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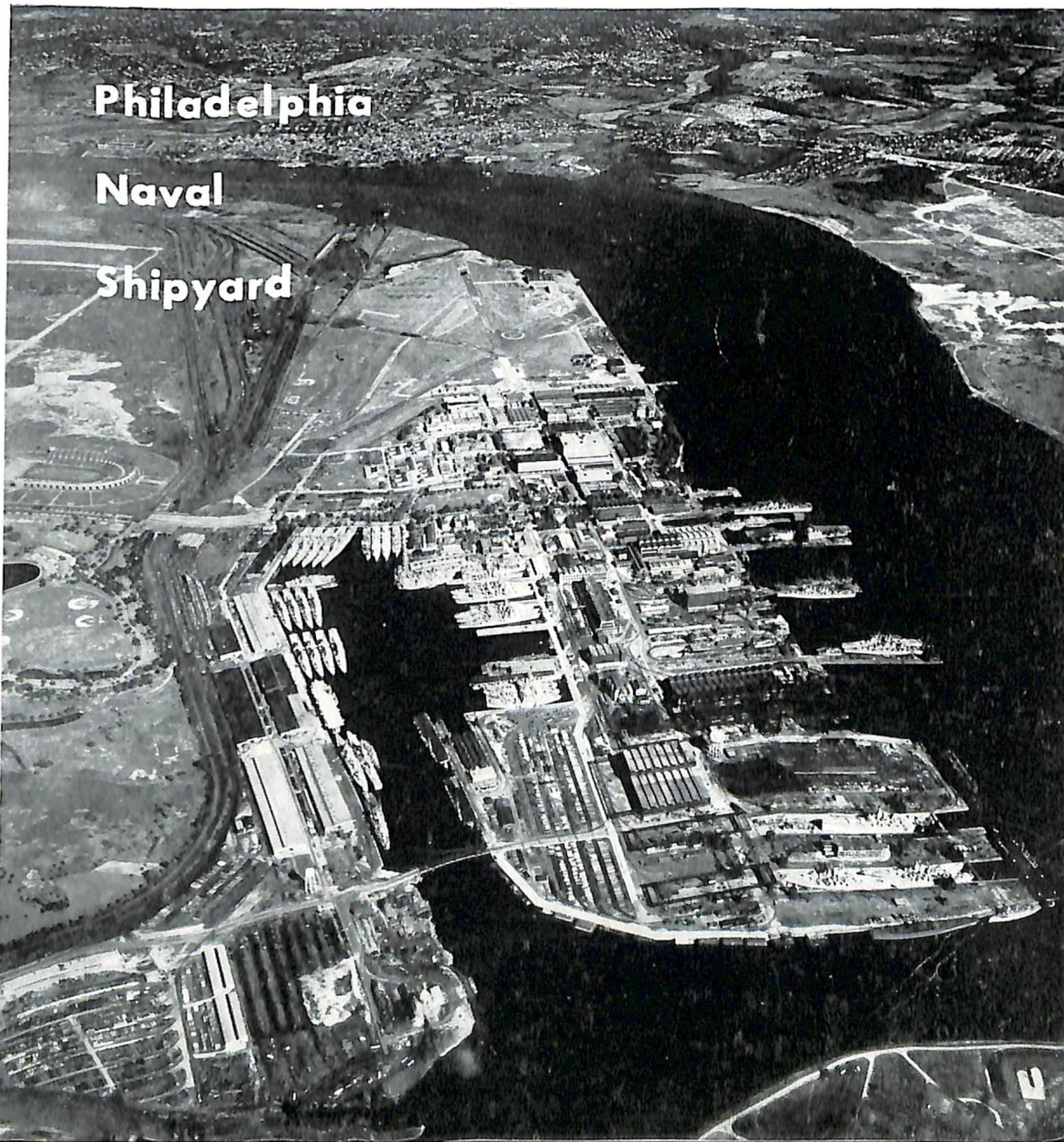
NavShips 900,100

BUSHIPS Electron

FEBRUARY 1949



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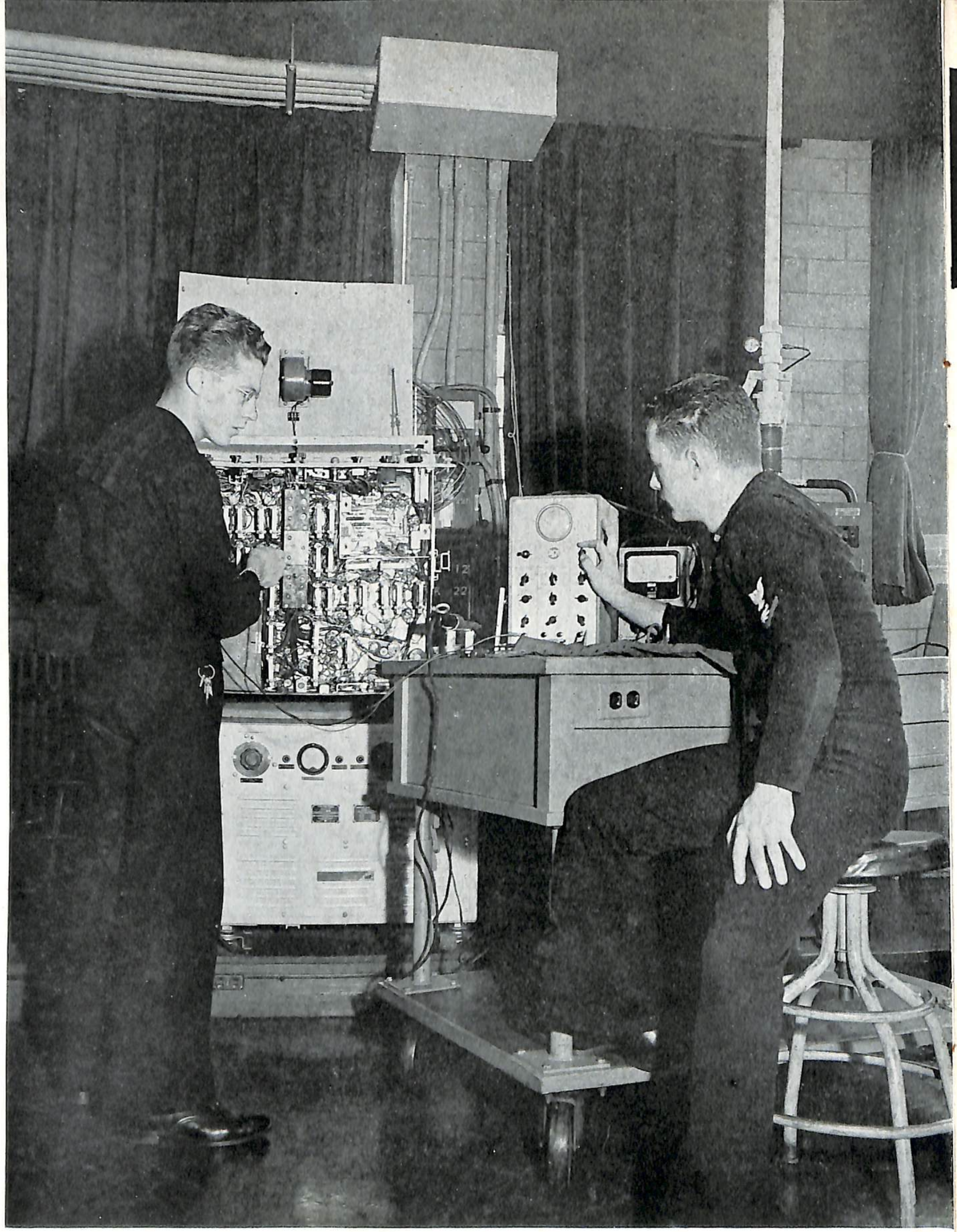

STUDENT TECHNICIANS,
Electronics School, Philadelphia Naval Shipyard

BUSHIPS Electron

A MONTHLY MAGAZINE FOR ELECTRONICS TECHNICIANS

FEBRUARY · VOLUME 4 · NUMBER 8

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BUREAU OF SHIPS — NAVY DEPARTMENT

Rear Admiral Homer N. Wallin, U.S.N.
Commander, Philadelphia Naval Shipyard

HOMER N. WALLIN

REAR ADMIRAL, U. S. NAVY

Rear Admiral Homer N. Wallin assumed the duties of Commander of the Philadelphia Naval Shipyard on 7 January 1947, having reported from duty as Supervisor of Shipbuilding in the Seattle area.

Born in Washburn, North Dakota, on 6 December 1893, he attended Jamestown Academy, from which he was graduated in 1912. He entered the Naval Academy in 1913, and upon graduation in 1917, was assigned to the Atlantic Fleet. He served aboard the ***U.S.S. New Jersey*** in World War I, and was recommended for the Navy Cross in recognition of general over-all performance of duty aboard that vessel. Thereafter he transferred to the specialty of engineering, and completed post graduate instruction at Massachusetts Institute of Technology.

Rear Admiral Wallin has served in various capacities at several different Navy Yards and at the Navy Department. At the outbreak of World War II, he was serving aboard the ***U.S.S. California***, at Pearl Harbor when the Japanese attacked the Pacific Base, 7 December 1941. Thereafter, he was assigned as Salvage Officer for the Pacific Fleet, and was awarded the Distinguished Service Medal by Fleet Admiral Chester W. Nimitz, in recognition of his performance of duty. He later assumed the post of Assistant Fleet Maintenance Officer, and in November 1942 was assigned to the staff of Admiral William F. Halsey, as Maintenance and Salvage Officer. For his outstanding service to the Government in the latter post, he was awarded the Legion of Merit by Admiral Halsey.

In November 1943, he was assigned as Supervisor of Shipbuilding in the Seattle area where he served until the end of 1946. For his successful direction and supervision of the shipbuilding program in the Seattle area, Admiral Wallin was presented a Commendation from Secretary of the Navy James Forrestal.

HISTORY OF ELECTRONICS AT THE PHILADELPHIA NAVAL SHIPYARD

ELECTRONICS LAB

By William C. Bechler

Electronics Laboratory, Philadelphia Naval Shipyard

Shortly after the Navy Department came into being in 1798, the Philadelphia Navy Yard began its career as a government establishment.

Philadelphia had been one of the leading ship-building centers for Naval vessels of the Revolution, the Tripolitan War and the Naval War with France. The first Naval constructor, Joshua Humphreys, fitted out the first American Fleet in his private yards at Philadelphia. This little fleet left Philadelphia for service in the Revolutionary War in 1776 under the command of Captain Esek Hopkins. In 1797 the *United States,* first of the six frigates which were to play such an important part in our fight for freedom of the seas, was launched at the yards of Joshua Humphreys, on the Delaware close to Old Swedes Church. The *Constellation, Constitution, Congress, Chesapeake* and *President* followed shortly and were privately constructed.

The Secretary of the Navy was directed to have constructed two docks, and to have built or purchased six ships of war having 74 guns, and 6 sloops of 18 guns. Philadelphia was chosen as the site for a Navy yard to construct these ships, and in 1801 a total of seventeen and three-quarters acres of ground was acquired on the Delaware river front, extending from the foot of Washington Street to Reed Street. From 1815 to 1875 a total of 35 vessels of war was constructed at this Navy yard. The first of these was the 75 guns line-of-battleship *Franklin* launched in 1815. The first screw-propelled vessel built for the U. S. Navy was completed in 1843. A revival of Naval ship building was caused by the Civil War, and Philadelphia played a prominent part in the construction of the blockade fleet of that war. The increased activity caused by that war and the advent of the ironclads clearly revealed the limitations of the old Navy yard as a building yard for modern vessels. In 1862, the City of Philadelphia purchased the present site of the Navy yard, League Island, and offered it to the Federal Government for use as a Navy yard. The yard was established at its present location on January 7, 1876.

The original site had 406 acres above water but by filling in the marshes and back channel the usable acreage was increased to 685.

In its new location, the shipyard specialized in overhaul, repair and modernization work until shortly before World War I when the transport *Henderson* was laid down, an event which marked the advent of the shipyard into the ranks of new construction yards. During World War I, the yard itself was modernized by the addition of three shipways, two drydocks and the 350-ton hammerhead crane. This facilitated the construction of the first mechanically stabilized hospital ship *Relief,* the destroyer tender *Dobbins,* and four minesweepers. Between World Wars I and II the yard assumed its original role of repairing, overhauling and modernizing the Navy's ships, and it was not until 1931 that new construction was once again undertaken with the building of the cruiser *Minneapolis,* followed by the destroyers *Alwyn, Cassin* and *Shaw,* four Coast Guard cutters, and the cruisers *Philadelphia* and *Wichita.*

More than 1200 fighting ships were repaired and outfitted between 1939 and 1945. These ships included the battleships *New Jersey, Washington* and *Wisconsin;* the cruisers *Chicago* and *Los Angeles;* the carriers *Antietam, Princeton* and *Valley Forge;* and numerous LST's. The workload was such that the number of yard employees increased from 5400 to 46,000. During the World War II expansion program, Drydocks 4 and 5 were added. At the close of the war, the yard began to get back to a peacetime basis. At present, approximately 10,000 employees are engaged in maintaining the forces afloat and the Reserve Fleet Units.

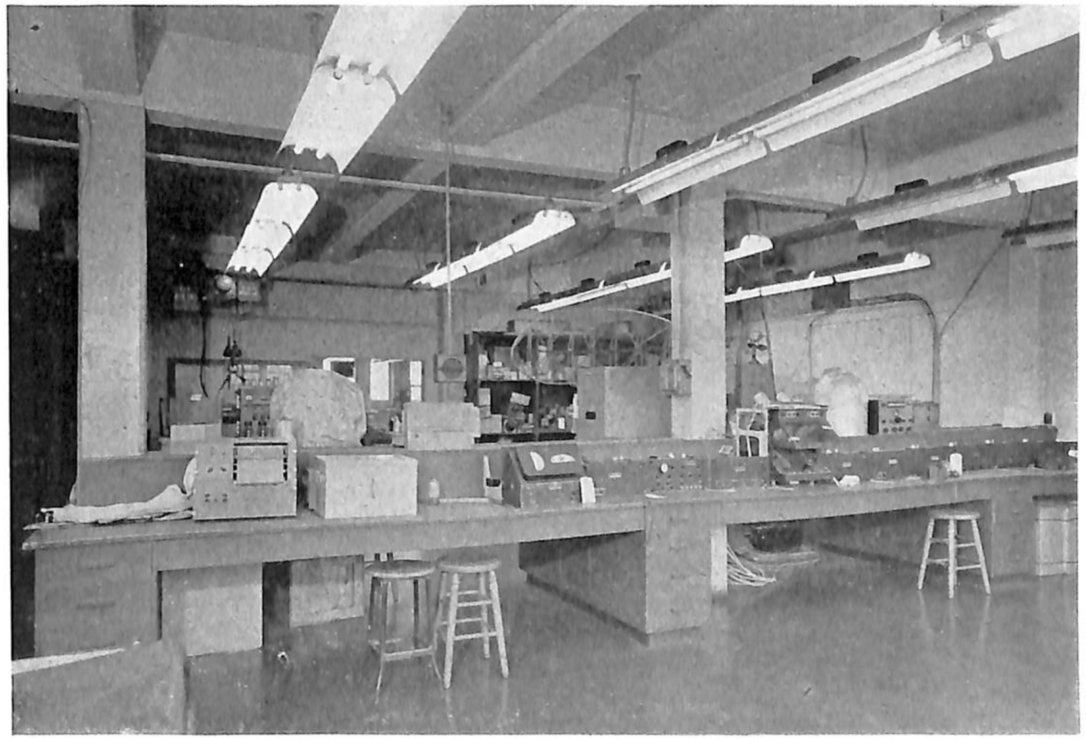
The Electronics Laboratory

The Electronics Office was originally established as the Radio Laboratory by the Bureau of Steam Engineering in May 1916, for the purpose of providing a space for the testing of radio equipment by technicians. Senior technicians were known as Expert Radio Aids and their assistants as Radio Electricians; all were technically trained in the art of wireless communications.

