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NavShips 900,100

JUNE 1948

BUSHIPS

Electron

U. S. Navy Underwater Sound Laboratory

Confidential

BUSHIPS Electron

A MONTHLY MAGAZINE FOR
ELECTRONICS TECHNICIANS

JUNE, 1948 VOLUME 3 NUMBER 12

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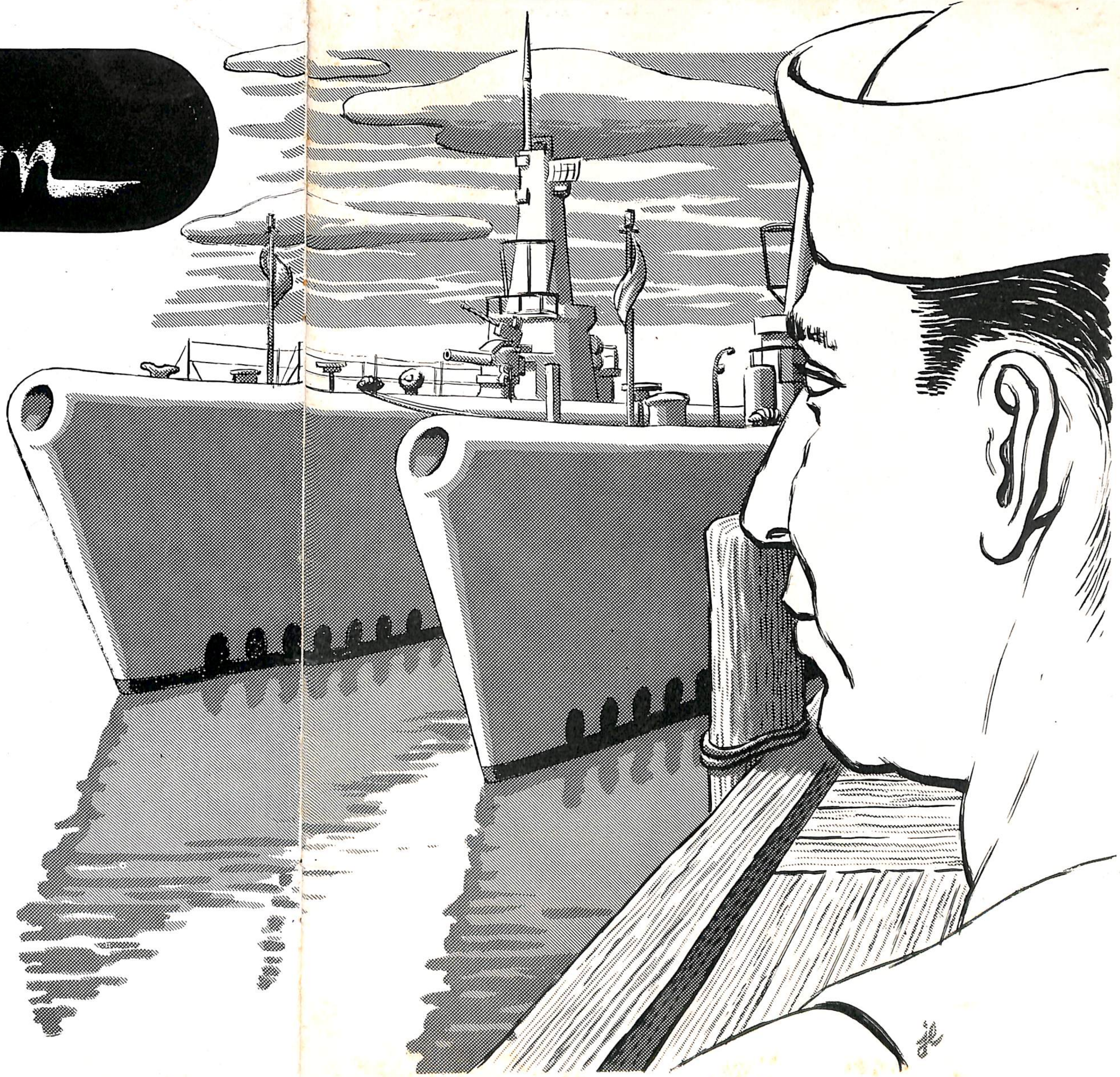
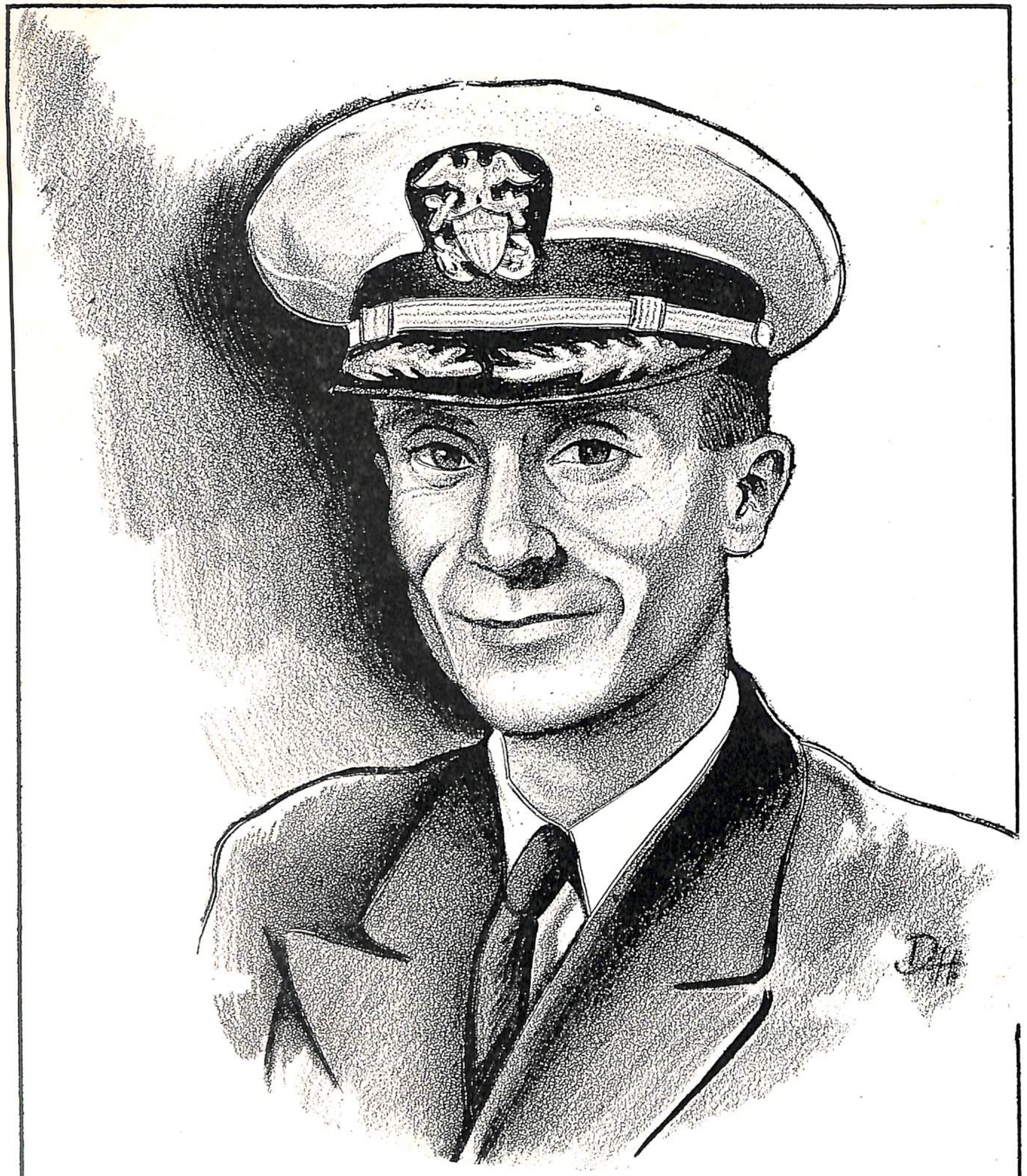




Captain William L. Pryor, Jr., U.S.N.

Commanding Officer, U.S. Navy Underwater Sound Laboratory

WILLIAM L. PRYOR, JR.

CAPTAIN, U.S. NAVY

Captain W. L. Pryor, Jr., was born in Washington, D. C. on September 23, 1905. He attended school in the District of Columbia, and in Pennsylvania, Virginia and Connecticut. He entered the Naval Academy in June 1922 and graduated in 1926.

After "aviation summer" at the Naval Academy his first assignment was to the U.S.S. ROCHESTER, *flagship of the Special Service Squadron, where he learned the fundamentals of practical naval engineering and was also privileged to serve briefly as a Marine platoon commander and to learn to eat field rations in the open during Nicaragua's too-frequent tropical downpours.*

He was disappointed in his desire to enter Naval Aviation and after two years in destroyers, entered the submarine service late in 1929. During his 3½-year tour in gunnery, torpedo and communications work in submarines based at Pearl Harbor he participated in an extensive series of exercises to determine the limitations of communication and fire control equipment then available to submarines.

In 1933 he requested assignment to the Postgraduate School for a course in electronic engineering, and in 1936 obtained his M.S. in communication engineering at Harvard University under Professor G. W. Pierce.

Upon leaving Harvard he was assigned as Radio Officer of the U.S.S. WEST VIRGINIA. *The* WEST VIRGINIA *had the first of a new type of radio direction finder covering a considerably wider frequency range than previous models. Captain Pryor devised a new and successful type of calibration which greatly facilitated the use of the wide-range direction finder.*

His next assignment was as Staff Communication Officer of Destroyer Squadron Two, the first squadron of 1500 tonners with an 1850-ton leader. While on this duty he organized and conducted the first fleet sound school to teach Navy personnel the use and maintenance of echo ranging equipment, based on the techniques developed by Destroyer Division 19.

In 1938 he became Radio and Sound Officer, under Rear Admiral Walter R. Sexton, for Destroyers, Battle Force. During this duty his primary job was to devise sonar training exercises and see that they were carried out. He had the privilege of witnessing such exercises in practically every active destroyer, and in several submarines, and of selling echo ranging equipment to many capable commanding officers who sincerely believed at the start that the whole project was a "gigantic scientific hoax" (to quote one of them) but who came back convinced it would work.

Having acquired many valuable ideas from the destroyer and aircraft operating personnel, he was made secretary of a board which prepared the tactical bulletins prescribing the Battle Force anti-submarine doctrine.

He also secured approval for the reassignment of Destroyer Division 19 as a full-time sound training division, and obtained headquarters and classroom space ashore at San Diego for the start of a permanent school.

In 1939 he was assigned to the Sound Desk in the Bureau of Engineering. Shortly thereafter, this Bureau was merged with the Bureau of Construction and Repair to become the new Bureau of Ships. While on this duty, with a staff of two engineers, and one part-time draftsman and a secretary, he was responsible for all design, procurement and installation of underwater sound and visual signaling equipment for the Navy. The fitting out of all 1200-ton destroyers, the procurement of harbor defense equipment, and the acceleration of equipment procurement to match accelerated shipbuilding, were among the major problems arising. He was privileged to meet Mr. A. E. W. Pew, who came over with Sir Henry Tizard's technical mission, and make the first exchange of information on A.S.W. with the British.

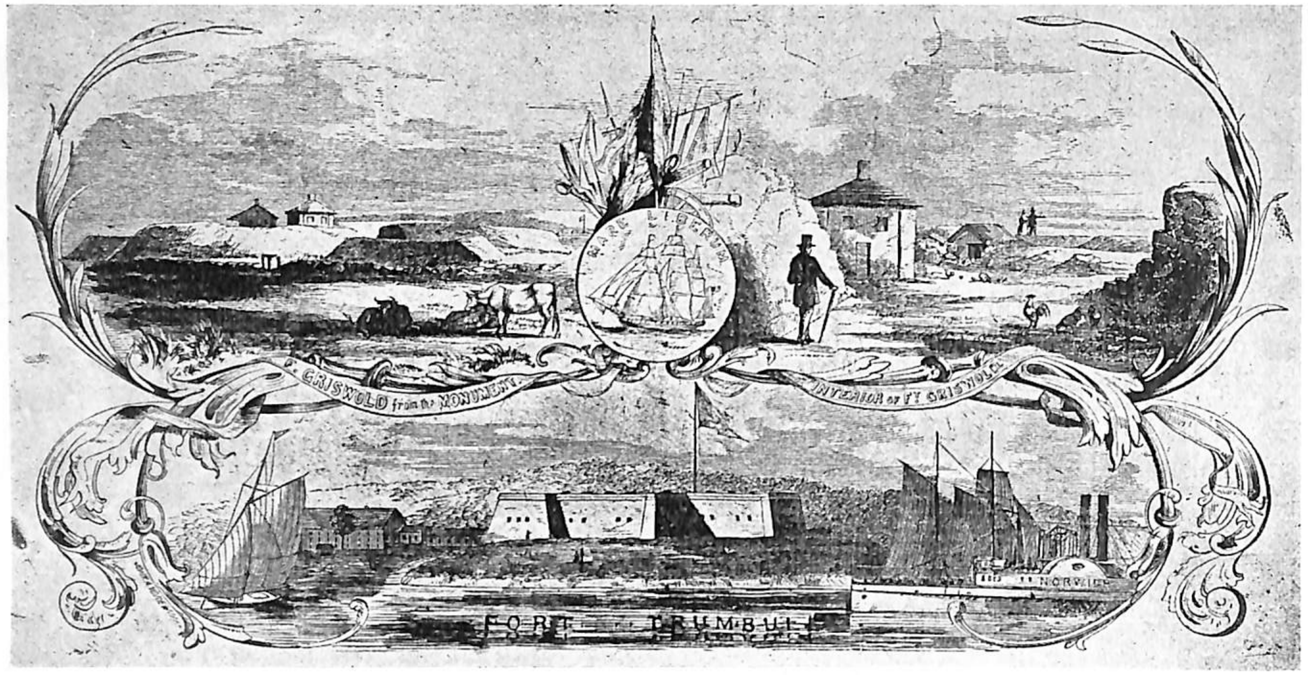
In 1941 he took command of the U.S.S. SEMMES *and put in two years trying out his Bureau successors' improved models of sonar and the first shipboard microwave radars against, first, friendly and, later, hostile targets.*

In 1943 he was assigned to the Naval Research Laboratory where he initiated a project covering the development of an integrated A.S.W. system, sponsored several pro-submarine projects, and gave full support to the development of scanning sonar.

