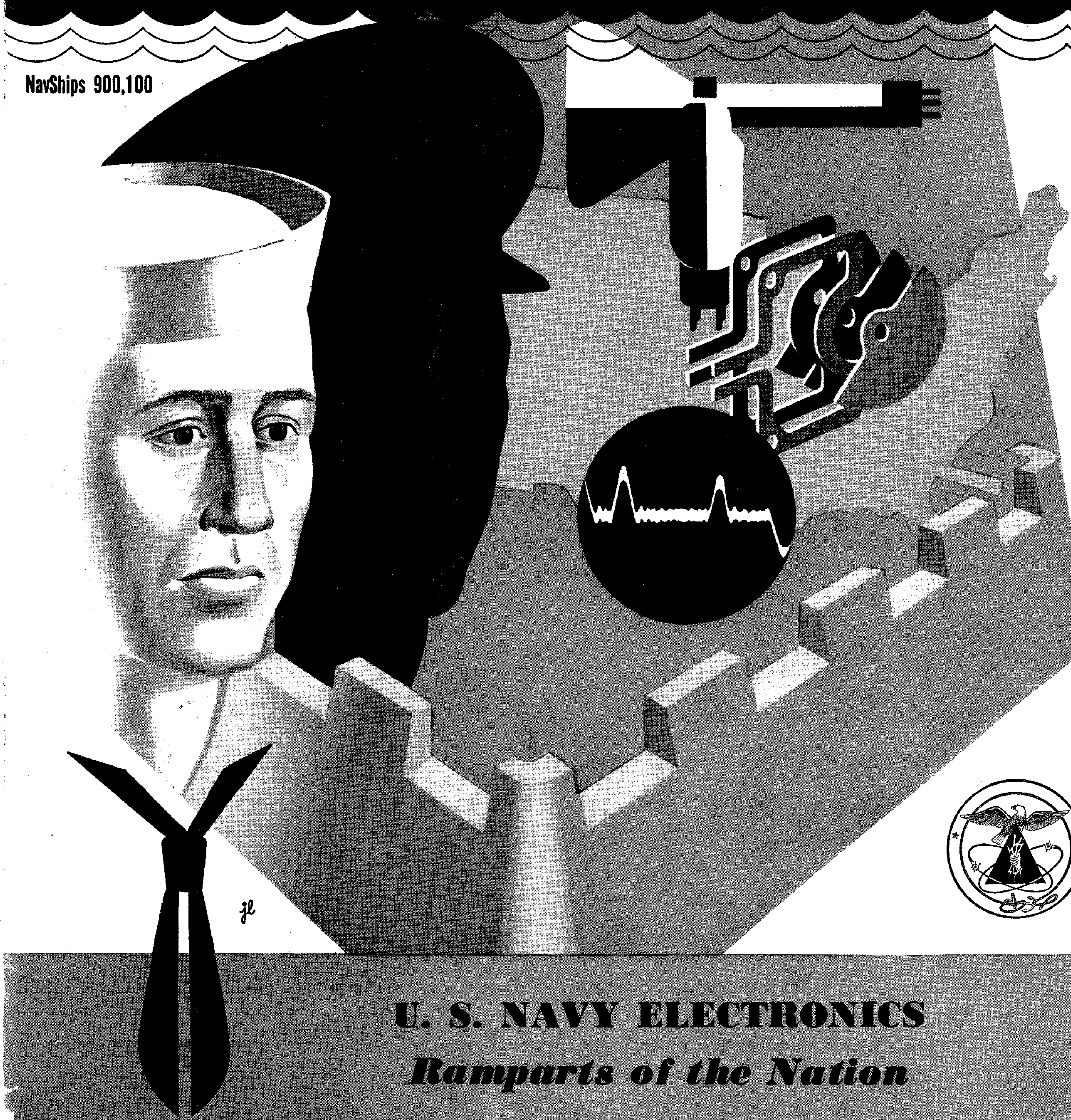
BUSHIPS

MARCH 1950

ELECTRON

NavShips 900,100



U. S. NAVY ELECTRONICS

Ramparts of the Nation

VOLUME 5 MARCH NUMBER 9

BUSHIPS Electron

THIS ISSUE

A MONTHLY MAGAZINE FOR ELECTRONICS TECHNICIANS

DISTRIBUTION: BuShips Electron is sent to all activities concerned with the installation, operation, maintenance, and supply of electronic equipment. The quantity provided any activity is intended to permit convenient distribution—it is not intended to supply each reader with a personal copy. To this end, it is urged that new issues be passed along quickly. Copies may then be filed in a convenient location where interested personnel can read them more carefully. If the quantity supplied is not correct (either too few or too many) please advise the Bureau promptly.

CONTRIBUTIONS: Contributions to this magazine are always welcome. All material should be addressed to

Bureau of Ships (Code 993-c)
The Editor BuShips Electron
Navy Department
Washington 25, D. C.

and forwarded via the commanding officer. Whenever possible articles should be accompanied by appropriate sketches, diagrams, or photographs.

CONFIDENTIAL: Certain issues of BuShips Electron are classified confidential in order that information on all types of equipment may be included. The material published in any one issue may or may not be classified, however. Each page of the magazine is marked to show the classification of the material printed on that page. The issue is assigned the highest classification of the material included. Classified material should be shown only to concerned personnel as provided in U. S. Navy Regulations. Don't forget, many enlisted men *are concerned* with the contents of this magazine.

BuShips Electron contains information affecting the national defense of the United States within the meaning of the Espionage Act (U.E.C. 50; 31-42) as amended.

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO

20 January 1950

Mr. Raymond F. Guy, President
The Institute of Radio Engineers
New York 20, New York

My dear Mr. Guy:

Through the years, I have noted the increasing importance of electronics, not only with respect to military applications, but as a means of enriching the lives of Americans and the other peoples of the world. The achievements and advances in this field have been, in great measure, the result of the untiring efforts of scientists and engineers, many of whom were members of The Institute.

On this, the thirty-eighth anniversary of the founding of The Institute of Radio Engineers, I extend to you and the members of The Institute, on behalf of the military and civilian personnel of the Bureau, most cordial greetings and best wishes for continued success and achievement.

D. H. Clark

D. H. Clark
Rear Admiral, USN
Chief of Bureau

THE INSTITUTE OF RADIO ENGINEERS
INCORPORATED
1 EAST 79 STREET
NEW YORK 21, N.Y.

December 28 1949

Rear Admiral D H Clark
Chief of the Bureau of Ships
Navy Department
Washington 25 D C

Dear Admiral Clark:

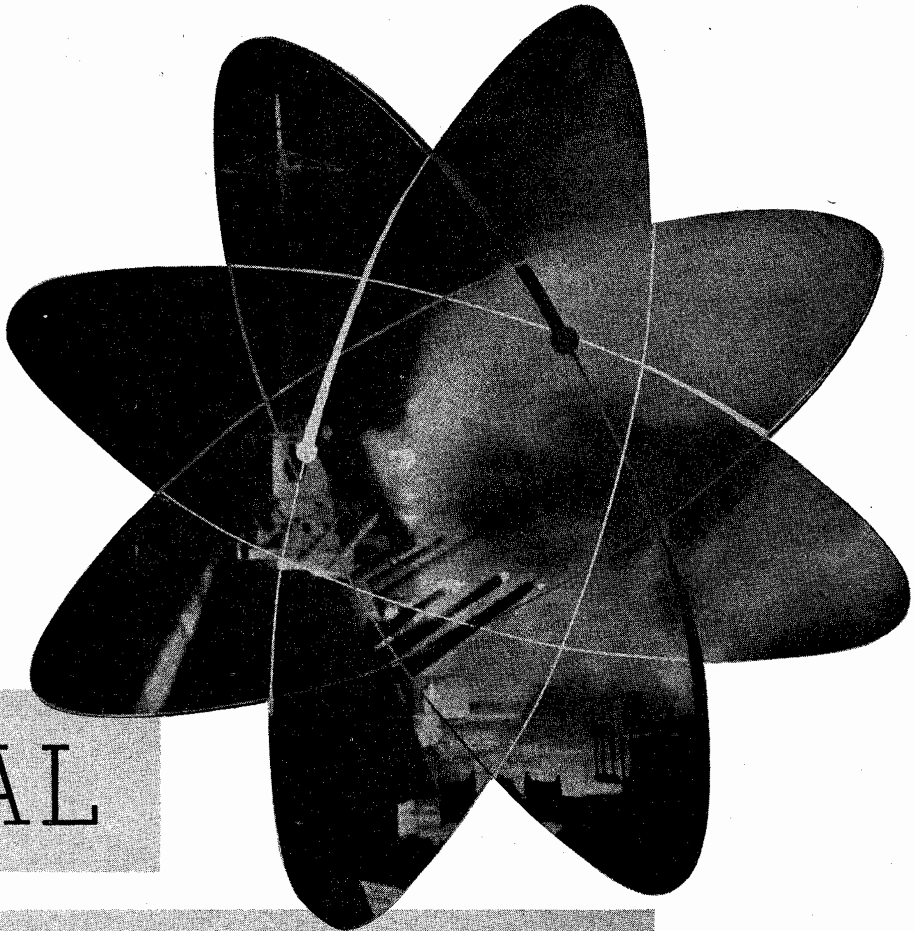
On the occasion of the publication of this special "Institute of Radio Engineers issue" of your splendid ELECTRON Magazine, I wish to extend, on behalf of our membership, to you and your superb staff of naval electronic engineers and technicians, our most cordial greetings and best wishes.

Throughout the history of the Institute it has been our privilege and pleasure to include in our Society many members of your organization, and to cooperate with you in many ways. I give you my warmest assurance that we in the Institute of Radio Engineers look forward to the continuation of the mutually helpful and pleasant relationship which has existed for the past 38 years.

Cordially yours

Raymond F. Guy

Raymond F Guy
President



NAVAL ELECTRONICS

A Naval Task Force, consisting of battleships, carriers, cruisers, and escort vessels steams at high speed, with no lights showing, through glassy-smooth waters in the South Pacific. On board these ships are thousands of men, older men with years of experience, young boys on their first sortie in hostile waters. All are manning their battle stations, for the Task Force Commander has been told to expect strong enemy forces in the vicinity. Suddenly in the dimly-lighted radar room on one of the battleships a young operator calls out "targets bearing 060 degrees range 23,000 yards." This information is quickly relayed to the bridge of the battleship and to other ships in the task force. All ships are alerted and ordered to stand by for action by the Task Force Commander. Engineers are told to be prepared for flank speed, gunners are told to stand by to load and everything is ready for the crucial test to come. Slowly the range closes—22,000 yards, 21,500 yards, 21,000 yards—all guns are bearing on the invisible target—invisible except to the magic eye of science—*electronics*. Suddenly there crackles over the short range high-frequency radio an order from the Task Force Commander personally—"Open fire when ready." Almost immediately a battleship fires a broadside, a second broadside follows the first, then a second battleship opens with a broadside. The tracers on the shells can be seen to arch through the dark night, slowly settle toward the water—then terrific explosions light up the sky, over 10 miles away, and if one is observing the radar he sees the target echoes slowly diminish in amplitude on the radar screen, and in only a few minutes all that remains is a wavering green line, the normal sweep on the cathode-ray tube. Thus it went throughout the war, enemy ships being detected, tracked, fired on and sunk without their knowing that their presence had been detected by the sixth sense of man—*Radar.*

Millions of people have read descriptive stories such as the above in newspapers and magazines, but how many of them stopped to think of the unwritten story behind such unbelievable feats. Such events as that described above are not just a result of hit-or-miss guesswork—they are the result of long years of research, experimentation, and unselfish devotion to the cause by countless thousands of military and civilian scientists and engineers.

Many years ago the Navy realized the tremendous importance of wireless communication from ship to shore, ship to ship, and shore to shore. It was a medium for transmitting vital information rapidly and thus presented a decided advantage in strategic situations. In the early years of this century, arc and spark transmitting equipment with comparable receiving equipment was being employed by Naval ships and stations. Progress was steady but slow through those first years of the art, but the Navy was ever pressing for improved communication facilities. The transition period from the arc-spark-crystal days to the highly complex equipment employed in the past few years embraced many significant advances: TRF receivers, crystal controlled transmitters, electron-coupled oscillator applications, high-frequency communications, multi-channel transmitters and receivers, remote transmitter and receiver control facilities, airborne equipments of various types, direction finding equipment, and many others equally as important in the program.

Rear Admiral D. H. Clark, Chief of the Bureau of Ships, and Captain A. L. Becker, Assistant Chief of the Bureau of Ships for Electronics, inspect modern Naval communications equipment.

In the late 1930's, scientists and engineers of the Navy were working on a revolutionary electronic development, which if successful would change the course of military history. This project was highly secret at that time and little was learned of it until shortly before the outbreak of World War II, when initial tests had been completed and it was deemed ready for shipboard evaluation and operation. This new development has since become a byword in every American home and all the people of this great nation can thank those farsighted scientists and engineers for pursuing the elusive goal of *radar* (RAdio Detection And Ranging), for this was the weapon which was highly instrumental in our decisive victory in the recently concluded conflict. However, *radar* alone did not accomplish all the electronic miracles during those years, there were others such as coordinated radio communications using the latest developments in that field, *sonar* (SOund Navigation And Ranging) for use in undersea warfare, and many less important equipments which contributed to the overall superiority of our Naval forces.

The man on the street did not realize any personal benefit from this multi-billion dollar industry during the war years because practically all electronic developments were considered military secrets and protected as such. However, the money spent by the armed forces, led by the Navy, was actually contributing to the improved living conditions which we are now realizing. Innumerable developments of both Naval and civilian scientists and engineers during those years between 1941 and 1946 have since been applied directly to commercial products. These products embrace many fields—entertainment, medicine, nuclear physics, mathematics and the associated sciences. There is little reason to doubt that the tremendous investments in the electronics program during the war have advanced commercial electronics many years ahead of what it would be had there been no war. This is not to condone war, but only to point out that the Naval electronics program through its own requirements and investments has aided private industry to advance more rapidly. Without the working capital, scientific research, technical know-how and initiative developed during those war years, we very probably would not have available today such devices as black and white television, colored television, advanced principles of broadcast and FM radio, and the numerous machines dedicated to the health and welfare of mankind. At least those machines, if available, would not be within the reach of the average citizens of the country as they now are.

MISSILE being launched at the U.S. Naval Air Missile Test Center, Point Mugu, Calif.

Naval Electronics Organization

The Naval Electronics Organization is a far flung and vast network, encompassing scientific research and development at laboratories, electronic maintenance and upkeep at Naval shipyards, maintenance training at various schools, active operation and maintenance on board the units of the fleet and in Naval aircraft, actual operational evaluation of new electronic instruments, and last but not least logistic support of all these activities through an elaborate Electronic Supply Organization. The center of this bustling activity is located in the Navy Department in Washington, D.C. Actually, there are three electronics organizations in the Naval electronics program, one located in the Bureau of Ships, a second in the Bureau of Ordnance and a third in the Bureau of Aeronautics. As most of us know, electronics has grown so rapidly in the past few years that it has become impossible for any one person or agency to keep abreast of the latest developments in all the fields of the science in an organization as large as the Navy. Each of the three Bureau organizations has problems which are peculiar to that bureau only and bear little relation to the problems of the others. However, there are many items of common interest to all the electronics personnel of the Navy and these are handled jointly by the three Bureaus when occasion demands.

The electronics organization of the Bureau of Ships is divided into four divisions; 1—Design and Development, 2—Logistics, 3—Shore and 4—Ship, Marine Corps and Amphibious. These are combined to form the Electronics Divisions of the Bureau of Ships. Each of the four divisions is under the direction of a responsible officer, proficient in his field and well qualified for that assignment. Overall direction of the Electronics Divisions is exercised by the Assistant Chief of the Bureau of Ships for Electronics.

Design and Development Division

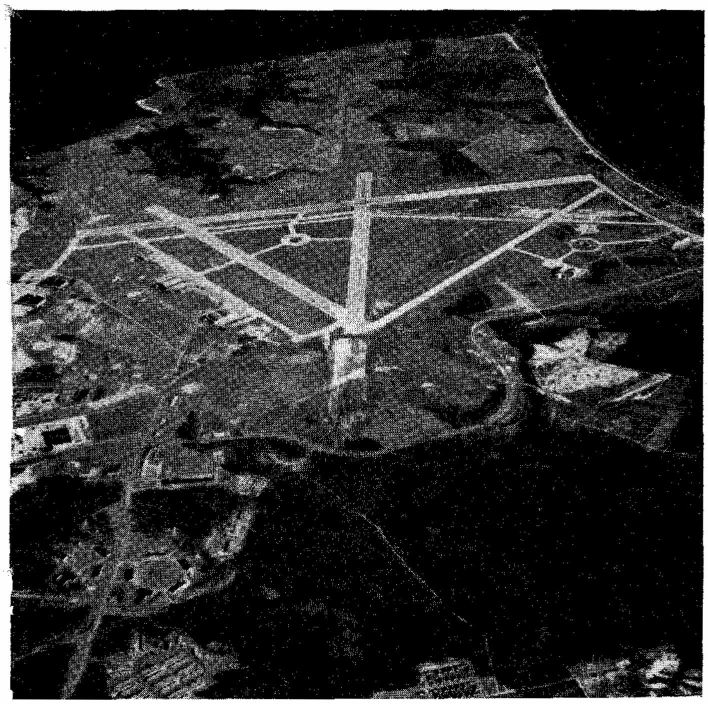
The Design and Development Division is responsible to the Assistant Chief of the Bureau of Ships for Electronics and the Assistant Chief of the Bureau of Ships for Research and Development, for directing the planning and the execution of plans for applied research, design, development, test and evaluation of electronics systems, equipments, assemblies, sub-assemblies and component parts and their related auxiliary devices designed for Naval use aboard ship and ashore. In addition, the Design and Development Division is responsible for the prosecution of programs of an investigative nature required to support this mission.

This Division plans, implements and supervises electronics applied research, design, development, test, and evaluation of programs including radio, radar, sonar, radiac, photic, cryptographic, electronic countermeasures, special applications, and related auxiliary systems, as approved by the Chief of Naval Operations and the Research and Development Board and as coordinated with counterpart agencies within the National Military Establishment. These programs are designed to meet the material requirements in fulfillment of the responsibilities of the Chief of the Bureau of Ships. The responsibility of the Division includes the preparation and control of electronics manufacturing specifications, electronic systems, functional sketch plans, electronic systems engineering integration and coordination, electronic equipment manufacturers' drawings, technical review of electronic systems and electronic equipment manufacturers' drawings, technical review of electronic systems and electronic equipment instruction books and electronics manuals prepared by the several Electronics Divisions, as well as standardization criteria for electronic circuit component parts. The Division is responsible for maintaining technical records of research and development programs, and for budget preparations, justifications and allocation of electronic research and development funds together with such management and fiscal data as is necessary to effect adequate control of this program.

Logistics Division

The Logistics Division, under the supervision of the Assistant Chief of the Bureau of Ships for Electronics, accomplishes the following for all electronics material under the cognizance of the Electronics Divisions: 1—Determines the total requirements for Electronics Divisions, 2—Directs procurement and contract planning, 3—Supervises the preparation and justification of budgets, 4—Supervises industrial relations, including production, 5—Maintains control of inventories and stock, issue and disposition, 6—Prepares planning for mobilization and war preparedness, and 7—Exercises maintenance of fiscal control.

In addition, under the direct supervision of the Director of the Logistics Division, the Division maintains close liaison with the Bureau of Supplies and Accounts, maintains liaison with all field activities on supply matters concerning electronics material, places representatives at conferences with other departments where electronics material supply problems are discussed, and in general furnishes advice and assistance to all activities concerned with electronics on the immediate and planned logistics program.



Air view of the U.S. NAVAL AIR TEST CENTER, Patuxent River, Md.

Ship, Marine Corps and Amphibious Division

The Ship, Marine Corps and Amphibious Division is charged with directing the planning of installation, maintenance, and allowances of electronic equipments and systems, under the cognizance of the Assistant Chief of the Bureau of Ships for Electronics, for Naval ships and amphibious applications. This division also exercises authority over Marine Corps electronic equipment in accordance with Bureau of Ships doctrines.

The Division's responsibilities are broken down into several groups defined as follows: 1—Establish electronic equipment and system maintenance parts allowances for all Naval activities utilizing electronic equipment under Bureau of Ships cognizance, 2—Standardize and properly identify maintenance parts for Bureau of Ships electronic equipment, 3—Furnish technical advice regarding electronic components and parts to the Electronic Supply Officer, 4—Supervise the recommendations, review, revision, compilation and dissemination of electronic equipment and system allowances for Naval ship and amphibious applications, 5—Supervise the planning of installation and maintenance of electronic equipments and systems for Naval ship and amphibious applications, 6—Plan the maintenance, repair, alteration, and modification of all Naval ship and amphibious electronic equipment and systems, 7—perform application engineering including technical analysis of electronic equipment characteristics and operational reports with the view of extending the application of these equipments to shipboard installation, 8—Plan maintenance and application engineering of Marine Corps electronic equipment, 9—Maintain a program to keep constantly appraised of the material condition of electronic equipment and systems installed in ships of the Reserve Fleet, as well as keeping abreast of the amount of electronic equipment, testing instruments, funds, etc. necessary to bring ships of the Reserve Fleet up to approved allowances, 10—Make recommendations relative to the technical aspects of electronics installation and maintenance training, 11—Coordinate special electronics engineering services provided by contractors, Naval shipyards, Electronics Officers and special groups, 12—Coordinate all electronics publications, including maintaining working files of instruction books for electronic equipments and systems, and 13—Provide drafting services for electronics publications and associated requirements.

Shore Division

The Shore Division is responsible to the Assistant Chief of the Bureau of Ships for Electronics for the installation and maintenance and systems engineering of electronic equipment at all Naval shore activities. This responsibility embraces all the Naval radio stations engaged in point-to-point and general fleet broadcast service; fixed aeronautical communications at Naval air and Marine Corps air stations; all electronic navigational aid equipment employed at fixed installations throughout the Naval service; and the engineering plans and allowances for use at Naval advanced base activities. The Electronics Shore Division consists of four branches, each of which is charged with a portion of the responsibilities outlined above. The duties of each branch are briefly outlined in the following paragraphs.

The principal mission of the Facilities Management Engineering Branch is to exercise managerial supervision of the installation, maintenance, and improvement of Naval shore-based electronic facilities both fixed, portable, mobile, and transportable at continental and overseas locations. This branch is divided into sections consisting of groups of engineers who have the responsibility of providing engineering services to particular types of electronics activities such as Radio Communication Stations, Aeronautical Radio Communication Facilities, Internal Security and Industrial Control Radio, Radio Installations for regular Navy and Naval Reserve Training Activities, Electronic Repair Shops and Laboratories, and Electronic Search and Guidance Facilities.