Research and development problems in which the Navy Department was interested were assigned to the Laboratory in addition to its routine test work. The original space for the Laboratory was provided by the allocation of approximately 500 square feet in the electrical shop building. Personnel was limited to one Expert Radio Aid and one Radio Electrician who were assisted in their work by the electrical shop personnel and one shop supervisor who had been previously trained at the Navy Yard, New York, in the art of "tuning" and adjusting spark transmitters.

One of the major research and development problems assigned to the Philadelphia Laboratory during its early days was the design of a radio compass (direction finder) for both shipboard and shore station use.

With the entrance of the United States into World War I, rapid expansion took place to meet the requirements of the fleet and shore stations. Additional space was provided and personnel increased rapidly until ap-



ELECTRONICS LAB Test Bench Facilities.

proximately thirty radio engineers were employed. At this time, the policy of assigning Radio Material Officers to the several Naval Districts was established and Cdr. R. T. S. Lowell, USN was assigned to the Fourth Naval District and the Navy Yard, Philadelphia.

It might be well to mention here that during this period the development of the radio compass for military use was prosecuted in the Radio Laboratory by Mr. Stewart Ballantine, whose papers on electronics were widely read by engineers throughout the country, and who later was honored by election as president of the Institute of Radio Engineers in 1935.

Immediately following the conclusion of World War I, the problem of establishing radio direction finder stations at all harbor entrances along the Atlantic Coast was authorized by Congress for the "safe return of troops from Europe." The Radio Laboratory, Philadelphia, performed all the engineering and drafting work in connection with this problem and established the first experimental group of stations at the Delaware Bay entrance. Similar stations were later established on the East and West Coasts and were maintained by the Navy for military purposes, while concurrently furnishing positions for navigational purposes to all foreign and American shipping until July 1941, when they were turned over to the U. S. Coast Guard.

As the ship construction program was completed in this area subsequent to the war's termination, the work of the organization decreased gradually to a routine maintenance and improvement program for ships and shore stations. By 1927, the personnel consisted of the Radio Material Officer and three technical engineers. Assignments of special research problems were few in number, as this work was concentrated at the Naval Research Laboratory. Several development projects were completed during this period, viz.: the design of suitable direction finder equipment for rigid airships and the aircraft carriers *Saratoga* and *Lexington*. The underwater sound work of the unit increased during this period. Many ships were equipped with both acoustical and electrical sounding and ranging devices. New models of depth finding equipment were installed on ships assigned to survey duty which used this yard as the home yard.

In 1933 a drastic reduction in Naval appropriations, coupled with employment of the major units of the fleet in the Pacific, further reduced the activities of the Navy yard and the work of the Radio Laboratory in the district. In 1933 the Laboratory was moved to a new building, occupying approximately 3600 square feet.

From 1934 to 1939 the activity was limited to the maintenance of district communication and direction finder stations and the technical supervision of initial electronic installations in new construction ships at this yard and in commercial yards in this area.

THE ELECTRONICS OFFICER

COMDR. HUBERT E. THOMAS, USN

After attending school at the Staunton Military Academy, Commander Thomas graduated from the University of Colorado in 1927 with a degree in Electrical Engineering. He joined the Radio Corporation of America as a radio engineer upon graduation and in 1931 was commissioned Ensign in the United States Naval Reserve. After 12 years with RCA he entered the Navy on active duty and was initially assigned to the Naval Air Station, Pearl Harbor, as Communication Officer. In 1941 he was transferred to the Electronics Office, Pearl Harbor Navy Yard, where he had charge of the shore electronics installation program in the 14th Naval District. In 1943 he reported to CincPac for duty on the staff as Radio Planning Officer and in 1945 was ordered to the Electronics Division, Bureau of Ships, as head of the Field Services Group. He received his commission in the regular Navy in 1946 just prior to his assignment to the Naval Gun Factory as Electronics Officer. He reported for duty as Electronics Officer, Philadelphia Naval Shipyard, in October 1947, relieving Capt. C. L. Engleman.

ELECTRONICS LAB DIRECTOR

WILLIAM C. BECHLER

Mr. William C. Bechler was born near Philadelphia, Pa. on May 8, 1899. Even before his graduation from high school he had become actively interested in amateur wireless and operated amateur station W3AAV. He completed an apprenticeship as an electrical machinist at the Philadelphia Navy Yard, specializing in ship and shore radio work in the Philadelphia area. In 1922 he was graduated in Electrical Engineering at the Drexel Institute of Technology.

In January 1927, he was appointed Senior Inspector of Radio and placed in charge of the Ship Section of the Radio Laboratory. He developed the remote control direction finder installation with demountable loop for use in 1200-ton destroyers. As a result of drastic reductions in Naval appropriations in 1933, he was the only electronics engineer retained in the yard organization. In 1939, he began the recruitment of an electronics organization to meet the rapid expansion of the Naval electronics program.

Mr. Bechler received the Meritorious Civilian Service Award for meritorious service of unusual value to the Navy by the organization and direction of the Electronics Laboratory during a period of remarkable advancement and expansion in the field of electronics during the national emergency and World War II. He is a member of I.R.E. and the Engineers Club of Philadelphia.

In 1937, due to the proposed erection of a copper and pipe shop in the area in which the Laboratory was situated, the activity was relocated in Building #48, which was fitted out by the Public Works Department Officer, using the WPA organization assigned to the yard. This building was a two-story brick building with approximately 5000 square feet of floor space, and with the addition of a material loading platform, it provided adequate facilities to meet the expansion necessary for the early days of the national emergency and World War II.

In the development of the organization for wartime operation, the Laboratory was divided into specialized groups, each group being responsible for its respective work on ships and at shore stations. Civilian engineers, as well as officer engineers, were assigned to the organization. The present electronics building containing approximately 7500 sq. ft. was conceived in 1942 to meet the expanding electronics program, but was not completed until early in 1944. At the close of hostilities, a plan was under way to erect an addition to the building, which was already overcrowded with the engineering staff. On 1 September 1945, a staff of 65 officers, 25 Navy civilian engineers and 36 contractor field engineers were engaged in the electronics program in shipbuilding yards and shore stations of the Fourth Naval District.

With the ending of the war, plans for an adequate peacetime organization were formulated. Certain estimates as to workload were assumed in order to determine the required number of civilian technical engineers. It was also assumed that the manufacturers' field engineering contracts for technicians' services would be terminated and that the commissioned engineering officers used to augment the Laboratory staff for wartime operation would be reduced through demobilization procedure.

The shipbuilding program in this area was rapidly completed, and with the exception of recently authorized construction, the yard has been gradually transformed into an almost 100% overhaul, repair and maintenance activity. It has, therefore, become necessary to develop a large electronics repair shop to meet this changing condition.

With the reorganization of the Navy yard into a Naval shipyard on 30 November 1945, and the designation of the Electronics Officer as Technical Assistant to the Shipyard Commander, the present engineering force was organized to carry out its responsibilities under the new shipyard organization. The engineers of the Electronics Laboratory working with the newly organized Shop 67 group are developing an organization which will be able to adjust to the everchanging needs of our "new" Navy.

FROM MOUNTAIN TERRAIN TO THE ROARING MAIN

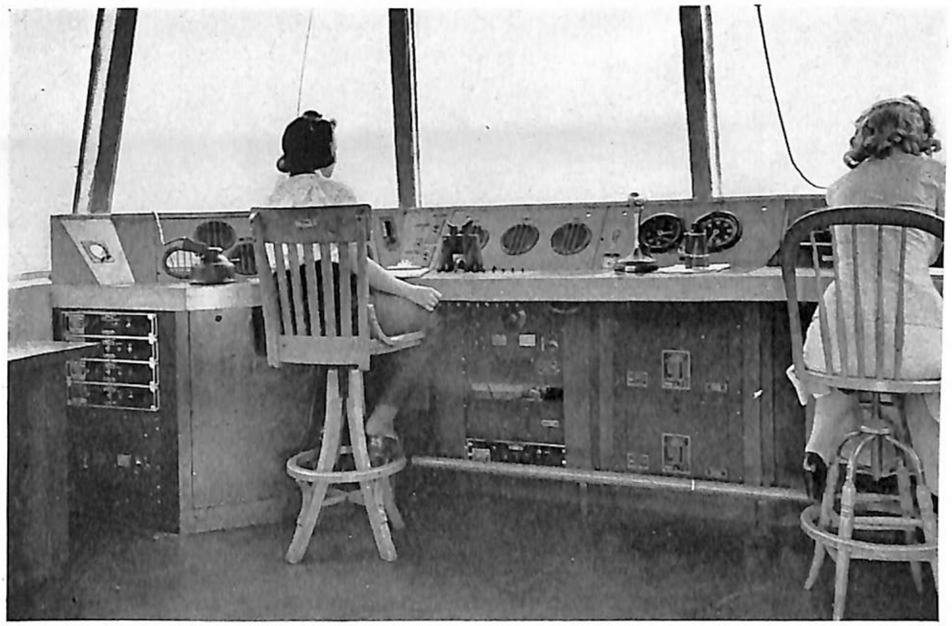
RADIO TRANSMITTING ANTENNAS, Cape May, N. J.

By Wm. F. Ebert, *Philadelphia Naval Shipyard*

Shore station activities of the Fourth Naval District are varied and cover a large geographical area extending from Erie and Pittsburgh on the west to the Atlantic Coast on the east. Much of the routine work of the Electronics Laboratory (which is a "must" in every organization) is accomplished by this section, but other phases of the work do not belong in this category. A large portion of the work is carried on at far-flung points, giving rise to difficulties not ordinarily met in the shipyard itself, which is interested primarily in the construction and maintenance of ships. The shore station section is responsible for the installation, maintenance and inventory of all communication equipment in air stations and auxiliaries, schools, reserve centers and facilities, and communications centers.

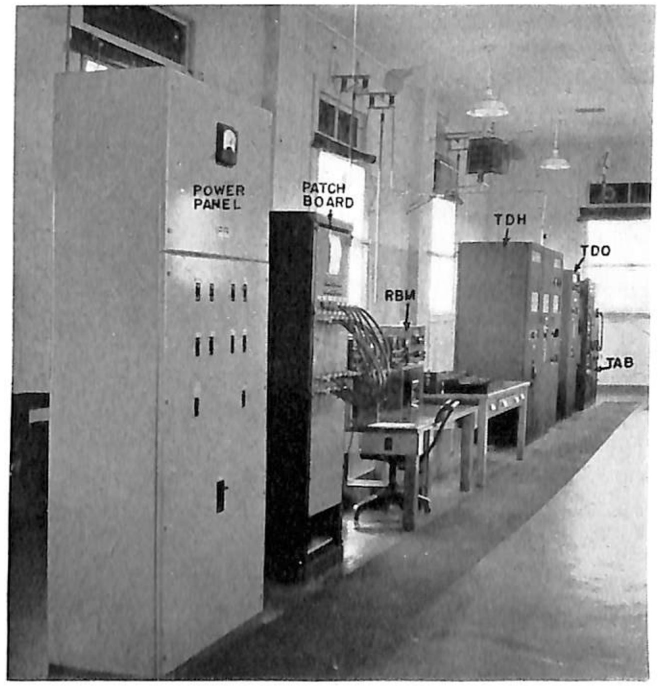
For example, in this district there are five Naval air stations and two communication stations which have, in addition to the more usual receiving transmitting and teletype equipment, air navigational aids such as radio beacons, racons, radiosonde, airway localizers, air surveillance radar and ceilometers. In connection with some of this equipment, many problems come up which call for originality of thought and engineering ingenuity on the part of the personnel in charge. The following are a few examples of particular interest.

1—When the Collins autotune transmitters, such as the Models TCC, TCB, TDO and TDH were first supplied for shore stations, it became apparent that for proper operation a telephone dial control, which is the only means of controlling these equipments, would be required at each operating position which sometimes numbered as high as fifteen or twenty. The only useful dials for remote use where those mounted on the two preamplifiers furnished with each equipment. To install a preamplifier at each operating position would have been impracticable due to space limitations, cost and lack of availability. The difficulty was overcome by supplying small portable units, consisting of an inclined front case approximately 4 x 4 inches, mounted with an 11-position dial. The unit was fitted with a short two-conductor cord and a two-contact phone plug. These portable units were plugged into two-circuit self-closing phone jacks which were mounted in each of the standard 23005A key-control panels at each position. The jacks were wired in series with the start-stop line of the control switch. With this arrangement it is merely necessary to insert the plug from the portable dial in the desired operating position, close the start-stop switch on the key panel, and the autotune transmitter, which is patched through the transmitter plug board, can be completely controlled and shifted to any of its ten frequency channels. Proper impedence matching circuits were also installed to adapt the dynamic desk microphones, furnished with the TDO and TDH transmitters, to the remote transmitter control system, to replace the carbon microphones originally supplied with the TCC and TCB transmitters. A system of automatic receiver muting by relays operated from the carrier press-to-talk circuit was developed to eliminate the objectionable receiver feedback which occurs when loudspeakers are used on the receivers.



CONTROL TOWER, Mustin Field, Philadelphia, Pa.

2—When the air station traffic control towers were first outfitted with electronic equipment, BuShips recommended that the transmitter control be arranged to permit simultaneous operation of any or all transmitters on the traffic control channels. This arrangement is referred to as "cornetting" of transmitters and is very desirable in control towers. However the intricate equipment to accomplish this type of operation has never been supplied. To meet these requirements a unit was developed by the shore section of this yard which has proved entirely satisfactory and is in use at all the stations in this district. The cornet unit consists essentially of a high-gain two-stage audio amplifier which couples the voice



NAS Radio Transmitter Building, Lakehurst, N. J.

MOBILE RADIO WORKSHOP,
Naval Shipyard, Philadelphia, Pa.

transmission from a crystal microphone into the grids of ten tubes, connected as cathode followers. The ten circuits are then carried through telephone type lever switches, through the patch boards and remote lines to the transmitters. Suitable attenuators are provided on each cathode follower to adjust individual lines to the desired db level. An additional circuit is incorporated for press-to-talk carrier control through a multiple contact relay with a make-break contact for each control channel. With this arrangement, any group of transmitters can be selected, or any number up to ten can be placed in simultaneous operation by merely flipping the lever switches. The cathode followers provide a wide range of impedence matching, and eliminate all cross-talk or circuit reaction. In this connection as in the communication station muting, relays were installed on most of the receivers to avoid audio feedback. Additional refinements were added in the form of a receiver control panel which provides instantaneous manual muting or signal boosting as desired on any of the tower receivers by the mere flip of a switch. This unit incorporated a visual indicator for each receiver, to indicate to the tower operator the channels over which signals are being received, and includes matching circuits to a voice recorder which records all incoming and outgoing communications. The operation of the recorder is controlled by a special relay circuit also developed by the shore section, which automatically starts the recorder whenever voice transmissions of sufficient levels for recording are present, and, upon cessation after a slight delay, the recorder is disabled.

3—Most air stations are now equipped with ceilometers as part of their air navigational aids. These equipments employ an elaborate spring-operated reversing switch on the light beam projector which oscillates through an arc across the zenith. The switches furnished with the equipment have in all cases been found erratic and unreliable. A new switch movement employing microswitch contacts and cam controls is presently being developed by this section and it is believed that this improvement will provide reliable operation and permit full use of these equipments to be realized.

4—Extensive improvements are being made in the use of radiosonde at NAS Lakehurst, N. J. By direction of BuShips, the operating frequency of these units was recently changed from 75 megacycles to 403 megacycles. This necessitated installation of entirely new equipment and antennas. Some experimental equipment was furnished by the National Bureau of Standards for this installation, and was set up for successful operation through the cooperation of personnel of this section with the representative of the Bureau of Standards. Development of improved antenna arrays is presently under consideration and the installation of a new type of radar equipment to replace the present Mark 4 radar is scheduled, for use in tracking the RaSonde balloons beyond the range of the regular receiving equipment.