In 1946 he was assigned to the Norfolk Naval Shipyard as Electronics Officer. Here he assisted in the modernization of our CVB's (MIDWAY *class) and in the conversion of the* U.S.S. MISSISSIPPI *to the world's biggest experimental ship (see article in this issue), and weathered the transition of the yard from a war to a peace economy. He also sponsored the initiation by the yard electric shop, under supervision of the electronics laboratory, of a production-line type of repair and renovation for electronics equipment.*

Captain Pryor took command of the U. S. Navy Underwater Sound Laboratory in November, 1947.

THE U.S. NAVY UNDERWATER SOUND LABORATORY



Old Forts Griswold and Trumbull, New London.

Any consideration of events leading to the inception of the U.S. Navy Underwater Sound Laboratory must necessarily go back to the spring of 1941 when the entry of this country into World War II, though imminent, was not yet a reality—specifically, back to 10 April, on which date Admiral S. M. Robinson, Chief of the Bureau of Ships, requested the newly formed National Defense Research Committee to undertake a comprehensive study of the submarine problem. To conduct this study, Division Six of the N.D.R.C. was formed and under its cognizance major laboratories were established at San Diego, New London, and Cambridge. Throughout the war, these laboratories were administered under U.S. Government contracts with notable success by the University of California, Columbia University, and Harvard University, respectively.

Laboratory facilities for the Columbia University Division of War Research, as the New London group came to be known, were erected by the Navy at historic Fort Trumbull, overlooking the Thames River. Although various other locations along the eastern seaboard were considered, the Fort Trumbull reservation was chosen as the most advantageous. Proximity to the Submarine Base and the Electric Boat Company (both situated across the river at Groton), the ideal testing areas offered by the adjacent protected waters of Long Island Sound, and the relatively short distance from New York and Washington were considerations which determined the selection. It is interesting to note, in passing, that history was repeating itself in this selection, for a small group concerned with the problems of underwater sound had operated at Fort Trumbull during World War I.

Late in July 1941, when the Navy had completed the construction of the first laboratory building, the Columbia group began its immense undertaking. In addition to the buildings, the Navy furnished test vessels and liaison with the fleet. The equipment, personnel, and administration of the technical program were provided by the University under its contract with the Government.

About the same time that the Columbia University Division of War Research was being established at New London, a sister organization, the Harvard Underwater Sound Laboratory, was being organized in university buildings at Cambridge. Like the Columbia group, that at Harvard operated under the general cognizance of Division Six of the N.D.R.C. To conceal its real purpose—the investigation of the physics of underwater sound—the program at Harvard was for a time simply designated "Anonymous Research."

The New London group throughout the war concerned itself primarily with the development of new devices and equipments, first for use in the anti-submarine phase of the battle for control of the Atlantic and later for use in the pro-submarine phase of the conflict in the Pacific. In addition, it assisted in training Naval personnel in the use of laboratory-developed equipments and sent field engineers to assist the fleet in the actual areas of conflict. Similarly, the Harvard group assumed the task of developing new sound equipment and improving that already in use. It was at Harvard that the term "sonar," for SOund NAvigation and Ranging, first came into being. In addition to their work in the field of underwater sound, both groups undertook a considerable amount of ordnance work. From their combined efforts flowed numerous devices and equipments, often radically new in design and function, which aided the Navy materially in reducing the threat to our shipping in the Atlantic and in carrying the war to the enemy's shores in the Pacific.

In October 1944, it was decided that the activities of the Columbia and Harvard laboratories would be continued under direct Navy cognizance. Accordingly, on 1 March 1945, the Naval Research Laboratory undertook the technical direction of the New London laboratory for the Bureau of Ships. Shortly thereafter, in July 1945, the sonar portion of the Harvard laboratory's development program was transferred to New London and merged with the work formerly undertaken by Columbia University. Thus reorganized, the U.S. Navy Underwater Sound Laboratory, as it is now known, began operations on a permanent peacetime basis. Direction of the laboratory at Fort Trumbull was continued by N.R.L. until 6 March 1946 when it relinquished this responsibility to the Bureau of Ships, under whose management and technical control it now operates.

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 the electronic arts.

The technical program of the laboratory is coordinated closely with the programs 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.

In carrying out its technical program, the laboratory works closely with other laboratories engaged in related fields of endeavor. Through such cooperation, the laboratory is able to maintain contact with associated branches of the Navy's research. Of no less importance is the fine spirit of cooperation demonstrated by the submarine forces afloat. The frequent exchange of ideas with the submariner has always played an important part in the successful fulfillment of the laboratory's mission.

Lt. Comdr. William H. Crawford, Jr., Executive Officer and Operations Officer at U.S.N. U.S.L.

The Commanding Officer of the laboratory is Captain W. L. Pryor, Jr., USN. In this capacity he is responsible to the Bureau of Ships for the laboratory's technical administration and to the Commandant of the Third Naval District for its military management. In discharging these responsibilities, he is assisted by Lt. Comdr. W. H. Crawford, USN, Executive Officer; Lt. Comdr. S. A. Bobczynski, USN, Budget Officer; and Miss H. G. McCabe, Personnel Administrator. Dr. John M. Ide, the laboratory's Chief Scientist, is responsible for the direction of the technical program. In administering this program, he is assisted by a number of section leaders and special consultants.

The civilian staff of the laboratory numbers 524. Of this total, approximately 155 are professional scientists, engineers, and supporting technicians. The remaining number consists of clerical, administrative, maintenance, and shop personnel. In addition to the civilian staff the laboratory has a complement of 3 officers and 33 enlisted men.

The technical staff is divided into six operating sections, each under the guidance of a section leader, and a number of supporting groups of a consultative 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. Some conception of the scope of this mission may be obtained by considering briefly the organization and function of each section.

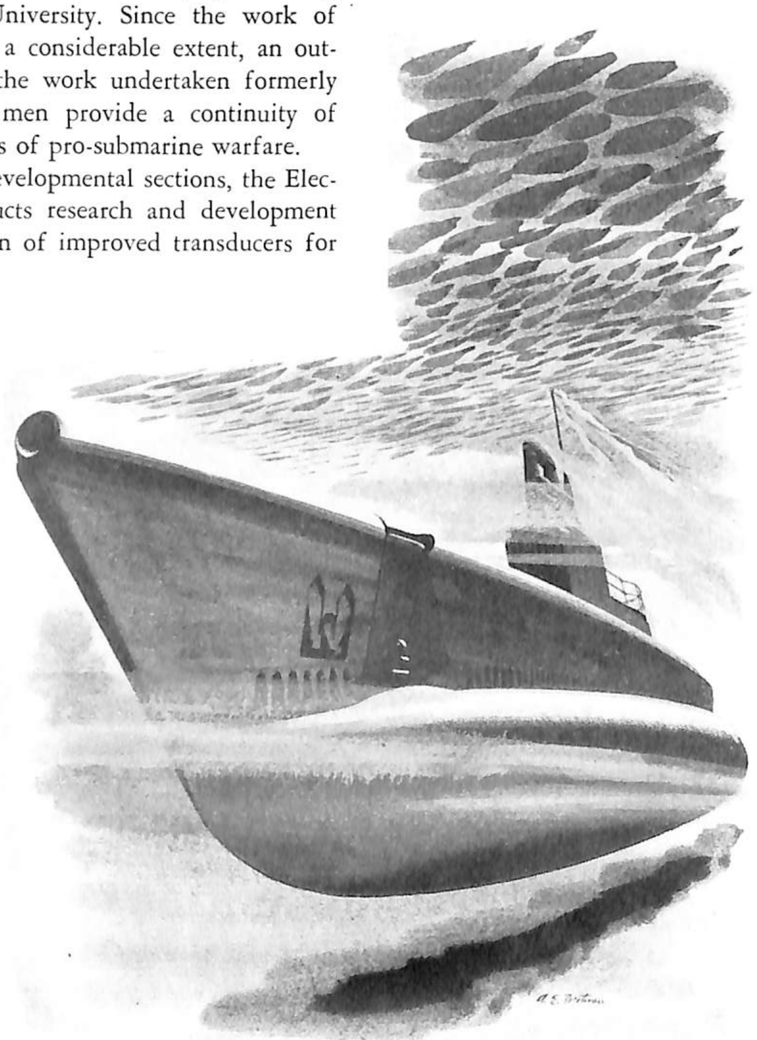
The Anti-Submarine Systems Section (see figure 1) under the leadership of Mr. H. E. Nash, is concerned primarily with the development and improvement of sonar equipment of the scanning type. Included in this program are studies of the problems of submarine and underwater object detection, the development of evasion and attack systems, and the investigation of a large number of subsidiary problems. This portion of the technical program has developed from the original inheritance from the Harvard Underwater Sound Laboratory. While many new men have been added to the section, several of the key personnel are former Harvard employees.

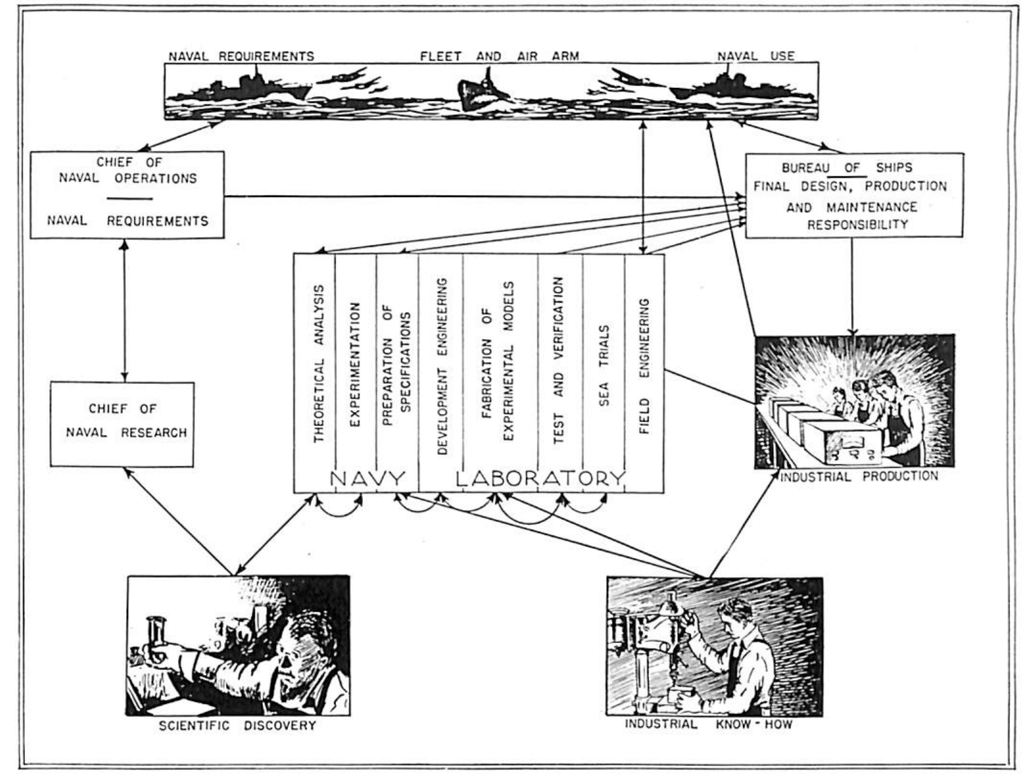
Working on behalf of the Navy's submersibles is the Submarine Systems Section. Under the leadership of Mr. G. S. Harris, this section devotes its attention to the problems of search, detection, attack, and communication. Although present emphasis is largely upon the development of search-attack equipment for new-construction submarines, considerable effort is applied to other phases of the submarine problem. In this section are a number of men who were employed during the war by Columbia University. Since the work of the section represents, to a considerable extent, an outgrowth of a portion of the work undertaken formerly by the university, these men provide a continuity of experience in the problems of pro-submarine warfare.

