Nonr 3178(00), NR 062-253; P. Kaplan.

This is a theoretical study to determine the lateral stability characteristics of representative hydrofoil craft designs and to relate them to configurational changes. The analysis will consider the three lateral degrees of freedom, (roll, yaw, and sideslip), for small disturbances from straight line equilibrium motion, with no control deflections. In addition, the response characteristics (to rudder and aileron deflections) will be studied, thus providing necessary information for the development of effective control systems. Configurational changes (i.e., changes in aspect ratio, foil separation, dihedral angle, foil arrangement, etc.) will be made for different types of craft and the change in dynamic behavior obtained thus providing guide lines for design purposes.

Unsteady Boundary Layer under a Plane Progressive Wave (U), RR 009-01-0078. Stevens Institute of Technology, Hoboken, New Jersey, Davidson Laboratory; Nonr 236(36), NR 062-254; S. J. Lukasik.

This task will make theoretical studies of unsteady boundary layers and apply new or existing theory to the boundary layer under a wave. A technique will be developed for the determination of the exact solution for progressive waves in water of constant depth and extended to examine waves along a sloping bottom. Additional study will be made of standing waves in water of uniform depth in order to determine if the theory predicts the expected major difference between standing and progressive waves. If experiment indicates that boundary layer separation occurs and is important, an attempt will be made to develop a theory incorporating this phenomena. Experimental studies under laboratory conditions will also be made of the physical phenomena taking place in a wave boundary layer. Measurements will detail the flow in the boundary layer and gross effects will be characterized in order to predict the behavior of full-scale waves.

Seaworthiness of Submerged Forms (U), RR 009-01-0079. Technical Research Group, Incorporated, Syosset, New York; Nonr 3171(00), NR 062-255; P. Kaplan.

This task will determine the forces and moments acting on various submerged forms which are performing heave and pitch oscillations in response to the excitation imposed by regular waves. This information serves as a basic device for determining the resulting motion of a submerged form operating near a surface disturbed by waves. Forces and moments due to waves (the exciting terms) will be determined including the effect of the wave-making of the body. The variation of drag force due to the heave and pitch motion while the body is translating at forward speed will be found. It is intended to consider bodies of revolution and possibly also flatter forms such as those with elliptical cross sections. An attempt will be made to determine certain "optimum" forms which will have least excitation or maximum damping for particular operating conditions of forward speed and wave properties.

Third Symposium on Naval Hydrodynamics (U), RR 009-01-0080. Netherlands Ship Model Basin, Wageningen, Netherlands; Nonr 3282(00), NR 062-256; W. P. A. van Lammeren.

This task is concerned with managing and conducting an unclassified international Symposium on Naval Hydrodynamics devoted to the subject of High Performance Ships. Specifically, the Netherlands Ship Model Basin took the responsibility for management of the Symposium, recording of verbal discussions, publishing of Proceedings, and payment of travel expenses and a nominal honorarium to certain scientists invited to speak or preside at the Symposium.

Research in Fluid Dynamics (U), RR 009-01-0081. University of California, Berkeley, California, Institute of Engineering Research; Nonr 222(79), NR 062-257; S. A. Schaaf, M. Holt.

This task involves theoretical studies in fluid dynamics with the principal objective being to gain further understanding of the propagation, reflection, and refraction of shock or explosive waves in water or other media. Initially the work will emphasize two areas (a) spherical explosions in sea water; and (b) refraction of shock waves in a non-uniform ocean.

Smooth Water Stability of a Surface-Piercing Hydrofoil Boat (U), RR 009-01-0082. Stevens Institute of Technology, Hoboken, New Jersey, Davidson Laboratory; Nonr 263(39), NR 062-258; H. W. MacDonald.

This task comprises a theoretical and experimental investigation of the smooth water stability of surface-piercing hydrofoil equipped vessels. This will be accomplished by studying the smooth water operation in six degrees of freedom of a single configuration of a tandem set of surface-piercing hydrofoils by applying experimental and theoretical results for the various hydrodynamic forces and moments to the solution of the equations of motion.

Theoretical Study of Free Surface Flow Past Surface-Piercing Bodies (U), RR 009-01-0083.

California Institute of Technology, Pasadena, California, Department of Applied Mechanics; Nonr 220 (41), NR 062-259; T. Y. Wu.

This task is concerned with a theoretical study of the basic mechanism of flow ventilation and the scale effect associated with the ventilating flow past surface-piercing bodies such as struts and hydrofoils.

Experimental Investigation Study of the Scale Effect on Ventilating Flows (U), RR 009-01-0084. California Institute of Technology, Pasadena, California, Department of Applied Mechanics; Nonr 220 (43), NR 062-260; T. Y. Wu.

This task comprises an experimental investigation of the basic mechanism of flow ventilation and the scale effect associated with the ventilating flow past surface-piercing or surface-approaching bodies such as inclined struts, yawed or unyawed hydrofoils and combinations of these. This study complements the theoretical investigations of this same problem under another task.

Study of Hydrofoil Boat Dynamics (U), RR 009-01-0085. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Naval Architecture and Marine Engineering; Nonr 1841(71), NR 062-261; M. A. Abkowitz.

Under this task very general equations of motion are being developed to adequately predict hydrofoil boat performance in waves throughout its range from hull-borne to foil-borne and in such form as to permit solution on a high speed digital computer. The equations will be tested by sample calculations and towing tank model tests for the particular case of a hydrofoil boat taking off in regular waves from a hull-borne to a foil-borne condition.

Effect of Struts, Fillets and Nacelles on the Hydrodynamic Characteristics of Hydrofoils (U), RR 009-01-0086. University of Minnesota, Minneapolis, Minnesota, St. Anthony Falls Hydraulic Laboratory; Nonr 710(39), NR 062-262; L. G. Straub.

This task comprises an experimental investigation of the effect of the presence of struts, fillets, nacelles or other appendages on the lift and drag of submerged hydrofoils. First, an experimental study is being conducted to determine the interference effect of a vertical unfilleted strut on the lift and drag of a submerged flat hydrofoil for various submergences, velocities, and angles of attack. Second, interference effects are being studied for various types of fillets, nacelles, and hydrofoil configurations currently being considered for practical applications.

Study of Non-Linear Motion of Hydrofoil Craft in Waves (U), RR 009-01-0087. Technical Research Group, Incorporated, Syosset, New York; Nonr 3327 (00), NR 062-263; P. Kaplan.

The objective of this task is to predict the vertical plane motions of hydrofoil craft in waves so as to allow determination of conditions for broaching or crashing. Equations are being formulated to describe the motion of a hydrofoil craft in pitch, heave and surge in waves. These equations will account for various unsteady or nonlinear effects not considered in prior investigations. Solutions to the equations are being obtained on a computer.

High Speed Wave Drag (U), RR 009-01-0088. Hydronautics, Incorporated, Rockville, Maryland; Nonr 3349(00), NR 062-266; M. P. Tulin.

This task comprises an investigation of high speed wave drag. The objectives are (a) to obtain a quantitative understanding of the behavior of large submerged appendages in the presence of high speed displacement hulls, and to investigate the optimum arrangement of appendage-hull combinations; (b) develop an understanding of the wave interference between catamaran hulls and investigate optimum shape configurations; and (c) obtain a quantitative understanding of the role of the bow shape of displacement hulls in producing wave resistance and to study methods for reducing bow-produced drag, especially through radical alterations in bow shape.

Fluid Mechanics and Flight Dynamics, WR 009-01-001. Naval Ordnance Test Station C/L, Allot, L. T. Jagiello; Naval Ordnance Test Station, Allot, J. G. Waugh; General Dynamics Corporation, Convair Division, NOw-61-0245, H. E. Brooke; General Dynamics Corporation, Convair Division, Unassigned, H. E. Brooke; General Dynamics Corporation, Convair Division, NOw-60-0494, H. E. Brooke; Naval Ordnance Laboratory W/O, Allot, R. E. Wilson.

To obtain a detailed understanding of hydrodynamic phenomena affecting the performance of underwater missiles and of water-based aircraft and to develop and improve methods of accurately predicting such performance.

Experimental data are obtained as necessary in water tunnels, tanks, rotating-arm basins and other hydrodynamic facilities. The results are correlated with associated analytical studies to confirm, extend or modify existing theories and hypotheses. New problem areas are defined and investigated.

The first part of the experimental program to investigate the effects of exit angle, cavitation, and angle of attack on the motion of missiles exiting from water has been completed and the results are being analyzed. Preliminary analyses indicate that for certain conditions of exit angle and cavitation, significant perturbations of the trajectory at water exit may occur. A laboratory test of the hydrodynamic performance of a swimming porpoise has been completed.

R009-02 Aerodynamics

Rarefied Gas Flows (U), RR 009-02-0001. University of California, Berkeley, California, Department of Engineering; Nonr 222(45), NR 061-003; S. A. Schaaf, G. S. Maslach, L. Talbot.

Theoretical and experimental studies of heat transfer and fluid mechanics phenomena at low pressures are being continued to provide insight into problems at high speed, high altitude flight. Major and unique experimental facilities include a supersonic low density wind tunnel as well as molecular and ion beam apparatus. Current effort is divided between wind tunnel and beam investigations in the hope the latter eventually will serve as an experimental probe incorporated in the former. At present, wind tunnel research includes

stability measurements of basic configurations together with heat transfer characteristics in the free molecular and slip flow regimes. Beam research emphasizes sputtering and gas molecule experiments.

Study of Shock Waves (U), RR 009-02-0002. University of Michigan, Ann Arbor, Michigan, Physics Department; Nonr 1224(18), NR 061-017; O. Laporte.

This task deals with development of the shock tube as an aerodynamic testing device and its application to studies of shock wave interactions (reflections, diffractions, intersections, etc.) and the aerodynamic behavior of real gases. Facilities employed are a 2" x 7" conventional shock tube, plus a unique sector shock tube for the production of diverging or converging cylindrical waves, the latter device having been developed with the aid of the AFSWP under this task. Current work includes optical studies of the passage of plane shock waves through channels of varying cross-section, constrictions or grids: theoretical treatment of a plane shock wave emerging from a constriction; preliminary optical studies of the formation of cylindrical shock waves and studies of the interaction of a stationary sound wave on the moving shock.

Strong Shear Waves (U), RR 009-02-0003. Cornell University, Ithaca, New York, Graduate School of Aeronautical Engineering; Nonr 401(25), NR 061-019; E. L. Resler.

Theoretical and experimental studies utilizing shock tube techniques are continuing on equilibrium properties and non-equilibrium behavior of very high temperature gases (T 4000°K). This task emphasizes a continuing study of dissociation and recombination parameters. In addition to experimental exploration of the dynamic interaction between conduction fluids and magnetic fields, extensive investigation is being undertaken of plasma diagnostic physics. The latter involves detailed examination of interdisciplinary fields such as a study of the propagation of electromagnetic radiation through an ionized medium.

Shock Tube Flows (U), RR 009-02-0004. Princeton University, Princeton, New Jersey, Palmer Physical Laboratory; Nonr 1858(20), NR 061-020; W. Bleakney.

This task constitutes a continuing study of energy transfer between atoms and molecules at high temperatures behind strong shock waves. Studies are carried out in a 3 inch diameter, combustion driven, high pressure shock tube, and a small glass shock tube, electromagnetically driven by electric condenser discharge through coils surrounding the tube. Both optical and electromagnetic techniques are used for observation. More specific objectives include a study of dissociation rate of gases as a function of temperature, and a study of ionization rates and plasma formation by the shock wave method.

Wind Tunnel Facility (U), RR 009-02-0008. University of Minnesota, Minneapolis, Minnesota, Aeronautical Engineering Department; Nonr 2363(00), NR 061-085; J. D. Akerman.

Since 1 April 1950, this task has arranged for the loan to the University of Minnesota of a complete supersonic wind tunnel facility (constructed by University of Minnesota under NR 061-050). The wind tunnel is a 6" x 9" test section blow-down type, operating at Mach numbers up to 3.

Discharge Shock Tube (U), RR 009-02-0009. University of Oklahoma, Norman, Oklahoma, Physics Department; Nonr 982(02), NR 061-087; R. G. Fowler.

Electric discharges between electrodes within a gas-filled tube have been employed to generate strong shock waves and high temperatures in the gas. Typical temperatures behind the shock are 10,000 to 30,000°K in rare gases, so that the gas is considerably ionized. The objectives of this task include a systematic evaluation of the mechanisms and efficiency of conversion of electrical energy to kinetic and radiant energy of the gas in such a device, and a critical study of the aerodynamical and physical details of the resulting flow. The development and evaluation of pertinent observational techniques such as pure gas or impurity emission spectroscopy, electrostatic and hydromagnetic probing, and Mach wave observation are important byproducts. Simple experiments on the interaction of moving plasmas and magnetic fields, to provide checks and guidance for a growing body of magnetohydrodynamic theory, are contemplated in the near future.

Electron Gas Densitometry (U), RR 009-02-0010. National Bureau of Standards, Washington, D. C., Electron Physics; NAonr 10-61, NR 061-098; L. Marton.