5—In connection with mobile radio installations in vehicles for security and other purposes, it has been found that few of the normal vehicular electrical systems are adequate to carry the added heavy load of these two-way radio equipments. To permit satisfactory and unlimited operation, special high-current low-speed generators with oversize batteries are being installed on all vehicles where necessary.

The outfitting of twenty-two Naval Reserve training centers and a number of Electronics Warfare and Naval Reserve Officer training centers are recent additions to the responsibilities of this section. All BuShips manufacturing projects awarded the Philadelphia Naval Shipyard are under the cognizance of the shore section, together with special projects for maintenance, improvement and expansion of communication facilities in the Fourth Naval District.

A special project assigned to shore stations is the periodic overhaul and reconditioning of ground-controlled-approach equipment. The area which is to be served extends west to the Rockies and over the Atlantic Ocean area. This is a program of large proportions and requires careful planning, and the coordinated efforts of many persons to keep it up to schedule and effect a satisfactory and complete overhaul. The scope of the GCA program takes in general overhaul, manufacture of parts, components and field changes, maintenance, training and field service. Since GCA has become the Navy's choice for bringing aircraft to safe landings during conditions of limited visibility, this special project has become increasingly important to the safety of airmen.

At present, installation of various electronic equipments is in progress in a section of the electronics building. This is part of a familiarization program recommended by BuShips for the purpose of instructing both military and civilian personnel in the operation and maintenance of new types of equipment which are constantly being developed to replace less efficient and obsolete types.

"HE JUST FOUND OUT A LETTER OF HIS WAS PRINTED IN THE Electron ORBIT"

The functions of this section involve the handling of large volumes of official correspondence, proper allocation of numerous funds, planning and scheduling of work, drawing of layouts and sketches and preparation of numerous routine reports. The handling of the perpetual inventory of all electronic and associated equipment at all of the activities in this district is the concern of the section. All of this work is covered by the engineering personnel of the shore section in addition to their engineering and supervision duties.

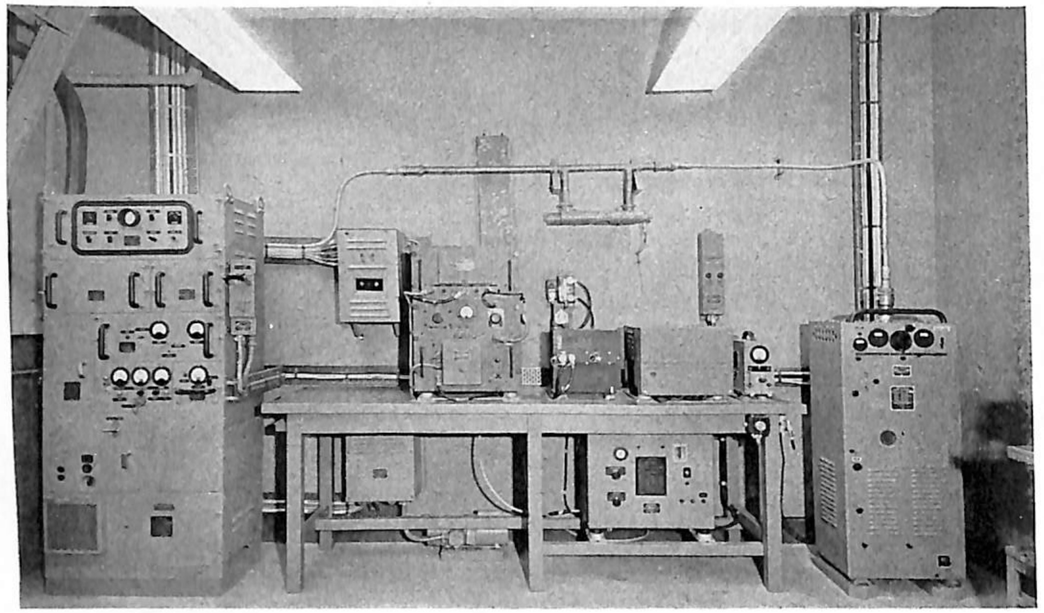
The upkeep of the Electronics Laboratory and the radar school which are housed in the same building with the Electronics Office are also the shore section's responsibility. This section is headed by Mr. William F. Ebert.

THE AUTHOR

Mr. Ebert came to the Philadelphia Naval Shipyard in May 1919 as a Radio Inspector in the Radio Laboratory. In 1921 he transferred to supply as a stockman for technical stores. He left the yard in 1925 but returned to the Radio Laboratory in 1926 and worked on shipboard and shore stations, installing and adjusting radio and sonar and radar equipment. Calibration of test equipment and direction finders was a major part of his work. The assignment of engineer in charge of shore station communication facilities came to Mr. Ebert in 1941. Since then the Shore Stations Section has assumed more and more responsibility for communication installation, maintenance and security of all shore-based electronic equipment.

ELECTRONICS INSTALLATION PROGRAM

RESERVE TRAINING CENTER
FOURTH NAVAL DISTRICT



N.R.T.C. Radar Transmitter Room, Lancaster, Pa.

By Lt. John Meehan, USNR

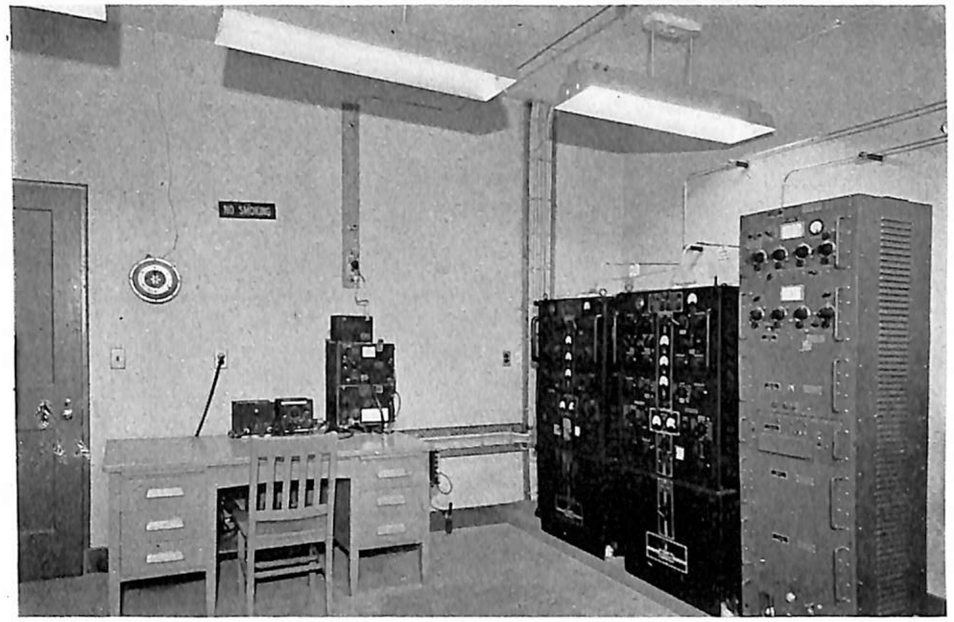
When the electronics installation program for the Naval Reserve Training Center was placed under the cognizance of the Naval Shipyard Philadelphia, there were twenty-one training centers in twenty cities to be fully equipped. A start had already been made through the Electronics Warfare Program, initiated in May 1946. Some equipment was provided at each armory although specific allowances had not been established. Reserve personnel on temporary duty and those in the Organized Units working during regular drill periods had installed and placed in operation some training equipment in every armory. All Organized Units of the Naval Reserve were participating in a regular scheduled drill circuit.

Meanwhile, CNO established an allowance for all training centers and BuShips set up the machinery necessary to supply the material and to get the program under way. The completion date was set for January 1949.

Considering the problems of supply, transportation and manpower requirements, together with the fact that this program had to be fitted in with the shipyard's own production schedule, it immediately became apparent that every short-cut possible would have to be taken. Extensive planning and detailed design were out of the question. Preliminary investigations and inventories indicated that many of the electronic items were inoperative, incomplete and in need of extensive repair. Space in the training centers was at a premium and shop facilities on the site were not always available.

The first two training centers to get under way were the two located in Philadelphia. From these two installations, requirements in the way of planning, design, and procurement of accessory materials were determined. Antenna brackets, radar platforms, and miscellaneous foundations were prefabricated at the Yard and shipped to the site. Equipment was installed from a general layout plan and elementary wiring diagrams. Included in the general layout was a radio receiving room, a radio transmitting room, a radar transmitting room, a CIC room, a code practice room and an electronics workshop.

The radio receiving room consisted of six operating positions complete with phone jacks and remote key control units, receiver, transmitter radiophone and antenna transfer panels; radio direction finder, frequency meter; supervisor's desk and emergency operating position. The transmitting room is laid out with two TDE's, one TBM or TBK, one TBL or TAJ, one TDT or TDQ, a frequency meter, supervisor's desk and emergency operating position. In the radar transmitting room are located the SA and SG radar transmitters, auxiliary control and power equipment, and the IFF transmitters and receivers. In CIC are the SA and SG console units, remote PPI's, remote radiophone units and speaker amplifiers. The code practice room included two code practice tables of eight operating positions each and a supervisor's desk equipped with code practice oscillator and a jack arrangement connected to the receiver transfer panel.



N.R.T.C. Radio Transmitter Room, Lancaster, Pa.

Five receiving and four transmitting wire-rope antennas were rigged from two seventy-foot poles, the receiving antennas being fed into the building through co-axial lines.

Work in the field was performed by four teams of shipyard electricians consisting of approximately ten men each. Installations were scheduled on a priority basis depending on the number and types of electronics rates being trained at each NRTC. Two Philco engineers were assigned to assist in supervision and checkout. Liaison between the shipyard Electronics Officer and District Headquarters, and assistance in planning and design were through the District Reserve Electronics Warfare Program Officer. In the overall picture, each training center was one hundred percent completed in an average of five weeks.

Every effort has been made to duplicate a typical shipboard layout in the completed installation in order to permit the maximum amount of training in Navy communications, radar operation and procedure, and maintenance techniques.

At this writing twenty of the Naval Reserve Training Centers are complete and by the time the present completion date arrives all will be finished. In addition to the completed shore-based facilities nine ships have been provided with electronic euipment. They are the *PC-566, PC-603, PC-1262, PC-1232, PCER-583, PCER-856, U.S.S. Permit (SS-178), U.S.S. Rhea (AMS-52),* and the *U.S.S. Crossbill (AMS-45).*

THE AUTHOR

John F. Meehan was graduated from St. Joseph's College with a B.S. degree in Physics in 1941.

After being commissioned, he attended radar school at Harvard University and was assigned to the Philadelphia Naval Shipyard for duty with the RMO as ship superintendent, electronics from August 1943 to August 1945. He served in the Pacific Area with OPI #1 aboard the *Matagorda* and the Allied Translator Service in Tokyo. Lt. Meehan was assigned to Com4 in the District Reserve Electronics Program in October 1946.

THE NAVAL RESERVE TRAINING FACILITY

By Lt. R. T. Blanchard, USN
Assistant O-in-C, USNR Training Facility

This facility is located in the third and fourth floors of Building #662, formerly a receiving barracks. The facility was originally activated as the Naval Reserve Training Center, occupying the space and taking over the residual equipment of the Fleet Training Center, which was deactivated in 1946, and consolidating the administration and personnel of the Electronics School in Building #712 and the Reserve Training Center. It was redesignated the U. S. Naval Reserve Training Facility on 1 January 1948 with the mission of providing training equipment and classroom facilities for the use of Naval Reserve and fleet units desiring to use the facilities, on the basis of their furnishing their own instructors, with such supplementary instruction as might be available from the small maintenance staff.

The facility was originally planned to provide classrooms and equipments for eight schools in addition to the electronics schools in Building #712. These were: two prototype CIC's (one CVB and one DD), an ASW School, an Emergency Shiphandling School, a basic and an advanced Radio School, a Signal School, a Telephone Talker, Lookout and Recognition and Night Vision School.

Conversion of Building #662 began in August of 1947, providing fifteen classrooms with a total capacity of 277 students. Installation of equipment started in January 1948, and the ASW and radio equipment was placed in operation in April. The CIC's were not completed due to lack of equipment.

SONAR ATTACK Teacher Room.

The ASW equipment consists of a Sangamo Attack Teacher, Model QFA-6 with tactical and parallel range recorders, ASAP and DRT. This equipment has been used by the Electronics Warfare Companies of the 8th and 9th Battalion of the Naval Reserve, and by a division of destroyers under overhaul at the Philadelphia Naval Shipyard.

The Radio School consists of two rooms. One, equipped as a lecture room, contains 20 operating positions utilizing automatic keyers for radio code training. The second room contains one TCS-12 transmitter-receiver, one TCS-8 transmitter-receiver (incomplete) and nine receiver positions. The present receivers are RAK-RAL, RAO-1, RBL-3 equipments and a DBM-1 direction finder with RDO and AN/SPR-2 receivers. It has been assigned call letters NAI 6 under the Fourth Naval District Communication Office. This installation has been in constant use by fleet units undergoing overhaul at the shipyard.

The Emergency Shiphandling School room is equipped with a partial Model QFA Sangamo Attack Teacher, consisting of the optical projector, two ship steering stands and two DRT's for the purpose of teaching conning procedures; and a VPR trainer for teaching radar navigation.

At the present time the CIC's are being completed, after complete revision of the original plans, and it is contemplated the date of completion will be early 1949. This installation will consist of two prototype CIC's—one CVB and one DD. The radar information for these CIC's will originate in two OCJ radar trainers feeding into two SR consoles, one in each CIC. These in turn feed their information into the repeater PPI circuits, permitting selection by the PPI's of either training equipment.

The CV CIC contains an SR console; two VD-2, one VF and one VG-2 repeater PPI's with associated plotting and status boards; and a DRT system which may derive its course and distance inputs from either a CIC attack teacher control or from a manually-operated course input and a dummy log transmitter. The DD type CIC contains an SR and an SG-1 console, the latter not yet connected due to technical difficulties in adapting it to the OCJ trainers; one VD-2, one VF repeater PPI, horizontal plotting table, summary plot, vertical plot and status boards; and a DRT system similar to but separate from the CV system. Between these two CIC's is a problem generating and monitoring room containing the OCJ trainers, a double DRT, the associated auxiliary equipment for the DRT systems, and the SG-1 transmitter. Communications installed consist of simulated TBS equipment plus separate internal sound-powered telephone equipments, with monitor outlets for both the TBS and telephone systems in the problem room. An MC system interconnects the CIC's and conn stations with other spaces on the same floor. In a room adjacent to the CIC's is a classroom containing synthetic plotting boards and a large classroom maneuvering board for instructions in plotting, maneuvering and relative motion.

The industrial section of the Naval shipyard, under the guidance of the Electronics Laboratory and the Assistant Officer in Charge of the Reserve Training Facility, performed the installation work of this project.

There has been a total of 1174 students under instruction in the training facility and the Electronics School since 1 June 1948; 531 reserve recruits receiving a two-week recruit training course, and 643 men receiving advanced training in one of the eleven training courses offered by the combined activity.

THE AUTHOR

Lt. Blanchard entered the Navy as a recruit in July 1929. After completion of recruit training he attended electrical school. During the next ten years, he had duty on the *U.S.S. Arizona, U.S.S. Tanager, U.S.S. Maryland, U.S.S. Rowan* and *U.S.S. Bernadou* and advanced to EM1c. He attended gyro school in 1940 and was appointed Warrant Electrician in 1941. Assigned to the *U.S.S. Wyoming,* he organized and conducted electrician mates school and over a period of 2 years graduated 600 electrical strikers. In May of 1943 he was commissioned Ensign and assigned to Cramp Shipbuilding Company in connection with the commissioning of the *Miami.* After duty in Chinese and Japanese waters as part of the occupational forces aboard the *U.S.S. Chicago* as Assistant Engineering Officer, he returned to Bremerton, Washington. Meantime, he was appointed Lieutenant in February 1946 and ordered to duty as Assistant-Officer-in-Charge of the U. S. Naval Reserve Training Facility in November of 1947.

