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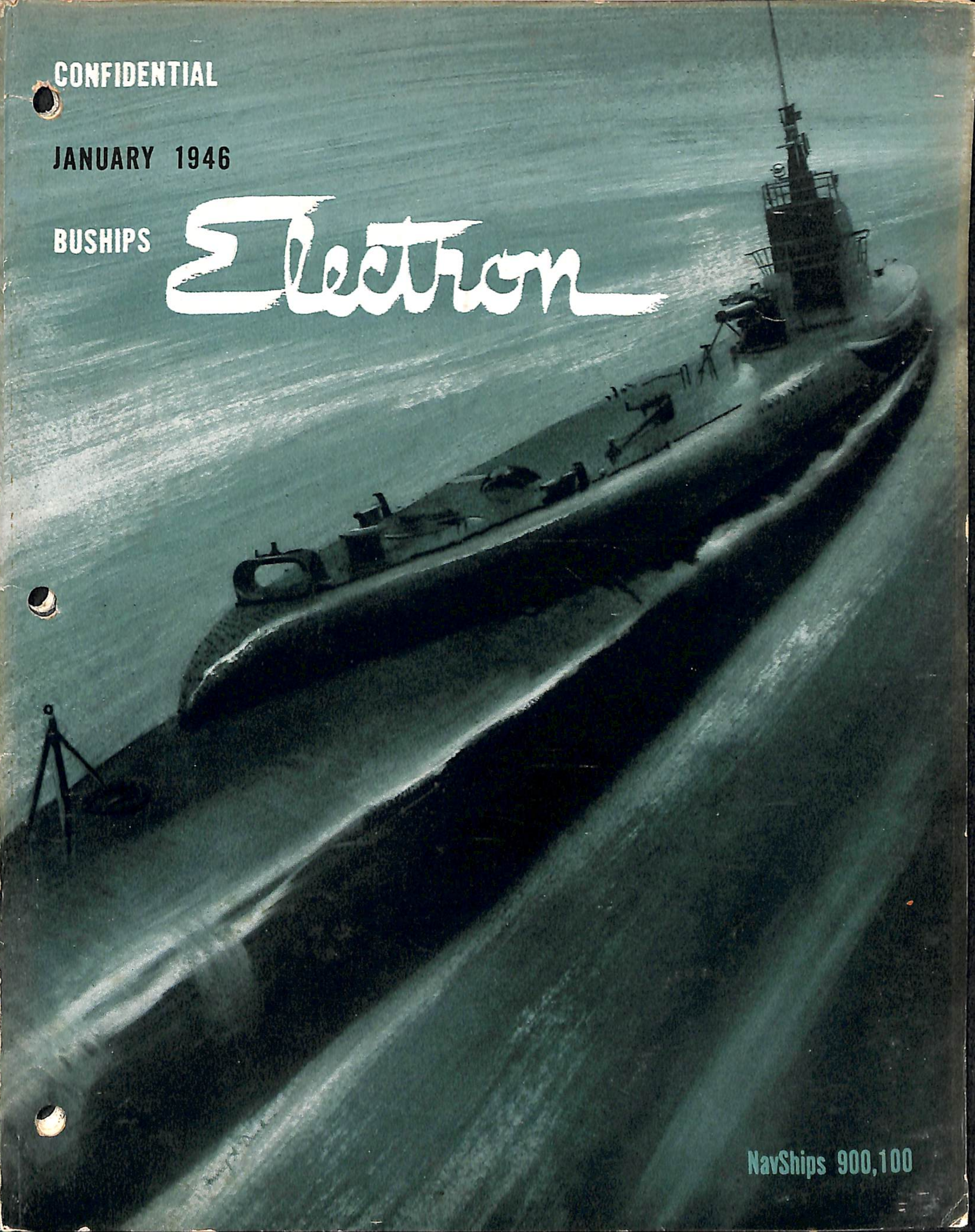
JANUARY 1946

BUSHIPS Electron



NavShips 900,100

JANUARY 1946 • VOLUME 1 • NUMBER SEVEN

BUSHIPS Electron

A MONTHLY MAGAZINE FOR RADIO TECHNICIANS

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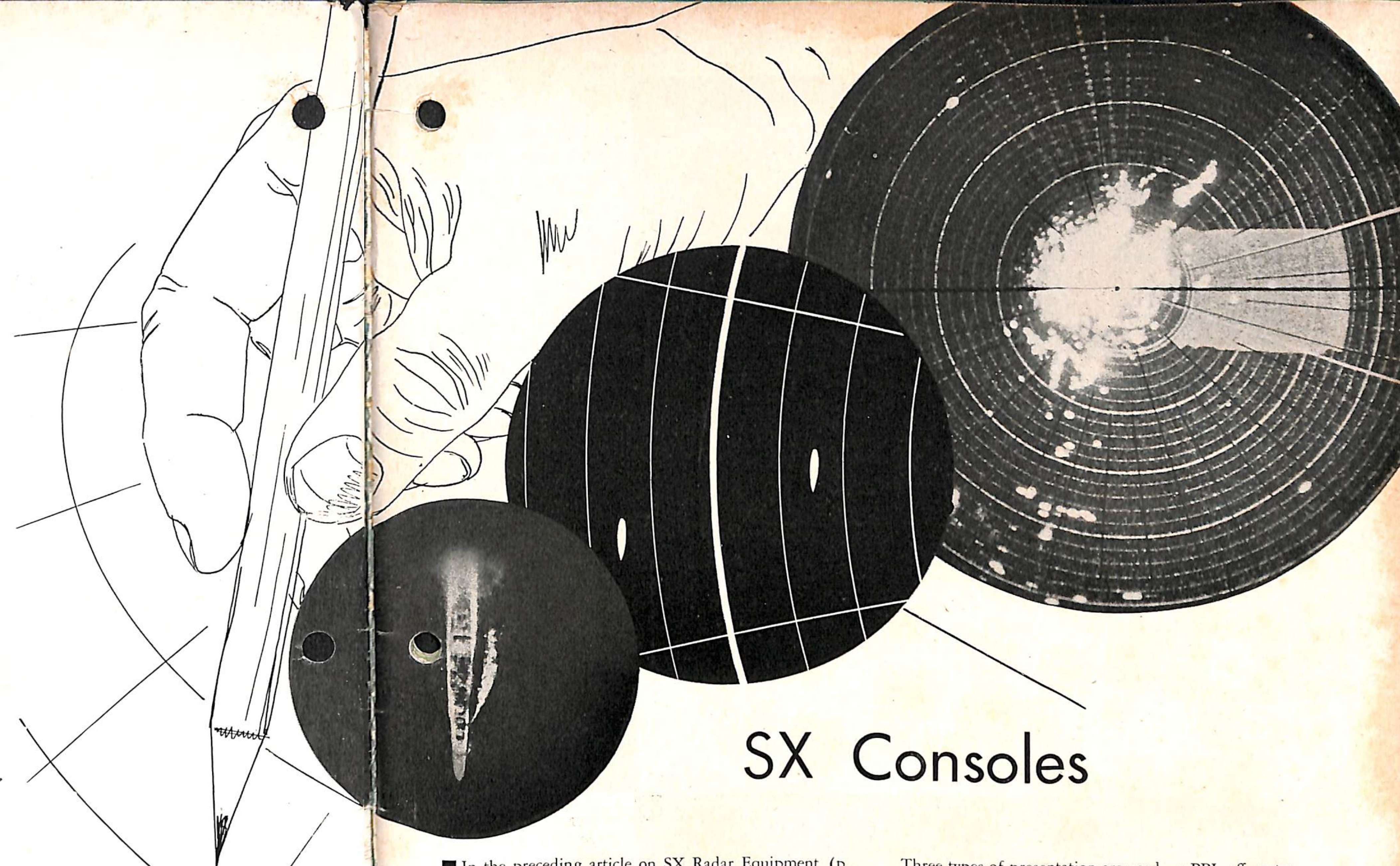


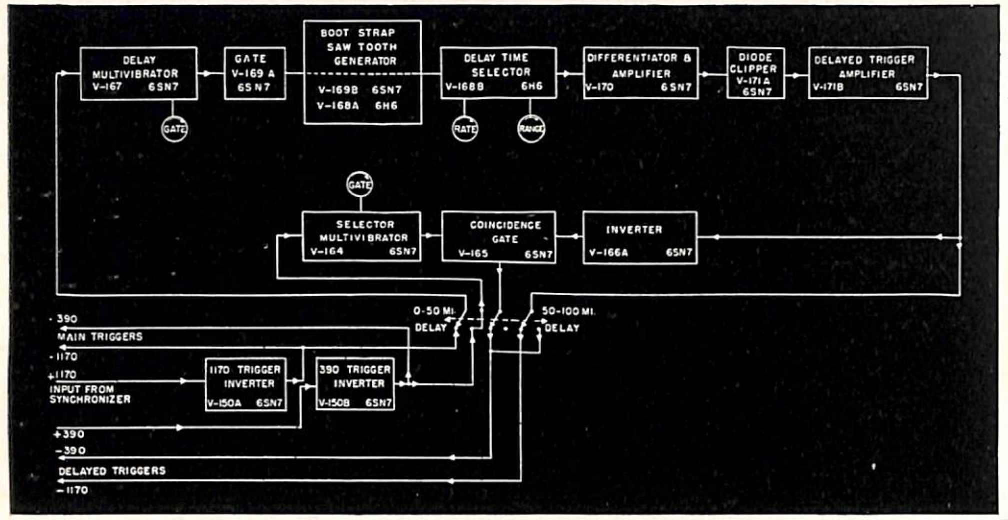
SX Consoles

■ In the preceding article on SX Radar Equipment (p. 14, December Electron) the reader was given a general description of the overall system. To understand the principles and advantages of the equipment, some knowledge of all the units, particularly the console, is required. Any installation employs four of these units, five in some applications. A detailed discussion of the circuits in the console is impracticable, but a brief summary of their functions and applications is given.

It will be recalled that the synchronizer furnished four outputs to each console, either directly or through an adapter or radar switchboard. These outputs are the 390- and 1170-cycle triggers, the 20-mile range markers, and the combined 2- and 10-mile range markers. In addition to these, each console has an E.W. *(early-warning)* and an H.F. *(height-finding)* video input, making a total of six single inputs to each unit. Necessary synchro inputs are furnished to each console.

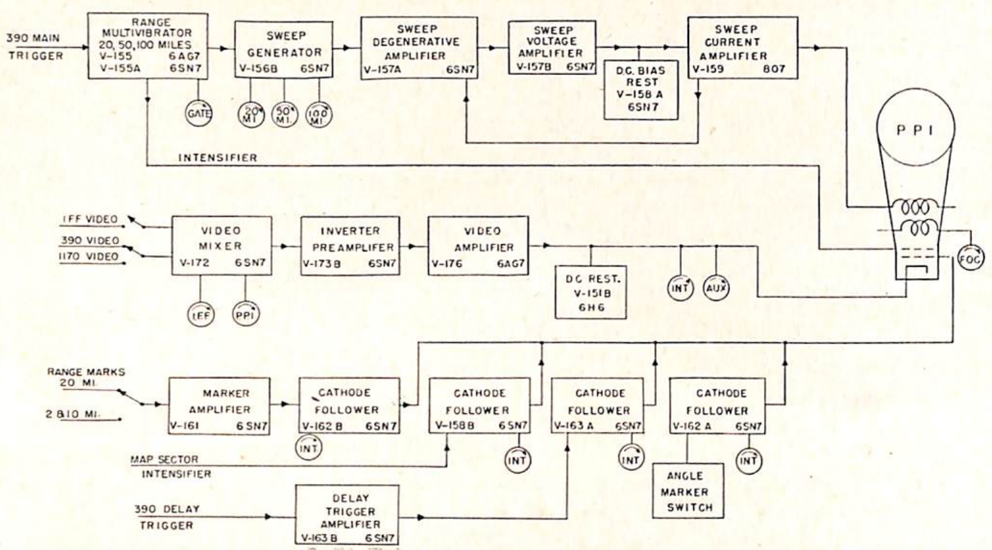
Three types of presentation are used—a PPI, off-center PPI, and an RHI *(range-height indicator)*. The PPI scope gives early warning of approaching targets, either aircraft or surface. The off-center PPI, which will henceforth be referred to as the MSS *(map-sector scan)*, expands the area in which the target is located, thereby giving a more detailed and accurate picture. The RHI scope gives altitude of air targets and is the principal scope when directing interceptions, since it shows the range and altitude of both the target and the intercepting plane or planes.

The PPI system generates and uses any one of three sweeps: 20, 50, or 100 miles. The 100-mile sweep is ample for long-range coverage since it is double the normal range (50 miles) of the RHI scope. The deflection coil for the PPI tube is conventionally coupled to the antenna drive. A variable delay circuit in the PPI section produces a second trigger following the main



◀ FIGURE 1 — *Simplified block diagram of trigger circuits. Note that there is no delayed 1170-cycle trigger when on the 100-mile sweep.*

FIGURE 2—(left, center) *Simplified block diagram of PPI circuits showing Range Sweep, Video, and Marker channels.*



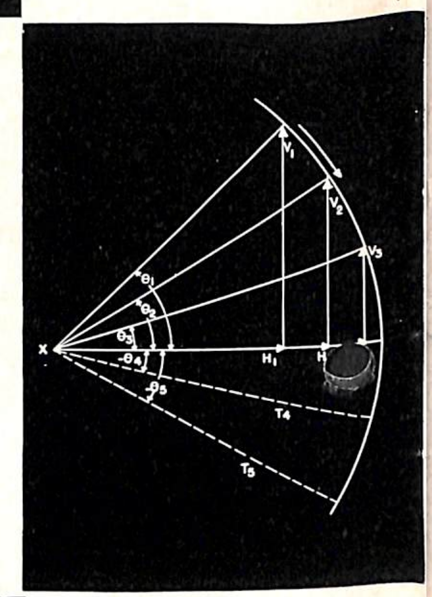
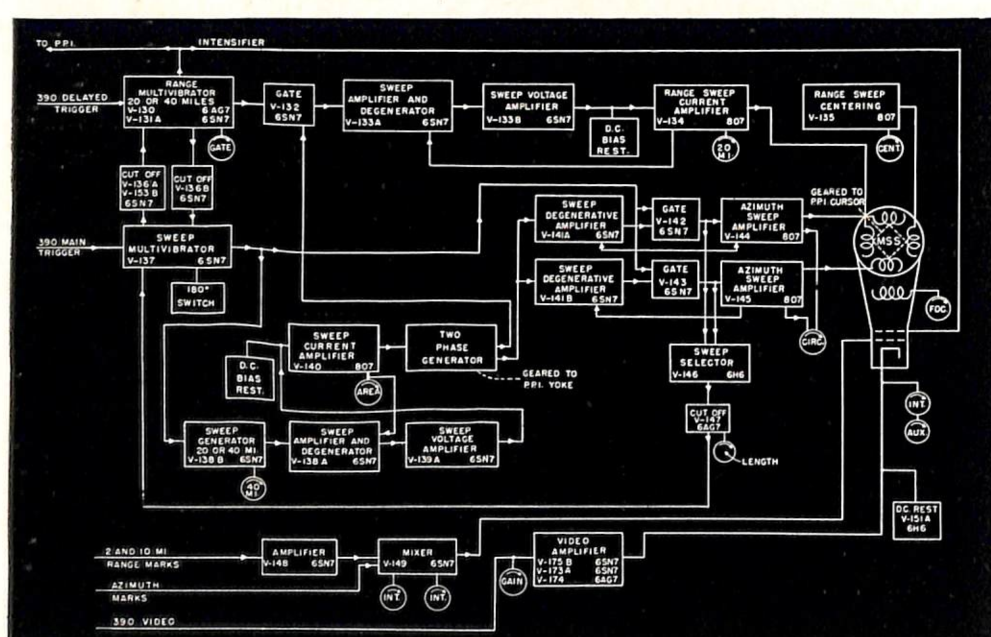


FIGURE 4 — *Development of sweeps on Map Sector Scan, showing decrease of vertical amplitude as angle decreases with accompanying increase of horizontal sweep amplitude.*



◀ FIGURE 3 — *Simplified block diagram of Map Sector Scan showing Delay Circuits, Horizontal and Vertical Range Component Generators, etc.*

trigger by a period which can be varied between the limits of 0 and 100 miles. This delay is manually controlled by a dial on the front panel and is calibrated in miles from 0 to 100. The delayed trigger trips either a 20- or 40-mile sweep which appears on the scope as a shaded area and is approximately rectangular in shape. The selection of length of this shaded area is determined by the presentation desired on the MSS. The angular positioning is determined by the setting of a cursor control on the front panel, operating in conjunction with the PPI yoke. The cursor line always bisects the shaded area, thus giving a reference for the operator to determine angles of targets on the MSS. The portion of the PPI presentation that appears on the MSS is that portion of the shaded area which is enclosed by the angle marks. These angle marks appear as bright lines on the PPI, making either a 10- or 30-degree angle at the center of the tube.

The MSS generates two sweeps, each driving its own set of deflection coils which are mounted at right angles, making possible a two-dimensional sweep. The deflection coil assembly is mechanically coupled to the cursor in such a way that the range sweep on the MSS will run in the same direction and bearing as the cursor in pointing. For example, if the cursor is pointing to 360°, the MSS presentation will start at the bottom of the scope and proceed upward, assuming 360° to be at the center top of the PPI tube. As the MSS is nothing more than an enlarged portion of the PPI, it follows that points on the MSS will duplicate similar points on the PPI in either the 20- or 40-mile sweep, depending upon which is being used. The first ten-mile range marker on the MSS scope is therefore 10 miles in addition to the number of miles noted on the range delay control dial on the PPI.

Since the PPI sweep is constantly rotating, a second set of deflection coils is provided in the MSS unit which will rotate the MSS presentation in phase with the PPI. The MSS pattern rotates at the same angular velocity as the PPI but is pivoted about a point somewhere outside the face of the tube rather than at the center as does the presentation on the PPI. When the PPI trace approaches the cursor line, the shaded area will appear on the PPI and at the same instant the sweeps will appear at one side of the MSS and sweep across it to the other side in synchronism with the sweep on the PPI.

Azimuth angles and position will offer little difficulty to the operator due to the angle marks, superimposed on the PPI, whose occurence is determined by the location of the cursor and the setting of the sector scan, either 10 or 30 degrees. The cursor line will be equidistant from these two angle marks at any point along their length, with the distance depending upon what point is used as reference on the cursor. The most important function of the angle marks is to show on the PPI the area which is being presented in cross section on the RHI scope.

The RHI is something new in scanning types of radar and its purpose in the SX is to furnish range and height information on target planes and interceptors simultaneously on a cathode ray tube face. It must be kept in mind by the operator that the presentation on the RHI scope is always 90 space degrees behind the presentation on the PPI and MSS. Another important point which should be remembered is that range as measured on the PPI is necessarily slant range rather than horizontal distance, and therefore the MSS and RHI must also be calibrated in slant range. This will introduce a slight error on the RHI (as compared to the PPI) of as much as 1000 yards, but this error has no effect on the ultimate result. The important point is that any error on the RHI will be the same for the target and the intercepting plane. Since the distance and angle between these two planes is displayed on the RHI, any error between ship and planes is relatively unimportant due to the fact that the interception will be made at a distance from the ship using the RHI presentation for vectoring. Slant range is displayed on the RHI by using a constant horizontal component of sweep. A vertical component is added to draw the sweep progressively downward, simulating the scanning of the RHI antenna beam without affecting the horizontal sweep. Range marks occurring at intervals after the start of the trace will appear as vertical straight lines crossing the horizontal traces. This completes the RHI presentation with the exception of the method of height finding. This is accomplished by a horizontal height line or marker which is created by brightening each vertical trace at a predetermined point. This point is controlled by two variables, one is an earth's-curvature compensation circuit, and the other by the height-indicating unit. The height-indicating unit is controlled by a dial calibrated in thousands of feet up to 40,000. By using the earth's-curvature correction, the height as indicated on the dial is the true altitude of the target at any range, rather than the height from the horizon as measured by line-of-sight from the antenna.

Three ranges are provided for use with the RHI system, 0-50, 0-100, and a delayed 20-mile range. The 100-mile range has not been mentioned previously in this article because it is used only in a special application in which the RHI system is switched to use the 390 trigger with a reduced scanning speed. The 100-mile range will only be used when the operator wishes to examine a target at greater range than 50 miles. The 50-mile range will normally be used for large area coverage and the 20-mile delayed range for making interceptions. This 20-mile sweep operates from the delayed trigger and presents the same range as the 20-mile MSS presentation.