Use will be made of electron schlieren optics to view beams of cadmium atoms. The conversion of an electron schlieren apparatus to stroboscopic operation is near completion. New data on pulsed molecular beams will be obtained in the very near future. Already observations of steady molecular beams, using a pulsed electron gun, demonstrate the electron pulse is within useful range for stroboscopic work. After synchronizing and phasing an electron pulse with the gas pulse, i.e., introducing an appropriate time delay of the electron beam, the reliability and accuracy of the completed instrument will be established. This will make possible studies of reflected beams with consequent determination of accommodation and viscous slip coefficients. These coefficients will be measured using varying parameters, such as molecular beam material and velocity, target materials, temperatures, orientations, etc. Extension of the method to visualization of beams of atmospheric gases will be tried if all goes well with cadmium or other metal atom beams at high energies.

Exploratory Fluid Dynamics (U), RR 009-02-0011. California Institute of Technology, Pasadena, California, Department of Aeronautics; Nonr 220(21), NR 061-102; H. W. Liepmann.

Experimental studies in the behavior of ionized and rarefield gases and of electrically conducting liquids are being made with the aim of clarifying the nature of basic physical phenomena involved and of testing the applicability of existing mathematical descriptions. Current work is concerned with the study of effusion of ions and electrons through a pinhole orifice in order to improve our understanding of plasma diffusion theory. In

addition, this task also will employ a hydromagnetic towing tank to make magnetohydrodynamic studies of forces on bodies moving through a liquid conductor in an axial field. Use will be made of sting mounted models instrumented for appropriate measurements and driven through a mercury column along its axis. Initial tests will concern drag measurements on a sphere.

Spherical Shock Tube (U), RR 009-02-0012. University of Toronto, Toronto, Canada, Institute of Aerophysics; Nonr 2335(00), NR 061-103; I. I. Glass.

Experiments on spherical shock waves are being made using the wave system originated by shattering a pressurized or evacuated glass sphere. The advantages of this technique lie in more reproducible specification of initial conditions and improved visibility of wave phenomena at the shock center. Either under investigation or proposed as research problems are studies of regular and Mach reflectors, refraction at plane contact surface, collisions of spherical shock waves with each other or with wire screens as well as explosions, spherical underwater explosions and spherical blasts in supersonic streams.

Hot Magnetohydrodynamics (U), RR 009-02-0013. AVCO Research Laboratory, Everett, Massachusetts; Nonr 2524(00), NR 061-105; A. Kantrowitz.

The basic dissipative mechanisms which occur in a plasma are important for determining the behavior of the plasma. Considerable evidence from high temperature plasma experiments indicates that the dissipation rates are much more rapid than would be expected on the basis of interparticle collisions. In these cases this results in a rapid diffusion of the plasma to the walls. Similar rapid diffusion processes would be of interest in astrophysical situations such as the penetration of gas streams from the sun into the earth's magnetic field. The experimental techniques involved are closely related to those used by Kolb at NRL, and Bleakney at Princeton, while techniques developed by this task relative to plasma diagnostics should find universal application in the field of rarefied gas dynamics.

Problems of Viscous Flow (U), RR 009-02-0014. Cornell Aeronautical Laboratory, Incorporated, Buffalo, New York, Aerodynamics Division; Nonr 2653(00), NR 061-106; F. K. Moore.

Research under this task is concerned with both low and high-speed viscous flows. The approach is chiefly theoretical, but critical experiments may be done from time to time. Current effort is directed toward the solution of problems in the following areas: (a) viscous shock layer, (b) the vorticity-interaction effect, (c) analysis of weak, nonequilibrium diffusive waves in the Rayleigh problems, (d) nonequilibrium chemical reaction in a steady boundary layer.

Heated Rarefied Gas Tunnel (U), RR 009-02-0015. Polytechnic Institute of Brooklyn, Brooklyn, New York, Aerodynamics Laboratory; Nonr 839(25), NR 061-107; A. Ferri.

The immediate aim of this task will be the fabrication of a tunnel which supplies hypersonic low density flows under conditions of thermodynamic equilibrium in the test section. The feasibility of a method for accomplishing this has been determined in previous study by this task. In essence, it involves the addition of energy into a flow which is already hypersonic. The basic flow is supplied by hypersonic wind tunnel now in use, the basic flow thus being at low static temperature. Energy addition will then be achieved in a manner which will not increase the static temperature of the flow above 6,000°R. In this way the flow with augmented total energy will remain undissociated; a further expansion of the augmented energy flow will then be established. Thus, the limitating velocity of the flow will be increased, while chemical equilibrium is maintained. In principle, this process may be repeated to provide further addition of energy.

Hypersonic Flow with Dissociation and Ionization (U), RR 009-02-0016. University of Michigan, Ann Arbor, Michigan, Aeronautical Engineering Department; Nonr 1224(31), NR 061-108; T. C. Adamson.

The objective of this task is the design and construction of an electric arc driven shock tunnel (with expansion nozzle) for the investigation of the effects of dissociation and ionization on boundary layer formation in high stagnation temperature hypersonic flows. Use will be made of X-ray absorption, schlieren, interferometer and spectrograph measurements in studying the dissociated boundary layer.

The Pumping of Rarefied Gases by Turbocompressors (U), RR 009-02-0017. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Mechanical Engineering; Nonr 1841(55), NR 061-109; A. H. Shapiro.

The general objective was to develop an understanding of the flow of highly rarefied gases through axial flow turbomachines. This understanding permitted evaluation of the merits of such a machine as a vacuum pump, and provided the basis for rational design. Theoretical calculations were made to establish how many stages were required as a function of pressure rise per stage, Reynolds number and volume rate of flow. An important advantage of this type pump, in contrast to diffusion pumps, is the extreme purity of operating atmosphere which are made possible.

Symposium on Magneto-Fluid Dynamics (U), RR 009-02-0018. National Academy of Sciences, Washington, D. C., Division of Physical Sciences; Nonr 2300(18), NR 061-110; J. S. Coleman

This task completed organization of a symposium on magneto-fluid dynamics.

Rarefied Gas Symposium (U), RR 009-02-0019. University of California, Berkeley, California, Engineering and Sciences Extension; Nonr 3114(00), NR 061-111; E. L. Downes, Jr.

This task provided support for the Second International Symposium on Rarefied Gas Dynamics held in August 1960 at the University of California, Berkeley, California.

Gas Lubricated Bearings (U), RR 009-02-0020. General Electric Company, Schenectady, New York,

General Engineering Laboratory; Nonr 2844(00), NR 061-112; B. Sternlicht.

This task is concerned with theoretical and experimental research to establish fundamental phenomena involved in gas lubricated bearing design.

Gas Lubricated Bearings (U), RR 009-02-0021. The Franklin Institute, Philadelphia, Pennsylvania, Laboratories for Research and Development; Nonr 2342(00), NR 061-113; D. D. Fuller.

This task is concerned with theoretical and experimental research to establish fundamental phenomena involved in gas lubricated bearing design.

Couette Flow with Slip (U), RR 009-02-0022. University of Washington, Seattle, Washington, Department of Aeronautical Engineering; Nonr 447(28), NR 061-114; R. E. Street.

To understand the aerodynamics of rarefied gas flows, simplified geometric flow conditions were studied. In spite of geometric simplifications, no simple criterion was found for predicting the point at which the Navier-Stokes equation fails. It is clear that somewhere between continuum flow and free molecule flow, the Knudsen number increases so that transition to the kinetic theory of gases must take place. The principle investigator established new equations for flow caused by two flat plates of infinite extent, at fixed separation, moving relative to each other at constant speed (Plane Couette Flow). Using a generalization of the Grad equations the principal investigator derived a set of equations valid for all Mach numbers and all Knudsen numbers. This task completed the solution by appropriate choice of boundary conditions.

Gas Lubricated Bearings (U), RR 009-02-0023. Illinois Institute of Technology, Chicago, Illinois, Department of Mechanics; Nonr 1406(06), NR 061-115; L. N. Tao.

The objective of this research is to pursue some theoretical studies of some specific problems in the fields of (a) gas lubricated bearings and (b) turbulent lubrication, that is, lubrication with turbulent flow with either a liquid or gas lubricant.

Bremsstrahlung in Plasma (U), RR 009-02-0024. New Mexico State University, University Park, New Mexico, Research Center; N9onr 953(07), NR 061-116; O. H. Theimer.

As a first approximation, it is usually assumed that, at any time of observation an electron in a plasma moves along a hyperbolic orbit in the unshielded Coulomb field of the nearest positive ion. The angular deflection associated with the orbit is assumed equal to the full deflection corresponding to an infinite interaction time. Actually, the field acting upon an electron is produced by many charges and only for very close encounters is the nearest neighbor contribution dominant. Furthermore, the time necessary for an electron to travel through a nearest neighbor zone is finite and, hence, insufficient to produce the full angular deflection given by Rutherford's scattering formula. This task will study this problem and calculate electron orbits with a minimum of "a priori" assumptions concerning the existence of a shielded nearest neighbor potential, the cutoff value of the collision parameter. The results will be used to calculate the low frequency Bremsstrahlung spectrum of a plasma which should be quite sensitive to the details of electron orbits. Numerical computations necessary for the proposed research will be carried out with facilities operated by New Mexico State University

AERODYNAMICS, Fluid Mechanics and Flight Dynamics - Aero., WR 009-02-003. Naval Ordnance Laboratory W/O, Allot (Task 002), R. E. Wilson, Naval Ordnance Laboratory W/O, Allot (Task 008), R. E. Wilson, Naval Weapons Laboratory, Allot, R. A. Niemann, National Bureau of Standards, IPR-19-61-8046 WEPS, G. B. Schubauer, University of Virginia, NOrd 18211, A. R. Kuhlthau, Office of Naval Research, Reqn. 19-61-5365 WEPS, H. Hayes.

To obtain a detailed understanding of phenomena affecting the flight of aircraft and air missiles and to develop and improve methods of accurately predicting their performance.

Wind tunnel, smoke tunnel, aerodynamic range and full-scale tests are performed as necessary to obtain experimental data. The results are correlated with associated analytical studies to confirm, extend, or modify existing theories and hypotheses. New problem areas are defined and investigated.

A program to investigate the momentum and energy exchanges taking place when gas molecules collide with solid surfaces in a rarefied atmosphere has continued. A molecular beam of adequate intensity has been developed and operated. The recent effort was devoted to developing devices for measuring the velocity distribution in the beam and to developing equipment to perform scattering experiments on rotating surfaces, for checking current theories. A test program to determine how the drag of a sphere is affected by dissociation of a gas at hypersonic speed was completed and the results are currently being analyzed. A test program for the study of boundary layer transition on cooled bodies was completed and a report is being prepared. A study to determine how the flow field adjacent to a body is affected by magnetic fields was recently initiated.

R009-03 Structural Mechanics

Analysis of Submarine Structures (U), RR 009-03-0001. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Aeronautical Engineering and Applied Mechanics; Nonr 839(14), NR 064-167; J. Kempner.

More accurate and practical procedures for calculating the strength of submarines are being sought, with emphasis on the analysis of non-circular hulls, conical and reinforced shells including the effect of axial loads, various possible modes of failure and development of improved criteria for frame and shell design. The following phases are being treated (a) analysis of frames with variable moment of inertia; (b) analysis of non-circular cylindrical shells; (c) investigation of large deflection theory including eccentricity; and (d) investigation of the effect of inelastic behavior upon the pressure.

Numerical and Approximate Methods of Stress analysis (U), RR 009-03-0002. University of Illinois, Urbana, Illinois, Department of Civil Engineering; Nonr 1834(03), NR 064-183; N. M. Newmark, A. S. Velestos.

Research under this task is investigating the range of applicability and merits of various approximate and numerical methods of stress analysis, with special reference to high speed digital computers, and in developing new and improved techniques when warranted. These methods are then applied to the solution of specific problems of current and general interest in such areas as stress and stability analyses, dynamic and impact analyses, and heat flow and numerical results are obtained over a sufficient range of the fundamental parameters to develop a fundamental understanding of their influence in a given problem. Wherever possible these results are reduced to a sufficiently simple form that they can be effectively used by the practicing engineer as a basis for design.

Specifically, the work includes: the development of new techniques for the numerical solution of boundary and sigenvalue problems; the analysis of shells under transient surface heating; the collapse of thin shells with time and temperature dependent properties; the collapse of elastically supported ring structures; the shock and vibration studies of multi-degree of freedom systems subjected to random excitation; and the dynamics of one-dimensional and plane stress systems, such as the transmission of shocks in visco-elastic materials.

Stress Analysis, Elastic Stability and Wave Propagation (U), RR 009-03-0003. Stanford University, Stanford, California, Division of Enginnering Mechanics; Nonr 225(29), NR 064-241; J. N. Goodier.

Studies are going forward on elastic stability, elastic waves, vibrations and stress analysis. The program includes (1) general theorems for thermal stress problems as adaptations of existing general theorems of unheated solids; (2) solutions of linear thermoelastic equations valid for simple heat flow in a conducting solid which is obstructed by an obstacle such as a cavity; (3) effect of stress on coefficient of therma expansion and its influence in thermal stress problems; (4) effect or propagation and successive reflections of a rotary pulse initiated at the inside or outside of a thick walled cylinder or an annular disk; (5) occurrence and characteristics of buckled patterns of cylindrical and spherical shells under end and lateral loads; (6) formation of permanent wave patterns of metal surfaces under rapid loadings; and (7) propagation of a disturbance along a chain of lightly coupled mechanical oscillators, and the propagation of flexural disturbances along a strip of edge-supported elastic plating.