* * *

ELECTRONIC FIRSTS

AT THE PHILADELPHIA NAVAL SHIPYARD

The following are some of the electronic installation "firsts" recently accomplished at the Philadelphia Naval Shipyard:

- SG-G
- SR-3
- Mk 56 G.F.C.S.
- VJ
- Modern target designation system, using the TDT Mk 11 and BRI Mk 3 Mod 2.
- Mark V IFF.
- SP with an SM antenna (modified to track guided missiles at 90° elevation).
- Mk 34 Mod 13 operating with TACU Mk 6 Mod 0.
- Mk 34 Mod 2 operating with TACU Mk 2 Mod 2 and hydraulic driven antenna mount Mk 25.
- Mk 8 automobile plotter.
- QHB on a submarine with dual transducers.
- CIC on a submarine.
- A missile tracking center Mark 13 radar with Mk 23 antenna mount (main battery director without optics).

And reaching way back:

- First direction finder (eventually the SE995).
- Tube transmitter for destroyers.
- Acoustical submarine detection.
- Antennas adapted to British ASV radar on destroyers.
- Coronet unit.
- DAK.
- Coaxial line for receiver antenna distribution system.
- U-H-F radio teletype.
- SU-4 with stabilized antenna.
- CXAM.
- Type installation on communications headquarters ships.
- CIC on a CVL.
- SA.

POINTERS ON THE MODEL SP RADAR EQUIPMENT

By John A. Zappacosta
Radio Laboratory, Philadelphia Naval Shipyard

Nutator Adjustments for SP Field Change 61

In installing Field Change No. 61 on the Model SP antenna, it is necessary to check the alignment of the reference generator. Much time and effort can be saved if the adjustment is made while the antenna is in the shop, prior to its reinstallation after completing the field change. The system used is shown in figure 1.

The leads from the zeroing commutator (E3192-H) must be removed from TB3158-1 and TB3157-12 before connecting it into the circuit as shown. The nutator is then run and the reference generator adjusted until a maximum indication is obtained on the oscilloscope.

Since the zeroing commutator is open only when the nutator is in its up position, the oscilloscope will indicate the reference generator voltage only at that particular instant of time. The reference generator should be adjusted to give a maximum positive voltage indication, this representing the lower target area. Figure 2 shows the indication on the oscilloscope when approaching and when on the correct setting of the reference generator. The 40,000-ohm resistor only serves to prevent the reference generator output from being shorted by the commutator. The resistor values are arbitrary and not critical. Maximum voltage indication can be obtained with either zero sweep or with a slow sweep on the oscilloscope. After the adjustment is made it is important that the system be checked in actual operating condition, as it is possible to make an error of 180 degrees in adjusting the reference generator. If this is the case, the reference generator should be rotated 180 degrees from its setting.

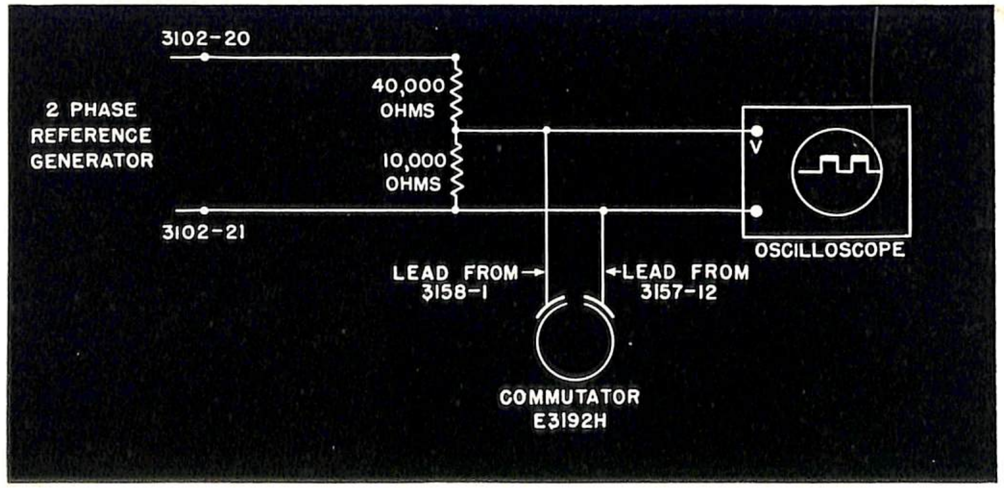
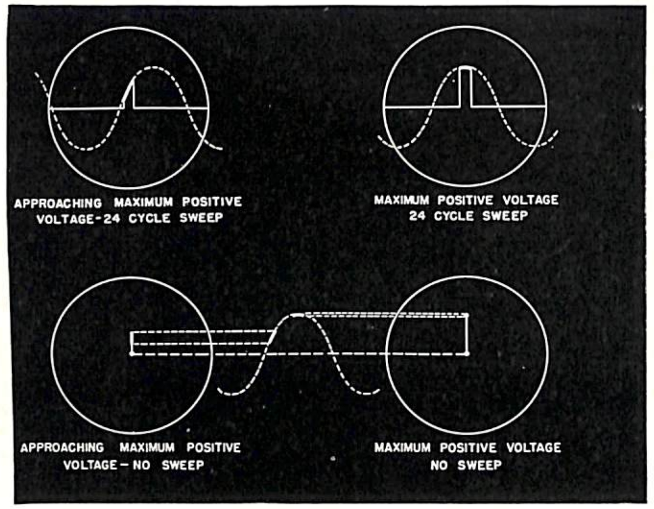


Figure 1

Figure 2



SP Synchronizing Cams

Many Model SP antennas recently overhauled have been found to have their elevation synchronizing cam assembly frozen to the shaft. Besides nullifying its action, this produces the effect of limiting the antenna elevation to the position at which the cam is frozen. When elevation is attempted beyond this point, the antenna will hunt badly, this hunt being caused by the synchronizing switches driving the antenna out of the switch position, and the antenna immediately driving itself back into the switches.

To free the cam, remove the end face of the switch assembly, remove the brake, and using the gear puller supplied with the SP antenna repair kit, remove the cam assembly, being careful not to damage the microswitches. The upper and lower cams should not be removed from the cam holder, as the adjustment of the cams is pre-set. If they are removed, they should be re-set to close immediately ahead of the limit switches. The cam assembly and its shaft should be cleaned with a solvent, polished with crocus cloth, and lightly oiled. When replacing the cam assembly, check to see that it is free enough to spin on its shaft before replacing the brake assembly.

SP AFC Operation

Several Model SP's have been received with the AFC inoperative. A check of the system has revealed that the local oscillator was operating at a frequency 30 megacycles above instead of below the transmitter frequency. A check of the local oscillator output frequency can easily be made with the Model LAD test equipment supplied with the SP. Although the LAD will not give direct frequency measurements, it will show whether the local oscillator is above or below the transmitter frequency, and also give a relative indication of a 30-Mc difference on its tuning dial. With this information, it is then easily possible to shift the local oscillator frequency 60 Mc in the proper direction if this is found necessary. It may be necessary to remove the receiver from the transmitter cabinet, and by using the test cable supplied, adjust the tuning slugs on the local oscillator cavity until the proper frequency is reached. The receiver can then be reassembled and replaced. Zero on the tuning dial of the LAD represents the high-frequency end of the dial.

THE AUTHOR

John A. Zappacosta received his B.S. degree in Electrical Engineering from the University of Pennsylvania in June 1941 and shortly thereafter entered the government service at the Philadelphia Naval Base. After a brief period in the Design Section he was transferred to the Radio Laboratory in December of 1941. He is presently employed as an Electronics Engineer in the Radar Section.

TDZ TUNING HINTS

When manually tuning the TDZ transmitter the technician should carefully follow the instruction book. However, the following hints which were contained in Atlantic Fleet Letter 40L–48 are considered excellent and should prove helpful.

First, turn the locking bars in the center of the dials counterclockwise one-quarter turn, and tune up the transmitter properly on one channel with low power. Disregard the autotone while doing this. Then log the dial settings when proper operation is obtained. Set each autotune for this channel by the following procedure:

1—Back a dial counterclockwise at least one-third of the way to zero. Note that this is seven complete turns of the multitune dials.
2—Bring the dial clockwise to the logged figure. Approach the final setting slowly so as not to overpass the figure.
3—Turn the dial counterclockwise one or two divisions so that it may be held with one hand without going beyond the logged setting, while the locking bar is being tightened with the other hand.
4—Proceed similarly with the other dials.
5—Check all dials to see that their autotunes are locked.
6—Dial some other channel.
7—Redial the channel just tuned.
8—Compare each dial setting with the logged setting and readjust any that have come up incorrectly.
9—Check the transmitter operation on low power to see that the logged settings, when tuned by the autotune, result in satisfactory operation.

One other point, although brought out in the instruction book, is considered to be sufficiently important to mention again. While the TDZ transmitter is being manually tuned, the TUNE-OPERATE switch must be in the TUNE position and the power-amplifier grid current should not exceed 40 ma.

In the OPERATE position, the total power-amplifier plate current should not exceed 100 ma. (This plate current is determined by subtracting the total p-a grid current from the total p-a cathode current.)

As Field Change No. 5–TDZ, the Bureau is now supplying dial cranks for the purpose of manually tuning and setting up channels on the TDZ. These dial cranks may be obtained from the Electronics Officer of any Naval shipyard, or N.S.D., Bayonne, and N.S.C., S.S.D., Oakland. It will be found that the cranks will help considerably in making adjustments.

VECTOR DIAGRAMS FOR TRANSMISSION LINES

By Lieut. Comdr. Charles W. Harrison, Jr., *USN*
Electronics Design Division, Bureau of Ships
(Formerly of the PhilaNavShipYd)

Introduction

The voltage E and current I at any point along a dissipationless[1] transmission line terminated in a complex load impedance Z_R are given by the familiar equations

$$E = E_R \cos \beta d + j\, I_R R_c \sin \beta d \quad \ldots\ldots\ldots\ldots (1)$$

$$I = I_R \cos \beta d + j \frac{E_R}{R_c} \sin \beta d \quad \ldots\ldots\ldots\ldots (2)$$

Here E_R (subscript R for "receiving") is the voltage developed across the load impedance Z_R; I_R is the current flowing in this impedance. R_c is the characteristic resistance of the line, and βd is the angular distance along the line from the load to the point where E and I are calculated. β is the propagation constant,

$$\beta = \frac{2\pi}{\lambda} \quad \ldots\ldots\ldots\ldots (3)$$

and λ is the wavelength.

For a transmission line of over-all length s, the voltage E_s (subscript s for "sending") and current I_s at the sending end of the line are obtained immediately from (1) and (2), respectively, by substituting s for d in each expression. Figure 1 gives a pictorial representation of the notation employed.

The circular trigonometric form of the transmission line equations, as given by (1) and (2) are very convenient for determining, for example, the input impedance Z_s ($= E_s/I_s$) of a transmission line terminated in an arbitrary way, and the impedance transforming properties of open and short-circuited line sections. To graphically portray certain other properties of lines, including the relationship between voltage and current existing along the line, the exponential form of the transmission line equations form a convenient starting point. Expressions for E and I, in exponential form, are:

$$/E/ = \frac{/E_R/\ /Z_R + R_c/}{2\,/Z_R/} \left| \left\{ 1 + /\Gamma/\, e^{-j\,2\beta d + j\Psi} \right\} \right| \quad \ldots\ldots\ldots\ldots (4)$$

$$/I/ = \frac{/E_R/\ /Z_R + R_c/}{2R_c\,/Z_R/} \left| \left\{ 1 - /\Gamma/\, e^{-j\,2\beta d + j\Psi} \right\} \right| \quad \ldots\ldots\ldots\ldots (5)$$

In (4) and (5), Γ, the reflection factor is given by

$$\Gamma = /\Gamma/\, e^{j\Psi} = \frac{Z_R - R_c}{Z_R + R_c} \quad \ldots\ldots\ldots\ldots (6)$$

Use of the magnitude signs implies that an angle common to both E and I has been discarded; however, due cognizance is taken of the angle ϕ existing between $/E/$ and $/I/$. By definition

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[1] It must be recognized that a lossless transmission line is not physically realizable. However, much valuable information pertaining to the operation of actual lines may be obtained from an analysis based on this assumption.

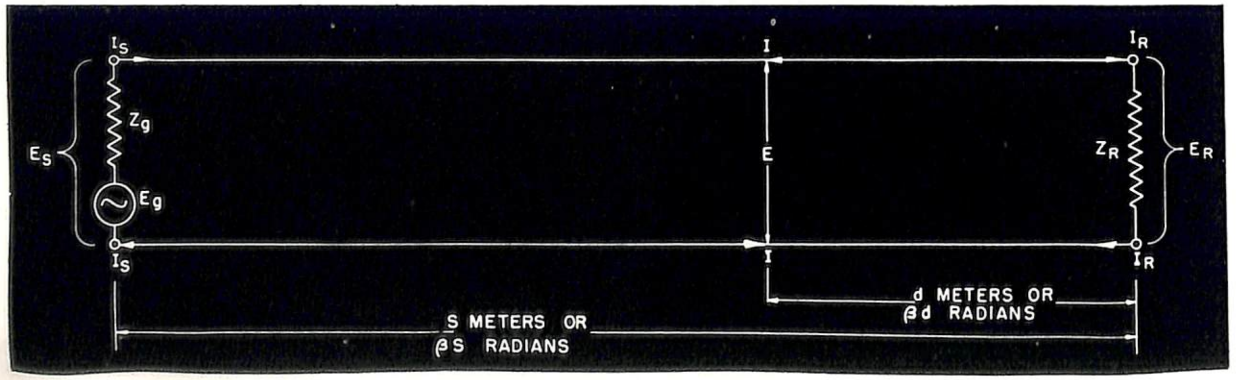

FIGURE 1—*Pictorial representation of the notation employed.*

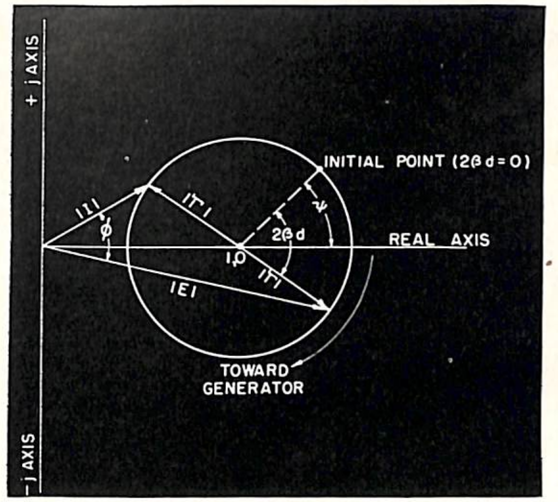

FIGURE 2—*Graphical representation of the voltage and current along a transmission line, terminated in an arbitrary complex impedance.*

$$\phi = \cos^{-1} \left\{ \frac{P}{/E/\ /I/} \right\} \quad \ldots\ldots\ldots\ldots (7)$$

where P is the total power being carried by the line.

