CONFIDENTIAL

BUSHIPS

Electron

JULY 1949

NavShips 900,100

BUSHIPS Electron

A MONTHLY MAGAZINE FOR ELECTRONICS TECHNICIANS

JULY · VOLUME 5 · NUMBER 1

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-b)
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.

BUREAU OF SHIPS — NAVY DEPARTMENT

NAVAL COMMUNICATION STATION AT WHEELER MOUNTAIN, WASHINGTON

by
C. E. Williams *and* V. C. Marsolan,
Electronics Engineers, Puget Sound Naval Shipyard

The establishment of a primary v-l-f transmitting station to afford maximum coverage in North Pacific and Alaskan areas has been under consideration by CNO for several years. Upon receipt of CNO authority, the Bureau of Ships, in August 1946, directed that Commander, Puget Sound Naval Shipyard proceed with surveys for determination of the most suitable and practicable site in the Pacific Northwest. A preliminary survey of Alaskan areas showed that construction and maintenance costs for such a radio station in that area would be excessive, that transportation of materials and fuel would be difficult and involved and that full-time operation could not be depended upon.

The projected station is to be established primarily for v-l-f "FOX" broadcasts on frequencies between 14.5 and 26.2 kc, using either dual 500-kw units for independent or simultaneous operation on separate antenna halves, or with maximum power of 1000 kw. The basic requirements for the siting of such an installation are as follows:

1—Reliability of communication and control circuits to district headquarters.

2—Accessibility to highways for logistic support and the availability of primary power sources.

3—Sufficient area in a valley between mountains to permit erection of 10 catenary spans 6000 to 8000 feet in length (at maximum heights) across the valley and to construct the transmitter and helix buildings.

4—Effective radiation of high power from the catenary spans at the specified frequencies.

5—Availability of land and economy of construction.

6—Location distant from centers of population, to avoid radio interference with other services.

7—Suitability of site for underground construction if eventually required.

A survey of the Northwest was carried on in the fall of 1946 for the selection of a site which would meet the above requirements. Within a radius of 100 miles of the district headquarters in Seattle there are more than 100 valleys with sufficient depth to accommodate the catenary antenna system, but of these, less than half could meet the requirements of accessibility to highways and primary power sources. Detailed surveys were made at about forty tentative sites and, after evaluating the merits and demerits of these, it appeared that the Wheeler Mountain site would be the most satisfactory; this site was so recommended by Commander, Puget Sound Naval Shipyard, to the Bureau of Ships. Representatives from the Bureau visited the proposed site in March 1947 and were pleased with the site's possibilities. Following endorsement of the proposed site by the Bureau of Ships, CNO approved the location subject to confirmation of the electrical properties of the area by suitable tests.

The Wheeler Mountain site is located in the foothills of the Cascade Range, approximately 50 miles airline from Seattle and 11 miles from Arlington, the nearest town. The area map, figure 1, shows the Puget Sound basin, the location of cities, towns, highways and the Wheeler Mountain area. The transmission path from the Wheeler Mountain site to seaward traverses 20 miles of lowlands to salt water and thence to sea over Puget Sound, the Straits of Juan de Fuca or the Straits of Georgia. A minimum area of 7000 acres is required to accommodate the installation and associated facilities.

The chief feature of the site is the valley cross-section and mountain slopes which permit erection of the catenary antenna between north anchorages on Wheeler

FIGURE 1—Navy Communication Station at Wheeler Mt., and proposed v-h-f/u-h-f communication links.

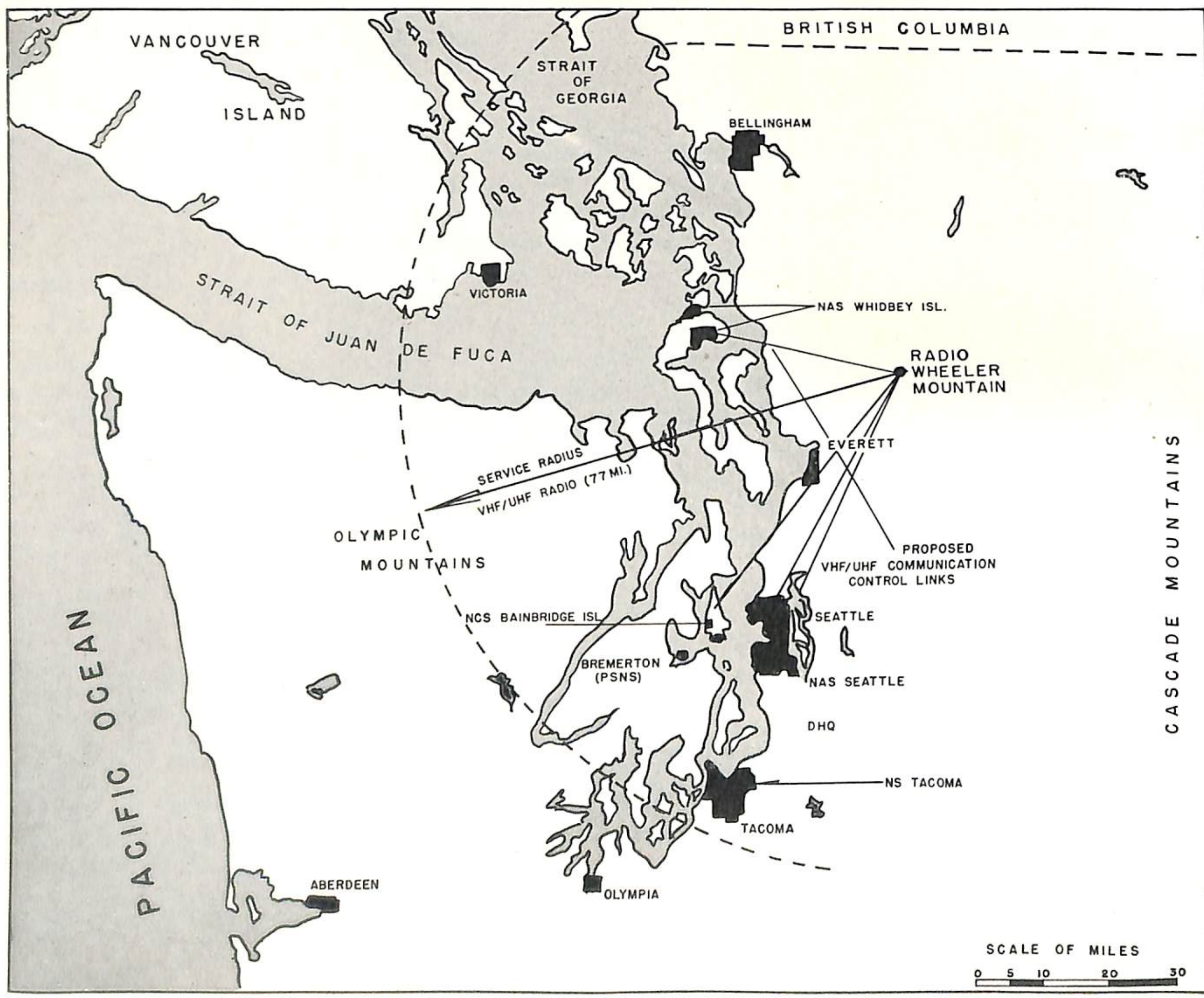


FIGURE 2—Jim Creek Valley, with Wheeler Mt. on left and Blue Mt. on right.

Mountain at elevations averaging 2788 feet above sea level, and south anchorages on Blue Mountain at average elevations of 2626 feet; Jim Creek in the valley is at an average elevation of 735 feet. This results in a mean difference between valley floor and anchorage sites of 1972 feet and, by use of 200-foot towers to be erected at each anchorage, the average height will be increased to 2172 feet.

Figure 2 shows the valley antenna area, with Wheeler Mountain at the left and Blue Mountain in the right foreground. The antenna area is generally clear of merchantable timber, having been partially logged off on the Blue Mountain side and on the lower portions of Wheeler Mountain, and burned off at the upper elevations. In order to prepare the antenna area for erection of antenna spans and the installation of a buried ground system considerable clearing of underbrush and vegetation will be necessary, as well as removal of debris and fallen timber which would be a fire hazard. A typical logged off area, such as prevails on Blue Mountain, is illustrated in figure 3.

Figure 4 shows the face of Wheeler Mountain. The six northern anchorages will be located just above the upper patches of exposed rock and within the present timber. Adequate foundation for all towers and structures is insured by underlying rock which is close to the surface or is exposed in most locations.

An abundant water supply is available at all times from Jim Creek which flows through the site, from numerous smaller creeks and springs on the mountain sides, and two large lakes which serve as a reservoir and feed Cub Creek—a tributary of Jim Creek—which enters Jim Creek near the area to be used for residential and service buildings. The residential and service building areas will occupy approximately 100 acres of land immediately adjacent to the west end of the main valley. The ground in this area is partially cultivated, with some grazing land and the remainder covered with alders, maples and second growth fir, hemlock and cedar. Because of its setting in the foothills, with abundance of natural life, wooded areas, lakes, streams, and ample land for cultivation, yet within 30-minute travel time from Everett, a city of some 32,000 population, this station when completed, should prove to be very appealing to service personnel who enjoy outdoor life.

Very extensive and detailed surveys have been conducted to facilitate planning of the station in general, and in particular the antenna-ground system. Because of the lack of topographical survey data upon which to base the antenna span locations it was necessary to conduct a complete survey of all the valley area and at possible anchorage positions, involving about 2000 acres, most of which lie in heavily-wooded areas or on precipitous mountain slopes.

In order to determine the radio-electrical properties of the antenna site, a single wire antenna was erected at a typical span position, with a temporary ground system on the mountain slopes and in the valley. Following this, measurements were made of the antenna characteristics and of field intensities throughout the north-western part of Washington and out to sea through the Straits of Juan de Fuca. A more complete description of the test antenna, ground system and transmitter and the ground measurements follows.

Ground resistance measurements were conducted in the antenna area by the following methods:

1—By obtaining the value of resistance between each pair of driven rods (electrodes) spaced 100 feet apart and arranged in form of an equilateral triangle and computing the ground resistance from the formula $R_X = \frac{R_1 + R_2 + R_3}{2}$. Values of resistance were obtained with a ground megger and with a Navy Model OJ 1000-cycle bridge.

2—By use of a ground megger and four electrodes spaced 100 feet apart in a straight line. In this method the value of resistance obtained from the megger is proportional to the voltage drop between the two inner electrodes directly in the path of a current flowing between the two outer electrodes. From this data the ground resistivities in ohms-per-cubic-meter were computed.

3—By measuring directly the current and voltage in a 60-cycle alternating current circuit consisting of an a-c generator, step-up transformer and a pair of No. 6 bare copper wires 100 feet in length separated 10 feet and buried 20 inches deep.

In general, results of methods (1) and (2) were in agreement and in some instances were proportionate. For example, where a high ground resistivity was encountered there was also a high value of resistance between electrodes. Because of the inaccessibility along the mountain slopes only three tests employing the 60-cycle method were performed. Values of resistance obtained by this method varied from 100 ohms in the valley floor to 175 ohms along the mountain slopes. With the 4-rod ground electrode method, a resistance of 367 ohms per cubic meter was typical of the valley.

The location selected for the test transmitter was more than a mile from the nearest abandoned logging road in the valley; thus it was necessary to construct an access road and to clear and grade a small area for the mobile equipment, power units and temporary housing. Additionally, old logging roads were opened up and extended to the top of Blue Mountain, the south anchorage of the test span. A swath was cut in the timber across the valley between the two anchorages. A temporary road was cut to the 1250-foot level on Wheeler Mountain, from which point the antenna tail cable was hauled by hand to the 2700-foot level and secured. The antenna, comprised of a single span of No. 6 Copperweld (40%) wire, 4500 feet in length with a No. 10 harddrawn copper vertical downlead at mid-point, was assembled on the ground. Steel tail cables completed the remainder of the span which totaled 7520 feet. The antenna was then hauled into position

FIGURE 3—Blue Mt., looking up from the 1500-foot level and showing nature of the terrain and logged-off areas.

by using the winch on a bulldozer on Blue Mountain. At a working tension of 1500 pounds this afforded a "T" antenna with a physical height at the center of approximately 1500 feet.

Although the ground conductivity was fair, a ground system was installed for the test transmitter. It consisted of a grid of 10 bare copper wires extending approximately 3000 feet up each mountain slope beneath the test antenna and 5 similar wires extending 2500 feet up and down the floor of the valley along Jim Creek. Ground rods were driven at the ends of each conductor and at many points in the vicinity of the test transmitter.

At the test site two temporary cabins were assembled for shelter of mechanics and test personnel, and a Model MBS communication unit was brought in for maintenance of communications with the mobile units used for measurements of field intensities. The 200-watt v-l-f test transmitter was housed in a surplus trailer formerly used as an airfield portable control-communication unit. Power was obtained from either of two 5-kw power units. The facilities described are illustrated in the accompanying photograph, figure 7.

Two Model OG field intensity measuring units enclosed in light wooden structures on flat body trucks were driven to various points within range of the transmitter, where measurements were made on 15.0, 15.55, 19.4 and 28.0 kc. Additionally, one of the Model OG field intensity measuring units was removed from a truck and placed on board a seagoing tug for observing field in-

FIGURE 5—A typical winter scene at Jim Creek.

tensities down the Straits of Juan de Fuca and off the West Coast. Messrs R. H. Berkheimer and V. C. Marsolan, Electronics Engineers, supervised these operations.

The purposes of the field intensity measurements were to determine the effective heights and the radiation resistances of the test antenna at various frequencies and to secure information on signal attenuations resulting

FIGURE 4—Location of six northern anchorages and v-h-f site (indicated by arrow).

from the character of the surrounding terrain. Moderate attenuation of signal strength was experienced in the mountainous areas of the Cascade and Olympic Ranges, especially at the highest frequencies; in the other areas the attenuation was negligible. Typical values of effective height and radiation resistance of the test antenna derived from these measurements are as follows:

Freq. (kc)	*Effect. Hght. (meters)*	*Rad. Resist. (ohms)*
15.5	201	.173
19.4	205	.278
28.5	213	.622

Characteristics of the test antenna were measured with a Navy Model OH impedance bridge at frequencies of 25 to 75 kc. A General Radio Signal Generator, 0 to 40 kc, was employed in conjunction with a Model RAK-4 receiver as a detector and the decade box of the Model OH impedance bridge to measure characteristics of the antenna at the lower frequencies of 14.5 to 25 kc. The results of the latter method were substantiated by the direct substitution method of inserting resistance and reactance between the output of the test transmitter and the antenna.

Data obtained from field intensity observations and from the characteristics of the test antenna furnished essential information for the design of the final antenna and ground system by the contractor.

The plans presently being prepared by RCA Communications provide for an antenna system which will, in all probability, exceed in size any antenna previously constructed. It will consist of 10 catenary spans averaging 7550 feet in length, with a minimum length of 5640 feet and a maximum length of 8740 feet. The lengths of the active radiators in the flattop array will vary between 4000 and 5500 feet and the average separation between radiators in each of the 5-wire sections will be 360 feet. The separation between the antenna halves will be in the order of 800 feet.