Ultimate Strength of Welded Structures (U), RR 009-03-0005. Lehigh University, Bethlehem, Pennsylvania, Department of Civil Engineering; Nonr 610 (03), NR 064-345; L. S. Beedle.

The objectives of this engineering study covering research on welded continuous frame and stiffened plate structures and their component parts are as follows (a) to determine the strength of component parts of steel frames and of stiffened plating in the inelastic range and to develop theories to predict such behavior, (b) to develop methods for predicting the ultimate load-carrying capacity of continuous structures and to compute deformations in the plastic range, (c) to develop practical procedures for utilizing the reserve plastic strength, but with due regard to such additional considerations as fatigue, deflections brittle fracture, local buckling, lateral buckling, etc. The necessary experimental information is being obtained through a well planned series of full-scale tests on structural components in general and on certain ship-type stiffened panels in particular.

Mechanics of Granular Media and Elastic Vibrations (U), RR 009-03-0006. Columbia University, New York, New York; Nonr 266(09), NR 064-388; R. D. Mindlin.

Work under this task is directed to the development of approximate equations of motion for very high frequency vibrations of plates and bars, with initial emphasis on extensional vibration, and the anomalous behavior of the higher vibrational modes, at long wave lengths, leading to: zero-velocities at finite wave lengths; non-zero group velocities at infinite wave lengths; and the recently discovered (under this task) appearance of complex propagation constants associated with real frequencies.

Thermal Material Effects (U), RR 009-03-0007. National Bureau of Standards, Washington, D. C., Mechanics Section; NAonr 28-60, NR 064-400; B. Wilson.

An experimental investigation is being made to (a) develop strain measurement and testing techniques for use at elevated temperatures (to 4000°F) in a controlled atmosphere, and (b) using these techniques to determine the properties of materials, i.e., viscosity coefficients, stress-strain curves and Poisson's ratio, which can be used in the strength analysis of structures operating at high temperatures. Tensile and tensile creep tests will be made on a variety of metals, such as high purity molybdenum and tantalum and OFHC copper specimens, at elevated temperatures during which strain will be measured in three orthogonal directions over a volume area of the material. The maximum temperatures will be close to the melting point of the materials. The effect of rate of strain and of the specimen's width-thickness ratio on axial strain-transverse strain ratios will be determined.

Structural Effects of Time Dependent Loadings (U), RR 009-03-0008. Columbia University, New York, New York, Department of Civil Engineering; Nonr 266 (20), NR 064-401; B. A. Boley.

Research under this task is devoted to investigations of the effect of time-dependent loadings, including thermal loadings, on various types of engineering structures, and of general methods of stress and temperature analysis, as well as some of the tools of applied mathematics applicable to critical problems of applied mechanics. Currently being studied is the development of a solution for a bar under axial impact, according to a coupled thermoelastic theory, and the problem of the stress and flow interactions on the surface of a finite slab ablating from aerodynamic heating and undergoing both mechanically and thermally induced inelastic deformations. Also being investigated is a promising technique for establishing criteria for deter-

mining such quantities as the speed of stress propagation and the magnitude of discontinuities by numerical analysis of their Fourier and Laplace transforms.

Studies in Solid Mechanics (U), RR 009-03-0009. Brown University, Providence, Rhode Island, Division of Applied Mathematics; Nonr 562(10), NR 064-406; E. H. Lee, W. Prager.

Solid mechanics research under this task includes: development of methods of stress analyses for elastic and visco-elastic materials; the dynamics of crack propagation; the formulation of methods of design in the plastic range; and the determination of the influence of crystalline structure of metals on continuum behavior.

Transverse Impact on Plates and Shells with Internal Damping (U), RR 009-03-0010. Purdue University, Lafayette, Indiana, Division of Engineering Sciences; Nonr 1100(02), NR 064-410; A. C. Eringen.

Research studies are being made of the vibrations, dynamic deflections and stresses produced by dynamic loads on structural components. This research includes the development of exact and approximate mathematical methods for determining various moments and probability distribution functions of stochastic linear systems. Consideration is being given to determine the modes of vibrations, frequencies, displacements, stresses and bending moments in beams, plates, and shells resulting from purely random loading. The effect of internal damping is included. This uniquely appropriate investigation also includes studies of hydrodynamic noise, elastic dielectrics and elastic wave propagation.

Thermal Stresses in Shells (U), RR 009-03-0012. University of Illinois, Urbana, Illinois, Department of Theoretical and Applied Mechanics; Nonr 1834(14), NR 064-413; A. P. Boresi.

Now completed is work which was underway to develop a general theory of thermal stresses in shells, without restriction of symmetry. For the general development of the theory, the coefficient of thermal expansion and Young's modulus were regarded as functions of the temperature. However, inertia effects due to extremely rapid temperature changes were not considered. Also, attention was given to the treatment of thermal stresses in shells by the equilibrium equations for moments and tractions and the compatibility conditions. Applications of the theory to specific problems involving non-homogeneity was undertaken. Also, consideration was given to review the major shell theories and include an appraisal and comparison of the approximations employed in these theories.

Stress-Strain Relationships in Plastic Flow of Materials (U), RR 009-03-0013. Yale University, New Haven, Connecticut, Department of Civil Engineering; Nonr 609(12), NR 064-415; A. Phillips.

The object of this investigation is to (a) establish experimentally actual stress-strain relationships which occur in the yielding, creep, and relaxation of materials under various ratios of multiaxial stress and under various paths of loading and changing temperatures, and (b) to utilize the information thus obtained to discriminate among the several currently conflicting theories of plasticity as to their validity under differing loading histories, and their applicability to certain engineering problems of importance.

Combined tension and torsion tests under multiaxial stress have shown definite but quite obtuse yield surface corners which appear to move with the path of loading. Further tests will be run to determine the shape and condition for the occurrence of these corners, and the effects thereon of creep relaxation.

Structural Effects of Interactions Between Load and Temperature (U), RR 009-03-0014. Columbia University, New York, New York, Department of Civil Engineering; Nonr 266(34), NR 064-417; H. H. Bleich.

For materials responding visco-elastically to applied loads, research is underway on the propagation of longitudinal and surface waves in cylindrical shells and half-spaces, respectively, and on the non-linear vibration of bars and plates.

Problems in Elasticity (U), RR 009-03-0015. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Mathematics; Nonr 1841 (17), NR 064-418; E. Reissner.

It is planned to determine theoretically the stresses, deformations and response of elastic shells and other related structural components subjected to static and vibratory loads. This research includes studies on combined finite bending and twisting of plate strips, influence coefficients for circular shells of variable thickness, non-axially symmetric vibrations of shallow spherical shells, finite deflections of spherical shells, small deformation of helicoidal shells, and small deformations of thick circular shells.

Problems in Elasticity and Plasticity (U), RR 009-03-0016. Harvard University, Cambridge, Massachusetts, School of Applied Science; Nonr 1866(02), NR 064-420; B. Budiansky.

This study is investigating analytically stress-strain relations for strain-hardening polycrystalline materials, and attempting the solution of specific problems of stress-distribution, buckling and post-buckling behavior in the plastic range. In the stress-strain studies, which include the plastic behavior of strain-hardening thick walled tubes and the determination of the distribution of slip angles in plastically deformed polycrystalline materials, emphasis is being given to the physical approach which seeks to discover the stress-strain relations of plasticity on the basis of realistic physical models of the plastically deforming material. In the analysis of specific problems, solutions are being sought for the behavior of bodies containing plastic inclusions, the elastic-plastic behavior of bycrystals, the elastic-plastic buckling of clamped shallow spherical shells, and the formulation of an appropriate set of general equations for thin shells.

Thermo-inelasticity (U), RR 009-03-0018. Brown University, Providence, Rhode Island, Division of Engineering; Nonr 562(20), NR 064-424; D. C. Drucker.

An attempt is being made to establish a fundamental theory which will predict the stresses and deformations in structures and their life and strength as time proceeds and the loads and temper-

atures vary either slowly or rapidly. This program includes the following (1) a theoretical and experimental study of stress-strain-time-temperature relations with emphasis on varying stress and temperature; (2) experimental study of material strength including effects of creep and fatigue as influenced by time and temperature; (3) an attempt to obtain fundamental theorems and general procedures for the solution of problems; (4) solution of static problems with assumed stress-strain-time-temperature relations which will be improved as experimental information becomes available; (5) solution of dynamic problems as in (4); (6) small scale tests to guide and to check the solutions under (4) and (5); and (7) subsidiary problems such as special thermal effects and problems of heat transfer and their significance in terms of the stress-strain-time-temperature relations and the solutions of problems.

Structural Effects of Hypersonic Flow (U), RR 009-03-0019. Stanford University, Stanford, California, Division of Aeronautical Engineering; Nonr 225(30), NR 064-425; N. J. Hoff.

Research is underway to determine theoretically and experimentally the effects of hypersonic airflow on the surface and interior of structural elements. An effort is being made to develop theories that predict the temperature distribution in the metal, the melting rate and the stability of the melting process. This task also includes a study of the sublimation and burning of the surface of the structure, and behavior of such composite materials as a refractory in which metal, or asbestos fibers are embedded. The temperature history of the element and the deterioration of the surface will be investigated in the blow-down tunnel.

A blow-down wind tunnel with a capacity heater is being built for investigating the behavior of the surface of a structure when exposed to hypersonic flow. It will be possible with such a tunnel to obtain carefully controlled testing conditions with reasonably high ratios of heat transfer, and to simulate the distribution of thermal and mechanical loadings. A design has been made for a zirconium-oxide pebble heater, capable of producing an airflow of 1 lb. per second for a running time of 60 seconds at a temperature of 4000°F and a pressure of 2000 psi.

Structural Effect of Blast (U), RR 009-03-0021. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Aeronautical, Engineering and Applied Mechanics; Nonr 839(17), NR 064-427; J. Kempner, F. Romano.

An accurate method is being sought for determining the response of, and the stress distribution in shell-type structures subjected to dynamic loading. Work to be undertaken on the extension include the following (a) establish a theoretical dynamic analysis which will account for the actual initial deviations of the shape of the hull from the ideal circular cylinder, and (b) determine the actual damage mechanism and to investigate the effect of flattening of shells. Analytical studies will be continued in order to estimate the ability of submarines to resist a graduated scale of transverse and longitudinal shock waves.

Dynamic Strength and Behavior of Submarines and Ships Hulls Subjected to Underwater Explosions (U), RR 009-03-0022. Columbia University, New York, New York, Department of Civil Engineering; Nonr 266(08), NR 064-428; H. H. Bleich.

A rational theoretical analysis is being sought which will be applicable in designing for the strength of submarine and surface ships' hulls under the types of loadings to be expected from underwater explosions. Both transverse and axial loadings are being considered. Emphasis is being placed on the effect of large underwater explosions on surface vessels. For analysis purposes, the surface vessel is replaced by an idealized structure such as a rectangular box floating on the surface. To investigate the elastic-plastic response of a submerged or floating box structure, it will be necessary to obtain the values of the virtual mass of the fluid for the deformation modes of the box, and also the coupling terms if more than one mode is considered. A secondary problem to be studied is the longitudinal propagation of a shock wave in a conical shell. This problem is of interest because the ends of submarine hulls are long tapered or conical sections.

Structural Inelasticity (U), RR 009-03-0023. Illinois Institute of Technology, Chicago, Illinois, Department of Mechanics; Nonr 1406(04), NR 064-429; P. G. Hodge.

Research is being carried out to investigate theoretically the plastic response of plate and shell structures. An attempt is being made to determine (a) the static collapse loads of rotationally symmetric shells; (b) the dynamic response of rotationally symmetric shells; and (c) the plastic behavior of shells with cutouts. Theoretical plasticity research concerned with large deformations will be initiated. As it may not be possible to obtain closed form solutions, limit load analyses will be applied to find reasonably close upper and lower bounds.

Thermoaeroelastic-modeling (U), RR 009-03-0024. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Aeronautical Engineering; Nonr 1841(46), NR 064-430; R. L. Bisplinghoff.

An investigation is being made of the model scaling laws required for simulation of the aeroelastic phenomena in the presence of aerodynamic heating. The investigation included studying the effects of relaxing different scaling requirements and the determination of optimum model construction materials and scale factors. Consideration is being given to the change in elastic properties of the structures under the action of temperature and thermal stresses and to the possibilities of aerothermoelastic coupling mechanisms arising and requiring simulation. A study is being made of the types and sizes of physical facilities and techniques that can be utilized for aeroelastic testing in the presence of aerodynamic heating. It is also planned to initiate a theoretical and experimental study of the propagation of high intensity stress waves through isotropic materials as a result of impingement by high velocity particles.

Three-Dimensional Elasticity (U), RR 009-03-0025. Brown University, Providence, Rhode Island,

Division of Applied Mathematics; Nonr 562(25), NR 064-431; E. Sternberg.