The actual derivation of (4) and (5) from (1) and (2), respectively, depends on (6) and the following relations:

$$\sin \beta d = \frac{e^{j\beta d} - e^{-j\beta d}}{j2} \quad \ldots\ldots\ldots\ldots (8)$$

$$\cos \beta d = \frac{e^{j\beta d} + e^{-j\beta d}}{2} \quad \ldots\ldots\ldots\ldots (9)$$

$$I_R = \frac{E_R}{Z_R} \quad \ldots\ldots\ldots\ldots (10)$$

It is of some interest to observe the similarity of equations (4) and (5). R_c appears in the denominator of (5); it does not appear in the denominator of (4). A positive sign appears before $/\Gamma/$ in (4); a negative sign appears before $/\Gamma/$ in (5). The terms outside of the braces $\{\ \}$ in (4) and (5) are constants independent of d. The brace term is the vector sum of a unit vector and a rotating vector of length $/T/$. The angle depends upon the co-ordinate d along the line. Now

$$/E/ \propto \left\{ 1 + /\Gamma/ e^{-j\,2\beta d + j\Psi} \right\} \quad \ldots\ldots\ldots\ldots (11)$$

and

$$/I/ \propto \left\{ 1 - /\Gamma/ e^{-j\,2\beta d + j\Psi} \right\} =$$

$$\left\{ 1 + /\Gamma/ e^{-j\,2\beta d + j\Psi + j\pi} \right\} \quad \ldots\ldots\ldots\ldots (12)$$

It is evident that (11) and (12) are susceptible to similar graphical representation. A circle diagram plot of (11) and (12) is shown in Figure 2 for the case of an arbitrary terminating impedance Z_R. The parallelogram rule for addition is employed. The resultant is the vector drawn from the origin to the tip of the rotating vector. (The rotating vector has its center at +1 on the real axis, and has a length $/\Gamma/$.) For convenience the appropriate entities in Figure 2 and in subsequent figures are labeled $/E/$ and $/I/$. It is to be remembered that $/E/$ and $/I/$ must be multiplied by the constant factors outside of the braced terms in (4) and (5) to obtain the true values of voltage and current, respectively, at any point along the line.

The initial point ($2\beta d = 0$ radians) is determined by the angle ψ. Clockwise rotation is equivalent to moving toward the generator from the receiving end of the line.

Many interesting properties of transmission lines may be deduced from the circle diagram. It is clear that $/E_{max}/$ and $/I_{min}/$ occur at the same point along the line. Where $/E_{min}/$ occurs $/I_{max}/$ occurs also. For these positions the voltage and current are in phase, i.e. the angle $\phi = 0$ degrees. Accordingly the impedance looking toward the load is a pure resistance[2] for these specific positions.

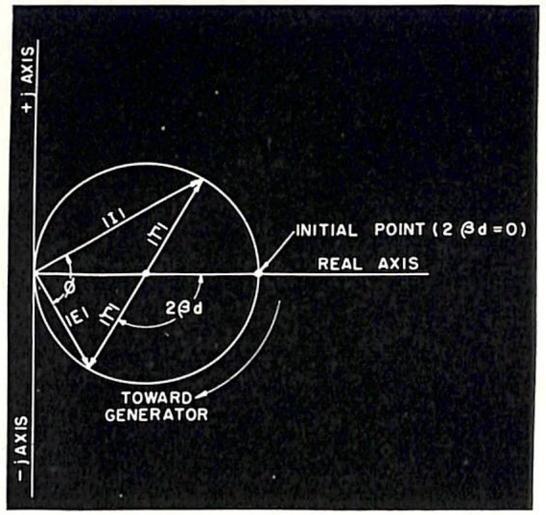

FIGURE 3—*Graphical representation of the voltage and current along an open-circuited transmission line.*

By inspection of Figure (2) one sees that $/E_{max}/ \propto (1 + /\Gamma/)$ and $/I_{min}/ \propto (1 - /\Gamma/)$. Combining these facts with (4) and (5),

$$/E_{max}/ = \frac{/E_R/\ /Z_R + R_c/}{2\,/Z_R/} (1 + /\Gamma/) \quad \ldots\ldots\ldots (13)$$

---

[2] The impedance at any point along the line consists of the parallel combination of the impedances observed by looking toward the generator and toward the load. For purposes of the present discussion only the impedance looking toward the load is considered, i.e. the line may be regarded as broken at the appropriate distance from the termination.

$$/I_{min}/ = \frac{/E_R/\ /Z_R + R_c/}{2\,R_c\,/Z_R/}(1 - /\Gamma/) \;\ldots\ldots\ldots \quad (14)$$

But

$$Z = R = \frac{/E_{max}/}{/I_{min}/} = R_c \left\{ \frac{1 + /\Gamma/}{1 - /\Gamma/} \right\} = \rho R_c \;\ldots \quad (15)$$

Similarly at a voltage minimum (corresponding to a current maximum)

$$Z = R = R_c/\rho \;\ldots\ldots\ldots\ldots\ldots \quad (16)$$

By definition

$$\rho = \frac{E_{max}}{E_{min}} = \frac{I_{max}}{I_{min}} = \frac{1 + /\Gamma/}{1 - /\Gamma/} \;\ldots\ldots\ldots \quad (17)$$

ρ is the outstanding wave ratio.

Notice that a line electrically equivalent to the one represented by Figure 2 (from the point of view of input impedance, standing wave ratio, etc.) consists of a line terminated in a pure resistance ρR_c, and shorter in length by the angle Ψ, i.e. $2\beta d = \Psi$, $d = \Psi\lambda/4\Pi$.

Since the power P transferred by a dissipationless transmission line is the same at all points along the line, one may write

$$P = \frac{E^2}{R} = \frac{/E_{max}/^2}{\rho R_c} = \frac{/E_{max}/\ /E_{max}/}{\rho R_c} \;\ldots\ldots \quad (18)$$

Since

$$\frac{E_{max}}{\rho} = /E_{min}/$$

$$P = \frac{/E_{max}/\ /E_{min}/}{R_c} \;\ldots\ldots\ldots\ldots\ldots \quad (19)$$

Similarly

$$P = (/I_{max}/\ /I_{min}/)\ R_c \;\ldots\ldots\ldots\ldots\ldots \quad (20)$$

It has been pointed out that at a voltage maximum or voltage minimum the voltage and current are in phase. Now the distance $2\beta d$ from the load to a voltage maximum or minimum, together with the standing wave ratio ρ, may be determined experimentally. Since $\rho = (1 + /\Gamma/) \Big/ (1 - /\Gamma/)$,

$$/\Gamma/ = \frac{\rho - 1}{\rho + 1} \;\ldots\ldots\ldots\ldots\ldots \quad (21)$$

Sufficient information is available to construct the circle diagram. One rotates through the angle $2\beta d$ in the counter-clockwise direction (toward the load) from the point of voltage minimum (or maximum) to locate the initial point. The angle Ψ is the central angle between the axis of reals and the line drawn from the point 1,0 to the initial point as shown in Figure 2. One may then compute Z_R directly from (6), ie.

$$Z_R = R_c \left\{ \frac{1 + \Gamma}{1 - \Gamma} \right\} \;\ldots\ldots\ldots\ldots\ldots \quad (22)$$

The above illustrates one method of determining the value of a complex load impedance, in terms of the physically measurable entities ρ and d. It is assumed that R_c is known.[3] The terminating impedance Z_R may be determined in terms of ρ, d and R_c by direct calculation.

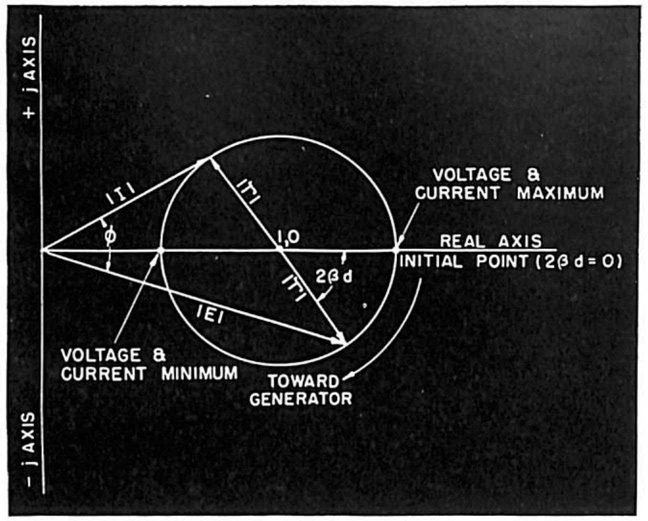

FIGURE 4—*Graphical representation of the voltage and current along a transmission line terminated in a pure resistance $R_R = 3R_c$.*

On dividing (1) by (2) and employing (10), one obtains

$$\frac{E}{I} = Z = R_c \left\{ \frac{Z_R + j\,R_c \tan \beta d}{R_c + j\,Z_R \tan \beta d} \right\} \;\ldots\ldots\ldots \quad (23)$$

Let d_{min} be the distance from the load to a voltage minimum. Then from (16),

$$Z = \frac{R_c}{\rho} = R_c \left\{ \frac{Z_R + j\,R_c \tan \beta d_{min}}{R_c + j\,Z_R \tan \beta d_{min}} \right\} \;\ldots\ldots \quad (24)$$

Solving (24) for Z_R:

$$Z_R = R_c \left\{ \frac{1 - j\rho \tan \beta d_{min}}{\rho - j \tan \beta d_{min}} \right\} \;\ldots\ldots\ldots\ldots \quad (25)$$

Let d_{max} be the distance from the load to a voltage maximum. Then from (15) and (23),

$$Z_R = R_c \left\{ \frac{\rho - j \tan \beta d_{max}}{1 - j\rho \tan \beta d_{max}} \right\} \;\ldots\ldots\ldots\ldots \quad (26)$$

For the particular situation portrayed in Figure 2, it is seen that /I/ leads /E/ by the power factor angle ϕ. Accordingly, the impedance Z (looking toward the load) is capacitive in character for the specific angular distance $2\beta d$ involved. The variation of voltage and current along the line for the particular termination chosen, is obtained by allowing the angle $2\beta d$ to increase. Notice that when $2\beta d$ increases by a total angle 2Π (d increases by one-half wavelength) the same values of voltage and current are again obtained.

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[3] The characteristic resistance of a balanced two wire open line (air dielectric) is approximately $R_c = 276 \log_{10} (D/a)$ where D is the distance between wires from center to center, and a is the radius of the wire employed, expressed in the same units as D.

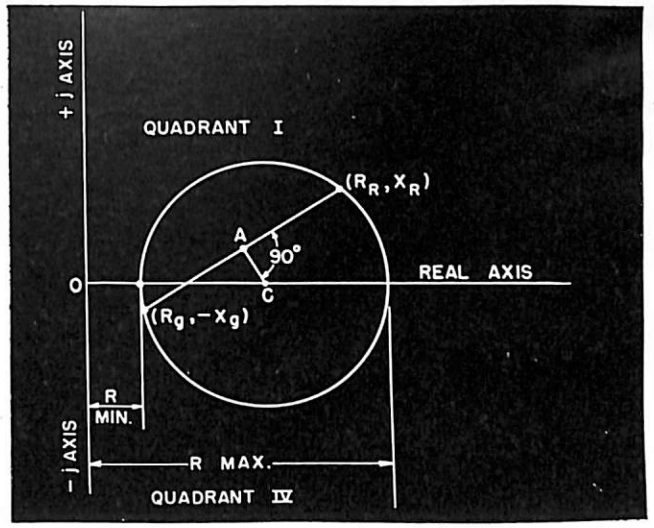


FIGURE 5—*Construction for determining the value of R_c for use in the solution of the problem of impedance matching.*

Vector Diagrams for Open-Circuited and Short-Circuited Transmission Lines

Consider a transmission line terminated in an open-circuit. For this case (6) may be written in the form

$$\Gamma = /\Gamma/e^{j\Psi} = \frac{1 - \frac{R_c}{Z_R}}{1 + \frac{R_c}{Z_R}} \;\ldots\ldots\ldots\ldots \quad (27)$$

Since $Z_R = \infty$, $/\Gamma/ = 1$ and $\Psi = 0$ degrees. The circle diagram for a line so terminated is shown in Figure 3. Observe that a voltage maximum exists at the end of the line ($2\beta d = 0$ radians). This is consistent with the assumption that the attenuation of the line is zero. Further, the diagram shows that the current at the end of the line is zero, for no current can flow off the ends of an open circuited line into empty space. For $0 < 2\beta d < \Pi$ the line acts like a capacitance (/I/ leads /E/), and may be replaced by a lumped (lossless) capacitor of appropriate value. When $\Pi < 2\beta d < 2\Pi$ the line acts like an inductance (/E/ leads /I/), and may be replaced by a lumped (lossless) inductor of appropriate value. Note that ϕ is always 90 degrees, i.e. the voltage and current are always in time phase quadrature (except when /E/ or /I/ passes through zero). This follows from the geometrical theorem which states that an inscribed angle is measured by one-half of its intercepted arc. The intercepted arc in this case is 180 degrees. Thus no power can be delivered to this transmission line, which is another way of stating that the line behaves like a pure reactor, regardless of its length.

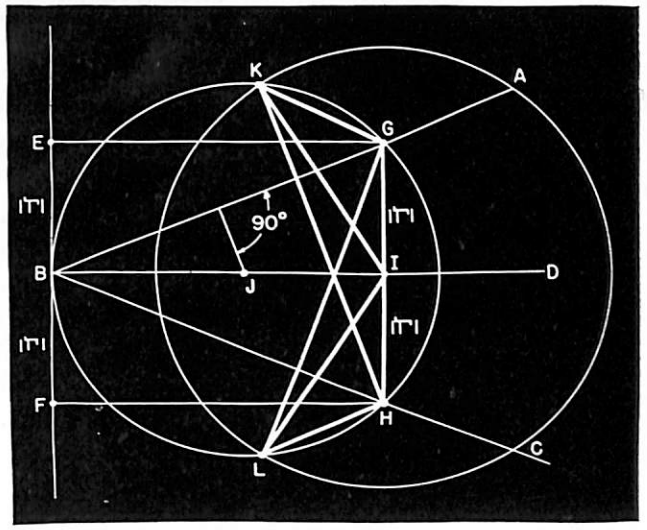


FIGURE 6—*Construction of a triangle when its base length, opposite angle, and median length are known.*

If the line is terminated in a short circuit, $Z_R = 0$, $/\Gamma/ = 1$ and $\Psi = 180$ degrees. For this case Figure 3 may be used, but the vectors /E/ and /I/ are interchanged. The angle ϕ remains 90 degrees. When $0 < 2\beta d < \Pi$ the line acts like an inductance, and when $\Pi < 2\beta d < 2\Pi$ the line acts like a capacitance.

Transmission Line Terminated in a Resistance Equal to its Characteristic Resistance

Consider a transmission line terminated in a resistance R_R equal to the characteristic resistance R_c of the line. For this case (6) shows that $\Gamma = 0$ and $\Psi = 0$. Accordingly the Γ circle vanishes and the voltage and current lie along the axis of reals (i.e. $\phi = 0$ degrees). The standing wave ratio $\rho = 1$, since $E_{max} = E_{min} = E$. The input impedance (looking toward the load) is always R_c, and the power transferred by the line is the voltage E squared, divided by R_c. The amplitudes of the voltage and current along the line are constant and independent of the angle $2\beta d$. It is to be observed that maximum power for a given voltage can be transmitted by a non-resonant line.

Transmission Line Terminated in a Pure Resistance not Equal to the Characteristic Resistance of the Line

Consider a transmission line terminated in a pure resistance $R_R \neq R_c$. To begin the argument, suppose $R_R > R_c$, i.e., let $Z_R = 3R_c$. $\Gamma = (Z_R - R_c)/(Z_R + R_c) = 0.5\,\underline{|0 \text{ degrees}}$. The circle diagram is shown in Figure 4. Notice that a maximum voltage (current minimum) exists at the load. In fact when $R_R > R_c$ a voltage maximum must necessarily occur at the load (and at half-wave intervals along the line measured from the load).