The span conductors will be stranded cables; each conductor will be composed of 37 strands of No. 7 Copperweld, extra high strength (total diameter approximately one inch), insulated from steel tail cables by 2100-pound insulators. Although these spans have a calculated breaking strength of 89,000 pounds, sufficient sag will be allowed to maintain the working tension at or below 45,000 pounds when loaded with 1/2-inch of ice and a wind pressure of 8 lbs. per foot of projected area of span cables. The horizontal feeders from the transmitter to the terminals of the vertical downleads will consist of hollow conductor cables 0.920 inches in diameter. The feeders will be supported by 125-foot steel towers at the junction points of the vertical downleads. Additional antenna height will be gained by installation of 200-foot steel towers at anchorage positions.

The v-l-f transmitting equipment (figure 9) comprises a Type AN/FRT–3 high-power v-l-f dual 500/1000-kw radio transmitter incorporating the latest developments in electrical features and circuits which are especially designed by RCA-Victor Company to fulfill the military and technical requirements of the Naval service for a shore-based radio station. Two 500-kw radio-frequency sections are arranged symmetrically about the center line of a U-shaped equipment area to afford an unobstructed view of all indicating instruments, local controls, and equipment sections of the transmitter proper from the operator's supervisory console position.

The design of the transmitting enclosure features the latest developments in industrial styling. Each section compartment is totally enclosed in aluminum shielding, bolted to aluminum structural members. Electrical interconnections are enclosed in shielded metal raceways and terminated at appropriate terminal boards. A fabricated steel enclosure containing instruments, controls, observation windows and access doors provides an outer wall facing the operator's console. A color scheme based upon a harmonious combination of light and dark cobalt blue trimmed in stainless steel enhances the attractiveness of the entire transmitter.

FIGURE 6—Blue Mt. slope, showing standing timber that will be removed from the antenna area.

Units of the transmitter proper, the watch operator's supervisory console and the master frequency bay are located on the operating level or the main deck of the transmitter building. In the lower story directly below is the machinery area containing cooling equipments, power equipments and utility spaces. Unit assemblies such as rectifiers, exciters and high-power amplifier elements are designed as self-contained and self-supporting units of welded or formed sections supporting vertical chassis-type panels with surface mounted components. This method of construction, evolved from the broadcast transmitter field, provides great flexibility and ease of maintenance combined with minimum space requirements. Since this type of construction lends itself to modern production methods, considerable economy is realized.

Basically, the electrical features of the transmitter consist of duplicate oscillator units, each containing a simple master oscillator held in step with an extremely stable master frequency control system; F.S.K. with provision for a deviation of plus or minus 25 cycles is included. Following the oscillator stage is a duplicate exciter chain of untuned stages requiring no adjustment over the operating frequency range of 15 to 35 kc. These stages drive either or both power amplifiers through a driver transformer system which requires no adjustment.

The duplicate 500-kw power amplifiers are driven by either of the duplicate exciters to maintain correct in-step phasing of the output currents. Each power amplifier consists of an untuned grid filter-network, bias supply, two water cooled tubes in push-pull, and a plate tank circuit having individual variometers and a balanced bank of fixed oil-mica capacitors with a selective switching arrangement for obtaining optimum Q over the frequency range. Energy is transferred to the antenna system through an output coupling inductance and antenna helix apparatus associated with each of the duplicate power amplifiers. Each antenna output system is resonated by means of a remotely controlled motor-operated variometer and is separately shielded to permit grounding of either antenna system without disturbing the operation of the other.

The transmitter power-amplifiers are designed to deliver 1000 kw of power into the ten-span catenary antenna, and the calculated radiated power output is expected to be approximately 400 kw at 14.5 kc, increasing to 600 kw at 35 kc.

The main transmitter building will house the AN/FRT–3 transmitter and associated equipment, offices, two helix rooms and other facilities. The transmitter and control consoles will occupy a space 60 by 80 feet with 20-foot ceiling height on the second floor. Two rooms about 75 feet square and 75 feet in height located directly back of the transmitter will house the antenna coupling and loading circuits. The transmitter will be air conditioned, with blowers, heat exchangers, circulating pumps for both pure and raw water for cooling vacuum tubes, etc. located immediately below the transmitter spaces. Provision will be made for maximum utilization of low temperature water from Jim Creek

FIGURE 7—Test transmitter site.

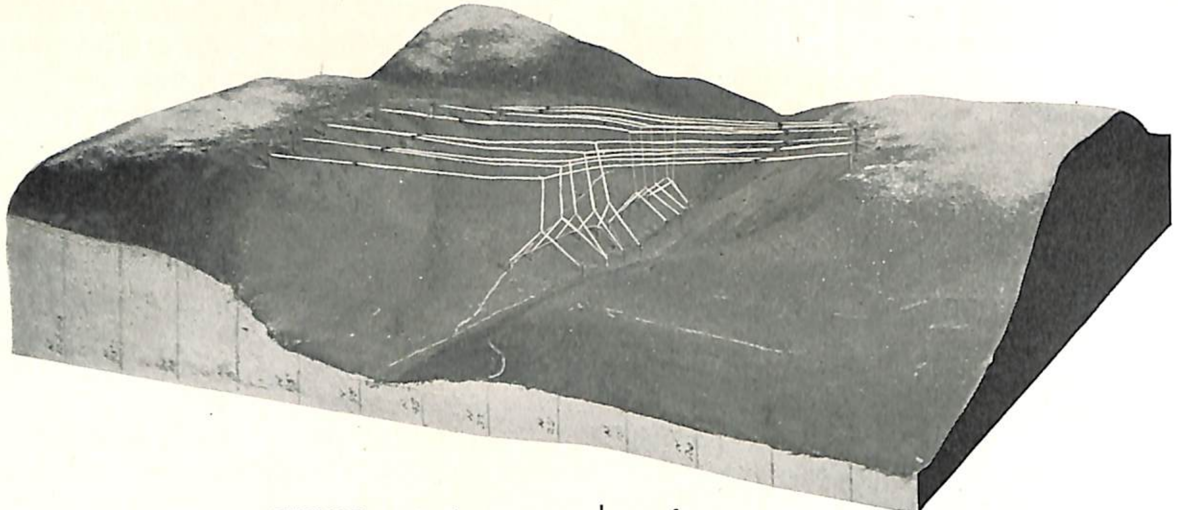


FIGURE 8—Preliminary mock-up of proposed antenna.

for cooling purposes. Included on the lower floor will be electrical and mechanical shops and the main rectifier transformers and electrical distribution system for the building. Provisions will be made for testing facilities, vacuum tube and small parts storage, and offices on the upper floors. The structure will be completely fireproof with special provision for bonding and grounding of all metallic materials because of the high intensity radio-frequency field in proximity to the antenna and feeder system.

All major power sources in the Northwest operate into a common distribution net, thus the combined generator capacity exceeds 3,000,000 kva, at the present time. For operation of the Wheeler Mountain Station, primary power probably will be obtained from the nearest feeder which is about 11 miles distant, and delivered via a new high-tension line to a substation within the reservation. This substation will have a capacity of 3,000 kw with provision for transferring the station load to auxiliary generating units, which will be capable of carrying the full station load continuously. These standby units will be in duplicate; thus there will be installed two 2500-kva diesel-driven generators for supplying the transmitter plate rectifier and keying loads, and two 600-kva diesel units for supplying vacuum tube filaments and general station loads, about 300 kw of which will be for lighting and general utilities.

Although construction of the v-l-f transmitter has been underway by RCA-Victor for over a year, and site surveys and tests are practically complete, the major part of the program, which is the development of the site, is just beginning. An initial construction appropriation of $4,000,000.00 is now available and an additional sum of $3,000,000.00 is expected to follow. These funds will be used for construction of roads to the antenna anchorages, erection of steel towers, clearing of 2,000 acres in the antenna area, grading of building sites and improvements to Jim Creek channel, building of bridges, dams, water and sewage systems, and construction of buildings. Because of the high potential gradient in the antenna field and large ground currents in the area, special attention must be given to the type of building and electrical construction to avoid creation of fire hazards or injury to station personnel. In addition to the main transmitter building previously described, the building program calls for construction of a diesel electric power plant, shop and service buildings, storehouses, barracks, quarters for married employees, recreation building and outdoor facilities, garages for trucks, cars and special station maintenance equipment, and a fire station. This will be followed by installation of the radio ground system and construction of the main antenna. This project including equipment will ultimately involve an expenditure of close to $10,000,000.00.

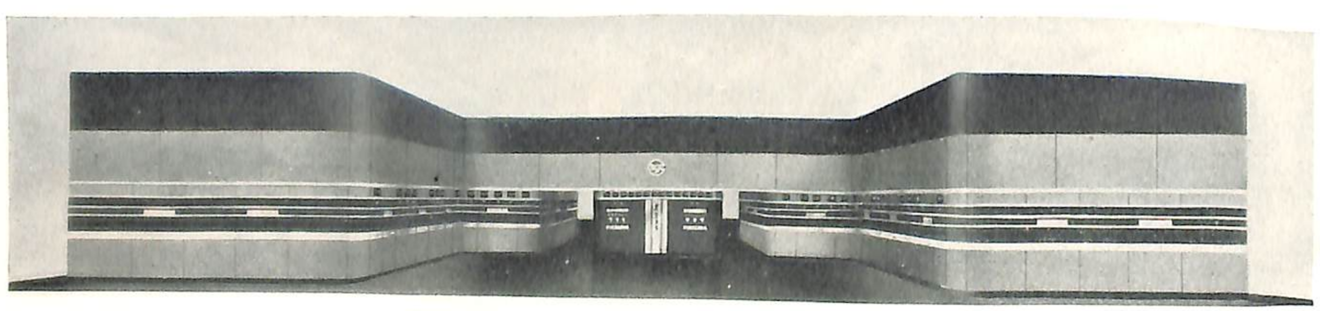


FIGURE 9—1000-kilowatt v-l-f transmitter.

RADIO WHEELER MOUNTAIN

PROPOSED RADIO RELAY CENTER

by
J. M. Paterson,
Electronics Engineer, Shore Section, Puget Sound Naval Shipyard

Primarily the new Navy Communication Station, Wheeler Mountain, will be a high-powered very-low frequency transmitter station. The site, however, is also admirably suited for use as a focal point or relay center for radio links operating at frequencies limited to line-of-sight transmissions. The proposed site for the relay station is at an elevation of approximately 3000 feet and offers satisfactory radio transmission paths to nearly every Naval activity in western Washington. Its proposed location is one mile north and 2400 feet above the low-frequency transmitter building. The presently planned facilities will be reached by a branch from the access road to the antenna anchorages on Wheeler Mountain; the equipment will be housed in a concrete building.

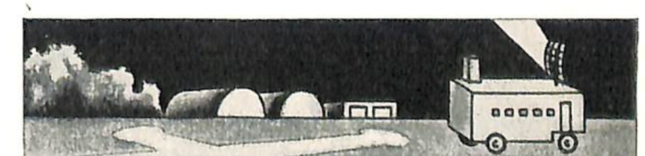
The basic communication control link network proposed for Radio Wheeler Mountain is outlined on the location map, figure 1, of the preceding article. The present v-h-f repeater station at Paine Field, which links the Naval Air Station, Whidbey Island, with the Naval Air Station, Seattle, would be replaced by the relay center at Radio Wheeler. New links would be established from Radio Wheeler to the Navy Communication Station, Bainbridge Island, and to the Thirteenth Naval District Headquarters, Seattle. An extensive system of terminal equipment would provide the means for interconnecting as many voice, teletype, telegraph, or control circuits from the remote stations as may be required. At least a portion of the control and switching system would be operated automatically from remote stations.

The terminal equipment and operating spaces are to be so designed that new radio links may be easily incorporated into the basic network when the need arises. This feature will be extremely valuable in the event that the acquisition of additional sites for Naval activities become necessary, for it will greatly reduce the problem of communication with these sites.

The same feature which makes Radio Wheeler Mountain a good site for a Communication Control Link Relay Center also makes it a good site for a Ship-Shore Radio Relay Station. No present Navy-controlled reservation in the Puget Sound area even approaches the elevation offered by this site. Innumerable islands and peninsulas in Puget Sound introduce a very serious shadow effect on signals originating from stations at lower elevation. The extent of shadow effects on signals from Radio Wheeler will be less because the intervening land areas are relatively insignificant in elevation. A dependable service radius of 77 miles is anticipated for this station, based on the accepted method of computing v-h-f coverage and taking into consideration refraction of waves at very high frequencies. The approximate area over which reliable coverage can be expected is indicated by the arc shown on figure 1 of the preceding article on the Wheeler Mountain Station.

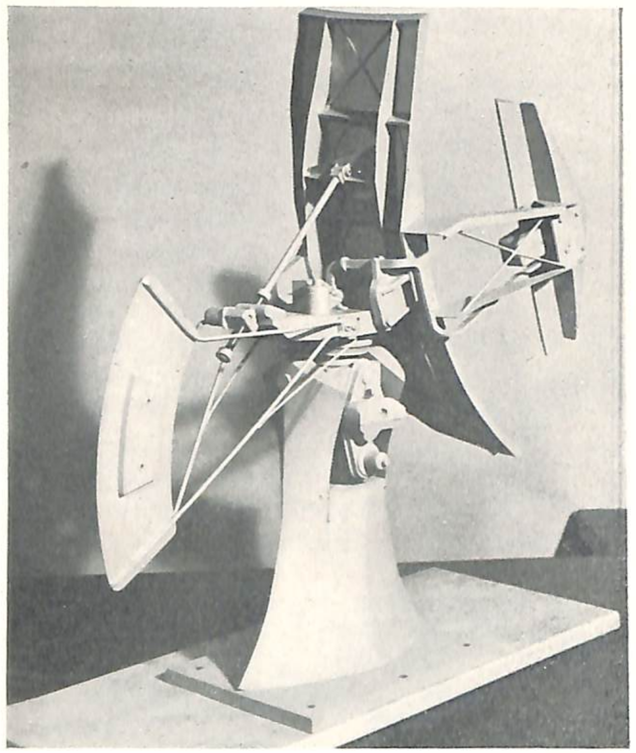
To further utilize the height advantage offered by Wheeler Mountain, the eventual installation of a long-range air surveillance radar station is contemplated at a site which will be set apart from the v-h-f/u-h-f relay center to reduce the likelihood of interference to radio circuits. A means of providing remote control and of repeating the indications to remote plan position indicators via radio link will be required. Remote stations would probably be located at Naval Air Station, Seattle, and Naval Air Station, Whidbey Island, where present radar equipments are extremely limited in range by heavy ground return from surrounding hills and obstructions. This project will be one of the later phases of development of Radio Wheeler Mountain.

Type of Approach	Last Month	To Date
Practice Landings	8,332	211,298
Landings Under Instrument Conditions	201	9,097



SHIPBORNE SEARCH RADAR

by
Lt. Cdr. I. L. McNally, *USN,*
Electronics Design and Development Division, Bureau of Ships



SPS–8 antenna model.

