

**ANNUAL REPORT FOR THE YEAR
ENDING 30 JUNE 1947**

JUNE 1947

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NAVAL RESEARCH LABORATORY

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I. SUMMARY OF THE YEAR'S ACCOMPLISHMENTS

During the fiscal year 1947 the Naval Research Laboratory continued the gradual reorientation toward peacetime research which was commenced in 1946. This was accomplished by a general revision of the management, administrative, and service functions of the activity, by a careful regrouping of some of the scientific divisions, and by the declaration of a thoughtfully planned, comprehensive research and development program.

The reorganization of the management, administrative, and service functions was undertaken in order to enable the Laboratory to carry out more efficiently its mission of applying basic and applied research to the needs of the fleet. The aim has been to concentrate into centralized units the "overhead" work of the Laboratory, so that the individual scientist or engineer could devote the major portion of his energies to his primary mission: research. This reorganization is described more at length in Section III of this Annual Report.

The scientific effort which supported naval developments during the recent war, with its "crash" programs, the necessity for immediate evaluation, and the rush to answer enemy weapons with new countermeasures, left to the Laboratory a legacy of far more problems than could be solved for many years to come. Obviously, a careful screening process was necessary. This could best be accomplished by an introspective consideration of the entire technical program, and the formulation of an overall plan based on the foreseeable needs of the future. Consequently, an objective study was undertaken by a committee of senior scientists appointed by the director. The result of their deliberations was the "Research and Development Program of the Naval Research Laboratory," published in October 1946. This document recommended that certain projects of transitory interest be dropped, that others be transferred to other research or developmental agencies, and it outlined the principal programs of research to be undertaken or continued by each of the scientific divisions. Most of these recommendations have been confirmed by Laboratory Orders issued during the last six months of the fiscal year.

The changes outlined in the foregoing paragraphs were effected with a minimum of interference with the operation of the Laboratory. By and large, most of the programs in progress at the close of the fiscal year 1946 were continued through or completed in 1947. The past year has seen the Laboratory take the leadership in basic upper-atmosphere research by means of rockets; scientists and engineers from Naval Research Laboratory have participated in all of the Navy's scientific expeditions such as "Crossroads," "Highjump," "Nanook," and "Apollo"; the joint Army and Navy Atmospheric Electricity Project was brought to a successful conclusion under the auspices of the Laboratory; new applications were found for radar techniques, and naval radar was made more effective by a number of new developments; significant advances were made in the design of vacuum tubes; and basic research at Naval Research Laboratory widened the knowledge of radio microwave phenomena. The specific contributions made by each division are enumerated in Section IV of this report.

The Laboratory acquired a number of new facilities such as a plastics molding shop, a larger and more functional sound barge, a new ballistics range, and a high-altitude temperature and pressure chamber.

With the removal, in the months following V-J Day, of many of the security restrictions on the dissemination of technical information, the researchers at Naval Research Laboratory have taken an ever-increasing interest in the brotherhood of science.

During the past year more non-government scientists have visited the station than ever before in its history, and Naval Research Laboratory employees have within the funds available continued to attend technical meetings. Papers presented at scientific meetings, and articles published in professional journals have reached an unprecedented volume of more than 30 per month.

The Scientific Training Program, launched in 1945 and greatly expanded in 1946, reached a new high in popularity and usefulness. Over 300 employees registered for the 37 courses offered for the spring term of 1947. Most of the enrollment is on the graduate level, and many of the young students are already working on doctoral dissertations. The training program is more fully described in Section VI.

Finally, two steps were taken cooperatively, with the Office of Naval Research and other naval research agencies, which should prove to be of inestimable value in insuring a steady flow of well-qualified young scientists and engineers to the Laboratory. These steps were: (1) the establishment of a Board of Civil Service Examiners for naval research units in the Washington area with its headquarters at Naval Research Laboratory, and (2) a recruiting campaign, highlighted by radio announcements and by lectures delivered by contact representatives sent to the leading universities and technical colleges, urging young college graduates to take the Civil Service Examination for chemists, physicists, and engineers. These measures have already resulted in hundreds of applications for the few professional positions still remaining vacant at the Laboratory.