The Search, Guidance, and Instrumentation Systems Engineering Branch prepares type installation plans for the use of field activities in making specific installation plans and estimating costs on such installations as Ground Controlled Intercept Facilities; Command Operations Centers for Training of C.O.C. operators, officers and teams; Radar Traffic Control Systems; Air Navigational Aids; Radiation Detectors, Identifiers, Indicators and Computers; Sound Detection and Ranging Equipment; Magnetic Detecting Equipment; Surface Search Radar; Photo-electronic Detection, Ranging and Signalling Equipment; Weather Tracking Radar; Radar Identification Equipment; and Industrial Electronic Equipment.

The Advanced Base Electronics Facilities Engineering Branch is responsible for selecting certain equipments or systems approved by the Chief of Naval Operations, or indicating other equipments or systems for developmental action and/or prototype layout to meet the operational requirements of Advanced Base Facilities from the standpoint of sound electronic engineering principles. This requires that each branch engineer be thoroughly familiar with the progress of both military and civilian research and development in electronics and allied fields. Coupled with this engineering planning is the task of preparing the detailed lists of all the installation and maintenance parts and material—weeding out all duplications and non-essential items while insuring that no essentials are omitted. At the same time, sufficient information such as stock numbers, descriptive data, etc., must be applied to each of the several thousand items in order that supply activities may readily assemble from their stocks, the systems ordered by the Advance Base Commanders.

The Communication Systems Engineering Branch is responsible for the installation and maintenance of radio and wire line communication equipment including transmitters, receivers, terminal, control, and telegraph equipment—and with radio direction finder equipment and all associated items. Briefly its functions correspond to those of the plant engineering group of any of the large communication carriers or public utility organizations. It deals entirely with problems at shore based communication stations which include long range point-to-point, the shore end of the ship-shore circuits and the ground portion of air-ground circuits. It develops plant requirements to meet the operating requirements established by the Chief of Naval Operations and prepares electronics specifications for construction of new equipment and improvements to existing equipment.

Laboratories

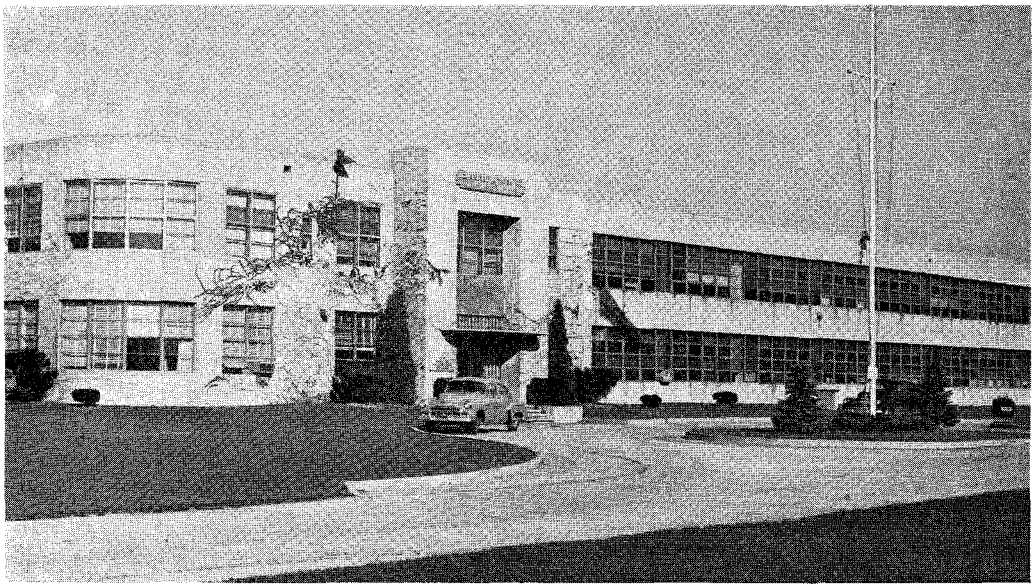
The Naval Electronics Organization maintains numerous research laboratories, such as the Naval Research Laboratory, Bellevue, D.C., the U. S. Navy Electronics Laboratory, San Diego, Calif., the U. S. Navy Underwater Sound Laboratory, New London, Conn., all under the direct control of the Bureau of Ships; the U. S. Naval Ordnance Laboratory, White Oak, Md. under the direct control of the Bureau of Ordnance; and the Naval Air Test Center, Patuxent, Md., the U. S. Naval Air Missile Test Center, Point Mugu, Calif., and the U. S. Naval Air Development Center at Johnsville, Pa. under the direct control of the Bureau of Aeronautics. There are others, but the above present a good cross section of the laboratory facilities available for advancing the cause of Naval Electronics.

Obviously, the above laboratories are not identical in make-up or organization, since each is charged with different projects and different types of projects, although facilities are available at all to undertake basic electronic research and experimentation. As can be deduced from the names listed in the preceding paragraph, certain of the Naval electronics laboratories are maintained primarily for a certain type of electronic research such as, in the case of the Underwater Sound Laboratory, sonar and its applications in undersea warfare. Although the laboratories are not identical in departmental make-up, the personnel assignments, in general, are quite similar. All are operating under certain basic doctrines laid down by the Bureau to which they are subservient, as well as broad Naval policies.

Those laboratories under the direction of the Chief of the Bureau of Ships are each headed by a responsible and capable Naval Officer, while civilian scientists, engineers, and other Naval Officers constitute the nucleus of the organization. These laboratories are under the technical control of the Bureau of Ships and their work programs are largely determined by the scientific and technical problems assigned by that Bureau. The function of the laboratory is to serve the Chief of the Bureau of Ships in the design, development, procurement, testing and installation planning of fleet electronic equipment. This requires work in theoretical science and basic research; in applied science from design up through production engineering; and in training for the operation and maintenance of electronic equipment. Usually the complement of a laboratory is approximately equally divided—one-half being professionally trained men and women including physicists, mathematicians, electronics engineers, mechanical engineers, and chemical engineers—with their technical assistants. The remainder of the staff is composed of supporting personnel, such as draftsmen, photographers, machinists, and maintenance and administrative groups.

The assignments given the laboratories are broad, indicating a need for extensive work in a number of fields. They call for a long-term program of system engineering—the study and improvement of all the electronic equipment on ships of the fleet and at shore stations. These plans call for a continuation of the wartime task of developing, modifying, and testing electronic equipment with the ultimate goal to make our Navy the leader in electronics research, development, and actual application. The program assignments are far-reaching and touch on all the phases of electronics, particularly, radar, radio, sonar, etc. They also encompass research in a considerable number of allied fields including basic physics, mathematics, geology, geophysics, meteorology, marine biology, psychometrics (psychological tests and measurements), accoustical psychology, and electrical and mechanical engineering.

The Naval Research Laboratory, Bellevue, D.C. is the oldest of Naval Laboratories, being founded in 1923. This Laboratory is located, as the name implies, in Bellevue which is a suburb of Washington, D.C. However, there is an annex to this Laboratory, located a few miles outside of Washington on Chesapeake Bay.



ADMINISTRATION BUILDING at the U.S. Naval Air Development Center, Johnsville, Pa.

The Naval Research Laboratory is charged with basic design, testing, experimentation, etc. concerned with Naval Electronics. The functions of the Chesapeake Bay Annex are to further test and evaluate pre-production and experimental models of various types of electronic equipment. In addition to continued research and consequent advancements in the electronics field, personnel of the Laboratory are active in many other fields. A complete photographic laboratory, chemical research division, modern machine shops and foundries are only a few of these activities.

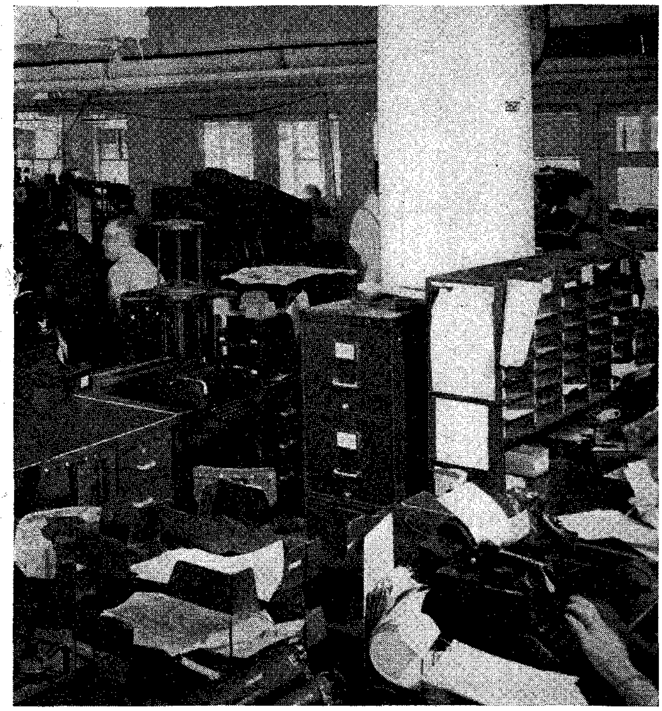
The U. S. Navy Electronics Laboratory, San Diego, Calif. is a wartime-founded institution, being established in 1942 to assist the Bureau of Ships in the field of electronics. This mission is accomplished under general program guidance of the Chief of the Bureau of Ships, and under a broad policy that requires a two-way flow of information between the Bureau and the Laboratory on one hand, and the Laboratory and the fleet on the other. It is possible, under this two-way information system, for the Laboratory personnel to understand the immediate problems confronting the fleet while at the same time remain aware of the general program requirements as formulated by the Chief of the Bureau. Close contact with the Fleet is favored by the Laboratory's location at San Diego, Calif. Much of the Pacific Fleet is based at San Diego, so that work in direct support of the fleet is greatly facilitated. Location also favors work at sea in the laboratory submarine and surface ships, which have been specially equipped for research and development investigations. Laboratory personnel have carried out tests and special investigations throughout the Pacific area—from the Antarctic to the Arctic; from the Mariannas to Mexico. Very broadly, the research and development program of the Laboratory embraces four principal fields: sonar, radio, radar, and the human factor in applied electronics. Both applied research and development work are carried out. The research and development program is administered by the Director, a Naval Captain, and is under the immediate technical direction of a Superintending Scientist. The Research, Development, and Systems Engineering Divisions carry the bulk of the research and development program.

The U. S. Navy Underwater Sound Laboratory, New London, Conn. was officially founded under its present name in 1945. Broadly speaking, the Underwater Sound Laboratory is a development organization concerned with the investigation and solution of problems in anti- and pro-submarine warfare. While these problems are concerned largely with the field of underwater sound, as the name of the establishment suggests, a number of them fall into certain other fields of electronics. The technical program of the Laboratory is coordinated closely with the program conducted at other Naval research establishments. In formulating and administering this program, the Bureau of Ships is guided by the special advantages afforded by the Laboratory, such as contacts with the fleet, sea-going test facilities, excellent shops, and nearness to the ocean test areas. Thus maximum benefit is derived from limited funds, equipment, and personnel. The technical staff of the Laboratory is divided into six operating sections, each under the guidance of a section leader, and a member of supporting groups af a consulting nature. While they may be expected to overlap one another to some extent, each group consists of a number of specialists devoted to a specific phase of the technical program. As a whole, they represent a highly integrated team, organized for the expeditious accomplishment of the Laboratory's mission.

The Electronics Test Division of the Naval Air Test Center, Patuxent, Md. is responsible for conducting engineering tests and investigations to technically evaluate the operating performance of airborne electronic and electrical equipment under laboratory and flight conditions, in order to determine the suitability and value of these equipments for operational use in Naval aircraft. Further, when applicable, the division will determine necessary engineering changes or modifications to the electrical, electronic or mechanical characteristics and construction of the equipment to render it suitable for use and to provide operating characteristics necessary to make this equipment of military value to Naval aircraft. In carrying out this mission, some 300 civilians are employed in the Electronics Test Division, about one-third of whom are in technical capacities. An additional 200 military personnel are stationed here, principally engaged in flight operations, although a number are scattered throughout the various sections in technical positions. The Division consists of three major departments: Engineering, All Weather Aids, and Flight Operations—plus a small Inspection Department. The Engineering Department, which is the basic unit of the Division, employs electronics, electrical and mechanical engineers of all grades, who are trained and generally specialize in particular engineering fields, such as radar, power supplies, radio and communication, antenna, and composite systems operations. The department is under the direct supervision of a civilian chief engineer, who is supported by civilian section heads, with their aides and consultants.

Interior view of a portion of the COMMUNICATION TRAFFIC CENTER, Navy Department, Washington, D.C.

The Naval Air Missile Test Center at Point Mugu, Calif. is located on the Pacific coast. The primary mission of the Test Center is the testing and evaluation of guided missiles. While supported by the Navy, it also provides facilities for the Air Force, Army, and the Marine Corps, as well as for a large number of contractors who carry out advanced phases of missile development at the Center. Physically, it consists of about 4200 acres of land on shore and a number of observation and instrumentation points on islands located off the coast. The field of guided missiles is under intensive development. In order to extract all the possible information from each flight at Point Mugu,



it is necessary to provide very complete instrumentation. This may be considered in two parts, external and internal. The external instrumentation provides data on gross behavior, the position of the missile in space, its velocity and acceleration, the relation between its trajectory and its target. Internal instrumentation covers voltages, pressures, temperatures, and other factors which describe the behavior of components during flight. The application of both the external and internal instrumentation requires a high level of engineering experience.

The U. S. Naval Air Development Center, Johnsville, Pa. comprises three laboratories, one of which is the Aeronautical Electronic and Electrical Laboratory, founded to centralize the responsibility and authority for aircraft electronic and electrical equipment and systems. The development of high speed, high performance aircraft during the war made it imperative that aircraft electronic and electrical systems be designed first as a system, rather than as an assembly of unrelated "black boxes" and second, but equally important, as an integral part of an aircraft design. The Center is organized into three divisions: Development Division, Test and Evaluation Division, and the Engineering Services Division. This organization permits the development and test and evaluation engineers to devote their major efforts to the furtherance of projects assigned by the Bureau of Aeronautics, while the burdensome and time-consuming functions such as facilities, publications, administration, and program coordination are assumed by the Engineering Services Division.

The U. S. Naval Ordnance Laboratory at White Oak, Md. represents the ultimate in laboratory facilities available to the Bureau of Ordnance for test, research, evaluation, experimentation, etc. This Laboratory was founded in 1929 and originally employed only a handful of employees. At present there are more than 2200 scientists, engineers, technicians, clerical help and shop workers attached to the Laboratory. It includes seventy-five buildings and five field test stations dispersed over a 938-acre site in nearby Maryland.

The 2200 employees are under the administrative and military control of a Rear Admiral, U. S. Navy, and under the technical control of a senior scientist. The facilities of the Laboratory are employed by the staff in hundreds of scientific explorations from the development of supersonic guided missiles to the classification of deep sea fish noises, from quality control by radiography to the cultivation of delicate transducer crystals. This highly diversified program of scientific research and development is geared essentially to one purpose—equipping the U. S. Fleet with the weapons necessary to not only keep it abreast, but ahead, of all other similar organizations. Originally, the Laboratory devoted practically all of its efforts and facilities to mines, mine warfare and fuzes. Not until World War II did the Laboratory branch out to embrace degaussing operations for American vessels. This involved exploration in the field of terrestrial and electrical magnetism.

Some idea of the diversity of the Laboratory program may be gleaned from a partial examination of its record during the past war. 1—Conceived, designed and tested airborne mines which destroyed or damaged two million tons of Japanese shipping during the last three months of hostilities; 2—Developed a series of detectors using the influence field principle for the detection of submerged ordnance. This device enabled the recovery of approximately $60,000,000 worth of torpedoes alone; 3—Adapted the British 40mm antiaircraft fuze to American manufacture with a simplification which saved millions of dollars. This fuze brought down more airplanes than any other fuze used in the war; and 4—Aided by the Bell Telephone Laboratories, the Laboratory developed the Magnetic Airborne Detector, which successfully detected and led to the destruction of a number of submarines, and today is proving of great usefulness in geophysical exploration.

But, perhaps what will eventually prove to be NOL's most significant contribution to the security of the United States, is the pattern of cooperation between the military and scientific professions. Thus while NOL is essentially a military establishment, it functions as a scientific organization, with youth, foresight, and cooperation resulting from the merging of these two professions.

Naval Shipyards

The Navy maintains numerous Naval shipyards on both coasts of the U.S. and in Hawaii. The administrative make-up of these yards follows, in general, a pattern laid down by the Navy Department. Each Naval shipyard includes in its organization an Electronics Department, headed up by a capable Naval Officer, usually a Captain or Senior Commander. The internal organization of the Electronics Department, from the Electronics Officer down through the engineers and shop personnel, follows the same general line at all Naval shipyards.

The Electronics Officer is responsible to the Shipyard Commander for the proper functioning of his office, advises and assists him in all matters pertaining to electronics work, supervises field work at all the district electronics activities (regular and reserve), is responsible for technical control and inspection of electronics work and for maintenance of shore radio, radar, sonar and other electronics activities in the district. He maintains liaison with all Naval and commercial electronics activities in the area. He acts as Deputy Shipyard Commander in all matters pertaining to district electronics activities. As Deputy Planning and Production Officer, he has supervision over all electronics work in the Planning and Production Departments.

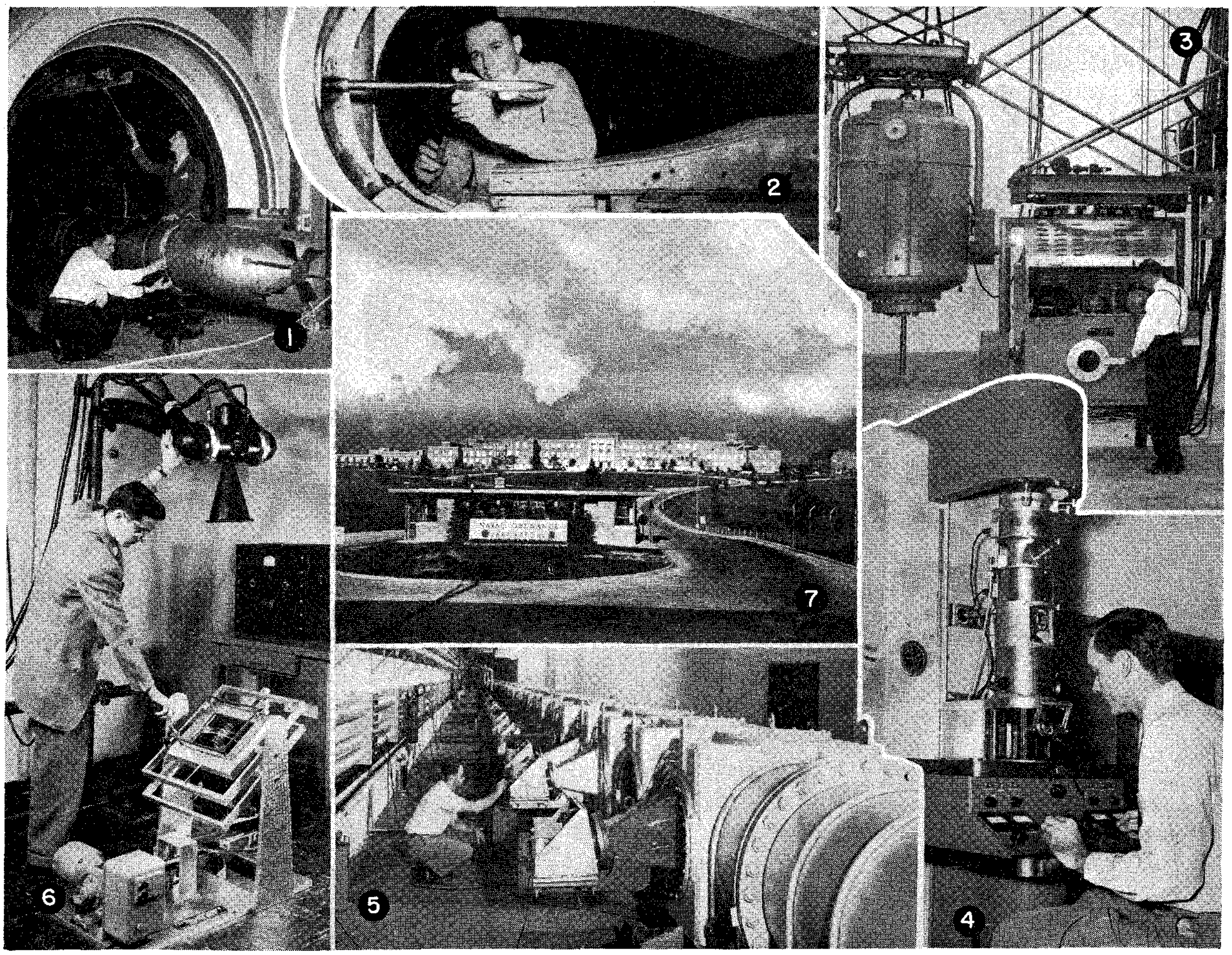
The Electronics Officer has three immediate section heads subservient to him, the Assistant Electronics Officer for Shore, the District Reserve Electronics Officer, and the Senior Civilian Assistant. The Assistant for Shore is directly responsible to the Electronics Officer for preliminary design, development, installation and maintenance of all shore electronics activities in the district. He maintains liaison with the Commanding Officer of the Navy Communication Stations located in the district, and with officers-in-charge of all district communication stations and electronics activities. In the absence of the Electronics Officer, the Assistant for Shore acts in his capacity. The District Reserve Electronics Officer is assigned to investigate and report on all problems which arise in connection with district reserve electronics activities. He is responsible for the maintenance of equipment records and installation priority schedules concerned with district reserve activities. He maintains liaison with all district reserve electronics activities and wth reserve training organizations and programs. The Senior Civilian Assistant directs and coordinates the work of all sections, groups and units of the office, maintains liaison with all heads of departments, divisions and offices of the shipyard and with district electronics activities. He advises and assists the Electronics Officer and maintains technical and management control over all activities of the office.

The Electronics Office is divided into three general sections; Technical, Inspection, and Clerical. The Technical and Inspection Sections have wide duties and responsibilities, being sub-divided into four groups to more efficiently allocate those duties and responsibilities. The Installation and Maintenance Group is responsible for the installation and maintenance of all shore radio, radar, sonar and other electronic equipment at shore electronics activities in the district. They establish suitable schedules of maintenance by station force or shipyard personnel as required, make inspections and test, calibrate and adjust installed equipment. The Progress Control Group maintains liaison with officers-in-charge of district electronics activities, arranges priority of work, directs the initiation of job orders, prepares correspondence and maintains progress control records. The Ships Test Group performs all necessary tests, calibrations and engineering measurements on shipboard radio, radar, sonar, teletype and other electronic installations. They supervise the work of contract engineers, provide engineering information and data to shipyard shops and other shipyard branches as required. They provide engineering services for all GCA units installed in the district or undergoing overhaul in the shipyard, and perform special engineering work as assigned. The Engineering Group is responsible for the preliminary planning, development, engineering and design of all shore radio, radar, sonar, teletype and other electronic installations in the district. They supervise the preparation of plans and specifications, provide engineering data and act as technical engineering consultants on all shore station problems.