Supporting the other developmental sections, the Electroacoustics Section conducts research and development leading to the construction of improved transducers for specific sonar applications. In addition to its calibration and measurement facilities (figure 2), this section has a well-equipped shop for constructing limited numbers of transducers for experimental use by the laboratory. The personnel of this section, under the direction of Dr. Fritz Pordes, comprise a highly specialized group working primarily in the field of magnetostrictive transducers.

It is with the Electromagnetics Section, headed by Mr. C. M. Dunn, that the laboratory's program departs from the field of underwater sound. Established at the laboratory in June 1945 to conduct radiation, propagation, and reflection research in the field of radio, the section was augmented in June 1947 by an infrared group which operated formerly at Fort Miles, Lewes, Delaware, as a Bureau of Ships Test Station.

The program of the section's Antenna Group is concentrated at present largely upon the design, development, and testing of various antennas to meet the requirements of the new-design, high-speed submarine. To supplement this work, the group is developing antenna systems to meet new submarine needs, improving





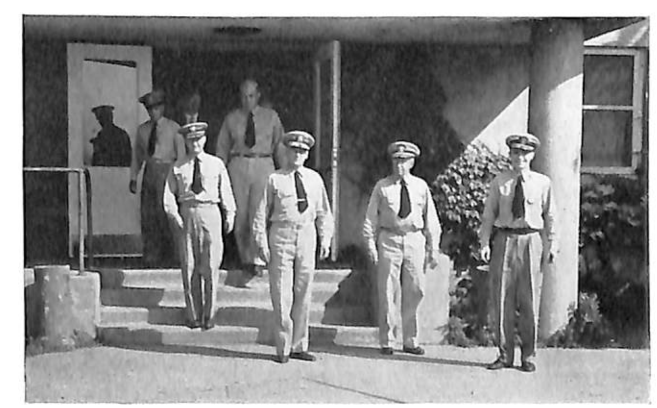
existing antennas, and carrying on a number of fundamental investigations (figure 3). The section's Infrared Group is engaged primarily with studies in the infrared and ultraviolet spectra and with the evaluation of infrared equipment for communication, detection, identification, reconnaissance, and special tactical applications.

The General Engineering Section, under Mr. R. L. Whannel, provides the other sections with specialized assistance involving instrumentation, sound recording and analysis, mechanical engineering, and experimental shipboard installations. The facilities of this section include an exceptionally well-equipped recording laboratory (figure 4) and an extensive library of recordings covering a wide variety of underwater sounds. A specifications compliance and test laboratory will be added in the near future.

Finally, the Technical Services Section, under Mr. W. A. Benson, designs and fabricates models, parts, and assemblies to the specifications of the other laboratory sections and undertakes small-scale quantity production of equipments requested by the Bureau of Ships. Such production is based, for the most part, upon pilot models of experimental equipment designed and developed by the laboratory. The section operates the laboratory's well-equipped machine shops, electronic shop, and drafting room (figures 5, 6, and 7).

Having discussed the scope of the technical program in a general way, it may be of interest to consider briefly a few of the specific problems on which the laboratory is working. In the field of underwater communication, the laboratory has been devoting considerable effort to the problem of providing surface vessels and submarines with long-range underwater telephony. From this effort, several experimental equipments have resulted. The most successful of these is a 400-watt single-sideband suppressed carrier equipment, consisting of a specially developed non-directional scroll-type magnetostriction transducer, a transducer, a transmitter receiver, and master and remote control stations. Tests with this equipment under various operating conditions have provided good communication at ranges in excess of 30,000 yards.

Of particular interest to the submariner is the laboratory's emergency communication system, developed to



Admiral Blandy's party leaving the Electromagnetic Section, U.S.L. Left to right: Lt. Comdr. I. J. Schuyler; Mr. W. A. Benson; Capt. J. N. C. Gordon, MC, U.S.N.; Comdr. J. A. Tyree, Jr.; Admiral W. H. P. Blandy; Rear Admiral James Fife; and Capt. W. L. Pryor, Jr.

FIGURE 1—*Portion of the Anti-Submarine Systems Laboratory.*

provide communication between submarines in distress and search and rescue vessels. Essentially, the system is a small portable version of the larger equipment, incorporating a 24-kc tone signal which can be keyed and on which the rescue craft may "home" by listening on standard echo-ranging equipment.

One of the more spectacular experiments conducted in this field has been concerned with an attempt to provide communication between an airplane in flight and a completely submerged submarine. Believed to be the first of its kind on record, this experiment provided good submarine-to-plane communication at a distance of 20 miles. The success obtained may well pave the way for a development of considerable tactical importance. While a telephony-equipped sonobuoy gave satisfactory communications between the underwater sound channel of the submarine and the radio channel of the airplane, tactical usage will require the development of an expendable link to be released from the submarine or dropped from the aircraft.

Turning now to the field of sonar, the laboratory has been pursuing a vigorous program devoted to the improvement of a number of wartime developments, the evaluation of enemy devices, and the development of new equipments for submarine and surface vessel search

FIGURE 2—*Measurements Laboratory, Electroacoustics Section*

and attack. Coincident with an investigation of the problems of long-range search and detection for submarines, an experimental 50-foot 36-element listening array has been constructed and installed aboard the *USS Quillback* (SS–424). Approximating a straight line, the array is installed in the skin of the submarine's forward superstructure. Although only a limited number of sea tests have been made, target ranges of from 30,000 to 50,000 yards have been obtained under favorable sonar conditions.

Among the more promising scanning sonar developments are the Integrated Type B and XQKA systems. The Type B System has been designed to enable an A.S.-W. vessel to detect and distinguish between moving and stationary targets in all directions at ranges up to 3750 yards, to maintain contact with submerged targets as it approaches and passes over them, and to plot own ship's and target's courses with respect to true north. Combining scanning in depth with scanning in azimuth, the system provides range and stabilized bearing, depth, and depth-angle information; enables the operator to listen to noise sources; and includes a communication channel.

The XQKA Scanning Sonar is an electronically rotated system for forming and rotating a beam of sensitivity by means of electronic switches. It provides rotation speeds

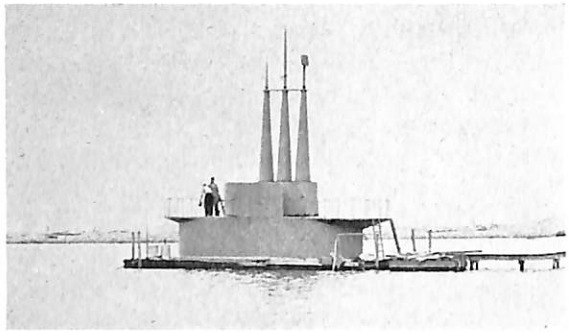


FIGURE 3—*Submarine Mock-up, Electromagnetics Field Station, Fishers Island*

of 300 cps, the use of 3-millisecond pulses, and continuous alertness in all directions. Designed for installation aboard submarines, this equipment has demonstrated its extreme versatility. Of particular promise is its use in assisting submarines in the location and penetration of mine fields and similar barriers.

Challenging the experience and ingenuity of the laboratory's Electroacoustics Section are a number of problems concerned with the design and development of new types of magnetostriction transducers for specific applications. Typical of these problems is that concerned with the design of five scanning transducers with operating frequencies 2 kc apart in the frequency band from 20 to 30 kc. These transducers are required to operate with existing production-type scanning sonar equipment. Their use is intended to permit scanning installations aboard vessels operating within sound range of one

another to operate simultaneously without an excessive degree of mutual interference.

With the advent of the new-design, high-speed submarine, several new antenna designs are under development. One of these, an around-the-mast type, is of particular interest. This type of antenna, cylindrical in shape, is mounted around a retractable mast and electrically isolated from it. Among its more obvious advantages are the following: 1—it need not be mounted at the top of the mast, but can be positioned anywhere along it; 2—no mast insulator is required; and 3—it permits several antennas to be stacked on the same mast. Experimental antennas of this type are being investigated for the A.E.W. video link, u-h-f communication, and IFF.

Nearing completion is an improved sonar intercept equipment or "sonaramic receiver," as it is called. Designed to provide both directional and omnidirectional operation, this equipment presents bearing and frequency information on a 7-inch cathode-ray tube. As an incoming signal is received, a brightened spot or dash

FIGURE 4—*Dubbing Console, Sound Recording Laboratory, General Engineering Section.*

will appear on the frequency base radius of the cathode-ray indicator. To provide bearing information, the radius rotation is synchronized with the acoustic axis of a rotating directional hydrophone. The equipment will scan the spectrum from 5 to 150 kc at scanning rates of either 100 or 10,000 cps.

These are but a few of the seventy problems confronting the laboratory at the present time. Approximately 70 per cent of this total results from specific assignments from the Bureau of Ships; the remaining number consists of related investigations introduced locally. The provision for locally initiated work within the general definition of the laboratory's scope is particularly desirable since it invites and stimulates the investigation of problems of fundamental importance to the technical program as a whole.

On 1 March 1945, when the Navy assumed direct cognizance of the laboratory, the major portion of the

FIGURE 5—*Portion of the Machine Shop.*

technical program was being carried on in the badly cramped quarters of Building No. 1, a temporary structure erected in stages during the recent war in an effort to keep pace with the work of Columbia University. While a number of Quonset huts offered some relief during the ensuing months, expansion of the technical work and the attendant increase in personnel steadily aggravated the situation. Fortunately, the Electromagnetics Section was able to occupy the field station on Fishers Island used during the war by the Radiation Laboratory of the Massachusetts Institute of Technology. Although this location was well adapted to certain phases of the section's test and evaluation work, the lack of laboratory space on the mainland presented a severe handicap.

It was not until very recently that some relief finally came with the transfer to the Navy of a number of buildings formerly occupied by the Coast Guard at Fort Trumbull. Although most of these buildings were non-

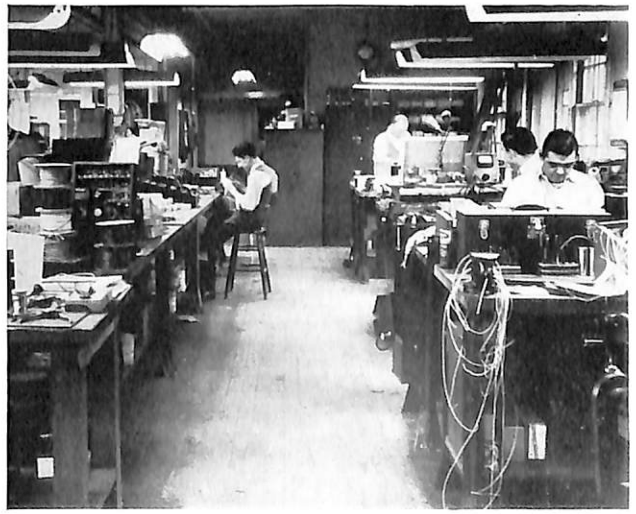


FIGURE 6—*View of the Electronics Shop.*

FIGURE 7—*View of the Drafting Room.*

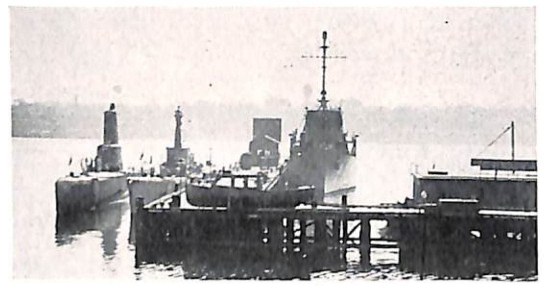
fireproof structures of old vintage, it was possible to use some of them to good advantage. Retaining its test station on Fishers Island, the Electromagnetics Section moved onto the mainland, and Building No. 24, a former messhall, was converted into laboratory space for the Electroacoustics and Anti-Submarine Systems Sections. As a result of these moves the plant, in general, has taken on an entirely new aspect.

The Navy reservation at Fort Trumbull now occupies approximately 11 acres. Distributed throughout this area are the laboratory's six major buildings and numerous smaller structures. Taken as a whole, they represent an approximate total of 117,400 square feet of laboratory, shop, office, and storage space. The aerial view of Fort Trumbull (front cover) gives some idea of the reservation, the finger piers, and the various laboratory buildings. Numerous other unidentified structures may be noted interspersed among the laboratory buildings. These, for the most part, are temporary buildings erected for the Maritime School, operated on the reservation during the war. Currently utilized as an emergency branch of the University of Connecticut at New London, most of these buildings will be razed when the main campus at Storrs can accommodate the university's total enrollment.