II. HISTORY

The Naval Research Laboratory, conceived by the Naval Consulting Board in 1915, was established by Act of Congress the following year and commenced operations in July, 1923.

During World War II the Laboratory grew in size and scope from a relatively small unit to one of the largest research centers in the world. The research behind the war effort of the Navy reached a peak in the calendar year 1945, for during those twelve months approximately 900 problems were reported on by the Laboratory. The more important ones were continued through 1946 and into 1947, and their magnitude and variety permitted little reduction in the operating force following the cessation of hostilities.

In its twenty-four years of existence, the Laboratory has operated for various lengths of time under the Secretary of the Navy, as a part of the Bureau of Engineering, and, during most of the recent war, as a subordinate function of the Bureau of Ships. Regardless of these changes of cognizance, the Laboratory has undertaken technical problems for all of the naval bureaus. Meanwhile, a direct annual appropriation from Congress permitted a considerable degree of autonomous operation, and this enabled the Laboratory to maintain an independent continuity of policy. On 19 May 1945, the Naval Research Laboratory was transferred from the Bureau of Ships to the Office of Research and Inventions, now the Office of Naval Research.

During the course of Naval Research Laboratory's development several subordinate activities were added to the parent unit or housed on the Laboratory station grounds. The U. S. Naval School (Electronics Materiel), established in 1924 as the Radio Materiel School, is a subordinate command under the Director of Naval Research Laboratory, but is not an integral part of the Laboratory organization. In

the same category are the Electronic Field Service Group and the Airborne Coordinating Group, activities of Bureau of Ships and Bureau of Aeronautics respectively, which were established on the station during the recent war. The Chesapeake Bay Annex, on the other hand, is a functional unit of the research organization. It was established in 1941 as a field station, and in the following years it became a large and extremely useful branch of the main Laboratory. The Boston Field Station was taken over from the National Defense Research Committee at the close of the war, and is now operated as a branch of the Naval Research Laboratory.

The Naval Research Laboratory has always functioned within reasonable limits as a scientific service for the fleet, and for the materiel bureaus of the Navy Department. Upon the request of a bureau or office, the Laboratory undertakes to act as expert consultant or to undertake active work on any technical problem which comes within the scope of its several divisions.

III. ORGANIZATION

The chart shown on page 3 portrays in broad outline the current organization of the Laboratory. Under the direction of the director, the research program is carried out by nine research divisions organized generally on the basis of scientific fields. Specific research problems are assigned to appropriate divisions upon the recommendation of the Scientific Program Board, a standing committee composed of the civilian scientists serving as superintendents of the research divisions. It provides the director and his naval staff with the technical advice required in the planning, formulation, and execution of the Laboratory's program. This committee together with *ad hoc* committees for special problems also serves to coordinate the work of the divisions. This is of particular importance as a research problem may require work by several divisions or may be carried out by a team of scientists selected from various divisions for their specialized abilities. Such organization permits a maximum specialization of work and a thorough use of technical talent.

During the fiscal year 1947 adjustments in organization within the program divisions were relatively minor. Except for a realignment of functions among the radio divisions, changes amounted to refinements in terminology. The present division titles, compared with those of a year ago, follow.

<u>1946</u>	<u>1947</u>
Chemistry	Chemistry
Aircraft Electrical Research	Electricity
Metallurgy	Metallurgy
Physical Optics	Optics
Mechanics and Electricity	Physics
Electronic Special Research	Radio I
Ship Shore Radio	Radio II

1946

Airborne Radio }
Missile Control }

Sound

1947

Radio III

Sound

The work of these scientific divisions is supported by several services and facilities which are organized centrally for efficiency and economy and for enabling scientists to spend maximum time directly on research. The Engineering Services Office provides a design and drafting service and a number of large and well-equipped shops for the production of prototypes and experimental models. The Technical Information Office disseminates information, provides editorial services for scientific reports, and maintains extensive research library facilities. The Supply Office is responsible for procurement, storage, and issue of materials and equipment required by the scientist. The remaining offices, Administrative Services, Budget and Management Analysis, Fiscal, Personnel, and Public Works not only provide services to the program divisions, but assist in the management and maintenance of the Laboratory. The activities of these eight offices are coordinated by the deputy director, who spends a large proportion of his time on matters of administration, while the director concentrates on the research program.