The Electronics Shop has been established under the Production Department, Shop Superintendents Office. This shop is charged with maintenance, repair and upkeep of electronic devices in numerous different fields including Teletype and Cryptographic Repair Facilities, Instrument Repair, Crystal Grinding, Radar-RCM-IFF-Loran, Infra-Red Equipment Repair, Radio Receivers, Radio Transmitters, etc. An outside section of the Electronics Shop is charged with the removal and installation of electronic equipment on shipboard as well as accomplishing shipboard electronic repairs. Electronics Shop personnel, under the direction of an Electronics Engineer, overhaul all ground-controlled approach (GCA) equipment from all areas in the district. A complete machine shop is maintained for light manufacturing work incident to the repair and installation of electronic equipment. Parts that cannot be procured from commercial sources are manufactured in this section. Fabrication and assembly of complete units is often necessary.

Electronics in the Naval Reserve

In the preceding pages we have discussed those activities concerned with electronics in the active and operating shore and fleet establishments. There is still



1. NOL engineers prepare a Naval mine for pressure testing in a specially designed 105-ton pressure vessel. 2. Engineer secures a guided missile model in the supersonic wind tunnel working section prior to running test. 3. Scientist adjusts the "eye" of the 10,000,000-volt betatron. At left is a 2,000,000-volt resonant X-ray generator. 4. Another useful instrument is the electron microscope. 5. Scientist adjusts spark camera on the 320-foot pressurized ballistics range used to record performance of a missile in flight. 6. Strange looking instrument is the spiral laminagraph, an X-ray machine designed at NOL to focus on one particular plane in an object and blur all other planes. 7. Main entrance to the U.S. Naval Ordnance Laboratory, White Oak, Md. Entire station covers 983 acres and is the center of underwater weapon development for the Navy's Bureau of Ordnance.

another phase of Naval Electronics, the Naval Reserve Electronics Program, which is administered by Naval Reserve Activities, but receives logistic and administrative support from active Naval organizations. The purpose of the Naval Reserve is to provide a force of qualified officers and enlisted personnel who are available for mobilization in the event of a national emergency, and who, together with the active and retired personnel of the regular Navy, can effectively meet the needs of the expanding Naval establishment while an adequate flow of newly trained personnel is being established. The Electronics Warfare Program in the Naval Reserve is designed to accomplish this purpose for electronics personnel requirements as set forth in the mobilization plan. General policies relating to the size, location, organization, administration, training, and mobilization of the Naval Reserve, before being adopted, are submitted to the Secretary of the Navy for approval, via the Chief of Naval Operations.

One of the most important divisions of the Naval Reserve Organization is the Naval Reserve Electronics Warfare Unit, consisting of reserve officers and enlisted personnel grouped together at various locations throughout the continental limits of the U.S. and at certain other locations. The Electronics Warfare Program of the Naval Reserve is concerned with the training of personnel in three principal operational fields plus training in technical electronics. The three principal operational fields, showing types of equipment involved, are described in the table on the next page.

In addition, technical training will be given in radiological safety devices, missile guidance, electronic train-

Communications	Combat Operations Center	Anti-Submarine Warfare
Radio Direction Finder Visual Signalling Infra-Red Remote Control and Telemetering Data Transmission Automatic Transmission Wire and Terminal Radio Navigational Countermeasures	Radar (air and surface search—fire control) IFF Navigational System Countermeasures GCA and CCA Display Systems AEW	Sonar Depth Finding Sofar and Rafos Harbor Defense Listening Devices Underwater Countermeasures Sono-buoys

ing aids, nuclear physics, and related subjects not included in the above listing.

Because the techniques of electronics warfare necessitate the closest cooperation between air, surface and submarine components of the Navy, the same close cooperation is maintained by Naval Reserve air, surface and submarine organizations in order to provide realistic useful training in electronics warfare.

Electronics warfare personnel are trained in both the Organized and the Volunteer Reserve as an integral part of the over-all Naval Reserve Organization. They are assigned to Organized Reserve divisions, battalions, companies and platoons; and in the Volunteer Reserve, personnel are organized as electronics warfare companies and platoons. For planning purposes a quota of 500 companies and 750 platoons has been established. Volunteer Reserve personnel participate in Organized Reserve drills and train on a voluntary basis and may be retained on full time status as instructors, station keepers, and/or consultants in the reserve electronics training program. In addition to Reservists assigned to drilling units described above, individual Reservists holding FCC Amateur Radio Operator and Station Licenses may be issued Navy call signs, publications, and furnished piezo-electric crystals for frequency control of their transmitters. In this manner these Reservists may drill in radio procedure, and participate in Naval District emergency and disaster network activity.

A tremendous amount (approximately $200,000,000 worth) of electronic equipment has been made available to the Naval Reserve Electronics Warfare Unit for installation in the various Naval Reserve Armories for training in installation, maintenance and operation. Electronics Warfare Companies and platoons receive substantially the same type allowance of equipment and publications on a comparable basis with the same training as conducted in Organized Reserve Armories. This allowance includes visual equipment, radio, radar, IFF, sonar, and electronic laboratory equipment as well as commercial and Navy publications. The level of training in the Naval Reserve is of the highest order and constant efforts are being made to improve the quality and quantity of material available to the organization for training purposes.

In general, the curricula in Naval Reserve training programs parallels that given for similar ratings in the regular Navy training centers. Training methods include classroom lectures and demonstrations by regular instructors and visiting lecturers, maintenance and operation of equipment on both shore-based and shipboard equipment, assignment of laboratory problems and homework, extensive use of training films, recordings and correspondence courses, visits to laboratories (civilian and Naval) and manufacturing plants, and widest possible use of regular Navy activities.

Undoubtedly many people are not aware that the Naval Reserve is a constantly expanding organization, and applications from interested persons are always welcome. Prospective applicants may obtain full information on joining this fast-growing organization from the Naval Reserve Activity in any Naval District Headquarters.

Training Program

Due to the increasing complexity and quantity of electronic equipment throughout the Naval service, it has been a prime objective of the Navy Department to maintain a high level of technical ability among the officer and enlisted personnel who are assigned to maintain and operate this electronic equipment. To accomplish this objective, a long range training program was initiated and is being prosecuted by the Navy, both for operational and technical personnel. Many radio operator and teletype schools are situated at strategic locations throughout the country to train young men in the art of radio and teletype procedures. As these young men are graduated, they are assigned to duty at large shore radio stations or on board units of the fleet. Obviously, they are not finished operators upon graduating from the schools and their training continues at their new assignment. It is this principle of on-the-job training which has paid large dividends to the Navy throughout the past years, producing outstanding radio operators and communications experts.

In addition to the operators schools, several electronics maintenance schools have been established in the U.S., for both enlisted and officer personnel. It is the mission of these schools to take high "General Classification Test" boys from the various training centers and over a period of about eight months teach them the fundamentals of mathematics, radio, and a limited amount of more complex electronic equipment such as radar, sonar, etc. As in the case of operators, these boys upon graduation are assigned to shore establishments (in isolated cases) or to fleet units. Their training continues after arrival at their new assignment, although they are immediately integrated into the shipboard electronics maintenance organization. As they increase in ability and professional knowledge, they are advanced in rating commensurate with this newly acquired ability and knowledge. After a period of some years, depending on the individual, they reach the highest pinnacle in enlisted ranks, Chief Petty Officer. If the individual has the professional ability and the inherent desire, he may go on up to officer rank, through the media of Warrant Officer and Chief Warrant Officer. Thus, each man who enters the Naval service and elects a career in the field of electronics is assured of the possibility of continuous advancement until he reaches the limit of his abilities. The technicians are the men who, during the war, were indirectly responsible for the overwhelming superiority enjoyed by our Naval forces in the application and usage of electronic equipment designed, developed, and produced through the combined efforts of Naval and civilian scientists, engineers, and mass production techniques, facilities and abilities outstanding among American manufacturers.

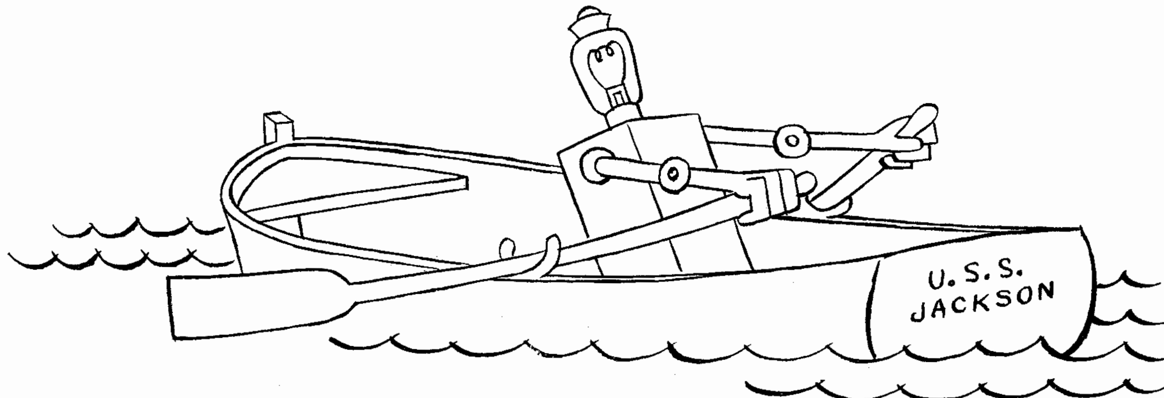
The Naval Electronics Organization is not complete without giving a due share of praise to the officers and enlisted personnel who man our ships and stations throughout the world. As in the case of all other departments of the electronics organization, an individual ship or station is also organized to obtain maximum efficiency from the personnel available. A typical shipboard electronics organization is made up as follows: The Electronics Officer, usually a Lieutenant (junior grade) or Lieutenant (senior grade) is in overall charge of the electronics maintenance organization. On large ships he is usually assisted by a Warrant Officer or Chief Warrant Officer (Radio Electrician or Chief Radio Electrician) who is directly responsible for the actual maintenance assignments and satisfactory completion of these assignments. The Electronics Officer is directly responsible to the Department Head (Engineering Officer) for the overall functioning of the electronics maintenance organization. In the case of small ships, where no Warrant rank is assigned to the ship, the Electronics Officer is assisted by either a Chief Petty Officer (Chief Electronics Technician) or First Class Petty Officer. Depending on the size of the organization, responsibility and work assignments are made on an equitable basis among the remainder of the technicians.

No organization, operating on so vast a scale as the Naval Electronics Organization, could function without a complete and thorough logistics support program. This is true not only in the Navy but in private industry as well. The Navy has developed during the past years an extensive world-covering logistics program for electronic parts and material. The central point in this organization is located at Chicago, Illinois, in the office of the Electronics Supply Office. This office operates under the technical control of the Bureau of Ships and under the management control of the Bureau of Supplies and Accounts. The office is charged with the inventory control of electronic maintenance repair parts for Bureau of Ships equipment. Fundamentally, this merely means the providing of parts required for the maintenance of equipments when and where demand arises. It is merely a matter of knowing what parts comprise each equipment, how many equipments there are in use, the location of those equipments, and the rate at which the several parts are consumed or will be required.

Only within the last few months have there been adequate parts lists of equipments and equipment inventories that could be applied to this problem. In addition, many parts that were provided in the spare parts boxes (supplied by manufacturers with the equipment) at time of acquisition were not properly identified or stock numbered, and many parts were never provided. This is understandable due to the crash nature of many programs during and immediately after the war. However, these conditions confronted the Navy with a tremendous problem. The development of adequate parts lists is going forward, the proper identification of all parts progresses, the introduction into the system of parts in spare parts boxes continues, the application of failure data to the equipment application and population is coming into being with the end result that eventually the electronic supply system will be able to have available to the maintenance personnel a much more intelligent span of parts than at present. Maintenance is completely ineffective without proper supply. Proper supply is dependent upon the factors indicated above, plus information from those involved in maintenance, operation, equipment development and procurement. As supply is vital to maintenance, so is information from all sources vital to supply.

It is with pardonable pride, therefore, that the Naval Electronics Organization views the accomplishments made in all fields related to the electronics program. Maintenance information from those engaged in actual work has proven invaluable to those engaged in basic research and design. This information has aided in the elimination of weak components, unsatisfactory units, and in many cases complete discard of entire equipments and systems which were proven unreliable or unsatisfactory. Actual field trials by engineers and scientists from the Bureau of Ships and the Laboratories have been highly instrumental in cutting down time between breadboard design and finished product, between initial trials and eventual acceptance or rejection of a mass of electronic equipment. The supply organization has grown with this growth in the technical field and the net result is a far more efficient Naval Electronics Organization at the present time than was ever anticipated in the preceding years.

TEST EQUIPMENT GOES TO SEA



by

ISIDORE PLOTKIN, *Electronics Engineer*
Ship, Marine and Amphibious Division, Bureau of Ships

The primary purpose of electronic equipment aboard ship is to aid Naval vessels in performing as effective fighting units. This equipment is kept in optimum operating condition by trained technicians using adequate test equipment.

The Bureau of Ships provides a wide variety of electronic test equipments aboard its vessels. These range from simple multimeters to large and expensive radar test sets. On some classes of Naval vessels, as many as 130 individual equipments are allowed. Some idea of the number of types of test equipment aboard Naval vessels is given by Table I.

Because of the limitations of weight and space, electronic test equipment designed for use in Naval vessels is made as versatile and multipurpose as feasible. Thus combination tube tester-multimeters are used instead of ordinary tube testers; electronic multimeters (volt-ohm-milliammeters) are used instead of electronic voltmeter or volt-ohmmeters; combination frequency-power meters are used instead of individual instruments.

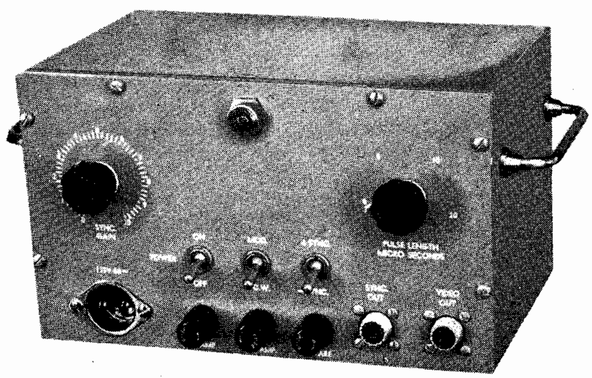
TABLE I

TYPES OF ELECTRONIC TEST EQUIPMENT ABOARD VESSELS OF U. S. NAVY

- Adapter Kit (Tube Socket)
- Amplifier (D.C.)
- Audio Oscillator
- Bridge (A.C., Capacity and Resistance)
- Bridge (Audio Frequency)
- Bridge (Radio Frequency)
- Bridge (Wheatstone D. C.)
- Crystal Rectifier Test Set
- Detector-Amplifier Assembly
- Dummy Load
- Echo Box
- Electronic Switch
- Field Strength Meter (Including Interference Meter)
- Fluxmeter
- Frequency Meter (Crystal Controlled Heterodyne)
- Frequency-Power Meter
- Frequency Standard (Radiosonde)
- Graphic Milliammeter
- Loran Test Set
- Megger
- Multimeter (Volt-Ohm-Milliammeter)
- Multimeter (Electronic)
- Ohmmeter (Electronic Megohmmeter)
- Oscilloscope
- Radar Test Set
- Range Calibrator
- Signal Generator, R. F.
- Signal Generator (Wobbulator)
- Sonar Test Set
- Spectrum Analyzer
- Synchroscope
- Teletype Distortion Test Set
- Test-Tool Set
- Tube Tester (Bulkhead Mounted)—Patchcord Type
- Tube Tester–Multimeter (Portable)
- Voltage Divider
- Wave and Power Meter
- Wavemeter
- Wavemeter—Oscillator
- Wattmeter (R.F.)

Test Equipment Allowances

The Bureau of Ships attempts to furnish test equipment in accordance with the type and amount of electronic equipment aboard, the number and ratings of the maintenance personnel aboard, the space and facilities available and the type of maintenance expected to be done.



PULSE GENERATOR SG–18(XN)/U. This pulse generator is designed to pulse modulate a u-h-f signal generator now used by the Navy. The pulse length is variable from 3 to 40 microseconds. Because of miniaturization, this equipment weighs only 35% as much as its predecessor.

TABLE II. Dimensions and Weights of Past and Present Procurements.

Item No.	Past Procurements: Nomenclature	Dimensions (inches) H	W	D	Weight lbs	Present Procurements: Nomenclature	Dimensions (inches) H	W	D	Weight lbs
1	Cathode-Ray Oscillograph Navy Model OBT	15½	10⅜	17	60	Oscilloscope OS–8/U	8⅝	6	13½	14
2	Detector-Amplifier Assembly AN/UPA–1	12	18½	10¾	55	Detector-Amplifier Assembly AN/UPA–1A	8⅛	16 11/16	15⅜	22
3	Signal Generator (Pulse) Navy Model OCD	9¼	14⅛	8¼	37	Pulse Generator SG–18/U	6⅛	12¼	6⅞	13½
4	Audio Oscillator Navy Model LAJ	10¼	15	9 7/16	37	Audio Oscillator Navy Model LAJ–2	8	11½	11	25
5	R-F Standard Signal Generator Navy Model LP Series	17 7	15 12	11½ 6 Total	55 20 75	R-F Signal Generator Set AN/URM–25(XN)	10	13	10	31
6	U-H-F Signal Generator Navy Model LX–2	12 7/16	10 5/16	10¾	40	R-F Signal Generator Set AN/URM–26(XN)	10	14	10	30

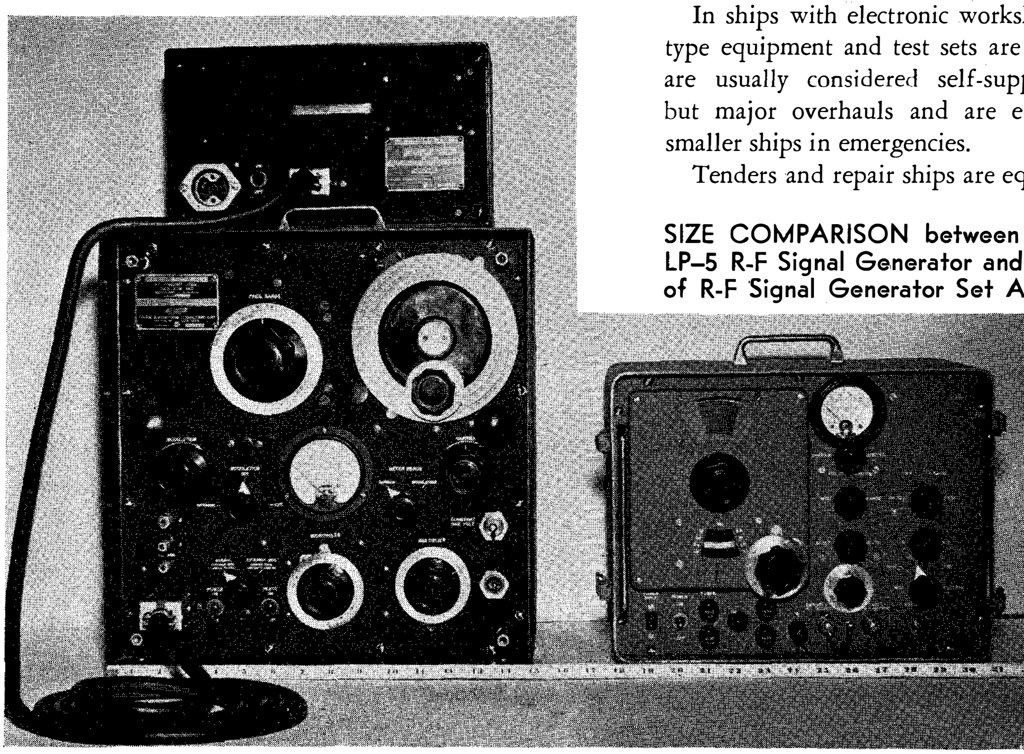
NOTE: The use of "(XN)" denotes an experimental or pre-production model developed by the Navy.

On small ships with no technicians aboard, only simple instruments such as combination tube tester-multimeters, echo boxes and other such items which can be used by the operators are allowed.

On larger ships with technicians aboard but no established electronic workshop, some of the more elaborate test equipment is supplied. Multimeters, oscilloscopes, signal generators, capacity-resistance bridges and similar equipments are allowed. These ships are expected to keep their equipments in good repair for all but major breakdowns.

In ships with electronic workshops, the heavier bench type equipment and test sets are furnished. These ships are usually considered self-supporting for everything but major overhauls and are equipped to help other smaller ships in emergencies.

Tenders and repair ships are equipped to do practically



SIZE COMPARISON between present Navy Model LP–5 R-F Signal Generator and pre-production model of R-F Signal Generator Set AN/URM–25(XN).

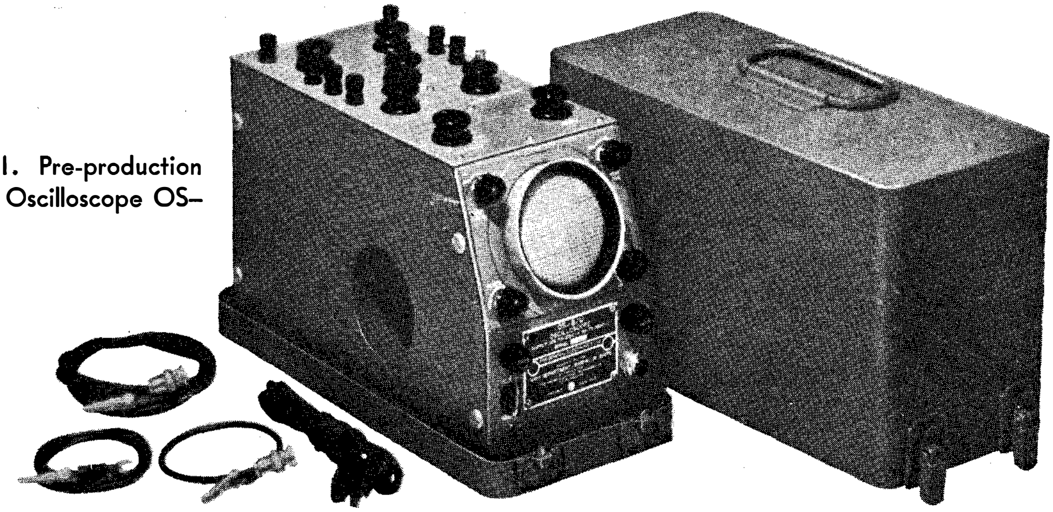


FIGURE 1. Pre-production model of Oscilloscope OS–8(XN)/U.

any repair or maintenance job and are therefore given all types of test equipment including laboratory or precision types.