Under the Electronics Design and Development Division of the Bureau of Ships, the Radar Branch is responsible for planning, implementation, and supervision of development and design of Shipborne Search Radar Equipment, Approach Control, Simulators, Radar Recognition and Identification, Beacons, and Electronic Aids to Navigation.

Major sub-divisions of equipment included in this category are Air Search Radar, Surface Search Radar, Interception Radar, Target Indication Radar, Special Purpose Radar, Radar Displays, Radar Simulators, IFF, Ground Controlled Approach Radar, Carrier Controlled Approach Radar, Beacons, Loran, and Electronic Navigational Aids.

CNO policy and directives govern the extent of the effort in any particular field. The recently published "Supporting Plan for Fleet Air Defense Policy" states in part:

"The major threat to the accomplishment of the Fleet's mission will be in the form of enemy airborne attacks. The defeat of airborne weapons can be accomplished most efficiently in the following order of priority:

1—Destroy the launching sites.
2—Detect, intercept, and destroy airborne weapons well clear of fleet units, by employing intercept aircraft or guided missiles.
3—Utilize the coordinated efforts of all available air defense measures in the near vicinity of fleet units."

The basic elements of an Air Defense System are as follows:

1—Detection and display
2—Recognition and identification
3—Evaluation and indication
4—Designation and acquisition
5—Control of aircraft or guided missiles
6—Guns
7—Passive measures
8—Communications

Detection has been listed as the first element in an air defense system and the priority of the military characteristics of a long range search radar have been set up as follows:

1—Range
2—Recognition and identification
3—Altitude determination
4—Vertical beam coverage
5—Hemispherical coverage
6—Increased azimuth scan rate
7—Accuracy

Recognition and identification are closely associated with detection. Recognition is the determination by *any means* of the friendly or enemy character and individuality of another. Identification is the identification by *any act or means* of your own friendly character.

The basic fundamentals and problems associated with the design and development of a long-range radar are in general the same for all classes of radar except for refinements in scan and accuracy. Pulse radar makes it possible to detect the presence of objects at long range, and to measure this range with a high degree of accuracy. Frequency-modulated radar, target pulsed continuous carrier radar, pulse doppler and continuous carrier doppler all have specific and highly desirable characteristics for many applications, but in general, to meet the military characteristics specified, pulse radar is the most satisfactory.

Range is the most accurate of the space dimensions obtainable by radar and it is determined by accurately measuring the time between the transmitted pulse and the return echo. Knowing the speed of propagation and the elapsed time, the radar indicator sweep is designed to give a direct reading in any desired units. The speed of propagation of electro-magnetic energy has been determined with great accuracy, yet a small but variable error does exist due to variations in the atmosphere. At extremely long ranges this may well become a serious source of error in some applications, although at 50 miles it is only in the order of 5 to 10 yards. The accepted standard employed by the Navy is 163.88 yards/μsec and is established by an 81.94-kc crystal oscillator which gives calibration markers every 2000 yards.

The use of pulse techniques and special components enables high peak powers of radio-frequency energy to be generated at ultra-high frequencies. Peak powers in the neighborhood of 1 megawatt are employed in current fleet radars and peak powers of 10 megawatts are contemplated for future models. Pulse lengths are from a fraction of a microsecond, for high resolution surface radars, up to 10 microseconds for long range air search radars. Pulse length is one of the limiting factors of range accuracy and resolution. As a general rule the error is about ± 10 yards for each microsecond of pulse length. A radar using a 5-microsecond pulse may be expected to have a range accuracy of $\pm(.01R \pm 60)$ yards. This accuracy is a function of propagation errors and circuit limitations. Targets separated in range by less than 0.5 pulse length (even though slightly offset in bearing) are very difficult to resolve.

Bearing accuracy is primarily a function of beam width, servo accuracy, and stabilization. Narrow beam widths increase the accuracy to which the apparent bearing of a target can be determined. A faulty synchro transmission system, however, may not only sacrifice the advantage due to the increased resolution, but actually cause discrete targets to be superimposed. Bearing accuracy is dependent to a considerable degree on the stabilization of the antenna. Under conditions of a 30° roll and a 10° pitch, the bearing obtained on surface targets by an unstabilized antenna will be 5 degrees in error.

The range of a radar is dependent on the following factors:

1—Antenna gain
2—Receiver noise factor
3—Peak power
4—Effective area of target
5—Pulse repetition rate
6—Pulse length
7—Radio frequency
8—System efficiency
9—Scan rate in azimuth and elevation

The designer must know three primary military characteristics in order to initiate the design of a search radar. They are as follows:

1—Maximum range
2—Target
3—Rate of information

The designer then can determine the optimum radio frequency, peak power, pulse length, pulse repetition rate, vertical coverage, resolution, and accuracy. The maximum range of the radar determines the pulse repetition rate. It must be slow enough to allow for the two-way time interval of the pulse and echo. Additionally, the horizontal beam width and azimuth scanning rate must be so related that the echo will return within the beam pattern of the antenna. The speed of propagation is the limiting factor in determining the relation between beam width and scanning rate for a given maximum range. As an example, the proposed 300-mile long-range air search radar employs a pulse repetition rate of 200 and a horizontal beam width of 1.5°, which together limit the horizontal scan rate to 10 rpm. Requirements for increased vertical coverage further reduce the value of antenna gain which may be realized. Increases in antenna gain can be achieved by employing higher frequencies, increased antenna size, multiple antennas, and stabilization.

The choice of frequency is based on considerations of propagation, range, power, antenna gain, and allocation. For long-range search radars the optimum frequency has been determined to be about 1200-1300 megacycles. Considerable power is available, optimum antenna gains can be achieved, solid coverage is possible, and relative freedom from adverse propagation effects exists.

A large increase in peak power will provide for a range increase but shipboard limitations such as installation, weight, size, life, voltage breakdown, pressurization, radio interference, primary power, maintenance, and reliable operation set a practical limit to the amount of power which may be employed. Extremely high voltages are required and must be supplied by very large modulator units. As an example of the magnitude of the power requirements it is estimated that three 10-megawatt magnetrons employed in a high coverage long range radar would require 100 kw of primary power, 15 tons of modulator, and 10 tons of stabilized antenna.

In order to utilize the narrow beams associated with the high antenna gains required for long range and high resolution, it is necessary to stabilize the antenna. Interception and target indication radars must be stabilized in order to furnish elevation and height information. Carrier-controlled-approach radars must be stabilized in order to reduce sea return and reliably follow low flying aircraft in the traffic control zone of carrier-controlled-approach.

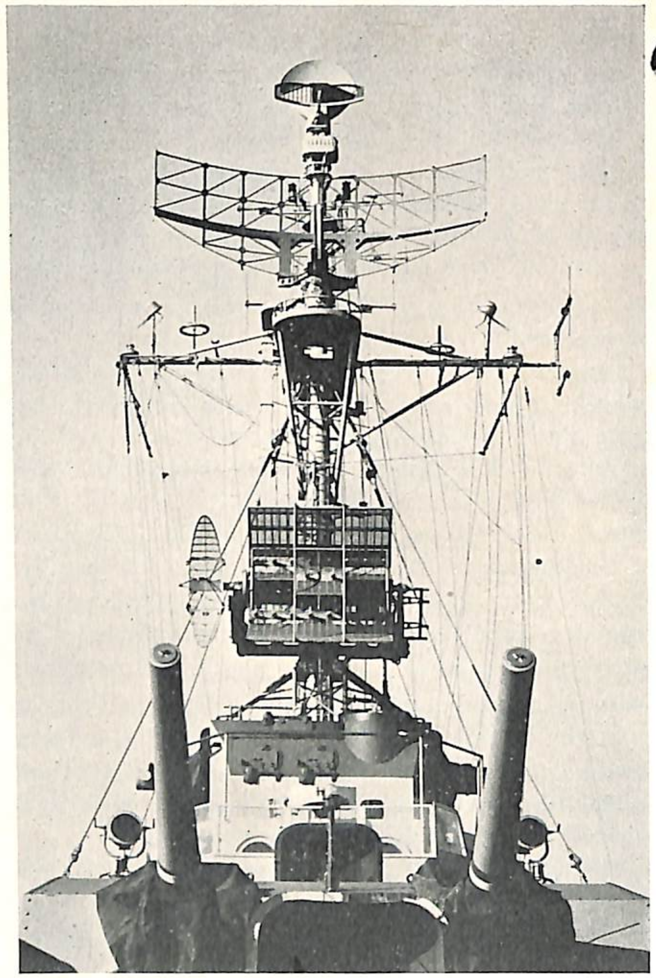
Noise in a radar receiver is caused by several sources, the most important of which are:

1—Cosmic
2—Thermal
3—Vacuum tube

Cosmic noises have their source in space. Thermal noises are caused by the molecular motion within the resistive elements employed. Electron motion in a vacuum tube contributes noise in the form of shot noise, partition noise, electron bombardment, etc. Most radar receivers employ crystal detectors because the noise figure of a crystal is lower than that of presently available vacuum tubes. Crystals have an extra source of noise, which is distinct from diode and thermal agitation noise, caused by rough whisker tips, imperfect solder, etch, and tapping. The efficiency of a radar receiver, called its noise factor, is a measure of how closely this figure approaches the theoretical minimum due to thermal agitation. Noise is further aggravated by the fact that radar receivers must employ extremely broad bandwidths (which admit more noise) in order to receive the short pulses employed. A novel development which is being studied at the present time is a low temperature detector maintained at 30°K (—400°F) by a liquid neon/nitrogen refrigeration unit. This technique which reduces thermal agitation to a very small value offers the remarkable possibility of a 5db improvement in the noise figure. A 12db improvement in radar performance whether achieved by antenna gain, power, efficiency, or any other factor will give a 100% increase in range performance.

The effective area of the target is being reduced drastically with the development of jet bombers, jet fighters, and guided missiles. During the last war, areas varied from 20 to 60 square meters. The Baka which appeared late in the war had an effective area of 8 square meters and presented a very difficult target even at its short operational range. Present or contemplated targets are estimated to be in the vicinity of one square meter. Their small size, high speeds, and stratosphere altitudes render nearly all existing radars inadequate.

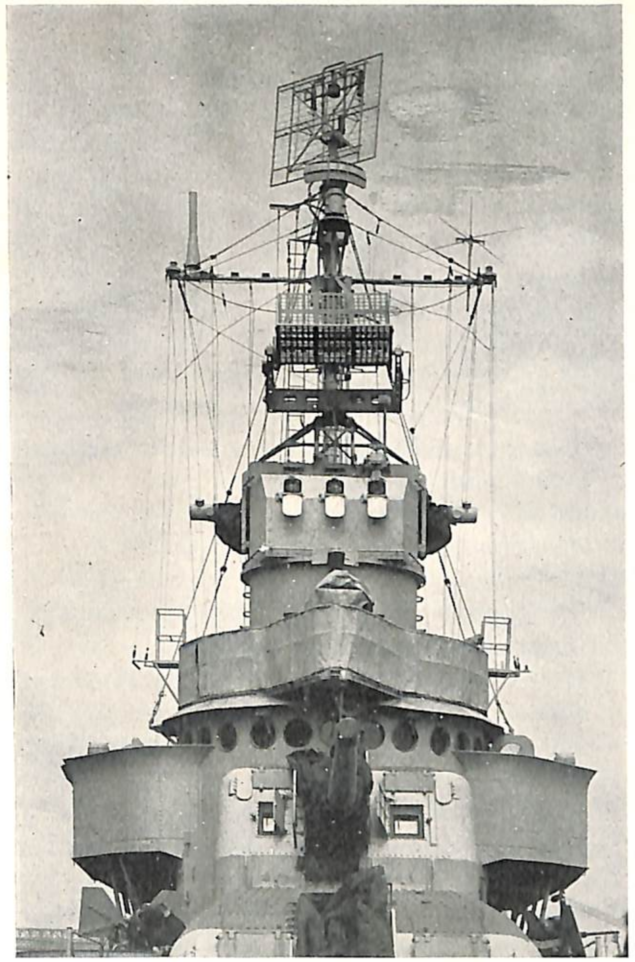
Once the radar echo is obtained, it is useless unless adequately displayed so that it can be evaluated. The designer collects all the elements of display and calls them visibility factors. They include:



Antenna array aboard the U.S.S. MASSEY; SG–6 mounted above the SPS–6B.

1—Pulse length
2—Bandwidth
3—Pulse repetition rate
4—Azimuth and elevation scanning rate
5—Beam width
6—Range scale
7—Scope size
8—Spot size
9—Screen persistence
10—Noise
11—Visual acuity
12—Blip/scan ratio

It can be seen that the dependent relationship of radar range parameters is further complicated by the fact that many of these visibility factors are also range factors. With range considerations setting up most of these factors the visibility is enhanced by employing high definition cathode-ray tubes. In this respect the new 10-inch flat face cathode-ray tube developed from the 10-inch television cathode-ray tube shows great promise of providing a 4-fold increase in the number of display elements by virtue of its more efficient phosphor, spot size, and display surface. New indicators will use expanded scales extensively which will permit the most efficient ratio of range scale to scope dimension to be employed. The visual acuity of the average operator calls for a +4 db margin of signal strength over minimum detectable to assure that the echo "will be observed with certainty." Automatic devices may improve this, but the human eye and brain still can exercise judgment in evaluation of noise and interference not yet achieved in a machine.



Antenna array aboard DD–443; SC–1 and SG–1.

The radar designer must also consider the following factors:

1—All possible anti-jamming features
2—Sea and cloud clutter
3—Weather factors such as rain, snow, icing, and wind loading
4—Roll and pitch
5—Shock
6—Vibration
7—Stack gases and corrosion
8—Installation limitations
9—Operation
10—Plotting
11—Range scales
12—Ships head marker
13—True-relative presentation
14—Range and bearing measurement
15—Target indication
16—Automatic tracking while scanning
17—Moving target indication
18—Radio interference
19—Maintenance 5–12 db

In the field of air search radar the SPS–6 series will be the first of the postwar models. This equipment, operating in the 1200-Mc band, will employ 500 kw peak power and a new 18-foot paraboloid antenna. The range on two F8F aircraft at 20,000 feet altitude is about 60 miles. Under similar conditions the range of the SR–3 was about 20 miles. The SPS–11 will utilize a larger stabilized antenna with increased peak power. With expected receiver improvements employing multi-beam reception, the range should be increased to 100 miles. The SPS–2 is a long-range long-term development which contemplates at the present time the use of 3 beams fed by a single megawatt magnetron. It will employ a stabilized 35-foot paraboloid antenna and is expected to have a range of 300 miles against 1 square meter targets. A submarine model of the SPS–11, known as the BPS–2, will be developed for submarine picket application. Valuable experience on submarine installation problems has been gained with the 600-Mc SR–2 air search radar installation on the Migraine boats. Moving target indication (MTI) will be applicable to all new models of air search radar. By means of this technique all permanent echoes are removed from the display by a storage and cancellation circuit and only moving targets displayed. This permits the detection of aircraft in the presence of heavy land clutter.