As the antenna rotates, the sweep on the PPI will pass over the first angle mark on the PPI. This automatically turns on the sweep on the RHI which will remain on until the sweep passes over the second angle mark on the PPI. At all other times the video to the RHI is blanked out by the sweep. Range markers and height marker will remain on. If the PPI is operating on the 360° sector, the RHI will duplicate the PPI except that it will be lagging by 90 degrees.

TRIGGER CIRCUITS

Four separate triggers are necessary for operation of the scopes and their associated circuits. These triggers will be considered in pairs, the first pair being the 390 and 1170 *main* triggers, the second pair being the 390 and 1170 *delayed* triggers. The requirements of the delayed triggers are coincident 390 and 1170 negative pulses that will start the sweeps a variable time after the start of the PPI sweep. A complication occurs when the delay is greater than 50 miles, so at present only delays of less than 50 miles will be considered. Since there is one 390 trigger for every three 1170 triggers, it follows that we need only delay the 1170 triggers and pick off the correct one in a coincidence gate circuit to obtain a delayed output of both 1170 and 390 triggers. This is accomplished in a series of steps. The output from the 1170 inverter, V-105A (figure 1) is applied to a delay multivibrator, V-167, whose output, a gating pulse, is applied to a sawtooth generator utilizing a *bootstrap* circuit to charge the sweep capacitor. The sawtooth generator is held at ground potential by a gating tube, V-169A, until the negative block from the M.V. is applied to the grid of the gating tube. The negative block must be longer than the maximum range (50 miles in this case) but must be less than 70 miles so that the stage can be restored to its original condition before another 1170 trigger is applied to the delay M.V.

The output from the sawtooth generator, a positive sawtooth voltage, is applied to the plate of V-168B, the delay-time selector. This stage has a certain d-c potential on the cathode, determined by the setting of the range delay dial on the front panel which controls a potentiometer in the cathode circuit. The lower end of this potentiometer is at ground potential and corresponds to zero range. The upper limit (50 miles in this case) is adjusted by a second potentiometer, thus affording a means of adjusting the dial to read exactly 50 miles as checked against the range marks. When the sawtooth voltage is applied to the plate, at some certain point its value will reach and start to exceed that of the cathode. At this point the diode will conduct, forming a positive

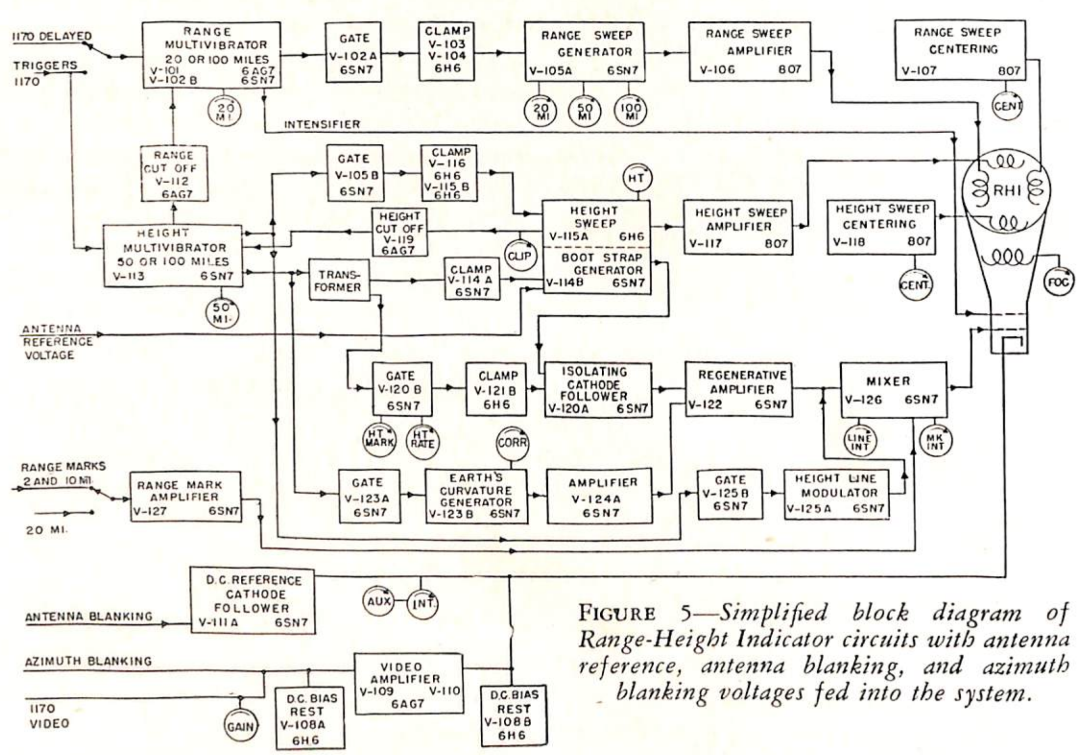


FIGURE 5—*Simplified block diagram of Range-Height Indicator circuits with antenna reference, antenna blanking, and azimuth blanking voltages fed into the system.*

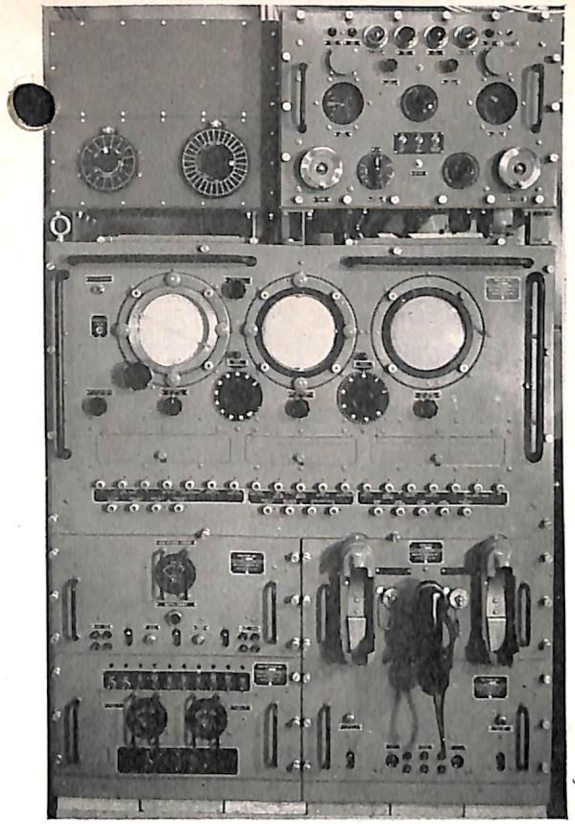


FIGURE 6—*Front view of the SX Console with Fighter-Director Officer's Panel and Communication Switchboard mounted on top.*

block of voltage since the output is taken off the cathode. The leading edge of this block is the delay point for measuring time. This block is then passed through a differentiator and amplifier, V-170, which gives a negative pulse for the leading edge and a positive pulse for the trailing edge. Transformer coupling is utilized in coupling to the next stage which again makes the leading edge positive and the trailing edge negative. These negative and positive pulses are applied to the grid of an amplifier, V-171B, which is biased beyond cutoff. The output, a negative pulse, has two applications. One is used for the 1170 delayed trigger output and the other is applied to an inverter stage, V-166A, which gives a positive pulse output.

Up to this point we have developed only the delayed 1170 trigger without any mention of the delayed 390. The output of the 390 inverter, V150B, is applied to a selector M.V., V-164. The time constant of this M.V. is adjusted so that its output will be a negative block with a time duration equal to that of the delay M.V., V-167. This output is applied to V-165B, the coincident gate tube. The pulse output from the 1170 inverter, V-166A is applied to the other half of the coincidence gate tube, V-165A. V-165B is normally conducting, while V-165A is cut off by a fixed bias. It is obvious that only one 1170 pulse out of each three appearing on the grid of V-165A will cause conduction because the tube is blocked, except when the negative block is developed in the selector M.V. by each 390 trigger.

If a delay greater than 50 miles is concerned, some changes must be made. It will be noted in figure 1 that when the switch is thrown to the 50-100 mile delay, the delay M.V. is triggered off by the 390 rather than the 1170 trigger. This switching is accomplished by a micro-switch when the 50-mile delay point is passed. Not shown on the diagram is another switch which changes the time constants of the delay M.V. circuit to give a negative block output equivalent to 100 miles rather than 50. The selector M.V., coincidence gate, and 1170 inverter (V-166A) are not effective in this condition. The only output is the 390 delayed trigger.

PLAN POSITION INDICATOR

The PPI circuits are more or less conventional and can be divided into six channels: sweep, video, range-marks, MSS intensifier, delay trigger, and angle marker.

The main sweep circuit is composed of a range multivibrator, sweep generator, degenerative sweep amplifier, sweep-voltage amplifier, and sweep-current amplifier (figure 2). The incoming main trigger trips the range M.V., V-155 and V-156A, producing two outputs, a positive block of voltage which is applied to the grid of the PPI as an intensifying voltage for the duration of the sweep, and the other a negative block to be applied to the sweep generator, V-156B. The duration or length of these blocks may be either 20, 50, or 100 miles depending upon which is chosen by the operator. V-156B is normally conducting, but the pulse from the M.V. cuts it off, allowing the sweep capacitor to charge in a positive direction creating a sawtooth waveform, the rate of rise depending upon the size of the sweep capacitor in use. This sawtooth waveform is passed through a degenerative amplifier V-157A and a voltage amplifier V-157B and applied to the grid of the current amplifier, V-159. The sweep is taken from V-159 and applied to the deflection coil of the PPI.

The incoming videos, IFF, 390, and 1170 are passed through a switching arrangement whereby it is possible to use either the 390 or 1170 video and permits cutting out the IFF video at will. The switch is connected to the video mixer (V-172), one-half of which is used for a video amplifier and the other half for an IFF amplifier. Both plates are tied together, however, with a common plate load, thus affording mixing action in the output. The output of the mixer is passed through two stages of amplification (V-173B and V-176) and applied to the cathode of the PPI as negative voltages.

The range marks are applied to an amplifier (V-161) which drives a cathode follower (V-126B). The output of the cathode follower is applied to the grid of the PPI.

The MSS intensifier input is passed through a cathode follower (V-158B) to the control grid of the PPI.

The 390 delayed trigger is amplified in the trigger amplifier (V-163B) and applied to the PPI grid through a cathode follower (V-163A).

It will be noted that three cathode followers have been used in the preceding three circuits to apply different voltages to the PPI. There is a fourth cathode follower in this series and all four have a common cathode resistor. The fourth is in the Angle Marker Intensifier circuit. Two microswitches, S-118 and S-119, are connected between –150 volts and the angle marker switch which is connected to the grid of the cathode follower V-162A. The microswitches are closed or opened by cams on the PPI yoke, one during 10, and one during 30 degrees of rotation. Whether closed or open they apply a negative 150 volts to their respective points on the angle marker switch. This tube is cut off at all times except during the instant that the switches are momentarily opened. This will allow the cathode follower to conduct only at the instant the cam opens or closes the contacts placing an intensifying voltage on the control grid of the PPI, making the trace brighter at that instant and giving the required angle marks. If the switch is on the 360° point, a constant –150 volts will be on the control grid of the cathode follower, which will prohibit it from conducting, thus no angle marks. The MSS control grid is also connected to the angle-marker switch and its pattern will show the same markers. Two additional switches, S-116 and S-117, are operated by the cams on the PPI yoke when the PPI rotates an additional 90 degrees. In normal position these switches are closed to the –150 volts and blank out the RHI video signal, but when operated by the cams they open and remove the blanking. Thus the signals which are seen on the RHI scope are those from targets in the area outlined 90-degrees previously on the PPI.

MAP SECTOR SCAN

Figure 3 shows a simplified block diagram of the circuits in the MSS system and the following discussion will be based on this diagram. An inspection of the diagram reveals two independent but closely related sweeps, one for range and one for azimuth, derived from one sweep generator. The method of generating and presenting these sweeps are the important functions of the unit and the key to the entire presentation.

The sweep multivibrator V-137 is the initial point in the circuit. It is triggered by the 390 main trigger and has one fixed time constant equivalent to 140 miles in range. This allows a complete 40-mile sweep to be displayed with a range delay as great as 100 miles. The 180-degree switch shown on the diagram effectively divides the PPI scope into two 180-degree sectors, the switch being operated by cams geared to the PPI yoke. The sweep multivibrator will function only when the switch is in the open position, limiting the picture on the MSS to an area 90 degrees ahead and 90 degrees behind the cursor line which bisects the area. The three cut-offs shown in the diagram are tubes which form an interlocking circuit for controlling the sweeps. On the diagram, V-136A and V-153A are parallelled cut-offs which, when open, allow the range M.V. to operate, but when closed prevent it from operating. These tubes will be open while the sweep M.V. is operating, as it places a negative block of voltage on their grid.

V-136B is the return cut-off tube and is normally open. It closes at the end of the range M.V. period. By this arrangement of the cut-offs the sweep M.V. may be tripped without regard for the range M.V. But when the range M.V. finishes its period, it cuts off the sweep M.V., stopping the sweep. A third cut-off (V-147) connecting back from the sweep selector to the sweep M.V. will be discussed in conjunction with the azimuth sweep.

The output of the sweep M.V. is applied to the sweep generator V-138B which develops a sawtooth waveform of a time duration equal to either 20 or 40 miles. The sweep rates of both must be such that, regardless of the range (20 or 40 miles), the voltage increase will be of the same magnitude, thus assuring the same length of trace for both the 20- and 40-mile sweeps. Only one variable, in the 40-mile section, is available for adjusting the sweeps to identical lengths.

Following the sweep generator are a degenerative amplifier (V-138A), a voltage amplifier (V-139A), and a current amplifier (V-140). These circuits function in a manner similar to the sweep circuits in the PPI, except the load is connected in the cathode circuit of the sweep current amplifier. The load of the current amplifier is the rotor of a transformer (called a two-phase generator) which has two secondary windings placed at right angles to each other. This rotor is synchronized with the PPI yoke and the antenna.

The two-phase generator separates the sawtooth wave into two waves and then amplitude-modulates them, one sinusoidally and the other cosinusoidally. This modulation is necessary when the final presentation is considered as each trace must have both a vertical and a horizontal component, varying in length with each succeeding trace. From figure 4 it can be seen how these functions are performed with the amplitude of the "V" lines decreasing as the "H" lines increase. The generator supplies two sawtooth waveforms in the output, one to the range-sweep chain, and one to the bearing-sweep chain.

The range multivibrator (V-130 and V-131A) can be adjusted to a period of time equivalent to either 20 or 40 miles. The output is applied to a gate tube (V-132) in conjunction with the sawtooth sweep from the two-phase generator. The gate tube effectively picks off a portion of each sawtooth sweep, passing it through a degenerative amplifier, voltage amplifier, and current amplifier to the horizontal deflection coil on the PPI. These circuits operate in the same manner as their counterparts in the PPI system. The range sweep-centering stage V-135 is an 807 which furnishes current for centering the sweep by the use of a second deflection coil in the same plane as the horizontal deflection coil.

The azimuth sweep is a push-pull type of circuit using the output of the two-phase generator for activation. The initial output of the generator is to V-141 (6SN7). The inputs to the two sections of this tube are 180 degrees out of phase since they are taken off the opposite ends of the transformer stator winding. Gating tubes are used in each of the channels, the gate being furnished by the sweep M.V. The sweep selector (V-146) is a 6H6 with a common cathode resistor and the first and second plates connected respectively to the upper and lower channels in the push-pull azimuth sweep amplifier. V-146 in conjunction with the cut-off tube V-147 is used to adjust the azimuth sweeps to the correct length.

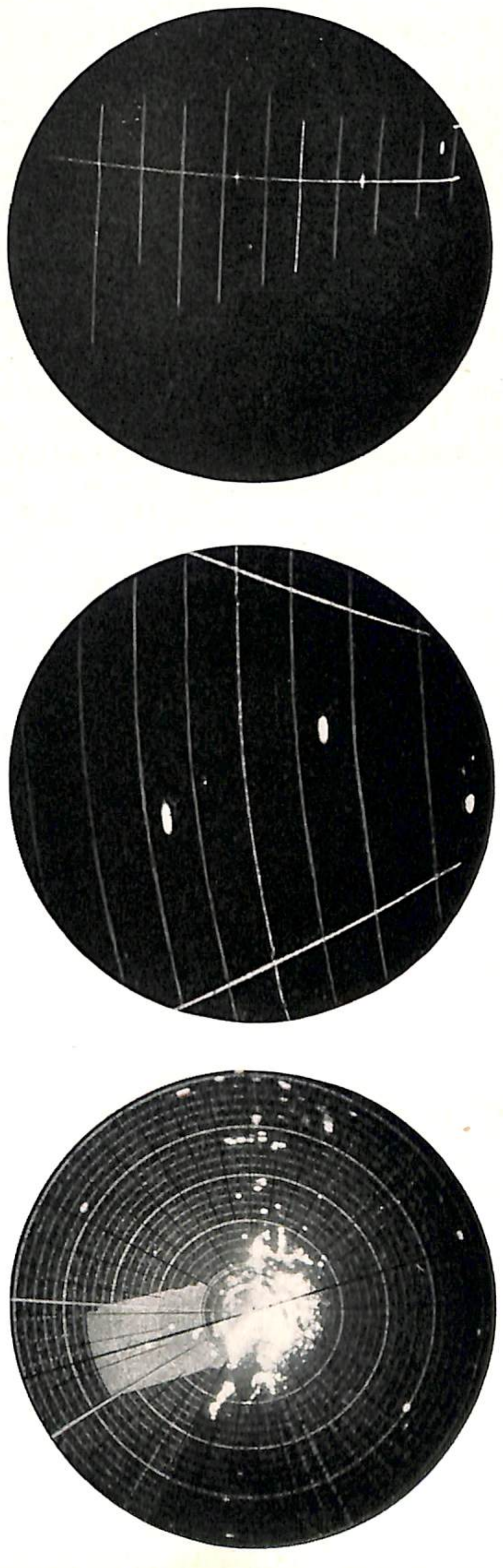
The remaining circuits in the MSS unit are conventional and require no explanation. It must be remembered that either the 390 video or the RHI video can be used by both the PPI and MSS.

RANGE-HEIGHT INDICATOR

The RHI unit was designed for sweep ranges of 20, 50, and 100 miles, requiring three M.V. time constants and three adjustments. All of the sweep adjustments are included in one sweep generator, but the time constants are divided between two multivibrators. In figure 5 the two M.V.'s are at the upper left. The range M.V. (V-101 and V-102B) is triggered by either the 1170 main or delayed trigger while the height M.V. (V-113) is triggered by the main trigger only. The range cut-off tube (V-112) turns off the range M.V. and renders it inoperative except during the period of the height M.V. This limits the range to the interval between a main trigger and the end of the height M.V. period. The main trigger is normally the 1170, but for a special application on the 100-mile range the 390 trigger is connected in to the 1170 circuit. The RHI range switch simultaneously selects sweep rates, M.V. time constants, and range M.V. triggers.

The output from the range M.V. operates gate tube V-102A and also supplies an intensifying voltage to the grid of the RHI scope. V-103 and V-104 act as clamps to hold the sweep capacitors at ground until the gating voltage is applied to their cathodes. This allows the sweep capacitors to charge, forming a sawtooth waveform. This sawtooth is passed through the range sweep generator (V-105A), a cathode follower. The output of

FIGURE 7—*Typical scope presentations on the PPI, MSS, and RHI.*



V-105A is applied to the range sweep amplifier (V-106), an 807 which drives the horizontal deflection coil. A second coil, in the same plane as the deflection coil, is driven by V-107 and is used as a centering adjustment on the scope. One point worthy of note is that the deflection coils on the RHI are stationary, making the range sweeps run horizontal and the height sweeps vertical.

The height-sweep bootstrap generator (V-114B and V-115A) operates on the same principle as the one used for the delay triggers. The sawtooth developed at the cathode of the triode drives the height-sweep amplifier V-117 and the height-cutoff tube V-119 which feeds back to the height M.V. V-117 is an 807 current amplifier, the output of which drives the vertical deflection coil. A second 807 (V-118) is used to drive another deflection coil in the same plane as the vertical deflection coil, which controls the vertical centering on the scope. The antenna reference voltage, a 10-cycle sawtooth wave, is applied to the plate of the generator diode V-115A. This voltage has a magnitude which is proportional to the sine of the angle between the RHI antenna beam and the horizon. In this manner we can control the rate of charge of the sweep capacitor. When the reference voltage is zero, no height sweep will be generated and the scope trace will be horizontal. When the reference voltage is maximum, the height component of sweep will increase rapidly making the trace slope steeply at a large angle with the horizon. About 115 traces occur on the RHI scope during each tooth of the 10-cycle antenna reference voltage, thus each succeeding sweep will receive a slightly smaller height component, giving the impression of the trace sweeping from a maximum angle to zero (horizon).