IV. THE SCIENTIFIC DIVISIONS

Although the "Research and Development Program" provided an overall, comprehensive program for the nine scientific divisions, it did not alter appreciably the type of work already in progress. The trend of research has been away from short, evaluation problems, or problems of transitory interest. Therefore, though the number of problems assigned was considerably less than in previous years, each one has been generally longer in range and has required far more man-hours for completion. It must be borne in mind that much of the work undertaken by the Laboratory is classified "Restricted," "Confidential," or "Secret"; consequently many of the more important problems may not be mentioned in this unclassified report. The individual achievement reports which follow are therefore in no sense a summary of the work accomplished by each division, but they will serve to illustrate the type and scope of the division investigations.

A. The Chemistry Division:

During the Fiscal Year 1947 the NRL Chemistry Division operated with essentially the same organization and procedures as it had the preceding year, and there was little change in the scale or scope of its work.

In general, the programs in progress at the close of the last fiscal year have been continued in 1947. There has been a decrease in emphasis on applied research of purely wartime application, such as chemical warfare development, and an increase in emphasis on long-term research.

The Chemistry Division carries on field studies of climatic and fungistatic deterioration of electronic equipment and similar materiel. The findings in the field will be supplemented by experiments conducted in a tropicalization chamber at the Laboratory.

The application of spectroscopic methods to chemical problems, an activity started during the war, has proved very useful for the determination of molecular structure and as an analytical tool. Significant results in the study of natural and synthetic rubbers and in the analysis of insecticides have been obtained by infrared methods. Both infrared and ultraviolet measurements have contributed to the solution of many problems in the general fields of fuels, lubricants, and polymers.

Extensive studies have been undertaken of the physical and chemical properties of sodium and potassium alloys which are liquid at ordinary temperature.

A synthetic, nonflammable hydraulic fluid, desired particularly for use in aircraft, has been developed. The formulation has been turned over to Bureau of Aeronautics and its manufacture is now in progress under a Navy specification. The new fluid virtually eliminates the fire hazard which had formerly discouraged the use of hydraulic systems in naval aircraft.

In order to extend the facilities for the study of polymers, and to develop new plastic products for special naval applications, a plastics molding and fabrication shop has been established.

Chemical warfare, and chemical decontamination studies are continuing. Also in progress are problems in such diverse fields as mechanical foam fire-fighting devices, anti-fouling paints and primers, the flame-proofing of plastics and oils, the blending of aviation and diesel fuels, and the development of alloys for storage battery grids.

B. The Electricity Division:

The Electricity Division was reorganized to provide for an Experimental Development Section and a Test Section in addition to three other sections: Physical Research, Systems and Applied Research, and Facilities Engineering.

To implement the Division's program in research into the electrical and magnetic properties of matter, particularly at low temperatures, the facilities of the division were enhanced by the acquisition of a Collins-type helium cryostat. This equipment is the nucleus of a proposed well-rounded cryogenics laboratory which should be completed during the coming year. Experimental work in the vicinity of 2°K is now underway.

Some of the accomplishments of the division during the last year include the following:

A theoretical analysis of experimental data available to date on the phenomena of superconductivity was conducted, and a number of new relationships among some of the relevant physical properties of solids have been revealed.

In the systems analysis connected with the problem of devising an ideal electrical system for carrier-based aircraft, a complete study was made of the XF2D airplane.