Apart from the major facilities at Fort Trumbull are the Fishers Island and Dodge Pond field stations. The station at Fishers Island, approximately six miles by water from the laboratory, is employed by the Electromagnetics Section for infrared and antenna tests. This station, situated at the island's Fort H. G. Wright, presents an uninterrupted view of submarine operating areas in Long Island and Block Island Sounds and a line-of-sight view to the section's facilities at Fort Trumbull. The Dodge Pond Station, situated at Niantic, Connecticut, also a distance of six miles from the laboratory, consists of a sound barge moored in 45 feet of water on a small quiet, fresh-water lake. It is particularly well adapted to performance studies of transducers and to the evaluation of certain types of experimental sonar equipment. The facilities at this station complement those provided by an additional measurements barge at Fort Trumbull, moored in the Thames River.

Attached to the laboratory as experimental vessels are the E-PCE(R)s 849, 850 and 852 and the *USS Callao* (IX-205). The *Callao,* formerly the German *Externsteine,* was converted in 1945 to an infrared test vessel. Originally designed and constructed as a trawler at Rotterdam, she was utilized during the war as a weather ship until captured off Iceland in 1942 by the Coast Guard. Also converted to an infrared test vessel is the *E-PCE(R)* 852.

The *E-PCE(R)* 850 was converted recently to a sonar test vessel at the Boston Naval Shipyard. Considered to be the finest of its kind, the converted vessel is equipped to handle sonar projectors up to 34 by 40 by 66 inches, to make noise level measurements from 50 cps to 60 kc, to take vertical and horizontal projector directivity patterns, and to make sound transmission, bearing accuracy,



View of the piers at U.S.L., showing a Guppy submarine, a "Fleet-Type" submarine, and an E-PCE(R).

and underwater telephony tests. Four sea chests are provided, two with hoist-train shafts and high bearing accuracy training systems, and two with hoist-lower shafts. The laboratory space is equipped with a periscope and two sets of target bearing transmitters which can be linked with any combination of the trainable shafts. All shafts, with the exception of that provided for deep monitoring, can be remotely controlled from the vessel's laboratory. The remaining vessel, the *E-PCE(R)* 849, is now undergoing a similar conversion.

In addition to the above experimental vessels, others are assigned as required for the experimental installation and evaluation of laboratory equipments. The proximity of the Submarine Base, headquarters of the Commander Submarines, Atlantic Fleet, aids greatly in this respect.

From the foregoing, it is evident that the Underwater Sound Laboratory, through its period of transition, has evolved into a well-equipped, well-staffed peacetime organization. Under the guidance of men who are experts in their fields, this organization exists to meet the scientific needs of the forces afloat. Believing that the first line of defense rests in the hands of the scientist, it is dedicated to the objective of keeping the United States Navy out in front.

BIOGRAPHICAL DATA ON LABORATORY SUPERVISORY PERSONNEL

Supervisory personnel at U.S.N. U.S.L.

Left to right: Mr. W. A. Benson; Mr. C. M. Dunn; Dr. Fritz Pordes; Dr. S. J. Haefner; Mr. G. S. Harris; Dr. J. M. Ide; Capt. W. L. Pryor, Jr., USN; Lt. Comdr. S. A. Bobczynski, USN; Lt. Comdr. H. T. Murphy, USN; Miss H. G. McCabe; Mr. R. L. Whannel; Mr. H. E. Nash; and Mr. H. W. Marsh, Jr.

Absent from this picture: Dr. J. W. Horton.

R. L. Whannel, after receiving the B.S. degree in Civil Engineering in 1923 from Iowa State College, served during the next 20 years as a consulting structural engineer for municipal and state departments in Illinois. In 1943 he became affiliated with the Columbia University Division of War Research and was assigned to the Underwater Sound Laboratory at New London. A member of the CUDWR Field Engineering Group, he was stationed at the Submarine Bases at New London and at Pearl Harbor, and aboard the USS Proteus (AS-19) at Guam. Returning to U.S.N. U.S.L. in July 1945, he was Liaison Engineer with COMSUBLANT until June 1946. Since that time he has held various supervisory positions at the laboratory and in October 1947 became Section Leader of the General Engineering Section.

H. E. Nash, Anti-Submarine Systems Section Leader, came to U.S.N. U.S.L. from the Harvard Underwater Sound Laboratory in July 1945. A graduate of the University of California, Mr. Nash spent the first two years of the war as radar engineer with the Signal Corps at McClellan Field, California. Early in 1944 he became associated with the Scanning Sonar project at HUSL. At the termination of HUSL's wartime contract, Mr. Nash transferred to the USN Underwater Sound Laboratory at New London.

Lt. Comdr. S. A. Bobczynski, USN, was graduated from the Naval Academy in 1939 and served on the heavy cruiser USS Pensacola and on the mine-laying destroyer USS Pruitt until January 1941, at which time he entered Submarine School. For the next 4 years he saw service on the USS Gudgeon and the USS Archer Fish. During the latter part of World War II he commanded the USS Baracuda, USS Dolphin, and the USS Pike. On his last tour of shore duty he served one year with the New London Group, Atlantic Reserve Fleet, and one year in his present assignment at U.S.N. U.S.L. as BuOrd Liaison Officer and Budget Officer. Comdr. Bobczynski will shortly return to sea to command the USS Diablo.

G. S. Harris, Section Leader of the Submarine Systems Section, holds the A.B. degree from Wittenberg College and has devoted a number of years to teaching mathematics and physics in secondary schools and colleges. During World War II he was associated with the Columbia University Division of War Research as a Bureau of Ships field engineer in submarine sonar, serving with ComSubPac in the Pacific. Mr. Harris returned to U.S.L. in the spring of 1945.

H. W. Marsh, Jr., staff consultant in applied mathematics and head of the Theory and Analysis Group, came to U.S.L. in September 1946. After obtaining the B.S. degree from the University of Chicago, Mr. Marsh was a consulting mathematician for the Owens-Fiberglas Corporation from 1940 to 1942 and from 1945 to 1946, and served during the intervening period as a submarine officer, U.S.N.R.

Miss H. G. McCabe joined the Underwater Sound Laboratory staff as Personnel Administrator in November 1945, coming directly from the First U.S. Civil Service Region, where she held various posts including that of Area Supervisor for the Commission's branch office covering western Massachusetts and Connecticut. Prior to entering the federal service, Miss McCabe held office manager positions with the Packard Motor Car Company and the Boston Belting and Rubber Company.

S. J. Haefner, who holds B.S., M.S., and PhD degrees in Electrical Engineering, from Union College, was employed from 1925 to 1927 by the General Electric Company in their Test Department. Following this employment, Dr. Haefner served as instructor in Electrical Engineering at Union College until 1937 and Assistant Professor until 1942, when he joined the scientific staff of the Columbia University Division of War Research at the Underwater Sound Laboratory, New London. In 1945 he became Development Supervisor in Electronic Design and Measurements, and since 1947 has been Chief Electronic Consultant at the Laboratory.

DR. FRITZ PORDES, after obtaining the PhD degree in 1935 from the Institute of Technology, in Vienna, did research at the Elektrische Industrie (Elin A.G.) and at the Institute of Technology. Coming to the United States in 1938, he held various development and research positions in Illinois, at the Victor Chemical Works, the Eureka X-ray Tube Corporation, and the Russell Electric Company. In February 1946, Dr. Pordes joined the U.S.L. scientific staff and is Section Leader of the Electroacoustics Section.

W. A. BENSON taught industrial subjects in Pennsylvania and New Jersey from 1928 to 1944 and holds the B.S. degree from Syracuse University and the Ed. M. degree from Temple University. From 1941 to 1944, he was employed by the Budd Manufacturing Co., Bendix Aviation, Henry L. Crowley Co., and Thos. A. Edison Industries. Mr. Benson came to U.S.L. in April 1944 as Chief Draftsman for Columbia University Division of War Research, becoming Production Superintendent in 1945. His present position is that of Technical Services Manager.

C. M. DUNN officially joined U.S.N. U.S.L. staff as Section Leader of the Electromagnetic Radiation Section on 18 June 1945. Prior to this he operated as a Field Engineer with Columbia University Division of War Research. Before joining Columbia's staff, he served with the U.S. Army as Radar Instructor for the Signal Corps. He has had extensive test and design engineering experience with the Northern States Power Company and majored in Physics at the University of Wisconsin.

DR. J. WARREN HORTON, Scientific Consultant to the Chief Scientist, holds B.S. and Sc.D. degrees from the Massachusetts Institute of Technology and was an instructor in physics at M.I.T. from 1914 to 1916. For the next twelve years, he was a member of the technical staff of the Bell Telephone Laboratories, and from 1928 to 1933, chief engineer, General Radio Co. He was a research associate in electrical engineering at M.I.T. from 1933 to 1937 and later associate professor in biological engineering. From the spring of 1941, when the Columbia University Division of War Research was established at Fort Trumbull, through the termination of its activities in 1945, Dr. Horton served in various capacities, including those of Assistant Director of the Laboratory and Consultant to the National Defense Research Committee. Dr. Horton returned to U.S.L. at the beginning of this year to serve in his present capacity.

THE CHIEF SCIENTIST

The Chief Scientist at the Underwater Sound Laboratory, Dr. John M. Ide, brings to his position twenty years of professional experience consisting of approximately equal periods of (a) teaching and research in communication engineering at Harvard University; (b) industrial research in geophysics for the Shell Oil Company and (c) research and development for the U.S. Navy in the field of underwater sound at the Naval Research Laboratory and at the U.S. Navy Underwater Sound Laboratory.

Dr. Ide was born on August 17, 1907 at Mount Vernon, N. Y., grew up in California, and obtained his Bachelor of Arts Degree (*magna cum laude*) from Pomona College in 1927. He won a prize scholarship at Harvard University, where he completed his Master of Science Degree in engineering in 1929, followed by a Doctor of Science Degree in communication engineering in 1931. He remained on the teaching staff of Harvard University until 1936, completing a number of researches in the field of magnetostriction devices and measurements of the velocity of sound in rocks and glasses. A number of papers containing the results of this work were published in the I.R.E. Proceedings and in the Proceedings of the National Academy of Sciences. Dr. Ide's development of various dynamic methods of measuring elastic constants initiated a program of geophysical research on the elastic behavior of rocks at high pressures and high temperatures. This program, still continuing at Harvard University, has yielded numerous scientific papers in this field.

From his interest in geophysics, Dr. Ide became employed by the Shell Oil Company as Research Geophysicist for a period of five years at their laboratory in Houston, Texas. In this position he developed a recording camera for a gravity pendulum, improvements to torsion balances and instrumentation for precision measurement of the force of gravity. He holds several patents on magnetostriction vibrators and on design of gravimeters.

Early in 1941 he joined the Sound Division at the Naval Research Laboratory in order to engage in work more directly related to the oncoming war. During the period 1941–1945, as Section Leader in charge of Measurements and Analysis he was responsible for the development of various types of underwater loudspeakers, low frequency acoustic mine-sweeping devices and small-scale telephony and homing equipment for the use of small craft and Commando swimmers. He wrote a number of extensive reports on the propagation of low frequency sound in shallow water. Most of this work has since been declassified and has been presented in part to the Acoustical Society. For his development of acoustic mine-sweeping devices, Dr. Ide was awarded the first Meritorious Civilian Service award given at the Naval Research Laboratory.

In March 1945 Dr. Ide became Technical Director (later changed to Chief Scientist) of the Underwater Sound Laboratory, newly reorganized from the wartime programs of the Harvard Underwater Sound Laboratory and the Columbia University, Division of War Research. Since that date the staff and the program of the Laboratory have expanded to become one of the Navy's major facilities for the development of electronic equipment.

DESIGN TRENDS IN SONAR

By GEORGE B. CUMMINGS
Sonar Design Branch
Electronics Division
Bureau of Ships

The winning of the battle of the Atlantic in World War II virtually assured us a final allied victory. Some very interesting facts on the sonar picture are indicated by an analysis of the report on enemy submarines sunk. Out of 149 enemy submarines sunk, 34% were sunk by ships using unimproved sonar equipment, designed prior to 1941; 56% were sunk by ships using equipment designed prior to 1941, but improved by the addition of domes, recorders, etc., during the war; 10% were sunk by ships using what was then a modern design—developed during the latter part of the war.

At the close of the war, it was discovered that the Germans had developed and produced on a very small scale a new type submarine which, by using snorkel or breather tubes, remained submerged almost indefinitely and presented effectively little or no radar target. They had also developed and built two experimental true submarines operating on closed-cycle engines which offered absolutely no radar target. Samples of each type of submarine were obtained for study by the Navy.