Under this task, a theoretical study is being made of the three-dimensional state of stress in elastic plates of arbitrary thickness having simple and complicated loading conditions. More general approximate methods for dealing with three-dimensional stress concentration problems are also being sought. This research includes the determination of (1) inertia effects in transient thermoelastic problems; (2) effect of non-uniform time-dependent surface temperature in the vicinity of a boundary of a body of general shape; (3) exact determination of stress waves propagated in a spherical shell of arbitrary thickness; and (4) three-dimensional stress concentrations in elastic, anisotropic media.

ONR First Symposium on Naval Structural Mechanics (U), RR 009-03-0026. Stanford University, Stanford, California, Department of Mechanical Engineering; Nonr 225(35), NR 064-432; J. N. Goodier, N. J. Hoff.

Work under this task was to organize, conduct and report upon an unclassified symposium on Naval Structural Mechanics. Specifically, Stanford University organized the symposium, prepared and disseminated announcements and distributed the Proceedings.

High Temperature Effects (U), RR 009-03-0027. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Aeronautical Engineering; Nonr 839(23), NR 064-433; A. Ferri, J. Kempner.

Research under this task is investigating theoretically and experimentally the effects of hypersonic airflow on structural components. Emphasis is being placed on the following studies (a) ablation of surface through melting and mechanical action by the air flow; (b) ablation of the surface through vaporization and sublimation; (c) ablation of the surface through burning; (d) temperature distribution in loading-edge region of structure; and (e) changes in stress distribution and problems of structural stability arising from high thermal gradients and various flow (creep) in the structure.

The tests are being performed in the Freeport hypersonic facility of the Polytechnic Institute of Brooklyn. A maximum stagnation temperature of 3000°R has been reached with a maximum pressure of 600 psi and it is expected that higher temperatures of 4000° and 5000°R will be realized through the use of the compression heater. Models tested to date are 7 3/4 inches O.D. and a shroud technique is employed.

Dynamic Buckling (U), RR 009-03-0028. Stanford University, Stanford, California, Department of Aeronautical Engineering; Nonr 225(47), NR 064-434; N. J. Hoff.

Research under this task seeks to clarify the details of the buckling process in structures and structural components. Boundary conditions such as those corresponding to rapid load applications and to strain hardening elastoplastic material behavior are being explained experimentally and analytically, and the validity of the creep buckling theory of columns is being determined more definitely. A slight amount of time under this task will be devoted also to editorial work and minor technical clarifications pertaining to a book series on Airplane and Missile Structures being edited by Professor Hoff.

Stability of Shells (U), RR 009-03-0029. Southwest Research Institute, San Antonio, Texas, Department of Engineering Mechanics; Nonr 2650(00), NR 064-435; R. C. DeHart.

This investigation is determining experimentally the relative strength and stability of various structural arrangements and materials to arrive at the optimum combination of these parameters for the pressure hulls of oceanographic research and related type submarines having depth capabilities in the neighborhood of 20,000 feet. The geometries and materials under study include stiffened and unstiffened cylindrical and spherical shells of steel and aluminum and, as warranted, sandwich and other types of construction.

Guided by an initial and brief ad hoc review of appropriate shell theories, this model program of about 30 test units is expected to shed considerable light on the limits of applicability of such theories with increasing thickness and depth, and to culminate in the model test of an optimum design of 20,000 foot submergent oceanographic research vehicle.

Static and Dynamic Problems in the Elastic and Plastic Ranges (U), RR 009-03-0030. University of California, Berkeley, California, Engineering Mechanics; Nonr 222(69), NR 064-436; P. M. Naghdi.

The object of this task is to develop practical solutions for a series of important problems involving the elasto-plastic bending of plates and shells of revolution with large deflections, and certain other static and dynamic problems in the elastic and plastic ranges. In the problems involving plastic action, both the theory of deformation and the theory of flow will be utilized in the solutions as a check of their relative validity and the solutions obtained will be checked experimentally. Included in this program will be problems involving (a) the bending of elastic-plastic shells of revolution of various configurations under axial symmetric loading; (b) the effect of time dependent boundary conditions on structural response; (c) the development of approximate solutions in plasticity by application of variational principles; and (d) the examination of stress-strain relations in plasticity from the thermodynamic point of view.

Strength of Cylinder Intersections (U), RR 009-03-0031. Polytechnic Institute of Brooklyn, Brooklyn, New York, Department of Aeronautical Engineering and Applied Mechanics; Nonr 839(26), NR 064-437; J. R. M. Radok.

Research under this task is seeking to develop numerical methods of analysis for computing the stress, deformation and stability of areas around the normal openings in and intersections of circular cylinders under uniform external pressure. The study will include both single and multiple pairs of intersections, and infinite and finite cylinders with various edge support conditions. By methods of functional extrapolation recently developed by Dr. Radok, asymptotic solutions to

such static problems are also being sought by analytical or numerical deductions from an artifically introduced time dependency. The Computing facilities at NYU are being used in this research.

Analysis of Submarine Hulls with Cutouts (U), RR 009-03-0032. New York University, New York, New York, Institute of Mathematical Sciences; Nonr 285 (42), NR 064-438; E. Reiss.

Research is underway on the investigation of the response of shells, with and without cutouts, subjected to hydrostatic loading. Attention is being directed towards the development of a three-dimensional linear theory of elasticity, considering rotationally symmetric and unsymmetric deformations of cylindrical shells. Upon completion of the work concerned with rotationally symmetric deformations, the solutions of the exact theory will be compared to the results of the approximate linear shell theories. Following the research on linear elasticity, it is planned to initiate a general investigation on the non-linear deflections of cylindrical shells with particular reference to buckling problems. Appropriate boundary value problems will be derived, and approximate analytical (perturbation, ineration, boundary layer, etc.) and numerical methods (finite difference) for their solution will be developed.

Exploratory Research on New Structural Configurations (U), RR 009-03-0033. David Taylor Model Basin, Washington, D. C., Structures Division; Allot. #526, NR 064-440; E. E. Johnson.

Further exploratory tests will be carried out on novel structural configurations to be used in pressure hulls for deep submergence. Efforts will be made to (1) optimize the tube-type and web-type configurations by fabrication and testing of additional models in which the apparent shortcomings in the previous designs and fabrication techniques are corrected, (2) continue the exploratory nature of this research program by studying other types of sandwich cylinders such as steel shells with plastic cores or other arrangements of metal cores, (3) extend investigation of the application of glass-fiber reinforced epoxy resins, and (4) perform tests on titanium models under consideration in the ONR coordinated program of structures and materials research for deep submergence application. Some advance planning will also be given to studies on fabrication, welding techniques, the merits of riveted or bolted construction, static and dynamic response under combined loading conditions, vibration characteristics, impact strength, structural compressibility, improvement of strength-weight-ratios by use of other materials, bimetal arrangements, use of plastics with or without metal cores for improved acoustical and damping properties, and effect or reinforced openings for both plate and shell applications in naval structures.

Computer Services at the AEC's NYU Facility (U), RR 009-03-0034. U. S. Atomic Energy Commission, New York Operations Office, New York, New York; NAonr 19-60, NR 064-441; J. R. M. Radok, J. Kempner.

The purpose of this instrument is to provide funds for the reimbursement of the Atomic Energy Commission for the use of its IBM 704 computer at New York University by certain ONR contractors conducting basic research at other educational institutions, namely:

Contractor	Contract Nonr	NR No.	Chief Invest/Area
Polytechnic Institute of Brooklyn	839(26)	064-437	J. R. M. Radok/ Blast Shells
	839(23)	064-433	A. Ferri/Temp Effects
	839(17)	064-427	F. V. Pohle/Explosive Loading
	839(14)	064-167	J. Kempner/Hydrostatic Loading
Columbia U.	266(08)	064-428	H. H. Bleich/Explosive Loading
Princeton U.	1858(02)	047-017	O. Morgenstern/ Opt. Source of Mn.

Translation of Russian Monograph "Structural Mechanics in the USSR (1917-1957)" (U), RR 009-03-0035. Pergamon Institute, Inc., New York, New York; Nonr 2861(00), NR 064-442; G. Hermann.

Work under this task translated into English the authoritative Russian monograph "Structural Mechanics in the USSR, 1917-1957", edited by I. M. Rabinovich, Corresponding Member of the Academy of Sciences of the USSR and full member of the Academy of Structures and Architecture of the USSR. It was published in Russian by the State Publishing House of Structures and Architecture in Moscow in 1957.

Symposium on High Speed Aerodynamics and Structures (U), RR 009-03-0036. Stanford University, Stanford, California, Department of Aeronautical Engineering; MIPR 15-59, NR 064-443; N. J. Hoff.

Work under this task was to organize, conduct and report upon an unclassified symposium on problems arising in aeronautics and astronautics in consequence of high speeds and high temperatures. The subject contract permitted the participation in this presentation, as contributors, of the leading authorities of the world in the various phases of interest.

Propeller Blade Analysis (U), RR 009-03-0037. General Applied Sciences Laboratory, Inc., Hempstead, New York, Department of Applied Mechanics; Nonr 3072(00), NR 064-444; F. Lane.

It is proposed to investigate the static stress distribution in propeller blades having a wide range of planforms and various thickness, twist and camber distributions. The study will include typical ship and supercavitating configurations with arbitrary load distribution over the surfaces. The first year's effort was concerned with the development of a linear, thin shell theory. It is planned to develop a computer program for the IBM 704 for determining the stresses in a sector of the shell. A combination of finite-difference and Rayleigh techniques will be used in the theoretical analysis. The theoretical values of stresses will be compared to those obtained experimentally by DTMB.

2nd Symposium on Naval Structural Mechanics (U), RR 009-03-0038. Brown University, Providence,

Rhode Island, Department of Applied Mathematics and Engineering; Nonr 562(28), NR 064-445; E. H. Lee, P. S. Symonds.

The Second Symposium on Naval Structural Mechanics was held at Brown University on April 5, 6 and 7, 1960. The Symposium was concerned with the field of plasticity. It consisted of six sessions concerned respectively with:

1. Naval applications and basic physical theory
2. Stress-strain relations, thermoelasticity, and creep
3. Uniqueness and stability of solutions
4. Boundary value problems, and plates and shells
5. Dynamic loading and plastic waves
6. Design progress in steel frames, plates and shells.

Solid Propellant Mechanics (U), RR 009-03-0039. Columbia University, New York, New York, Department of Civil and Engineering Mechanics; Nonr 266(78), NR 064-446; A. M. Freudenthal.

Research under this task is investigating the mechanical behavior of solid propellant-like materials under a variety of loadings, particularly those which simulate the multiaxial stress conditions of actual service. The study is both experimental and theoretical and includes: structural and mechanical properties; principles of stress, deformation and failure; and critical analyses of technological test methods of mechanical evaluation.

Aero Structural Sciences (U), RR 009-03-0040. Columbia University, New York, New York, Department of Civil Engineering; Nonr(G)-0004-61, NR 064-447; B. A. Boley.

Research is to be carried out in structural mechanics with particular emphasis on aero-flight structures.

Mechanics of Viscoelastic Media (U), RR 009-03-0041. Brown University, Providence, Rhode Island, Division of Applied Mathematics; Nonr 562(30), NR 064-450; R. S. Rivlin, E. H. Lee.

With the objective of resolving basic problems related to the mechanics of solid propellant materials, research under this task will (a) extend the linear theory of visco-elastic media to a wider variety of problems in which more general types of boundary conditions exist; (b) develop a non-linear theory of visco-elasticity which is needed particularly for the investigation of the behavior of granulated materials; and (c) experimentally investigate relations between stress, strain and time of realistically simulated solid propellant materials, under both slow and rapid loading conditions.

New Experimental Techniques for Determining Strain in Filled Viscoelastic Materials (U), RR 009-03-0042. Southwest Research Institute, San Antonio, Texas, Department of Structural Research; Nonr 3363(00), NR 064-451; R. C. DeHart.

With the objective of developing new, adequate, and other than photoelastic methods of determining experimentally realistic strain conditions in solid propellant rocket motor grains, research under this task will investigate several techniques of promise, such as (a) embedding strain gages in the propellant grain during the casting process; (b) casting into the materials a grid system of reference points whose initial and subsequently varying relative positions are readily determinable by X-ray photography and isodensograph means; and (c) the use of radioactive gamma emitting particles to form the reference points of a grid system with the use of multiple arrays of collimated dectors. Both inert and live propellant formulations will be used and successful techniques will be thoroughly evaluated.

Bi-refringent Techniques for Measuring Strains in Pressurized and Thermally Loaded Filled Viscoelastic Materials (U), RR 009-03-0043. Armour Research Foundation, Illinois Institute of Technology, Chicago, Illinois; Nonr 3362(00), NR 064-452; A. J. Durelli.

Research under this task will develop new methods of photoelastic and photoviscoelastic analysis for determining states of stress and strain in pressurized and thermally loaded viscoelastic materials of the type used as solid propellant rocket fuels. Bi-refringent coatings and calibrated viscoelastic models of realistic configurations bonded to simulated casing rings will be thermally loaded and studied stress optically to evaluate non-linear elastic, viscoelastic, and three-dimensional effects on strain distribution. Optimum methods for various loading conditions will be delineated and summarized.