Considerable progress has been made toward developing an integrated electrical power unit for missiles and pilotless aircraft. A suitable alternator to be driven by a gas turbine has been designed, and the work is now in progress on a

cooperative basis in the Chemistry Division, leading to the development of a fuel for driving the turbine.

An investigation was conducted of the feasibility of employing inductive heating to prevent ice formation on 20-mm aircraft machine guns and to assure their operation under extreme conditions.

Research was continued on the problems connected with sliding contacts on rotating machinery at high altitudes. To cope with some fundamental problems associated with this investigation, new equipment has been designed to measure friction and electrical characteristics of commutators, slip rings, and brushes at altitude conditions.

Newly-established problems on which work has begun include the following: a study of the operating characteristics of electrical systems in new submarine types, an investigation of conductivity phenomena, research on surface phenomena covering fundamental physical studies of the electrical characteristics of surfaces of metallic and semi-conducting crystals, and an engineering study aimed at the establishment of a firm set of requirements for the design of aircraft electrical motors.

C. The Metallurgy Division:

The Metallurgy Division was not changed in its organization, or procedures during the reporting period. Most of the programs in progress at the close of the previous year were continued in 1947. Efforts to increase appreciably the size of this division continue.

The facilities of the division were augmented by: 1) the completion of an enlarged foundry building, 2) the addition of a well-equipped welding laboratory, 3) the completion of a laboratory for creep and stress rupture measurements at high temperature.

The division undertook a number of basic and applied research problems. A study was begun to determine the influence of different metals used in electrical contact points on electrical transients. An investigation of isoelastic alloys and the development of a laboratory for the production and study of titanium alloys were undertaken.

In the investigation of aluminum alloys for use at high temperatures, one very promising alloy was discovered which is being investigated further. The use of microradiography for the study of graphite flakes in cast iron was continued.

A number of problems which aimed at the improvement of welding techniques were continued. The causes of brittleness and cracking in welded steel joints, the failure of ship steels as a result of welding, and the welding methods for copper-base alloys were studied.

An extensive series of investigations was conducted on gray iron, including studies of stress relief, the improvement of test-bar specifications, and solidification.

In order to reduce the occurrence of flaws and to improve the quality of castings, experiments were undertaken on the gating and risering of both ferrous and nonferrous metals. The experiments included induction heating of risers, application of hyperatmospheric pressure, use of thermally insulated risers and an investigation of the segregation of carbon resulting from the use of necked-down risers.

D. The Optics Division:

The Optics Division carries on basic research in the fields of light propagation and absorption, spectroscopy, and electron optics, and applies these studies to the naval needs for illumination devices, paints, infrared and ultraviolet devices, and various optical devices. The division is subdivided into five scientific sections, and has employed an average of 44 persons during the past year.

Two major accomplishments have been achieved. The division has photographed the spectrum and measured the total optical radiation of an atomic bomb explosion, and it has obtained spectra of the sun at altitudes above the ozone region of the atmosphere.

In collaboration with Radio Division I a new type of automatic vacuum spectrograph was designed to photograph the solar ultraviolet spectrum from a V-2 rocket. Two films carrying spectra taken at altitudes up to 100 miles were recovered. As a result, knowledge of the solar ultraviolet spectrum was extended from 2863 A to 2100 A. Analysis of new Fraunhofer lines continues. The vertical distribution of ozone in the earth's atmosphere was determined.

Measurements of the near infrared radiation emitted by the flames of V-2 rockets in flight were made at White Sands, New Mexico, and the spectrum of an acid-aniline rocket engine flame was photographed in New Jersey.

Equipment was designed for measuring the brightness and polarization of the skylight at altitudes up to 35,000 feet from the B-29 aircraft made available by Office of Naval Research.

Progress in physiological optics included design and construction of a new type of infrared pupillometer, and experimentation which investigated the cause of near-sightedness at night and proved that it is largely due to the spherical aberration of the eye.

Photometers for the measurement of the visual and infrared transmissivity of filters for near infrared signalling devices were completed and sent to various agencies producing and studying the filters.