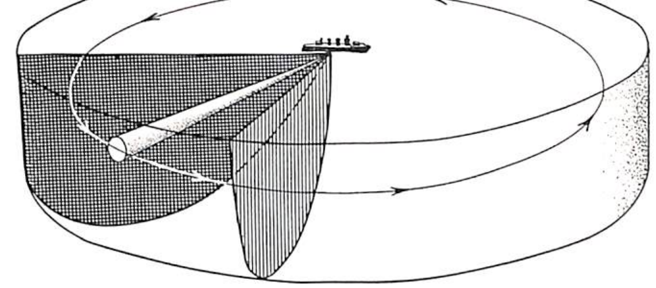
In summarizing the above-mentioned facts from a design standpoint, we note that the old slow types submarines and the older sonar equipments have served their useful life; that the newer type submersibles will require a new sonar design approach; and that the most effective equipment used in World War II against submarines was designed and, in most cases, manufactured prior to our actual entry into the war. We could, therefore, conclude that the preparation for any possible future war or assisting in preventing its occurrence depends upon the progress we make now.

In establishing the present and future trends in sonar, a complete and basic concept of the problem indicates that any potential enemy will depend on submarines of the above-mentioned improved types. The anti-submarine problem then falls logically into three parts:

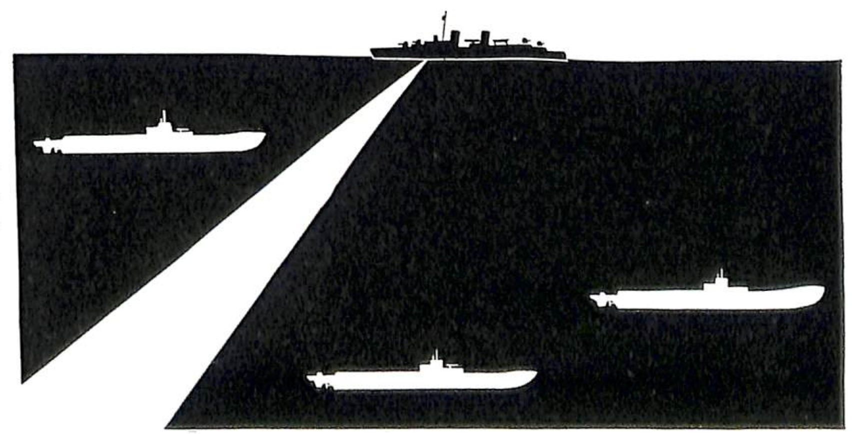
1—Detection at long ranges. This will involve new listening techniques and a special equipment designed to give early warning of submarines' presence at a minimum of 10,000 yards. Four of these (Models AN/SQR-1) are on order and first delivery is expected in late summer. Tests of a new technique are underway which are consistently detecting snorkelling submarines at 35 miles with occasional detection at 70 and 105 miles.

2—Search attack for use at ranges within the effectiveness of present or proposed A.S.W. ordnance. This equipment can be considered as a general purpose sonar suitable for detection and search at medium ranges, and of sufficient accuracy to furnish useful fire control information to the associated ordnance equipment. Models QHB, QHBa and SQS-1 are developed.

3—Direct attack sonar equipment which shall be of such precision and efficiency as to give required ac-



Energy from a scanning sonar projector is radiated in all directions. The receiver rapidly scans the entire circular area around the ship.



Conventional "Searchlight" sonar signal must be trained a few degrees at a time to cover the search area.

curate information to the fire control apparatus. Four Model AN/SQG-1's are in production with first tests scheduled for late this year.

These three phases are analogous to similar fields of activity in radar and are resulting in three general classes of anti-submarine sonar.

In summary, sonar design is vigorously pursuing equipment designs specifically aimed at fulfilling the three types of requirements outlined above. At this point, it might be well to state that complete discussion of all three types of A.S.W. equipment plus the myriad other component developments, and basic and applied research, would be most impracticable. Therefore, the remainder of this discussion shall be devoted to a brief explanation of the basic sonar ranging equation, a discussion of the most promising development in the search attack field, and a general summary of the program. The basic sonar equation for a noise limiting case is

$$2H = S + T - (N + 10 \log w + \Delta r) - \delta$$

$H = 20 \log R + \alpha R$ and represents transmission loss one way. It includes the spreading or divergence term $20 \log R$ (related to area of sphere of radius R), and attenuation or absorption factor αR.

$S =$ Source level—intensity of sound source plus directivity factor of transducer for sending.

$T =$ Target strength—db expression of ratio of sound energy striking a target to the amount of energy reflected back in the direction of the source.

$N =$ Self noise level (per cycle) at the transducer tending to mask received echo.

$10 \log w =$ Correction for total band width of noise accepted by the system (must include band width for pulse length (w width), target doppler and own doppler).

$\Delta r =$ Receiving directivity index—a measure of the ability of the system to discriminate between noise or signals received from direction other than the target direction.

$\delta =$ Recognition differential—the ability of the ear or eye to recognize target indications 50% of the time.

In considering the above equation, there are certain items over which the design engineer has control, and certain items over which limited or no control can be exercised.

Analyzing the equation, we start at symbol S. The source level can be controlled by design by increasing power and size and shape of the transducer. There are practical physical limitations to the use of either excessive power or excessive size. Proper choice of frequency is also involved.

T—Target Strength. Target strength can be estimated, calculated and controlled on our own submarines, shape, size and materials being the main factors. However, we have no control over enemy submarines and must assume that every effort will be made by an enemy to reduce the target strength of his own submarine to a minimum.

N—Self Noise. Self noise can be controlled partially by proper design. This includes the proper design of streamlined housing surrounding the transducer, the platform or vessel on which mounted, and the operating speeds. Control of self noise is basically a ship design problem.

$10 \log w$. This item can be controlled partially, but here again there are certain practical limitations based on pulse length, frequency and doppler.

Δr. Receiving directivity index. This can also be controlled by proper design within limitations; again, it is controlled by size, shape and frequency.

$\delta =$ Recognition differential. This can be controlled by proper design but is definitely limited by the audible and visual rejection and acceptance ability of the individual operators concerned. In any event, it can be improved upon, particularly from a psychological and acoustic angle.

Transmission loss, which includes attenuation and absorption, scattering and other effects, can be controlled only to a minor degree, the proper choice of frequency being probably the best method of control, but subject to severe limitations.

Continued studies in the field of sound in the sea indicate that some additional progress may be made in controlling the natural losses in the medium by further study and understanding of the basic scientific and mathematical problems involved.

Similar equations exist for reverberation-limited cases, target-noise limiting cases and listening cases. These equations have been arrived at by mathematical computation, analysis, and investigation by many scientists and engineers working both in the basic and applied fields of physics, acoustics, hydro-acoustics, hydro-dynamics, electronics, psychology, and just plain electricity. The Sonar Design Branch makes use of scientists at the U.S. Navy Electronics Laboratory, the U.S. Navy Underwater Sound Laboratory, the Naval Research Laboratory, the Massachusetts Institute of Technology, the Marine Physical Laboratory, the Scripps Institution of Oceanography, the Woods Hole Oceanographic Institution, and numerous specialized commercial contractors.

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BATTLE OF THE SUBS

WORLD WAR II

34% Sunk by unimproved equipment built prior to 1941.

56% Sunk by improved equipment designed prior to 1941 and improved by adding domes, recorders, etc.

10% Sunk by ships using modern design, developed late in the war.

(149 submarines sunk by ships.)

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

In considering developments in the search attack field, the Sonar Design Branch has produced a new type of equipment called scanning sonar. Basic work on this equipment was started by members of the Harvard Underwater Sound Laboratory and others, and by the Sangamo Electric Company, Springfield, Illinois. The Sonar Design Branch picked up this development at the end of the war, and now has the equipment in successful production. It has been thoroughly evaluated and highly endorsed by the operating forces as the best single development for all-purpose sonar to be used against modern submarines.

Briefly, in describing this equipment, let me go back to the conventional type of sonar now commonly called the searchlight type. In this equipment, a highly concentrated beam of sound was sent out from a trainable projector and swept mechanically by hand (through electric and electronic controls) to various points in the azimuth. It was necessary to transmit (ping) and wait a sufficient amount of time for an expected echo to return, then to train again (ping again) and listen again. This process took quite a period of time to cover the area forward and back to both beams. Certain gaps in the searched area were left uncovered, especially if any speed was used. Also, this equipment required a considerable number of vessels to screen any given convoy.

In the scanning-type equipment, the signal is projected simultaneously in all directions and the entire circular area around the ship is rapidly scanned electronically at rates of 30, 60, 90, or 300 cycles per second. In addition to the usual PPI presentation, a listening channel was incorporated to give aural as well as visual presentation. This listening channel may be rotated by hand to investigate any suspicious indication for separately audible confirmation of a target's presence. The listening channel is in effect a highly efficient searchlight type equipment independent of the visual channel.

In effect, we have the old searchlight type rotating at a speed impossible to obtain by mechanical methods, thus giving a far greater coverage rate for search, the ability to detect one or more submarines almost simultaneously, and the ability to maintain a contact in a degree of performance never previously obtained.

Certain comparisons of the pre-war and war searchlight-type equipment against the scanning type are enlightening. The pre-war equipment without domes became inoperative at speeds of 10 to 14 knots. The addition of domes and minor improvements, mentioned previously, allowed operating speeds up to 20 knots. The present scanning sonar has been operated successfully very close to 30 knots. This gain in itself is absolutely essential for use against present-day submarines.

Dependable ranges for the pre-war searchlight sonar were probably not much in excess of 1500 yards without domes. With the dome and other minor improvements, this range is extended to an average of approximately 2,000 yards. With the QHB scanning sonar, we have dependable ranges in excess of 2500 yards. In fact, numerous contacts are being reported in excess of 3500 yards. This gain again reflects what modern design and engineering can accomplish. In addition, the QHB is an excellent torpedo-detection device for all except slow-speed "fish."

We have in process several developments which offer and, in some cases, have produced experimentally very definite improvements both in the presentation, the ease of operation, the range and the bearing accuracy. In addition, accurate determination of the depth of the target is practically a reality.

In summary, we note that our future anti-submarine sonar must be able to effectively seek out and destroy a high-speed (20 knots submerged) deep-running (800 to 1500 feet) quiet submarine. In attacking this problem, the importance of continued research and applied research in the basic characteristics of the medium is necessary. Development and design of many supporting items go hand in hand to solve the problem. The present scanning development, in the event of an early conflict, offers sufficiently good equipment which at least will tip the scales in our favor.

This scanning development is now being successfully applied to pro-submarine equipment, to harbor-defense equipment, and is in the preliminary stages of being adapted for airborne equipment. The refinements, which the Sonar Design Branch has underway and planned, should result in a few years in our being able to meet any threat to the national security. Sonar will not win a war alone, but, without it, we are lost!

The Sonar Design Branch of the Design Division is vigorously pursuing all possible avenues of approach to the problem. We are proud to be able to say that promising progress is being made in all of the required fields of Naval activity, with greatest emphasis being placed on the anti-submarine requirements. Pro-submarine, harbor defense, navigational, and special devices follow in the order stated.

May I emphasize that in sonar we have the only present usable known means for self-protection against existing fast enemy submarines and for submarines of our own, which can overcome the limitations imposed by Mother Nature in her oceans.

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THE USS MISSISSIPPI (EAG-128) . . . . . .
. . . . . . ITS FUNCTION WITH THE FLEET

The U.S.S. MISSISSIPPI *after conversion at Norfolk Naval Shipyard from BB–41 to EAG–128.*

The *USS Mississippi* (EAG-128) has an interesting function relative to the Fleet. Her aim is to advance the art for Navy electronic and ordnance equipment. The purpose of this article is to show, in a small measure, how she accomplishes this aim.

This ship, while under the administrative control of Commander Battleships and Cruisers, Atlantic, is under the operational control of Commander Operational Development Force. It might be in order to point out briefly the function of the Operational Development Force and then show how the *Old Miss* fits in with this function.

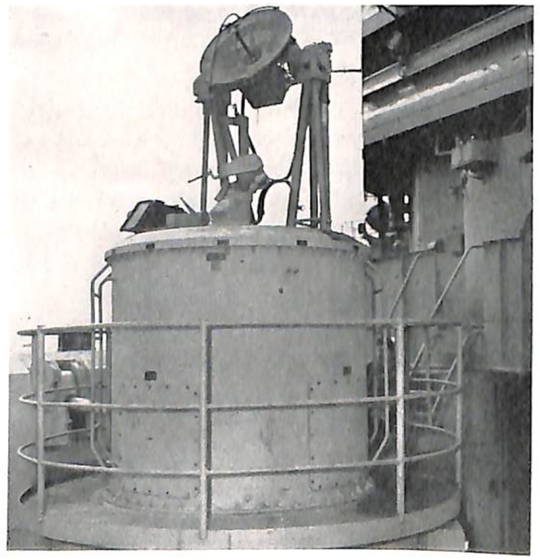
The force is under the operational control of the Chief of Naval Operations with Commander in Chief, U.S. Atlantic Fleet and Commander in Chief, U.S. Pacific Fleet exercising administrative control and providing logistic support to the units of Operational Development Force operating in the Atlantic and Pacific.