Development of Bi-refringent Materials and Embedded Polariscope Technique for Measuring Strain in Filled Viscoelastic Solids (U), RR 009-03-0044. New York University, New York, New York, Engineering Research Division; Nonr 285(50), NR 064-453; H. Becker.

For application to the determination of stress-strain conditions occurring in solid propellant rocket fuels, research under this task will (a) evaluate existing photoelastic plastics for use in photoviscoelasticity and photothermoviscoelasticity and search for new plastics for these purposes; (b) ascertain the utility of the embedded polariscope technique to the viscoelastic rocket grain problem; and (c) explore the details of stress-optic methods needed to obtain mechanical and thermal stress concentration factors in rocket grain configurations.

Random Vibration Research (U), RR 009-03-5750. U. S. Naval Research Laboratory, Washington 25, D. C.; FO2-13; R. O. Belsheim.

This task includes research on missile vibration simulation in the laboratory. It will yield a better understanding of why and how items fail in this environment, and also how to better ascertain their reliability from laboratory evaluation.

Development of Vibration Measuring Instruments (U), RR 009-03-5751. U. S. Naval Research Laboratory, Washington 25, D. C.; FO2-14; M. W. Oleson;

Various facets of rocket vibration instrumentation and data analysis are being pursued as a corollary to concurrent vibration measurements on specific vehicles. These facets include studies to determine the way in which vibration data can

be incorporated into equipment design and test, studies to determine analysis techniques which can provide the data in a useable form, and development of equipment to implement the techniques.

Methods for Design of Structures (U), RR 009-03-5752. U. S. Naval Research Laboratory, Washington, D. C.; F02-05; R. O. Belsheim.

This is a theoretical and experimental investigation on response of structures to transient loads, and methods of design-checking structures to resist these loads. At present it emphasizes linear, elastic response theory, using normal-mode and mechanical impedance techniques, which is being adapted for use in design-checking ship and/or submarine equipment subject to shock. Inputs are specified in an empirical fashion from available test data, as supplemented by laboratory and field experiments.

Vibro-Analysis of Materials (U), RR 009-03-5753. U. S. Naval Research Laboratory, Washington, D. C.; F03-01; S. D. Hart.

This task uses low amplitude acoustic vibrations to study the mechanical properties of materials. This has both a pure and applied science aspect. In the field of pure science, ultrasonic vibrations are being used to measure the elastic constants and internal damping of single crystals and other materials. In the practical field, ultrasonics are being used in nondestructive testing materials and for thickness measurements.

Studies of Shock, Vibration, and Their Instrumentation (U), RR 009-03-5754. U. S. Naval Research Laboratory, Washington 25, D. C.; F03-02; Irwin Vigness, E. W. Kammer.

Calibration techniques for acceleration pickups are being devised which will conveniently and accurately permit calibrations by means of transient acceleration pulses from maximum values between 1 and 20,000 g (g equals one unit of gravity or 32.2 ft/sec^2). Changes of thermoelectric power, of resistivity, and of resistivity with elastic and plastic strain, are being studied with relation to crystalline imperfections and impurities throughout a wide temperature range. A vibration machine of large capacity has been constructed and installed. Its performance will be evaluated for use as a test machine and a research tool. A large drop-table type shock machine has been installed. Techniques for obtaining acceleration pulses of various shapes (half-sine, sawtooth, etc.) will be studied.

Shock Strength of Materials (U), RR 009-03-5755. U. S. Naval Research Laboratory, Washington, D. C.; F01-02; Irwin Vigness, E. R. Seibert, N. J. Rendler.

This task was established to provide information concerning the properties of structural materials when subjected to rapidly applied loads. The factors to be determined are yield stress, delayed yield time, flow stress, elongation, inelastic microstrain, energy absorption, and cycles to failure. These factors are studied as a function of strain, strain-rate, duration of stress, frequency and number of cycles, previous history, and neutron flux exposure.

Shock and Vibration Centralization (U), RR 009-03-5756. U. S. Naval Research Laboratory, Washington, D. C.; K01-01; W. W. Mutch, H. C. Pusey.

The aim of the Centralizing Activity is to serve the Department of Defense and other government agencies and their contractors by the collection, correlation and dissemination of needed information on the environmental factors shock, vibration, temperature, pressure and radiation. In 1960 the emphasis has been on the mitigation of environmental hazards through protective construction. ICBM systems will suffer from induced environments whether they are designed for fixed, hardened, deployment or for mobile launching schemes. The development of advanced weapons systems will be accelerated by providing the technical workers in the field with new information as fast as it becomes known.

Structural Design Monograph (U), SR 009-03-1988. Southwest Research Institute; NObs 84333; Dr. R. C. DeHart.

The work involves the preparation of an index to the "Guide for the Analysis of Ship Structures" prepared under contract NObs 72286. The index will consist of two parts, an "Author Index" and a "Subject Index."

Seakeeping Monograph (U), SR 009-03-1990. Soc. Naval Architects and Marine Engineers; NObs 72373; Dr. B. Korvin-Kroukovsky.

The objective is to prepare a monograph starting with (1) the summary of knowledge of the properties of the complex seaway, to continue with (2) a discussion of the forces producing ship motions, (3) determination of motions, and to end with (4) an evaluation of dynamic and hydrodynamic loads imposed on a ship structure, and the resultant stresses.

The monograph has been completed and edited in book form. It is now in the printing press and copies are expected to be available in early 1961.

Brittle Fracture Mechanics (U), SR 009-03-1991. University of Illinois; NObs 65790; Prof. N. M. Newmark.

The objective is to observe the different nature of the strain pattern associated with slow fracture velocities.

Four 6 ft. wide plate specimens with high residual compression in the central region were tested. Speeds as low as 50 fps were recorded, and were associated with much smoother texture of the fracture surface. In the compressive zone, peak strain magnitudes decreased and the width of the strain-time pulses increased.

Future work includes further investigation of (1) the change in shape and extent of the strain field surrounding the tip of the advancing fracture, and at distances from the fracture, with changes in fracture speeds, and (2) the effect of redistribution of stress on the fracture process.

Low Cycle Fatigue (U), SR 009-03-1992. University of Illinois; NObs 77008; Prof. W. H. Munse.

The objective is to study the low-cycle, high strain fatigue behavior of materials and structural components of ship steels.

The initial experimental work has consisted of

tests from 0 to tension (constant load) on smooth and notched small-scale specimens at one cpm. The applied stresses required for failure, up to 500 cycles, were close to the ultimate tensile stress and a considerable amount of deformation occurred. Specimens subjected to sustained constant load or intermittently sustained cycles of load where the time at maximum load was held constant for each cycle, the number of cycles to failure varied considerably depending on the loading pattern applied and the time spent at maximum load.

Tests of 3/4" thick X 10" wide centrally notched specimens of rimmed steel are currently underway. The study of the fundamentals on small specimens will be continued for guidance in the planning and interpretation of subsequent tests.

Ship Response Statistics (U), SR 009-03-1993. Lessells & Associates, Inc.; NObs 77139; Mr. F. C. Bailey.

The objective is to accumulate strain-level data for statistical analysis in determining the frequency of the worst loads that occur on a ship.

An unmanned magnetic tape recorder has been installed aboard the S.S. HOOSIER STATE, a C4 dry cargo ship. The recorder will accumulate strain data 15 minutes in each 4 hour period. The instrument is being calibrated and checked during the first voyage by an operator with the aid of a play back recorder. The first voyage started 10 Nov 1960 and is on regular North Atlantic service.

Additional ships of different types will be instrumented as funds allow.

Model in Extreme Waves (U), SR 009-03-1994. Stevens Institute of Technology; NObs 78211; Prof. E. V. Lewis.

The objective is to determine the upper physical limit of longitudinal seaway bending moments by direct measurement on ship models in tank waves of maximum steepness, supplemented by theoretical calculations.

Preparatory work has consisted mainly of preparation of a tentative model lines drawing and preparing special instrumentation for the experiments.

The proposed work has been divided into two parts:

1. Complete study of one ship type in head and following seas for 3 extreme types of wave conditions: regular progressive gravity waves, steeper standing waves obtained by reflection, and extreme irregular waves with breaking crests.
2. Extension to two additional ship types, taking advantage whenever possible of the results of Part 1.

Slamming Studies (U), SR 009-03-1995. University of California; NObs 78253; Prof. H. A. Schade.

The objective is to investigate slamming pressures and structural responses (using beam, box girder and finally large scale box girder models with stiffened plating), and to develop and check corresponding theoretical predictions.

Existing work on hydrodynamic impact loading has been reviewed to permit evaluation of the impact loadings involved in slamming.

Experimental studies of response to impact are being made on a prismatic bar to check instrumentation.

Model studies will be conducted to determine the dynamic response to impact loading of box girders and of models representing ship type structures.

Coordination Service (U), SR 009-03-2004. National Academy of Sciences; NObs 72046; Dr. D. K. Felbeck.

The National Academy of Sciences supplies the necessary personnel and facilities, utilizes its existing committees, subcommittees, and other available facilities for advising, reviewing, editing, duplicating and distributing applicable investigator's reports, and advises the Bureau of Ships as contracting agency for the Ship Structure Commitee on research problems related to the improvement of the hull structure of ships.

Macrofracture Fundamentals (U), SR 009-03-2011. Brown University; NObs 78440; Prof. D. C. Drucker.

The objective is to study the effect of gross compressive strain upon the mechanical and metallurgical properties of steel and to relate these to steel embrittlement.

Major effort has been in the exploration of the concept of exhaustion of ductility and a continuation of tests on size effect in notched plates of E steel. The most interesting result obtained was the direct determination of the large loss in ductility produced by precompression of cylindrical bars to strains as high as 47%. A series of tests on bars which are bent very sharply to produce precompression gives considerable promise of leading to a field test of a simple type which can distinguish between steels that are prone to brittle fracture and those that are not.

Future plans are to continue the tests on exhaustion of ductility by precompression and by bending to include larger values of prestrain and a more systematic investigation of the effect of aging. Comparisons will be made between E steel and several commercially available steels to determine the difference in behavior.

Thermal Stress (U), SR 009-03-2012. University of California; NObs 78634; Prof. J. L. Meriam.

The objective is to formulate a satisfactory method for calculating ship hull stresses resulting from temperature gradients in three dimensions and having lateral restraint effects included.

One or more of the Boulder Victory conditions (a previous full scale test) will be simulated in a model and comparisons made. Stresses will be measured around transverse sections between bulkheads, at a bulkhead, and along a limited number of longitudinal lines, cover the effects of temperature gradients in all three directions. The response of the model at two different waterlines will also be investigated. The model tests will be accompanied by the development of theoretical solutions where as many of the boundary conditions as possible will be satisfied.

Work is underway on construction of a tank, preparation of instrumentation, and development of model plans.

Forces Imposed on Ship Moorings by Waves (U), YR 009-03-001. NCEL, Appn:17x1319.2514 RDT&E, Bu. Control No. 10601, J. T. O'Brien; California

co., Cooperative Program.

The objective is to obtain data on the forces induced on a moored ship by particular waves and to analyze these data toward generalizations, in order to improve the design of ships moorings. The principal elements causing concern in the design of safe mooring for vessels of the fleet, particularly in storm conditions are currents, wind and waves. While usable data is available on stresses imposed by currents and wind, no reliable data for forces induced by waves are available.

Forces Induced by Ocean Waves on Piles (U), YR 009-03-002. NCEL, Appn:17X1319.2514 RDT&E, Bu. Control No. 10601, J. T. O'Brien; California Research Corporation, NBy-3165, R. M. Meith & N. F. LeBlanc; National Engineering Science Co., NBy-3196, Dr. L. Skjelbreia.

The objective is to obtain data on the forces induced by particular waves on large piles and to analyze and publish this data for use by designers in order to improve the design of waterfront and offshore structures.

Experimental and analytical studies by the University of California on the forces and moments induced by waves on small laboratory size piles and a study by Texas A&M on wave forces on an 8" pile located in the open water in the Gulf of Mexico have been conducted. While these studies resulted in considerable data and useful analytic techniques, more information was considered to be desirable on forces and moments induced on large piles under field conditions where high waves were present, in order to check the validity of results obtained to date. Accordingly, a contract was entered into with the California Company (CALCO) for the purchase of data on the forces induced by 250 large hurricane type waves (heights up to 25 feet at periods of 10 seconds) on instrumented cylindrical piles of 1, 2, 3, and 4 feet diameter as fixed in water about 30 ft. deep in the Gulf of Mexico. Under this contract about 1000 charts containing plots of the experimental data using various arguments were obtained, along with 250 charts and tables indicating wave pressures induced in the piles by waves.

Buckling of Wedge-Beams under Combined and Direct Stress (U), YR 009-03-101. Columbia University, NBy 24967, Appn:17X1319.2504 RDT&E, Bu. Control No. 10696; Prof. W. J. Krefeld.

The objective is to formulate criteria predicting the load carrying capacity of wedge-beams under direct stress and bending.

An investigation of the buckling strength of wedge-beams in bending only has been carried on for a number of years at Columbia University under the sponsorship of the Welding Research Council. Bu-Docks contributed to the task prior to FY 59. Tests were conducted on a series of beams having both I and channel sections, with various dimensions, span lengths and degree of taper. Analytical formulae which could be used in practical work were developed.