A program of research and development in connection with methods of detecting nuclear radiations led to the development of a new type of low voltage Geiger counter and advances in the theory of the discharge process in counter tubes.

High temperature X-ray diffraction equipment was designed and applied to structure studies of metals and alloys.

Electron diffraction research advanced the theory of the structure and binding of hydrocarbon films on metal surfaces.

A method for measuring the brightness and color characteristics of low luminosity radiations by means of photomultiplier tubes has been developed.

E. The Physics Division:

The former "Mechanics and Electricity Division" was redesignated the "Physics Division" by a Laboratory order issued in January 1947. The change in title involved no change in personnel or organization, and its former program was continued with little alteration.

The joint Army and Navy Atmospheric Electricity Project, which had been operated as a field activity of the division, was successfully terminated. This has been one of the most fruitful research projects ever undertaken by the Laboratory because the reduction of precipitation static interference with aircraft radio communication greatly enhances the safety of both military and commercial aviation. A part of the research project, the development and preparation of specifications for antenna hardware, is being continued at Naval Research Laboratory as a division problem.

The Ballistics Section was recently equipped with a new two-story annex which provides better working areas for studies involving laboratory ballistics techniques than have been available in the past. Basic research in plastic flow and rupture, and in free flight supersonic aerodynamics was continued along the lines of the revised program of last year. Studies of new armor materials were continued. Considerable activity was devoted to liaison with armor development and related research in other establishments. The studies of fracture of ship plates were assisted by a contract with the University of North Carolina.

Members of the division participated in, and prepared reports for, both of the "Crossroads" tests at Bikini.

Other accomplishments of the year were: the design and manufacturing specifications of an electrical micrometer tube; the completion of a torsionmeter model which measures accurately and directly the power output of a ship's propeller shaft; and the facilities for the study of pulse-jet motors were expanded.

The following changes in the division structure were effected as a result of the general reorganization of the Laboratory: The betatron laboratory was transferred to the division from the Metallurgy Division; and the shock and vibration problems and personnel of the Physics Division were transferred to the Sound Division.

F. Radio Division I:

This division was formed as the "Electronics Special Research Division" in July 1945, and redesignated "Radio Division I" in November 1946.

The Naval Research Laboratory's upper-atmosphere research program has been carried forward by the division's Rocket-Sonde Research Section. Since June 28, 1946, the section has utilized seven of the V-2 rocket firings for studies of high-altitude pressure and temperature, jet-gas attenuation of radio waves, the influence of the ionosphere on radio wave propagation, and atmospheric physics.

When the German rockets have been expended, the studies will be continued by two American-developed rockets, the HASR-2 and the XASR-1. The Rocket-Sonde Section has assisted in the preparation of designs and specifications for both of these commercially-built high-altitude missiles.

The Vacuum Tube Research Section, established in 1945, and augmented in the past year by a greatly improved Vacuum Tube Model Shop, has produced: a cathode-ray tube which stores signals indefinitely, a target simulator tube for use in testing radar equipment and in training radar personnel, a new type of microwave oscillator and a scaled model of a high powered magnetron.

The Antenna Research Section has completed a book entitled "Microwave Antenna Theory and Design," designed a special bombing antenna, and converted microwave energy directly into visual energy.

The Security Systems Section collected into one report information on factors affecting choice of transmission frequencies for line-of-sight systems. It was concluded that for a universal system the range profitable to consider lies between several hundred and roughly 3000 megacycles per second.

The Radio Frequency Research Section has developed techniques and equipment, such as r-f waveguides and oscillator and measuring equipment for the wavelength region between 1.25 cm and 0.5 cm.

G. Radio Division II:

This division, formerly designated "Ship-Shore Radio Division," was re-designated "Radio Division II" in November 1946. The principal fields of research and development assigned particularly to the division are indicated in the titles of its five sections: Communication, Radio Techniques, Search Radar, Countermeasures, and Systems Utilization.