Miniaturization and Reduction in Size

Shipboard test equipment raises problems unique to the Naval service. Electronic equipment is widely dispersed aboard ship. It is obviously impractical to assign to each space containing electronic equipment a full complement of the test equipment necessary to repair, calibrate and maintain such equipment. Since some of the equipment is used sporadically, its use in only one space cannot be economically justified.

Naval test equipment must be designed to be extremely portable. This test equipment must be carried up ladders and through small hatches, sometimes to the top of masts. Due to the importance of these considerations some of the first evidences of the use of miniaturization techniques in components, tubes and printed circuits are to be found in new procurements of Naval test equipment. A comparison of the sizes and weights of several instruments now in stock or under procurement with their predecessors is shown in Table II.

Oscilloscope OS–8/U

For some time the usefulness of oscilloscopes in servicing electronic equipment has been curtailed by the size and weight of the available oscilloscopes. In order to extend the usefulness of this type of test equipment the Bureau has developed the oscilloscope shown in Figure 1. While it was possible to design and build a miniature oscilloscope within the size limitations listed in Item I of Table II using standard JAN components, it was only with the application of miniature components and printed circuits that the weight was reduced 75% from that of the previous model. A preproduction model built with standard components is shown in Figure 2. An internal view of the final preproduction model is shown in Figure 3.

Oscilloscope OS–8/U is unique in many respects. The oscilloscope is attached to the bottom of the transit case by means of shock mounts. A rubber gasket makes the oscilloscope waterproof when in its transit case. It is ruggedly built for military use. Despite its small size, it has a 3-inch tube and a vertical deflection sensitivity

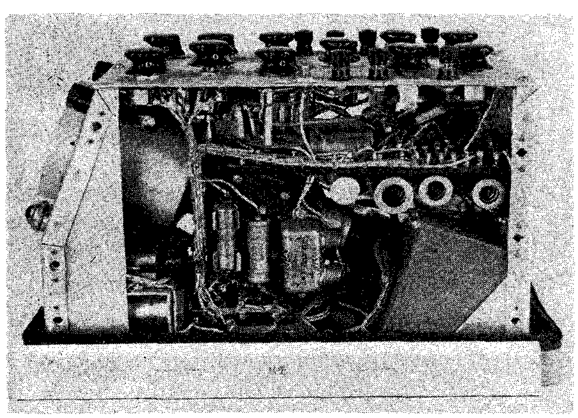


FIGURE 2. Pre-production model Oscilloscope OS–8(XN)/U with standard components.

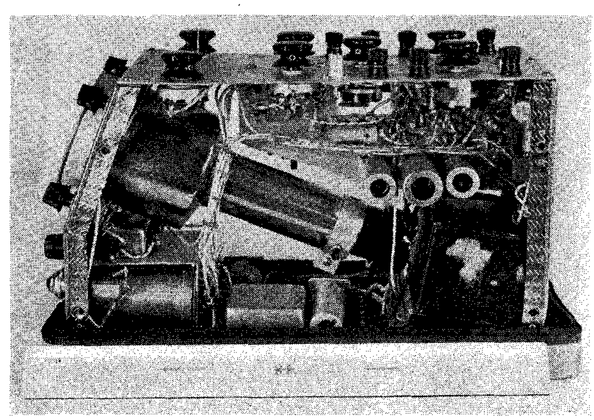


FIGURE 3. Final pre-production model Oscilloscope OS–8/U with miniature components and printed circuits.

Pre-production model of TEST-TOOL SET AN/-USM–3, showing all units.

of 0.1 volts RMS per inch flat within 3db from 5 cycles to 2 megacycles. The vertical input can be switched to a type of direct coupled amplifier that has a d-c sensitivity of 0.4 volts per inch. The sweep circuit can be varied from 3 to 50,000 cycles per second.

In its new convenient portable form this oscilloscope is expected to make military servicing easier and faster.

Test-Tool Set AN/USM–3

The Navy's condensed servicing kit, Test-Tool Set AN/USM–3 has already been described in detail in

TABLE III

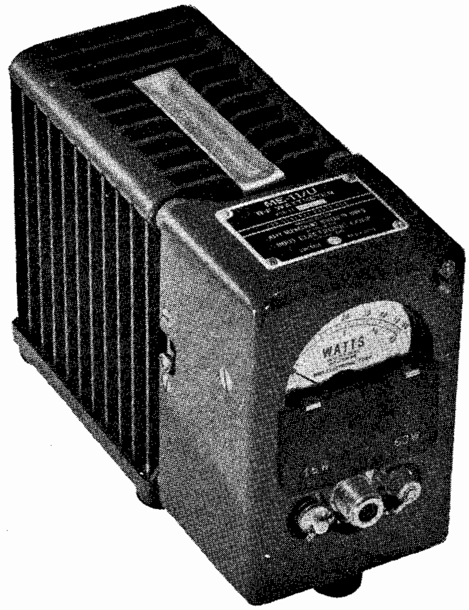
MAJOR UNITS OF TEST-TOOL SET AN/USM–3

Item	Nomenclature	Brief Description
1	Tube Tester TV–4/U	Tests practically all tubes for emission, filament continuity shorted elements and open elements Measures capacities from 0.001 to 100 microfarads
2	Signal Tracer TS–673/U a) Test Prod MX–933/U(AF) b) Test Prod MX–934/U(RF) c) Telephone Receiver Navy Type 491901	R-F range 15 kc to 400 Mc Sensitivity 0.005 volts A-F range 47-15000 cps Sensitivity 0.002 volts Has terminals for electronic meter or oscilloscope
3	Interference Generator SG–23/U	Frequency range—approx 2000 cycles to 400 megacycles Buzzer type in pencil form with attenuator
4	Voltage Indicator-Probe ID–265/U	Indicates 0-440 volts AC or DC. Shows polarity. A-C frequency range 10 to 10000 cycles Input impedance 500,000 ohms. Pencil type
5	R-F Indicator-Probe ID–263/U	Frequency range 100 kc to 400 mc Sensitivity 1 volt R.F. for 25% deflection. Pencil type
6	Resistance Indicator-Probe ID–264/U	Pencil type—Indicates 0 to 10,000 ohms
7	Decade Resistor TS–672/U	One ohm to 12 megohms in steps of one ohm. Tolerance ±5%—All resistors 2 watts
8	Decade Capacitor TS–671/U	0.0001 to 48 microfarads Voltage rating 500 volts DC (paper); 450 volts DC (electrolytic)

the May 1949 ELECTRON. This test-tool set is 9½″ x 9½″ x 7″ and weighs 23 lbs. The major units are listed and described briefly in Table III.

The tools and accessories include four test leads, twelve patch connectors, three screwdrivers, hexhead wrench set, socket wrench set, small size long nose and side cutting pliers, fuse puller, insulated tweezers, pilot light extractor, combination alignment tool and tuning wand, pen type soldering iron, neon test light, flashlight with Lucite extension and dental type reflecting mirror, small compact technician's handbook and a tube data index.

The test-tool set is intended to supply in a compact form the necessary tools and test instruments to determine the cause of trouble and make emergency repairs under battle conditions. Aside from the tube tester and signal tracer the equipment is "rough and ready" with no knobs to turn or complicated connections to make.



R-F WATTMETER ME–11/U. An r-f wattmeter rated at 60 watts in the 100- to 500-Mc region. It weighs 7 pounds and is 8″ x 6″ x 4″.

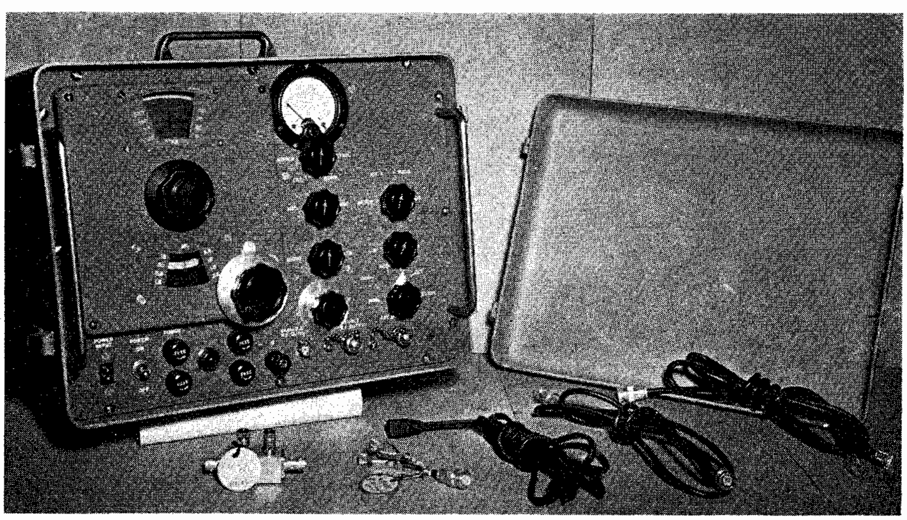
R-F Signal Generators

As can be seen from Item 5 of Table II, the signal generator now in use in the frequency range from 10 kc to 50 Mc is very large and heavy. The Navy Model LP Series also has a variable output impedance and consequently is inconvenient to use especially at the higher frequencies. R-F Signal Generator Set AN/URM–25, the new signal generator, is smaller and lighter than its predecessor, has a constant output impedance and meets its performance characteristics under rugged military tests. The specification performance requirements are as follows:

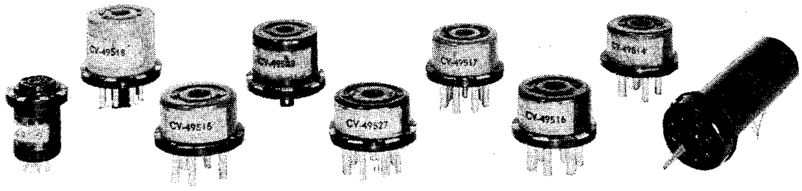
1—Accuracy of output indication ±10%.
2—Frequency calibration accuracy ±0.5%.
3—Application of 30% modulation shall not result in a frequency shift of more than 0.001%.
4—Spurious frequency modulation shall not be more than 0.0025% with 30% amplitude modulation.
5—Leakage within 6 inches of the cabinet shall not exceed 0.5 microvolts for a 3-inch loop.
6—Internal modulation of 400 cycles and 1000 cycles.
7—Output variable from 0.1 to 100,000 microvolts.
8—Output of approximately 1 volt available at a panel jack.

A companion signal generator with a frequency range of 3 to 405 Mc is also under procurement as R-F Signal Generator Set AN/URM–26. This signal generator whose physical characteristics are listed as Item 6 of Table II has the following specification requirements:

1—Output variable from 1 to 100,000 microvolts.
2—Internal modulation of 400 and 1000 cycles variable up to 50%.



Pre-production model of R-F SIGNAL GENERATOR SET AN/URM–25(XN).



NAVY TYPE –49992 ADAPTER KIT. Used for obtaining socket voltages above the chassis, when servicing electronic equipment.

3—Accuracy of output indication ±10% up to 100 Mc; ±20% from 100 to 400 Mc.
4—Frequency accuracy ±0.5%.
5—Spurious frequency modulation with 15% amplitude modulation shall not exceed 0.035%.
6—Stray leakage less than 1 microvolt as measured with an antenna two inches long, two inches from the signal generator.

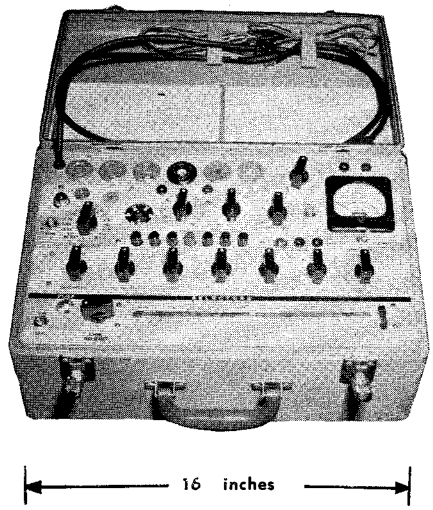
Other Portable Instruments

R-F Wattmeter ME–11/U is a small compact instrument used primarily for the Navy's u-h-f transmitters in the 200- to 400-Mc range. It consists essentially of a dummy load (good from d.c. to over 1000 Mc with a maximum VSWR of 1.1) with a dual range crystal rectifier type meter across it. The scale on the meter is calibrated directly in watts with maximum readings of 15 and 60 watts and an accuracy of 5% over the rated range of 100 to 500 Mc.

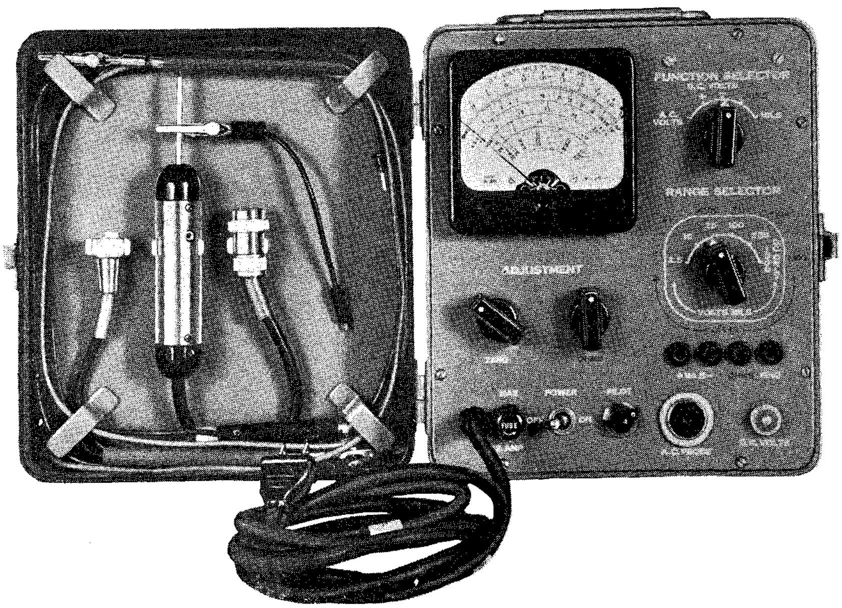
Adapter Kit Navy Type –49992 consists of a set of adapters which allow access to tube terminals from above the chassis. They are supplied together with an adapter puller to aid in servicing those chassis which are so constructed that it is inconvenient to get at tube pins. Because of their straight through connections, they can be used in most audio circuits and most non-critical video circuits. Where only d-c potential is to be measured they may be used even in r-f circuits.

The Navy Model LAJ–2 Audio Oscillator (Item 4 of Table II) is a small portable audio signal source for use when a variable frequency source is necessary for testing audio circuits or for external modulation of r-f signal generators. The oscillator is resistance-tuned and covers the frequency range from 20 to 20,000 cycles with a maximum output of 250 milliwatts across an output impedance of 600 ohms.

Multimeter ME–25/U is a compact general purpose electronic multimeter with provisions for measuring a-c and d-c voltages, d-c current and resistances over a wide range. It will measure d-c voltages up to 1000 volts with an input impedance of 9 megohms, a-c voltages up to 250 volts at frequencies from 25 cycles to 100 Mc with an input impedance of 6 mmf shunted by 12 megohms, d-c current up to 1000 milliamperes



TUBE TESTER TV–3(XN)/U. A combination tube tester and multimeter now in the process of being produced for the Navy.



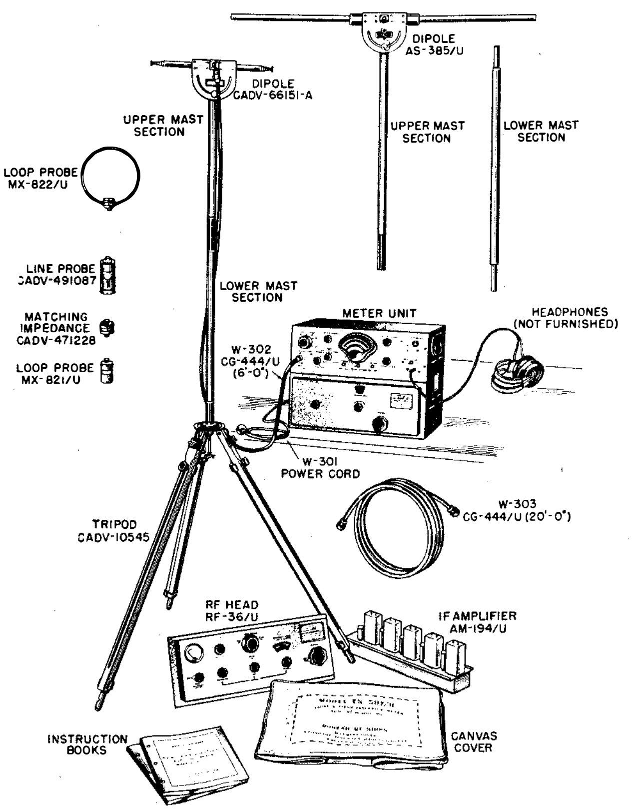
MULTIMETER ME–25/U. An electronic volt-ohm-milliammeter with ranges 0-250 volts a.c., 0-1000 volts d.c., 0-1000 megohms, 0-1000 milliamperes, —10 to +42 db.

TABLE IV. Radio Interference Measuring Equipments.

	Radio Test Set AN/URM-6	Radio Test Set AN/PRM-1	Noise Field Intensity Meter TS-587/U	Radio Test Set AN/URM-17(XN)
Frequency Range	14-250 kc	150 kc-25 Mc	15-400 Mc	375-1000 Mc
Sensitivity as Two-Terminal Voltmeter	1 microvolt	1 microvolt	15-125 Mc 2 microvolts 100-400 Mc 5 microvolts	50 microvolts
Sensitivity as Field Intensity Meter	1 microvolt/meter	2 microvolt/meter	15-125 Mc 5 microvolt/meter 100-400 Mc 20 microvolt/meter	Not yet determined
Bandwidth 6db down	100 to 600 cycles	3 to 5 kc	15-125 Mc 150 kc 100-400 Mc 210 kc	600 kc

and resistances up to 1000 megohms. An improved meter now under procurement will allow voltages as low as 0.9 volts full scale to be measured. The new meter will also be based on peak-to-peak voltages so that the voltages of pulsed signals can be measured.

Tube Tester TV–3/U is the latest Navy combination tube tester–multimeter. It is designed to be as flexible as possible without too much bulk. It reads mutual conductance directly in micromhos and also has provisions for limited measurements of a-c and d-c volts, d-c milliamperes, resistance and capacity. It is enclosed in an aluminum carrying case with a built-in compartment for accessories and operating repair parts. The tube tester tests tubes for shorts, gas and noise in addition to mutual conductance.



NOISE-FIELD INTENSITY METER TS–587/U, showing equipment, including dipole antennas, tripod, and accessories.

Radio Noise Field Intensity Meters

The Navy has developed a line of radio interference measuring equipment to fit into its integrated interference reduction program. Each set comes equipped with calibration charts, test antennas, probes, line coupling units, impedance matching units, etc. Some have power conversion equipment, recorders and other special accessories. All are designed for use either in the field, on shipboard or in the laboratory. A tabulation of their major characteristics is shown in Table IV.

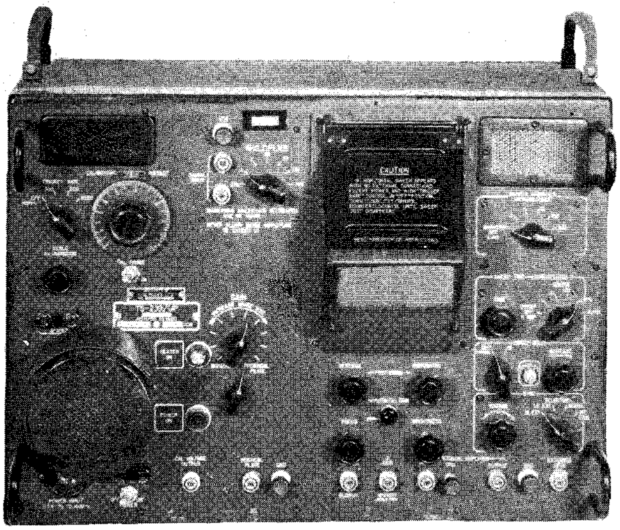
Shop and Bench Type Test Equipment

The fleet is also a large user of shop and bench type equipment particularly in tender and repair ships and on large ships equipped with electronic workshops. Some of the more unusual designs are described below.

Oscilloscope TS–239/UP is the Navy's general purpose bench-type oscilloscope and synchroscope. The main unit illustrated weighs 63 pounds and its dimensions are 21½ inches by 16½ inches by 13½ inches. It utilizes a 3-inch cathode-ray tube and features a measuring scale (30 x 40 divisions) which is optically produced, free from parallax and visible only when wanted with any desired brightness. The instrument is designed for operation over a temperature range of −40° to +50°C in an atmosphere having a relative humidity in excess of 95%. Some of its pertinent characteristics are enumerated in Table V.

Signal Generator TS–535/U is a high accuracy signal generator operating in the frequency range from 7 to 160 kc. The output is calibrated from 0.5 microvolts to one volt and is accurate to within 10% down to one microvolt below 70 kc and within 10% or 0.5 microvolt above 70 kc. The output impedance is 5 ohms. The signal generator may be externally amplitude modulated at 30% at 400 cycles. The rated frequency accuracy is 0.1% below 70 kc and 0.5% above 70 kc although accuracies of 0.03% have been shown in tests. This frequency accuracy is obtained by beating the output signal with a self contained fixed frequency precision calibrator on a built-in oscilloscope.

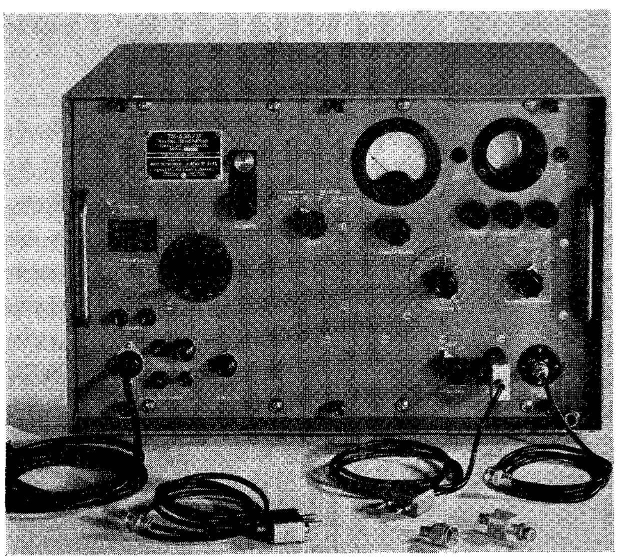
Electronic test equipments described herein have been designed or developed by the Navy. Only unclassified



OSCILLOSCOPE TS–239/UP. General purpose bench type oscilloscope and synchroscope.

equipments which are unique or have some interesting features have been included. Equipments which have a higher security classification have not been mentioned.