The 6000-Mc band SG–6 is a high resolution surface search radar which will eventually replace the SG–1. New and improved features include increased power, better resolution, increased azimuth scan rate, higher vertical coverage, and larger display. As an interim measure to provide zenith watch an overhead antenna has been provided which gives coverage out to a slant range of 15 miles from 20 to 80 degrees elevation. The SPS–4 will be identical to the SC–6 in all respects except the frequency of operation will be in the 5000-Mc band. Smaller versions of these models will be the SO–6, SO–10, and SPS–10 intended for use on the smaller classes of ships. The SPS–5 will utilize the same basic units but adapted to the particular requirements of PT boats.

The success and great utility of the experimental K-band (25,000 Mc) CXJG in polar operations has resulted in the initiation of development of the SPS–7.

This very high resolution radar will operate in the 30,000-Mc band. Although the range is in the order of 5 miles and performance is adversely affected by precipitation, it is extremely useful in pack ice, navigation, piloting, and mapping. The SPS–9 is a long term development which will provide very high resolution in the order of 20 yards of range and 0.5° bearing. Small object detection in the presence of heavy sea clutter is being investigated along several different lines as follows: Doppler systems in which the change of radio-frequency phase between successive echoes from a moving object is used to display the echo distinctively; Pulse doppler systems in which the change of phase is detected by using the beat between the echo and a permanent echo; Coherent systems in which the change of phase is detected by beating the echo with an artificially generated reference oscillation; Direct presentation systems which expand the intensity modulated echoes to show the doppler modulation; FM radar which frequency modulates a low power carrier and determines range by the beat note between instantaneous transmitter frequency and echo frequency, and target movement by doppler response; and conventional MTI which removes clutter by storage of signals for a recurrence period and subtraction from the next group, giving an output only from moving echoes. Own ships motion, antenna scan, oscillator stability, variation of "fixed" echoes from pulse to pulse, and fidelity of storage present difficult technical problems to be solved. Acceptable MTI using mercury delay lines is available on the lower frequencies used in air search radar. On the higher frequencies non-coherent systems show acceptable possibilities. The two-color VM indicator unit has been used with a 3000-Mc non-coherent system to display fixed echoes in green and moving targets in red on a single combined display.

Interception radar provides high quality three coordinate search information. The current models in the fleet are the SP and SX. The SP although giving high quality three coordinate information can only display one altitude at a time and does not display it in a manner suitable for ready evaluation. The SX radar provides for continuous scanning in elevation and azimuth. Three displays present a standard PPI, expanded off-center PPI, and RHI (range height indicator). The stabilized antenna assembly weighs 6400 pounds which limits its installation to only the larger ships. It will detect jet fighters out to a range of 60-70 miles and up to an altitude of 18,000 feet. The 4-rpm azimuth scan, 11-degree vertical scan and lack of an integral IFF are serious operational limitations. Specifications are being written for a procurement to modify one SX antenna to give height coverage up to 31°. By employing VK–VL radar repeaters instead of the present consoles, the installation problem of below deck units will be less severe. The 3700-Mc SPS–8 is the replacement model for the SX. It will be considerably lighter and employ 2 megawatts of peak power. Selection of any 11° elevation scan up to 36° will be provided and the azimuth scan rate will be increased to 10 rpm. An additional feature will be the provision to select within 2 seconds any 30° sector which can be scanned once every 2 seconds. The display equipment will consist of a standard VK or VK–2 off-center PPI and VL range height indicator. A 15-foot parabolic reflector with its 1.1° beam will give excellent resolution and range out to approximately 80 miles.

The air intercept problem is quite complicated and the correct parameters for a suitable system have not been determined. Several points appear reasonable.

1—Greatest range obtainable is required for the height finding radar.

2—IFF must be continuously available.

3—Resolution should be as good as practical.

4—Information every 2 seconds may not be necessary and calls for compromises on the important requirements.

5—The use of several precision type radars for the intercept problem may not be practical because of space and weight limitations and in addition very little gain can be realized over a versatile scanning radar used in conjunction with an air search radar.

6—A transpondor operating in the frequency band of the height finding radar may have to be installed in fighter planes to permit positive and continuous identification and 3-coordinate data during intercepts. This "traffic control" feature must not in any way compromise basic detection and recognition.

7—Automatic or semi-automatic devices are needed to assist in the intercept problem and to evaluate by test the parameters of jet interception.

The SPS–3 target indication radar provides high quality three coordinate information out to a slant range of 15-20 miles and 80° elevation at an azimuth scan rate of 15 rpm. The requirements for 30-rpm azimuth scan and 80° elevation scan on a stabilized base have not been satisfactorily solved. Present design proposals call for all the radio-frequency components to be assembled with the antenna. This results in 2000 lbs. of masthead weight and a difficult maintenance problem.

The development of effective countermeasures and ASW techniques has brought about the initiation of the BPS–1 attack radar for submarines. Basic SS radar below-deck units will be employed. The antenna will be mounted on a retractable mast with provision for 4 seconds of exposure. Full azimuth scan or sector scan search features will be provided. Interim modifications are being adapted to the SV submarine air search series to provide height finding and guided missile control.

Carrier-controlled-approach systems have been under test for some time and the requirements for such a system are fairly well known. The SPN–6 traffic control radar will utilize SG–3 below-deck units and a special stabilized antenna. This antenna has a vertical pattern distribution to give maximum discrimination against sea clutter and still give adequate response against low flying aircraft in the approach pattern. The SPN–8 will be developed for precision control in the final approach.

Several models of radar display equipment are in the final stages of development or early stages of installation. The VK off-center PPI will provide a general purpose expanded PPI with many desirable operating features. The VL will be a companion unit to display range height information. The VM is a dual indicator which optically combines two independent different color displays. One application that suggests itself is to present standard radar on the red scope and IFF reply on the green scope.

The SPA–4 indicator will be a universal standard PPI suitable for wide application. Its most unusual feature will be its "rubber range scales". The range scale will be continuously variable from 1-5, 4-20, 10-50, and 40-200 miles. This feature permits optimum range scale selection or adjustment and chart matching by VPR application.

A new development which is showing considerable promise and one which will fill an urgent operational requirement is automatic tracking while scanning. This technique will permit an operator to set a series of strobes to different targets on a PPI. These independent strobes will automatically and continually follow the selected targets providing a smooth flow of multiple target indication information.

The requirement for a large display is being investigated by developments covering conversion to television scan, new optical direct projection techniques, photo transfer projection, and large cathode-ray tubes.

Shipborne terminal equipment, used in conjunction with airborne early warning radar, is primarily display apparatus. New lightweight equipment will make it possible to install the system onboard most classes of ships. Modified versions of the VK with numerous special operating features will increase the utility and flexibility of operation.

It can be seen from the above that the design of shipborne search radar follows the typical pattern of "compromise" associated with all forms of Naval design. Just as the destroyer must sacrifice armor and endurance for speed and maneuverability, so must the radar parameters be chosen to achieve the desired performance. In the final analysis the good judgment and experience of the fleet combined with the skilled design engineer and American industry will provide the best answer to the problem of shipborne search radar.

RADIO RECEIVING SETS AN/URR-3 THROUGH AN/URR-8

The Bureau has under development a new series of radio receiving sets to be known as Models AN/URR–3 through 8. Each receiver will employ two identical tuning units, two identical i-f/a-f assemblies and a self-contained power unit suitable for operation from a 105/115/125-volt, single-phase, 40- to 400-cycle primary power source. The two sections of each receiver may be employed individually or simultaneously. The equipment is manually controlled and continuously variable throughout its range. The two sections of each receiver may be operated from separate antennas if necessary.

Tuning units will be designed to cover three separate frequency ranges. Tuning Unit "A" covers 14 kc to 600 kc. Unit "B" covers 250 kc to 8000 kc and Unit "C" covers 2 Mc to 32 Mc. Receivers will be furnished complete with tuning units installed. These units may be interchanged by installing activities, but due to resultant complications in receiver nomenclature and ship inventories, changes in the field will be discouraged.

Receiver nomenclature and frequencies are listed below:

Receiver	*Frequency*	*Tuning Units*
AN/URR–3	Two 14 kc to 600 kc	2 Type "A"
AN/URR–4	Two 250 kc to 8000 kc	2 Type "B"
AN/URR–5	Two 2 Mc to 32 Mc	2 Type "C"
AN/URR–6	One 14 kc to 600 kc and one 250 kc to 8000 kc	1 Type "A" and 1 Type "B"
AN/URR–7	One 14 kc to 600 kc and one 2 Mc to 32 Mc	1 Type "A" and 1 Type "C"
AN/URR–8	One 250 kc to 8000 kc and one 2 Mc to 32 Mc	1 Type "B" and 1 Type "C"

The receiver is mounted in a submersible cabinet measuring approximately 9¼″ high by 21¼″ wide by 16¼″ deep. Weight is not presently available.

The above descriptive material is of a preliminary nature and is furnished as advance information only. The first model of this receiver is not expected to become available for evaluation prior to July 1950.

CONVERSION OF THE USS NORTON SOUND

by
WILLIAM S. PATCHELL,
Sr. Civilian, Radio Section, Philadelphia Naval Shipyard

Forward view of the U.S.S. NORTON SOUND, showing the miniature flight deck for the landing of helicopters and launching of balloons.

Philadelphia Naval Shipyard was selected by the Bureau of Ships to accomplish the first conversion of a Naval vessel for use as a guided missile test vessel.

The modifications to the *USS Norton Sound (AV–11)* were accomplished in order that the vessel could conduct experimental firings of various types of guided missiles and pilotless aircraft adapted to Naval use. Provisions were made for specialized handling, fueling, tracking and control of guided missiles. Telemetering and guidance radar were not provided, inasmuch as development was not yet complete.

Modifications were made to the vessel in the accomplishment of its present assignment, in such a way that the basic characteristics of the vessel as an AV were not altered. The major features of the conversion were as follows:

1—Installation of a missile tracking center and associated electronic equipment and interior communication used for tracking purposes.

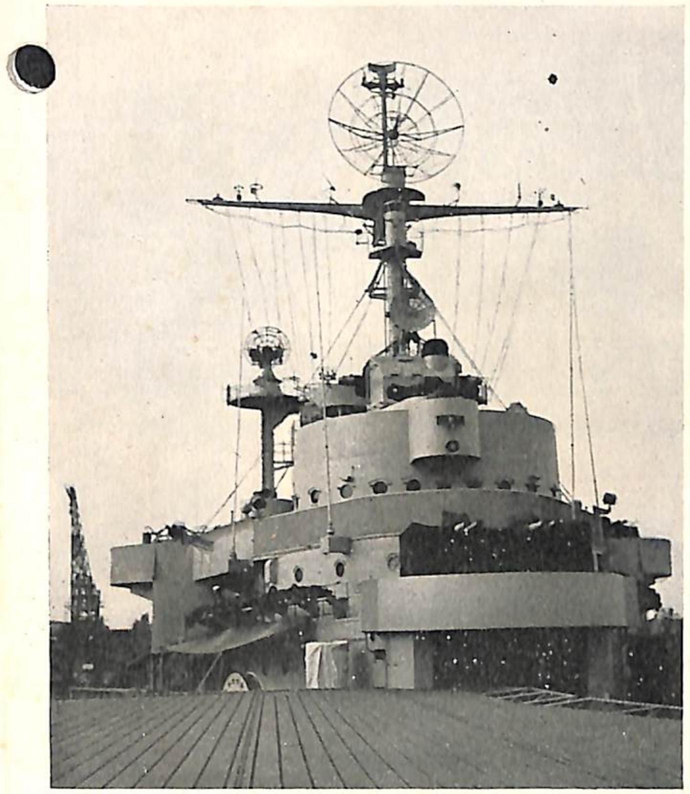
2—Installation of a control and observation booth with associated test and control equipment, wired in accordance with BuShips specifications for future test setups, wired for telemetering and doppler systems insofar as practicable.

3—Installation of recording devices, timing signals and photographic equipment.

4—Provisions for handling the missile, additional fire pumps and necessary alterations to power and lighting systems and air conditioning in the missile tracking center and missile control station.

The major portion of the conversion involving electronics was centered in the missile tracking center. Basically, the missile tracking center was laid out with two things in mind; first, surveillance of the area in which the missile is to be fired and second, actual tracking of the missile. It was assumed in the layout that personnel in the missile tracking center, utilized in setting up the problem and in surveillance, could at the proper time shift over to the other side of the room to handle the tracking problem. The communication facilities, consisting of twelve radiophone units with appropriate desk facilities, were concentrated in the after portion of the room with remote switching units placed at various desirable locations about the room.

A Model SP radar using a modified SM antenna was used as an interim tracking radar since the SM antenna could be elevated to 90° or more. The console of this



Close-up view of the bridge of the U.S.S. NORTON SOUND. Quad-mount 40mm guns remain, though the two 5-inch gun mounts were removed for installation of the foredeck landing platform.

equipment was located in missile tracking center, with bearing and range information being passed to various radar repeaters, and to the Mk 8 Mod 0 automatic plotter also located in missile tracking center. Tracking information was likewise plotted on the Mk 8 Mod 0 plotter from information received from the Mk 25 fire control radar. The Mk 8 Mod 0 automatic plotter is a development of the Reeves Instrument Co. and the Bureau of Ordnance, incorporating beneficial suggestions of personnel at the NMTC Pt Mugu.

To facilitate surveillance, the previously installed SG series and SK series radars were tied into VK and VF radar repeaters in missile tracking center. Horizontal and vertical plotting boards were arranged in a manner similar to a CIC setup. An airborne early warning system was installed to supplement these radars in order to extend the range of the area under surveillance.

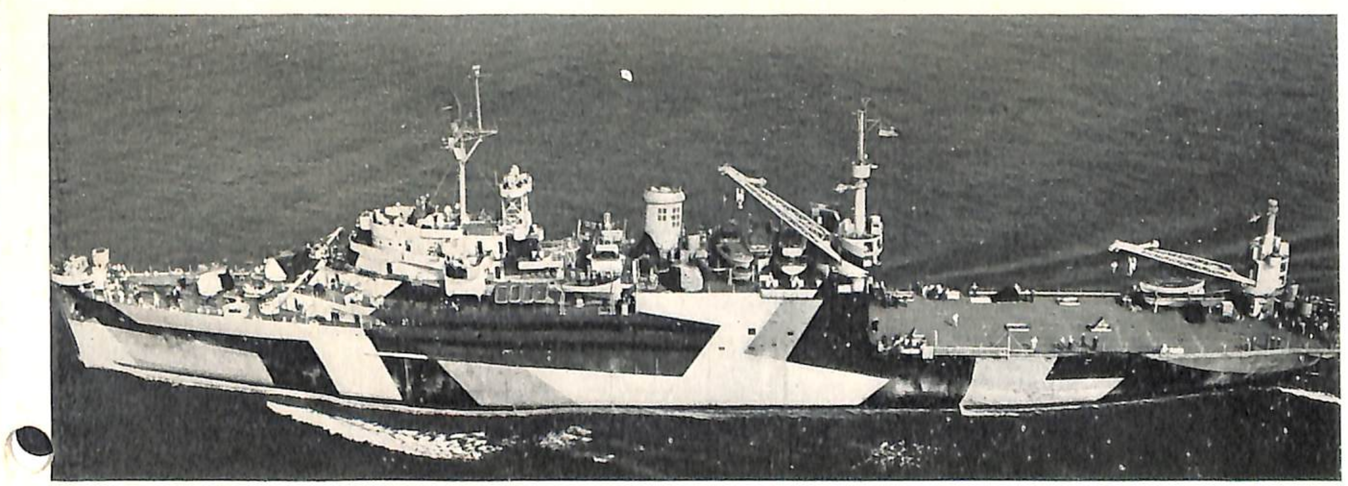
For permanent records, facilities were installed for mounting cameras on the Mk 25 radar antenna and the modified SM antenna. A third camera location was over the specially constructed data dial box consisting of synchro repeaters, receiving range and bearing information from the various radars and interior communication systems.