In the field of communications the division has devoted a major portion of its efforts to the higher frequency bands. During the past year studies were made of the VHF and UHF bands in order to assist in the allocation of frequencies, analyses were made of interference within 100 primary Navy communication channels, and an elaborate frequency standard (the LAM) was designed and assembled for use at various Navy monitoring stations. In support of these and similar developments, division engineers made studies of harmonic crystals for use in UHF bands, developed microwave signal generators, made an analytical evaluation of AM vs. FM for use in UHF communications, and studied the possibility of feeding several transmitters into a common antenna. A significant expansion in the scope of this general field was the addition of the Airborne Communications Program to the operations of the division.

A number of outstanding accomplishments were made in support of the programs which were established to improve the performance and versatility of search radar. For example, improvements were made in methods of radar signal presentation, a system was developed for more certain detection of fast, close-in aircraft, and new circuits were developed which greatly extend the range of search radar.

Similarly, the work of the Radio Countermeasures Section has resulted in the development of several new devices which will simplify and make more certain the jamming and/or interception of radar signals.

The following are indicative of the other achievements of the division: a series of analyses determined the ideal pulse shape for LORAN signals, considerable progress was made in the development of submerged reception techniques, and instrumentation was well underway for a submarine emergency radio buoy designed for release from damaged submarines.

H. Radio Division III:

On 26 November 1946, the Missile Control and Airborne Radio Divisions merged to become Radio Division III. This combined division is concerned with research and development in the fields of radar fire control, missile control, and airborne electronics systems.

During the reporting period, two basically new radar tracking systems originated by Radio Division III were demonstrated for the first time. The systems minimize jitter caused by echo fading and modulation, and have demonstrated tracking accuracy not possible with earlier techniques. One of the systems is now operating with completely automatic tracking in train, elevation, and range. The new radars will be applied in fire and missile control systems.

In the development of missile guidance and control systems, preliminary experimental equipments for both automatic and command guidance by radar have been completed and successfully tested. Much of the division's effort in this new field has been applied to research studies, the findings of which must precede effective design of control components and systems. Periodic guided missile seminars have been initiated by the division. These are attended by representatives of a number of Navy bureaus and contractors concerned with guided missile development.

The design and construction of carrier-based homing and carrier-controlled approach equipments was completed during the reporting period. Field trials of these equipments have indicated satisfactory performance. The Carrier-Controlled Approach System has impressively demonstrated its effectiveness in bringing carrier aircraft quickly into position for landing, even under conditions of poor visibility.

Two subminiature ten-channel pulse-time airborne telemetering systems have been developed and constructed for operation in the KUV-1 missile. Following field and mechanical engineering tests, a contract was let covering the construction of fifty units of this device.

The human factor in tracking situations is being analyzed to determine the degree of predictability of certain physical response characteristics of the human operator. Simulators and measuring and recording equipment have been developed and considerable data taken for this analysis. Findings will be applied in the development and evaluation of training equipment and of service fire-control gear.

A radar pulse analyzer has been completed that will automatically measure and indicate the pulse width and pulse repetition rate of a received radar signal. This countermeasures device can be used either in aircraft or aboard ship.

Multichannel communication equipment for the 225-400 megacycle frequency range was completed during the reporting period. This equipment permits the rapid selection by an operator of any of the 875 communication channels provided by this device.

I. The Sound Division:

The Sound Division program covers the field of sound and vibration over a wide range of frequency and intensity in solid, liquid, and gaseous media. About 40 per cent of the division effort is devoted to applied research and development of sonar systems. Separate underwater sound-listening and echo-ranging systems are being developed for submarines, surface ships, certain types of aircraft, and fixed positions (harbor defense).

Extensive studies have been in progress throughout the year to determine the laws of transmission, absorption, reflection, and scattering of sound in sea water. The reflection and scattering phenomena are particularly interesting at the surface and bottom. Definite progress has been made in separating the direct wave from the reflected wave by use of apparatus developed and installed on the USS FOSS.