The Navy through its membership on a joint Test Equipment Sub-Panel is standardizing on common designs of general purpose electronic test equipments suitable for use by all of the armed forces. This procedure provides equipment capable of meeting military requirements at a minimum cost to the Government because of the elimination of duplicate development and the economy associated with common procurement.

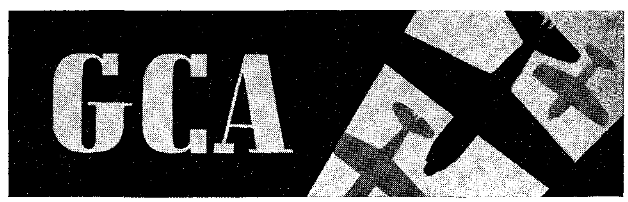


SIGNAL GENERATOR TS–535/U. This high accuracy signal generator (.03% in frequency) has a built-in 5-kc tuning-fork-controlled calibrating oscillator and a cathode-ray tube for standardizing the main oscillator. The maximum output is one volt and the signal is modulated internally at 400 cycles.

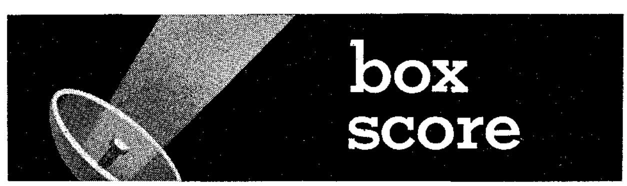
TABLE V

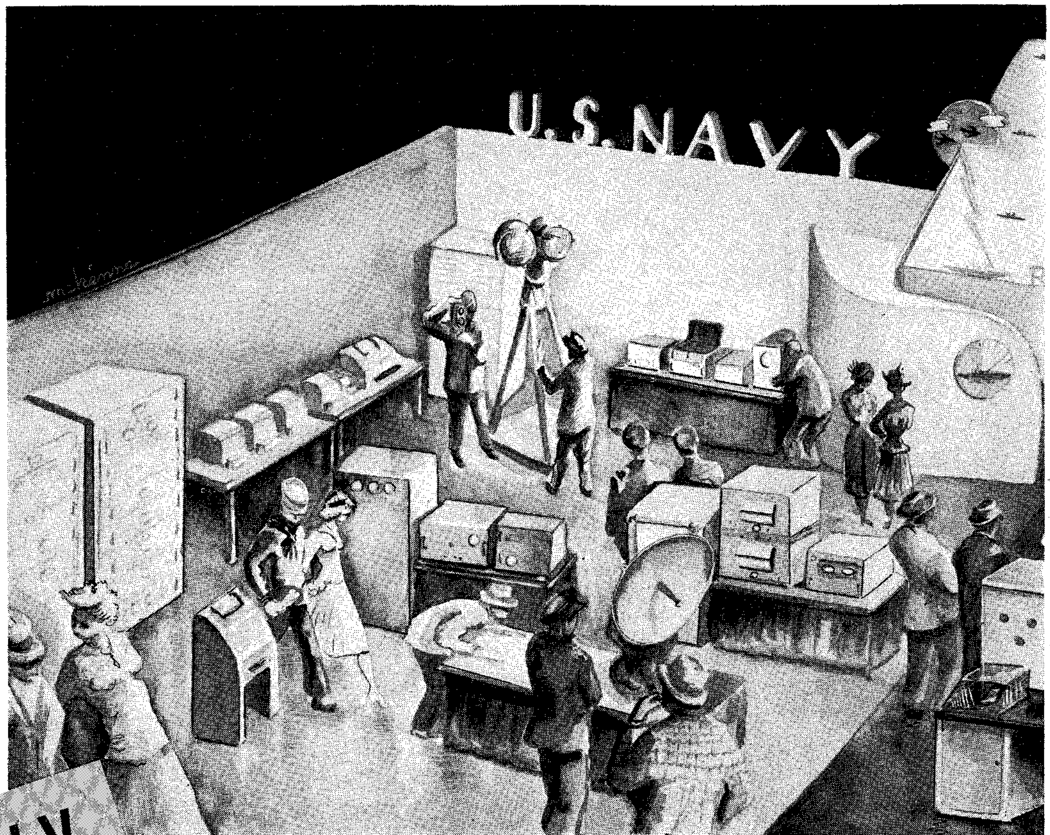
OPERATING CHARACTERISTICS OF OSCILLOSCOPE TS–239/UP

Transients observable	
Minimum rise time	0.08 microseconds (10% to 90% full amplitude)
Maximum square pulse duration	5000 microseconds
Sine waves observable	10 cycles to 5 megacycles per second
Input impedance	
Oscilloscope alone	300,000 ohms paralleled with 30 micromicrofarads
Oscilloscope with probe	3 megohms paralleled with 12 micromicrofarads
Sensitivity for 0.6 inch nominal standard deflection	0.01 to 100 volts, peak
Calibrating voltage	Internally generated square wave adjustable from 0.1 to 1 volt peak to peak
Sweep circuit	Start-stop, each sweep independent
Sweep time	0.5 to 50,000 microseconds per inch continuously adjustable
Sweep delay and expansion	Any portion of sweep over 10 microseconds may be delayed and expanded about 10 times for detailed examination
Timing Markers	Synchronized with sweep and available at intervals of 0.2, 1, 10, 100 or 500 microseconds



Type of Approach	Through December	To Date
Practice Landings	8,580	303,032
Landings Under Instrument Conditions	476	11,740



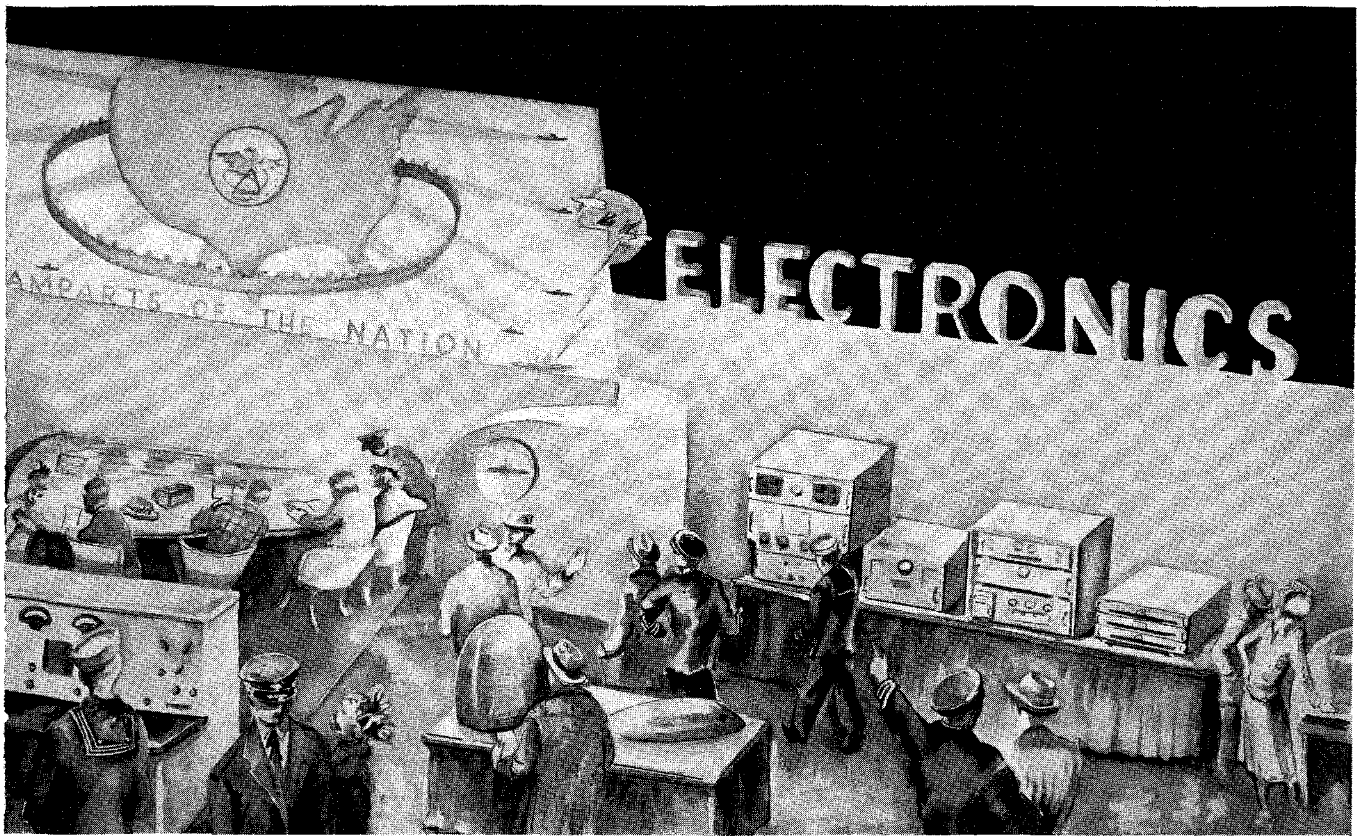


U.S. NAVY EXHIBITS AT THE I.R.E. CONVENTION

Electronic Multiplex

The latest development in Navy teletypewriter equipment is the AN/FGC–5 electronic time-division multiplex telegraph terminal consisting of two sets: 1—the telegraph transmitting group OA–151/FGC–5, and 2—the telegraph receiving group OA–150/FGC–5. The combined weight of the two groups is 1370 pounds, both groups being physically identical except for minor internal wiring variations. The cabinets are $72\frac{7}{8}''$ high by 27″ wide by $24\frac{3}{16}''$ deep. The power necessary to run each unit is 750 watts at 110/220-volt, 50/60-cycle, single-phase a.c.

The teletype transmitting group accepts on-off d-c start-stop signals from local transmitting circuits, converts them to multiplex signals and applies these in sequential order, channel-by-channel, to the telegraph circuit. The signals are then delivered to the distant receiving group which accepts similar multiplex signals and converts them to start-stop signals and then transmits the start-stop signals in their original on-off d-c form to the proper local receiving circuit. The set is capable of supplying a maximum of four channels from any one telegraph circuit at a speed of either 60 or 75 wpm. However, all apparatus attached to the set and the set itself must be set for either one speed or the other. The transmitting and receiving groups, cycling



at identical rates of speed, operate in synchronism at all times and are held in synchronism by means of a highly accurate crystal-controlled oscillator.

This equipment has many features which make it highly desirable for Navy use. Once the transmitter and receiver have been synchronized they will remain so from one to one and one-half hours with the telegraph circuit disconnected. If either the receiving or transmitting circuit is inadvertently broken, there is both a visual and an audible warning signal. The fault can be readily traced by means of an oscilloscope mounted in both the receiving and transmitting groups. The equipment is so designed that the oscilloscope may be patched into all important points of the circuit by means of a patch cord and monitor switch.

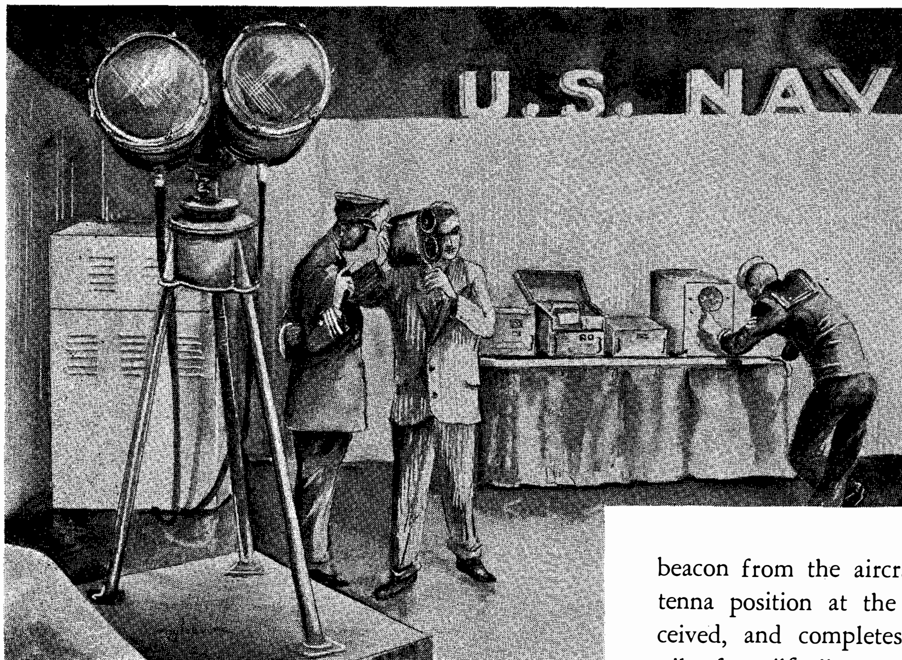
Infra-Red Communications

With the exception of sound recording on film, practically all of the research directed toward improving light beam voice and code communication systems has been sponsored by the military organizations of the several countries engaged in the last two major wars. The object of this research is the perfection of a supplementary means of communication to cover short distances which cannot be readily detected and interpreted by the enemy. Light beam systems are particularly effective against enemy detection because: (1) Their range is definitely limited to line-of-sight, (2) They can easily be confined to narrow beams and directed where desired; and (3) By means of optical filters the radiation may be rendered invisible beyond 300 yards or so.

The essential elements required for optical communications consist of: 1—A transmitter consisting of a source of modulated light, an optical reflector for beaming the radiation, an optical filter for removing visible light as required, a microphone for voice, a key for code, an amplifier when required for modulation of the source, and connections to power supplies for operation of the apparatus; and 2—A receiving system consisting of a light-sensitive detector, a reflector for increasing the detector sensitivity, an audio amplifier and demodulator as required, and headphones for reproducing the original speech or code.

Telegraph Test Recorder

The Navy-designed Telegraph Test Recorder Model AN/PRM–3 is used for testing telegraph equipment and telegraph communications circuits. This equipment represents an extremely valuable high-speed and precise recorder and signal generator not presently available to the field. Its precision is such that any differential in the received and transmitted signals provides an indication of the quality and character of the equipment or circuit under test. The AN/PRM–3 consists of a signal



INFRA-RED and TELEGRAPH TEST SET display.

generator, a recorder and a power supply for the recorder. The signal generator generates a signal which is applied to the telegraph equipment or communications circuit under test. The recorder simultaneously receives the telegraph signal from the equipment or circuit under test. The test signal generated is repetitive in character, each repetitive cycle consisting of a minimum of 30 bauds, each of which can be made to represent either a marking or spacing condition at the will of the operator by operation of toggle switches on the control panel. The cycle is made to repeat itself at the rate at which lines are scanned on the recorder.

Air Navigation by Radar Beacon

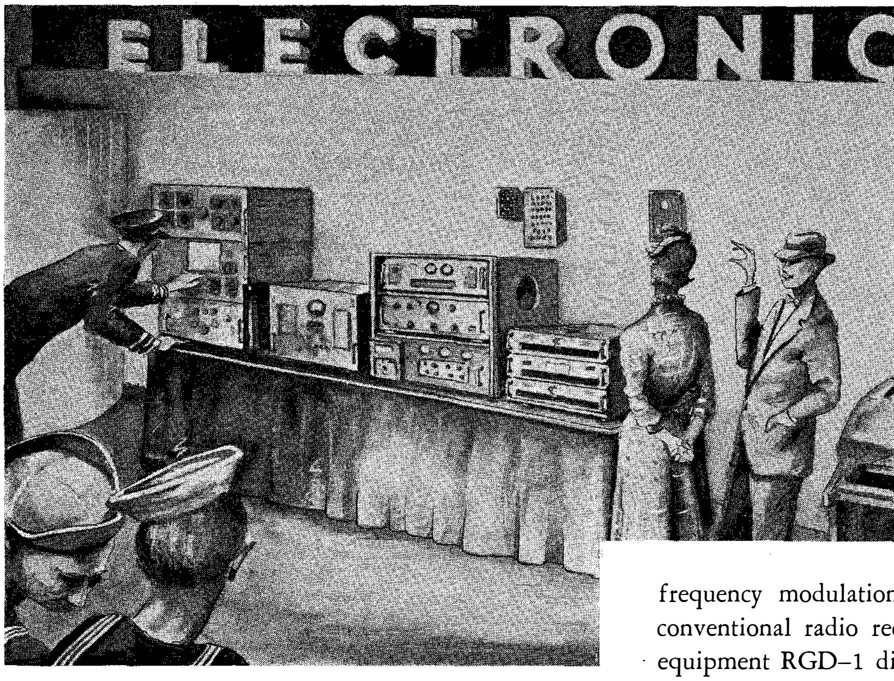
The radar beacon exhibit is designed to demonstrate how the pilot of an aircraft equipped with microwave radar determines his position by using his radar to interrogate a radar beacon on a ship or at a shore station. It also shows how a series of such position determinations is used to navigate along any desired route from one point to another.

When an airborne radar is switched to BEACON operation, the pulse width of its transmitted signals is expanded so that the discriminator of any radar beacon within line-of-sight range will accept the signal. At the same time the discriminator rejects ordinary short search pulses from other radars in order to permit maximum numbers of simultaneous responses to deliberate interrogations. The beacon transmits a response, coded for identification, in synchronism with the received pulses. This signal appears on the oscilloscope of the airborne radar. The relative bearing of the beacon from the aircraft is determined from radar antenna position at the time the beacon response is received, and completes the information needed by the pilot for a "fix."

In the exhibit, the observer presses a button to simulate the airborne interrogation by furnishing an intermittent voltage actuating the coder of the receiver section of a beacon. Coder output is displayed by a synchroscope, showing beacon response as it would be displayed by an "A" scope of an airborne radar, with antenna searchlighting on a beacon. Enlarged photographs show typical PPI (plan-position-indication) presentations, how these are interpreted to determine navigational fixes, and how a pilot may use the beacon responses to fly either a homing course, or any pattern which his mission may require.

Facsimile Exhibit

The Navy-designed Facsimile Recorder Model AN/UXH–1 is the first continuous page type recorder of this large size, capable of unattended operation, which has been developed in this country. Its use will result in considerable saving in operator's attendance. The complete recorder consists of a recorder, amplifier and power supply. The recording medium is a dry direct recording facsimile paper. The recorder is additionally capable of recording satisfactorily on a hecto-type duplicating paper. Recording is accomplished on a continuous-page basis at 96 lines to the inch. The recording consists of black on white. The marking stroke is a minimum 18 inches long. The index of cooperation is 576 as calculated by the product of the drum diameter and the scanning lines per inch. The scanning speed corresponds to 60 lines per minute or to 30 lines per minute as selected. The marking element is easily replaced and does not require replacement or adjustment



U-H-F COMMUNICATION EQUIPMENT display.

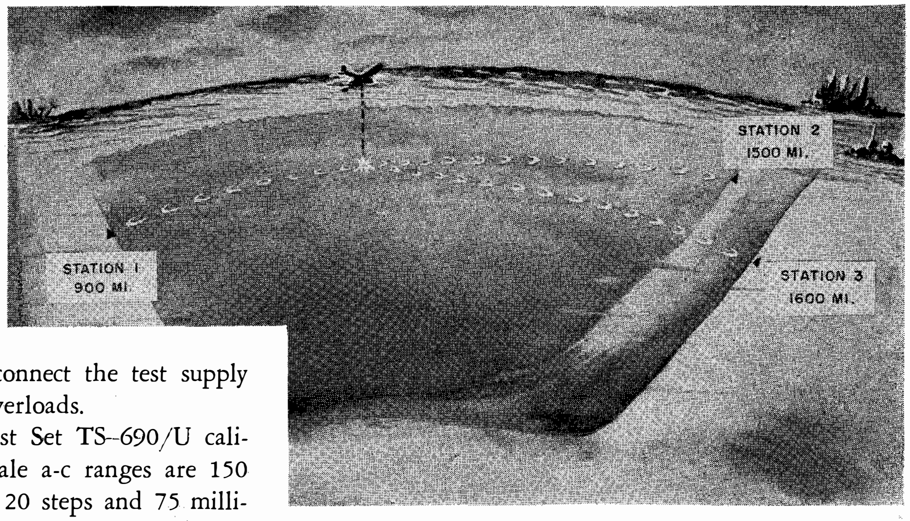
more often than once each 24 hours of continuous operation. Paper replacement is not required more often than once each 24 hours of operation. Facsimile Transceiver Type TT–1( )/TXC–1 is used to generate the facsimile signal which is recorded. Two sliding drawers are included at the bottom of the rack, one of which is suitable for storage of recording paper stock and the second for maintenance parts necessary for daily maintenance.

The Times Facsimile Corporation Recorder, Model RG, is a new and very efficient low cost recorder leased by the Navy for reception of national weather network maps. The recorder is designed to make direct recordings of copy transmitted from an AN/TXC–1 Transceiver, or TXC Type Transmitter. The Model RG recorder is a self-contained unit mounted on a standard 12¾-inch relay rack panel. The unit consists of a main chassis and four plug-in subassemblies. A voltage tripler power supply and series tube heater connections are used to eliminate transformer weight and permit d-c operation with the addition of a small vibrator unit. Indicators are provided for fuse and series filament connected tubes to indicate a blown fuse or burned out tube heater instantly. A test switch mounted on the front panel provides a means for quickly testing all important circuits. The Model RG recorder may be used for recording facsimile signals from either wire or radio communication circuits. When used with wire lines the Model RG is connected direct to the line. When using a conventional (amplitude-modulated) radio receiver, the 500-ohm output of the receiver is connected directly to the input terminals of the RG recorder. When using the RG recorder for sub-carrier frequency modulation, the 500-ohm output from the conventional radio receiver is connected to an auxiliary equipment RGD–1 discriminator, and the output of the RGD–1 to the input of the RG recorder. For receiving frequency-shift modulation, one auxiliary equipment is required—an RGD–1 discriminator. The RGD–1 discriminator is designed to convert 1500-2300 cps facsimile signals, received from a radio circuit, to AM signals.

D-C Standard Instrument Calibration Equipment

The Navy has developed a line of instrument calibration equipments for use at Naval shipyards and overhaul depots. These equipments, which are semi-military in construction, are designed to be extremely versatile and are capable of calibrating all pivot-type electrical indicating instruments generally available. All of these instruments are similar in physical appearance, consisting of a console type steel cabinet and a vertical control panel with work bench space for instrument handling. They will perform within their rated accuracies under conditions of relative humidity varying from 0 to 75%, and under temperatures from 10° to 45° Centigrade, from sea-level to 10,000 feet above sea-level.

The d-c instrument calibration equipment, Meter Test Set TS–689/U can calibrate d-c meters having current ranges from 75 microamperes full scale to 150 amperes full scale in 20 steps and voltage ranges from 75 millivolts full scale to 1500 volts full scale in 14 steps. The rated accuracy is 0.5%. Operator protection is provided by a hinged transparent plastic hood which covers both the meter under test and the voltage terminals. This hood is connected through an interlock switch behind the panel so that when the hood is lifted, the power supply is shut off. Changing the range setting



SOFAR display.

also operates interlocks that disconnect the test supply thereby preventing accidental overloads.