Sonic recordings were made possible by installation of two VRR–1 voice recorder racks, with inputs from radio and sound-powered voice circuits properly matched to the voice recorders.

For the purposes of tracking down spurious emissions of radio-frequency signals, COMCM and RADCM equipments were authorized and installed.

Other departments made extensive changes to the hull and electrical systems in order to fulfill requirements for fueling, launching and controlling the missile. Cables for test circuits between the launching site and control room were installed. A more adequate fire and flushing system with elaborate systems for storing and handling fuel and oxygen were incorporated into the conversion.

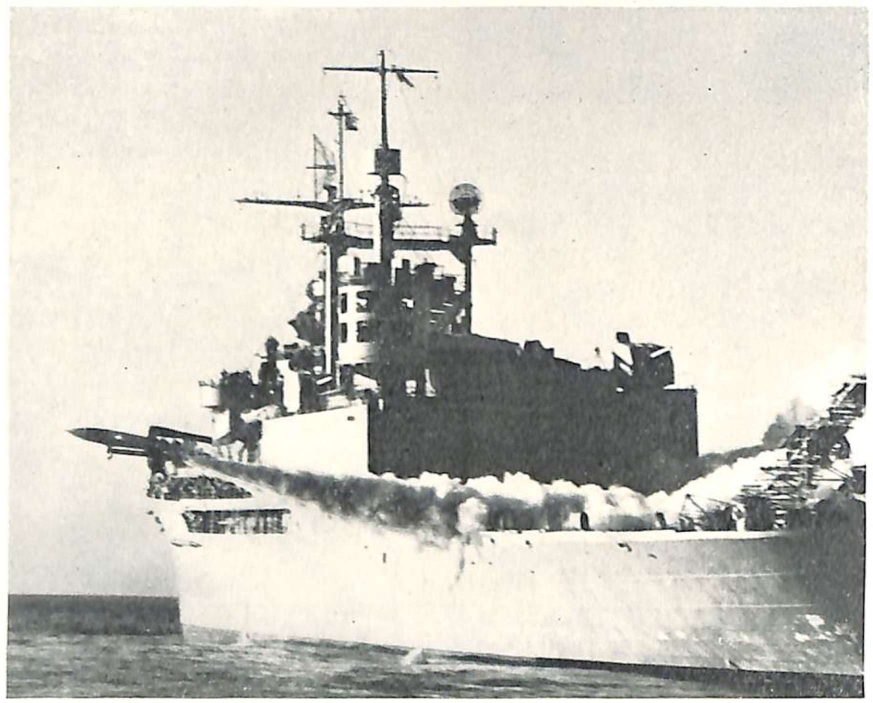
All in all, the problem presented to the Philadelphia Naval Shipyard was one of great interest, and one in which "suit-case liaison" with the Bureau of Ships had to be maintained.



The U.S.S. NORTON SOUND as a seaplane tender, prior to her conversion.

MISSILE TRACKING AND PLOTTING SYSTEMS ON THE USS NORTON SOUND

by
JOHN A. ZAPPACOSTA,
Radio Laboratory, Philadelphia Naval Shipyard



SWOOSH! Launching of a "Loon" from the deck of the U.S.S. NORTON SOUND.

The modification of the *USS Norton Sound* (*AV–11*) to a guided missile launching ship created the need for a long range tracking radar which would fit into the pattern determined by the general ordnance radar system. Since no such radar was available, an SP radar was modified and outputs taken which would satisfy the needs of the plotting equipment. This article discusses the tracking and plotting system as it was finally evolved using the modified SP radar as its primary tracking radar.

The General System

Figure 1 shows the tracking and plotting system used. There are two sources and three receivers of tracking information. The sources are the SP and the Mk 25 radars. The receivers are the Mk 8 automatic plotter, the Mk 1 horizontal manual plotting table, and the dial box. The Mk 8 plotter receives information from either the SP or the Mk 25 through a selector switch. The Mk 1 plotter receives information directly from the SP. The dial box receives information from sources throughout the ship, this information being recorded by a camera mounted on the dial box. An optical target acquisition system is used with the SP, in which the optical bearing and elevation information is fed to match-pointer indicators.

The SP-SM Radar Equipment

Several modifications were made to extend the usefulness of the SP to a missile tracking system. The SP antenna, which has a maximum mechanical elevation limit of 60 degrees, was replaced by the SM antenna, which has a limit of 96 degrees. This necessitated replacing the antenna control unit and the various amplidynes of the SP with those of the SM. The only major change required in the antenna was the changing of the cross level gearing from a 2- and 72-speed system to a 2- and 36-speed system as used in the SP. The synchro and synchro drive gears were changed from spur gears to helical gears in order to achieve the proper ratio in the given shaft space. A camera mount and camera control circuits were added to the antenna as an adjunct to missile tracking. The IFF dipoles were removed from the antenna.

Since elevation up to 90 degrees was desired, the console assembly had to be modified to provide this information. The elevation sector gear was replaced by a full gear. Before this change was possible, the plane of the elevation gearing had to be shifted with respect to the azimuth gearing, since the new elevation system interfered with the azimuth system. The original 30-degree stop was removed, and adjustable stops installed. The elevation dial was engraved to 110 degrees. The height potentiometer and height circuit were disconnected. The upper limit switch in the antenna was set to operate at 95 degrees, and the upper synchronizing switch set to operate at 94.5 degrees. The console stops were adjusted to give elevation from —5 degrees to +93 degrees. Besides these major changes, a variety of minor changes were made to allow the SM equipment to work in the SP system. The Model SP was connected into the system as described in the following sections (see figure 1).

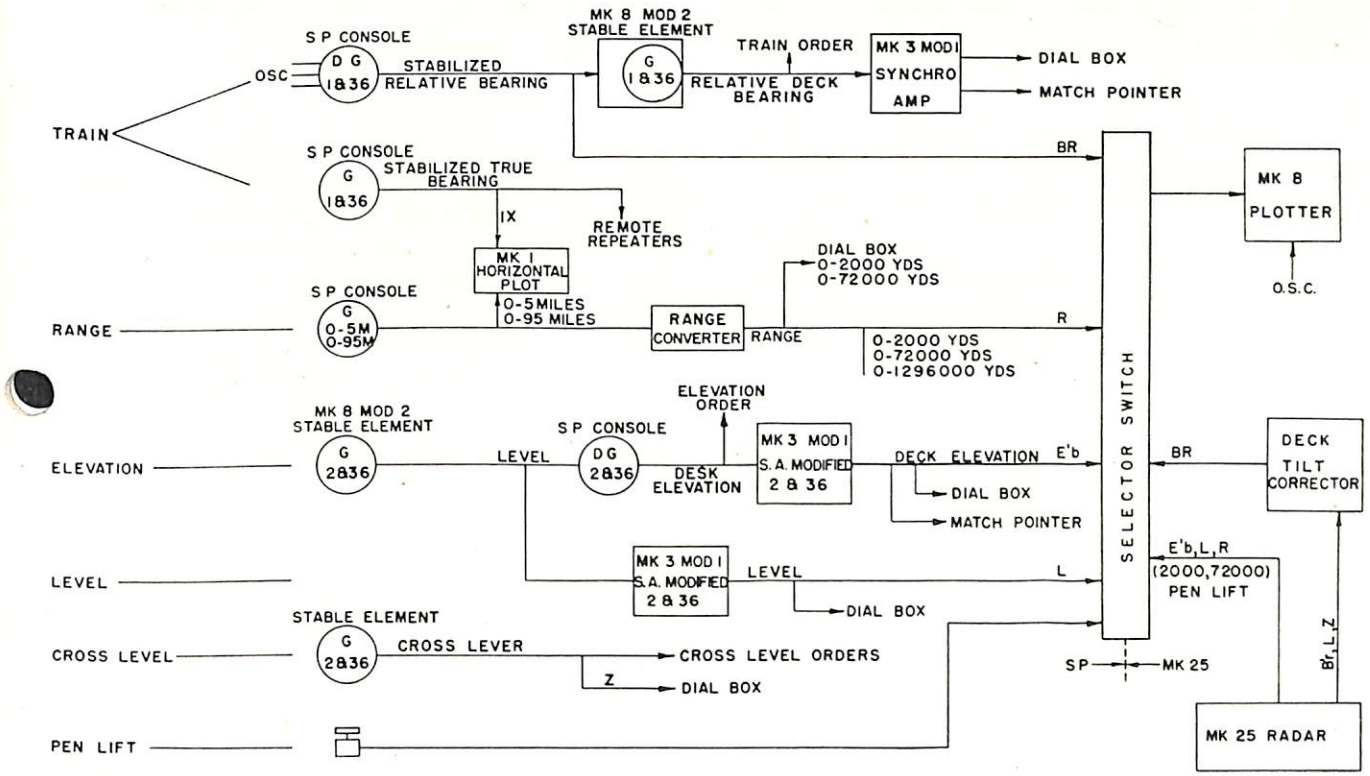


FIGURE 1—Tracking and plotting systems.

Train

Stabilized relative bearing is fed to the Mk 8 plotter selector switch from the train DG's in the SP console. Since all the receivers in the plotter are 1CT's, synchro amplifiers are not necessary. Relative deck bearing is fed

Stern view of the U.S.S. NORTON SOUND, showing the ADJUSTABLE ROCKET LAUNCHING RACKS capable of launching V–2 type rockets as well as the smaller "Aerobees."

from the Mk 8 Mod 2 stable element through a Mk 3 Mod 1 synchro amplifier to the dial box and match-pointer indicator. Stabilized true bearing is fed from the remote bearing synchro in the SP console to the manual plotter and to the remote repeaters.

Elevation, Level, and Cross Level

Deck elevation is fed from the DG's in the SP console, through a Mk 3 Mod 1 synchro amplifier modified for 2- and 36-speed operation, to the Mk 8 plotter, the dial box, and the match-pointer. Level information is taken from the stable element, through a Mk 3 Mod 1 synchro amplifier modified for 2- and 36-speed operation, to the Mk 8 plotter and dial box. Cross level information is fed directly to the dial box from the stable element.

Range

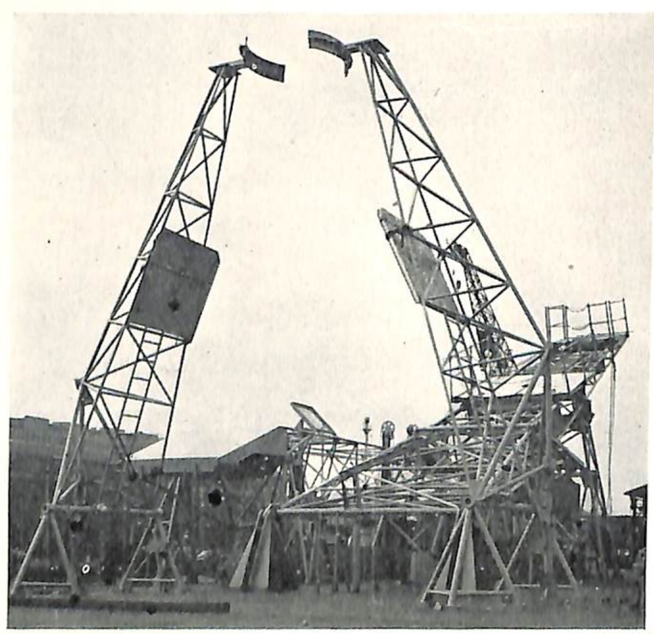
Range is fed from the fine and coarse range generators in the SP range unit to the Mk 1 manual plotting table, and to the Reeves range converter. The range converter converts the SP output from miles to yards. The 2,000-yd., 72,000-yd., and 1,296,000-yd. outputs are fed to the Mk 8 plotter switch, and the 2,000-yd. and 72,000-yd. outputs are fed to the dial box. In order to use a standard servo system in the range converter, the SP console had to be modified to lock together the coarse and fine range output synchros. This was accomplished by gearing together the two range dials on the range unit, and removing the coarse range handwheel from the coarse range dial. The fine range handwheel then controlled both the fine and coarse range outputs. This system does not affect the stepping system of the coarse range unit, since it now steps whenever the fine range handwheel crosses zero.

The Mk 25 Radar Equipment

The Mk 25 radar feeds deck elevation, level, range (2,000 yds. and 72,000 yds.), pen lift information, and (indirectly) stabilized relative bearing to the Mk 8 plotter selector switch. The stabilized relative bearing is obtained by feeding relative deck bearing, level, and cross level information from the Mk 25 to a deck tilt corrector, which performs the necessary computations.

The Mk 8 Automatic Plotter Equipment

The Mk 8 automatic plotter receives range, level, stabilized relative bearing, and deck elevation information from the radars and their stable elements. In order to plot the course of a missile in either the horizontal or vertical plane, stabilized true bearing, range, and altitude are required. Since range is one of the quantities received by the plotter, it must compute only altitude and stabilized true bearing. Stabilized true bearing is obtained from stabilized relative bearing and O.S.C. information. Altitude is computed from range and stabilized elevation. Stabilized elevation was not one of the quantities from the radars, but is computed from deck elevation and level. These computations are all performed in the plotter, which plots the course of the missile from the results obtained.



Close-up view of the ROCKET LAUNCHING RACK installed on afterdeck of the U.S.S. NORTON SOUND.

ATTACK SONAR CONSIDERATIONS

In order for an ASW ship to carry out successful attacks against an enemy submarine, with present day weapons and weapons of the foreseeable future, it is necessary that the sonar equipment be capable of supplying bearing, range and depth information with a relatively high degree of accuracy. It is also necessary that analysis of this information be made automatic or nearly so, in order that delays due to evaluation may be kept to a minimum, so that weapons may be brought to bear and fired at the proper times.

In order to obtain the above information with the necessary accuracy, the attack sonar equipment should have the following features:

1—Very precise training and tilt mechanisms to aid in determining the bearing and depression angle of the submarine as measured by the sonar equipment.

2—A transducer capable of operating at several frequencies and split electrically in the horizontal and vertical planes. In order to obtain the highest degree of accuracy the transducer should be stabilized in at least two axis and probably in three.

3—Sufficient power to guarantee useful echoes at high speeds, where sonar self-noise is limiting, and on a noisy target.

4—Single dial tuning to allow the operator to select operating frequency in the presence of jamming.

5—Display of bearing, range and depression angle on a cathode-ray tube, or by other suitable means, which will allow the operator to supply the best information to the fire control equipment.