Investigation of piezoelectric crystals has led to the development of new crystals, particularly in the techniques of growing synthetic crystals from solutions and melts under controlled conditions of temperature, pressure, and environment. Considerable success has been attained in growing quartz crystals. These techniques have also been extended to growing crystals for infrared windows and for luminescent materials used in cathode-ray tubes.

Certain techniques in the use of ultrasonic vibrations have found application in varied fields such as the determination of the thickness and the detecting of flaws in diesel cylinder liners, the flocculation of suspended particles such as smoke or fog, the determination of the molecular weights of large molecules in solution, the dissipation constants of a wide variety of alloys, and the detection of air bubbles in acoustic rubber windows.

Two sections have been added during the year in the field of shock and vibration. The division is now collecting and disseminating information in this field by means of bimonthly conferences and bulletins in a way that is leading to better correlation among the interested activities. In addition, extensive experimental work is in progress in cooperation with several naval activities to determine the intensity and the effects of shock on ships structures and the apparatus mounted therein.

There have been no major reorganizations during the year, but the two sections in Shock and Vibration have been added and the Reports Section transferred to the Technical Information Office.

V. FINANCE

In its financial administration the Laboratory underwent two significant changes during the fiscal year 1947. The first of these changes was a rather thorough-going revision in its internal accounting procedures which will permit greater budgetary control over available funds and provide more meaningful reports of the use made of these funds. Briefly, the new system calls for the allocation of all direct cost funds to each of the scientific divisions for each officially established program and the accounting for funds under each program by research problem. As part of the new system, problem and job-order numbers were integrated in a coding system which permits the accumulation of costs according to a number of different bases, e.g., field of research, type of research, program, appropriation, etc.

The second change has been reflected in a trend away from the financing of the Laboratory's operations by means of small, narrowly-written project orders. This trend is the result of two developments, viz. the availability of sizable sums from the appropriation "Research, Navy" for research work as well as overhead costs and, secondly, a willingness on the part of the material bureaus to write project orders broadly in terms of the Laboratory's "Research and Development Program" rather than confining them to specific problems or small groups of problems. The effect of this change is to permit greater flexibility in the use of funds and consequently greater flexibility in the development and conduct of the research program proper.

The table below shows in summary form the estimated obligations for the current fiscal year. An analysis of the table shows that approximately 19.0 million dollars will be obligated. This compares with 15.6 million for fiscal year 1947. Of the total 19.0 million, 12.9 million or 68 per cent, will be devoted to direct costs of research while 6.1 million will be necessary for indirect costs. By field of research, by far the greater amount of funds, approximately 70 per cent, will be consumed in radio research with the remaining 30 per cent being distributed more or less evenly over the other six fields. By type of research, almost 72 per cent will be devoted to applied and development work as contrasted with 17 per cent for basic, and 11 per cent for technical evaluation and type-testing work.

Estimated Obligations by Type of Cost,
Field of Research, and Type of Research
Fiscal Year 1947

	<u>Applied and Development</u>	<u>Basic Research</u>	<u>Technical Evaluation</u>	<u>Type Testing</u>	<u>Total</u>
Direct Costs of Research					
Chemistry	710,000	290,000	---	---	1,000,000
Electricity	410,000	25,000	105,000	20,000	560,000
Metallurgy	185,000	98,000	42,000	---	325,000
Optics	295,000	145,000	---	---	440,000
Physics	90,000	580,000	5,000	---	675,000
Radio	6,960,000	960,000	370,000	750,000	9,040,000
Sound	570,000	250,000	10,000	30,000	860,000
Subtotal	9,220,000	2,348,000	532,000	800,000	12,900,000
Indirect Costs of Research	---	---	---	---	6,100,000
Total	---	---	---	---	19,000,000