The height marker line is a horizontal line across the scope which can be adjusted for any height up to 40,000 feet. The line is composed of a series of bright spots, one for each vertical trace. This line must meet three qualifications; the appearance of the spots must be delayed until the height sweep reaches a certain value, the line must be corrected for earths curvature, and the dots must all be of the same uniform brilliance. To meet these requirements, three separate but interlocked circuits are necessary. The output from the transformer is applied to a gate and clamp circuit (V-120B and V-121B). The signal is then applied to the grid of the isolating cathode follower (V-120A) which is initially clamped to the same potential as the gate and clamp. One output of the height-sweep generator is coupled to the grid of this cathode follower. Thus, when the gate is opened, the grid will follow the sawtooth voltage of the sweep generator. The Height Mark Control in the cathode of V-120B controls the operation of the cathode follower which ultimately determines the height of the marker. The dial on the control is calibrated in thousands of feet and a Height Rate Control makes the calibration correspond to the actual marker height on the scope.

The regenerative amplifier (V-122) operates somewhat similar to a M.V. having a common cathode resistor with one section conducting while the other is cut off. The resulting rise in plate voltage at the output (when the circuit is tripped by the sawtooth from the cathode follower) is very steep and momentarily carried above the supply voltage by using an inductive load, thus a pulse is formed in the output voltage wave.

The earth's-curvature generator is a simple circuit for developing a sawtooth, with an integrating system added, composed of a charging capacitor and resistor. The integrating system is charged by the sawtooth generated in the sawtooth generator. The result is that the integrating capacitor charges slowly at first then more rapidly as the sawtooth generator capacitor voltage increases. Instead of the regular type of sawtooth wave this one will have teeth which curve upward. The wave is inverted in V-124A and made to curve downward from a level start, simulating the earth's curvature. This waveform is applied to the grid of the second section of the regenerative amplifier. The output of the first section is also applied to this grid, thus both voltages have an effect on the grid voltage and plate current of the second section. The effect in the output will be a succession of pulses, with those at the right of the scope pattern occurring closer to the base line. This is true because the longer it takes the height sweep to reach the pulse-producing value, the more curvature is introduced and the lower the mark appears on the trace.

The output from the height-line modulator (V-125A) and its gate (V-125B) is a sawtooth wave. This voltage is used to control the bias on the mixer tube (V-126A) and thus determine how much of the height-mark pulse will be used. The longer the time before the pulse occurs, the less the bias on the mixer and the greater the amount of pulse which will be passed.

The range marks are amplified in V-127 and applied to the grid of the mixer (V-126B). V-126 has both plates tied together and uses a common cathode resistor. The output is taken from the cathode circuit and applied to the grid of the scope tube.

The remainder of the block diagram shows the antenna blanking, azimuth blanking and video signals applied to the cathode of the scope. The azimuth blanking is controlled by cams in the PPI MSS gear system in such a way that it will be removed only when the antenna is sweeping the area between azimuth markers on the PPI. The antenna blanking signal originates at the antenna at the end of each downward sweep. It is simultaneous with the end of each tooth of the 10-cycle antenna reference voltage.

Review on Crystal Protection

■ A conference was recently held by engineers of the Western Electric Co. for the purpose of discussing the problems of crystal protection in *S-* and *X*-band radars. As a result of this meeting the following notes are published for information.

TR BOX CONSIDERATIONS

The life of a TR tube of the hydrogen—water-vapor type is determined by hydrogen "clean-up" and is almost wholly dependent on the number of hours *keep-alive* voltage is applied.

The use of water vapor in the tube improves the recovery time after the transmitted pulse and increases the tube life. After absorption of the water vapor the hydrogen is rapidly lost and the tube fails to protect the crystal.

In *S*-band TR tubes such as the 721B the addition of water vapor has a more pronounced effect on recovery time than in the *X*-band radars. It is therefore probable that 721B tubes (used in SL radars and others) are replaced in the field before adequate crystal protection is lost. Since this warning of impending tube failure is not obtained with the 724B *X*-band tube, crystals may fail before it is realized that the TR tube has failed.

Some of the characteristics of TR boxes are described as follows: 1—Direct coupling through the TR cavity represents a fixed loss, the energy to the crystal being a function of transmitted power. This is usually limited to acceptable values of TR box design. 2—The remaining power transmitted during the pulse consists of a spike at the leading edge of the pulse and a flat area which is independent of power level. It is generally the spike energy which results in crystal damage. The spike amplitude is more uniform with keep-alive applied. 3—It has been observed that the height of the spike decreases with time. The height drops rapidly after the first few pulses but continues to decrease over a period of many hours. It has also been observed that the height of the initial spike depends upon the length of time since the last discharge. This effect has been termed the poor *turn-on* characteristic and appears to be present in all TR tubes. 4—The same general characteristics outlined above are expected to apply equally to the 724B tube and the 1B24 (the latter being used in the new plumbing for Mk 22 and SS/ST-1 radar systems) with some modification. In the 1B24 tube a gas reservoir is used which should improve tube life. In addition, the tube construction with built-in cavity provides a discharge path across the inside of the coupling iris as well as in the normal path within the tube. At high powers (in the order of 50 kw) ionization at the iris may result in some improvement in *turn-on* characteristics.

Other factors which require consideration are: 1—Transmittal of power through the TR box is a function of load impedance which cannot readily be predicted because of changes in crystal impedance during the pulse. An unfortunate selection of distance from the TR to crystal might result in excessive power transmission to the crystal. 2—Magnetron misfiring generally results in generation of spurious frequencies which are not adequately attenuated by the TR box.

Two methods have been used to determine whether a TR tube is defective. They require little equipment, but presuppose considerable experience on the part of the observer. One method involves observation of the color of the discharge. A change in color from that of the original during satisfactory operation indicates a loss in efficiency. The second involves the use of dry ice to bring about condensation of the water vapor. The first method would be useless without a large amount of experience, and the second requires close inspection by a skilled observer because of the small amount of vapor present. Neither is recommended for field use.

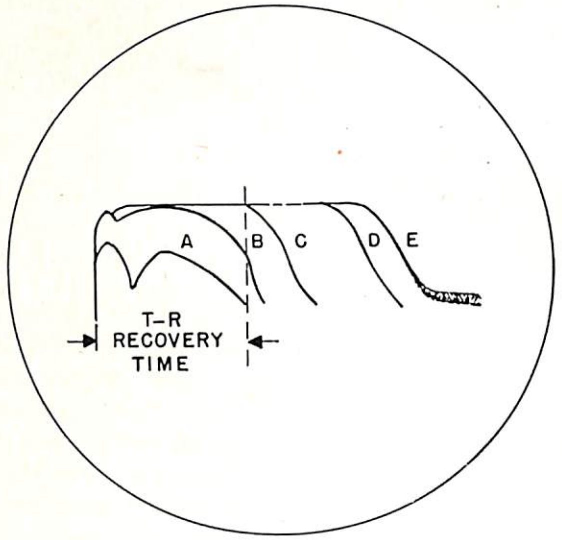
Conclusions: 1—Pay close attention to TR tube keep-alive hours and replace tube shortly before the end of expected life. That is, apply preventive maintenance. 2—If poor turn-on protection is not provided, and if equipment has not been in operation for several days, remove the crystal (with the usual shielding precautions) and operate for about ten seconds before replacing the crystal.

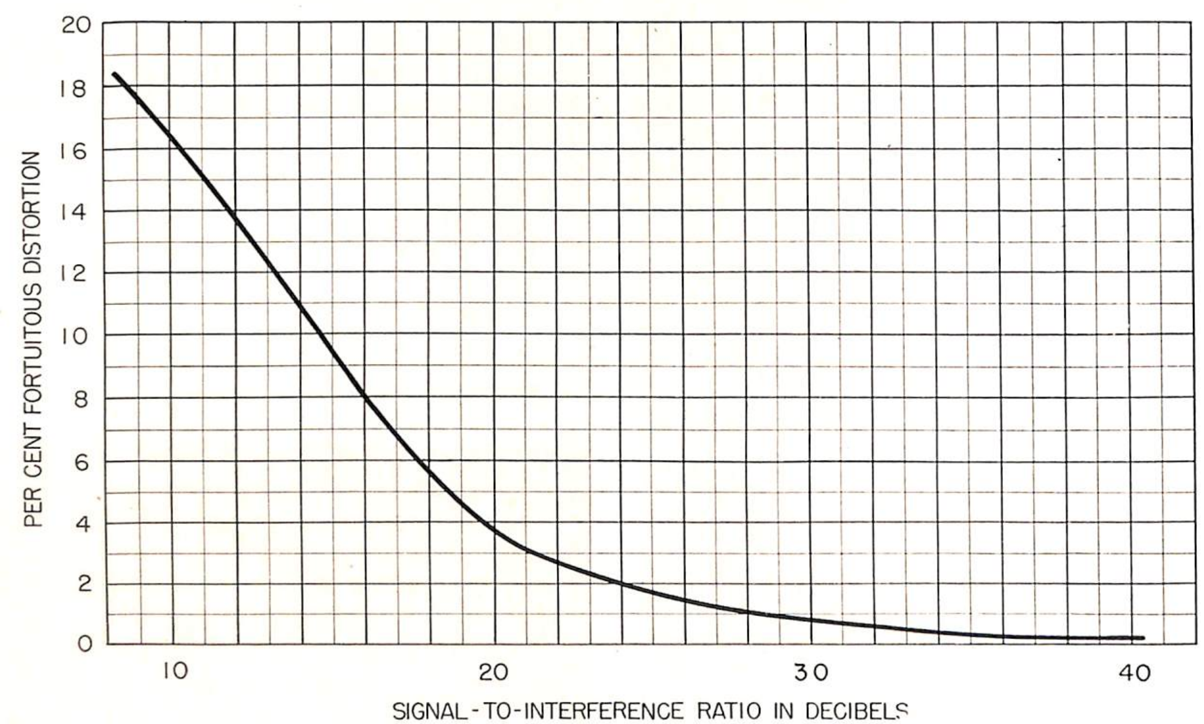
—*Western Electric Co.*

Bureau Comment: In addition to the information supplied above, the Bureau recommends the following procedure as a check on TR behavior and recovery time.

Adjust the echo box tuning control for maximum deflection of the output meter. Stop the radar antenna from rotating. Adjust the *A*-scope indicator of the radar for a good ringing time pattern, such as curve E in the figure. Start slowly and gradually to reduce the radar receiver gain setting or, better yet, detune the local oscillator. A pattern will result such as curve D in the figure, having the same relative shape as curve E. Further slight detuning or reduction in gain will produce a pattern similar to curve C. Continue until a change in the slope occurs, as in curve B. This point of change marks the TR box recovery time of the radar. For a correctly operating radar the TR recovery should be at one mile or less.

If the gain control is reduced still further, a greatly distorted pattern will appear, such as Curve A. This curve shows that the TR box has *not* recovered. Refer to the radar instruction book for correction of the trouble. If the above procedure does not produce a series of curves giving a TR recovery point, and if the ringing time is short, then it is probable that the TR recovery time is much too high (greater than ringing time), and a new TR tube is needed. Check the keep-alive current. The keep-alive should be negative, and the current between 0.1 and 0.2 milliamperes. Greater current or positive polarity will shorten TR tube life.

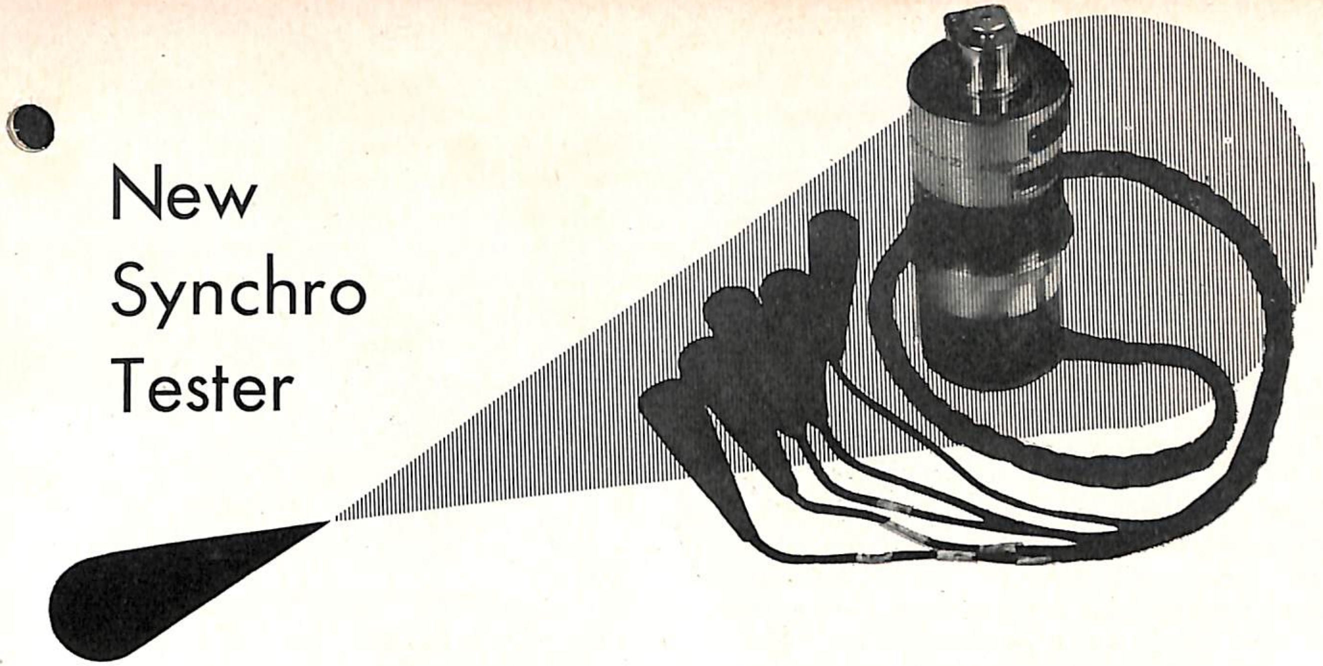




This curve shows the percentage of garbles to be expected in radio telegraph, teletype, and similar systems, as a function of the intensity of interfering signals. The curve should be of value in predicting the performance of new circuits.

(From Advances in Carrier Telegraph Transmission, Bell System Tech. Journal for April, 1940).

New Synchro Tester



■ The Mk 2 Mod 3 Synchro Tester is now available to the fleet for testing synchro motors, generators, and transmission circuits. The tester is a 1F synchro motor fitted with a dial, test leads, clutch, and dial-knob assembly. When the clutch is engaged, the rotor can be turned by the knurled knob on one end of the tester, a dial calibrated from zero to 360° turning with the rotor. When the tester is to be driven by a synchro generator, the clutch is disengaged, allowing the rotor to turn freely.

The rotor leads R1 and R2 are marked with one and two red stripes respectively while the three stator leads are marked similarly in white. A white index line is inscribed on the inner side of the dial window supporting frame which is adjusted and locked in a manner to insure that alignment will be maintained. Whenever desired, alignment may be checked very easily.

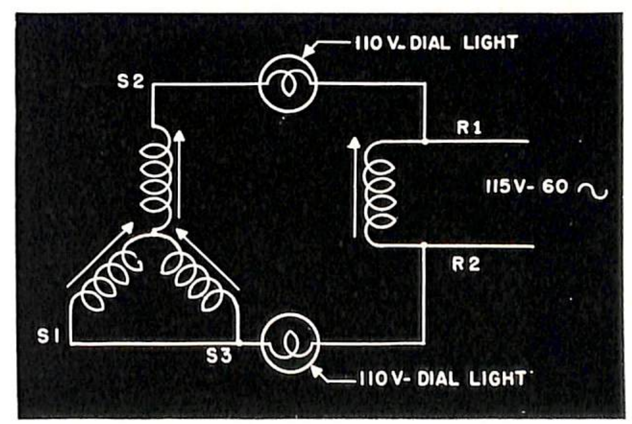
Test for electrical zero: Electrical zero is defined as that position of the rotor with respect to the stator in which there is no induced voltage between terminals S1 and S3 and the voltage on S2 is in phase with that in R1. Keeping this definition in mind, connect the synchro rotor (R1 and R2) across a 110-V 60-cycle supply. The clutch should be disengaged so that the dial is free to turn. Connected in this manner, the rotor will stop at electrical zero. The lamps will be dimly lighted by the current flowing to the S-leads of the synchro. When at electrical zero the 78-volt stator voltage is subtracted from the 115-volt rotor voltage leaving 37 volts impressed on the two 110-volt lamps connected in series.

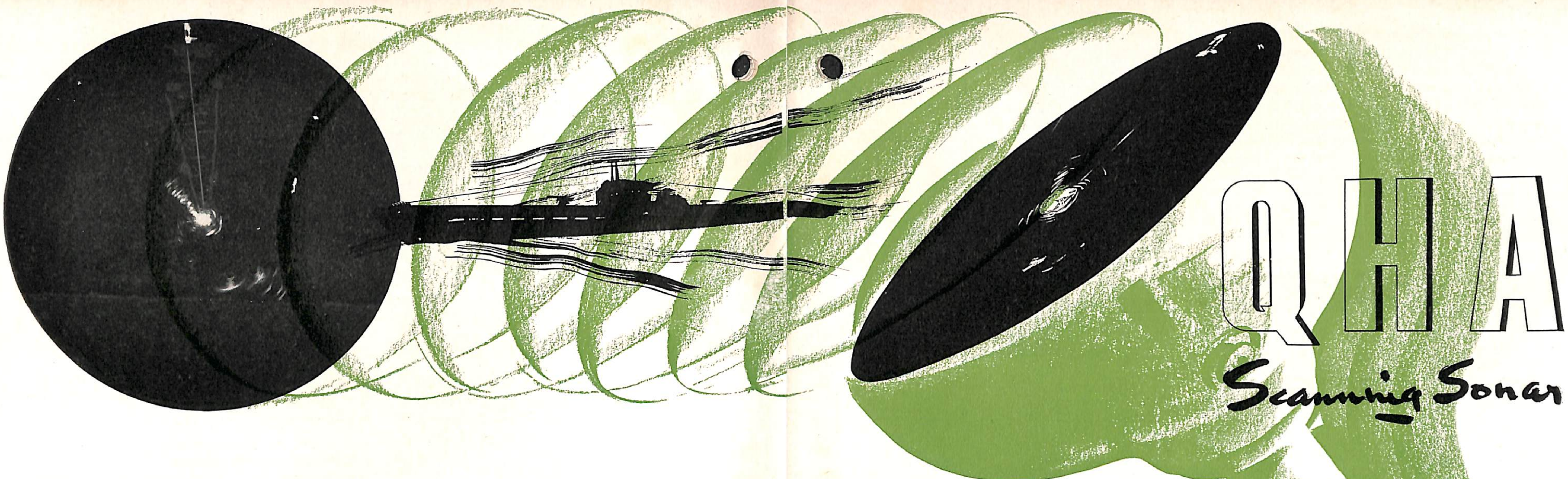
Caution: It is important that the clutch be disengaged when the instrument is connected to a synchro bus. Upon connection the tester will automatically position itself and thereby preclude the possibility of overheating and introducing reflections which will affect other synchros connected in the system. As a rule it is best not to release the clutch until after the tester is connected to the synchro circuit.

A complete discussion on the operation, maintenance and testing of synchros in general is contained in Ordnance Pamphlet No. 1303. A copy of this publication should be aboard each vessel. Additional copies may be procured upon request to the Bureau of Ships, Code 253.

Synchro Testers Mk 2 Mod 3 are now available in Ordnance Supply Stores and may be procured in the same manner as other ordnance-type synchros. The current allowance to fleet and repair activities is as follows:

3 each for BB's, CA's, CL's, CVB's, AS's, and ARL's.
2 each for CV's.
1 each for CVE's, CVL's, and DD's.
4 each for AD's, AR's, and ARH-1's.
15 each for all Naval Shipyards; U. S. Naval Drydock, Hunters Point, Calif.; U. S. Naval Repair Base, San Diego, Calif., and INDMAN 15th N.D., Balboa, C. Z.