Work in the past included: (a) Analytical studies to determine a simple expression for the Euler buckling load of tapered columns under pure thrust and experimental verification. (b) A survey of available results on the bending-thrust interaction problem for straight members with a view toward extending these results to tapered members. (c) Experimental determination of bending-thrust interaction curves for wedge beams having various tapers under end transverse loads and with an end brace on the top flange.

Development of Welding Procedures to Minimize Possibilities of Crack Development (U), YR 009-03-901. University of Illinois; Appn:17x1319.2504 RDT&E, Bu. Control No. 25/10696.

The objective is to develop welding procedures to minimize the formation of cracks on weldments.

Many attempts have been made by the welding industry to detect causes of cracking in welds and to formulate procedures which would minimize or eliminate the cracking. The Welding Research Council is coordinating the effort which has been concentrated on post-heat or thermal stress relieving treatments. Future phases of study include:

a. Preheating and interpass temperatures.
b. Significance of weld metal porosity.
c. Procedures for welding low-alloy steels.

R009-99 Other Engineering Mechanics

Theoretical Mechanics (U), RR 009-99-5800. U. S. Naval Research Laboratory, Washington 25, D. C.; B01-01; R. A. Toupin, B. Bernstein, L. A. Beaubien, H. M. Trent, L. Auslander (Consultant), T. Y. Thomas (Consultant), J. W. T. Youngs (Consultant).

The work of this group is entirely theoretical although, on occasion, we may collaborate with experimental physicists and engineers in other Sections of this Laboratory. The overall aim of our work is the formulation of mathematical theories of the mechanical and electromagnetic properties of elastic solids, plastic materials, and fluids. This work often requires the creation of new mathematical techniques for the solution of physical problems. Thus some of our reports are almost purely mathematical when it is thought that the mathematical techniques have an intrinsic interest and value. Some of our purely mathematical interests are differential equations, integral equations, potential theory, and tensor analysis.

Mechanism of Ballistic Damage (U), RR 009-99-5801. U. S. Naval Research Laboratory, Washington, 25, D. C.; F04-04; J. A. Kies, L. F. Campbell.

This is an analytical and experimental investigation to determine the mechanism of ballistic damage to metallic and non-metallic structures. Projectile velocity in excess of 24,000 ft/sec has been achieved and design of a light-gas accelerator calculated to produce velocities in the 30,000 ft/sec region is being considered. Ballistic damage effects include the study of cratering of thick targets using various combinations of projectile and target materials.

Theory and Application of Optimizations (U), RR 009-99-5802. U. S. Naval Research Laboratory, Washington 25, D. C.; F04-05; S. P. Thompson.

The distribution of anti-fragment body armor over a marine infantryman is studied as a problem in mathematical optimization. The current approach

is to evaluate numerically a definite integral which measures munitions effectiveness; parameters in the integrand specify the armor distribution, ballistic characteristics of the munition and its mode of delivery, and the shielding afforded by irregularities in the terrain. Work is anticipated in theoretical studies of the optimum means for enhancing, or suppressing, ballistic damage to guided missiles. The sponsors use results of these studies to guide their development effort.

R010 ENERGY CONVERSION

R010-01 Single-Step Energy Transformation

Secondary Loop Fluids for Aircraft Nuclear Propulsion Systems (U), RR 010-01-0002. North Carolina State College, Raleigh, North Carolina, Department of Engineering Research; Nonr 486(03), NR 099-341; A. C. Menius, Jr.

This investigation was undertaken to establish criteria for the evaluation of secondary cooling fluids in an aircraft nuclear propulsion system. The secondary cooling fluid is the heat transfer medium intermediate between the reactor coolant and the working fluid of the power plant. The scope of this investigation was limited by those conditions imposed by a range of reactor temperatures, reactor types, reactor coolants, and power fluids presently under consideration for aircraft nuclear propulsion systems. In addition the interrelationship of the secondary heat transfer fluids on the performance of the air radiator was studied. The results of a feasibility study for replacing the secondary heat transfer fluid by gas were published and a compilation of unclassified literature relative to the secondary heat transfer fluids were completed. (U).

Properties of Lithium (U), RR 010-01-0003. Stanford Research Institute, Menlo Park, California; Nonr 2117(00), NR 099-342; M. F. Parkman.

The contractor investigated the mechanics of corrosion and mass transfer of metals in a liquid lithium environment. The data obtained substantially corroborated the theory proposed to explain the dependence of these phenomena on the degree of lithium purity and the possible choice of container materials and inhibitors necessary to allow satisfactory operation of circulating lithium systems up to temperatures of 1800°F. (U).

Properties of Lithium (U), RR 010-01-0004. Nuclear Development Corporation of America, White Plains, New York; Nonr 2857(00), NR 099-344; B. Minushkin.

The contractor will investigate the factors which relate to the corrosion and mass transfer phenomena in high temperature liquid lithium systems. Solution and deposition phenomena will be studied using radiochemical techniques. (U).

Kinetics of Electrode Reactions (U), RR 010-01-0005. Western Reserve University, Cleveland, Ohio, Department of Chemistry; Nonr 2391(00), NR 359-277; E. Yeager.

The kinetics of the electrochemical reduction of oxygen, hydrogen peroxide, and halogens at carbon and metal electrodes are being studied. Anodic behavior of amalgams, metals, and hydrogen are also investigated. The techniques being used include determination of current-potential characteristics of electrodes, isotopic tracers (where applicable), current and voltage pulse methods and measurement of the alternating components developed in electrode potentials as a result of impressed sinusoidal pressure variations. Under investigation are alkali, alkali earth, and ammonia amalgams, and aluminum and magnesium metal electrodes. The anodic and cathodic properties of oxygen relative to defect properties of metal oxide surfaces are also being studied.

Silver-zinc Battery Research (U), RR 010-01-0006. Calvin College, Grand Rapids, Michigan, Department of Chemistry; Nonr 1682(01), NR 359-364; T. P. Dirkse.

Factors influencing the operation of the silver-zinc-alkali battery are investigated. The several phases of the investigation are (1) phase relationships of zinc-oxide/aqueous potassium hydroxide systems; (2) kinetics of the electrode reactions; (3) phase relationships of the several oxides of silver/potassium hydroxide systems; (4) electrode potentials of silver and its oxides in potassium hydroxide solutions; (5) effects of additions of other oxides on the performance of silver oxide.

Hydride Formation (U), RR 010-01-0008. City College, New York, New York, Department of Chemistry; Nonr 1597(02), NR 359-367; H. W. Salzberg.

The object of this task was the elucidation of the mechanisms of cathodic hydride formation. Hydrides were generated at cathodes of antimony, tin, lead, mercury, and bismuth under conditions of controlled current density, temperature, pH, and electrolyte concentration. Measurements were made of the hydrogen overvoltage of these systems to provide information on the mechanism of hydrogen evolution at cathodes. The results of these investigations were applied to problems associated with the negative electrode in the lead/acid storage battery.

Electrochemistry of Fused Carbonates (U), RR 010-01-0009. Rennselaer Polytechnic Institute, Troy, New York, Department of Chemistry; Nonr 591(10), NR 359-394; G. T. Janz.

The electrochemical and thermodynamic properties of fused carbonates are investigated. Attention is focused on the nature of the ionic species present in pure and mixed fused alkali metal carbonates; on the process of electrical conduction in such systems; on the temperature dependence of ionization and decomposition and other processes which may influence the conduction process; and on the charge transfer process at the metal/electrolyte interface.

Electrode Processes in Molten Salts (U), RR 010-01-0010. New York University, New York, New York, Department of Chemistry; Nonr 285(37), NR 359-396; B. Sundheim.

The electrochemistry of fused-salt systems is investigated with special emphasis on electrode processes associated with the reversible carbon monoxide electrode and on fused-salt thermocells. Information is sought on the role of transition-

metal carbonyls in the electrochemical oxidation of carbon monoxide; the effects of fused-salt compositions; the dependence of the cell reaction on temperature, current density, and other pertinent variables. A complementary investigation is made of the thermopotentials and thermal and electrical conductivities of a series of metal/fused-salt/metal thermocells.

Electrode Catalysts in Fuel Cell Operation (U), RR 010-01-0011. Alfred University, Alfred, New York, College of Ceramics; Nonr 1503(03), NR 359-399; G. J. Young.

An investigation is being made of the electrochemical oxidation of carbon-containing gases at temperatures below 100°C using aqueous electrolytes. Examples of the gases being studied are carbon monoxide, methane, ethane, ethylene, and acetylene. Special attention is given to the study of catalysts which promote such oxidation and to the theoretical basis for the catalytic action. To elucidate the mechanism of the oxidation process, a study is also being made of the chemisorption of the carbon-containing gases as a function of electrode composition and geometry.

Conversion of Nuclear Fission Heat in Plasma Diodes (U), RR 010-01-0012. General Motors Corporation, Warren, Michigan, Research Laboratories; Nonr 3109(00), NR 099-345; F. E. Jamerson.

General Motors Research Laboratories propose to investigate the direct conversion of nuclear fission heat to electricity in a plasma diode. This device will use fission fragments from a uranium bearing cathode to produce ionization in noble gases. Calculations show that the ionization of these gases will effectively neutralize the space charge generated by the emitting cathode.

The principal lines of investigation include the following:

(a) Thermionic emission studies of uranium carbide in vacuum.

(b) Power characteristics (no external voltage source) of diodes using Ta and UC cathodes and low work function anodes (such as impregnated tungsten) will be measured in vacuum and noble gas environment.

(c) Heat transfer study of second reactor cell.

(d) Investigate arc melting techniques for fabricating UC, ZrC, and UC-ZrC alloys.

(e) Continue theoretical analysis of a thermionic diode utilizing fission fragment ionization to reduce the space charge limitations.

(f) Design and operate reactor cell pre- and post-irradiation to determine cell characteristic in the absence of fission fragment ionization.

(g) Operate reactor cell in-pile.

Direct Conversion Reactor Study (U), RR 010-01-0013. North American Aviation, Incorporated, Canoga Park, California, Atomics International Division; Nonr 3192(00), NR 099-346; N. S. Rasor.

Atomics International will conduct a study to determine the feasibility of using a thermionic diode for direct conversion of heat to electrical power in large nuclear power plants.

Cesium-Cell Element (U), RR 010-01-0014. General Atomic, San Diego, California, Division of General Dynamics Corporation; Nonr 3193(00), NR 099-347; R. W. Pidd.

General Atomic will build, operate, and obtain performance data on a cesium-cell element, the design of which is applicable to direct conversion of heat to electricity. Electric heating will be used instead of nuclear heating.

Remote Underwater Reactor (U), RR 010-01-0015. U. S. Atomic Energy Commission, Oak Ridge, Tennessee, Reactor Division; NAonr 33-60, NR 099-348; M. Rosenthal.

The Oak Ridge National Laboratory completed a feasibility study of a remote operated, unattended nuclear power plant producing 1-3 MW(e) power. Emphasis was placed upon conventional (rotating machinery) energy conversion as opposed to direct conversion designs. It was concluded that a reliable, simplified, pressurized-water system based on present technology would be constructed to produce one electrical megawatt.

Thermoelectric Nuclear Power (U), RR 010-01-0016. Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, Astronuclear Laboratory; Nonr 3216(00), NR 099-349; R. C. Cunningham.

The contractor studied the feasibility of a 3 MW(e) Nuclear/Thermoelectric power plant for long life, submerged, unattended operation, identifying probable capabilities of the device and problems requiring major engineering effort. Critical materials solutions and design approaches which could lead to solutions to the problems were indicated. Major effort was centered on a low temperature (575°F) water system, with secondary consideration given to a higher temperature (1100°F) system. The study concluded that the low temperature power plant concept was feasible. In addition parametric studies were completed concerning the most efficient and lowest cost plants.

Magneto-Thermionic Diode (U), RR 010-01-0017. Republic Aviation Corporation, Farmingdale, Long Island, New York; Nonr 3285(00), NR 099-350; A. Schock.

Republic Aviation Corporation proposes to experimentally measure the effect of magnetic fields (both self-induced and applied) on a thermionic power generator.

Plasma Thermionic Converter (U), RR 010-01-0018. North Carolina State College, Raleigh, North Carolina, Department of Engineering Research; Nonr 486(07), NR 099-351; A. C. Menius, J. S. Doolittle.

The contractor's work will be divided into three phases as shown below:

Phase I - Review ongoing research in the plasma type thermionic converter area. Emphasis will be placed on instrumentation and measurement techniques currently employed.

Phase II - Design and construct experimental converters, with design oriented toward instrumentation.

Phase III - Conduct an extensive experimental and theoretical program to investigate the dependence of converter efficiency on the many variables of a vapor diode converter unit and system.

Direct Conversion Nuclear Reactors (U), RR

010-01-0019. Texas Instruments, Incorporated, Dallas, Texas; Nonr 3344(00), NR 099-352; R. A. Chapman.