The mission of the Operational Development Force is to evaluate by operational test new weapons, equipment and methods of warfare to determine more effective uses of standard equipment and weapons currently installed in the Fleet, and to recommend training procedures, countermeasures and changes in tactical doctrine incident to new weapons and equipment or improved methods of use.

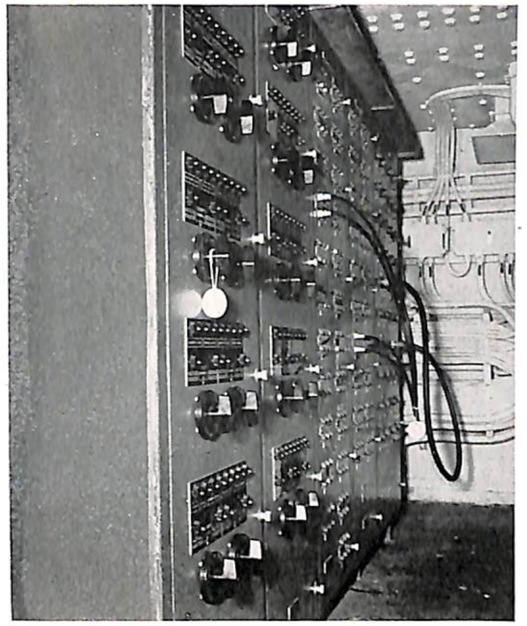
The tasks assigned to the Operational Development Force include all conceivable phases of warfare. To accomplish these tasks a great variety of types of ships and aircraft comprise the Force.

The *USS Mississippi* (EAG-128)—E for experimental, AG for miscellaneous auxiliary—is assigned duties in the Heavy Surface Division under the Surface Development Detachment. This ship is an experimental gunnery development ship but is also assigned RCM, radar, target designation, and C.I.C. projects. She is actually a test and development ship rather than a training ship. ComOpDevFor assigns the various projects to this ship and specifies the procedures and test methods to be followed. An officer from the staff is usually sent with the ship as a technical observer in the evaluation and testing of new equipments. The ship in accomplishing these assignments is looking for the answers to the following typical questions:

1—Does the equipment perform in accordance with operational requirements?



Mk61 G.F.C.S. installed in EAG–128.



Special switchboard manufactured by NNSY for target designation system on EAG–128.

2—What are the performance capabilities of the equipment?

3—Is an equipment too complicated to be repaired by shipboard technicians?

In obtaining the answers to these questions the EAG-128 also obtains other information which is useful and valuable to the fleet. Some typical examples follow:

1—Maximum and minimum ranges of radars on different types of targets.

2—Check for normal operation of various equipments.

3—Check how fire-control radars stand up and find what to expect under actual firing conditions at sea from various equipment against various types of targets.

4—Check of cost to maintain equipments.

5—Recommend improvements in operation and design for best possible use of equipments.

To accomplish these assignments the *Mississippi* usually goes to sea for a period operating in the Atlantic Fleet operation area off the capes where the ship undergoes gunnery exercises and conducts projects. There are various projects going on at the same time. Some typical ones are as follows:

1—Evaluation of the Mk 25 Mod 2 fire control radar.

2—Evaluation of the VK as a remote indicator.

3—Evaluation of the VK as a possible replacement for the VE in the A.E.W. search radar system.

4—Evaluation of C.I.C. operation in tracking jet aircraft.

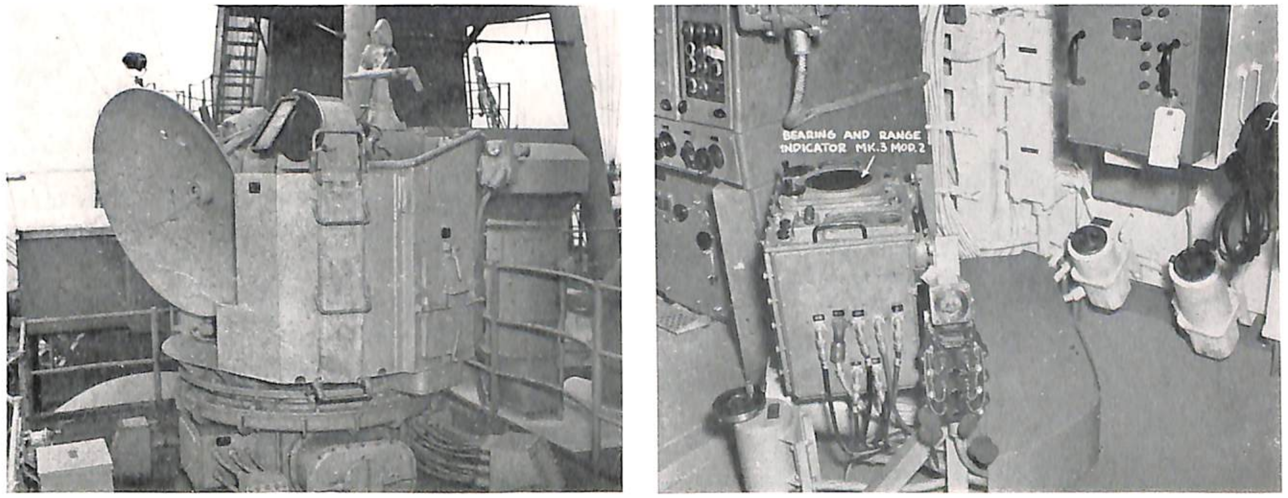
5—Evaluation of the Mk 61 G.F.C.S. including the Mk 47 fire control radar.

6—Evaluation of various gun fire control systems against various types of targets such as drones, sleeves, conventional and jet aircraft.

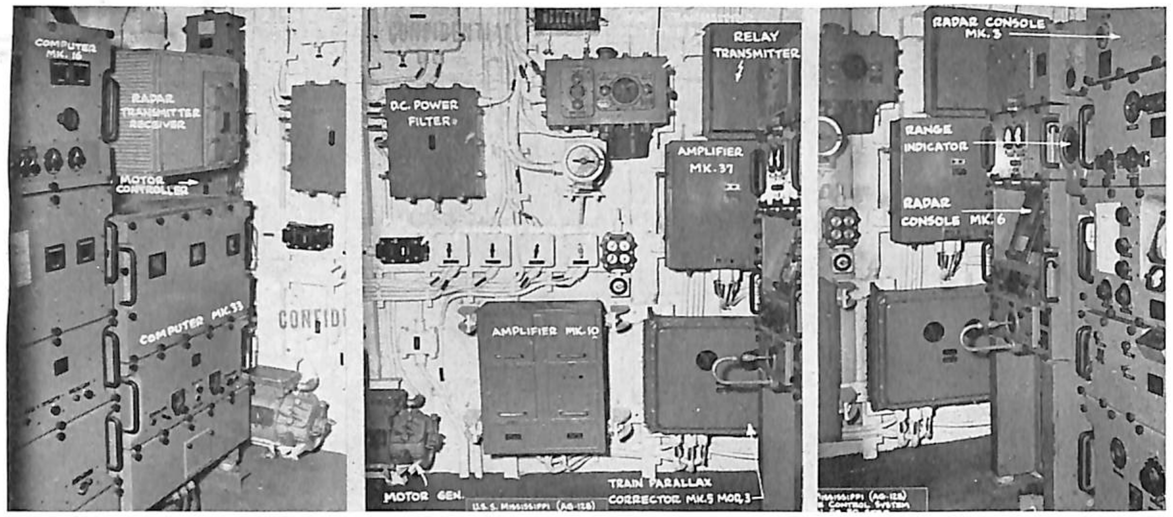
To accomplish these various projects the *Mississippi* has a typical BB allowance of equipment with some exceptions.

Her communication and countermeasure installation is typical of that of a BB. Her radar installation includes the normal BB complement of remote PPI's; SX, SR-3, SG-6, SG-1B, and PO search radars; Mk 25/2, Mk 34/2, Mk 35, Mk 39/3, and Mk 47 fire control radars; and Mk 11/1 T.D.T. and Mk 3/2 B.R.I. for her target designation system. Her guns include three 5″/38 twin mounts controlled by Mk 63 G.F.C.S.; two 5″/54 single mounts controlled by Mk 37 or Mk 57 G.F.C.S. The Mk 61 G.F.C.S. can also be shifted in plot to control the 5″/54 or 5″/38 mounts.

The installation of equipments on this ship is not usually the normal shipboard installation. Installations are usually accomplished for some definite experimental purpose.



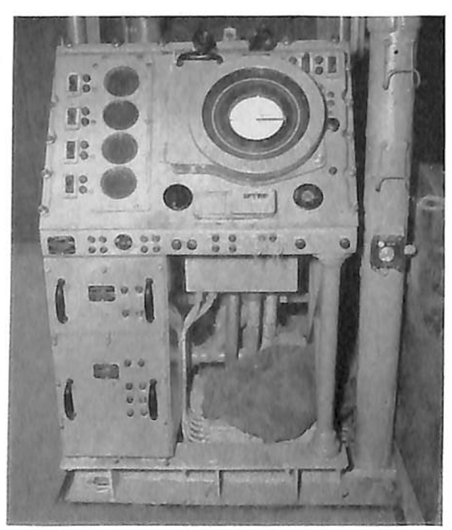
Mk56 G.F.C.S. installed in EAG–128.



Mk39 installation on the EAG–128.

In addition to her assignments of evaluating electronic and ordnance equipment she may be called on by ComOpDevFor to evaluate various other types of equipment such as mattresses and life rafts. She also assists other ships in the OpDevFor Task Force in accom-projects. From time to time, she indoctrinates personnel from various ships who send parties out with the *Mississippi* to become familiar with new equipments.

Her function is well worth while. Because of her tests several electronic items have been accepted, rejected, or changed. Her purpose is to improve the Navy by saving money in operation and maintenance of equipment, indicate improvements in equipments, advance the art, and increase the value of personnel. The results this ship obtains in her tests are passed on to the fleet through ComOpDevFor reports.



Mk11 Model 1 TDT located in CIC.

The target designation system in the *Mississippi* is a typical experimental installation for this ship. This installation and a similar one that is installed in the *Macon* are the latest types produced for designating targets to fire control systems. These designation systems are being evaluated in comparison with verbal designation over sound powered telephones and with optical designation.

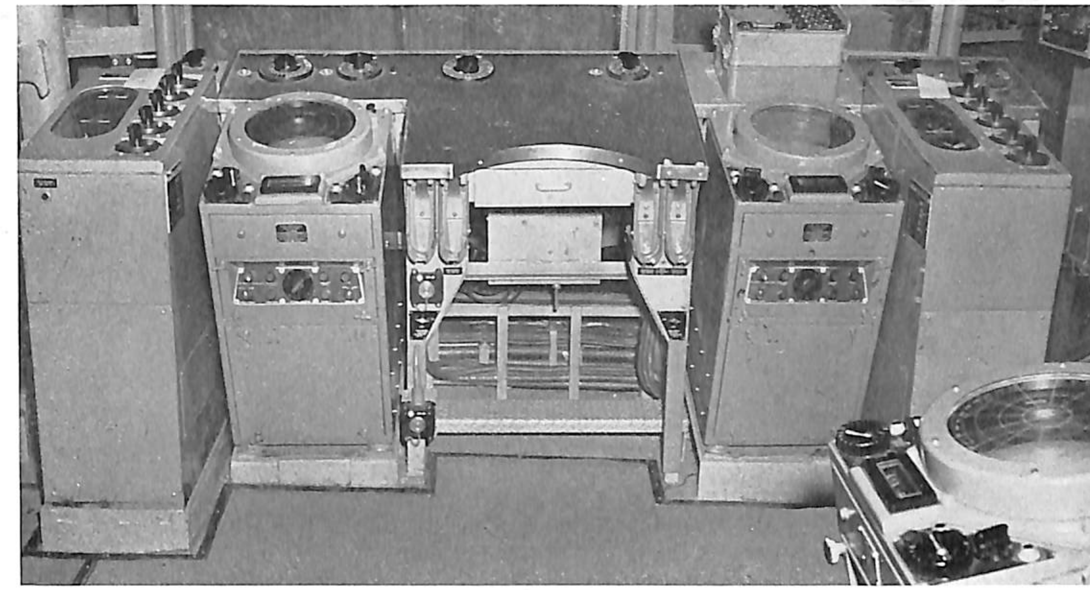
The cycle of designation using this system consists of three steps:

1—The target to be designated and the fire control system to which it is to be assigned are selected by the primary designator and designation information is transmitted.

2—The Bearing and Range Indicator Mark 3 Mod 2 (for each director) acquires the designated target on its P.P.I. scope by manually matching designated range and bearing, then releases the primary designator, and transmits designation to its respective director.

3—The fire control director acquires the target by matching the designated range and bearing from the primary designator or the B.R.I.