Power may be supplied to the line, since $\phi \neq 90$ degrees. Suppose now that the line be terminated in a pure resistance R_R such that $Z_R = R_c/3$. For this case $\Gamma = 0.5 \underline{|180}$ degrees. Figure 4 may be used to discuss this case, provided /E/ and /I/ are interchanged. Notice that if $R_R < R_c$ a voltage minimum will occur at the load (and at half-wave intervals along the line measured from the termination). Further, by reference to Figure 2 one can readily see that for any arbitrary termination, if Ψ is positive ($\Psi <$ II), a voltage maximum will occur first (as $2\beta d$ increases). If $\Pi < \Psi < 2\Pi$, a voltage minimum will occur first (as $2\beta d$ increases).

Elementary Impedance Matching

Another problem that is generally susceptible to solution by use of Figure 2, and several auxiliary geometrical constructions may be stated as follows: Given: The generator impedance Z_g and load impedance Z_R. Required: The length s and characteristic resistance R_c of a transmission line, such that a conjugate impedance match is effected between the generator and load.

Here the line is to serve a dual purpose: Transmission of power, and suitable impedance transformation. Unless $Z_g = R_c = Z_R$, a standing wave system will exist along the entire length of line.

It is evident that a fundamental requirement is that

$$\frac{E_s}{I_s} = Z_s = Z_g^* = R_g - j\,X_g \;\ldots\ldots\ldots\ldots\ldots \quad (28)$$

Here Z_s is the input impedance of a transmission line of length s terminated in Z_R. Z_g^* is the complex conjugate of the generator impedance. The first step in the solution of the problem is to plot Z_R and Z_g^* on a complex plane, as shown in Figure 5. Draw a straight line between these two points. Erect the perpendicular bisector to this line. The intersection of the perpendicular bisector with the real axis locates the center of a circle which passes through the points $(R_g, -X_g)$ and (R_R, X_R). The intercepts of the circle on the real axis are labeled R_{min} and R_{max}. R_{min} is the coordinate of the center of the circle minus the circle radius; and R_{max} is the coordinate of the center of the circle plus the circle radius.

Then

$$R_c^2 = R_{min}\,R_{max} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (29)$$

Equation (29) states in effect that unless the circle lies entirely within the first and fourth quadrants no value of R_c exists which enables a conjugate impedance match to be effected between the generator and load. Furthermore, for purposes of conjugate impedance matching only one value of R_c is possible, i.e. the required value is independent of the length of transmission line employed.

Proof of the validity of (29) is accomplished as follows:

From (23)

$$Z_g^* = R_g - j\,X_g = R_c \left\{\frac{Z_R + j\,R_c \tan\beta s}{R_c + j\,Z_R \tan\beta s}\right\} \ldots \quad (30)$$

Since (30) is complex it may be regarded as a simultaneous equation from which $\tan\beta s$ may be eliminated.

By equating reals to reals in (30), and solving,

$$\tan\beta s = R_c \left\{\frac{R_R - R_g}{X_g\,R_R - X_R\,R_g}\right\} \ldots\ldots\ldots\ldots \quad (31)$$

By equating imaginaries to imaginaries in (30), and solving,

$$\tan\beta s = R_c \left\{\frac{X_g + X_R}{R_R\,R_g + X_g\,X_R - R_c^2}\right\} \ldots\ldots \quad (32)$$

By equating (31) to (32), and solving for R_c^2,

$$R_c^2 = \frac{R_R(R_g^2 + X_g^2) - R_g(R_R^2 + X_R^2)}{R_g - R_R} \ldots\ldots \quad (33)$$

A second relation for R_c^2 is obtained from Figure 5 by use of elementary analytic geometry. The slope of the line connecting points $(R_g, -X_g)$ and (R_R, X_R) is $(X_R + X_g)/(R_R - R_g)$. The slope of the line AC is then $-(R_R - R_g)/(X_R + X_g)$. Since the coordinates of point A are $(1/2)\,(R_R + R_g)$ and $(1/2)\,(X_R - X_g)$, the equation for the line AC is given by

$$X - \frac{1}{2}(X_R - X_g) = -\frac{R_R - R_g}{X_R + X_g}$$
$$\left\{R - \frac{1}{2}(R_R + R_g)\right\} \ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

The coordinates of the center of the circle are desired. Obviously the center of the circle is at $X = 0$. Upon setting $X = 0$ in (34), and solving for R, one obtains

$$R = \frac{\frac{1}{2}\left\{(R_g^2 - R_R^2) - (X_R^2 - X_g^2)\right\}}{R_g - R_R} \ldots\ldots \quad (35)$$

Now the radius of the circle is

$$\sqrt{X_R^2 + (R_R - R)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (36)$$

Since $R_{min}\,R_{max} =$
{coordinate of the center of the circle}² minus
{radius of the circle}², one has

$$R_{max}\,R_{min} = R_R \left\{\frac{(R_g^2 - R_R^2) + (X_g^2 - X_R^2)}{R_g - R_R}\right\}$$
$$-X_R^2 - R_R^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (37)$$

On clearing the right side of (37) it is found to be identical to the right side of (33). This establishes the validity of (29).

Having determined the only possible value of R_c which will permit a conjugate impedance match to be effected, one now constructs a vector diagram similar to that shown in Figure 2. This is possible, for $/\Gamma/$ and Ψ are calculable from (6) when Z_R and R_c are known. Since Ψ is known, the initial point ($2\beta d = 0$ radians) is known. The only question remaining to be settled is how large the angle

$$\delta = 2\beta d \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (38)$$

should be in order to achieve a conjugate impedance match. When δ is determined, the required line length d (= s) is

$$d = \frac{\delta\lambda}{4\Pi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (39)$$

But the angle ϕ is known at the sending end of the line, together with its "sense" i.e. whether E_s leads or lags I_s, for by (28),

$$\phi = \tan^{-1}\left(\frac{-X_g}{R_g}\right) \ldots\ldots\ldots\ldots\ldots\ldots \quad (40)$$

Accordingly, one rotates clockwise through the angle δ until the correct angle ϕ is obtained. When this is done (39) is employed to determine the required length of line s.

There is a more "scientific approach" for determining the "stopping" point in Figure 2. Observe that in the triangle formed by the sides /E/, /I/ and $2/\Gamma/$, the angle ϕ, the median (of unit length), and the base $2/\Gamma/$ are known. Figure 6 illustrates the construction of such a triangle.

Lay out the angle ABC equal to angle ϕ, and bisect it. Next, erect a perpendicular to the line DB, and let it pass through the vertex of the angle. With point B as center, lay out $/\Gamma/$ on this line. Designate the points obtained E and F. Draw lines parallel to BD passing through points E and F. Designate the intersections with the sides of the angle ABC, G and H. Then GI = IH = $/\Gamma/$. Erect a perpendicular bisector(s) to the line(s) BG or BH to determine the center of the circle J (lying on line BI) which will pass through points BGH. Draw in the circle. With the point I as a center, and the median length (unity) as radius, draw a second circle. The intersections of the second circle with the first circle are labeled K and L. The triangle GHK, or triangle GHL is the one required. The triangle GKH (or triangle GLH) meets the specifications for the base has a length $2\,/\Gamma/$, a median length KI = LI of unity, and an angle GKH (= angle GLH) equal to angle ABC i.e., angle ϕ. The latter statement regarding angles is based on the fact that an inscribed angle is measured by one-half its intercepted arc.

Much additional information regarding the characteristics of transmission lines may be deducted from circle diagrams of the type described here. They are particularly useful in aiding one to visualize transmission line properties. Further elaboration on this subject is reserved for another edition of the ELECTRON.

THE AUTHOR

Lieut. Comdr. Charles W. Harrison, Jr., USN, was born in Virginia. He attended the U. S. Naval Academy Preparatory School, the U. S. Coast Guard Academy, and the University of Virginia, where in 1939 he received the B.S. degree in engineering, and in 1940 the degree of electrical engineer. In 1942 he was graduated with the M.S. degree in communication engineering from Cruft Laboratory, Harvard University, and that summer completed the Navy course in radar engineering at the Massachusetts Institute of Technology. From the fall of 1942 to the spring of 1944 he was engaged in lecturing to officers of the Armed Forces assigned to the radar schools at Harvard and Princeton universities. His experience includes amateur, Naval, and broadcast-station operation, in addition to some four years of research work in the Bureau of Ships, Navy Department and the U. S. Naval Research Laboratory. He is the author of several papers dealing with various phases of electronics.

In 1945 Lieut. Comdr. Harrison was Naval liaison officer at the Evans Signal Laboratory, Belmar, New Jersey. In early 1946 he matriculated at Harvard to continue work on the degree of Doctor of Science in Engineering. Later in that year he reported for duty at the Philadelphia Naval Shipyard where he served as Acting Electronics Officer for approximately a year. Other assignments included duty as Electronics Planning Officer, and Assistant for Shore Electronics.

Lieut. Comdr. Harrison is presently attached to the Electronics Design Division, Bureau of Ships. He is a member of the Harvard Chapter of Sigma Xi; the American Physical Society; the Institute of Radio Engineers; and the Audio Engineering Society. He is registered as an electrical and radio engineer in Virginia.

SOME INTERESTING ASPECTS OF U-H-F AND RADAR PROPAGATION

By Rodman V. Buggy
Electronics Laboratory, Philadelphia Naval Shipyard

It is well known that high-frequency radio energy is propagated along an approximately straight line path and when the curvature of the earth is considered, a limitation or restriction is placed on the maximum detectable range of this energy. Neglecting all earth effects, this condition can be illustrated as in figure 1.

Considering a source of u-h-f energy at a height above the surface of the earth, the maximum range at which this energy could be detected on the earth's surface would be the length of the tangent to the earth at this point passing through the source of energy. Referring to figure 1,

let h = height of source of energy
r_e = radius of the earth
p = point on surface of earth at which energy is detected.
d = length of tangent.

$$\text{then } (h + r_e)^2 = r_e^2 + d^2$$
$$h^2 + 2hr_e + r_e^2 = r_e^2 + d^2$$
$$d^2 = h^2 + 2hr_e$$

$$\text{but since } h \ll r_e$$
$$d^2 = 2hr_e$$
$$d = \sqrt{2hr_e} \qquad (1)$$

Since $r_e = 3960$ miles (mean radius of the earth)

$$d = 1.225\, h \qquad (2)$$

where d is in miles and h is in feet.

If, for example, $h = 100$ ft. then

$$d = 12.25 \text{ miles.} \qquad (3)$$

Now suppose that the point of detecting this energy were elevated. Then the problem would be as in figure 2.

Similar to equation (2),
we have $d_1 = 1.225\ h_1$
and $d_2 = 1.225\ h_2$
or $d = d_1 + d_2 = 1.225\ (h_1 + h_2)$ (4)

If, for example, $h_1 = 100$ ft.
$h_2 = 75$ ft.
then $d = 22.8$ miles.

Or, if a plane were flying at 10,000 ft.,
and if $h_1 = 100$ ft.
then $h_2 = 10{,}000$ ft.
then $d = 134.5$ miles

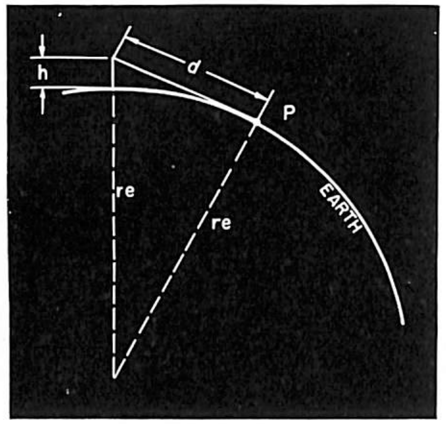


Figure 1

It is also well known that the propagation of u-h-f radio energy is affected by both the surface and the atmosphere of the earth. This energy is a function of the resistivity of the earth, the frequency, the height of the transmitting and receiving antennas, the earth's curvature and the variation of refractive index of the earth's atmosphere with altitude. It is not the purpose of this article to discuss all these effects, however significant, but to call attention to a few.

The variation of the refractive index of the earth's atmosphere with height and its effect upon line-of-sight propagation is rather interesting. In the preceding discussion, it was assumed that the atmosphere or medium through which the radio waves were propagated was uniform, which is to say the dielectric constant and the index of refraction of the atmosphere and thus the velocity of propagation, were all constant. Actually they are not. Considering the index of refraction alone, the path of a wave being propagated is curved in accordance with the equation below:

$$\frac{1}{\text{radius of curvature}} = \frac{1}{u}\,\frac{du}{ds} \qquad (5)$$

u = index of refraction
s = distance measured normal to the direction the wave is traveling

It is noted that the rate of curvature is greatest when the index of refraction varies most rapidly and the path becomes a straight line when the refractive index is a constant.

The dielectric constant of the atmosphere is slightly greater than the value unity obtained in a vacuum. This is due to the presence of gas molecules and the value depends upon the number and kind per unit volume. The dielectric constant is particularly sensitive to water molecules because of the high dielectric constant of water vapor. This dielectric constant of air can, accordingly, be expected to decrease with height above the earth and vary depending upon the amount and distribution of water vapor in the atmosphere. This variation causes radio waves passing through the atmosphere to be refracted downward toward the earth in accordance with equation (5) (the dielectric constant E and the index of refraction u are related).

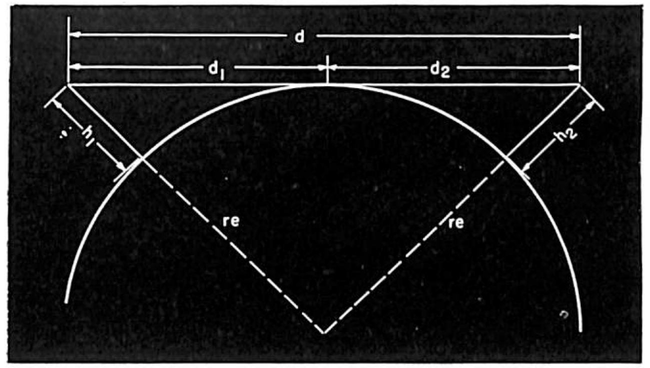


Figure 2

Another method of explanation of this condition is to say that the velocity of propagation varies inversely with the refractive index and hence the waves move more rapidly, have greater velocity, in the upper atmosphere than they do near the surface of the earth resulting in downward bending of the radio waves.

Assuming that the dielectric constant E of the air changes at a uniform rate $\frac{dE}{dh}$ then

$$k = \frac{1}{1 + \frac{r}{2}\frac{dE}{dh}}$$

where r is the actual radius of the earth.

Although the actual value of k will vary from hour to hour, its average value is 1.33.

This downward bending effect of the radio waves can be taken into account by assuming a fictitious earth having a radius k times larger than the actual radius.

When this is done, equation (1) becomes

$d = \sqrt{2hkr_e}$ where h is in feet and d in miles.
or $d = 1.414\ h$ [compare with equation (2)].

If, for example,
$h = 100$ ft., then
$d = 14.14$ miles [compare with equation (3)].

Similarly, for two antennas each elevated
$d = 1.414\ (h_1 + h_2)$. [compare with equation (4)].

If, for example, $h_1 = 100$ ft.
and $h_2 = 75$ ft.
then $d = 26.4$ miles.

Or if a plane were flying at 10,000 ft.,
as a value of h_2 and $h_1 = 100$ ft.,
then $d = 155.5$ miles.

Compare the examples above with those given under equation (4).

Thus it is seen that due to the bending of radio waves in the earth's atmosphere, greater ranges are obtained than would be expected on the basis of a straight-line path.

The details of the phenomenon of the bending of radio waves in the atmosphere have not been discussed in order to obtain a simplified approximate equation which can be used readily in the calculation of line-of-sight ranges for u-h-f propagation given the heights of the transmitting and receiving antennas.

In order to consider the problem more fully, the following additional factors should be considered:

1—sky and surface waves.
2—magnitude and phase relations of the direct and ground-reflected components of the ground wave.
3—polarization.
4—conductivity of the earth.