6—In order to improve the sonar information, provision should be available for aided following in bearing, range and depression angle. The signals for aided tracking should probably be supplied by the analyzers which are a part of the fire-control equipment.

7—The sonar information should be corrected, by a suitable resolver, for variations in temperature which effect the accuracy of the sonar range and depth.

8—Provision should be made to retract the transducer while the ASW ship is searching. After contact has been made and the range of the target is within that of the attack sonar, its transducer can then be quickly lowered. This is necessary in order that the self noise in the search equipment be kept at a minimum.

An attack sonar equipment which is expected to meet most of the requirements listed above is now being produced. It has been designated the AN/SQG-1 (XN). Installation aboard a destroyer will be made about July, 1949. Evaluation should be completed early in 1950.

In addition to the three-axis stabilized searchlight sonar, there are other projects aimed at providing the accurate target information required for fire-control. One of these is a system which scans in depth as well as in azimuth, with provisions for sector scan indication in both planes. Some difficulty has been experienced in differentiating between surface-reflected and direct echoes in the vertical scanning beam. This has led to the use of a larger depth-scanning transducer, with a narrower beamwidth.

Investigation is being made of the application of frequency-modulation techniques to the attack problem. Such a system would have the obvious advantage of providing continual target information, thus speeding up the solution of the fire-control problem. FM sonar has been relatively successful for use in submarine echo-ranging equipment. It is believed that additional improvements in FM techniques must be found before the principle may be applied to surface ship attack sonar equipment, due to the high noise level of these ships.

In general terms, we may say that the attack sonar must provide target information sufficiently accurate to allow placing of the anti-submarine weapon within its lethal radius, at target ranges greater than the range of the weapon. This is an ever-changing problem and one whose solution can never be final, but it is believed that equipment which will meet these requirements for today's anti-submarine weapon can be produced today.

MEASUREMENT AND REDUCTION OF SUBMARINE NOISES

by
Richard L. Hershey,
Chief Engineer, Sonar Section, Electronics Office, Philadelphia Naval Shipyard

The reduction of sound in submarines is a relatively new field of engineering. Prior to World War II the noise transmitted through the medium of water by a submarine under way was not taken into account. This was primarily caused by the fact that effective coverage of the sonic frequency spectrum was limited. When it was found that our submarines were being detected by the enemy using improved sonic listening equipment, it was evident that some measures had to be undertaken to quiet the submarine while under way and even while motionless.

A system of noise measurement was started at the Submarine Base, New London, Conn. Sound officers were trained and teams formed to measure the noise created by the submarine and its auxiliaries. Special measuring instruments were developed and maximum limits of permissible noise levels were set by comparing levels measured on a number of submarines with auxiliary equipment known to be operating normally. Since that time much has been accomplished in the field of noise reduction by designing quieter operating equipment, shock mounting auxiliaries to insulate the machinery vibration from the steel hull of the vessel, etc. With the cessation of hostilities and subsequent demobilization, the noise measurement teams were lost to the Navy and no effective noise reduction was undertaken for about two years. Noise levels increased alarmingly with operating service and it was found necessary to re-establish this "vital preventive maintenance." The Bureau of Ships directed the Commanders of Naval shipyards and other activities servicing the submarine fleet to establish "noise measurement groups."

Such a group was established in 1947 by the Philadelphia Naval Shipyard. Responsibility for establishing and maintaining this organization was vested in the Electronics Officer with co-ordination of the group under the Sonar Section. This in itself is interesting since it is believed that this is the only shipyard in which such work is carried on by the Electronics Office. It seemed obvious at the time that the relation between sound measurement and sonar work was close enough to combine them in one section and thereby permit maximum economy of operation. The organization, implemented by selected shop specialists, has worked remarkably well, although many obstacles had to be surmounted. Men who were acknowledged specialists in sonar work and submarine maintenance had to be taught the technique of detecting and evaluating unwanted sound. The most difficult task was the selection of a test area for underway tests. The area had to be free of normal ship traffic. General weather conditions must be favorable for such tests and depth of the water must be great enough to permit submarines diving to periscope depth. After extensive survey, an area was selected in Delaware Bay 92 miles from Philadelphia. Through the courtesy of the U. S. Coast Guard an 83-foot Coast Guard cutter has been placed at the disposal of the Shipyard when needed. This boat was utilized as a sound measuring boat, thereby eliminating the need for a full time Navy boat and crew. This type of boat is particularly adapted for the purpose, as it is gasoline-engine-driven and can be silenced by stopping the engines, but at the same time permitting a quick emergency start to get under way if fast maneuvering is required.

Underway noise tests are conducted on the surface or submerged at periscope (snorkel) depth. The vessel makes various speed runs on both main motors and engines, with evasive machinery operating. During the main motor runs, the ship removes power from the shafts when the props are opposite the test hydrophone on the sound boat. In this way, defects in the shafts and props can be detected and evaluated as the shafts slow down to a stop.

Many problems arise during an underway sound test. Fish in the vicinity of the test contribute noises which to the untrained ear approximate the noises common to poor shaft clearances, bad packing and prop deficiencies. The "porpoise" grunts and squeals; the "weak fish" chatters and the "drumfish" beats out a mournful dirge. A school of porpoises playing around the sound boat is a pretty sight to behold, but a headache to the test crew. Underway tests have hazardous moments, since the sound boat must lay to with all propulsion and controls shut down. Sudden changes in wind direction and unpredictable drift have, in many instances, brought the craft so close to the submarine under way as to almost capsize the smaller vessel. When the submarine is travelling submerged a very close watch must be maintained to prevent a casualty.

The dockside test of auxiliaries raises many problems when the tests are conducted at the completion of an overhaul. It may be readily understood that in order to make a test of all auxiliary machinery, each machine must be operating satisfactorily, all loose gear must be removed from the vessel, deck plates must be secured and loose brackets and fittings must be tightened so that no spurious vibrations are set up when the auxiliary is operating. The time interval between yard completion date and RFS period is very limited. Deficiencies noted in the test must be corrected immediately or be reported as "uncorrected deficiencies."

The very nature of noise tests precludes the possibility of conducting them other than at night or on a non-work day in an industrial area such as a shipyard. This in itself places drastic limitations on the time interval between overhaul completion and ship's departure. Publicity for this work within the shipyard, without disturbing the classified nature of noise tests, has aided materially the indoctrination of interested personnel and has overcome many of these limitations. Shop personnel are told the basic reasoning behind a noise test, and why each submarine must be inspected thoroughly for poor workmanship, sound short circuits, improper or misaligned shock mounting, etc.

Much instrumentation is required to evaluate noise, its cause and its cure. The noise measurement group at Philadelphia uses as a basic test instrument the OAY noise level monitor. This has been implemented by a GR sound level meter and vibration probe, a GR sound level analyzer, vibration meter, vibration analyzer and a frequency response recorder. Each instrument serves its own particular purpose in a final evaluation of the problem at hand.

A Magnatape tape recorder with three capstans covering a frequency range of 50 to 12,000 cycles, is used to record each noise test. For recording the overall noise test a capstan with tape speed of 4″/sec is used, covering a frequency range of 50 to 5000 cycles. Problems involving higher frequencies bring into use the 7½″/sec or 15″/sec capstans with respective frequency response of 60 to 9000 cycles and 100 to 12,000 cycles.

Recordings are catalogued and filed for future reference. Excerpts from recordings are now being gathered together and spliced into one recording tape for use in a noise elimination training program for the shipyard work.

Many items contribute to the high noise level of submarine auxiliaries. Foremost among these are (1) sound short circuits, i. e. metallic objects making direct contact with the auxiliary and the hull; (2) loose lockers and cabinets; (3) improper seating of brushes on motors and generators; (4) bad packing; (5) excessive air in hydraulic systems; (6) improper compression of rubber mountings; (7) bad valves; (8) improper end thrust; (9) bad contacts in control panels; (10) loose and squeaky handles for hand controls; (11) bad couplings; (12) loose flywheels; (13) tilting blocks; (14) bad bearings; and (15) loose objects in superstructure.

In addition to providing information which will lead to silencing submarines, noise measurements can and do provide an excellent indication of the mechanical condition of various auxiliaries that have been repaired or overhauled during the submarines availability.

Many instances have occurred during a dockside noise test where the recorded noise level of an auxiliary was safely under BuShips permissible limits but gave evidence of noise not common to the particular machine. In each case further investigation revealed defects in moveable parts which would have damaged or disabled the auxiliary in a short time.

The noise measurement group does not accept an item just because it is within the acceptable limits but attempts to investigate each unidentified sound and makes recommendations for corrective action. It is believed that such action helps to keep the auxiliaries in the "silent zone" for a longer period of time. The instruments used in noise measurement will detect and record sounds that are not normally heard by a mechanic.

Noise tests are conducted prior to the start of the overhaul period and again upon completion.

When an auxiliary fails to pass the noise test and the deficiency cannot be corrected in place, the machine is removed to the cognizant shop for corrective action. Tests are again conducted in the shop and by use of a vibration probe, the deficiency is isolated. After completion of repairs, the auxiliary is assembled and tests are conducted again prior to reinstallation. During dockside tests the auxiliary is tested in place and if the noise level is over permissible limits the trouble can readily be traced to causes other than within the auxiliary.

Painted-over shock mountings are the most common source of trouble. A painted shock mounting may spell the difference between "over limit" or "under limit" as defined in a noise measurement report.

Constant surveillance by ship's force and repair activities can do much to keep our submarines "the silent service."

The author foresees the day when the isolation or reduction of noise will be carried forward on a much greater scale, and will eventually encompass every combat ship of the Navy.

The Philadelphia Naval Shipyard and its electronics engineering group are doing their part in carrying this program forward.

SOME TECHNICAL ASPECTS OF RADIAC

by
J. FORSTER,
Radar Section, Electronics Laboratory, Philadelphia Naval Shipyard

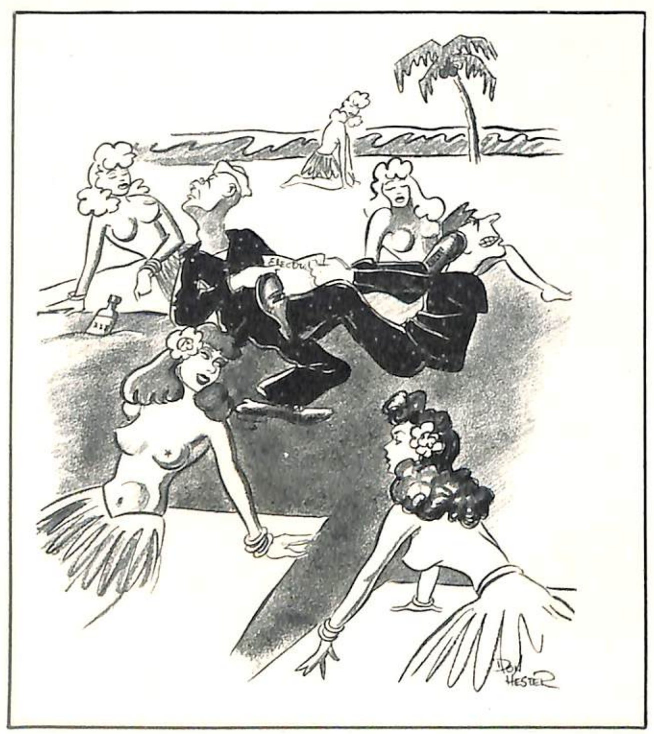
Several questions about *radiac* have repeatedly been asked of the Electronics Laboratory. Here are some of them together with the answers.

What Are You Measuring With Radiac Equipment?

Some substances naturally, or when they have been "processed," emit radiation. These substances are then said to be radioactive. They emit

α–radiations which are heavy positively-charged particles.

β–radiations which are high-speed electrons.



"Oh these ET's! All they care about is who is first on that radiac article."

γ–radiations which are electromagnetic waves of a frequency 10^{20} cycles per second.

neutrons—which are neutral radiations of great penetrating power.

The term *radiac* is gotten from *r*adio *a*ctivity *d*etection *i*dentification *a*nd *c*omputation. The equipments do just that to the emitted radiation.

How Does the Radiac Equipment Measure Radioactivity?

Some of the radiac equipments operate on the principle that these radiations (α, β, γ, neutrons) as they pass through a gas-filled tube cause the gas molecules to ionize. The tube has two electrodes across which a potential of several hundred volts exists. The ions accelerate toward oppositely-charged electrodes and in so doing hit and ionize other gas molecules which in turn ionize others. An avalanche of electrons (pulse) reaches the anode about one microsecond after the primary ionizing event.

The number of pulses occurring is proportional to the amount of radiation. Usually in field equipments the charge or amount of ionization (roentgen) reaching the anode per unit time is amplified by electronic circuits and read on a microammeter. This reading is called the intensity of radiation and is measured in roentgens per unit time.

Some ionization chambers are open cylinders or otherwise air-filled, while others are glass or metal enclosed tubes known as Geiger-Mueller tubes.

Two other basic means of detecting radiation are as follows: One uses the ionization principle to discharge a charged electrometer. Such equipments read total radiation received, rather than intensity and are of two types, the pocket chamber and the pocket dosimeter. The pocket dosimeter is a self-reading equipment while the pocket chamber requires a detector-charger in order to be read. The other basic method utilizes the fact that radiation will darken unexposed film. The opacity of the developed film is measured and is proportional to the amount of exposure to radiation. A calibration curve can be obtained showing the total dosage received.

What New Units Are Needed to Understand Radiac?

From the foregoing explanation, the roentgen is a measure of the amount of ionization. Specifically, one roentgen will produce one electrostatic unit of charge (esu) in 1 cc of air at standard conditions. This is equivalent to enough radiation to cause the formation of 1.6 x 10^{12} ion pairs. The unit of intensity is roentgens per day or milliroentgens per hour.

How Much Radiation Can I Take?

The fear of the unknown surrounding radiological defense should be dispelled. At Hiroshima the number of casualties due to the radiation from the atomic bomb air burst was less than 15%. Today the legal and medical dosage limit is .1 roentgen per day, taken indefinitely over the entire body. The radiation from a wrist watch with luminescent dials is often nearly that of the daily dosage but since it does not irradiate the entire body it is negligible.

Who Takes Care of Radiac Equipment?

At Naval shipyards the electronics laboratory has full cognizance over the maintenance, calibration, and repair of radiac equipment. Aboard ship this work would logically fall to the ETM.

What Are Some of the Common Radiac Equipments?