QHA

Scanning Sonar

■ One of the latest developments in the field of echo ranging and listening is the QHB scanning sonar equipment, now in the early stages of production. This equipment is an azimuth-scanning system employing the capacity commutator-rotation principle, and was designed to eliminate the tedious search procedures of conventional sound gear by providing a means whereby the sound horizon might be searched at a rate limited only by the velocity of sound and the maximum expected range. The system is conventional in that it utilizes intermittent pulses of supersonic power, but unique because these pulses are nondirectional rather than beamed. Bearing determination is obtained by rapidly rotating only the receiving beam. This is accomplished electrically, and the bearing and range are presented on a cathode-ray indicator. The equipment may be used purely as a listening device which is continuously alert to sound from all directions. An auxiliary receiving channel provides for reception along any fixed line of bearing so that audio response similar to that of conventional equipment is available to assist in target and noise identification.

Although the QHB contains a large number of functional elements, the interrelations of which are complex, the apparatus as installed is extremely simple from the operational standpoint. Unlike most echo ranging equipments, it does not require constant manipulation on the part of the operator.

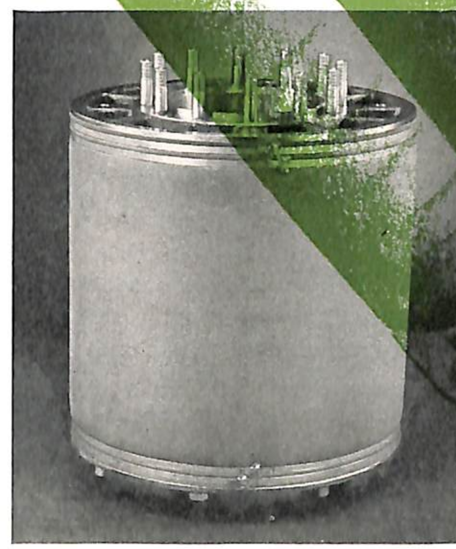
After initial adjustment, range and azimuth information of a number of targets is obtained by merely viewing the scope.

To provide the above features of operation, the basic functions required are, 1—a means for control of directional sensitivity, 2—cathode-ray tube indication of range and bearing, and 3—provision for simultaneous sound transmission in all directions.

The projector or transducer is composed of 48 independent magnostriction elements arranged vertically in a cylinder 18 inches in diameter. The assembly is mounted rigidly to the ship and does not rotate. Each element therefore remains facing a fixed direction relative to the ship. If plane waves from a remote sound source impinge upon the transducer, it is evident that signals will be inducted which have a magnitude and electrical phase angle determined by the angular position of the individual element involved. The phase shifts are very large since the radius of the transducer (8.85 inches) is very large compared with the wave length of the sound (2.31 inches at 26 kc). Actually, signals from a group of adjacent elements are converted to the same phase angle and combined, thus forming a receiving beam pattern equivalent to a conventional plane-faced projector. In order to obtain greater sensitivity, signals from any other elements are attenuated. This operation is accomplished by introducing the output of consecutive elements into the proper points of a time delay and attenuation network, or lag line, the maximum phase shift being given to the center elements and the maximum attenuation to the side elements. Finally, switching this network progressively around the cylinder to various arrays of elements, electrical rotation of the receiving directivity can be accomplished.

This switching is done by a capacity commutator, the rotor of which houses a time-delay network capable of simultaneous connection to 16 elements. Points on the network are connected to 16 of the 48 symmetrical metallized segments on the plane surface of a glass disc secured to the rotor shaft. This disc is mounted concentrically with an identical stationary disc. The air gap between the two discs is .00035 inch, thus providing a capacitance of 100 $\mu\mu$f between rotor and stator segments when fully meshed. This makes a circuit for applying a signal from a given stator segment to any of the 48 rotor segments, and hence to any point on the time-delay network. Each stator segment is connected individually to an element through a step-down transformer. Suitable slip rings deliver the combined output signal of the lag line to the amplifier circuits of the equipment.

The QHB actually employs two of the commutators described above. One is driven through gears by an



QHB transducer is shown with a rubber boot covering. The unit remains stationary, while scanning is accomplished electrically.

induction motor at a speed at 1760 rpm. This is used to sweep the sound horizon with the receiving beam approximately 30 times per second. The other is driven by a servo system so that the receiving beam may be positioned at any desired fixed line of bearing. It is connected to a receiving channel which provides audible signals such as are obtained in echo ranging or listening with conventional equipment.

C-R TUBE SCANNING

A 5HCT control transformer is geared to the continuouly-rotating commutator spindle to operate at the same speed. The rotor of the 5HCT is supplied with a direct current, increasing in value from zero at the time of the main pulse to a value necessary for deflection of the electron beam from the center of the scope to the outer edge. The time required for the current to reach this value is, of course, dependent on the range scale in use at the time. A 3-phase a-c voltage of a frequency proportional to the speed of the commutator and of a magnitude proportional to the range is therefore induced into the control transformer stator. This synchro is connected to the deflection coils (a synchro stator) of a cathode-ray tube, thereby causing the spot to trace a spiral on the screen. The position of the spot is synchronized in azimuth with the commutator rotor and proportional in radius to the time since the last transmitted signal.

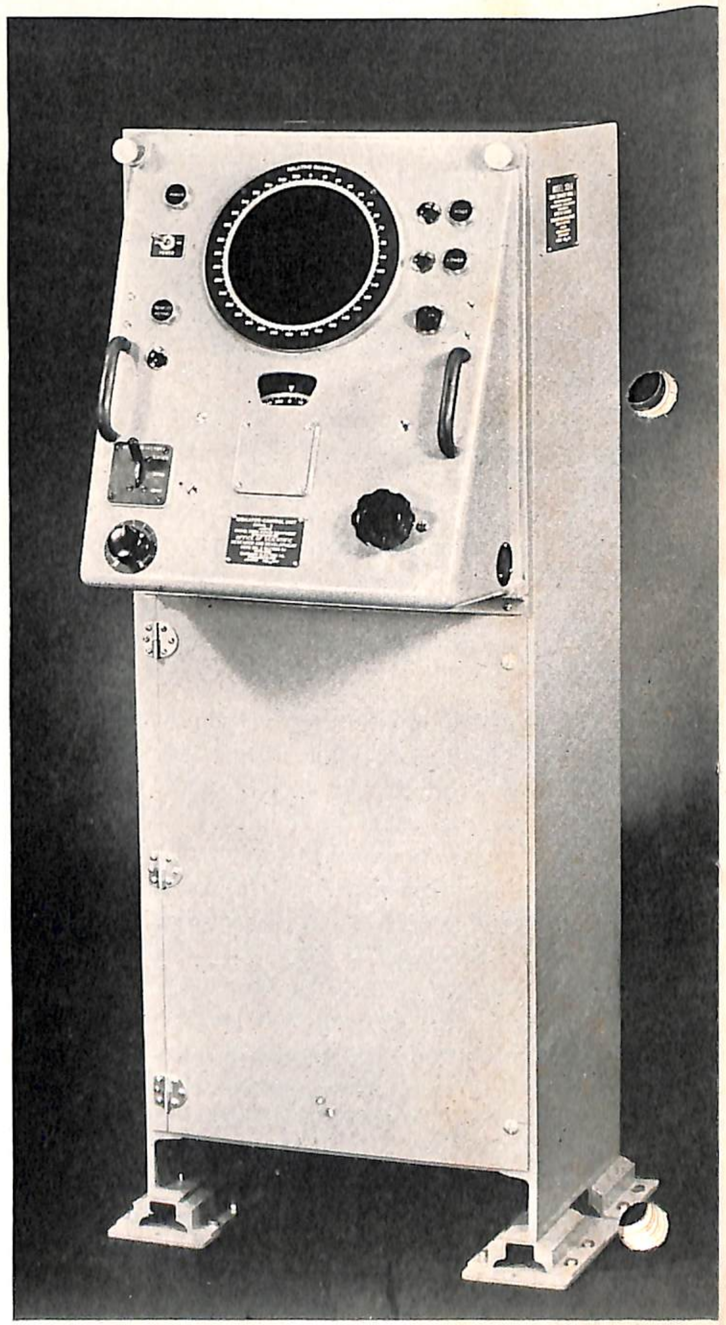
In transmission, all elements of the transducer are connected in parallel and fed from an impulse-type transmitter, the keying of which is synchronized with the sweep generator current-control circuit. This results in a uniform pulse of sound energy which travels out in all directions from the transducer. The length of the transmitted pulse is made equal to or slightly greater than the time for one rotation of the rotor and hence, if a reflecting target returns an echo before the next transmission, the rotor will form a sensitive beam in the direction of the echo at least once during a rotation. The output of the rotor lag-line amplifier is connected to the control grid of the cathode-ray tube. The result is a bright arc on the face of the PPI tube which is indicative in angular position of the target bearing and in radius of the target range. It is evident therefore, that for every pulse of the transmitter, the cathode-ray tube screen will be alert in all directions for any possible energy return. Positive identification of an apparent echo can then be accomplished by use of the fixed bearing or listening commutator.

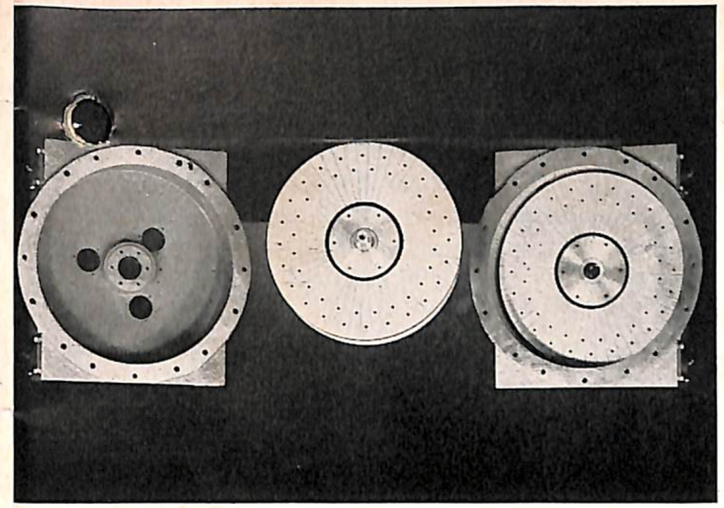
ELECTRONIC CURSOR

Since rotation of the commutator is rotation of the receiving beam relative to the ship, the cathode-ray tube display presents a relative bearing indication. The training control order to the servo mechanism of the listening commutator is accomplished by the positioning, with the operator hand wheel, of a differential synchro generator excited by gyro compass. The card affixed to the rotor shaft of this generator therefore indicates the true bearing. Gyro excitation of the generator provides maintenance of true bearing feature to the listening commutator training control.

During the transmission interval, while the current in the sweep generator is being restored to zero, the deflection coils are switched from the differential generator to the synchro order, and simultaneously a 60-cycle signal is applied to the cathode-ray tube grid. The result is a radial line which indicates the relative bearing order to the listening commutator. This not only indicates the fixed line of bearing from which audio response is obtained, but is useful as a means of ascertaining the center of an echo arc on the scan display. Means are provided whereby the operator may switch the line on at will in lieu of the scan and manipulate the training control to center the bearing line on an echo arc, thereby accurately determining sound bearing.

Indicator console for the experimental model of the QHB. There may be slight changes in the production models.





Interior view of one of the two capacity commutators of the QHB scanning sonar.

Means are not provided on the surface of the cathode-ray tube for accurate determination of range. It may only be estimated on the basis of echo arc radius and it is presumed in the design of the equipment that accurate knowledge of range would be obtained from a conventional sound-range recorder. The keying circuits of the equipment are designed to provide self-keying at several keying rates, or to operate from the keying circuit of a recorder. It is considered that the estimated range is adequate until such time as the sound-range recorder commences to operate in the course of a contact.

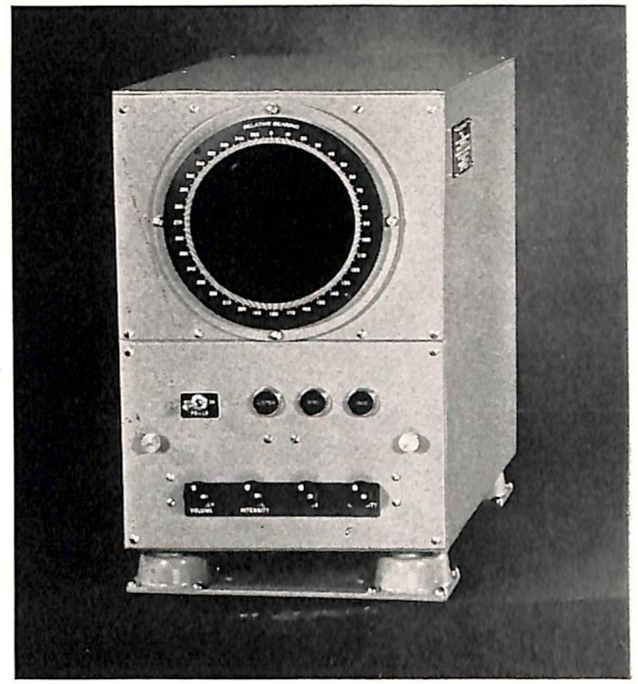
"LISTENING" SCANNING

In using the scanning feature for determining the bearing of noise sources, the transmitter-keyer circuit is disconnected but the sweep-generator current continues the saw-tooth variation at the 3750-yard rate. The result is that a noise source, such as a ship's propeller, will come through the scanning commutator and appear on the PPI tube as a bright sector, the center of which is the bearing of the noise source. It is evident that, as in echo ranging, the scanning display is alert to noise sources from the entire sound horizon.

REMOTE INDICATOR

Use of a cathode-ray tube as the scanning indicator has made possible an exceedingly useful piece of auxiliary apparatus: a second cathode-ray tube with its own power supply is connected in parallel with the signals to the tube at the operator's station. Thus there is made available to the controlling officer an exact duplicate of the scanning information, a presentation which can be extremely useful in many situations. Local volume controls govern the intensity of the display of this repeater unit so that it may be operated under lighting conditions altogether different from those of the control equipment.

Remote Indicator which may be placed at any desired location aboard ship.



TUNING SYSTEM

Tuning of the system is accomplished by a single control which tunes a master oscillator in the receiver through a range of about 6 kc above and below 86 kc. Energy from this oscillator is used in both receiver and transmitter sections where, by the heterodyne principle, conversion is made to the proper operating frequency.

Thus, the output from this oscillator beats with a fixed 60-kc oscillator in the transmitter to produce a signal in the 26-kc band. This frequency is then amplified and applied to the transducer.

Similarly, signals returning to the transducer are fed to the receiver where they are mixed with the frequency of this same master oscillator, producing an i-f frequency of 60 kc. Note that at any time the operating frequency is always 60 kc lower than the frequency of the master oscillator.

TRANSMITTER

To provide sound pressures equal to or greater than the pressure obtained in conventional narrow-beam echo ranging equipment, it is obvious that a tremendous transmitter would be required if built for continuous emission. An impulse type system has therefore been developed which employs large storage capacitors for the plate supply of the power output tubes. An exponentially-decaying driving impulse is obtained which, at the slowest keying rate, develops a total power input to the transducer of 7.8 kw, the attenuation at the end of the transmission impulse being approximately 3.5 db. Since the acoustical efficiency of the transducer is from 30 to 40%, the result is a maximum of about 3 kw of sound power. This compares more than favorably with any conventional equipments in service. The arrangement is exceedingly economical, the average power input to the transmitter being 550 watts. Facilities are provided for underwater communication by code. When hand keying, 120-cycle modulation is imposed on the driving impulse to reduce the power output and the drain on the supply line.

RECEIVING AMPLIFIERS

The output of each commutator is amplified by a preamplifier located immediately adjacent to the commutator, the amplifier circuit including a band-pass filter to improve the signal-to-noise ratio as much as possible before entering the receiver. Both the scanning and audio receivers are essentially identical up to the output stage. The output of the scanning channel intermediate frequency is rectified, providing a d-c signal to the grid of the cathode-ray PPI tube.

The intermediate frequency of the audio channel terminates in a mixer supplied by a beat-frequency oscillator which is controlled by an Own-Doppler-Nullifier circuit. The latter is of the reverberation-sampling variety and had been modified in the XQHA equipment to provide a very rapid correction rate since the training speed of the listening channel commutator is 8 rpm, and very large changes in bearing may be encountered since there is no reason to progressively alter the bearing as in search procedures with conventional equipment. The Own Doppler Nullifier circuit employed uses the rectified output of a discriminator transformer to control the bias of a triode, the plate of which is capacity coupled into the oscillating circuit of the beat-frequency oscillator, variation of the plate resistance of the triode changing the effective incremental capacity in the tank circuit of the oscillator.

The output of the audio circuit is employed to provide reverberation control of gain which is operative in both the listening and scanning channels. The time constant of the time-varied gain is very short (80 yards for 5 db down) in accordance with the latest Navy Department specifications. The control unit of the equipment has a single volume control which affects both channels identically. A top-of-chassis adjustment in the receiver provides independent control of the audio output so that the equipment may be set up in accordance with local or current doctrine, but such independent control is not accessible to the operator of the equipment.