The contractor will study the heat transfer and nuclear characteristics of thermoelectric direct-conversion nuclear reactors. These studies will be used to determine the optimum design for a water-moderated UO_2 fueled reactor. By considering different fuel element geometries the range of thermoelectric design parameters, as constricted by reactor design variables, will be determined. Reactor-converter couplings can be achieved by placing the converter elements either outside or inside the core. The latter case is of primary interest in this study.

Parametric Study of Direct Conversion Reactor Systems (U), RR 010-01-0020. General Atomic, San Diego, California, Division of General Dynamics Corporation; Nonr 3371(00), NR 099-353; R. C. Howard.

General Atomic will conduct a parametric study of the coupling of thermionic converter devices to nuclear reactors for direct conversion-nuclear power systems.

Thermal, Mechanical and Environmental Characteristics (U), RR 010-01-5600. U. S. Naval Research Laboratory; E02-01; D. Friedman.

This task is concerned with the use of semiconductor surface coatings as a means of controlling the temperature of satellites and space vehicles. The fundamental thermal and thermodynamic characteristics of photovoltaic cells to be used in space applications are also being studied. Work has been carried out to determine how accurately actual thermocouple performance could be predicted by the analytical equations used to design entire thermoelectric systems. Results showed that over a limited temperature range, results checked to within a few percent.

Advanced Energy Sources and Conversion (U), RR 010-01-5601. U. S. Naval Research Laboratory; E02-02; W. H. Lucke.

This task is divided into three phases:

Thermoelectricity - This phase consists of theoretical studies of basic thermoelectric processes and experimental determination of material and device characteristics. Magnetofluiddynamics (MFD) - This study stresses the direct extraction of electrical energy from flowing ionized liquids or gases in magnetic fields and conversely, the utilization of electromagnetic energy to cause flow of these ionized fluids to produce thrust or pumping action. Solid State Electrical Power Conversion - Work on electrical dc to ac and ac to ac conversion using transistor-switched magnetic cores has resulted in a single phase square wave output circuit with efficiencies above 90 percent. This circuit may be synchronized with a constant frequency reference. This work is to be extended to three phase devices.

Distillate Fuels Research (U), RR 010-01-5850. U. S. Naval Research Laboratory, Washington, D. C.; C01-03; H. W. Carhart.

This task was established with the view toward providing better distillate fuels, increasing their availability and improving the performance of available fuels. Emphasis at present is given to (1) basic studies on the liquid-phase oxidation of fuels and hydrocarbons and other organic compounds; (2) flammability characteristics of such materials, both spontaneous and induced; (3) basic studies of vapor-phase oxidation of hydrocarbons; and (4) studies of the generation and separation of static electrical charges during the flow and handling of fuels and allied liquids.

Liquid Propellant Properties (U), RR 010-01-5851. U. S. Naval Research Laboratory; C01-05; H. W. Carhart.

Studies on the supercooling of hydrazine have shown that extreme care must be used to exclude moisture and suspended particles but that a freezing point of -70°C can be attained using proper experimental precautions. Tetrafluorohydrazine is insoluble in ClF_3, BrF_5, BrF_3 and IF_3 below 0°C. About 6% N_2F_4 dissolves in ClF_3 at 20°C and about 9% dissolves in BrF_5 at 35°C.

Solid Slow Burning Fuels (U), RR 010-01-5852. U. S. Naval Research Laboratory, Washington, D. C.; C01-06; R. R. Miller.

A number of small units using solid slow burning fuels were developed to run gas turbines and to pressurize dynamic systems. Drawings and specifications of units developed were included in the final report to Bureau of Ships.

Studies of the Fuel-Water System (U), RR 010-01-5853. U. S. Naval Research Laboratory, Washington, D. C.; C01-11; H. W. Carhart.

This task was established to investigate the fundamental characteristics of the fuel-water system. In particular it is aimed at defining better the nature of the interface and at elucidating physicochemical interactions which occur at such boundaries and in the bulk fluids. Among properties being investigated are the force-displacement characteristics obtained on the rupture of interfaces, the effects of displacement rate on rupture, the examination of the breaking of emulsions and the water wettabilities of different solids in the presence of different fuels and fuel-additive combinations.

Reactor Shielding (U), RR 010-01-5854. U. S. Naval Research Laboratory, Washington, D. C.; H01-13; L. A. Beach.

The Monte Carlo Technique is applied to solve various specific shielding problems of immediate interest whose geometrical factors prevent solution by more conventional techniques. This technique utilizing the NAREC, a fast electronic digital computer, is used to estimate the albedo or reflected radiation when gamma radiation is incident upon reactor materials, such as iron, concrete and water. In addition this technique is used to estimate the transmission of gamma radiation through thick slab shields of such typical materials as lead, iron, concrete and water. Results for other materials can be obtained by substitution of proper absorption coefficients into these general codes.

Reactor Operations (U), RR 010-01-5855. U. S. Naval Research Laboratory, Washington, D, C.; H01-14; J. O. Elliot.

This task covers the scientific and administrative supervision of the NRL research reactor. The staff operates the reactor to provide neutron flux to experimenters routinely 80 hours-per-week with a minimum of down-time for maintenance. The staff also provides consultation service to potential experimenters in the design of experiments to insure that they are compatible with safe reactor operation.

Reactor Studies (U), RR 010-01-5856. U. S. Naval Research Laboratory, Washington, D. C.; H01-15; J. O. Elliot.

Experimental and theoretical investigations are carried out in fields of advanced reactor technology - especially, direct conversion, marine propulsion, safety aspects of reactors and measurement of flux and neutron spectra in high flux reactors. Work in these fields performed by private industry for the Navy is reviewed and evaluated.

Single Step Energy Transformation (U), WR 010-01-001. Naval Ordnance Laboratory; 73-212; Mr. M. A. Knight (RAAE-511).

The objective of this task is to conduct the advanced research and development necessary to provide electric power for planned weapon systems, equipment and installations where conventional electro-mechanical generating systems are not adequate and utilizing all forms of available energy.

The direct conversion of energy to electric power, although old in general theory, is relatively new in known knowledge of the fundamental concepts. Energy sources for conversion to electric power includes heat from fossil fuels, the sun and nuclear energy; the free energy content of chemicals; and solar and nuclear radiation. Primary conversion methods include thermoelectric, thermionics, magnetohydrodynamics, photovoltaic, fuel cells and ferroelectrics.

The primary endeavor of research in each conversion method area is to obtain a full understanding of the fundamentals and phenomena which affect and control the conversion process.

Energy Studies (U), YR 010-01-001. Contractor has not been assigned.

The objective of this task is to investigate the potential of Fuel Cells and Thermoelectric Energy and develop required techniques to adapt them to the Bureau's use.

R010-02 Multi-Step Energy Transformation

Heat Transfer and Fluid Flow Studies (U), RR 010-02-0001. University of Minnesota, Minneapolis, Minnesota, Mechanical Engineering Department; Nonr 710(14), NR 090-324; E. R. G. Eckert, J. P. Hartnett.

In many applications and especially in high energy propulsion systems the limiting problem is that of maintaining a tolerable surface temperature in the high temperature components. Under this task studies are being made of the fluid flow and heat transfer at surfaces and of means for cooling such surfaces.

8th Combustion Symposium (U), RR 010-02-0002. Combustion Institute, Pittsburgh, Pennsylvania; MIPR 16-60-ONR, NR 090-336; B. Lewis.

This task is to provide for partial support of the 8th International Symposium on Combustion which was held at the California Institute of Technology in Pasadena, California, between August 29 and September 2, 1960.

Thermophysical Properties Research (U), RR 010-02-0003. Purdue Research Foundation, Lafayette, Indiana; Nonr 1100(09), NR 090-341; Y. S. Touloukian.

The objective of this task is to collect, and in some cases generate, analyze, evaluate, assemble, and supply thermophysical data on materials of interest to the Navy.

Studies in Heat Transfer and Thermodynamics (U), RR 010-02-0004. Stanford University, Stanford, California, Department of Mechanical Engineering; Nonr 225(23), NR 090-342; A. L. London, W. M. Kays.

The purpose of this task is to investigate experimentally and analytically several problems in both heat transfer and thermodynamics as follows:

(a) Heat Transfer - (1) heat transfer from rotating surfaces, (2) influence of ultrasonically induced cavitation on liquid convection, (3) measurement of the heat transfer rate from one surface to the other of a hollow oscillating piston partially filled with a liquid, (4) continuation of the compact heat transfer surface investigation, (5) heat transfer and flow friction behavior for a matrix consisting of few rather than many rows, (6) effect of gravity forces on forced convection.

(b) Thermodynamics - (1) electrical analog studies of the transient behavior of heat exchangers, (2) cycle studies of the influence of charge conditions in supercharged internal combustion engines.

Heat Transfer in Critical Regions (U), RR 010-02-0005. Technische Hochschule, Munich, Germany; N62558-1906, NR 090-343; E. Schmidt.

Experimental investigation of heat transfer by liquids in the neighborhood of the critical point.

Heat Transfer from Ionized Gas to a Gaseous Coolant (U), RR 010-02-0006. Princeton University, Princeton, New Jersey, Department of Aeronautical Engineering; Nonr 1858(31), NR 090-344; J. Grey.

The purpose of this task is to investigate theoretically and experimentally certain transport properties of gases, with particular emphasis on diffusion and heat transfer, from a hot ionized plasma region whose boundaries are in contact with a gaseous coolant. The particular conditions of extreme temperature gradients, large ionized fractions, high radiation intensities, and nonequilibrium flows, together with the possible application of magnetic fields in some design configurations will be investigated.

Thermodynamics of Engines (U), RR 010-02-5900. U. S. Naval Research Laboratory, Washington, D. C.; F05-01; C. D. Porter.

The powered whirling arm has been enlarged and strengthened to accommodate various vehicles for "g" loading tests up to 100g for agencies such as

NASA and APL.

The laboratory facility has been converted to a hypervelocity range with installation of a light-gas gun. Plans are underway for a facility for conducting shaped charge experiments. The current work has been suspended.

R010-04 Energy Utilization

Aeronautics Publications Programs (U), RR 010-04-0001. Princeton University, Princeton, New Jersey, Aeronautics Publication Program; Nonr 032-(01), NR 094-102; C. D. P. Donaldson.

This task calls for the publication of a series of graduate level textbooks, incorporating the work of many scientists and engineers during and since World War II in the fields of high speed aerodynamics and jet propulsion. The effort attempts to correlate many reports, notes, lectures, and studies in a compact, useable, and readily available reference form. When completed, there will be twelve volumes in the series, as follows:

I	Thermodynamics and Physics of Matter
II	Combustion Processes
III	Fundamentals of Gas Dynamics
IV	Theory of Laminar Flows
V	Turbulent Flows and Heat Transfer
VI	General Theory of High Speed Aerodynamics
VII	Aerodynamic Components of Aircraft at High Speeds
VIII	Problems and Experimental Methods in High Speed Flight
IX	Physical Measurements in Gas Dynamics and Combustion
X	Aerodynamics of Turbines and Compressors
XI	Design and Performance of Gas Turbine Powerplants
XII	Jet Propulsion Engines

Rocket Motor Performance Studies (U), RR 010-04-0003. Purdue Research Foundation, Lafayette, Indiana, Department of Mechanical Engineering, N7onr-39418, NR 094-192; M. J. Zucrow.

This task is an experimental and analytical study concerned with the operation, performance, heat transfer, and combustion phenomena of liquid propellant rocket motors at various combustion pressures ranging from very low pressure, on the order of 30 to 50 psia, to very high pressure, on the order of 2,000 psia. (U)

Investigation of Gas Driven Jet Pump (U), RR 010-04-0006. Purdue Research Foundation, Lafayette, Indiana, Department of Mechanical Engineering; Nonr 1100(07), NR 094-341; M. J. Zucrow.

This task consists of an experimental and theoretical investigation of a new type of jet pump in which a liquid is driven by compressed gas.

Gas Turbine Studies (U), RR 010-04-0007. Sundstrand Corporation, Pacoima, California; Nonr 2292 (00), NR 094-343; O. E. Balje.

The purpose of this program is to conduct an analytical and experimental program to study turbine design parameters for conditions existing when operating in space or under extremely low back pressure conditions.

New Propulsion Systems (U), RR 010-04-0008. Aerochem Research Laboratories, Incorporated, Princeton, New Jersey; Nonr 2773(00), NR 094-344; H. F. Calcote.

This task involved a survey and comparative evaluation of advanced "unconventional" propulsion systems to show where they fit into the engine spectrum picture. Its objective was two-fold; first, to ascertain which systems were feasible for future propulsion and second, to point out problem areas for research, in order that ONR might help to make feasible systems practical. The main systems analyzed and compared to each other and existing propulsion systems were (a) high altitude ramjets, (b) liquid or metallic hydrogen fueled rockets, (c) electrostatic propulsion or ion-rockets, (d) magnetogasdynamic propulsion, (e) nuclear electronvoltaic power plants employing semiconductors, and (f) solar energy conversion schemes, including simple thermo-boilers. (U)

Reasonant Combustor (U), RR 010-04-0009. Hiller Helicopters, Palo Alto, California; Nonr 2458(00), NR 094-345; R. M. Lockwood.