The following is a chart of field equipments:

Set No.	Components	Characteristics	Ranges
AN/PDR–2	Radiac Set DT–12/PD PP–310/PD	An ionization chamber which detects gamma radiation and indicates the cumulative intensity.	0 to 200 mr/hr
AN/PDR–3	1. Radiacmeter IM–9/PD 2. Radiac detector charger PP–311/PD	1. A dosimeter of the self reading type. This is carried on person. 2. Required only to charge the IM–9/PD	200 milliroentgens
AN/PDR–4	1. Radiac detector DT–16/PD 2. Radiac detector charger PP–316/PD	1. A dosimeter which requires the PP–316/PD to charge it and to read the radiation received. It is carried on person	200 milliroentgens
AN/PDR–5	1. Radiacmeter IM–1/PD	1. A Geiger-Mueller survey meter which reads intensity when calibrated by the radiation from a radium source.	Three ranges: 0 to 20 mr/hr 0 to 2 mr/hr 0 to .2 mr/hr
IM–3/PD	Radiacmeter	An ionization chamber which detects gamma radiation and indicates instantaneous intensities.	Four ranges: 0 to 2.5 mr/hr 0 to 25 mr/hr 0 to 250 mr/hr 0 to 2500 mr/hr
IM–5/PD	Radiacmeter	An ionization chamber which detects gamma radiation and indicates instantaneous intensities.	Three ranges: 0 to 50 mr/hr 0 to 500 mr/hr 0 to 5000 mr/hr
IM–7/PD	Radiacmeter	An ionization chamber which measures alpha, beta and gamma radiation.	Two ranges: 0 to 100 mr/hr 0 to 1000 mr/hr

ARE YOU ON THE BEAM?

Never in the history of Naval Communications has the radio-frequency spectrum been so limited as it is today. The operation of communication equipment within prescribed tolerance limits was highly desirable last year and the year before. Today, frequency adherence is an *absolute necessity.*

In addition to the limited spectrum, demands within the spectrum itself are continually increasing. To satisfy these conditions, tolerance limits have been reduced to the following:

Class of Station	Below 50 kc	50 kc to 535 kc	535 kc to 25 Mc	Above 25 Mc
Shore	0.1%	0.02%	0.005%	0.01%
Mobile and Portable		0.05%	0.015%	0.01%

These tolerance limits are prescribed in USF 70(B). Table I is an example of frequency tolerances for U.S. Naval vessels based on the new tolerance of 0.015% for frequencies from 535 kc to 25 Mc. Reliable communication can be established and maintained only by absolute adherence to the operating frequency.

Radio-frequency measurements on transmissions from U.S. Naval vessels and mobile units are continuously being obtained by communication security activities at Bellmore, Long Island, New York; Imperial Beach, California; Skaggs Island, California; and Guam, Marianas Islands. Results of these measurements obtained during the past two years are shown in figure 1. The number of transmissions in which tolerance limits were exceeded in terms of per cent of total transmissions is plotted against the time base.

Analysis of figure 1 indicates that a general overall improvement has been made. This improvement must continue if the established spectrum and frequency assignments are to be utilized efficiently.

In order to effect improvements, all vessels and activities should comply with the following regulations as stipulated in USF 70(B).

1—Immediately upon being assigned to a task force, each ship shall, at first opportunity in port when not engaged in combat operations, calibrate all transmitters and receivers (including portable equipment) on all appropriate task force frequencies.

2—After initial calibration, shipboard transmitters should normally be checked with the frequency meter only when it becomes necessary to transmit.

3—Under no circumstances should transmissions, however brief, be made for the purpose of testing or adjusting transmitters during combat operations. If, while at sea, a transmitter must be shifted to a new frequency, calibration settings alone should suffice. If the calibration settings are inadequate, adjustments may be made with the frequency meter, provided no plate voltage is applied to the final stage and the transmitting antenna is grounded. Tuning of the final stage and antenna will be accomplished only when it becomes necessary actually to transmit.

NOTE: A method, not requiring any equipment in addition to that already provided aboard ship, has been devised for tuning all of the stages of standard communication transmitters without the necessity for radiation from the antenna. Full explanation of this method is published in the Communication Equipment Maintenance Bulletin (NavShips 900,020A), Page ANT:5.

FIGURE 1.

4—Unless a circuit has been active, it should be standard practice to check the tuning of receivers at least once an hour, using the frequency meter.

5—Frequency measuring equipment should, if practicable, be checked against the standard frequency transmissions broadcast by the Bureau of Standards from radio station WWV near Beltsville, Maryland. Information regarding these broadcasts is published in the Communication Equipment Maintenance Bulletin (NavShips 900,020A) Page GEN:100.

6—Transmitters ashore should be checked as frequently as necessary to insure their being at all times accurately adjusted to the authorized frequencies, *but don't stop there.* After your frequency meters transmitters and receivers have been checked and calibrated and all corrections made for proper operation and emission on the required frequencies, continue to check them periodically. Operators and technicians, working together, are primarily responsible for the operation of communication equipment. Only by proper maintenance and operation will your equipment be on the beam.

TABLE I

INDEX OF FREQUENCY TOLERANCE
FOR U.S. NAVAL VESSELS

Frequency (*kc*)	*Tolerance* (*cycles*±)	*Frequency* (*kc*)	*Tolerance* (*cycles*±)
2058	309	2698	405
2196	329	2716	407
2336	350	2780	417
2656	398	2820	423
2830	425	6692.5	1004
2844	427	8470	1271
2956	443	8590	1289
4155	623	12637.5	1896
4235	635	12705	1906
4295	644	16550	2483
4610	692	16940	2541
5335	800		

Example: For determining frequency tolerance:
Frequency: 8470 kc or 8,470,000 cycles.
Tolerance: 0.015% = 0.00015.

8470000
0.00015
―――――
42350000
8470000
―――――
1270.50000

Tolerance is 1270.5 or 1271 cycles/second.

RADIOLOGICAL DEFENSE AND THE ELECTRONICS LABORATORY

by

J. FORSTER,
Radar Section, Electronics Laboratory, Philadelphia Naval Shipyard

In March 1947, the Bureau of Ships defined the instrumentation for radiological defense as a responsibility of the Electronics Officer. It then became the function of the Electronics Laboratory to distribute, maintain and repair these equipments known as radiac.

By the following year (April 1948) the Chief of Naval Operations had directed that a Navy-wide radiological defense organization be started. To implement this directive the Bureau of Ships initiated (1) a training program, and (2) a small allowance of interim equipment to be used until better field equipments became available.

During recent months, the Philadelphia Electronics Laboratory has been vitally concerned with this twofold program. As regards the training program, one engineer has attended the six-week course at the Army Chemical Center in Maryland. Another engineer and three men from Shop 67 attended the Radiac Maintenance Course held at Hunter's Point, California, in Nov. 1948. In turn, these men are to institute additional local training programs.

In drawing up a radefense bill for the Shipyard, the Electronics Laboratory was actively integrated therein. It is the duty of the Laboratory to train monitoring teams, hold frequent exercises to prepare for emergencies, and calibrate and maintain the radiac equipment. The communications equipment necessary for monitoring in the field is also to be provided and maintained by the Laboratory. From the foregoing, it is logical to include at least one man from Shop 67 on each monitor team. As outlined in the radefense bill, the Radiological Defense Officer has as his assistant a chief monitor to coordinate the monitor teams. The electronics engineer with previous training at Maryland was an obvious choice for chief monitor.

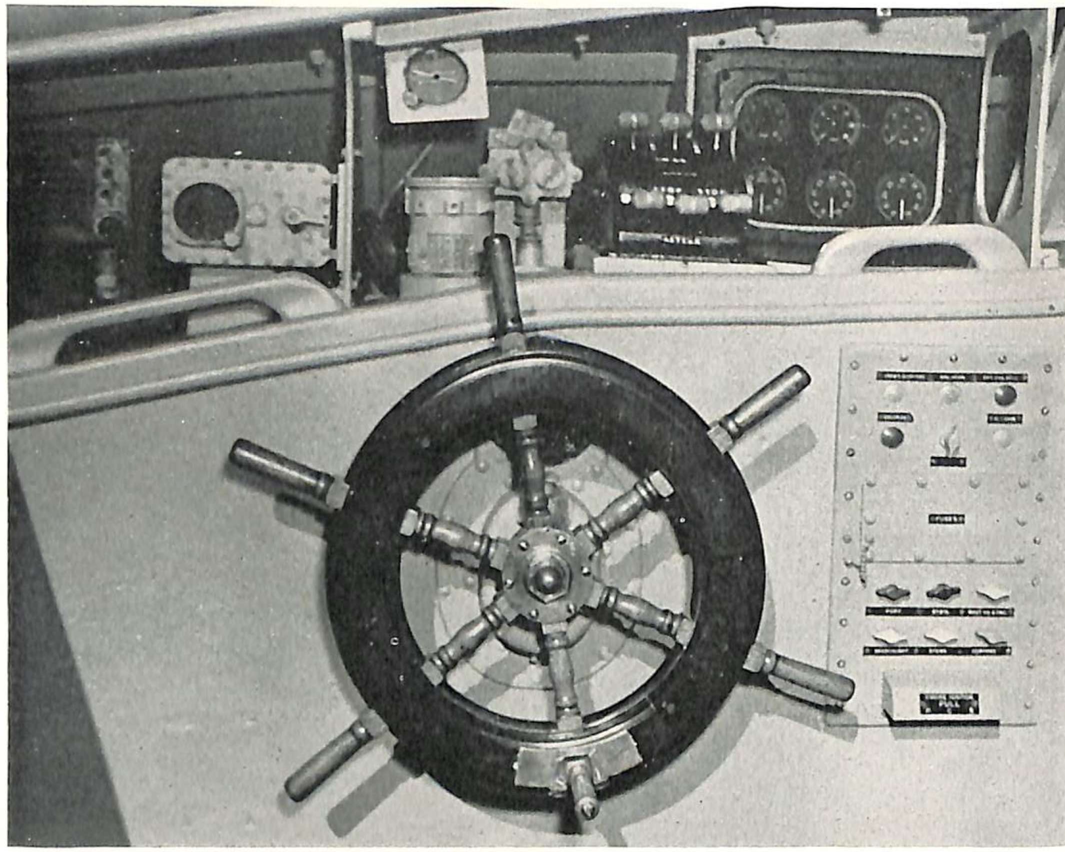
At present, the Laboratory has two Radiac Sets Model AN/PDR–5 (Victoreen Model 263 Survey Meter). One was acquired when the former E. O. at this Laboratory, Captain C. Engleman, returned from the Bikini tests. The other was received on BSSO #126241 of 16 Feb. 1949 for radiac maintenance familiarization purposes. This equipment has been put to a variety of uses. On one occasion, the Material Test Laboratory dropped a radium source in the hold of a submarine. In order to find it the services of the AN/PDR–5 were required.

As this is being written, the Bureau of Ships has issued a modified allowance list for radiac equipment which now includes several equipments for familiarization and several more for use in the area. From another allowance list, the damage control center in this shipyard is to receive a large number of radiac equipments for training of shipboard personnel. At present, the prospective installation of radiac equipments aboard ship is quite limited but surely will increase before long.

From the foregoing, it is certain the future of radiac equipment is intimately bound up with that of the Electronics Laboratory.

ELECTRONICS DESIGN SECTION AT LONG BEACH

by
F. J. FLYNN,
Head, Electronics Design Section, Long Beach Naval Shipyard



EXPOSED CONTROL STATION as it would appear when RCT is under radio control.

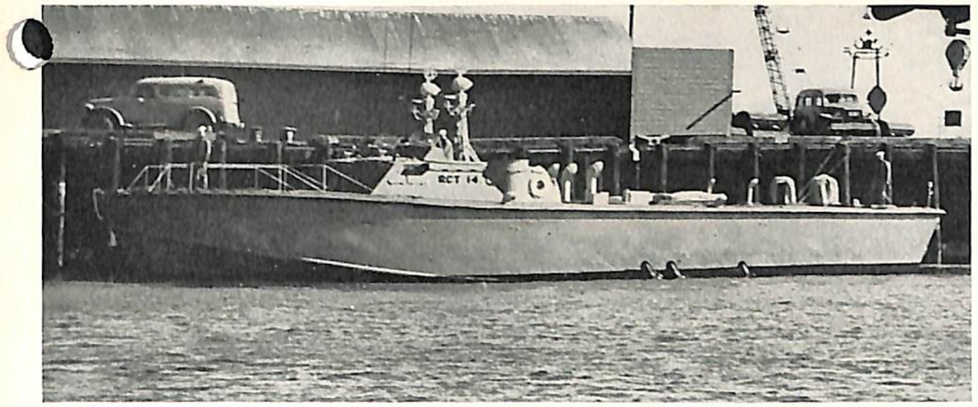
The Electronics Design Section of the Planning Department, Long Beach Naval Shipyard, operates as design agent for all shipboard and some shore electronic installations within the cognizance of the Shipyard.

The routine electronic installations in vessels for which Long Beach Naval Shipyard is planning or home yard are interestingly interspersed by a generous sprinkling of novel conversion or modification jobs to be developed in plan form for application to ships of the fleet.

Most recent was the conversion job undertaken to fit out PT boats as radio-controlled target craft, to be utilized by Naval Air Missile Test Center, Point Mugu, California.

Three PT boats, under command of Lt. R. F. Murray, USN, arrived here for the major operation, and electronics design engineers swarmed aboard to collect essential data. The finished plans included a number of features relevant to the operation of the boats that had not been listed among the general requirements but were considered sufficiently desirable for inclusion. An automatic ignition advance/retard was integrated with the radio controlled throttle operator; an automatic fire extinguishing system was so interconnected with the engine control system as to shut down the engines in the event of fire; selector switch facilities were provided to permit operation of the boats as either drone or control boat as desired. Modifications were necessary to the fluxgate compass system to enable it to operate in control of the radio-controlled boat steering system. Modifications to the steering servo amplifier were required to permit it to control the rudder in the absence of radar in the boats. Special testing techniques were established for the alignment of the radio control transmitters and receivers to ensure maximum stability and interchangeability factors.

Trial runs made by the boats revealed that control could be maintained in a condition 3 seaway on a fixed course and through a distance that was more than adequate. The course could be changed in 1° increments and the speed could be changed in ten steps from idle throttle to full throttle. The writer had seen the old *Utah, Boggs* and *Williamson* under radio control but they could not conceivably provide the spectacular aspect these small fast craft presented by the sight of the helm turning to keep the boat on course while all hands literally went along for the 50-knot ride.



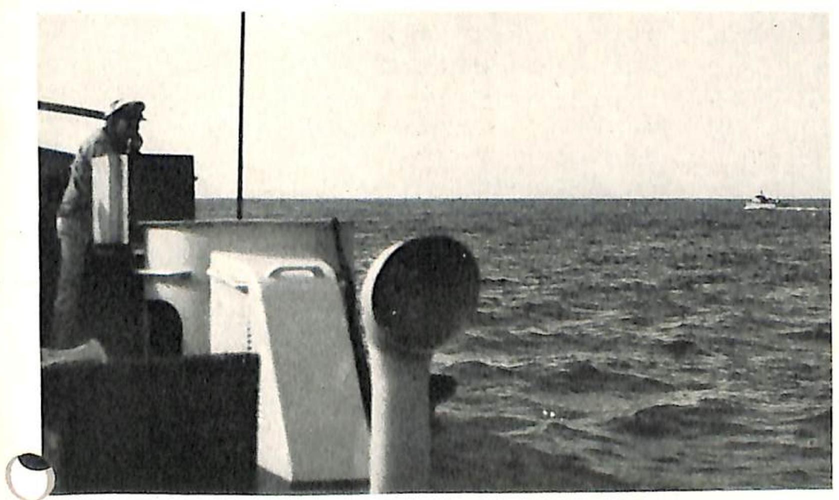
RCT–14 and –15 alongside, prior to a radio-controlled run.