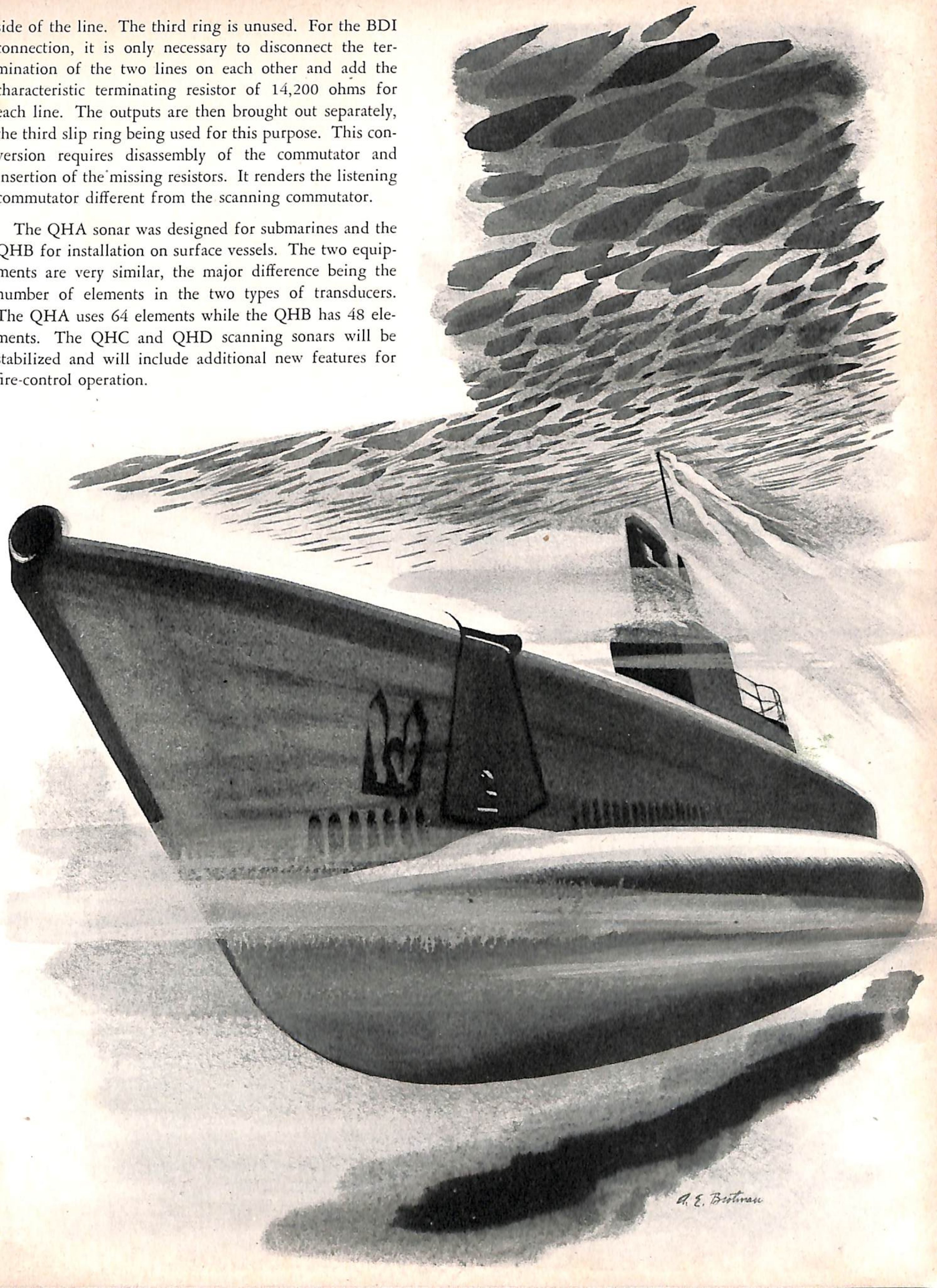
BDI OPERATION

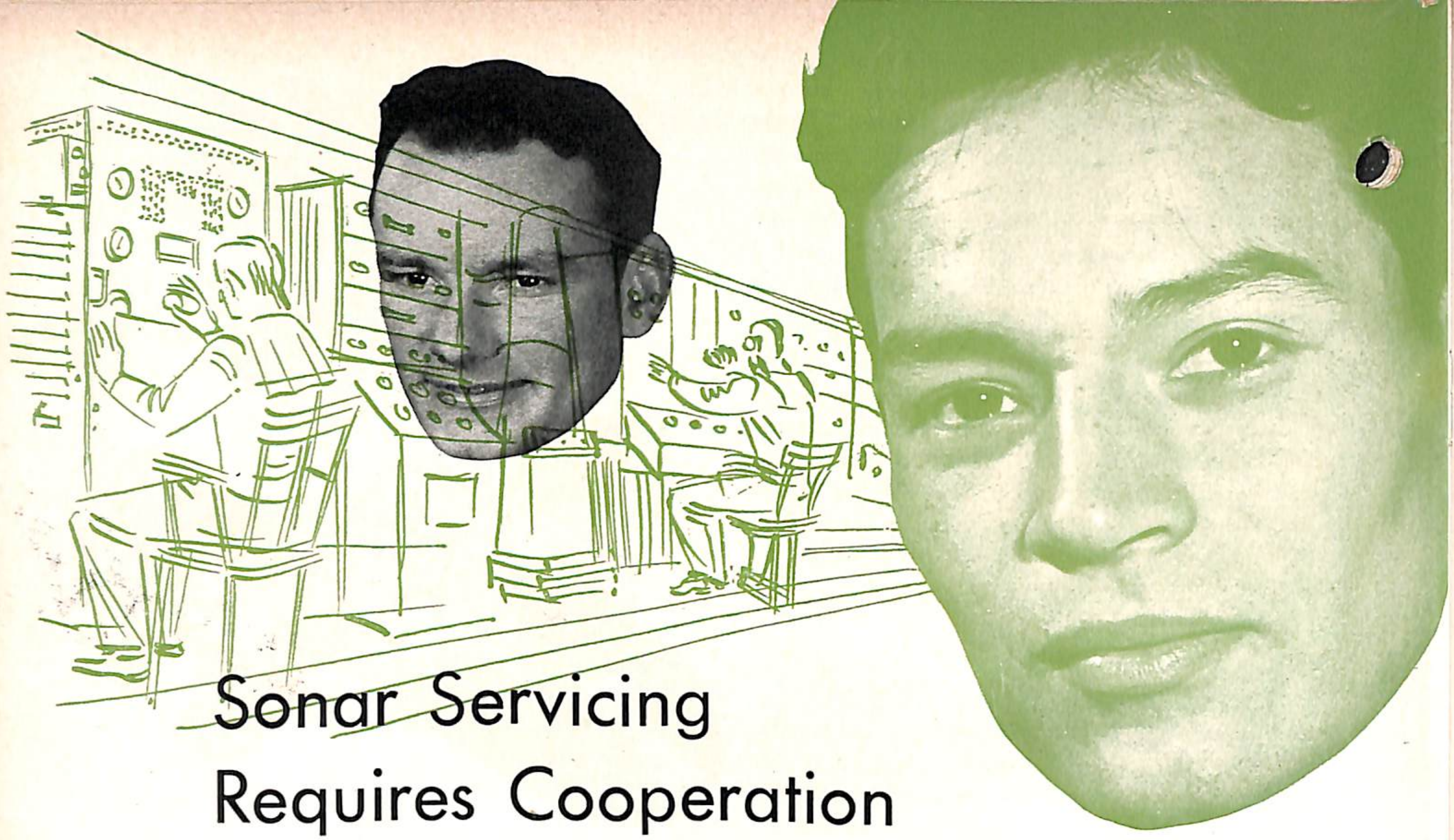
It was stated that the determination of target bearing is accomplished by inspection of the scan with the assistance of the target bearing line or electronic cursor. With increasing emphasis on bearing accuracy, it is evident that improvement on this method of bearing determination may be mandatory. Provision has been made in the design of the time-delay network of the commutator and the commutator itself for application of the simultaneous-lobe-comparison principle of the conventional BDI (bearing deviation indicator) circuit to the QHB equipment. It is expected that one or more of the equipments produced will be so modified in order that bearing accuracies by the lobe-comparison method may be compared with those obtained by inspection of the scan.

The formation of a beam by the device of lagging and attenuating the signals from a given array of elements must be accomplished by performing identical electrical operations on the signals to the right and to the left of the leading elements (or those on bearing with the sound source). The lag line may therefore be split mechanically and electrically into two symmetrical sections. The signals available at the termination of the two lag lines thus provided must be, by analogy, the equivalent of the signals available from the two halves of the conventional vertically-split transducer. If the two lines have a common ground it is therefore possible, by adding a third slip ring to the commutator, to bring out the two halves of the equivalent beam and introduce the right-left signals into identical preamplifiers which, in turn, may be connected to a conventional BDI receiver. As the listening commutator is trained, the response of the BDI should be the exact equivalent to that which should obtain if a conventional split transducer were employed.

In designing the lag line of the QHB commutator, the possible necessity for this BDI circuit arrangement dictated construction of the line in two entirely separate halves. In both the listening and scanning commutators, the lines were terminated on each other rather than into the characteristic resistance, since the lines constitute mutually-correct terminations. The outputs of both sections of the line were therefore connected in parallel. The common termination was connected to one of three slip rings, one of the two remaining being the ground side of the line. The third ring is unused. For the BDI connection, it is only necessary to disconnect the termination of the two lines on each other and add the characteristic terminating resistor of 14,200 ohms for each line. The outputs are then brought out separately, the third slip ring being used for this purpose. This conversion requires disassembly of the commutator and insertion of the missing resistors. It renders the listening commutator different from the scanning commutator.

The QHA sonar was designed for submarines and the QHB for installation on surface vessels. The two equipments are very similar, the major difference being the number of elements in the two types of transducers. The QHA uses 64 elements while the QHB has 48 elements. The QHC and QHD scanning sonars will be stabilized and will include additional new features for fire-control operation.



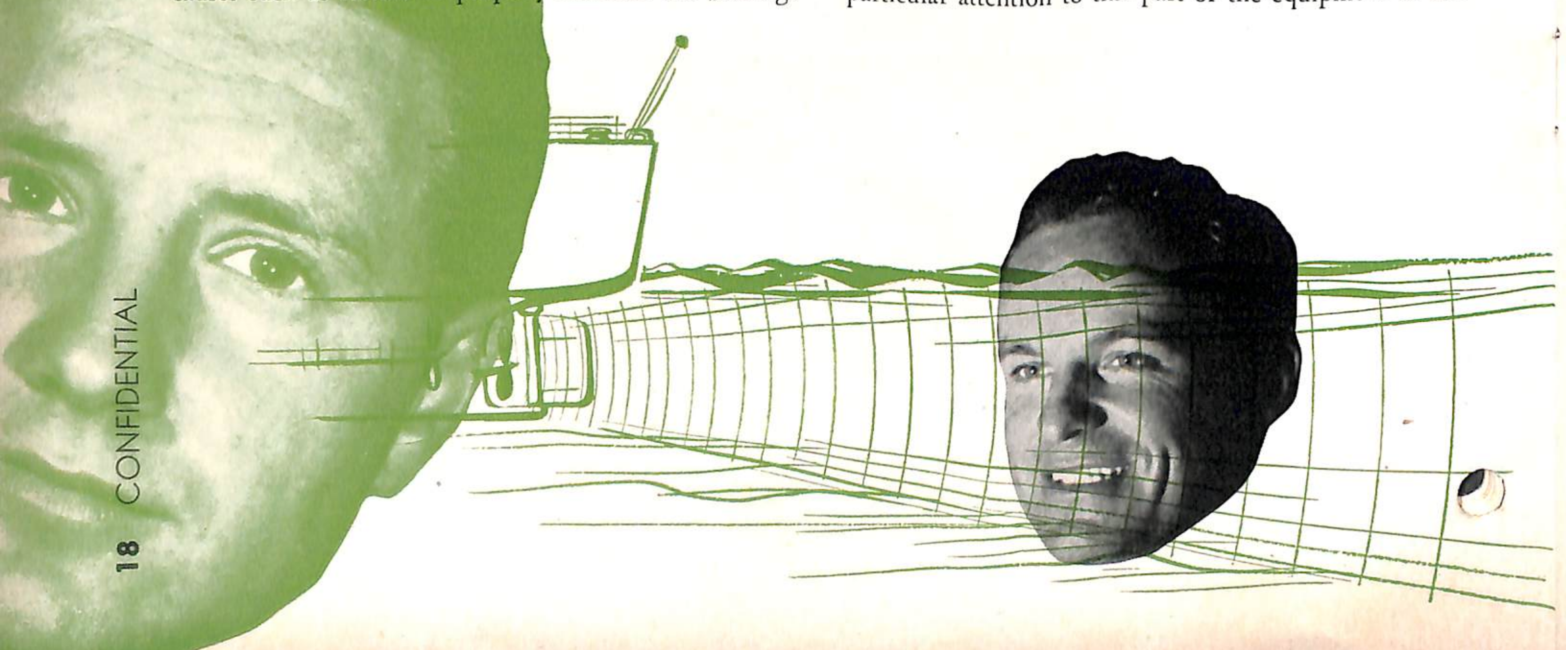


Sonar Servicing Requires Cooperation

■ Radio technicians and sonar maintenance men often show a tendency to become "electron happy" and may lose sight of the fact that the mechanical features of their electronic equipment are sometimes the sources of major and even disastrous trouble. This is particularly true in the maintenance of sonar equipment.

Failure reports indicate that a great number of sonar breakdowns are of a mechanical nature. While such failures are many times the result of faulty installation, more often they can be traced directly to preventable causes such as failure to properly lubricate the bearings and other moving parts of the equipment. Too often the cause of a sonar casualty may be the result of the radio technician's failure to maintain the specified mechanical tolerance of the equipment or to his lack of knowledge of the requirements which must be met by the mechanical parts of the sonar installation.

The mechanical parts of sonar equipment demand preventive maintenance measures. This is particularly true of the directing-retracting mechanism, which is nearly "99.44%" mechanical. The radio technician should pay particular attention to this part of the equipment as one of the principal sources of sonar failures. Special tools to aid in the servicing of certain parts of the hoist-lower mechanisms are provided with the equipment. Keep these special tools such as tommie bars, gland-nut wrenches, etc., close by at all times and learn to use them properly.



Furthermore, failure of mechanical parts is often the cause of electrical breakdown. For example, improper lubrication of the gear-train mechanism in the QJA or QJB training control system results in a heavier load on the spinner motor which, in turn, causes a higher plate current to be drawn from the type 2050 vacuum tubes. This may result in the complete failure of these tubes and the subsequent breakdown of the electronic circuit. While on convoy duty in the Atlantic, the failure of the amplidyne generator of a DE was traced to the overload placed on the training mechanism when the mechanical lower stops of the hoist-lower system were displaced through corrosion or bending.

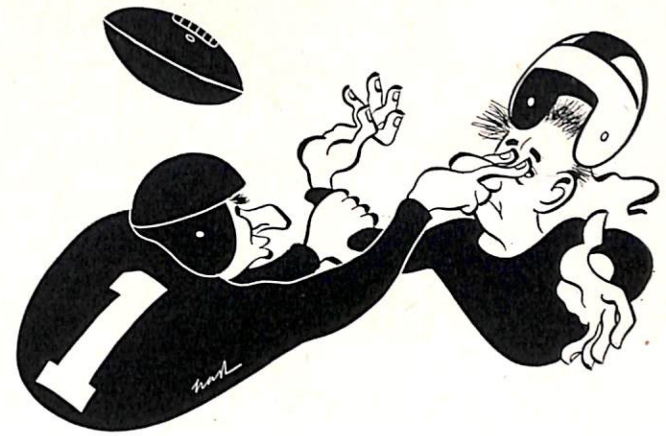
Often the mechanical training of the radio technician is rather limited, emphasis having been placed on circuit tracing, print reading, and trouble shooting along strictly electronic lines. Moreover, to locate, check, and replace defective items, to learn how to use new electronic test equipment constantly being issued to the fleet, and to keep up to date on the modifications and additions to the equipment itself, means that the RT has little time to devote to a study of mechanics. It is not surprising, therefore, that the radio technician should need help in maintaining those parts of his electronic equipment which require mechanical skill.

The radio technician should not hesitate to ask for help. He should not attempt to make mechanical repairs about which he knows little. It is best to enlist the assistance of Machinists Mates who can do the job correctly in much less time and with practically no effort. These men are trained specifically in the maintenance and replacement of gears, motors, shafts, valves, gaskets and mechanical parts which are as important to sonar equipment as vacuum tubes and capacitors.

Radio Technicians should solicit the help of their division officers in securing the professional services of ratings in other divisions. They will be a great help for preventive maintenance, and such an arrangement is particularly desirable in case of an emergency.

No sonar installation is stronger or more efficient than its weakest component. Since mechanical failures are predominantly the "weakest links", cooperation between the technician and mechanical rates to keep these parts in good working condition is very important. Every effort should be made to make this cooperation an actual working relationship.

YG Interference



■ The Naval Air Station, Daytona Beach, Florida, experienced considerable trouble with interference in communication receivers due to operation of YG beacon equipment. After extensive experimentation, several changes were made in the installation which eliminated the interference.

1—A power-line filter was installed between the YG power line and the receiver power line.

2—The Hertz antennas usually employed at air stations were replaced by whip antennas, feeding to receivers through coaxial lines.

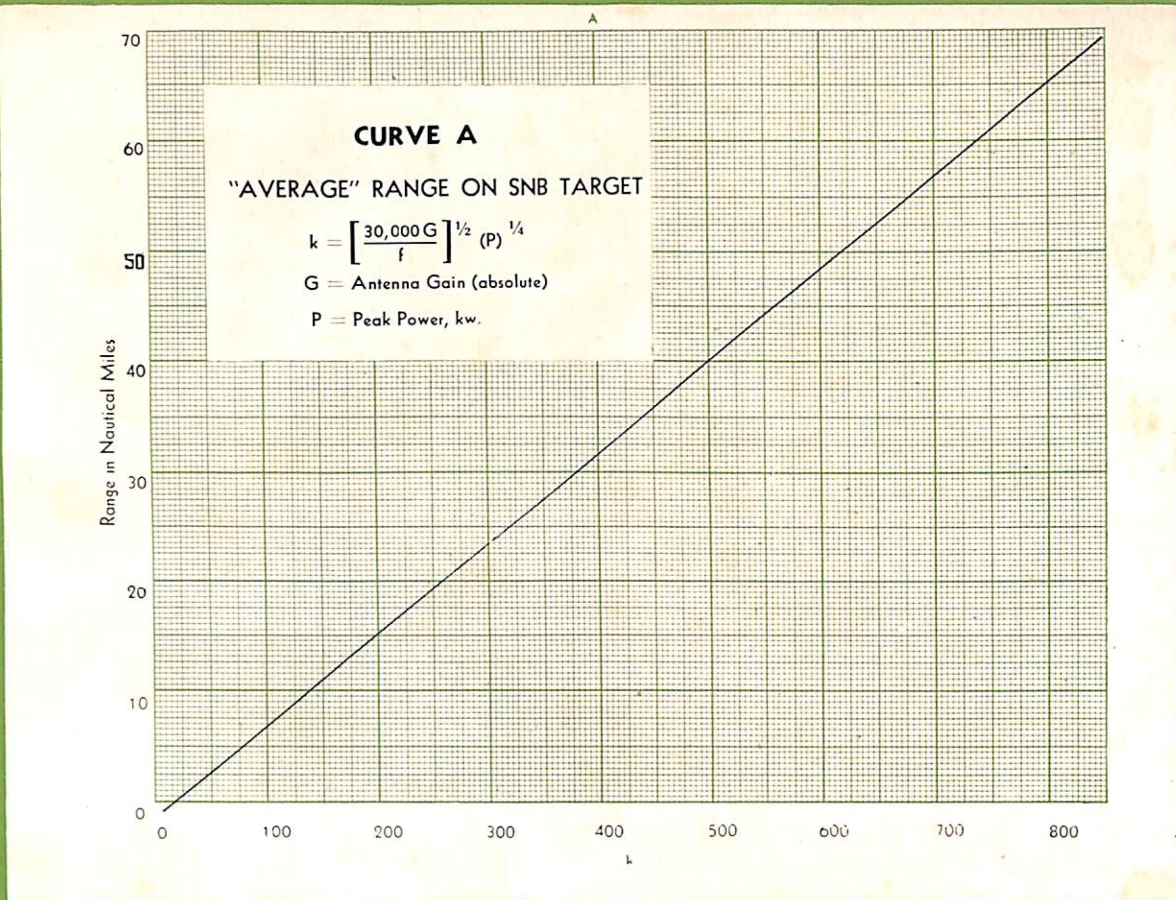
3—The YG keying relay was eliminated (YG field change No. 4).

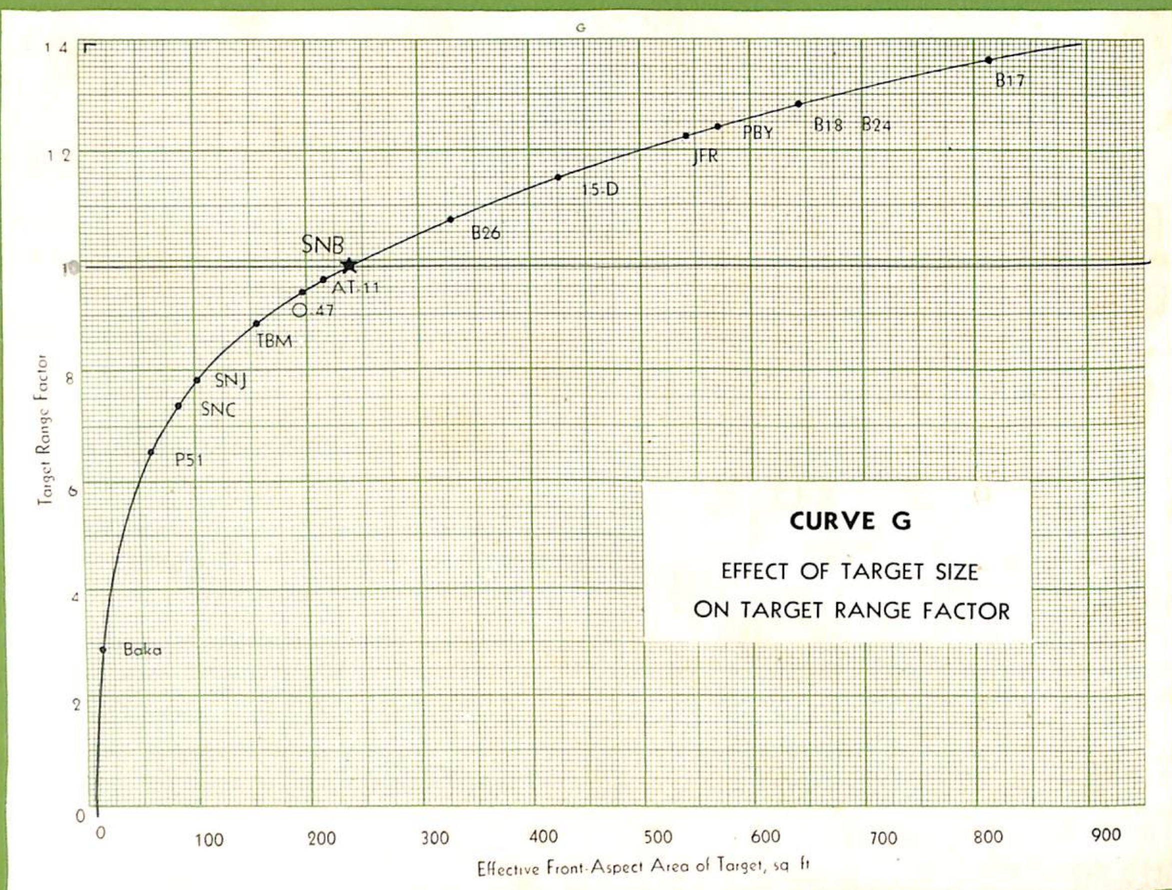
4—The V.H.F. antennas were lowered five feet below the YG antenna and placed approximately six feet radially from the antenna.