The last two steps occur simultaneously and the second step may be omitted entirely since the synchro designation information can be transmitted to the director through the B.R.I., without any attempt being made by the B.R.I. operator to match the designation. Except in rare cases, the B.R.I. acquires the target considerably in advance of the fire control system. Since designation can be sent to the director from the B.R.I. directly once it has acquired the proper target and the primary designator consequently left free to designate targets, the system is capable of designating more targets through the use of the B.R.I. than through its omission.



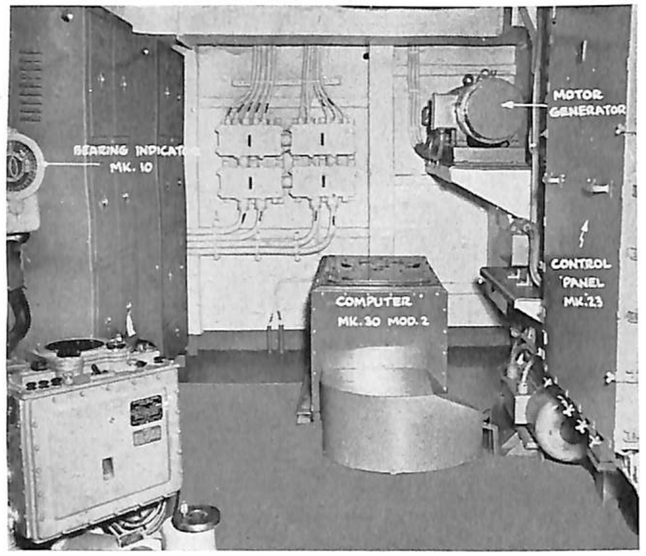
Type C and Type D target-designation panels with remote PPI's located in CIC.

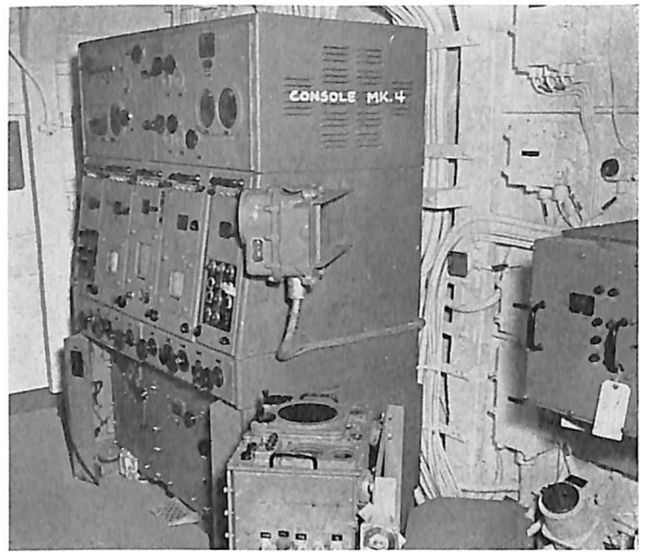
The primary designators are of two types. One is the Target Designation Transmitter Mark 11 Mod. 1. Three of these units are installed in the *Mississippi,* one in C.I.C. and one each in the antiaircraft plotting rooms. The other type of primary designator is the P.D. panel Types C and D in conjunction with a remote P.P.I. There are two of these units in the *Mississippi:* a Type C P.D. panel with a VJ repeater and a Type D P.D. panel with a VK repeater both installed in C.I.C.

The Target Designation Transmitter Mark 11 Mod 1, or T.D.T., is a production type instrument that was developed under the auspices of the Bureau of Ordnance. The instrument requires one operator. By the use of toggle switches on the left side and upper right hand corner of the instrument, the operator selects the director which is to receive designation. He then transmits the desired information by placing a hand-controlled bearing cursor on the target pip, which is shown on a seven-inch P.P.I. scope. Own ship's course is removed in the instrument and the designated bearing goes to the director as relative bearing. Range is transmitted as range in yards. A "designate" button in the center of the bearing cursor is used to indicate to the director when correct designation is being transmitted. There are four director repeat-back dials on the designator which enable the designator operator or the Gunnery Liaison Officer to ascertain if the directors are on the proper target. Two indicator lights are immediately adjacent to each of the toggle switches. The upper light glows when designation is being received in the director from the T.D.T. The lower light glows when the T.D.T. has been released by the B.R.I. and designation is being given by the B.R.I. or, if no B.R.I. is installed, when the director is on the designated target and no longer requires designation information.

The operation of the P.D. panel with either the VJ or VK is similar to that of the T.D.T. with the exception of the switching arrangement. Rotary switches instead of toggle switches are used for selecting the stations to which designation is sent. Some switches have four positions, offering a choice between two directors both simultaneously, or off. Others, which repeat back director train, have only three positions, the "both" position being eliminated. The reason for eliminating this position is that only two director repeat back dials are provided and selection for the director repeat back dials is accomplished by the designation selector switches. The P.D. panel system was developed under the auspices of the Bureau of Ships.

As mentioned previously the primary difference between the *Mississippi* target designation system and previous systems is incorporation of the intermediate step, the Bearing and Range Indicator. One of these instruments is provided for each director in the designation system. The B.R.I. for the Mark 37 director is inside the director shield, those for the Mark 56, Mark 57 and Mark 63 systems are in the director control rooms. One operator is required for the instrument. Designation from the primary designator is received by the B.R.I. and through the B.R.I. by the director. While the director crew is matching their designated bearing and range and attempting to acquire the target the B.R.I. operator matches the designated range and bearing on his instrument. When they are properly matched, a hand-controlled bearing cursor and a hand-controlled electronic range ring intersect over the target pip which is shown on a five-inch P.P.I. scope that can throw a switch on his instrument which releases the primary





Mk56 G.F.C.S. installed in EAG–128.

designator and give designation to the director directly from the B.R.I. by keeping his bearing cursor and range ring on the target pip. The synchro designation signals to the director from the primary designation are unaffected by the position of the B.R.I. bearing and range before the release switch is thrown and consequently this instrument can be completely bypassed.

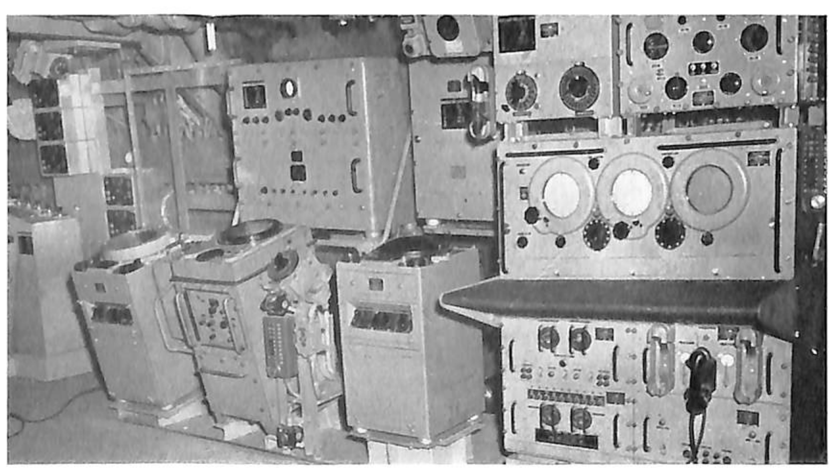
The T.A.U.'s for the Mark 57 and Mark 63 systems are incorporated in the target designation system by means of special wiring which causes the director pointer's designation spot to move directly as a result of the designation without any manipulation by the T.A.U. operator.

A special switchboard is installed as a part of the system to provide complete flexibility in the choice of designation instruments in order to facilitate experimental evaluation of the various components of the target designation system.

The *Mississippi* was converted from the BB–41 to the EAG–128 by the Norfolk Naval Shipyard. This conversion took over one year to accomplish and was completed in 1947. There were many problems to be solved in this conversion. Numerous conferences with representatives of BuShips, BuOrd, ComOpDevFor, and the shipyard were held to iron out these problems.

The conversion resulted in the installation of a new radar, target designation, countermeasure, and gunnery system. New control rooms, office spaces, and work shops were provided. A separate power plant for electronics was installed. New cabling was installed virtually throughout the ship. This conversion was a vast undertaking.

The *Mississippi* provides the shipyard with some interesting work. The installation of the new equipments she evaluates are usually the first of its type. These installations usually are accomplished aboard this ship for the express purpose of evaluation and may or may not be normal shipboard installation. The specifications for their installation are furnished to the shipyard by ComOpDevFor.



PO(AEW) and SX console located in CIC.

THE MODEL 28 TELETYPEWRITER

The Model 28 Teletypewriter which has been under development for almost 10 years is gradually nearing completion. During this period, various and sundry mechanical contrivances have been assembled and given lengthy operating tests only to be abandoned for some further improvements. One machine which came about as a result of this developmental work, however, is the Model 31 Tape Printer which is now used in Naval aircraft and is described in the February 1947 Electron.

The Teletype Corporation has been thoroughly schooled by the Navy in regard to the great need for reduction of weight and space for shipboard equipment. Very little has been or can be done to reduce the size of a teletypewriter due to several pertinent requirements; namely, the width of standard paper, adequate key spacing, and proper keyboard height for operation. It is readily admitted that if these requirements could be overlooked the entire machine could be reduced to a box approximately six inches square. Nevertheless, the overall dimensions have been reduced 3″ in depth and height, and the necessary features still retained.

Weight reduction has fared somewhat better. Aluminum has replaced much of the steel and cast iron parts previously used except where hard surfaces are required, and several hundred parts have been eliminated. These changes bring the total weight of the Model 28 including the console to approximately 40 per cent of the weight of the standard Model 15 previously provided to ships.

The development of the Model 28 has not been easy and, as pointed out in the first paragraph, was not accomplished overnight. The new printer is an entirely different machine with no parts or adjustments common to the Model 15. (Teletype technicians take note!) About the only features of the two machines which are similar are that they use the same teletype code, the same size paper, they both have a keyboard, and both are motor driven.

It is not the intent of this article to go into the technical details of the Model 28, but it is believed that a brief description of the principal differences will be of interest to individuals concerned with teletypewriter equipment.

The most radical change in the Model 28 Teletypewriter is the method of typing. Instead of a bulky type basket weighing 5¾ pounds with code bars, pull bars, type bars, bell cranks, etc., the Model 28 has a simple little type box weighing approximately 2 ounces and measuring about 1″ x 2″.

The type box contains 51 pallets, is divided into two sections, letters and figures, and for each section there is a neutral position.

For purposes of explaining the movement of the type box, assume that the hammer is fixed for its hammering action.

In figure 1, the type box is shown in the "letters neutral" position. When any particular letter character is selected, the type box is positioned horizontally and vertically so that the selected pallet is directly behind the hammer. This action takes place on the first half of the operating cycle. On the second half of the cycle,

	4TH ROW	3RD ROW	2ND ROW	1ST ROW	1ST ROW	2ND ROW	3RD ROW	4TH ROW	4TH ROW	3RD ROW	2ND ROW	1ST ROW	1ST ROW	2ND ROW	3RD ROW	4TH ROW	
TOP ROW	M --345	N --34-	H --3-5	SPACE --3--	BLANK -----	T ----5	C.R. ---4-	O ---45	. PERIOD --345	7/8 --34-	# --3-5	SPACE --3--	BLANK -----	5 ----5	C.R. ---4-	9 ---45	TOP ROW
2ND ROW	X 1-345	F 1-34-	Y 1-3-5	S 1-3--	E 1----	Z 1---5	D 1--4-	B 1--45	/ 1-345	! 1-34-	6 1-3-5	BELL 1-3--	3 1----	" 1---5	$ 1--4-	? 1--45	2ND ROW
3RD ROW	V -2345	C -234-	P -23-5	I -23--	L.F. -2---	L -2--5	R -2-4-	G -2-45	; -2345	: -234-	O -23-5	8 -23--	L.F. -2---	) -2--5	4 -2-4-	& -2-45	3RD ROW
BOTTOM ROW	LETTERS 12345	K 1234-	Q 123-5	U 123--	A 12---	W 12--5	J 12-4-	FIGURES 12-45	LETTERS 12345	(1234-	1 123-5	7 123--	— 12---	2 12--5	' 12-4-	FIGURES 12-45	BOTTOM ROW

LETTERS - FIGURES -

FIGURE 1—*Type box of Model 28 Teletypewriter, in the "letters neutral" position.*

the hammer hits the pallet and the type box is returned to the neutral position. There are two good reasons for having the type box return to the neutral position after each character is printed. First, it allows the operator to see what is being printed, and second, it eliminates the necessity for the type box to move more than four spaces horizontally during the positioning cycle or more than nine spaces during the shifting cycle.

When the figures code combination is received by the selector mechanism (note that #3 impulse determines whether the type box moves to the left or right) the type box moves nine spaces to the left or to the "figures neutral" position. This action is equivalent in length to the positioning of the type box, printing a character and return to neutral position. In addition to the movement described above, the type box and hammer simultaneously move across the platen, space by space, as characters are printed. The spacing cycle is concurrent with the return of the type box to a neutral position.