The a-c equipment, Meter Test Set TS–690/U calibrates instruments whose full scale a-c ranges are 150 microamperes to 200 amperes in 20 steps and 75 millivolts to 1500 volts in 14 steps. Its rated accuracy is also 0.5%. A built-in power amplifier supplies test voltages variable from 50 to 1600 cycles in frequency.

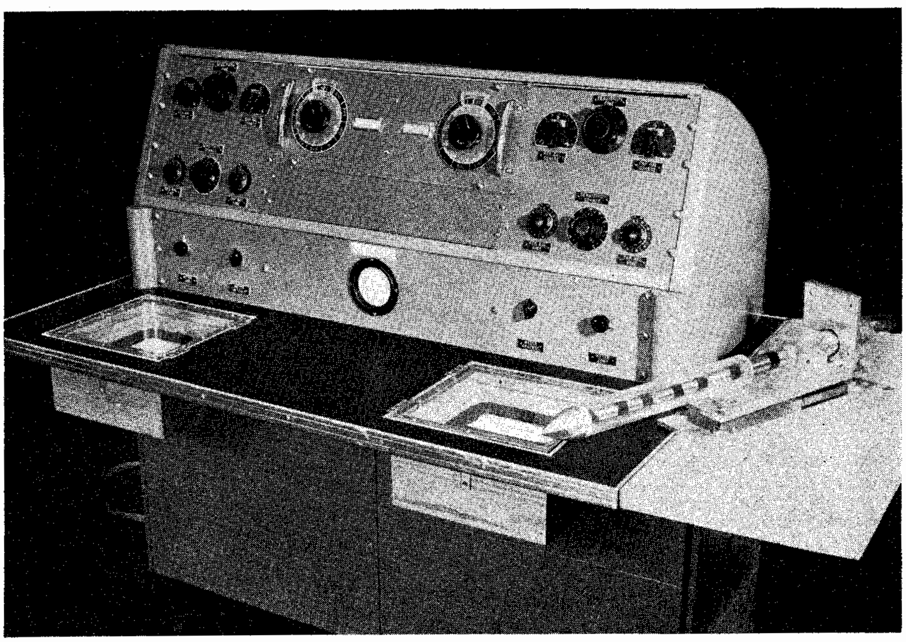
The third in this series of equipments is a dual potentiometer type ac/dc equipment having a rated accuracy of 0.1%. This unit provides for both a-c and d-c calibration for instruments with full scale ranges of 75 microamperes to 150 amperes (20 steps) and 75 millivolts to 1500 volts (14 steps).

Ripple Tank

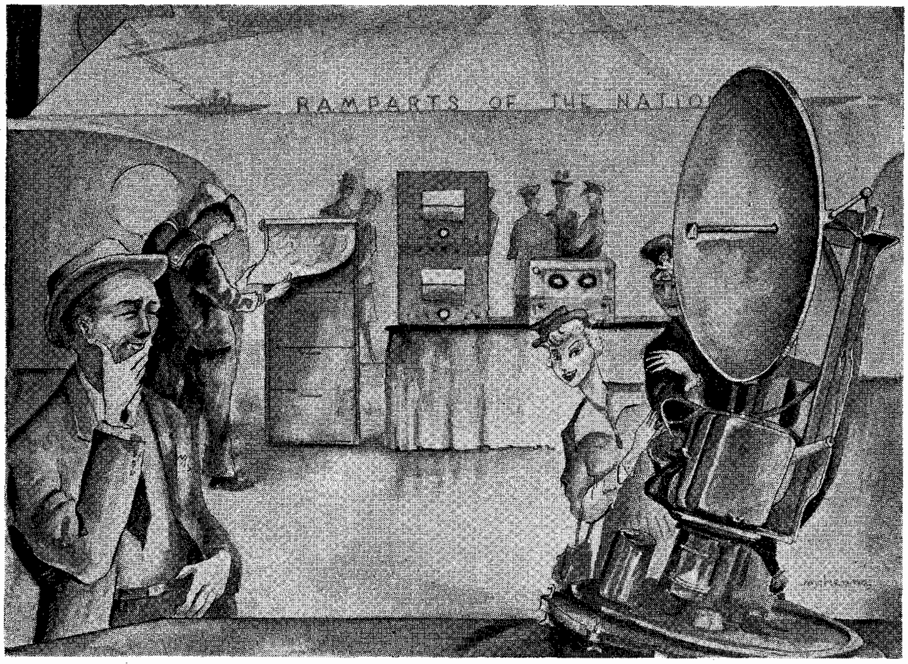
Water ripples are used for the qualitative and semi-qualitative study of phase fronts near two-dimensional models of antenna structures. Electronically driven probe-vibrators are used to excite the water surface of a glass ripple tank. Synchronously chopped light is directed through the tank to a ground glass screen where the phase front shadow patterns appear stationary. Using simple equipment, it is possible to visualize rapidly (or photograph) the changes in phase-front patterns brought about by changes in feed point position and in reflector configuration, as well as by changes of as much as several hundred percent in exciting frequency.

Gun Director

A gun director using a magnetic amplifier is displayed. This equipment was designed by the Naval Ordnance Laboratory. In operation, a ship is driven around a circle continuously, and a gun turret is operated by a servo and magnetic amplifier. When a push button is operated, the gun immediately comes to bear on the ship. It is pointed out that this exhibit utilizes the principle of a magnetic amplifier, with no vacuum tubes, to obtain rugged, reliable operation.



ELECTRONIC STRAIN INDICATOR for wind tunnel balance.



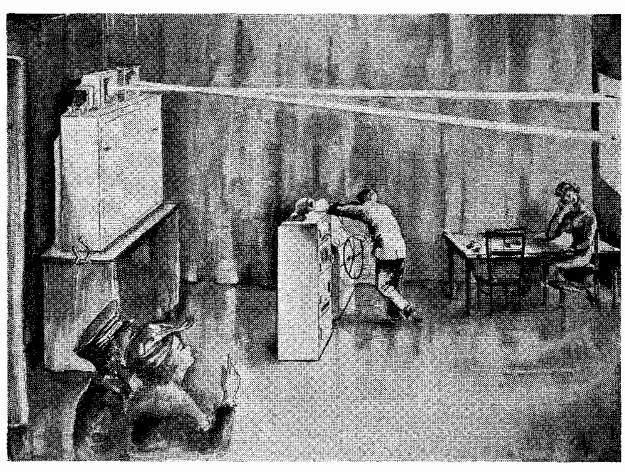
RADAR ANTENNA STABILIZATION and FAX display.

Electronic Strain Indicator for Wind-Tunnel Strain-Gage Balances

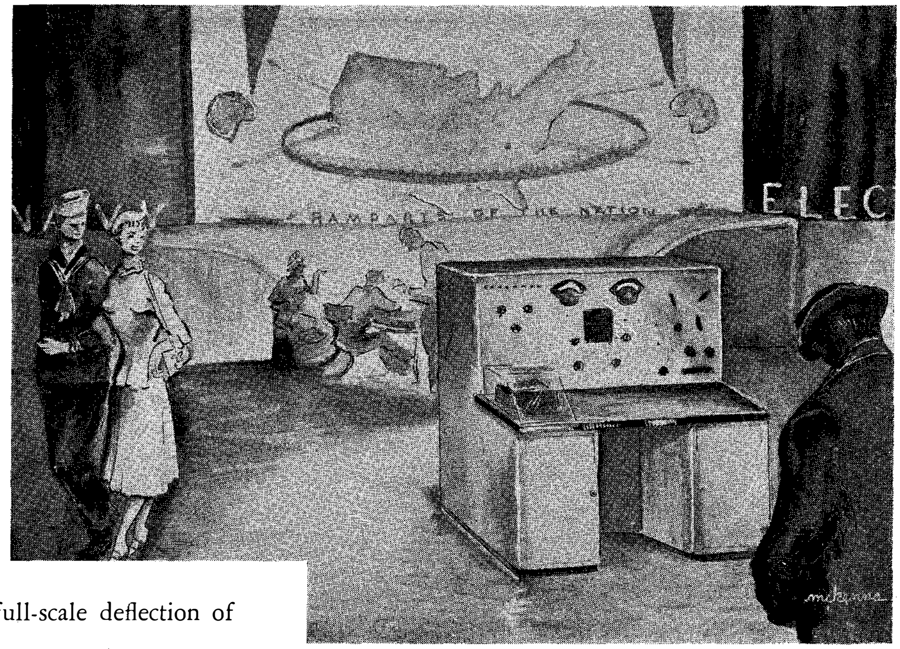
Many of the tests made in the supersonic wind tunnels at the Naval Ordnance Laboratory, White Oaks, Maryland, require the measurement of the aerodynamic forces and moments on a model subjected to the wind-tunnel air flow. The device that measures these forces and moments is known as the wind-tunnel "balance" and when located inside the model it is known as an "internal balance." It is desirable that the balance have rapid response and give a force reading in a second or two after the tunnel has been turned on. This follows because some of the NOL tunnels are of the intermittent type, and a short blowing time will allow more runs to be made per hour, leading to a greater tunnel efficiency. The intermittent feature lends itself well to the use of strain gages as sensitive elements since a zero reading can be obtained before and after the force measurement has been made, and within a few seconds of it.

The equipment described here has been designed to be used with internal strain-gage balances. As shown in the block diagram on the next page, it consists essentially of a balancing and calibrating circuit, an amplifier, an output circuit, an oscillator, and a cathode-ray null indicator. Commercially available units are used wherever possible. Two channels are provided in a single console, but a number of consoles may be connected together when additional channels are required. The oscillator frequency may be set at either 400 or 2000 cycles per second, and the voltage applied to the strain-gage bridge may be adjusted between 1 and 5 volts. The smallest measureable strain is approximately 0.1 micro-inches per inch when used with four active gages in a full bridge circuit.

Experience in the wind tunnel has led to the following operating procedure: Before the test the output meters are accurately adjusted to read zero. When the tunnel is turned on, the meters deflect, and the reading is noted. After the tunnel has been turned off, the meters normally return to zero again. At this time the operator rotates an accurately calibrated potentiometer in the balancing and calibrating circuit until the meters read the same as they did during the wind tunnel test. The reading of the potentiometer dial together with the known constant of the balance are combined to give the required force or moment. With this procedure, a measurement may be made in approximately one second,



SONAR TRAINER and FISH TALK display.



D-C STANDARD INSTRUMENT CALIBRATION display.

to an accuracy of 0.2% of the full-scale deflection of the meter.

Sonar Trainer

Most of our readers are familiar with the commonly used Link Trainer, employed widely by Naval aircraft facilities for training pilots and other airborne personnel in blind flying, aircraft handling, etc.

As the Link Trainer simulates air conditions on the ground, the Sonar Trainer simulates sea conditions, being developed and constructed for use in training operating personnel in the use and applications of many types of sonar equipment.

Sofar

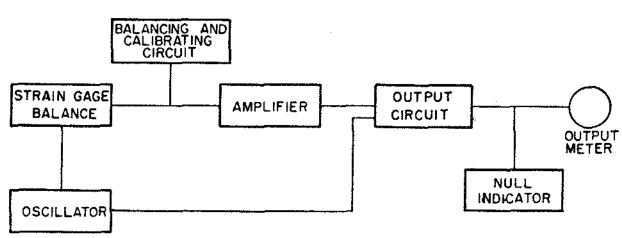
Sofar (SOund Fixing And Ranging) is a very recent development in the field of air-sea rescue principles and applications. While conducting underwater sound studies as purely military research for the U.S. Navy during the war, Dr. Maurice Ewing of the Woods Hole Oceanographic Institute postulated the sound channel theory which makes the sofar system possible, and proposed development of a system to effect air-sea rescues. Its logistic advantages alone were enough to obtain the consent of the skeptical, at least for experimental studies of the sound channel phenomenon. The U.S. Navy Underwater Sound Laboratory was directed to furnish the apparatus, technical and engineering service, and to cooperate with the Woods Hole Institute in the prosecution of the problem.

To describe the general principles of operation of sofar, let us assume that an aviator has been forced down in the middle of the ocean. To signal his location, he releases a one-pound bomb equipped with a hydrostatic fuse. At a certain critical depth, the bomb explodes and three listeners, who may be as much as two thousand miles away, pick up, on separate receiving instruments, the sound of the explosion. By comparing the times of arrival of the sound energy waves at each of the three listening stations, they can determine from tables and charts, the location of the distress signal. Thus the sofar system is, in a sense, an inverse underwater Loran.

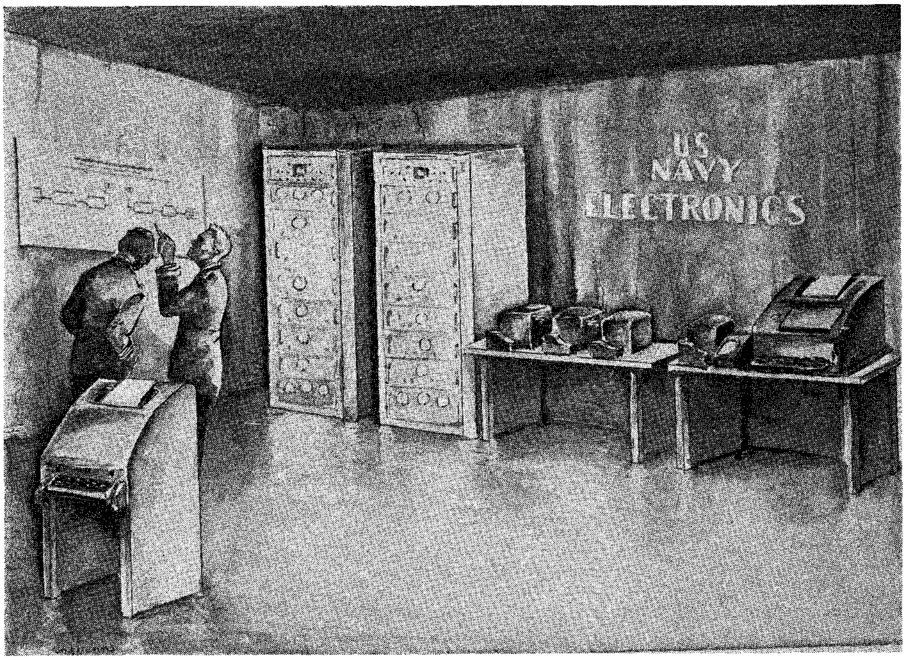
Subminiaturization Exhibit

The U.S. Naval Air Development Center at Johnsville, Pennsylvania, has prepared the following exhibit items:

Crystal Video Receiver With Blocking Oscillator Output. This is an eight-stage video amplifier 2½ megacycles per second wide. The voltage gain of the amplifier is approximately 50,000. The output is a 30-volt pulse 2 microseconds wide, with a rise time of about 0.15 microseconds. The amplifier features low current drain filamentary cathode, subminiature tubes, fired silver paint wiring, subminiature resistors and high K titanium capacitors. The base plates are of a ceramic resembling steatite. The entire assembly will be hermetically sealed. The outside dimensions of the case are 6″ x 2⁵⁄₁₆″ x 1¹⁄₁₆″. A conventionally wired unit is shown for comparison.



Block diagram for electronic strain indicator.



TELETYPE "MUX" display.

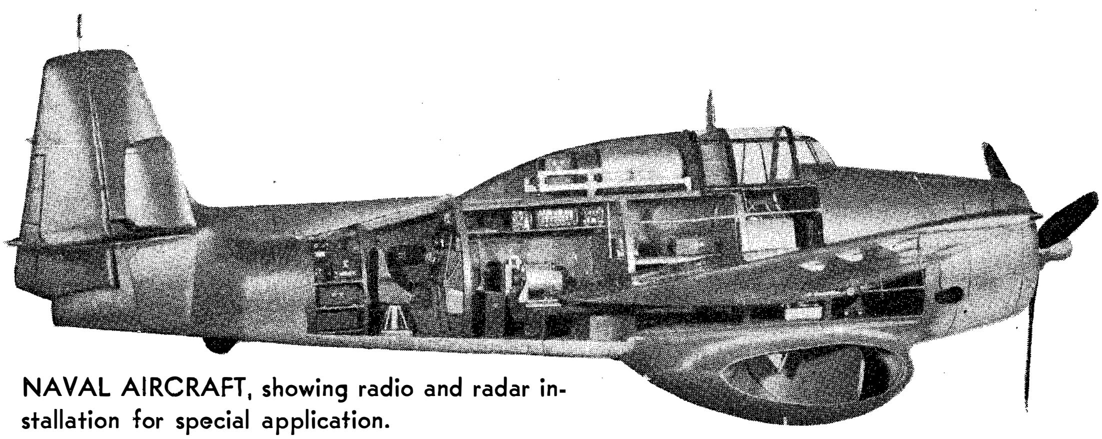
Oscillator. This is a 200 Mc/sec oscillator using an etched copper coil mounted on a Bakelite plate. Another version uses an etched copper coil on steatite. Due to the low thermal expansion of the steatite the frequency stability is excellent.

Audio Amplifier. An audio amplifier with a gain of approximately 15 x 10^6 from the input of the transformer to the output. The useful frequency response is from 500 cycles to 20 kilocycles.

Two versions of this amplifier are shown—one silver printed wiring on ceramic and the second etched copper wiring on Bakelite. The former features printed resistors while the second uses ceramic resistors. The tubes used are low drain subminiature filament type pentodes. The dimensions of the assembly are 2½″ x 1½″ x ¾″.

Crystal Video Receiver Including Amplifier, A.G.C., Blocking Oscillator, Filter Network, and Bias Battery. The unit contains 11 subminiature filamentary tubes and the current drain is 6½ ma at 135 volts and 650 ma at 2 volts. Only commercially available parts are used in this assembly. The unit weighs less than one pound. It is a cylinder 4¼″ in diameter and 2 inches high. Subminiature version is a cylinder 3½″ in diameter and 2 inches high. A three-stage audio amplifier has been added.

Also exhibited by the Navy were the latest in ultra-high-frequency transmitting and receiving equipment; a tilting table to demonstrate the action of radar antenna stabilization under actual operation; one of the standard fleet-installed PPI (plan position indicator) units for remote presentation of information received on various shipboard radars; a cutaway view of one type of Navy torpedo plane which was used in World War II; and a radome beacon.



NAVAL AIRCRAFT, showing radio and radar installation for special application.

Radio Interference Considerations

by

Leonard W. Thomas

Electronics Design and Development Division
Bureau of Ships

Radio interference is defined as any electrical disturbance which causes undesirable response or malfunctioning of electronic equipments. Electronic equipments include all electronic devices either systems or components thereof used in the transmission or reception of intelligence. Such equipments include radio, radar, underwater sound, television and electronic detection, recognition and relay devices, all of which employ radio-frequency energy transmitted through space or through other media for their proper functioning. Their effectiveness depends upon their ability to perform the function for which they were intended, utilizing to the fullest extent those characteristics which were designed into them. Such cannot be realized in the presence of interference. For instance, a receiving equipment constructed with a sensitivity of one microvolt cannot take advantage of its ability to receive a one-microvolt signal if such a signal is accompanied by high levels of interference. Many such receiving equipments are constantly subjected to interference levels of from 100 to 1,000 times the level of a satisfactory signal if such a signal were received with no interference present.

While the existence of interference is not new, the problem of its reduction to acceptable levels did not assume its present proportions until the sensitivities of electronic equipments were improved to the extent that existing levels of interference became intolerable. The development of intricate electrical and mechanical devices has also brought about new sources of interference, and in many instances these interference-producing devices are used in conjunction with, or in close relation to, many electronic equipments that are being interfered with. Among some of the typical devices that are known sources of interference are fluorescent lamps, gas-filled rectifier tubes, very high speed machinery employing anti-friction bearings, electric office machines and a multitude of utility devices all electrically operated that are used in homes, offices or factories. Electronic equipment functioning may be improved by increasing the signal-to-interference ratio. This may be achieved by the increase of transmitter power which is costly and increases weight and space requirements and may not be feasible under all operating conditions, or by the reduction of the radio interference to which the electronic equipment is subjected. Where such interference can be controlled and reduced to tolerable levels, its reduction in many instances has been far less expensive than a corresponding increase in transmitter power to effect the desired improvement in signal-to-interference ratio would have been.

History

The Navy has recognized for many years the problems of interference as they affect communications. A survey of ship to shore communications in 1934 disclosed that man made electrical interference was creating major interference to communication receivers, and the first systematic attempt to reduce such interference was made by Navy engineers. The first interference survey conducted aboard ship took place in 1938 on the carrier *USS Yorktown.* About four years prior to the advent of World War II a program was initiated to develop electronic equipment capable of measuring radio interference caused by electrical and mechanical devices. The Navy recognized generators and ignition systems to be prolific sources of interference and took steps to remedy the condition. In 1940 limits of allowable radio "noise" and standards of measurement were defined, and a systematic approach made to render all equipments at Naval activities and on shipboard interference-free. Unfortunately literature and available records do not treat interference-reduction efforts in such a manner that a complete history of this subject may be readily compiled. However, a brief sketch of interference reduction work as known to those presently engaged in certain phases of its measurement and reduction will be attempted. Early in 1942 the Navy proposed that a problem be set up under the auspices of the National Defense Research Council for a study of radio interference and its effects on communications. This study included methods of measurement and means for the reduction of interference to acceptable levels. Other research programs were initiated thereafter involving studies of radio interference produced by vibrating contacts, cable shielding efficiency, radio interference produced by direct-current machines, the design and development of radio interference filters for Naval use, and the development of proper instrumentation for the measurement of radio interference.

Difficulties Involved

In establishing any project for the study of radio interference, it must be realized that too little work has been done on this subject, and that literature in general scarcely treats this problem at all. So, in the establishment of the study and research project at the University of Pennsylvania, it was deemed advisable to start with the basic fundamentals of interference. As a result of this work, new definitions have been set up prescribing quantities and qualities peculiar to radio interference work. Then an analysis was made of existing instrumentation for the measurement of interference, ascertaining just what values those instruments measured and whether the results obtained were adequate for the proper assessment of the interference measured. The difficulty of the assessment of interference is increased because of many different forms of interference. It was found that existing instrumentation *did not* properly assess interference, nor did it make measurements that were meaningful or descriptive of the various parameters of all interference.