THE AUTHOR

Rodman V. Buggy, civilian section head of the Radar Group of the Electronics Laboratory, was graduated from the Moore School of Electrical Engineering at the University of Pennsylvania in 1935. For two years, he was employed as an engineer for Philco, dealing with problems involving quality control. In 1938, he joined the staff of the Electrical Design Section of the Philadelphia Navy Yard. In 1940, he became Assistant Radio Engineer in the Electronics Office and was assigned to radio and sonar. He is now in charge of the Radar Section. When not involved with r.f. officially, he is busy with it on W3KZ.

5—frequency.
6—actual distance.
7—height factors.
8—dielectric of the earth.
9—magnitude and phase relations of the direct and reflected components of the space wave.
10—meteorological conditions of the atmosphere.
11—divergence of waves caused by a curved surface.

For the consideration of the effect of these factors upon propagation and field intensity of radio waves, the reader is referred to any good radio engineering text, such as the "Radio Engineers Handbook" by Terman.

In conclusion, the practicing radio engineer should bear in mind that:

1—Experiments have shown that in radio propagation the strength of the ground wave on the shore immediately adjacent to the water is of the order of 8 or 12 db. greater than the strength of the ground wave a mile or more inland.
2—The dielectric constants of fresh and salt water are 80 and 81 respectively although their conductivities are 1 x 10^{-14} and 4.64 x 10^{-11} emu respectively, while the dielectric constants of soil vary from 20 to 10 although their conductivities vary from 3 x 10^{-13} to 2 x 10^{-14} emu.
3—There is so simple relationship between antenna height and field strength or range in the propagation of radio waves.

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

EMERGENCY ALIGNMENT
OF MODEL VF EQUIPMENTS

It is generally considered that alignment of the "B" range unit of the Model VF Radar Indicating Equipment can be accomplished only through the use of a Type-60ACZ "A" and "J" Oscilloscope. These oscilloscopes, however, are not ordinarily carried aboard ship and are rather scarce even at shore activities.

In an emergency it has been found possible to align these range units with reasonable accuracy by following a procedure suggested by Mr. Vaughn Kelly of the Pearl Harbor Naval Shipyard. This procedure utilizes a Range Calibrator TS-102/AP or TS-102A/AP together with an Oscilloscope TS-34/AP (fast synchroscope). The TS-102/AP provides trigger pulse and 500-yard markers, and has a control by means of which the phase of the markers can be adjusted with respect to that of the trigger.

To align the units, connect the trigger and marker output jacks of the TS-102/AP to the trigger and video input jacks, respectively, of the Model VF. Sweeps should appear on both scopes of the VF. Place the cursor above the PPI sweep, and adjust the "B" video gain and marker intensity controls. Both internal 1000-yard and external 500-yard markers should now appear on the "B" scope.

Pulsed Oscillator Frequency Alignment

Operate the range crank for counter readings from about 3000 to about 50,000 yards. If the frequency of the pulsed oscillator is correct, external markers should coincide with internal markers on the "B" scope at 1000-yard intervals. For example, coincidence might occur at 3000, 4000, 5000 . . . 40,000, 41,000, etc.; or at 3130, 4130, 5130 . . . 40,130, 41,130, etc. In either case, the frequency of the pulsed oscillator would be correct, since the interval between coincidences would be 1000 yards. Coincidences will also occur at intervals of about 500 yards, but only the 1000-yard intervals should be considered at this stage, since the 500-yard intervals will be affected by the phasing bridge alignment discussed in the next paragraph. If the interval observed is other than 1000 yards, correction should be made by adjustment of L-301 in the VF oven.

Phasing Bridge Alignment

The alignment of the Model VF phasing bridge may be checked and adjusted, if necessary, by observing the position of the external markers with respect to the internal markers at 90° intervals of the phase-shifting capacitor (250-yard intervals on the range counter). For example, if the markers coincide at 10,240 and 11,240, they should also coincide at 10,740 and 11,740. Furthermore, at 10,490 and 10,990 the external markers should be symmetrically disposed with respect to the internal markers. Since the "B" sweep is not perfectly linear, the grouping of the external markers on both sides of each of the four VF markers should be considered, rather than the grouping around a single VF marker. If misalignment of the phasing bridge is apparent, it may be corrected in the usual manner as described in the instruction book.

Phase-Shifting Capacitor Adjustment

Final alignment of the Model VF requires that, with the range counter set at any 1000-yard point above 2375, the "B" range markers be delayed, with respect to the initial trigger entering the VF, by exact multiples of 1000 yards. This may be checked and adjusted with the TS-102/AP by first adjusting its phasing control so that the outgoing trigger is exactly synchronized with one of the outgoing 500-yard markers. This may be done with a fast synchroscope by applying the trigger and markers to the vertical deflection circuit, either alternately or simultaneously, depending on the type scope which is available for this purpose (the Oscilloscope TS-34/AP mentioned earlier is satisfactory for this application).

When the VF is triggered with the TS-102/AP adjusted in this manner, coincidence of external and internal markers should appear on the "B" scope at exactly 500-yard points on the range counter above 2375. That is, coincidence should occur at 3000, 3500, 4000, 4500, etc. If this is not the case, correction should be made by adjusting the coupling between the phase-shifting capacitor and the gear box, as described in the instruction book.

Care must be taken, however, to avoid a 500-yard error which would be present if the phase-shifting capacitor shaft were 180° out of line. This is prevented by looking through the window in the phase-shifting capacitor cover (figure 5-21 of the preliminary instruction book) through which the top of the capacitor shaft may be seen. This shaft is slotted, and there is a bevel at one end of the slot. The bushing around the shaft is also slotted. With the counter set at, say, 10,000 yards, the two slots should be nearly lined up. The bevel should be on the side nearest the outer case of the equipment. If the bevel is on the opposite side, the shaft must be turned 180° with respect to the gear box.

After any readjustment of the phase-shifting capacitor, it is imperative that the zero and slope adjustments of the helipot be checked and adjusted, if necessary, to insure proper tracking of the 6-microsecond gate with the phase-shifted range markers. This should be done as described in the instruction book.

In conclusion it must be emphasized that this procedure is for use only in emergencies since it is not as precise as the usual method of alignment using the Type -60ACZ "A" and "J" Oscilloscope.

CORRECTION!

In the article "Dynamic Frequency-Shift-Spread Measurements at High Frequencies" on Page 17 of the October, 1948 ELECTRON, figures 1 and 2 are reversed (the captions are correct).

The author of "The U.S.S. Mississippi (EAG-128). . . Its Function With the Fleet" on Page 16 of the June, 1948 ELECTRON is Mr. Phil T. Goldberg, Ship Section, Radar Group, Norfolk Naval Shipyard. The illustration at the top of Page 18 shows Radar Equipment Mk 47, not Mk 39.

MODEL JT
SOUND ABSORBING COUPLER UNIT

Reports of damage to the Navy Type -10366 Sound Absorbing Coupler Unit of the Model JT Sound Receiving Equipment have been received in the Bureau of Ships. In most cases the Allen set screws binding the retaining caps to their studs were badly corroded and, in some instances, sheared. This condition results in the loss or loosening of the caps.

The plates, studs and retaining caps used in the assembly of this coupler are of a non-corrosive material. The set screws, however, binding the caps to the studs are of ferrous construction. Any undue stress applied to the JT hydrophone is transmitted to the retaining caps of the coupler. Since these caps are secured by a corrosive type screw, they eventually loosen.

If non-ferrous screws were used for this application, they would not be subject to corrosion, but they would not provide sufficient strength. Accordingly, stainless steel screws and washers are recommended. These screws should be coated, however, with a suitable paint to lessen the chances of corrosion. Suitable screws are 10-24, oval, fillister head, stainless steel, ⅝ inch long, Class 2 fit, slotted for screwdriver, Stock No. 43-S-15384-1030. Suitable washers are No. 10, stainless steel, split, 1/16" wide, 3/64" thick, Stock No. 43-W-6005.

Type of Approach	Last Month	To Date
Practice Landings	7,428	175,049
Landings Under Instrument Conditions	390	7,602

U-H-F ANTENNA LOCATIONS

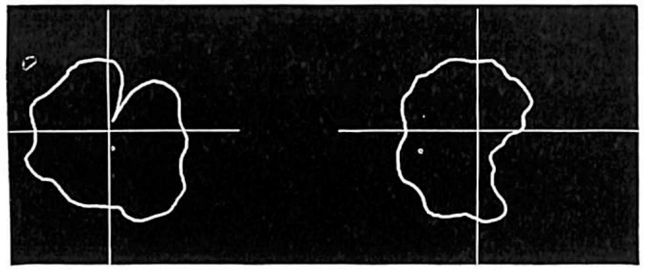
By Comdr. E. H. Conklin, USN,
ComBatCruLant, E. O.

The history of v.h.f. and u.h.f. in the Navy dates back a number of years—well into the 1930's. There were several Model CXL 30- to 60-Mc equipments procured in 1935 and installed in ships; there were some TCD/RAR equipments procured in 1939 and installed on two cruisers; and there were others. The first model TBS sets were ordered in 1938 and became the most widely used v-h-f set aboard ship. During the war, 100- to 156-Mc sets and 20- to 40-Mc f-m units also were installed.

From the very start, the line-of-sight type of communication encountered variations in the reliable distances it could reach, depending upon the relative bearing of the receiver from the ship. While this was present in the v-h-f equipment too, it was not so easily recognized. When voice radio became popular for tactical circuits, action reports started to include repeated comments on "blind spots," condemnations of one model as compared with another, and other troubles which were directly chargeable to the antenna locations. Many ships were well aware of these peculiarities, and undertook to correct them by common-sense and cut-and-try approaches. Laboratory checks of antenna patterns (plots of relative power radiated, or relative signal received, at various bearings from the ship) were made which confirmed the source of the trouble.

Acknowledging the fact that the only proof of satisfactory antenna locations is in the measurement of the resulting patterns, the Bureau procured and distributed Esterline-Angus recording voltmeters and direct-current amplifiers to facilitate measuring the patterns. Some of these voltmeters were sent to Electronics Officers in the form of recording fluxmeters which contained the necessary components. It still remained, however, to make suitable arrangements to obtain the measurements, including the availability of a circling ship or aircraft.

It was also decided that a laboratory development program was necessary, to work out completely satisfactory antenna systems for ships. Progress on this work was reviewed in Electron for February, 1948. This work has had to be so extensive, however, that it is desirable that more attention be given to the problems involved in locating v-h-f and u-h-f antennas, in advance of the laboratory's determination of ultimate, ideal types of topside construction. To this end, some of the more basic considerations are reviewed in this paper in the hope that they will help to improve future antenna installations.



Two theoretical antenna patterns. LEFT—*a narrow, sharp deep drop in signal such as might be caused by a nearby conductor acting as a "director" or "reflector";* RIGHT—*a broad shallow drop such as might be caused by the "shadow" of a large complex mast structure.*

Determining Antenna Patterns

Before going into the results of measurements and what causes them, let us review the more elementary ways in which horizontal radiation patterns may be determined. For this purpose, let us discuss the work done on the *U.S.S. Bennington* (CV-20) in 1944 and early 1945.

The basic requirements for measuring an antenna pattern are:

1—To transmit a signal from the ship being measured, or to send a constant signal to the ship. This signal should not be permitted to vary appreciably due to changes in the height of an assisting airplane, or changes in distance between the transmitting and receiving stations, or changes in relative bearing from the assisting ship, plane, or shore location.

2—To indicate changes in relative bearing from the ship being measured, resulting either from turning the ship or circling it in an assisting ship or aircraft.

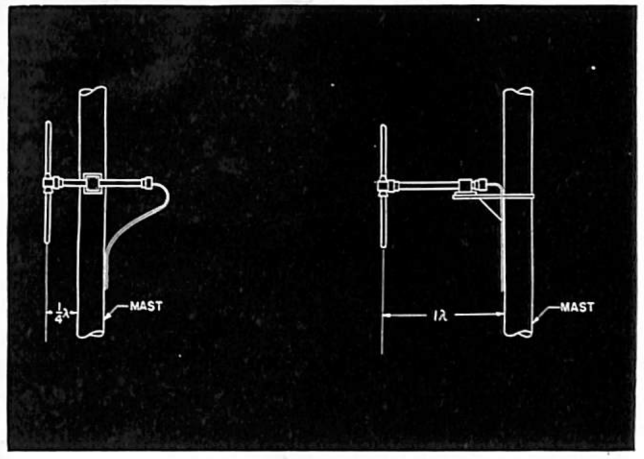
3—To measure the variations in receiver input (generally as reflected in the input meter or a-v-c voltage) and to log these changes for various relative bearings.

The first attempt on the *U.S.S. Bennington* was made with an assistant operating a pelorus on the bridge, and calling down to the radio room the relative bearings of the assisting ship or aircraft. For each 5-degree change in relative bearing, another assistant read off the receiver input meter readings, which were logged. This method was not very satisfactory, and the readings did not coincide well during the second revolution of the assisting ship or aircraft. Having brought along several Esterline-Angus recording voltmeters and d-c amplifiers, they were connected to the a-v-c terminals in the receivers, and the variations were recorded on paper tape. A marking line at the side of the paper was caused to make "dits" or "pips" whenever the assistant on the bridge called down a 5-degree bearing change. The spacing of these marks could be checked to see that there were no unusual changes or errors. After the tests, the output of a signal generator was fed to each receiver and the main chart lines were calibrated in microvolts input to the receiver. At the end of the day, the chart data were transferred in decibels to polar charts to show patterns, using only the highest and lowest chart readings (and the order in which they occurred) between each pair of 5-degree lines on the polar charts.

When antenna patterns must be measured without the recording voltmeter, it is suggested that the assistant watching the receiver input meter call out the highest and lowest meter readings and which comes first, between each pair of 5-degree changes in relative bearing. The recording assistant can put this in the log. This method will avoid too much smoothing of the dips in signal strength which are so important to the analysis.

Of course, with the recording voltmeters a number of antennas can be measured at the same time. Manpower and confusion may limit the number that can be done by the manual method. Each measurement should take about 1½ turns for confirmation, and the overlapping measurements should agree to about one decibel.