VI. PERSONNEL

A. Employment:

The continuing transition within the Laboratory from a wartime to a peacetime basis of operations and the resulting reorganization has been accompanied by many employment problems. As might be expected, the rate of personnel turnover has been high. While an average of 81 placements were effected each month, the approximate net increase in employees during the fiscal year was only 160. Somewhat restricted personnel ceilings resulted in a greater demand from the scientific divisions for professional personnel with highly specialized types of experience. As the nationwide employment situation became more stabilized, recruiting for this type of personnel became increasingly difficult. The Laboratory participated in an extensive recruiting campaign designed to attract young scientists to the employment opportunities offered by the activities of the Potomac River Naval Command. Representatives from the Laboratory, working in conjunction with representatives of other naval activities within the area, visited many outstanding technical colleges and universities in the country in order to address and to interview members of the graduating classes and graduate students. Examinations for probational appointment to most of the positions at the Laboratory were announced by the Civil Service Commission during the fiscal year and the Employment Section attempted to notify all employees holding indefinite appointments as to when and how to make application for examination. Although registers of eligibles were established for some of these examinations, and it was possible to convert a few Laboratory employees to a probational or permanent status, many are still serving under war service or temporary appointments pending the establishment of lists of eligibles by the Civil Service Commission.

B. Classifications:

During the fiscal year classification has been recognized as the leading personnel-office problem. All classification actions on professional positions have been taken by the Laboratory Classification Section. Surveys have been conducted by the section covering professional positions in the Boston Field Station and in several other subunits of the Laboratory. A Laboratory-wide survey of all professional positions, conducted in accordance with the directive from the Secretary of the Navy which calls for a post-war survey of all civilian positions in the Navy Department, was still in progress at the close of the reporting period. An informational program on classification principles and objectives was inaugurated concurrently with the survey.

C. Employee Relations and Services:

In order to establish a sound and progressive employee relations program, considerable time was spent surveying existing personnel policies and practices. Provisions were made for orientation interviews and for a counselling service. The Beneficial Suggestion Program was revived and has gained general acceptance in the Laboratory. An employees' Federal Credit Union was established and is expanding rapidly both in membership and deposits. Especial attention has been given to the development of group health units and to the group hospitalization program. The housing service is a continuing function and efforts were made to assist employees in finding adequate quarters. Procedures have been established to maintain current information on bulletin boards covering the fields of employee relations and employee services. Information of interest to new employees is being consolidated in the form of a brochure which will be issued in the near future.

D. Safety:

The function of the Safety Section is to administer the safety program in conformity with the departmental policies as promulgated by the Safety Branch, Office of Industrial Relations. In carrying out this function, the safety officer is the representative of the director on matters pertaining to safety. This office also serves as consultant to the division and department heads and to supervisors and foremen in work situations regarded as hazardous, aiding in the establishment of accident-prevention procedures. This office initiates activity for stimulating and maintaining interest in safe working practices and in the elimination of safety hazards.

E. Training:

A comprehensive training program, in effect at the Naval Research Laboratory, offers graduate and undergraduate courses in the fields of engineering, physics, and chemistry. These courses have been sponsored by the University of Maryland and by the Graduate School of the Department of Agriculture, and they are offered for full graduate and undergraduate credit by arrangement between Naval Research Laboratory and a number of graduate schools. In addition, research undertaken at the Laboratory may be applied for thesis credit at the cooperating institutions. This plan encourages independent research of a fundamental nature and serves as a means of attracting and retaining scientists who wish to continue their academic studies while working for the Navy. Recently arrangements have been made with departments at Princeton, Yale, Massachusetts Institute of Technology, Harvard, Brown, and Columbia universities for the accrediting of research undertaken at the Naval Research Laboratory for advanced degrees. Seminars and colloquia in engineering, physics, and chemistry are held regularly for personnel of the Laboratory and similar activities in the Washington area. The Naval Research Laboratory Graduate Advisory Committee, appointed by the director, consists of eight senior scientists. This committee plans academic policy and counsels students relative to programs of study and research.

Training courses are offered in typewriting, stenography, and office practices. Mechanical trade training is directed through the apprentice school which includes approximately one hundred students and offers trade training at the usual apprentice shop trades.