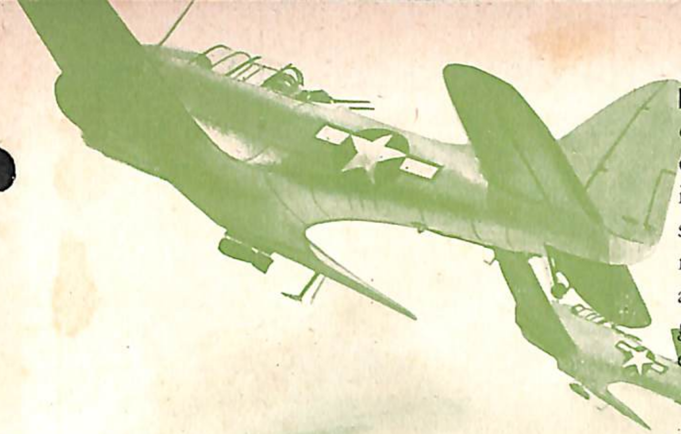
5—The outer conductor in the V.H.F. coaxial lines was grounded at six-foot intervals to the obstruction-light conduit.

It was found that changing from Hertz antennas to whip antennas with grounded coaxial lead-in made most of the improvement.

The installation of the equipment presented a rather difficult interference elimination problem as the YG is installed about five feet from the receivers and all equipments have a common power supply and ground.







Air-Search Radar Ranges

By Lt. Comdr. I. L. McNally, *USN.*

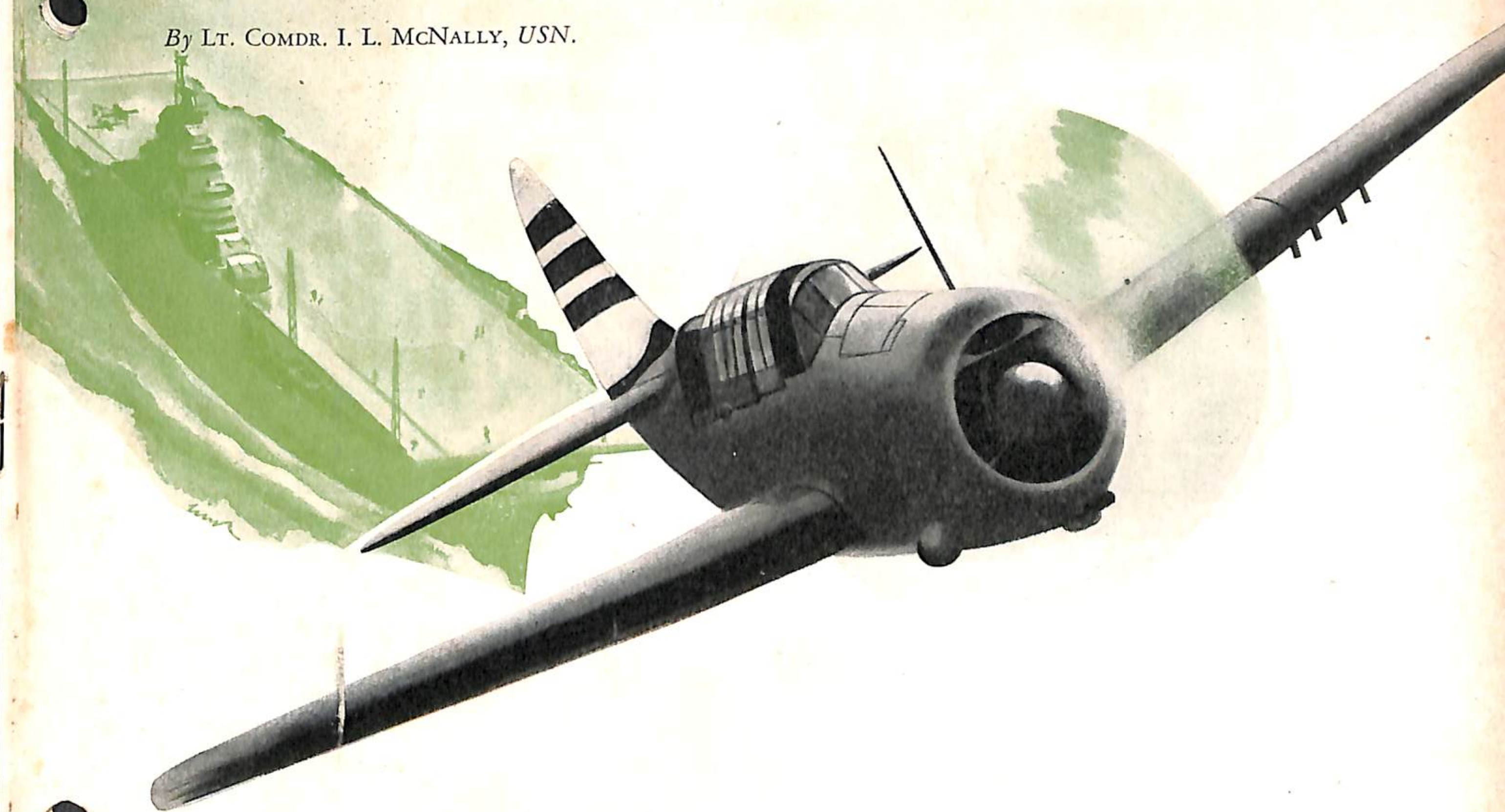
■ In estimating the performance of a radar system it is desirable to determine the range of a "standard" radar on a particular type of "standard" target. The characteristics of the standard radar were chosen as typical of a shipboard search radar. The Navy model SNB plane represents a target of fair size and one which is generally available. The curves and formulas were derived from general theoretical considerations and a vast amount of experimental data.

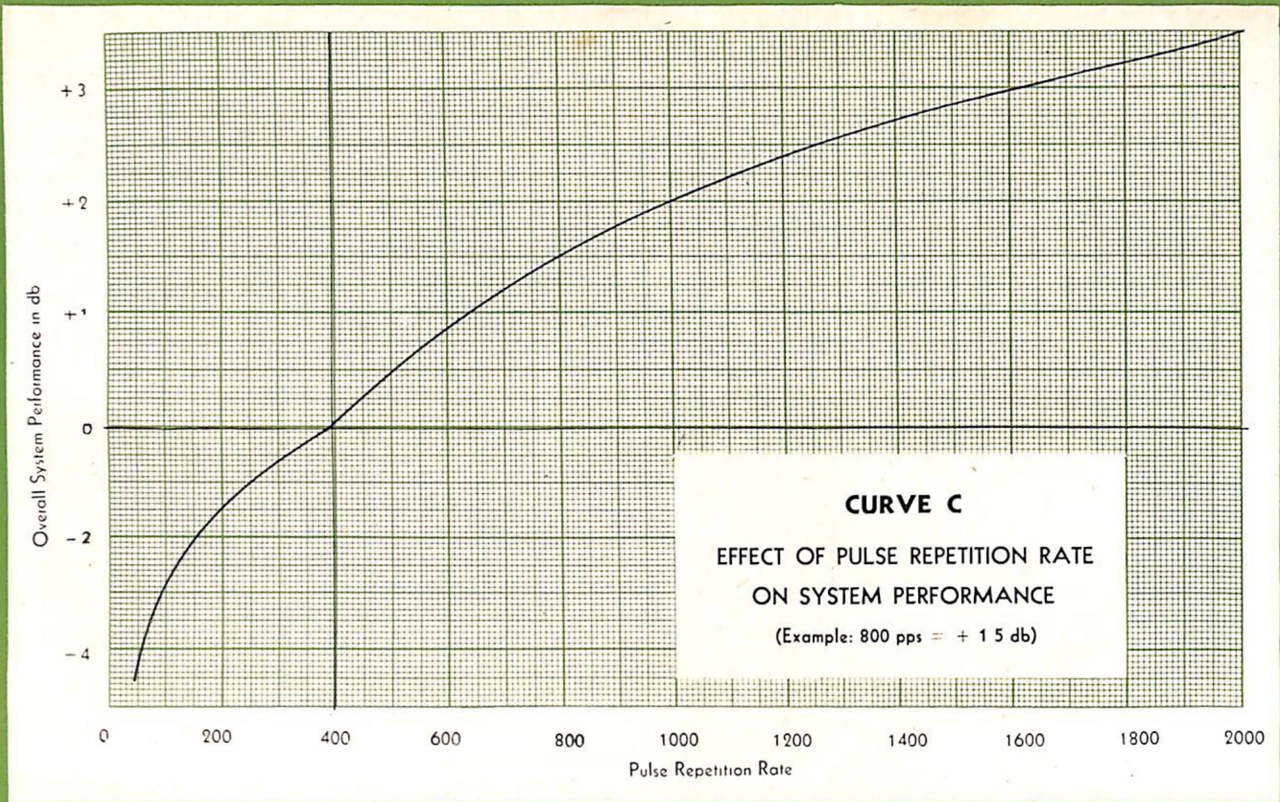
The following characteristics have been chosen for the standard radar:

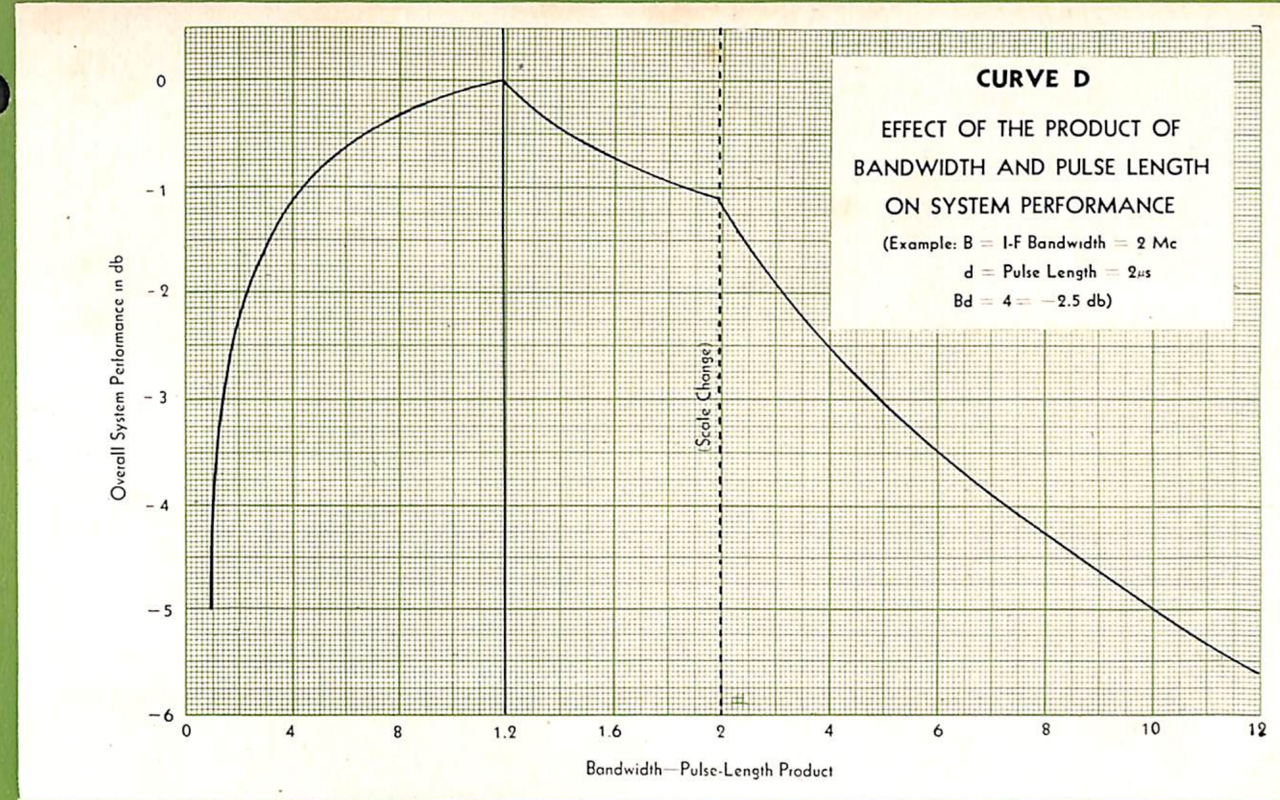
Item	*Definition*
(a)	Pulse length, $d = 1\ \mu s$
(b)	Pulse repetition rate = 400 pps
(c)	Receiver bandwidth, $B = 1.2$ Mc ($Bd = 1.2$)
(d)	Antenna rotation speed = 6 rpm
(e)	Horizontal beam width at half-power points = 6°
(f)	Receiver Sensitivity (above theoretical) = 15 db
(g)	Sweep length (PPI or DPPI) = 20 miles
(h)	Cathode ray tube, 7″ diameter, P7 screen
	Target = SNB (front aspect).

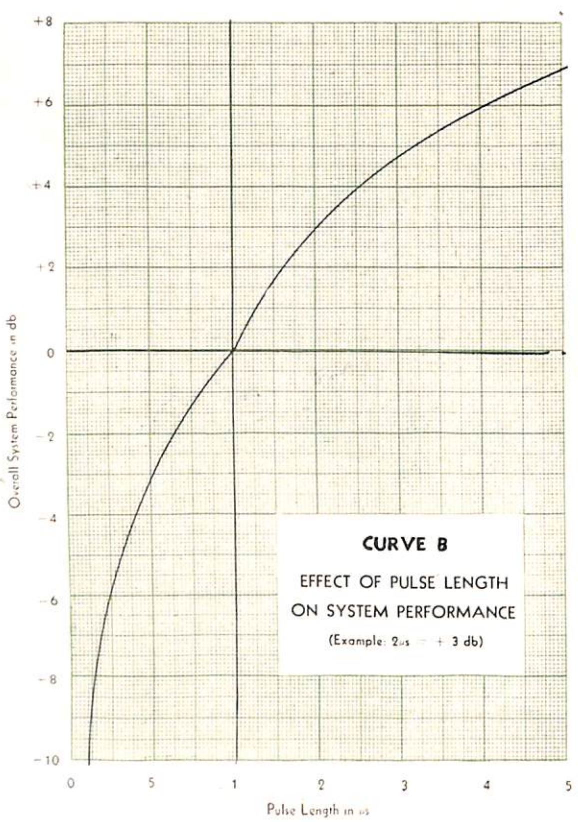
The range of a radar is proportional to the quantity k, defined by the equation

$$k = \left[\frac{30{,}000\,G}{f}\right]^{1/2} (P)^{1/4}$$









where $G =$ absolute antenna gain,
$f =$ frequency in megacycles, and
$P =$ peak power in kilowatts.

Example:
when $G = 1000$,
$f = 3000$ megacycles, and
$P = 400$ kilowatts,

$$k = \left[\frac{30{,}000 \times 1000}{3000}\right]^{1/2}\left(400\right)^{1/4} = 447$$

The quantity k is plotted against range on an SNB and is shown as curve A. Entering curve A at $k = 447$, the range on an SNB is shown to be 37 miles. This may be converted for other targets by the target range factors listed, and also plotted as curve G.

This range determination is adequate for most purposes for the given values of G, f, and P because the other factors generally balance out in their overall effect. However, if there is considerable difference in the pulse length, pulse repetition rate, scanning rate, etc., there will likewise be considerable effect on the range. The effect of a smaller PPI or longer sweep is to decrease the maximum range. The effect of these factors upon the range can be seen graphically by the curves B through E.

These curves show, in db, the relative change in overall system performance as a function of the following:

Curve B—Pulse length
Curve C—Pulse repetition rate
Curve D—Product of bandwidth and pulse length
Curve E—Scanning rate and beam width

In comparing the SG-3 with the "standard" radar, for example, the following information is obtained:

Item (see p. 21)	Standard	Curve	SG-3	Overall Performance Relative to standard
(a)	1 μs	B	1.37	+1.3
(b)	400 pps	C	750 pps	+1.35
(c)	1.2	D	2.74	−1.7
(d)	6 rpm	E	6 rpm	−1.2
(e)	6°		4°	
(f)	15 db		15 db	0
			Net:	−0.25 db

Curve F shows that this net loss of 0.25 db has only a negligible effect on range, so that the range determined from Curve A will be correct in this case. First compute k as follows:

$G = 500$,
$f = 3700$ megacycles, and
$P = 400$ kilowatts.

$$k = \left[\frac{30{,}000 \times 500}{3700}\right]^{1/2}\left(400\right)^{1/4} = 285$$

Entering curve A with the value of $k = 285$, the range is 24 miles on an SNB plane. From the table, or from curve G, a target range factor for a PBY is 1.25. The range on a PBY is therefore $1.25 \times 24 = 30$ miles.

TABLE I—*Range factor determined from target size, based on targets headed directly toward the radar. This information is also plotted in curve G.*

Target	Range Factor	Target	Range Factor
B17	1.37	0-47	.94
B24	1.29	OS-2V	.925
B18	1.29	Taylorcraft	.925
PBY	1.25	TBM	.90
JFR	1.23	FM-2	.85
J2F	1.18	SNJ	.795
Beaufighter	1.18	P47	.783
15-D	1.16	NSC	.75
B-26	1.08	P38	.711
SNB	1.00	P51	.68
AT-11	.97	Baka	.3

The antenna gain factor is usually given in db above absolute, that is, above an isotropic radiator, by

$$\text{db} = 10 \log_{10} G$$

Example: If an antenna has a gain of 25 db

$$25 = 10 \log G, \qquad \log G = 2.5,$$

and $G = 316$

It is preferable to use the measured or design value of G for determining range. However, if not obtainable, it may be estimated. Theoretically the gain factor of a parabolic reflector illuminated with a dipole feed, small in comparison to the size of reflector, is

$$G = \frac{4\pi A}{\lambda^2}$$

where A = area of reflector in square cm.
λ = wavelength in cm.

In radar applications the reflector is usually not a full parabola and furthermore the illumination is varied to give minimum minor lobes at a sacrifice of gain. This results in a general figure for gain of about 60% theoretical, or

$$G = .6 \times \frac{4\pi A}{\lambda^2}$$

Converted into other units,

$$G = 13\ aAf^2\ (10^{-6})$$

where a = illumination factor, .4 to .6,
A = area in square feet, and
f = frequency in megacycles.

The illumination factor a increases as the size of the reflector increases.