Coordination with Contemporary Work

About the same time that the Navy initiated the research and study programs relative to interference, the Army initiated a program for the design and development of instrumentation that would properly measure those values of interference found lacking. Fortunately, there has been a minimum of duplicatory work in the field of interference measurement and its subsequent reduction within the Armed Services. From the very beginning, there was Joint Services agreement on the Navy sponsoring the research and study program at the University of Pennsylvania, and since its establishment, fourteen progress reports have been distributed to the other branches of the service, to other federal agencies and to civilian industry. Up until its disestablishment in August 1948, the Interference Reduction Program of the three services was coordinated through the facilities of the Aeronautical Board. Such coordination is now carried on to a higher degree of perfection through the Interference Reduction Panel of the Electronics Committee, Research and Development Board. It can be truthfully stated that there is in existence no known duplication of work in the interference reduction field other than those projects wherein it is deemed that a parallel approach by separate avenues is justified. Through such agreements, research into the various fields has been coordinated, the Navy taking certain aspects that are of prime importance to the Naval service, the Signal Corps taking cognizance of those phases that are of primary importance to the Army, and the Air Force taking other phases which are of importance to their service. Within this program the field of instrumentation development is likewise coordinated. The Navy has taken the lower frequency ranges in which we are greatly interested, the Signal Corps has taken a range of frequencies a little farther up, and the Air Force has taken the higher frequencies of the radio-frequency spectrum. Progress reports of all of these developmental and research projects are constantly exchanged and furnished for permanent retention to the other services. At the present time, all three services are represented on the several working committees of this Panel. These working committees are charged with making recommendations to the Panel in connection with improvements to interference measurement techniques, methods of determining the efficiency of radio interference filters, the establishment of a standard line of filters for the Armed Services, the establishment of joint Service specifications for the measurement of radio interference and establishment of standard instrumentation for its measurement. All these committees are active and work is being earnestly prosecuted on these related subjects.

Work Within the Navy

Within the Navy, the interference reduction problem is being actively prosecuted by four Bureaus, namely Aeronautics, Yards and Docks, Ordnance and Ships. Each of these Bureaus is actively engaged in the reduction of interference originating in those equipments under its respective cognizance.

Bureau of Aeronautics

The Bureau of Aeronautics maintains an interference reduction section within its Electronics Engineering Branch. This section through its control over laboratory facilities at Johnsville, NRL and at Patuxent as well as at several commercial laboratories has contributed much valuable information to the Armed Services Interference Reduction Program relative to improving the interference rejection features of receiving equipments, the development of "go-no-go" broad band radio interference testers, internal combustion engine shielding systems, improved shielded flexible metallic conduit, standardization of spherical-seat couplings and improvements in the techniques of interference measurement.

Bureau of Yards and Docks

The Bureau of Yards and Docks has interference reduction sections in two of their Divisions, one in Research and the other in Specifications. Their immediate concern is applying fair and reasonable interference reduction requirements to all specifications for items or facilities that may create interference by their operation. Such items and facilities include earth-moving machinery, construction machinery, motorized equipments of all types such as lawn mowers, snow shovels and air compressors; special laboratory facilities such as the shielded hanger at Patuxent, the Human Centrifuge Building at Johnsville, the Standards Laboratories at Norfolk and

San Diego, special shielded rooms at Naval Communications Stations, Research Centers and Experiment Stations. To provide the proper design information and data for the formulation of such specifications, Yards and Docks has access to their Civil Engineering Laboratory at Solomons, Md., to NRL and various groups under contract to that Bureau in addition to the facilities and resources of the Bureau of Ships.

Bureau of Ordnance

The Bureau of Ordnance although just actively entering into this Navy program has made significant progress in the procurement of interference-free equipments from their contractors. Ordnance engineers have accompanied Bureau of Ships engineers on several shipboard interference surveys and upon their realization of the problem presented by unnecessary interference, have taken steps to reduce such interference to a minimum.

Bureau of Ships

The Bureau of Ships Interference Reduction Program is organized into three functional groups, namely Ships, Shore Establishments, and Research and Design.

Ship Electronics. The Ships group has dual objectives leading to the same end result. First, the realization of interference-free equipment, and second, the use of electronic equipments that are not susceptible to radio interference. Although there is no immediate prospect of attaining both these objectives in their entirety, diligent work along many avenues of equal importance may provide tolerable levels of interference that can possibly be rejected by properly designed electronic equipments.

To date the "Ships" Division of "Electronics" has conducted a far-reaching program of interference surveys on every class of vessel in the Navy. Sources of interference have been determined, and recommendations have been made for the reduction of such interference to tolerable levels. Such recommendations include:

- Well-filtered power supplies
- Well-shielded cases and chassis
- Use of high-pass and low-pass antenna filters
- Well-shielded antenna lead-ins
- Proper installation and maintenance of electronic equipments
- The adaptation of improved circuitry to receivers

To further implement the reduction of shipboard interference, procurement of filters, shielding kits, shielded cables and standard measuring instrumentation has been initiated.

A realistic study is being made of suitable specification limits for interference that will be applicable to electronic, electrical, interior communications, mechanical and other shipboard items that produce interference.

A training program has been initiated whereby selected personnel of Naval shipyards and other selected activities will be given an intensive course of instruction in the operation of standard interference measuring equipments, and the fundamentals of radio interference propagation aboard Naval vessels, concluding with practical measures for its elimination or reduction to acceptable levels.

Shore Establishment Electronics. The Shore Establishments Division has been requested by the Chief of Naval Operations to conduct radio interference surveys of 29 selected Naval air stations. These surveys were initiated in March, 1949. They consist of an analysis of existing conditions, location of the sources of interference detected, and recommendations for the reduction of such interference to tolerable levels at each station surveyed. Many new sources of interference have been brought to light as a result of these air station surveys. Portions of representative survey reports have been published in various technical publications of the Bureau of Ships.

Shore station radio interference reduction is being attacked from various angles, one of which is in the establishment of new communications stations. Certain criteria have been proposed with respect to the location of such stations. Any proposed Navy receiving site should be isolated from various sources of interference. Typical among such isolation requirements are that such a station be 25 miles from low frequency, high power transmitters and 50 miles from beamed transmitters; 10 miles from air fields and glide paths; 5 miles from unshielded teletype and electro-mechanical systems; 1½ miles from main highways; 3 miles from high tension power lines unless they are buried and 1½ miles from residential areas. After such a site has been established, the construction of the receiving station itself will include such necessary precautions as power lines buried throughout their entire course in the receiving area, teletype equipments of the interference-free variety, or if not available, existing teletype systems will be installed in shielded rooms properly filtered and removed from the antenna systems. Interference producing items such as fluorescent lamps, a.c.-d.c. motors, noisy emergency electrical systems, interference producing telephone systems, heating systems, portable gasoline engines and sundry devices for use on board the station will all be prohibited unless proper measures are taken prior to their delivery to reduce such interference to acceptable levels. Naval radio receiving stations are being constructed primarily to receive radio signals. It is incidental that the receiving station be earthquake proof, hurricane proof, rat proof and bomb proof. These latter requirements are of secondary importance compared to the reception of radio signals.

Design and Development Electronics. The interference reduction program of the Electronics Design and Development Division includes:

The establishment of a standard group of radio interference measuring equipments. This group presently covers the frequency range of 14 kilocycles to 400 megacycles and consists of three equipments. All these equipments measure in the same standard terms of reference. Their development was initiated and prosecuted by the Bureau of Ships and they incorporate those features that are deemed necessary for the proper assessment of radio interference. Within the frequency range 400 to 1000 megacycles, there is presently being developed new interference measuring equipments and it is expected that within the next year such instrumentation will be available for distribution to the field in limited quantities.

Uniform techniques must be worked out utilizing the standard instruments for the measurement of radio interference. It has been found that without establishment of such techniques, otherwise experienced personnel lacking such information, may make measurements of a specified value of interference in two or more locations, with results differing by factors of from two to ten to one, depending on the type of interference measured. In order that these discrepancies will not continue and that results of such measurements may be utilized in determination of the acceptability of Naval equipment respective to its interference producing characteristics, such measurement techniques are necessary. Existing Bureau specifications prescribe such techniques in part, and work is being actively prosecuted within this Bureau for further refinement of these techniques and their application to wider frequency ranges utilizing the now available standard measuring instruments.

Realistic limits must be established for the reduction of interference in any Naval equipment. The results of the extensive investigations presently being made by the ships and shore establishment groups, are being supplemented by additional studies and analyses by the design group. The ultimate objective is the establishment of such realistic radio interference limits. Only by determining the levels of interference presently encountered, utilizing standard instrumentation employing standard measurement techniques, and ascertaining those levels to which it is desired that radio interference be reduced to enable the realization of the full capabilities of the various electronic equipments utilized, will it be possible to arrive at such values. Such information is vital to the prosecution of a realistic program of interference reduction, for it is just as harmful to over-emphasize and to go beyond acceptable levels in the reduction of interference as it is to fall short of those desired levels. It has also been found that the attainment of lower values of interference is extremely expensive, and in many instances needlessly increases the size and weight of the basic equipment to which the interference reduction measures are applied.

All existing specifications of this Bureau are being reviewed with respect to the inclusion of provisions for the reduction of interference to acceptable levels. Proper specification requirements will be inserted in these specifications by means of addendums and made part of new contracts. During the construction of new vessels and the conversion of existing vessels, particular attention will be paid to the reduction of interference in the equipments installed on those vessels.

Another vital part of the interference reduction program of this Bureau is an active program of education and instruction, both in the use of existing standard interference measurement instrumentation and in the techniques of reduction of interference. Such information is presently in the hands of too few people. It is a specialized field and existing yard personnel, where much of the work should be done, generally have not had such information available to them. Where the yards have the information they do not have the necessary personnel to be of any great assistance at the present time. As a result, this Bureau is sponsoring with other bureaus the filming of a series of visual education aids in the form of motion pictures. These films will depict the various forms of interference, typical examples of its effects on communications, techniques for its reduction, proper methods for its measurement, and the results achieved by its reduction to acceptable levels. All material bureaus of the Navy and the other two services have indicated great interest in this film and have stated they will assist and cooperate in its production.

Overall Bureau Program. The immediate program of the Bureau is to attack those interference sources that are presently hindering communications to the greatest extent. Through field and ship investigations, it has been found that ignition interference and interference from those items of equipment largely purchased on the commercial market, and to a certain extent, those items of electrical and electronic equipment that have been purchased in accordance with Bureau specifications are largely at fault. In these cases, remedial measures can be applied, reducing the interference, not as much as is desired, but to tolerable levels that should suffice for the remainder of the life expectancy of those particular equipments. It has also been found from such examinations, both afloat and ashore, that the proper installation and maintenance of electrical, mechanical and electronic systems plays a great part in the reduction of such interference. Electronic equipments are particularly at fault in propagating radio interference. Radar equipment, improperly installed and improperly maintained has been found to create interference over practically the entire radio-frequency spectrum. Certain radio transmitters are particularly bad because of the fact that they radiate not only their assigned frequencies, but many other frequencies as well, consequently blocking many other vital communication links, which in time of emergency would be absolutely unusable. Another manner in which interference can be reduced is by the application of interference rejection features to the receiving equipment being interfered with.

Electrically operated office machines, galley equipments, motion picture projectors, interior communication systems and many other electrically operated devices, internal combustion engines and motors and generators under the cognizance of technical sections in the Shipbuilding Divisions of the Bureau, produce intolerable interference both on board vessels and at shore stations. These sections have recognized this interference problem and have taken steps to reduce this interference to tolerable levels where practical. Electronics Design and Development Division engineers have worked with these sections to secure interference-free equipments.

Non-Military Work

There are several non-military groups that are extremely active with respect to the interference reduction problem. Among these groups is the American Standards Association which has, since approximately 1942, maintained an active interest in the formulation of standard specifications for interference measurement instrumentation, and standardization of techniques for interference measurement. Through the American Standards Association, on which committee the Bureau of Ships holds membership, this work is affiliated with similar work being conducted in foreign countries through the International Electrotechnical Commission's Committee on interference. Much valuable information has been secured through these channels that has been of direct benefit to the Navy's interference reduction program. Likewise, the Federal Communications Commission of recent date has established a program of general interference reduction in the civilian field. The advent of television has made mandatory certain interference reduction measures on those items that produce interference that degrade television performance. Noteworthy among these equipments are automotive ignition systems, various electrical utility devices used by the public and, strangely enough, the television receiving equipments themselves. On 1 November, the Federal Communications Commission sponsored a conference with industry on the subject of radio interference and it was their stated objective "To clear the entire radio spectrum of all interference." As a result of this conference, the Federal Communications Commission has set up a master committee of three representative groups, the American Standards Association, the Radio Manufacturers' Association and the F.C.C. Technical Staff. This master committee has been requested to furnish the Commission by January 1950 specific recommendations concerning standard instruments proposed for adoption by the Commission for the measurement of interference over the frequency range of approximately 14 kilocycles to 400 megacycles, and to recommend standard techniques for the measurement of such interference using the recommended instrumentation. The Federal Communications Commission has prosecuted successfully a program for the control and reduction of interference from diathermy and industrial heating equiment, and as a result all operators of diathermy and industrial heating equipment in existence were given a certain period of time at the conclusion of which time those equipments were to operate under prescribed rules and regulations, on assigned frequencies or be completely shielded. It is unlawful for such machines that make interference beyond specified levels to be offered for sale. The Commission is now in a position to impose similar regulations on inert gas welding equipments that utilize radio-frequency energy in starting the welding arc. Bureau of Ships representatives have served on these many technical committees of the Federal Communications Commission and have been able to provide the Commission with much valuable information concerning acceptable levels and existing conditions of interference. By being members of such industry-governmental committees, the Bureau of Ships contributes toward the reduction of interference within the continental limits of the United States. Such interference affects not only the general public but also Naval communications stations to which such commercial apparatus and equipments are causing interference.

Future Planning

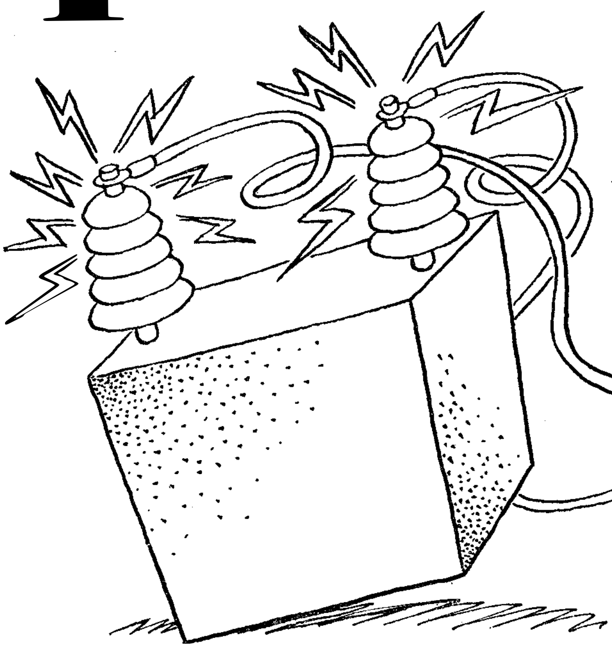
Future planning of the research and development phases of the interference reduction program of the Bureau of Ships is ambitious. Many research and study projects have been proposed, among which are:

1—Interference studies and investigations of infra-red and ultra-violet light systems, radio-frequency heating devices, electro-medical apparatus, high-speed jet-propelled devices, atomic weapons and devices, electric arcs and control mechanisms.

2—Studies leading to the development and usage of improved shielded flexible metallic conduit, interference leak-proof couplings and connectors, radio interference filters to cover wide frequency ranges, spray-metalized coatings as shielding, improved shipboard cables, radio-frequency absorption material and transparent radio-frequency conductors.

The budgetary restrictions to which we are all subject will not permit the realization of such a program in the immediate future. Available funds, however, are being utilized for the continuation of existing projects that provide the greatest returns, and for the establishment of projects that fulfill the immediate requirements of the Navy.

TRANSIENT CURRENTS in HIGH POWER FILTERS



by
LT. CDR. J. C. WALTER, USN
Electronics Shore Division, Bureau of Ships

This paper comprises a critical examination of three important transient phenomena which require consideration in the operation of high power transmitters. The three cases considered are: 1—Filter charging transient following the application of voltage; 2—Capacitor discharge transient following a d-c short circuit fault such as a transmitter tube gas arc; and 3—Transient build-up of rectifier short circuit current to terminal value following d-c short circuit. Each of these cases is analyzed by well-known methods and where applicable certain useful short-cut methods are discussed. While the circuit parameters herein considered are those usually found in high power equipments of 100-kw rating and above, the methods of analysis are equally applicable to the general case. In the circuit of Figure 1, the 32-ohm resistor represents the total series resistance of the circuit as used in computing the transient charging current, while L and C are the filter reactor and capacitor constants chosen to meet the requirements of ripple attenuation and modulation demands. Examination of the elements shows that $R^2C < 4L$, which indicates that the transient will be oscillatory. Standard texts give the following solution for the transient current under these conditions as:

$$i_t = (E/\omega L)(\sin \omega t)\,\varepsilon^{-Rt/2L} \qquad (1)$$

Where $\omega = (4LC - R^2C^2)^{1/2}/2LC$

Using the following data:

$E = 7600$ volts d.c.
$L = 1.5$ henry
$R = 32.0$ ohms
$C = 15.0$ microfarads

The transient current i_t is computed as follows:

$\omega = 211.0$
$E/\omega L = 24.0$
$R/2L = 10.67$
$Rt/2L = x.$

t	$E/\omega L$	ωt	α	$\sin \alpha$	x	ε^{-x}	i_t	
.001	24.	.211	12.1	.209	.01	.99	4.97	
.002		.422	24.2	.4099	.02	.98	9.64	
.004		.844	48.4	.748	.04	.961	17.3	
.006		1.266	72.6	.954	.06	.942	21.6	
.007		1.48	85.	.996	.07	.932	22.3	max.
.008		1.688	96.7	.993	.08	.923	22.0	
.010		2.11	121.	.857	.10	.905	18.6	
.012		2.52	144.5	.582	.12	.887	12.4	
.014		2.96	170.	.173	.15	.861	3.6	
.016		3.38	194.3	-.247	.16	.852	- 5.05	
.018		3.8	218.	-.616	.192	.82	-12.1	
.020		4.22	242.	-.883	.214	.81	-17.1	
.022		4.65	266.	-.997	.234	.79	-18.9	

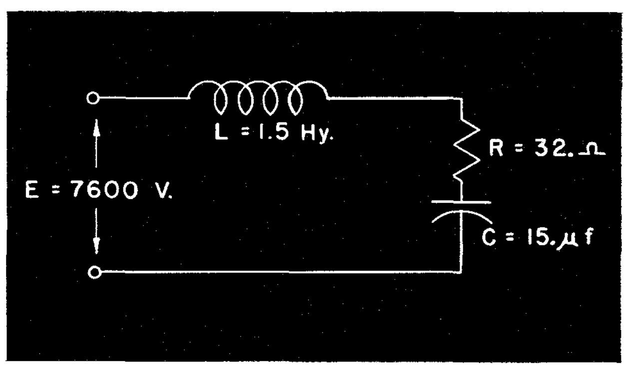


FIGURE 1.

.024	5.04	289.	-.945	.257	.775	-17.5
.026	5.50	314.	-.719	.278	.756	-12.9
.028	5.92	340.	-.342	.30	.741	- 6.08
.030	6.33	363.	.052	.32	.726	0.95
.034	7.18	412.	.788	.364	.693	-13.1
.036	7.60	435.	.966	.385	.68	15.8
.038	8.02	459.	.988	.407	.667	15.8
.044	9.30	533.	.122	.47	.625	1.8
.050	10.55	605.	-.906	.535	.585	-12.7
.052	11.00	630.	-1.0	.557	.572	-13.7

Fig. 2 is the plot of i_t in instantaneous amperes versus time.

A very useful approximate method may be used to obtain the maximum instantaneous surge current and the time required to attain this value. It is based upon the product of the applied voltage and the admittance of the circuit. This empirical formula as generally used is:

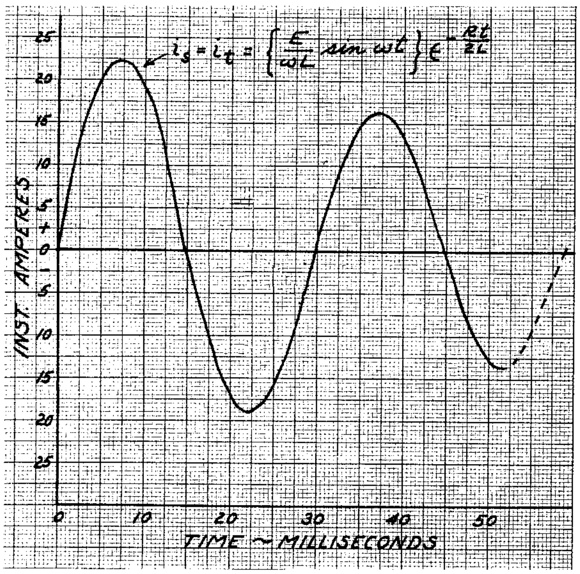


FIGURE 2.

$$\max i_t = aE(C/L)^{1/2} \qquad (2)$$

where a = regulation constant
E = applied potential in kilovolts
C = capacitance in microfarads
L = inductance in henries

The regulation constant (a) is set at 0.9 for 3-phase double-way (full-wave) rectifiers, based upon the nominal power factor of 0.95 and a system regulation factor of 0.95, or $a = .95 \times .95 = 0.9$.

The approximate time at which max i_t occurs may be obtained by assuming that the first positive lobe of the transient oscillation will be sinusoidal and deriving the time t for the first quarter cycle from:

$$t = (1/f_r \times 1/4) \text{ seconds} \qquad (3)$$

where f_r is the computed resonant frequency of the LC combination.

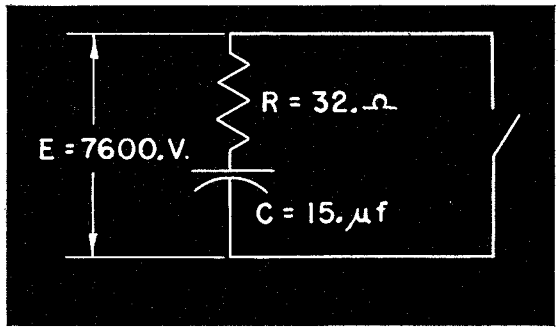


FIGURE 3.

Examination of Eq. (1) shows that by setting t equal to zero, i_t becomes:

$$i_t = (E/\omega L \sin \omega t)$$

and on a sine wave basis

$$i = E/\omega L = E/((L(4LC-R^2C^2)^{1/2}))/2LC = 2CE/(4LC)^{1/2} \quad (R^2C^2 \text{ disappears as insignificant})$$

$$i^2 = 4C^2E^2/4LC = 4CE^2/L$$

$$i = (CE^2/L)^{1/2} = E(C/L)^{1/2}$$

Assigning the values used in the original solution for i_t, Eq. (2) gives:

$$\max i_t = 0.9 \times 7.6(15/1.5)^{1/2} = 21.6 \text{ amp.}$$

$$f_r = 5033/(1.5 \times 10^3 \times 15)^{1/2} = 33.5 \text{ cycles/sec}$$

$$t = (1/33.5 \times 1/4) = 1/134 = .0074 \text{ sec}$$

These results compare very favorably with the values of 22.3 amperes and .007 seconds obtained in the rigorous solution.