Lt. Murray maneuvered the boats with unbelievable skill while under radio control, and when the dialing system of turning was not fast enough for him he simply punched the security button rapidly while holding the dial off zero. Lt. Murray, knowing the boats and their capabilities, was a far better demonstrator of the flexibility of the radio control system than any of the design engineers along on the sea trials. He even brought the boats into line of bearing by radio control, and racked the nerves of all aboard the controlled craft.

Currently the PT boats (now designated as RCT's 13, 14 and 15) are here for addition of radar and augmented radio communication facilities.

The Electronics Design Section is a portion of the Planning Department but works in close harmony with the personnel of the Electronics Office Ship Section and with the personnel of Shop 67.

It is our constant aim to develop completely workable plans for facile installation of electronic equipment so that this or any other shipyard may utilize them with a minimum of confusion.



NOBODY HOME. At left, Lt. R. F. Murray aboard RCT–15, controlling RCT–14 at the right. At right, RCT–14 under radio control, leaving RCT–15.

MODIFICATIONS TO OKA EQUIPMENT

Certain internal equipment modifications and external wiring changes to the Model OKA Sonar Resolving Equipment are required in order for the sonar system to provide correct outputs to the equipment comprising the Model UB Fire Control System. Although a limited amount of information concerning changes to the Model OKA has been previously provided to certain agencies, the following account contains a complete statement of procedure and material available.

The following field changes shall be accomplished in the Model OKA equipments affected:

Field Change No. 2—OKA, "Provision for External Excitation of Rq Synchros, B–206 and B–207." This modification involves a relatively simple wiring change to the range keeper assembly of the sound range recorder unit, to allow excitation of synchro generators (Type 1G) B–206 and B–207 from an external 115/60/1 source independent of main power input to the Model OKA equipment.

Field Change No. 3—OKA, "Modification to Provide 2000/72,000 Yards Range Transmission." This modification involves removal of four elements of the internal gear train of the range keeper assembly of the sound range recorder, and replacement by four new gear train elements. The replacement parts are supplied in a kit identified by Sangamo Electric Company Part No. 382465.

It must be emphasized that Field Change No. 3—OKA is to be accomplished under the guidance of one of the ASW Field Engineers (Philco Group); inasmuch as Field Change No. 2—OKA involves the same assembly of the OKA sound range recorder, it is desirable that the two changes be performed concurrently. This procedure has been dictated by two factors: the sets of gears required for Field Change No. 3—OKA are available only in limited quantity; and future conversion of Model OKA equipments, now under study, requires that the gear change be performed only in accordance with the field change instructions by an engineer thoroughly familiar with the function of the range keeper assembly of the OKA sound range recorder.

All Model OKA equipments contain, in the sound range recorder unit, a manual range control, B–203. Functionally, B–203 is a Type 1G synchro unit with a handwheel connected to its shaft; the stator order output drives a servo amplifier which positions the range dial and gear train constituting the range keeper assembly. When director transfer relay K–214 is in ON position the stator output of B–203 is transferred to a Type 1DG synchro in certain underwater battery fire control equipment, which adds a shaft order of incremental change of range; the electrical output of this 1DG is then accepted by the OKA and, through the servo amplifier mentioned above, causes the OKA range keeper assembly to follow target sound range changes without manual adjustment of B–203. Late model fire control equipments contain a Type 1G synchro in the computed sound range output and cannot, in consequence, accept the manually-set output of B–203. Discussion of the precise manner in which the $\Delta Rq/cRq$ synchro function shall be connected is currently under discussion between Bureau of Ships and Bureau of Ordnance. Until such time as these discussions are concluded and further instructions are issued by Bureau of Ships, input of computed sound range, originating externally to the OKA in a Type 1G synchro, shall not be connected to the OKA equipment. The external synchro order in question shall be stubbed back at the OKA No. 2A terminal board and director switch S–208 blocked in the OFF position.

Certain field activities have made informal inquiries as to the reason for promulgation of Field Change No. 1—OKA, detailed in the March 1949 ELECTRON as "Alteration to Permit Locking Switch S–204 in Three Positions." As a matter of general interest to all addressees, the reasoning behind this change is here stated. The keying internal switch S–204 on the OKA sound range recorder provides three positions—LONG SCALE, RANGE VARIABLE and FULL SCALE. The switch locks in the first two positions, but not in FULL SCALE. When a sonar target is obtained, keying control of the sonar ranging equipment is transferred to the OKA. At ranges beyond 1500 yards the keying internal switch would normally be locked in the LONG SCALE position; then as the sound range drops below 1500 yards the keying internal switch setting is changed to RANGE VARIABLE or FULL SCALE. The RANGE VARIABLE position re-cycles the OKA keying circuits at sound range plus a constant overtravel. It can therefore be demonstrated that in a series of attacks the consecutive ranges between a submarine target and its surface attacker can be determined by the submarine by monitoring the sonar ranging signals and measuring their interval. In the FULL SCALE keying position, however, the only information available is by monitoring the attack bearing, with current sound range somewhere within 1500 yards. A locking position for the FULL SCALE setting of S–204 has therefore been provided.

1949 ELECTRONICS CONFERENCE AT THE BUREAU OF SHIPS

The EO CONFERENCE in session.

Another milestone in the progress of Navy Electronics was passed May 20 upon termination of the 1949 Electronics Conference. More than seventy top-flight Navy Electronics Officers and their chief civilian assistants arrived 16 May from Naval shipyards, repair bases, fleet service forces, and electronics supply centers to attend the conference and improve coordination between the Bureau of Ships and outlying field activities.

At the start of the conference the representatives heard Rear Admiral D. H. Clark, Chief of the Bureau of Ships, and Captain A. L. Becker, Assistant Chief of the Bureau for Electronics.

Captain Becker opened the conference. In his brief talk he expressed his pleasure at the turnout and the interest displayed by the conferees in meeting with representatives of the Bureau to discuss common problems.

Admiral Clark extended a most sincere and cordial welcome to the conferees. In his talk he pointed out the tremendous expansion of Navy electronics during World War II and emphasized the fact that in any future conflict electronics will be increasingly important. He brought out the fact that economies will necessitate careful selective spending of available appropriations. He also expressed his confidence in the ability of the conferees to arrive at a workable solution to their problems.

During the course of the first day several committees were named, the 1948 conference was reviewed, and many items of progress during the past year were cited.

During the following days the complex ramifications of many questions and problems of wide general interest were brought to light. The "History of Development and Report on First Year Operation of Shop 67" at Mare Island Naval Shipyard was discussed. "Special Electronics Problems Regarding GCA Systems" were discussed. "Special Electronics Problems Concerning Relay Links" came in for their share of attention.

Captain R. J. Arnold, Assistant Chief of the Bureau of Supplies and Accounts for Material and Supply, talked on "Electronics Supply Problems," stating that the goal of the supply department was similar to that of any commercial supplying activity—that of having the material on hand and delivering it prior to the time of need.

One day of the conference was devoted to a familiarization tour of the Naval Research Laboratory. At the laboratory the conferees were met and welcomed by the Director, Captain F. R. Furth. Later, Rear Admiral T. A. Solberg, Chief of the Office of Naval Research, reviewed continuing requirements for a vast storehouse of knowledge in the physical sciences so that the cognizant material bureaus in the Navy Department may prosecute aggressive programs in order to maintain the fleet at the highest state of readiness.

In a speech on "Career Planning for Electronics Personnel" Rear Admiral C. D. Wheelock, Deputy and Assistant Chief of the Bureau of Ships, expressed his faith in the value of a long-range selection and training program for electronics personnel.

The "Shore Station Naval Reserve Electronics Program" also was discussed fully at the conference.

Captain Beltz, Deputy for Electronics, in his speech "What Is The Navy Getting For Its Money?" pointed out that with limited funds electronics activities must overhaul their accounting systems in order to get a dollar for dollar value from their allotments.

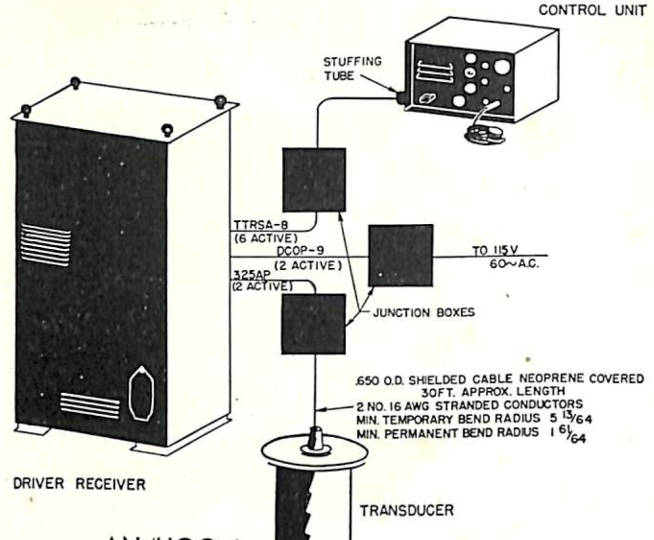
In the closing address of the conference, Captain Becker indicated that this had been one of the most interesting and profitable of such conferences. He felt that the interchange of ideas which had occurred would tend to stimulate thinking so that we could all do a better job of developing, installing, and maintaining Navy electronic equipment. He also stressed the need for team-work, cooperation and originality.

In regards to the "future of electronics," he pointed out that any defense against guided missiles and high-speed submarines will consist of some type of electronic device. "The Electronics Age is not around the corner," said Capt. Becker—"it is here!"

SINGLE SIDEBAND UNDERWATER TELEPHONE

One of the most significant advances in underwater communications since the end of hostilities has been the development of the underwater telephone by the U.S. Navy Underwater Sound Laboratory, New London, Connecticut. This equipment makes it possible for voice communication between two or more submerged submarines, submerged submarines and surface ships and even submerged submarines and aircraft. A carrier frequency of 8 kc is used, and single sideband suppressed carrier transmission is employed with the result that all of the energy transmitted conveys intelligence.

Upwards of a dozen underwater telephone equipments have been in service for over one year so that considerable operational evaluation has been done. Ranges of 10,000 yards may be considered reliable and communication distances of 30,000 yards and more have been reported. It is generally possible to communicate further using the underwater telephone than by telegraphic signaling on the same frequency. This rapid fire communication makes possible employment of submarines in exercises which would have been impossible heretofore. For example, at Surface Anti-Submarine Development Detachment the OCE will often be aboard a submerged submarine and direct the maneuvers of surface ships in the vicinity to carry out a particular mission. By stop-watch timing of mark signals, the range can be accurately determined within the limitations of the range of the day for the underwater telephone. Submarine Squadron 6 found the telephone to be a powerful aid in keeping station on a picket line. An exercise was recently performed which required the location of another submarine within an area of 100 square miles. With the use of the underwater telephone the lost submarine was located on the first pass through the area. This makes the equipment very valuable for effecting a rendezvous as well as for location of a submarine in distress.

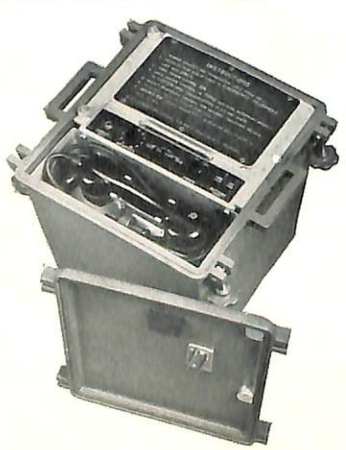


AN/UQC-1

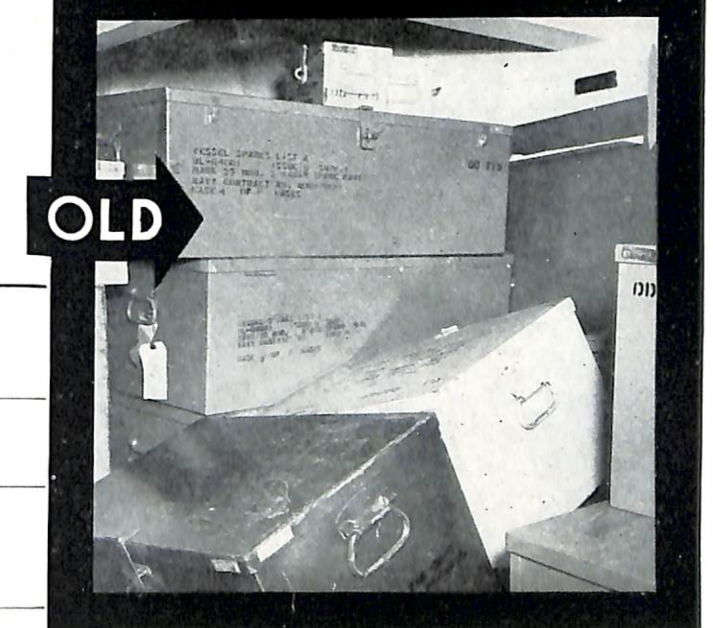
Underwater telephones are being manufactured in two sizes. The large unit (AN/UQC-1) for installation on submarines and surface ships as an instrument for regular communication use, has an output of 400 watts. One such equipment is being procured for each fleet submarine in commission and in addition for a limited number of surface ships which may regularly have occasion to operate with submarines. The second type of underwater telephone (AN/BQC-1) is intended for emergency use, contains its own battery power supply, and has a power output of one watt. A reliable range of 1000 yards is obtained. The emergency underwater telephone is also capable of emitting a beacon signal on a standard echo-ranging frequency. This will allow a surface vessel to home on a submarine in distress. Three of these equipments will be installed on each fleet submarine. They will be located at opposite ends of the hull and may be put into service when all other power on the boat has failed.

At the present state of development, the underwater telephone has practically no security insofar as interception is concerned. The addition of a speech-privacy system, if and when such an equipment is reduced to a practical size, could be readily accomplished. The present telephone transmits in all directions, which also invites interception. Current development is directed toward improvement of these conditions. Experimental transmissions have been maintained between aircraft and submarines using a surface vessel as a relay point. Development of an expendable buoy to serve as a sonar radio link between the two craft is now underway at the U.S. Navy Underwater Sound Laboratory.

AN/BQC-1



BUSHIPS Electronics Repair Parts Program



These on-the-spot photographs represent the "old" and the "new" method of electronic repair parts stowage. The May, 1949, issue of BuShips Electron shows the actual space and weight savings that have been realized by the new system of stocking parts in bins by standard Navy stock numbers in accordance with the Bureau of Ships new allowances.

The "box score" below shows the number of ships converted to the electron tube allowances and repair parts allowances to date.

PROGRESS REPORT
ELECTRONICS REPAIR PARTS PROGRAM

Allowance	Type Vessel	Percent Completed
Electron Tube Allowance	Submarine	100%
	Surface	80%
Repair Parts Allowance	Submarine	10%
	Surface	0%


YES....
this issue
is confidential!
SAY, AREN'T WE SUPPOSED TO PASS THIS AROUND FIRST?
But don't Bury it!
DON HESTER
CONFIDENTIAL