The SK is very interesting to use for an example because most of its characteristics are considerably different from those of the "standard" radar. Let us determine the ability of an SK radar to detect a PBY:

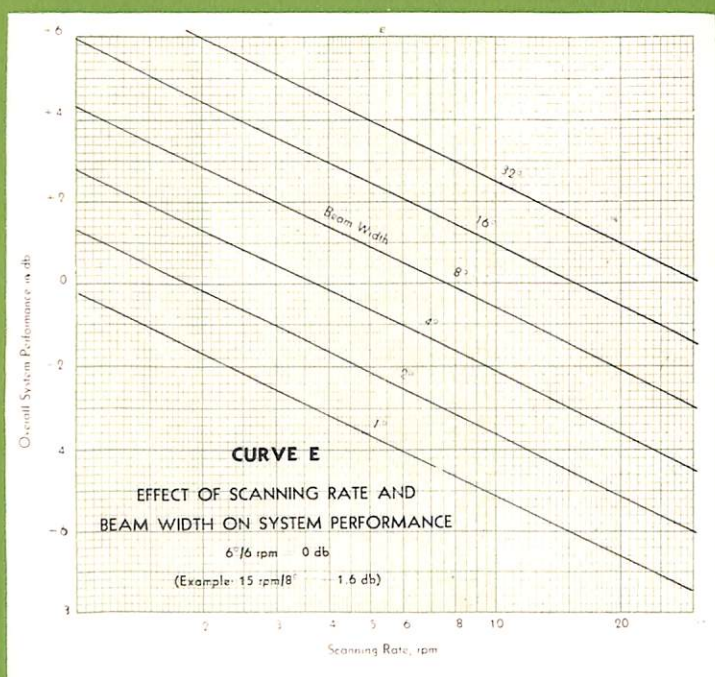
Item	SK	Curve	Relative Performance
(a)	5 μs	B	+7.0
(b)	60 pps	C	−4.0
(c)	B × d = 1.2	D	0
(d)	4 rpm }	E	+3.3
(e)	20° }		
(f)	7 db		+8.0
		Net:	+14.3 db

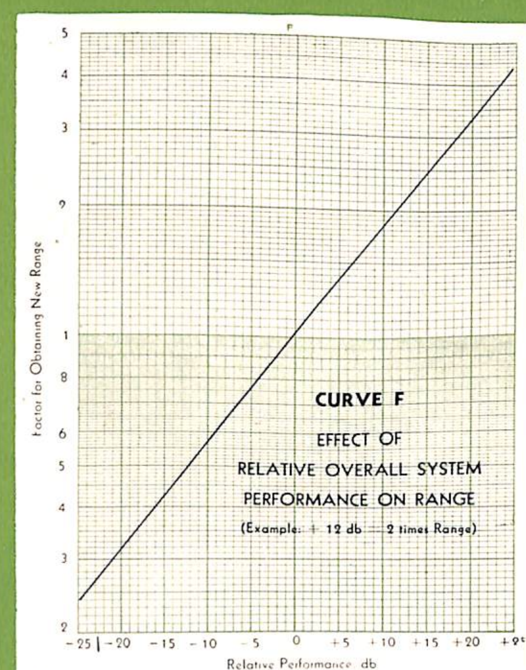
$G = 19.7$ db $= 93.3$ absolute
$f = 195$ Mc
$P = 200$ kw

$$k = \left[\frac{30{,}000 \times 93.3}{195}\right]^{1/2} \left(200\right)^{1/4} = 451$$

Range = 37.5 miles on standard SNB target.
PBY target range factor = 1.25 (from table).
+14.3 db = 2.28 range factor, (from curve F).
1.25 × 2.28 × 37.5 = 107 miles range on a PBY.

This represents a reliable range with 50% hits, and checks closely with average service reports.





SRa Modified Echo Box and Tuning Procedure

By L. H. Krause, *Westinghouse Field Service, and* Ens. W. H. Surber, Jr., *E.F.S.G.*

■ Considerable trouble has been experienced in endeavoring to tune the SRa equipments. The full capabilities of the systems have not been realized in numerous cases due to improper or incomplete tuning procedures employed. A tuning procedure developed by E.F.S.G. and Westinghouse has been endorsed by BuShips and is printed herewith for information and guidance.

GENERAL

The conversion of the SR to the SRa has eliminated the critical grid-keyer adjustments and the reaction of the oscillator tuning controls on the keyer circuit. This reduces the possibility of damage to the 527-type oscillator tubes during the tuning process. A modification of the monitor antenna and echo-box type of indication further simplifies the tuning procedure. This echo-box change will be designated field change No. 30. The conversion is relatively simple and no field change kit will be required.

As originally designed, the monitor antenna was connected through the echo-box, which acted as a transmission-type circuit, to a rectifier and meter. With the echo-box tuned to resonance, optimum transmission of power was obtained and the meter reading was at a maximum. The echo-box had to be tuned continuously to keep the meter reading maximized as the transmitter was adjusted, since the transmitter frequency varies during the tuning and matching process.

In the modified circuit the echo-box antenna is connected directly to the grid of the detector tube. This grid is also coupled to the echo-box. If the echo-box is detuned so that it presents a high impedance between the grid and ground, the meter reading will be proportional to some function of the total r-f power output from the radar. The indication will be almost independent of frequency since the circuit is untuned. If the echo-box control "G" is now tuned through the radar frequency, there will be a sharp dip in the meter reading. From the reading of "G" at this point, and by the use of the echo-box calibration chart, the radar frequency may be determined.

The echo-box conversion is made as follows: Disconnect and remove the short section of cable between J-203 in the monitor receiver and the echo-box. The connector at the echo-box may be left open. From the monitor receiver spares obtain the spare for either J-201 or J-202. This spare connector is already made up with a short section of shielded cable. Remove the cover over the 955 detector and connect the section of spare cable between J-203 and the grid of the 955. Connect the shield of the cable to the ground terminal located near the grid pin of the tube. Cut a slot in the top of the removable cover to allow the cable to pass through and replace the cover. An alternate method is to drill a hole in the shield box around the tube and bring the cable in through this hole.

Before attempting to tune the equipment, the following points should be checked: Read and thoroughly understand these instructions before attempting to tune the transmitter. Insert the transmitting tubes, making sure that no mechanical strain is placed on the glass and that all connections are tight. Check the antenna to see whether it is in the *blue* or the *green-yellow* frequency band. In the blue band, both grid-shorting straps are to be used on the 527 oscillator tube grid terminals. In the green-yellow band, place the shorting strap across the lower grid connections, and corona balls on the two upper grid terminals. Check the duplexer lengths. When operating in the blue band, adjust the duplexer length so that the distance between the lower edge of the upper casting and the center of the spark gap adjustment knob is $9\frac{7}{8}''$. For the green-yellow band the distance should be approximately $11\frac{5}{8}''$. This adjustment is available when the upper rear cover of the transceiver is removed. When tuning for the first time, check the settings of the duplexer spark gaps. They should be open between 1/32″ and 1/16″. This is roughly 1.25 turns on the adjustment knob which is located on the stub itself, above the gap. Access to the spark gaps is obtained by pulling the monitor receiver chassis forward and removing one of the side panels. Controls are provided on the front of the transmitter unit for adjusting the unit for proper oscillator operation.

The main controls are as follows: "A" Grid tuning control. Main control for setting the oscillator frequency. "B" & "C" Impedance matching stubs. These control oscillator frequency. "D" & "E" Duplexer controls. When properly set, control "D" prevents the received signal from being dissipated in the transmitter portion of the circuit. Control "E" prevents the loss of the transmitter energy in the receiver circuits. "F" Receiver tuning control. "G" Echo-box tuning control.

TRANSMITTER TUNING

With the radiation switch *off*, set all dials according to the chart for the center frequency of the antenna being used except "G", which should be set at 0. Apply power to the set and push the "Power On" button. After the 5-minute time delay relay has operated, adjust the filament voltage to 10 volts. Turn radiation switch *on* and raise the plate voltage to 3.5 kv. (The plate voltage is left at 3.5 kv instead of 5 kv during tuning in order to avoid excessive arcing.) Rotate the antenna until it is facing the monitor antenna, so that the echo-box meter reading is a maximum. Tune echo-box dial "G" until a dip occurs in the echo-box meter, and obtain frequency of operation from the calibration chart. The frequency should be kept within the antenna band (plus or minus 5 Mc of the center frequency). Turn the "RF Tune" control on the monitor receiver panel to 0 and tune "D" and "E" for proper firing of the spark gaps. The spark gaps may be observed through openings in the duplexers by either removing the blank panel below the monitor receiver or by removing the top side panel and pulling the monitor receiver chassis forward. Detune the echo-box (control "G") so that the frequency of the oscillator will not affect the echo-box meter readings. Tune "A" for a maximum reading of the echo-box meter. It will be observed that a series of maximum points may be obtained at definite frequency intervals. Set "A" on the point of maximum response nearest the center of the antenna band. Adjust "B" and "C" for maximum reading of the echo-box meter. Re-adjust "A", "B", and "C" for maximum reading of the echo-box meter. Raise plate voltage to 5 kv. If any r-f arcing occurs at the oscillator, it may be decreased by backing off the "B" dial setting slightly. If it persists, a different tuning point (combination of "B" and "C") may have to be used. Tune the echo-box for dips in the meter and check the frequency. If the frequency is out of the band, shift the "A" dial tuning to a point of maximum response within the correct range. Note that the frequency of operation cannot be set to any arbitrary value; it must be tuned on one point of maximum response. Tune dial "F" for maximum indication on the monitor scope. Tune dials "D" and "E" for maximum monitor scope indication. The "RF Tune" knob should be set to 0 when tuning "E". Tune the duplexer spark gaps for maximum monitor scope indication. Make a final adjustment on dials "D", "E", "F", and "RF Tune" knob for maximum echoes.

A set of typical meter readings when properly tuned would be similar to the following:

Filament	*Plate*	*Plate current*	*Grid current*
10 v.	5 kv.	20-30 ma.	4-8 ma.

CONSOLE RECEIVER TUNING

Adjust the "I-F Tune" knob on console receiver for maximum echo response on the range scope. This should be checked by the operator at the beginning of each watch.

Sonar Lubrication Chart

Radar and radio lubrication charts have appeared in previous issues of ELECTRON. The purpose of the chart in this issue is to aid technicians in the selection of correct lubricants for sonar equipments, and to provide sufficient information for requisitioning these oils and greases.

Instruction Book Designation	Navy Spec. Designation or Nearest Navy Equipment	Equipment In Which Used
Acid Free Bearing Grease	OS 1350	NJ-8
Andok C	14L3 Grade III	QGA, QFA-5
Chopper Motor Oil	NS 3050	QFA-5
Dash Pot Oil	OS 1362	QCJ-2/QCL
Dash Pot Oil	OS 1362	QCJ-8/QCL-7
Dash Pot Oil	OS 1362	QGB
Diehl Fan Grease	14L3 Grade II	QCQ/QCR
Diehl Fan Grease	14L3 Grade II	QCN-2/QCO-1 WBA
SAE 20 (Machine Oil)	NS 3050	WCA/1/2/3
Graphite Gear Grease	14L3 Grade II	QFD
Light Machine Oil	NS 3050	QFF
Light Oil	NS 3050	NJ-3/9
Light Mineral Oil (WECO Desig.)	NS 2110	QJA
Light Sodium Base Grease	14L3, Grade I	NJ-3/9
Lubriplate, Andok C	14L3 Grade III	QFA-5
Lubriplate 110	14L3 Grade III	NMB-1
Lubriplate 110	14L3 Grade III	NMC
Lubriplate 110	14L3 Grade III	QCQ-2
Lubriplate 110	14L3 Grade III	QCU
Lubriplate 110	14L3 Grade III	QGB
Lubriplate 100-S	14L3 Grade I	QFH
Non-gummy Light Oil	NS 2075	QFL
O-368 Grease (WECO Desig.)	OS 1350	QJA
O-561 Grease (WECO Desig.)	14L3 Grade II	QBF
O-561 Grease (WECO Desig.)	14L3 Grade II	QJA
O-562 Oil (WECO Desig.)	NS 3065	QJA
Petrolatum	14P1	QCJ-2/QCL
Petrolatum	14P1	QCJ-8/QCL-7
SAE 10	NS 9110 or 2110	NJ-8
SAE 10	NS 2110	QGB
SAE 20	NS 3050	NMB, WCA-1-3
SAE 20	NS 3050	NMC-1/2
SAE 20	NS 3050	QCJ-2/QCL
SAE-20	NS 3050	QCJ-8/QCL-7
SAE-20	NS 3050	QCN-2/QCO-1
SAE-20	NS 3050	QCQ-1/QCR-1
SAE 20 (Light Clean Lube Oil)	NS 3050	NMB-1
Singer Grease	14L3 Grade II	WCA-1/2/3
SAE 20	NS 3050	WBA
SAE 20 Oil	NS 3050	WEB
SAE 20 Oil	NS 3050	WAA
SAE 30	NS 3065	NJ-6
SAE 30	NS 3065	NJ-7
SAE 30	NS 3065	NJ-3/9
SAE 30 Oil	NS 3065	NMB
SAE 50 Oil	NS 3100	NJ-6

Instruction Book Designation	Navy Spec. Designation or Nearest Navy Equivalent	Equipment In Which Used
SAE 50	NS 3100	NJ-3/9
SAE 50	NS 3100	NJ-7
SAE 30 Oil	NS 3065	QFD
Univis 48 Oil	OS 1113	QJB
Singer Fan Grease	14L3 Grade II	QCS/QCT QCS-1 QCT-1
Singer Grease	14L3 Grade I or II	NJ-7
Singer Grease	14L3 Grade I or II	NMB
Singer Grease	14L3 Grade I or II	NMC-1/2
Singer Grease	14L3 Grade II	WEA-2
SAE 20 Oil	NS 3050	WBA
Singer Grease	14L3 Grade II	WAA- WBA
Singer Motor Lubricant	14L3 Grade I or II	NJ-6
Sodium Base Ball Bearing Grease	14L3 Grade II	NJ-3/9
Sodium Base Grease	14L3 Grade II	NJ-6
Sodium Base Grease	14L3 Grade II	NMC-1/2
Superla 18	14L3 Grade I	QGA
Superla #18 Grease	14L3 Grade I	QJB
Univis 48 Oil	OS-1113	QJB
Vaseline	14P1	QFD
Vaseline	14P1	WEA-2
Vaseline	14P1	QCQ/QCR
Very Light Machine Oil	NS 2190	QFK
WS-334(ESSO) Grease	14L3 Grade I	QGB

ORDERING INFORMATION

Navy Specification Designation	Federal Standard Stock Catalog No.	Standard Package
	GREASES	
14L-3 Grade I	14-L-131	1 lb
14L-3 Grade II	14-L-90-15	1 lb.
14L-3 Grade III	14-L-85-5	1 lb.
14-P-1	14-P-100	5 lbs.
OS 1350	14-G-715	10 lbs.
	OILS	
NS 2075	14-O-2586	5 gal.
NS 2110	14-O-2595	5 gal.
NS 2135	14-O-2610	5 gal.
NS 2190	14-O82625	5 gal.
NS 3050	14-O-2662	5 gal.
NS 3065	14-O-2663-8	5 gal.
NS 3100	14-O-2685	5 gal.
NS 9110	14-O-2162	5 gal.
OS 1113	14-O-884-10	5 gal.
OS 1362	14-O-2833-65	5 gal.

Frequency and Wavemeters

■ This is the second in a series of articles written for the purpose of familiarizing the technician with the various types of test equipment and the functions they perform. No attempt has been made to go into minute detail as that information is contained in the instruction books.

OAP SERIES

The OAP is a compact wavemeter-oscillator covering a range from 150 to 230 Mc. It is designed for use with equipments requiring a terminating impedance of 50 ohms, and should be used with transmitters having radiated pulse power between 100 and 3000 watts. Due to this limitation it is used almost exclusively in checking IFF interrogator-responsors such as BL, BM, BN, and BO's. The equipment is composed principally of a wavemeter, a detector-amplifier, a local oscillator, a dummy antenna, diode detector and cathode-loaded amplifier.

The detector-amplifier uses a 6E5 (magic eye) to indicate resonance between the tuned circuit in the wavemeter and the applied signal. The local oscillator is variable between 150 and 230 Mc, modulated at 60 cycles, with an output of 1.5 to 15 millivolts throughout the range. The diode detector and the cathode-loaded amplifier are used to drive an oscilloscope to check transmitter output power and pulse shape. An untuned VTVM input connection to the detector-amplifier is provided so that the equipment will serve as a vacuum tube voltmeter.

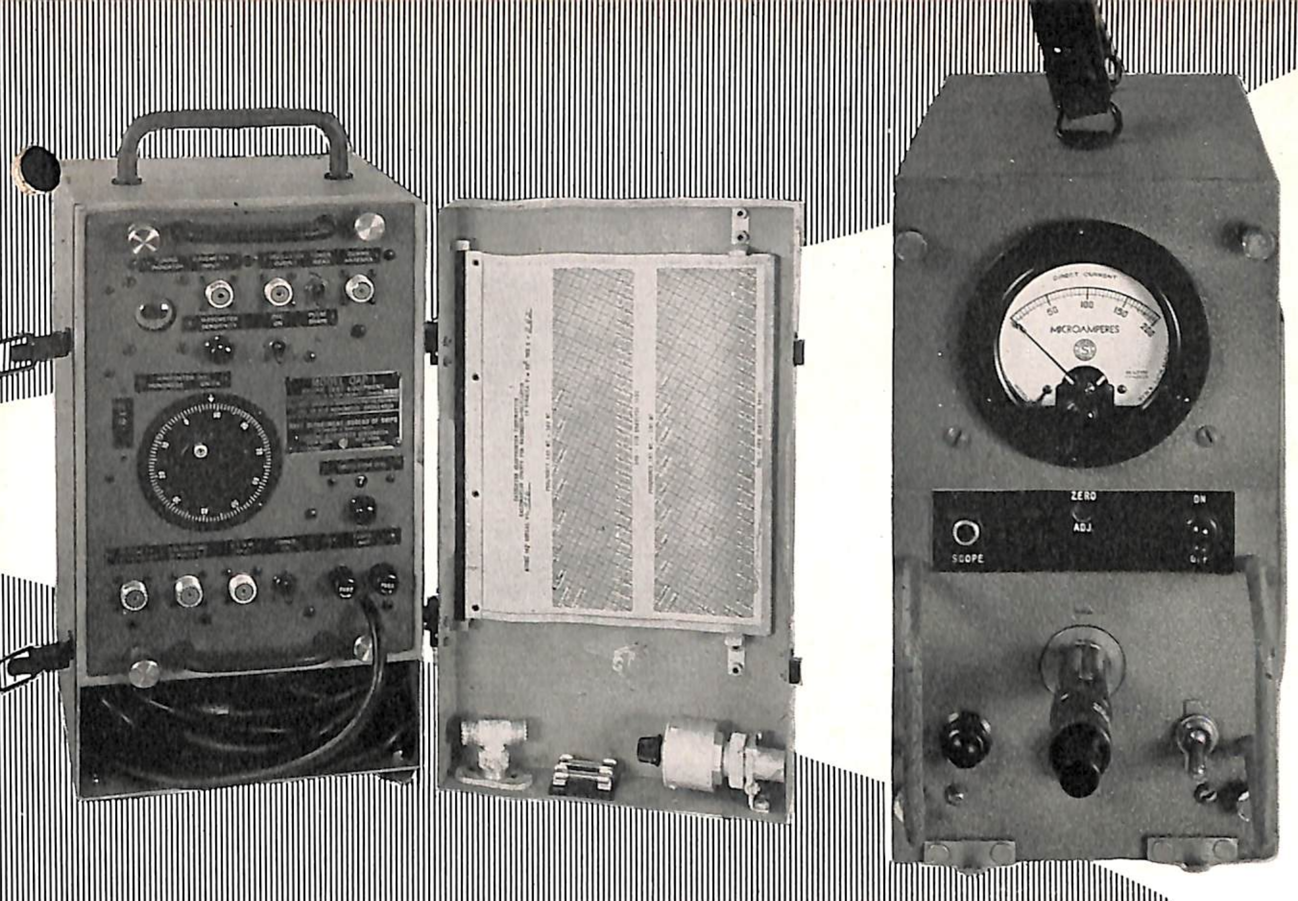
The power supply also furnishes a 60-cycle voltage for calibration of the vertical deflection of the scope used with the equipment.

In general the OAP has five functions: 1—to tune a transmitter to a desired frequency, 2—to tune a receiver to a desired frequency, 3—to adjust an antenna system for best performance, 4—to measure the relative power output and observe pulse shape of a transmitter (using an external oscilloscope), and 5—to monitor a transmitter during operation.

OAA SERIES

The OAA is a test instrument for checking SA, SC, SR, SK, and similar radar equipments. It is designed for use as a frequency meter, to indicate relative transmitter power output, to detect double pulsing, and for checking receiver sensitivity, tuning, and alignment. The tuning range is from 150 to 240 Mc with micrometer adjustments accurate to ± 0.5 Mc utilizing a frequency calibration curve which is included as a part of the instruction book. The unit is equipped with an antenna assembly for permanent mounting near any radar antenna, and is connected to the unit by a coaxial cable.

The instrument includes a resonant-line input to a 955 tube connected as a diode. The d-c output from the diode is passed through an r-f choke and can be utilized



(left) *Model OAP Wavemeter-Oscillator.* (right) *OAA-2 Radar Test Equipment. Antenna assembly is not shown.*

in either of two ways. In one connection the output is delivered to a d-c amplifier and microammeter circuit for measuring relative power output of a transmitter. This d-c amplifier is a 6SQ7 connected so that its plate resistance is in series with one arm of a wheatstone bridge. With no signal input the bridge must be adjusted for zero meter reading by the zero-set control. For tuning a transmitter and checking peak output and wave shape, the output of the diode is viewed on an oscilloscope which may be plugged into a jack provided for the purpose. When the scope is plugged in, the d-c amplifier is cut out of the circuit.