It is apparent that the relatively small R of 32 ohms has little effect on the charging current transient. It becomes important however when we examine the transient discharge of the capacitor into a short circuit

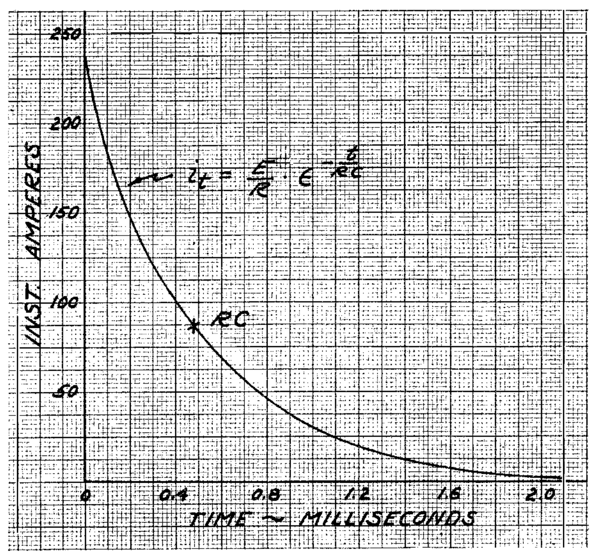


FIGURE 4.

fault in the load. Fig. 3 shows the circuit elements considered in computing this discharge transient.

The value of R in this example was set at 32 ohms to limit the maximum discharge current to less than 250 amperes in order to prevent damage to the load tube filament structure during tube gas arcs.

Instantaneous values of the transient discharge may be derived from the following equation:

$$i_t = (E/R)\,\mathcal{E}^{-t}/RC \qquad (4)$$

Maximum current obtains at $t = o$, or max $i_t = E/R$

Assigning the values:

$E = 7600$ volts d.c.
$R = 32$ ohms
$C = 15$ microfarads

and solving for i_t:

t	E/R	$t/RC = x$	$\mathcal{E}^{-x}$	i_t
0	238	0	1.0	238. max.
.0001		.209	.748	178.
.0002		.418	.66	157.
.0004		.836	.434	103.
.0006		1.254	.324	77.
.0008		1.672	.188	45.
.0010		2.09	.124	30.
.0012		2.51	.081	19.
.0014		2.93	.053	13.
.0020		4.18	.015	4.

Fig. 4 is the transient characteristic in amperes versus time. The RC product may be used as a means of quickly determining the time required for the current to fall to approximately 37 percent of its maximum value. This will usually provide the designer with sufficient information to evaluate his choice of resistance.

The transient fault currents initiated by d-c short circuits consist of two important components, the first of which has been examined above. The second and usually most important is the transient build-up of current delivered by the short-circuited rectifier. The circuit elements shown in Fig. 5 are used in the following analysis, where

$E =$ rectifier output potential $= 7600$ volts d.c.
$E_s =$ rectifier phase-neutral pot. $= 3250.$ volts RMS
$KVA =$ total transformer rating $= 137.0$ kva
$PU =$ system per unit impedance $= .092$
$X^\omega =$ rectifier commutating reactance
$r =$ resistance of filter reactor $= 1.8$ ohms

Terminal d-c short circuit current I_{sc} may be obtained from the following:

$$I_{sc} = 1.41\,E_s/(X^\omega + r/3) \qquad (5)$$

where $X^\omega = PUE^2_s/VA/3$

and the transient characteristic may be calculated from

$$i_t = (E/R)\,(1 - \mathcal{E}^{-Rt/L}) \qquad (6)$$

where $R = E/I_{sc}$

In the following example the value of .092 for the system impedance (per unit basis) represents the sum of 0.085 transformer (8.5% IZ from nameplate) and .007 (0.7% IZ) estimated for the power system on a 137 kva base. Using the data given:

$$X^\omega = .092 \times (3250)^2/(45600) = 21.2 \text{ ohms}$$

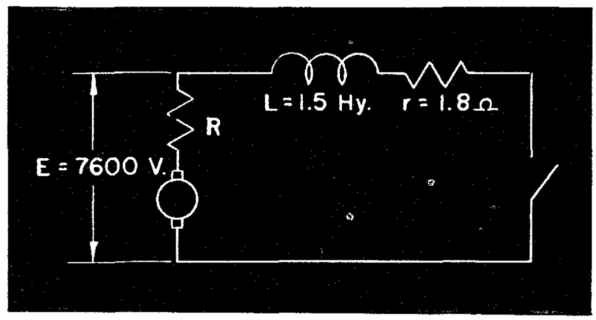


FIGURE 5.

$I_{sc} = 3250 \times 1.41/(21.2 + 0.6) = 211.0$ amp
$R = 7600/211 = 36$ ohms
$R/L = 24.0$
$i_t = (E/R)\,(1 - \mathcal{E}^{-Rt/L})$

t	$Rt/L = x$	$\mathcal{E}^{-x} = b$	1-b	i
.02	.48	.62	.38	80.
.04	.96	.38	.62	131.
.06	1.44	.24	.76	160.
.08	1.92	.15	.85	180.
.10	2.40	.09	.91	192.

Fig. 6 is the transient characteristic in amperes versus time. This information is extremely useful in determining the required circuit breaker characteristics. For example, the designer in this case would plot the time scale in terms of cycles and weigh the advantages of very high speed breaker operation of 4 cycles (1 cycle relay time plus 3 cycles breaker time) versus 6-cycle operation (1 plus 5), taking into account the various economic factors involved. In some applications, the advantages to be gained by reducing the fault current from 192 amperes (6-cycle operation) to 170 amperes (4 cycle) might well offset the greater initial cost of the high speed protection. Note that the time constant L/R is useful in determining the approximate slope of the characteristic, giving the time required for the current to attain 63% of its terminal value.

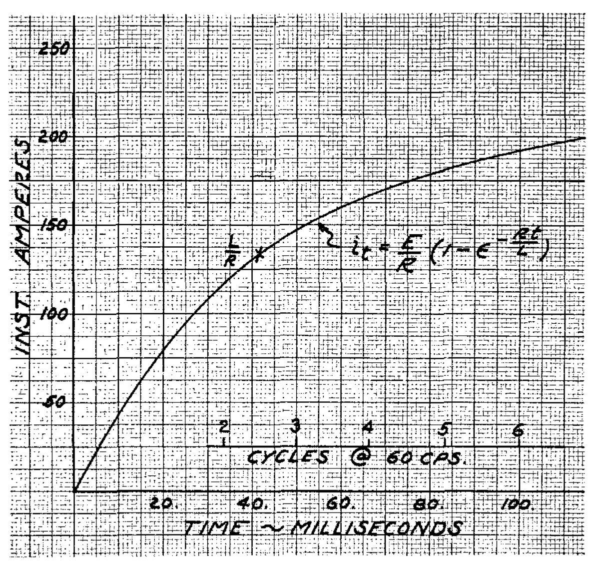
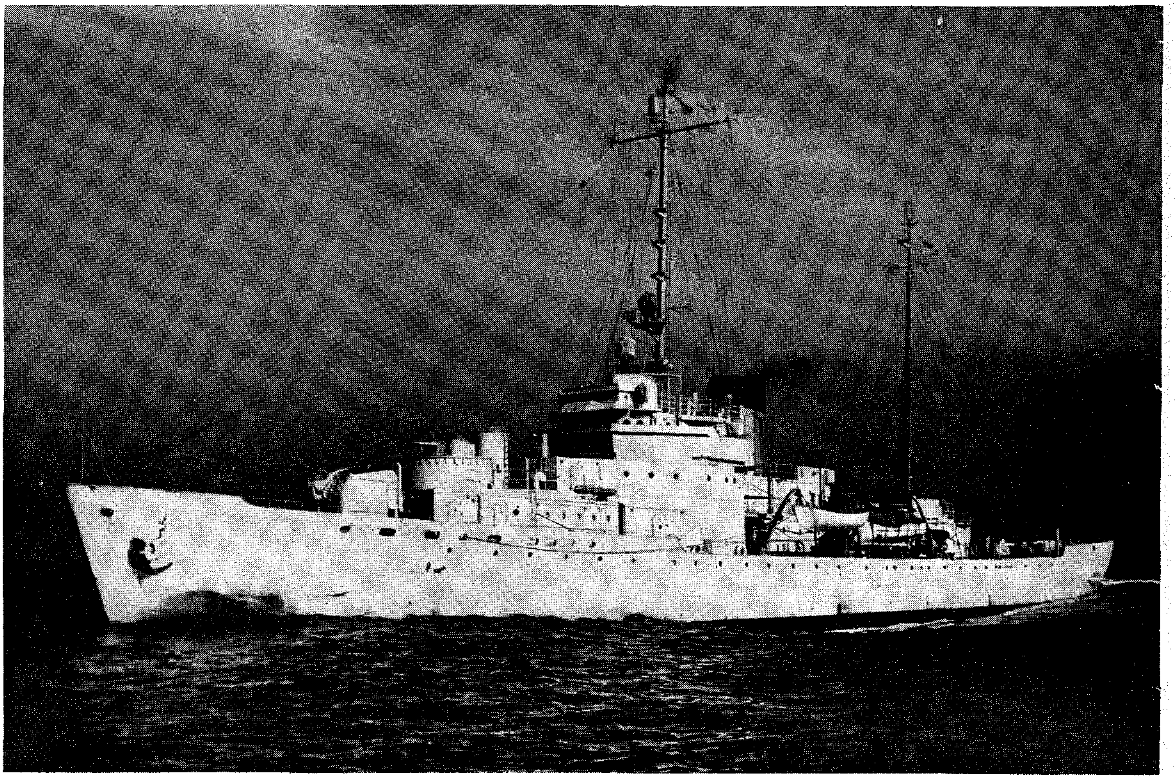


FIGURE 6.

ELECTRONICS



in the COAST GUARD

The U. S. Coast Guard, as a result of the recommendations of the International Civil Aviation Organization, carries out the obligation of the United States government by operating five and one third Ocean Weather Stations in the Atlantic and three in the Pacific. The one third station arises from the fact that one station is manned two periods out of three by Canadian vessels. Briefly, the functions of these stations under the international agreement are to obtain and transmit weather data, provide radio aids to navigation for transoceanic aircraft, provide distress communications for aircraft and provide mid-ocean search and rescue facilities.

Operation of these stations requires thirty-four Coast Guard cutters ranging in length from 255′ to 327′ and of approximately 2,000 tons displacement. Each ship is at sea four to five weeks on each patrol, sailing principally from Norfolk, New York, Boston, Portland, Seattle, San Francisco and Long Beach.

In addition to the functions mentioned above, the ships are equipped and do perform regular Coast Guard duties as well as being prepared to operate as Naval Vessels in time of war.

While the I.R.E. convention was in progress, visitors to the Navy exhibit were invited to visit one of these vessels, then at N.Y.C., and become acquainted with its electronic equipment.

It can be seen, then, that each OSV is really three ships in one, and the electronic gear required on a vessel of this size is something to behold. Seven communications transmitters, eighteen receivers, eight fixed or portable transceivers, a 750-watt aircraft beacon transmitter, air and surface search radars, remote PPI repeaters, echo sounding and ranging equipment with recorders and plotters, loran, MF direction finder, radiosonde receiving and recording equipment, 250-watt IC system with bullhorn and thirty speakers, speaker-amplifiers, remote control units, monitors, and so on.

Since all antennas required for this gear must be mounted on, or suspended from, two masts about 100 feet apart, electronics engineers shudder at the thought of what the interference problems must be, and are. Frequencies used run from LF to UHF and many of them are in use almost constantly during the thirty-day patrol period. For example, the air search radar runs continuously, the 750-watt beacon on 300-400 kc transmits five out of every fifteen minutes day and night, and the h-f weather transmissions on 8, 12 or 16 Mc are busy most of the time. Delayed weather information loses its value so when atmospherics hamper communication, necessitating relays from ship to ship, things become pretty difficult. Meanwhile, two v-h-f channels for transoceanic aircraft are frequently in use and there have been cases where a single ship has checked in 350 planes during a patrol and as many as fifteen at one time.

The interference in itself necessitates a separate category of additional equipment. Since each problem requires a specific solution, the lavish use of such devices as multicouplers, selective bandpass filters, radar interference filters, automatic antenna changeover switches, and complex patch panels, has made it possible to reduce the various interferences to a tolerable level and to provide maximum flexibility in selecting the best antenna for any circuit under different circumstances. In this connection, it has been proven that almost fanatic attention to proper bonding and grounding of stays, guys, etc., is worth much more than the considerable trouble it takes.

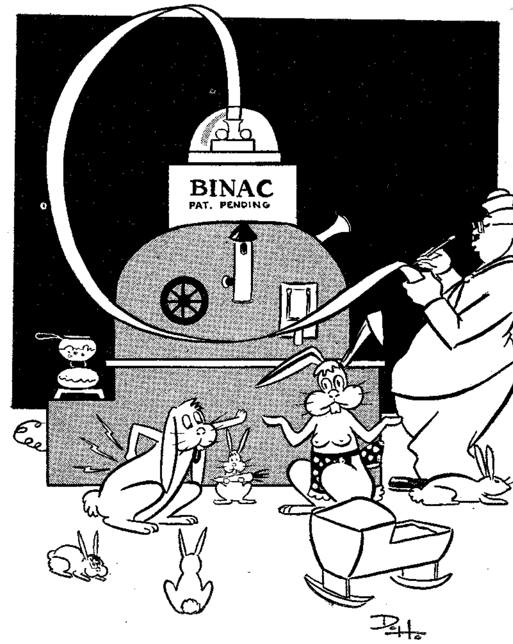
While the space on and around the masts is now almost completely taken up by various antennas, it is available for such changes as the electronics engineers deem necessary. Below decks, however, space must be reserved for such things as living quarters, propulsion machinery and magazines. Increases in functions performed by OSV's, changes in military and commercial frequency allocations, and the continuing need to provide more modern equipment, all create problems concerning where and how to install the equipment itself. Equipment spaces are now crowded to such an extent that only one minor change of equipment may require relocation of many other components, at great expense and further complexity.

The electronics technician shortage in the military services is well known. Considering the complexity of the installation, largely continuous operation of much of the gear for the period of a month, and the particularly rough weather and sea conditions these small ships undergo, it is rather remarkable that the OSV's have been able to successfully complete their missions with the single Electronics Officer and three or less technicians which each ship carries. This situation has of course resulted in great strengthening of maintenance forces ashore and each ship can expect a virtually complete overhaul of electronic equipment during each in-port period, if necessary. Emergencies at sea occur from time to time and on several occasions a Coast Guard airplane has been used to make an air drop of some small but vital repair part. That these cases are infrequent is a tribute to the OSV technicians, often young and inexperienced, who work not eight, but eighteen hours a day to help assure the safety of others on and over the seas.

BINAC . . .

SUCCESSOR TO THE NAVY ENIAC

A new electronic calculating machine which can figure out the answers to problems 12,000 times faster than a human being, has been invented. Named the "Binac", it is the successor to the "Eniac" which the Navy pioneered. The mechanical marvel can rattle off 3500 additions or subtractions a second. The more difficult multiplications and divisions take a little longer. The machine can do only 1000 of these a second.



"It just ain't no use Gertrude, nothing *can multiply like that Binac!"*

THE MARCH COVER

U.S. NAVY ELECTRONICS Ramparts of the Nation

by
LT. CDR. FRANK BAHRY, USNR
Ship, Marine and Amphibious Division, Bureau of Ships

The United States Navy—THE FIRST LINE OF DEFENSE
U. S. Navy Electronics—RAMPARTS OF THE NATION

More than 8 score years ago, sleek wooden hulls built on our Eastern seaboard attempted to stem the flow of the enemy and his mercenaries that threatened to engulf our seedling nation.

High up on the foremast, in the crow's nest, a seaman, keen of eye cried out, "Sail Ho!". Immediately from the bridge, "Where Away?"

Hours later the vessels engaged. The outcome was not always favorable to the Navy of the new born nation, but even then the enemy had a new force to deal with—no longer was access to our shores to be unopposed. The first line of defense did not hold, but backing the meager forces on the high seas were staunch hearts, the then bedraggled land forces, our army. What enemy overwhelmed our sea forces was turned back by our home defenses.

Thus was born that truly cooperative spirit, the American spirit, that has solidly withstood the test of almost two centuries of time.

Off Cape Esperance, recently, atop a mainmast, an electronic eye was scanning the vast expanse of the ocean. (The spirit of John Paul Jones must have worried that night as it gazed at that task force—there were no lookouts in the crow's nest on that mast.) Deep in the bowels of the vessel a radar operator studied the search radar screen and reported unidentified pips to the bridge. The necessary orders trained the fire control radars on the targets. One final IFF check—negative! Fire! Salvo after salvo is tracked to the target until it becomes lost in the grass on the screen—and in the grass at the bottom of the sea.

Thousands of miles from our shores, *the ramparts of the nation,* our first line of defense, prevents the enemy from reaching your soil and mine. It must always be so! The enemy must not reach our shore. He will not, while Navy radar, eyes over land and sea, keeps a vigilant watch thousands of miles away from our shores—*a formidable rampart.*

Times have changed. In this supersonic age, the enemy and his missiles must be detected thousands of miles away. The first line of defense will harry and destroy as much of the enemy host as it can, thousands of miles from home. No longer dependent on wig-wag flags, our ramparts warn our brother services that what is left of the enemy is on his way. Alarums! Radio, the electronic voice, booms forth. No longer, "one if by land and two if by sea." Now, "unidentified forces sighted and intercepted —— longitude, —— latitude, traveling west, speed 720 knots." As the enemy heads for our shores, *radar picket vessels,* a proven rampart, chart the enemy's course as he speeds toward our land. Carrier aircraft still harry and destroy but some will get through the first line. We must have a good line, but now is the time for the safety backs. With the enemy's course and position known accurately, land-based aircraft now tackle the job. Only a few hundred miles from our coast, the battered remnants are intercepted. Whatever may get through has a warm reception awaiting if it tries to land.

We, a democratic nation, "must first turn the other cheek." Therefore, we are dependent on our first line of defense—electronically, the ramparts of the nation.

Times have changed. Deep beneath the surface of the sea the interloper approaches. This time the Navy, *your first and only line of defense,* stands ready to repel and destroy. Again, Navy electronics standing by for action!

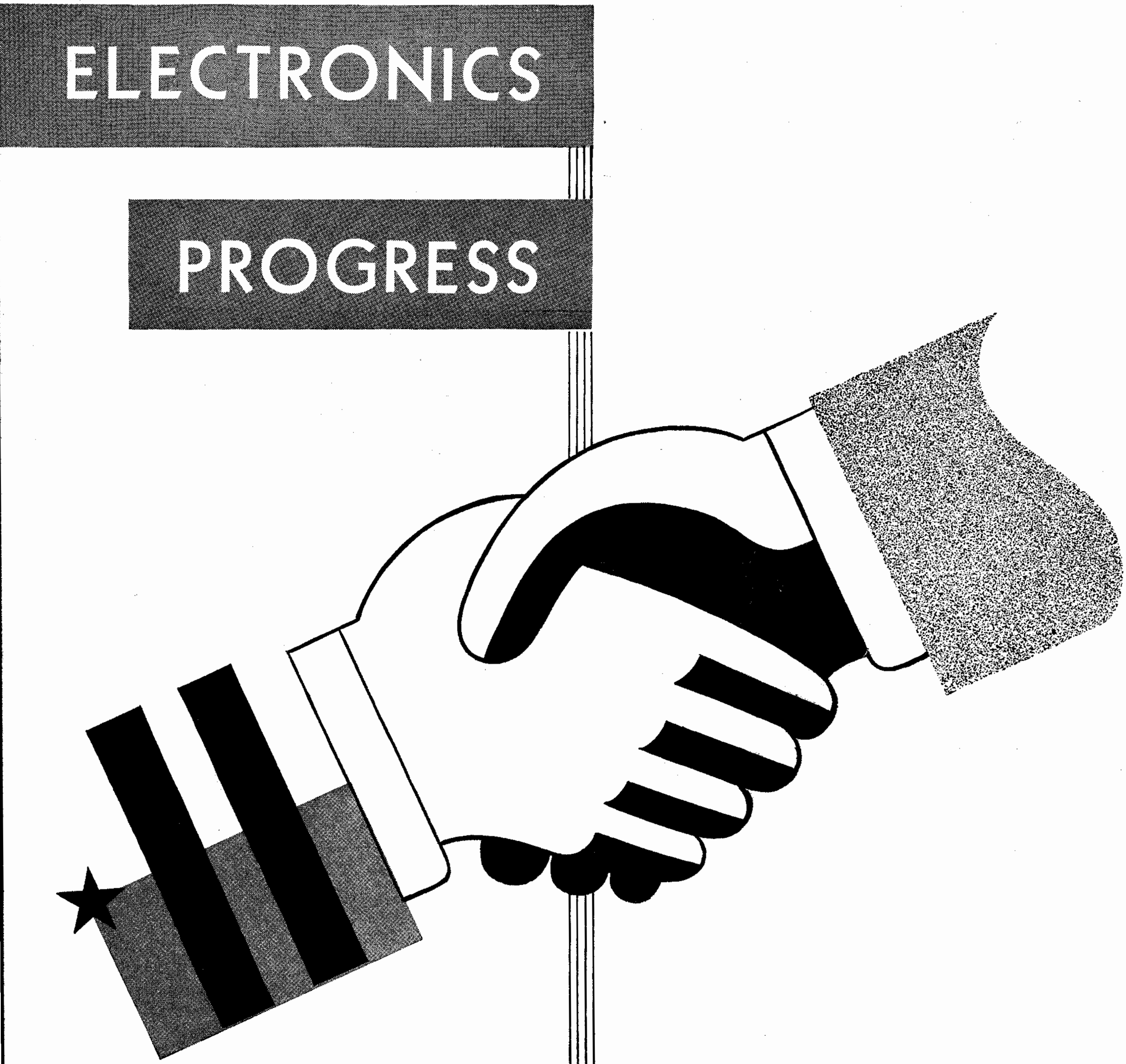
Sonar! Ears beneath the surface of the sea! *The only known technique for the detection of enemy submersibles.* The U. S. Navy in cooperation with civilian companies and agencies has fathered this unique science of underwater detection and location of suspicious craft and/or objects.

Yesterday, today, and tomorrow—by air, by sea, or beneath the sea—*The United States Navy,* FIRST LINE OF DEFENSE; *U. S. Navy Electronics,* RAMPARTS OF THE NATION!

STORY BEHIND THE FORM BROUGHT TO THE FOREGROUND

WHEN YOU MAIL YOUR FORM 383 TO THE BUREA

D.H.



through close cooperation between Bureau of Ships Electronics Divisions and the U. S. Electronics Industry