The purpose of this program was to investigate the characteristics and performance of a new concept of a resonant combustor. The device investigated was a multiple side inlet injector type resonant combustor. Preliminary tests of such a combustor indicated that as compared to a conventional valveless pulsejet, it had more complete and faster mixing of fuel and air, faster and more complete combustion, higher resonance rate, a fixed and shorter amplitude of resonance, and a higher pressure rise.

Two Phase Flow (U), RR 010-04-0010. Purdue Research Foundation, Lafayette, Indiana, Department of Mechanical Engineering; Nonr 1100(14), NR 094-346; M. J. Zucrow.

There are two phases to this work:

Phase I - The objectives of this research problem is the accurate determination of convective and total (including radiation) heat transfer coefficients for gases flowing turbulently in round tubes with large temperature differences existing between the tube wall and the gas. This investigation is being conducted over a wide range of gas bulk temperatures, gas pressures, and gas Reynolds numbers.

Phase II - The object of this investigation is to obtain a fundamental understanding of the interaction between a high velocity gas stream flowing in the core of a tube and a liquid film flowing along the wall of the tube. Specific objectives include the determination of the influence of the mean liquid film thickness and the structure of the liquid - gas interface upon the characteristics of the gas flow and the static pressure gradient in the gas stream.

Compact Charge Exchange (U), RR 010-04-0011. Curtiss-Wright Corporation, Quehanna, Pennsylvania, Research Division; Nonr 2886(00), NR 094-347; E. N. Petrick.

It was the purpose of this task to conduct an analytical and experimental program on various ion emitters, with the objective of obtaining optimum ion beam current conditions.

Pulsed Plasma Studies (U), RR 010-04-0012. Republic Aviation Corporation, Farmingdale, Long Island, New York; Nonr 2851(00), NR 094-348; A. E. Kunen.

It is the purpose of this task to investigate analytically and experimentally the methods of creating a pulse of plasma and driving it from a nozzle by means of an electrical discharge at frequencies up to 1000 pulses per second. This may be a useful space propulsion device providing it can be pulsed with sufficient rapidity. Primarily, two methods of pulsing are to be investigated (1) gas dynamical, using the generated shock and rarefaction waves of the first pulse to refill the pinch volume for the second pulse, and (2) an electronic switching device using the reversing polarity of the discharging capacitors. Both the above systems have severe practical limitations at the present time. This analytical and experimental investigation will attempt to overcome these limitations. (U)

Gaseous Thrust Control (U), RR 010-04-0013. Massachusetts Institute of Technology, Cambridge, Massachusetts, Naval Supersonic Laboratory; Nonr 1841(61), NR 094-349; J. R. Markham.

This task was to ascertain analytically and experimentally the feasibility of controlling the thrust vector of a rocket by means of injecting a secondary gas into the main stream of rocket gases, at or near the rocket nozzle throat. The secondary gas injection aerodynamically alters the size, and/or shape of the nozzle throat. This in turn can alter the thrust produced as well as its resultant direction. This task endeavored to ascertain how much secondary gas (in relation to primary gas) was necessary to control the thrust vector by a given amount. Also considered was the optimum configuration and position of the secondary flow ejectors. (U)

Arc Plasma Studies (U), RR 010-04-0014. Purdue Research Foundation, Lafayette, Ind., Department of Mechanical Engineering; Nonr 1100(17), NR 094-350; M. J. Zucrow.

This task is an analytical and experimental study of the nature of hot gas plasmas created by gas flowing through an arc. In particular, the study will concern the nature of hot gas plasmas as applied to jet propulsion, the determination of the characteristics of flow of hot gas plasmas through nozzles, and some of the heat transfer problems associated therewith.

Axial Flow Compressor (U), RR 010-04-0015. California Institute Technology, Pasadena, California, Mechanical Engineering Laboratory; Nonr 220(23), NR 097-001. W. D. Rannie.

These axial compressor investigations are concerned with stalling phenomena and with the deviations of flow from the idealized perfect fluid model, in particular the secondary flows resulting from wall boundary layers.

Investigation of Fluid for Power Cycles (U), RR 010-04-0017. Massachusetts Institute of Technology, Cambridge, Massachusetts, Division of Sponsored Research; Nonr 1841(14), NR 097-340; W. H. Rohsenow.

This task was directed toward a theoretical analysis of the physical, chemical and thermodynamic characteristics of various fluids to determine their suitability as working fluids for closed power cycles. Previous attempts to develop power cycles using special fluids were analyzed to ascertain reasons for their failure. Optimum fluids for power cycles for various temperature ranges and special applications were recommended. Available thermodynamic data for optimum fluids were examined and basic research as found necessary was recommended to determine design parameters and obtain values for these parameters.

Two-Phase Two-Component Flow Phenomena (U), RR 010-04-0021. Massachusetts Institute of Technology, Cambridge, Massachusetts, Division of Sponsored Research; Nonr 1841(52), NR 097-345; J. Kaye.

This is an analytical and experimental study of the two-phase two-component flow phenomena encountered in the mixing of a partially condensible jet with a uniformly moving fluid.

Gas Turbine Studies (U), RR 010-04-0023. Massachusetts Institute of Technology, Cambridge, Massachusetts, Gas Turbine Laboratory; Nonr 1841(13), NR 097-347; E. S. Taylor.

In the flow through compressors, turbines and similar machinery, boundary layer behavior governs not only the losses but also the range of useful operation. Study of the flow in the boundary layer has shown that it is generally skewed. Studies will continue on separation and stall with skewed boundary layer.

Radial-Flow Gas Turbine Wheel Cooling Study (U), RR 010-04-0025. The Garrett Corporation, Los Angeles, California, AiResearch Manufacturing Division; Nonr 2849(00), NR 097-349; W. T. Von der Nuell.

This is an analytical and experimental investigation of methods of turbine wheel cooling in radial-flow gas turbines with initial emphasis on boundary layer cooling techniques.

Study of a Fundamental Equation for Properties of Steam (U), RR 010-04-0026. Massachusetts Institute of Technology, Cambridge, Massachusetts, Department of Mechanical Engineering; Nonr 1841(60) NR 097-350; J. H. Keenen.

This is an investigation of the possibility of finding a fundamental equation for steam which would be manageable in view of modern computing techniques and machines.

This task demonstrated how Tchebichef polynomials can be used successfully to provide the basis for a fundamental equation for steam at temperatures in excess of the critical temperature over the entire useful range of densities. This represented a substantial advance in precise formulation of the properties of water in a form suitable for use in computers. Attempts were also made to extend this type of formulation to temperatures below the critical temperature. These attempts proved unsuccessful and indicated that some substantial change in mathematical technique is called for if this difficult region is to be formulated in a convenient way.

Project SQUID (U), RR 010-04-0027. Princeton University, Princeton, New Jersey, James Forrestal Research Center; Nonr 1858(25), NR 098-038; J. B. Fenn.

Project SQUID consists of an organized effort of directed fundamental and applied research in certain fields of science that are closely related to jet propulsion. It was conceived and initiated in order to aid in the development of various jet propulsion devices. Emphasis is placed on investigations of fundamental processes rather than on engineering development, and thus the probability is enhanced for uncovering new ideas and engine configurations and aiding in the development of various jet devices. The studies center, for the main part, on combustion problems and the application of combustion processes to various engine configurations. Related work is done in fluid mechanics, liquid transport properties, and heat transfer.

The coordinative effort is vested in the Director of SQUID who maintains a Headquarters Office at Princeton University, which hold a prime contract with ONR. Work at other institutions is conducted, for the most part, by subcontract with Princeton. The SQUID Director is responsible for the formulation of a technically acceptable program to the Power Branch of ONR. In carrying out his responsibility he has full authority to utilize such consultants and scientific talent as he sees fit, to both advise and conduct the work of the project. The SQUID Director is thus responsible for certain basic and applied research programs of a supporting and/or directed nature which contributes toward a better over-all understanding of problems in jet propulsion.

The participants in the SQUID program during calendar year 1960 were as follows:

1. Aeronautical Research Assoc. of Princeton, Incorporated.
   Phase (1). J. E. McCune - Fundamental Study of Partially Ionized Gases in Strong Electromagnetic Fields. (New 1 Oct 1960)

Flame and Ignition Phenomena (U), RR 010-04-0028. Department of the Interior, Pittsburgh, Pennsylvania, Bureau of Mines; Nonr 25-47, NR 098-117; R. W. Von Dolah.

The objective of this task is to advance our understanding of flame and ignition phenomena. For the period starting 1 October 1959, emphasis will be on Initiation of Spherical Detonations by Electric Sparks.

Heat Transfer in Oscillating Flow (U), RR 010-04-0029. Princeton University, Princeton, New Jersey, Department of Aeronautical Engineering; Nonr 1858(29), NR 098-200; L. Crocco.

This research task is directed at experimentally determining the effects of gas oscillations of various frequencies and pressure amplitudes on the heat transfer between the gas and the container walls, and at establishing the theoretical relationships which will fit the data observed.

Solid Propellant Burning (U), RR 010-04-0030. Princeton University, Princeton, New Jersey, James Forrestal Research Laboratory; Nonr 1858(32), NR 098-201; M. J. Summerfield.

The objective of this task is to explore, both experimentally and theoretically, the underlying physical and chemical factors that control the burning processes in solid propellants. More specifically, it is desired to confirm (or disprove) a recently developed theory for the burning rate of ammonium perchlorate propellants which has been devised at Princeton University. In addition, experimental verification will be sought for theoretically predicted effects of catalyst and oxidizer particle size on burning rates and studies will be undertaken to determine the effect of particle size distribution on burning rate plateaus. Studies of flame extinguishment in thin propellant strands will also be undertaken.

Study of a Propulsion System for a Deep Running Torpedo (C), RR 010-04-0031. Cleveland Pneumatic Industries, Incorporated, El Segundo, California, Advanced Systems Development Division; Nonr 3124 (00), NR 097-351; S. Thurston.

This is a feasbility study of an underwater propulsion system consisting of a supercavitating propeller propelled by reaction jets at the blade tips, thus combining the functions of a propeller and turbine within a single rotating unit. (C)

The feasibility study of jet-driven supercavitating propellers using solid or liquid propellant gas generators has shown that this propulsion system is very attractive for deep running torpedoes operating in the speed range of 50 to 100 knots. (C)

Due to the absence of reduction gears and other auxiliaries, the system is very simple and compact and can efficiently deliver large amounts of power. (U)

In the preferred configuration the propeller will have a relatively large hub/tip ratio and nozzles in the plane of the root sections. Ejecting the gas into the trailing edge cavity provides substantial relief from hydrostatic back pressure. Extension of the blade trailing edge into the cavity also provides a means for design control of blade temperatures and stresses. (C)

The next phase planned (under Bureau of Naval Weapons sponsorship) is the fabrication and test of such a propulsion system in a torpedo hull at Morris Dam, NOTS Pasadena.

The work on this feasibility study was completed in November of 1960 versus the contract completion date of 28 February 1961. (C)

Combustion Engine Research (U), RR 010-04-0032. University of Wisconsin, Madison, Wisconsin, College of Engineering; Nonr 3110(00), NR 097-352; J. A. Duffie.

This equipment (Phillips External Combustion Engine and Spares) is being loaned to the University of Wisconsin per their request for use in their closed cycle air engine research program.

Due to the fact that the principal investigator has left the University for a postion with Battelle Memorial Institute, the University has informed this Office that it desires to terminate this contact. There were no significant accomplishments on this task to date. This is a no cost contract.

Electrochemical Conversion Methods (U), RR 010-04-5950. U. S. Naval Research Laboratory; E01-01; D. S. Toffolo.

Studies of electrochemical and electrodynamical conversion for non-propulsive power on Naval vehicles and missiles, i.e., power to control servomechanisms, electronic equipment and other energy conversion devices, are being performed. The effort involves the study of high energy density electric and magnetic fields, the special problems involved in the application of the physics of electricity and magnetism for specific purposes and environmental factors.

Special Electrical Power Control and Utilization (U), WR 010-04-001. General Electric Company; NOw 60-0824C; Mr. M. A. Knight (RAAE-511).

Electric power generated by direct conversion of energy to electricity processes is inherently low voltage with a voltage variation of about 100% between open circuit voltage and maximum power output voltage. Utilization equipment requires that the voltage, frequency, and other power characteristics be controlled to a narrow tolerance band for optimized power utilization. Available regulation and control equipment cannot perform this power transformation without appreciable loss of power in the processes. In many applications this loss of power requires additional generation of power as well as creates a problem of heat removal of the lost power. The objective of this task is to promote research and development of equipment and systems which will permit power transformation at a high efficiency, low weight and maximum reliability and simplicity.

Research, investigation, and development of power regulation and transformation systems will be on a two-way procedure. In one procedure all direct conversion methods will be investigated as to factors affecting the voltage output in the conversion process. This information is needed to develop control systems which will regulate the output voltage of the generator by actual control or biasing of the conversion process. The second procedure is to conduct applied research and development of static devices and circuitry which will provide regulation and transformation of power characteristics to the narrow band requirement. Where information on the basic fundamentals of static devices and circuitry is not available, necessary research will be undertaken to secure this information. Optimization of the generator system as to voltage and circuitry as affecting performance and reliability will also be studied.

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