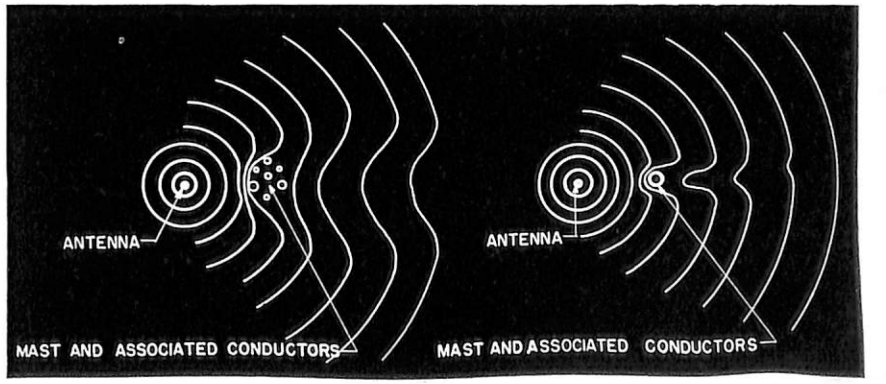
Analyzing the Patterns



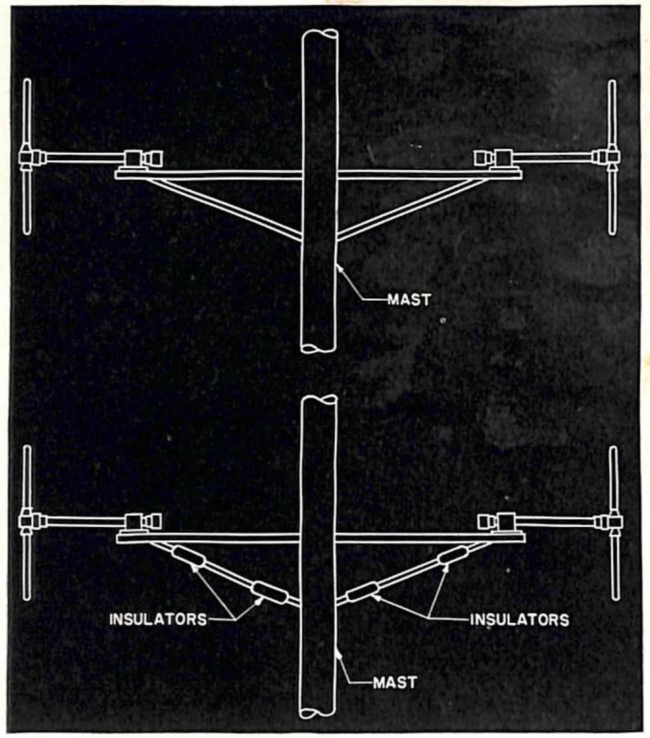
Antennas should be mounted a minimum *of one wavelength away from the mast.* LEFT—*unsatisfactory;* RIGHT—*better.*

Although there are some irregularities that are of little importance in the measured patterns, it will be seen from studying a few selected patterns that there are three general difficulties, as follows:

1—A narrow, sharp, deep drop in signal. This results from induced current flowing in a nearby conductor which acts like a "director" or "reflector." This effect is most marked for vertical metal within some ⅜ wavelength of the antenna, and is less likely to happen in metal which is several wavelengths from the antenna because less current can be induced in conductors that are far removed from the radiating antenna. In one pattern on the *U.S.S. Bennington,* a null was produced that was 39 decibels down from the average full-power part of the pattern. On this bearing, aircraft could not be contacted beyond five miles although other antennas were entirely satisfactory out to large distances at this same bearing. The difficulty was attributed to power induced in other antennas on adjacent outriggers which, in this case, were too short. At the post-shakedown availability, the matching sections of the antennas were mounted on outriggers instead of directly on a small platform surrounding the Model YG topmast, and a recheck showed that the trouble had largely disappeared. Other types of conductors might have been detuned if they could not be removed from the proximity of the antenna.



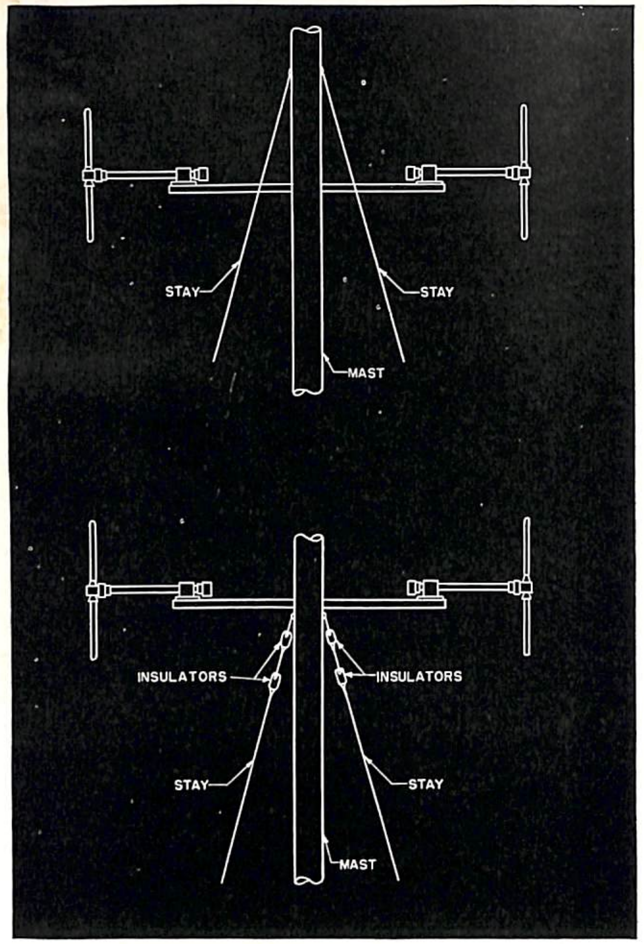
LEFT—*a representation of the effect of a complicated mast structure on antenna radiation;* RIGHT—*a representation of the effect of a single thin mast or conductor.*



TOP—*a method of mounting u-h-f antennas;* BOTTOM—*same mounting with insulators placed in the supports to lessen the "closed loop" effect.*

2—A broad, shallow null. This is found in essentially every pattern unless the antenna is mounted entirely in the clear. It is attributed to the "shadow" effect of the mast structure on which the antenna is mounted. It is less important than the deep null discussed above, and is frequently more difficult to cure. However, there are several things that can be done. One is to mount the antenna as far out from the mast structure as is possible, so that the shadowing angle is small. The second is to reduce the diameter of the supporting mast and associated rigging, for the same reason, so as to permit the signal to "fill in" around the mast. The third is to remove the closed loops of metal, especially those which measure less than one wavelength around the opening, so that the signal can pass through the hole in the same manner as through a waveguide. Antennas mounted out from railings are likely to have a bad shadow unless the railings are made of nonconducting material, or are broken up with insulators. Supports for outriggers are another source of trouble, unless they too are broken up with insulators.

3—A generally reduced response, even at the best angles. This was found in one of the four antennas on the *U.S.S. Bennington.* This antenna was 20 decibels worse than any of the others, comparing the best angles. It was confirmed by disconnecting the r-f coaxial cables from the antennas and connecting them together in turn, measuring the loss by comparing the receiver input meter reading when fed directly by a signal generator, with that when fed through the loop of coaxial cable. When the cable to the poor antenna was used in the loop, it indicated a loss 20 decibels larger than when other cables were used in the loop. This particular test, of course, would not apply to losses in the transmitter or in the antenna.



Two similar antenna mountings. TOP—*stays attached above antennas, and no insulators in stays;* BOTTOM—*stays attached below antennas leaving antennas in the clear, and insulators in stays lessening the closed loop effect.*

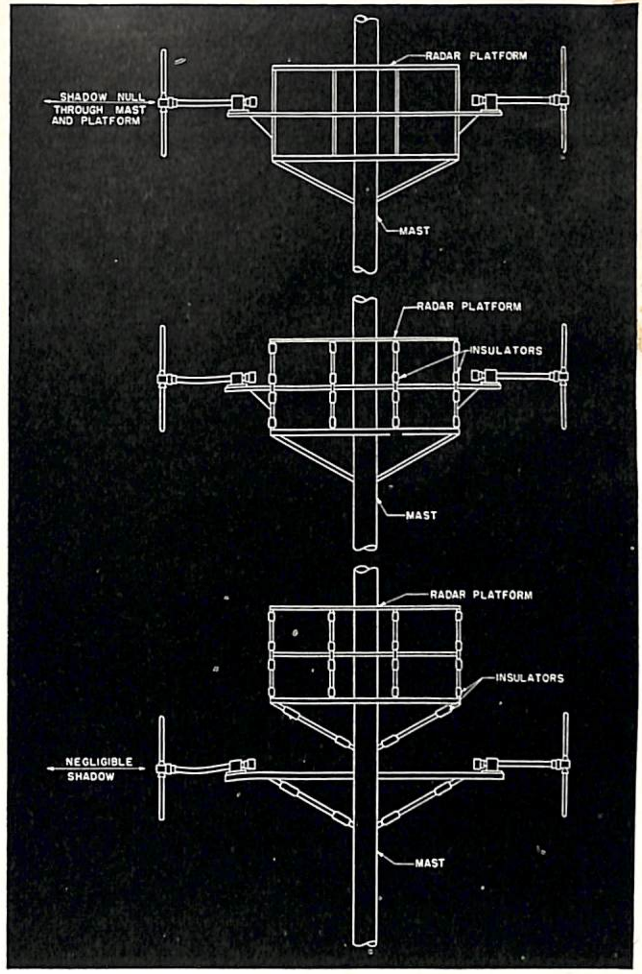
Installation Rules

From the above, it will be seen that there are several rules that can be applied immediately to u-h-f antenna installations:

1—Keep vertical u-h-f antennas at least one wavelength away from any vertical conductors.

2—If possible, detune any vertical conductors within two wavelengths of the antenna.

3—Mount antennas as far out from supporting structures as practicable. Wider antenna supporting structures and associated gear require a greater outrigger distance between the antenna and mast than narrow supporting structures, for the same distortion in the resulting antenna pattern.



Three antenna mountings. TOP—*poor because platform and mast cause severe nulls;* CENTER—*better because closed loops in the platform are broken up by insulators;* BOTTOM—*still better because antennas are now mounted away from the platform comparatively in the clear, with insulators in their supports. This arrangement, however, would still have some shadow for high close aircraft.*

4—Keep all conductors as close to the supporting structure as possible, to reduce the shadow angle through the structure.

5—Make the supporting structure electrically narrow by breaking up with insulators all closed loops, especially those smaller than one wavelength.

6—Pay attention to angles moderately above the horizon from the antenna, if aircraft communication is involved.

7—Check the resulting antenna patterns, preferably at several frequencies within the range of the equipment. Do this both for surface and for elevated targets if the equipment may be used for communication with aircraft.

After the 1944 tests, several of the participants came to the conclusion that it would be difficult to reduce variations below 10 decibels on an AGC and 20 decibels on a CV with typical installations of multiple antennas not mounted in the clear. Variations beyond that certainly can and should be corrected, however. It was also found that it is as easy, if not easier, to get a satisfactory u-h-f pattern than it is to get a good one on v-h-f; this assumes, of course, that the spacings for the u-h-f antenna are not deliberately reduced from those of the v-h-f antenna.

MODEL VF SYNCHRO SWITCHING RELAYS

In early Model VF Radar Indicating Equipments, synchro switching relays K–502 and K–504 of the servo amplifier and rectifier power unit were found to be extremely sensitive. Accordingly, it was usually necessary to "circuit select" the 6AG7 tubes of this unit, in order to obtain proper operation. This fact was not generally known by field personnel and usually resulted in unnecessary adjusting of the relays.

Beginning with Serial No. 643, Model VF equipments were supplied with less-critical, hermetically-sealed plug-in type relays. While this new type relay was not supplied as a retroactive field change for the early models, a quantity of them, together with the mounting brackets necessary for replacing the old type relays, were supplied in Model VF tender and stock spares under Tag No. 1615. If satisfactory operation of the old type relays cannot be obtained after adjusting them in accordance with the procedure outlined in Section 8 of the Radar Maintenance Bulletin, a complete new relay should be installed.

It should be noted that the new type relays are also supplied in equipment, tender and stock spares, *less the mounting bracket,* under Tag No. 503. This item should be used when replacement of a new type relay becomes necessary.

At the same time that the old type relays are replaced with the hermetically-sealed units, the value of capacitors C–502 and C–512 should be increased from one microfarad to two. Also, on equipments bearing Serial Nos. 585 to 643 incl., resistors R–296 and R–297 should be replaced with 620-ohm and 390-ohm resistors respectively.

Electron ORBIT

SINGING ARC OR OLD FASHIONED COHERER?

Apparently there is a bit of dissent over the reason for the "Singing Palm" mentioned in this department in the December issue of Electron. *Here are some answers:*

★ ★ ★ ★

Sirs:

. . . Sound created by Corona effect—brush discharge into palm—the singing arc. Another argument in the AM-FM question: Use FM to keep your palm trees from singing.

Cdr. W. B. Martin

D.R.E.W.P.O.,
Fourth Naval District.

★ ★ ★ ★

Sirs:

The article describing "The Singing Palm" is not in keeping with the high level of material usually published in Electron.

If Commander Horsley intended this article to be a scientific puzzler, I am afraid most amateurs could answer his question. What radio man hasn't at one time drawn an arc off the antenna with a pair of pliers and listened to the audio amplitude-modulated signal in the arc?

The audio component modulating the r-f amplitude causes the ionizing of the surrounding atmosphere to be an exact replica of the audio train, and the human ear detects the ionization taking place at audio frequencies.

James A. Cole

Electronics Engineer,
U. S. Naval Station,
Tongue Point,
Astoria, Oregon.

★ ★ ★ ★

Sirs:

Regarding the article in the December issue of Electron on the "Singing Palm," somewhat the same results have been noted at N.C.S., Norfolk. Transmitters at this station have, at times, been perfectly readable to persons in the immediate vicinity of the antenna arrays.

The effect has been noticed primarily from relatively high power transmitters. Although no extensive checks have been made on all frequencies and powers at which this is noticeable, the signals were heard with TDH transmitters on 3195 and 6290 kc, operating at a nominal power output of 2 kw. The sound appears to come directly from the antennas overhead, when under the array but at a considerable distance from the transmitter building. The voice component of the signal is clearly readable with good fidelity and volume.

Several theories and possibilities have been advanced by the men stationed here, among them:

1—The immediate vicinity of the transmitter station is used by the Naval Base supply activities as a storage area for galvanized pipe, structural steel and lumber, and as an automobile parking area. All of this is directly under the antenna array. It is thought possible that some of this pipe, being loosely stacked, is excited by the audio-frequency component of the transmitter output, allowing the modulation to be heard directly. The audio is much the same as that produced by loose laminations in audio and modulation transformers.

2—Several large coal loading docks are located adjacent to the transmitter station. Heavy concentrations of very fine coal dust settle continuously over the entire area (happy housekeeping!). Since the pendants, fittings, shackles, etc., and the antenna wire itself, are made of dissimilar metals, it is believed that a coherer or a crystal detector of a sort may be set up.

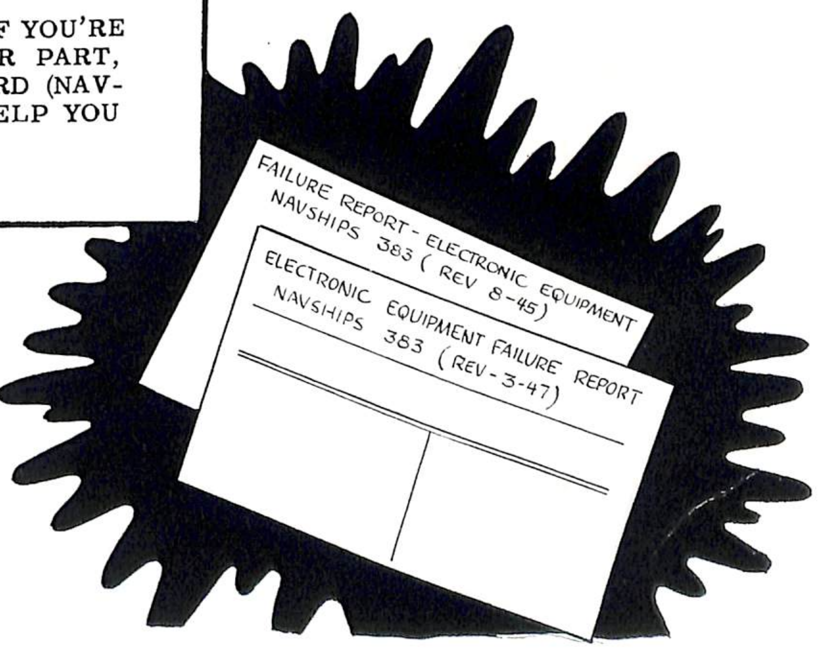
All hands here are interested in the reasons for these phenomena, which we hope will be published in a forthcoming issue of Electron.

C. A. Dillavou

U. S. Navy Communication Station,
Norfolk, Va.

Getting TEED OFF?

STOP PUTTING AROUND. IF YOU'RE HANDICAPPED BY A POOR PART, SEND US YOUR SCORE CARD (NAVSHIPS 383) AND LET US HELP YOU MAKE A NICE RECOVERY.



PHILADELPHIA

Navy Yard

RESTRICTED

RESTRICTED

1865