The printer is designed to operate at a normal speed of 100 words per minute with provisions, by a change of gears, for 60 words per minute and eventually up to 150 words per minute. At 100 words per minute, printing action appears to be effortless. Power required for operation of the motor is approximately one third of that required for the Model 15 resulting in the motor being greatly reduced in size. The speed of the motors, both synchronous and a-c governed, has been increased to 3600 r.p.m. thus allowing the same gears to be used for both types.

The keyboard unit has also been completely redesigned. In the Model 15, when a key is depressed, the selector bars are positioned which control the transmitting contacts through a series of levers. In the Model 28, the function of the key lever is somewhat different. It starts the transmitting mechanism operating similar to the universal bar in the Model 15 and acts as a stop for the selector bars which are mechanically driven. One desirable feature of this system is that as soon as the mechanism starts operating for one character, another key may be depressed and the code combination stored until the next cycle of operation. This system allows more flexibility on the part of the operator, as typing need not be as rhythmical as for the Model 15. Also, less key pressure is required which, since the number of selector bars has been increased, is most desirable.

In lieu of the six pairs of contacts as in the Model 15, five for the code combination and one for start-stop, the Model 28 has only two sets. One set is required for neutral operation but both sets are required for polar. Inasmuch as all shipboard radioteletype equipment is wired for neutral operation, one pair of contacts of the Model 28 replaces the six in the Model 15 thus effecting a considerable saving of parts.

This brief article would become a lengthy volume if each of the remaining changes or "different" features were described in detail but it is believed that the following list of a few of the advantages over the Model 15 will prove interesting:

CHARACTERS L.C.	U.C.	CODE SIGNALS START	1	2	3	4	5	STOP
A	–		■	■				■
B	?		■			■	■	■
C	:			■	■	■		■
D	$		■			■		■
E	3		■					■
F	!		■		■	■		■
G	&			■		■	■	■
H	£				■		■	■
I	8			■	■			■
J	'		■	■		■		■
K	(		■	■	■	■		■
L	)			■			■	■
M	.				■	■	■	■
N	,				■	■		■
O	9					■	■	■
P	0			■	■		■	■
Q	1		■	■	■		■	■
R	4			■		■		■
S	BELL		■		■			■
T	5						■	■
U	7		■	■	■			■
V	;			■	■	■	■	■
W	2		■	■			■	■
X	/		■		■	■	■	■
Y	6		■		■		■	■
Z	"		■				■	■
SPACE					■			■
CAR RET.						■		■
LINE FEED				■				■
FIGURES			■	■		■	■	■
LETTERS			■	■	■	■	■	■

SIGNAL LENGTHS IN ms STANDARD SPEED

	START	1	2	3	4	5	STOP
40 SPEED	33	33	33	33	33	33	47
60 SPEED	22	22	22	22	22	22	31
75 SPEED	18	18	18	18	18	18	25

The standard Teletypewriter Code, used by the Model 28 Teletypewriter.

1—A "paper feed-out" key instead of a platen crank or handwheel.

2—Provisions for many additional functions by means of a stunt box in place of individual function levers.

3—Much less maintenance is expected because of less driving torque required, several hundred less moving parts, fewer adjustments, improved hardening of wearing surfaces and replacement of many sleeve bearings with ball bearings.

4—Improved shock resistance through the use of additional mounts of a new design.

5—Operation is unaffected by inclination. It will operate satisfactorily in any position and even inverted. (We hope this last condition will not occur frequently in ships.)

6—Easily replaceable type sets—the type box may be removed and replaced in a matter of seconds in case of battered type or for other reasons.

7—Each printer is equipped for both friction and sprocket feed of paper without the need for making any changes or adjustments.

8—The selector magnets are designed to operate on 20 ma with provisions for 60-ma operation.

9—Higher operating speed, up to 150 words per minute.

10—A simplified new console cabinet reduced noise to approximately 25 per cent of that of the Model 15. The angle of the view glass is such that there is no reflection from overhead lighting.

11—Identical speeds for both synchronous and governed motors.

12—Lighter weight—78 pounds compared with 199 pounds for the Model 15.

13—Smaller size—20"w x 19"d x 40"h against the 20"w x 22"d x 43"h for the Model 15.

As stated above, development of the Model 28 has been going on for about 10 years and is now rapidly nearing completion. After this, approximately 20 months will be required for tooling up and removing the bugs from the preproduction models before full-scale production can begin. It appears now, therefore, that installation of the Model 28 teletypewriter in ships cannot be expected before June 1950.

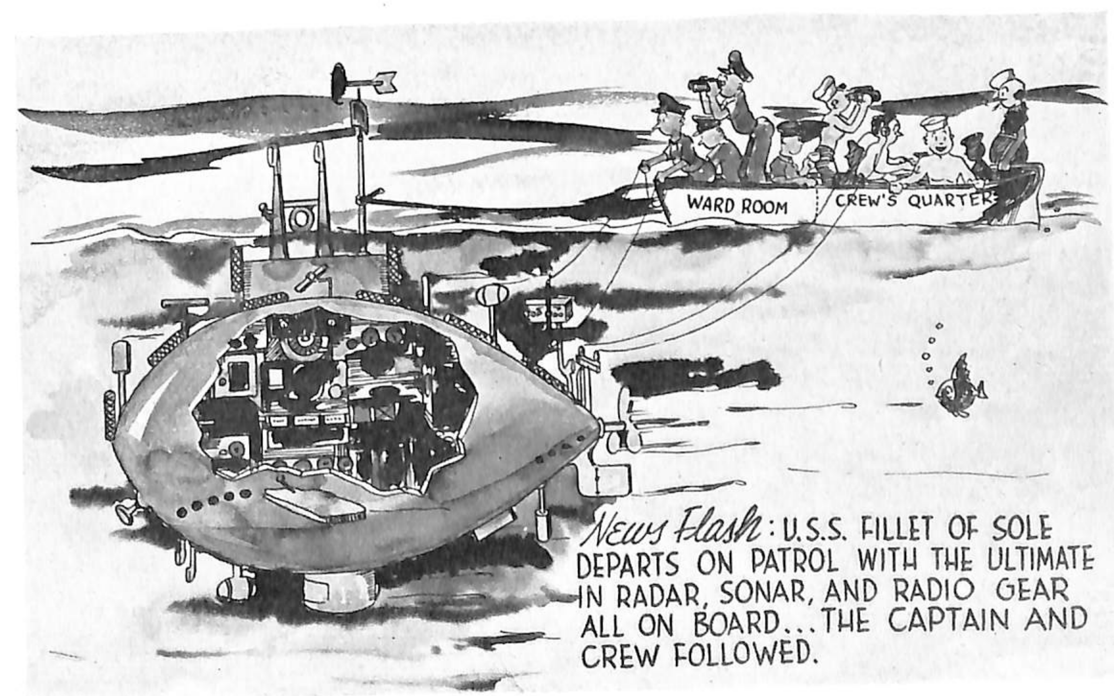
RADIAC . . . .

It was intended that this issue of BuShips Electron carry a comprehensive story on the Navy's new radiac equipment and a good deal of background material on the story of the atomic bomb and the subject of nuclear physics in general.

Editorial schedules, however, and certain difficulties encountered beyond the control of the Bureau, have made it impossible to carry out the original plan. Moreover, a great clamor has arisen from many persons and activities who have learned of the story and who want extra copies of "that issue of the magazine." These things make it desirable to publish the story as a separate unit.

Accordingly, instead of including the story in this issue of Electron as planned, the Bureau now intends to bring out the story as a special issue. The title is, The ET Looks at Radiac; the short title is NavShips 900,146.

When this issue of Electron is available it will get wide initial distribution. Most activities now receiving Electron will receive at least one copy. Other activities may obtain copies by writing to the nearest Publications Distribution Center.



FIRE CONTROL RADAR PUBLICATIONS

In the past, in accordance with a division of responsibilities agreed upon by the respective bureaus, the issuance of publications on fire control radar equipment has been divided between the Bureau of Ships and the Bureau of Ordnance. Specifications have been prepared and issued by the Bureau of Ships. Instruction books covering installation, operation and maintenance, and maintenance prints have been issued as Bureau of Ships publications. Publications on operation and tactical use have been issued as Ordnance Pamphlets.

The responsibility for fire control radar equipment has now been assigned in its entirety to the Bureau of Ordnance. All future publications and specifications will bear Ordnance designations and will be issued by Ordnance activities.

Publications that are available on each of the equipments in the active fleet are tabulated in the accompanying table. The specifications are listed to make the record complete and will be of interest primarily to design and procurement agencies. Two copies each of instruction books and maintenance prints were originally supplied with each equipment.

If additional copies are desired by repair and service activities, copies of Ordnance Pamphlets may be obtained from the nearest Publications Supply Depot, or from the Bureau of Ordnance, Navy Department, Washington 25, D. C. Copies of instruction books and maintenance prints bearing Ships or Navships numbers may be obtained from the nearest Publications Supply Depot, or from the Bureau of Ships, Navy Department, Washington 25, D. C. Copies of the equipment specifications may be obtained from the Fire Control Radar Section, Bureau of Ordnance, Navy Department, Washington 25, D. C.

Equipment	OP	Instruction book	Maintenance prints	Equipment Specification
Mk 8 Mod 1	OP 658	Ships 223	NavShips 900, 300-IB	RE 9271A
Mk 8 Mod 2	OP 658	Ships 265	NavShips 900, 301-IB	RE 13A 950A
Mk 8 Mod 3	OP 1298	Ships 325	NavShips 900, 364-IB	RE 13A 1034A
Mk 10 Mod 5	OP 1005	Ships 224		
Mk 12 Mod 0	OP 1076		NavShips 900, 302-IB	RE 13A 653A
Mk 12 Mod 1		Ships 270A	NavShips 900, 360-IB	RE 13A 653A
Mk 13 Mod 0	OP 1297	Ships 327	NavShips 900, 365	RE 13A 675C
Mk 22 Mod 0	OP 1153	(Ships 252A (Ships 252A-1	NavShips 900, 303-IB	RE 13A 784A
Mk 22 Mod 1		NavShips 900, 850	NavShips 900, 930	RE 13A 784A, CS-57, & CS-73
Mk 25 Mod 2	OP 1651 (Under preparation)	NavShips 900, 975	OD 6657	CS-420
Mk 26 Mods 3 & 4	OP 1154	Ships 250 (IB) Ships 349 (HMI)	NavShips 900, 316-IB	
Mk 27	OP 1155	Ships 315	NavShips 900, 304-IB	RE 13A 806A
Mk 28 Mod 0	OP 1156	Ships 274	NavShips 900-305-IB	RE 13A 846A
Mk 28 Mod 2	OP 1238	Ships 297	NavShips 900, 361-IB	CS-279
Mk 28 Mod 3	OP 1156	Ships 274	NavShips 900, 638	RE 13A 846A
Mk 32 Mod 1	OP 1300	Ships 350		RE 9563A
Mk 34 Mod 2	OP 1513	Ships 358	NavShips 900, 366	CS-146
Mk 34 Mods 3 & 4	OP 1301	NavShips 900, 883	NavShips 900, 363	CS-83 & CS-84
Mk 35	OP 1600 A			CS-331
Mk 39 Mod 3	OP 1514 OP 1748 (Under preparation)			

Sonar

POSES A CHALLENGE

With the advent of the new submarine, we are faced with a new challenge to our abilities and ingenuities. These new submarines are able to stay submerged for weeks, or months, and to cruise while submerged faster than many surface vessels. Combining these features with the fast, hard-hitting, target-seeking torpedoes with which they may be fitted, these submarines are a menace to any surface fleet they encounter.

Our defense against such submarines starts with the equipment used to detect them. Sonar is this equipment, for only with sonar can we detect them through the water.

Sonar equipment is no longer the relatively simple device of a few years ago; it is now an entire system with many complex circuits and techniques. And although it has never been "glamorized" as much as other types of equipment, sonar is now equally as important as any other, and in the future may well become even more important than it is now. Our effective use of sonar will be a major item in our control of supply lines in another war; certainly, sonar will be of vital importance to the Nation's defense.

We are challenged to keep advancing the state of this art. All of us, whether officer, enlisted man, or civilian engineer, must respond. The technician responds by mastering the technical features of his equipment so he can put his finger on any trouble without loss of valuable time. The operator responds by improving his perception and co-ordination and mastering the proper techniques for efficient operation of his equipment. Officers and civilian engineers respond by exerting even greater effort in devising new and better techniques and producing better equipment. Through our conscientious and applied efforts, all of us can improve the Navy's potential hitting power.

Confidential ? YES..

. . . . but it should be read, anyway. Before you lock it up, you should pass this copy of ELECTRON to all concerned persons as provided in Navy Regulations.