Since the input circuit is a high Q resonant line, it will oscillate for a short period of time after excitation by a transmitter pulse. This oscillation or *ringing time* is the signal source fed back into the radar receiver and indicator, thereby measuring the overall radar performance.

When used for checking relative power output, double pulsing, or receiver sensitivity, it is necessary to use the permanently mounted antenna assembly. However, frequency measurements can be made from the permanent antenna assembly or by the use of a pick-up rod furnished with the unit when employed as a portable unit.

The OAO is similar to the OAA except that the frequency coverage is 105 to 125 Mc.

OAJ SERIES

The OAJ (phantom target indicator) operates on the principle of continued oscillation in a resonant chamber for a few microseconds after excitation by a radar pulse. The unit operates in the *S*-band and is used to check the receiver and indicators of airborne radar equipments operating in this band. However, it contains no frequency-measuring or indicating device. The pick-up rod is mounted near the radar antenna and is coupled to the resonant chamber by a coaxial cable. When checking the system, the radar pulses into the pick-up rod, the energy being carried to the chamber which oscillates for approximately 28 microseconds after excitation if overall performance is correct. The energy of this oscillation is radiated back through the pick-up rod and into the radar antenna, appearing on the indicators as signals to be used for checking receiver sensitivity, tuning, and other adjustments.

The OAJ-1 is a test unit similar to the OAJ but with a frequency-measuring feature employing a micrometer adjustment. It is also designed for use with airborne radar equipments operating in the *S*-band.

Since the unit contains facilities for measuring frequency it has more application than the OAJ. These applications are: Checking transmitter frequency, determining pulse width, checking magnetron spectrum, and for setting the local oscillator frequency. The unit operates on the same principle as the OAJ for checking radar transmitter and receiver operation. For the other adjustments, however, it is necessary to use an external microammeter, a probe and crystal holder, a 0.5 μf capacitor and a length of coaxial cable to couple the crystal holder and the meter. The probe, crystal, and cable are similar to that contained in the phantom target test conversion kit part number 453-2507 as supplied by Philco. The meter should be a low-resistance type such as Weston Model 301.

CW-60ABM FREQUENCY METER

The CW-60ABM is designed for operation in the *S*-band. It has four applications: measuring transmitter frequency, adjusting local oscillator for desired i.f., measuring d-c crystal converter current, and checking standing-wave ratio in transmission lines.

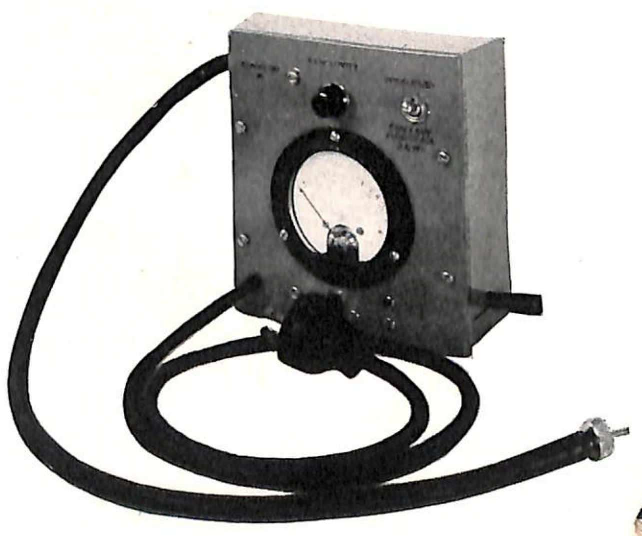
The instrument comprises 3 electrical components in one metal shielded can, consisting of a high-frequency pickup and resonator circuit, a d-c supply, and a d-c measuring circuit. The high-frequency pickup and resonator consists of a tuned r-f input circuit, varied by a micrometer and shunted by a negative temperature coefficient *Thermistor*. The thermistor is used because it responds to average power and is not damaged by peak pulses of r-f energy. The d-c supply circuit, energized from any 115-volt 60-cycle source, consists of a bridge-type rectifier to furnish current for measuring the resistance of the thermistor. The d-c measuring circuit is used to measure the crystal converter current of receivers.

The instrument is initially set without any r-f input. The meter is adjusted to mid-scale by the sensitivity control in the bridge rectifier circuit. When making this setting, the temperature of the thermistor is effectively being adjusted by setting the value of current flow through it. The r-f input plug is then connected to the instrument and to the radar being checked. The sensitivity control is now adjusted to give almost full-scale deflection. Assure the tuned circuit to be off resonance by turning it a few turns either way and noting any rise or fall of the meter indication. A quarter-wave line (or odd multiples thereof) at resonance, dissipates the maximum amount of power from the circuit to which it is connected. Conversely, when off resonance, it will dissipate the least amount of power. Since the thermistor is shunted by this tuned quarter wave tank, any change in power dissipation in the resonant or non-resonant circuit will affect the thermistor. If the tuned circuit is off resonance, the maximum amount of power will be applied to the thermistor, causing its temperature to increase. This causes the resistance to decrease and the current flow through it to increase, and this is indicated on the meter. Now as the micrometer adjustment is varied (changing the frequency of the tuned circuit), a point of resonance will be obtained. When this resonant point is reached, the tank circuit will be dissipating its maximum amount of power, and minimum r-f power will be applied to the thermistor. Its temperature will decrease, its resistance will increase, and the meter will show a sharp dip in current.

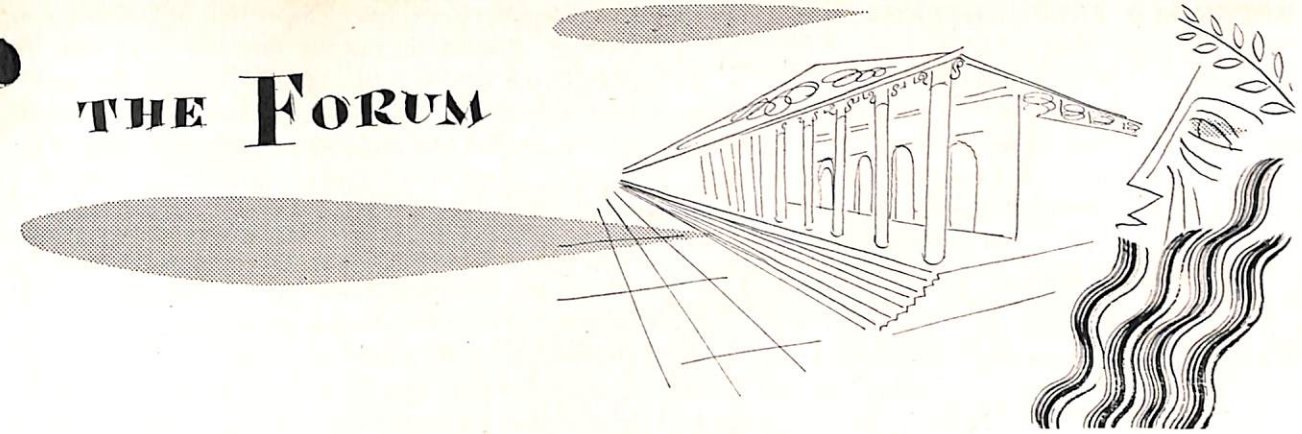
The instrument can be used to adjust the local oscillator in the receiver by resonating it to the tuned circuit in the wavemeter after the transmitter frequency has been measured, with the micrometer setting unchanged. The i.f. of the receiver together with the number of micrometer divisions equivalent to this frequency are determined from the instruction book. The micrometer is then moved the necessary number of divisions above or below its original setting and the local oscillator adjusted to resonance with this new frequency. This will place the local oscillator at a frequency which, when mixed with the magnetron frequency, will produce the correct i.f.

To measure crystal converter current, the wavemeter is connected to the receiver (if a jack is provided) by the r-f input cord provided with the meter. The "Frequency-Conv. Cur." switch is thrown to "Conv. Cur." and the current is read on the 0—2.5 ma meter.

When a transmission line is provided with a standing-wave detector, the wavemeter may be used to indicate the standing-wave ratio. Connect the detector to the r-f input of the wavemeter and adjust the transmission line tuners until the least variation is obtained as the probe is moved along the line.



Navy Type CW-60ABM wavemeter. This is view of unit removed from waterproof carrying case.



THE FORUM

GIVE YOUR SUCCESSOR A BREAK

By Lieut. B. B. Ostheus, Jr., USS Dayton

During the next six months or so many of our ships will be placed in reserve or in inactive status. Undoubtedly many key men will either return to civilian life or be transferred to a new ship or station. In view of these facts, now is the time to put your operating sets, spare parts, and test equipment in such condition that your successor may take over efficiently.

Your successor may take over immediately or he may take over a year after you have left the ship. Listed below are a few of the steps that you should take to help him and to protect your gear.

1—Bring your instruction books up to date. If you have made any circuit changes draw the changes into the schematics, and don't forget to enter them in your logs.

2—Inventory your spare parts. Put a copy in each spare parts box and leave a copy for your successor, along with a list of all shortages.

3—Check your test equipment and tag all gear that is not working properly if repairs cannot be made before you leave the ship. List your test equipment and leave this list for your successor. Check your allowance list and make a list of what is missing.

4—Summarize the peculiarities and capabilities of each equipment on a separate sheet, leaving these notes for your successor. By now these facts should be known to you, and what you have learned should be available to the next technician. Here is an example:

SK-2 gives out best at about 217 Mc. Fade chart for this frequency is attached to this sheet. Don't forget to tune C-1413 and C-4002 fairly often and especially when you change a 446A. She won't take proper plate voltage when the 327A's start to go, so have a tested and matched set ready for replacement. There are three knobs hanging down under the PPI unit which are fastened to speedometer cables. The other ends of these cables are soldered to the three centering screws inside the unit. Use these for centering easily without shutting down the equipment.

5—Go up on the antennas and see that they are protected from rusting by proper painting and greasing of threaded adjustments, etc. Cover your plugs, jacks, connectors, etc., with friction tape, rubber tape and glyptal to protect them from moisture, dust, stack gasses, and salt-air corrosion.

6—Cover all exposed equipments such as remote PPI's.

7—Sketch your power source layout, showing all fuses, switches, distribution panels, etc., in each feeder from the engine rooms to your sets. Remember a new man would have to do a lot of hunting for these things and your help in doing this will be greatly appreciated.

8—Collect all instruction books, pamphlets, and any other literature directly connected with your equipment and put them all in one place. After storing all these publications make a complete list of them, their location and custody, and leave it for your successor.

9—Collect all tools, prepare them for storage by properly greasing, etc., then lock them in a secure place. Leave the key in proper hands and leave a note for your successor, listing all tools and where they are located.

10—Make a note of the storage place of all blueprints, logs, and miscellaneous written material not covered under (8) above.

These suggested points give only a general idea, and while reading this you have undoubtedly thought of a number of other things. Add them on the list and start working on a program that will make things easier for the technician who is to relieve you.

IMPROVISED TCS-15 ANTENNA

By Robert E. Conroy, RT3/c, USS Sangay *(AE-10)*

When the TCS-15 was installed on this vessel it was impossible to obtain the recommended 20-foot whip antenna. In lieu of this we improvised a jury rig with which we obtained excellent results. The system includes a 40-foot antenna hung vertically and fed by a 20-foot length of armored coaxial cable.

To prevent the antenna current meter needle from hitting the peg, it was necessary to shunt the terminals with a piece of No. 18 wire an inch and a half long. The meter still reads one-third full scale on voice with the PA plate current meter reading below the maximum allowed. We did not connect the antenna loading coil.

Bureau Comment: The purpose for which the TCS was originally designed made necessary the use of a 20-foot whip antenna. If space permits, an antenna such as that described may be installed for better results. It will then be necessary to add a shunt to the antenna ammeter, as above, to avoid damage to the meter.

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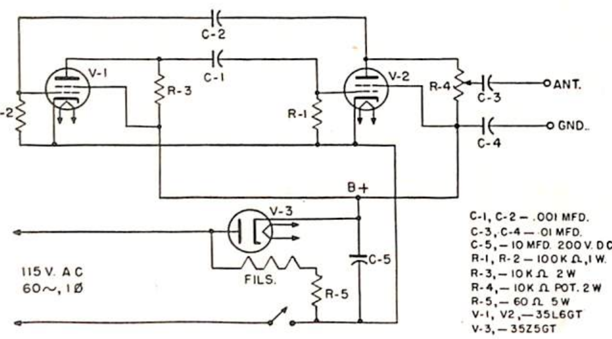
A MULTIVIBRATOR FOR SIGNAL TRACING

By Carl F. Evert, RT1/c, USS White Marsh *(LSD-8)*

In keeping with the policy of exchanging useful ideas, it is felt that the multivibrator described below may be of value as a signal generator in receiver servicing. Since many small craft and amphibious vessels do not have a readily portable device for signal tracing on all bands,



this unit may fill the gap nicely. The circuit is shown in the figure.

The inherent output wave form of any multivibrator is a square wave. Remembering that a square wave is composed of a sine wave fundamental and numerous harmonically-related frequencies, the wide frequency range of such a circuit used as a signal generator is at once apparent. This oscillator has been used successfully for point-to-point signal tracing on both audio- and radio-frequency amplifiers. The upper usable harmonics are high enough to permit this generator to be used in checking the TBS. It is also useful in the rapid location of defective bands in communication receivers. The output tone is a harsh raspy note that is clearly distinguishable.

The circuit has been designed to use as few components as possible and all parts are easily obtainable. A transformerless power supply was used for this reason. The omission of a filter choke in the power supply seems to have no adverse effect upon the operation. Rather, it adds a slight modulation to the carrier that is useful in audio work. The chassis layout is of the simplest type. A 4″ x 6″ x 3″ chassis is ample and makes the unit very light and portable. Constructional details are left to the individual technician.

Bureau Comment: Experiments with a multivibrator constructed as described reveal that it can be used for signal tracing or checking receiver bands for "dead spots". The bureau does not recommend using this unit in any application which normally would require a calibrated frequency source or a critical amplitude of output voltage.

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CHANGE TO LELAND MOTOR GENERATORS

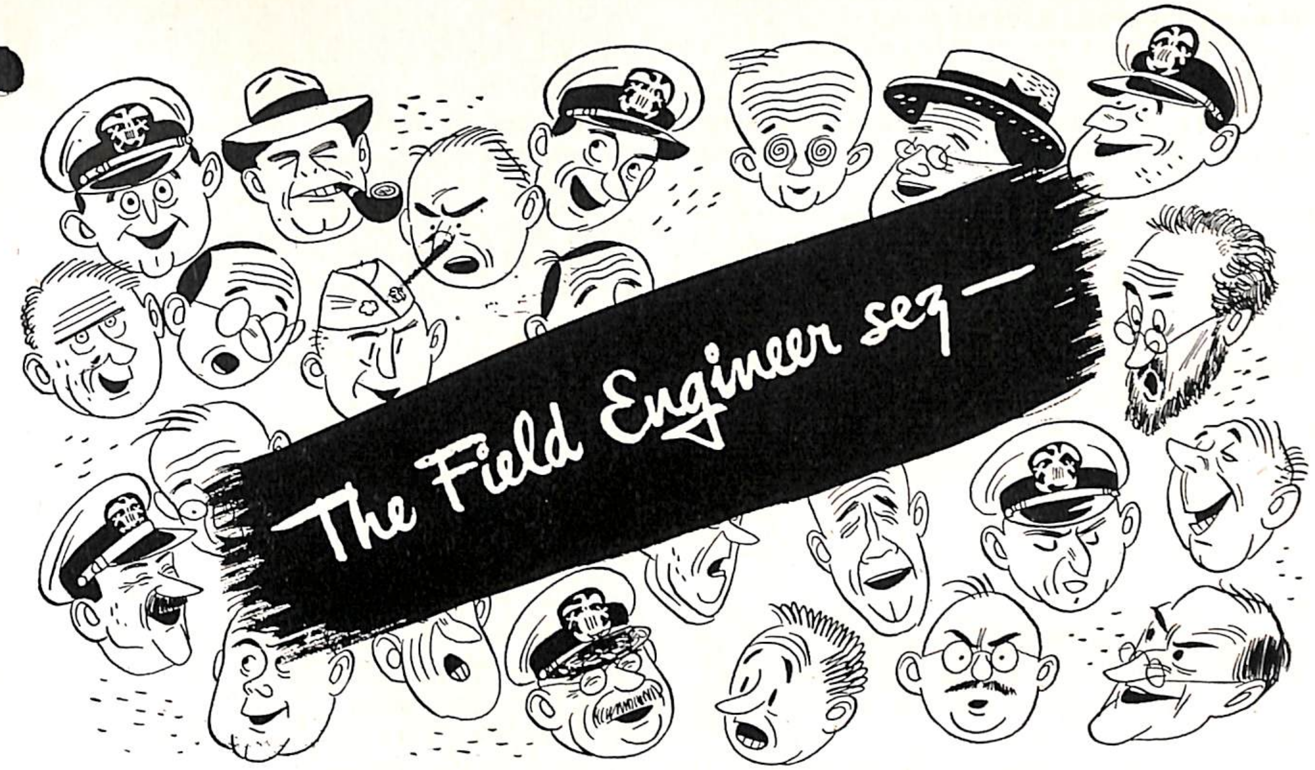
Darragh E. Johnston, CRM, USS Azimech *(AK-124)*

The power dissipation of an adjustable or tapped resistor is based on its entire resistance and thus will decrease as the portion of resistance used is decreased. Experience has shown that after elimination of the speed regulator for the type 21806 motor generator (Field Change #1), the 200-ohm, 50-watt resistor "A", and the 3-ohm, 50-watt resistor "B" overheat and often burn out due to insufficient power-handling capacity.

This condition can be relieved by replacing resistor "A" with a type 63262 200-ohm 120-watt resistor, and resistor "B" with a type 63375 2.5-ohm 120-watt resistor. Both type A resistors are tapped in ten equal parts.

The resistors should be mounted in such a manner as to protect them from mechanical damage, accidental contact by personnel, and in a position that will insure adequate ventilation. Due to the increased size, they cannot be satisfactorily mounted in the generator junction box. Once installed, the location of the proper tap connection is determined in the same manner as for previous resistors.

Bureau Comment: This is one example of how an idea submitted to the Bureau of Ships resulted in an authorized field change. (Field Change #2 to type 21806 Leland Motor Generators.)



MISTAKES IN SR TUNING

On one ship the SR was tuned following the new procedure (see p. 25) until the monitor antenna meter reading was maximum. The echo response on the *A*-scope, however, was considerably poorer than for several other tuning points for which the r-f power output was indicated to be less. This phenomenon proved somewhat baffling to the RT's. What they had neglected to do was to check and determine whether all of their power output at this point was at the same frequency. Since the monitor antenna in this procedure is connected directly to a rectifier and is untuned, it will indicate the sum of the power outputs at both frequencies. For this system, the maximum meter reading was obtained at that point, although the power output at either of the two frequencies alone was considerably less than the optimum value. The system was retuned to give maximum output at a single frequency.

—*E.F.S.G.*

✶

UNSTABLE PULSE RATE IN Mk 13

Engineers from Bell Telephone Laboratories have found that when operating the Mk 13 radar on precision sweep, long range, some show an instability of pulse rate at certain settings of the long range unit in the region between 60,000 and 70,000 yards.

An analysis of this trouble shows the cause to be coupling in the wiring between terminal 5 of V-1 and terminal 4 of V-13 in the receiver-control drawer. The remedy for this trouble is to retrain these two wires, keeping them as short as possible and maintaining the maximum possible separation.

It has also been found that the voltage generated by the sine wave generator, which produces the bearing sweep, contains too high a percentage of harmonics. These harmonics, when amplified in the bearing sweep amplifier, produce slightly unsteady echoes at the side of the pattern on the scope as well as jittery effect on the 50 mile bearing lines.

This trouble is corrected by the installation of a simple RC filter in the bearing sweep amplifier. Half-watt, one-megohm ±10% resistors are substituted for the wires running to grid pins 1 and 4 of V-2, and a 0.01 μf postage-stamp capacitor connected across the two grids. This filter introduces additional phase shift in the bearing sweep voltage, and to obtain the correct phasing it is necessary to move the magnet of the sine wave generator approximately 45° in a counter-clockwise direction, looking from above.

—*Western Electric.*

✶

REDUCED GAIN ON MARK 34 MOD 2

Several instances have been found recently of a marked reduction in gain on Mark 34 Mod 2 radars. This condition is indicated by a condition of no grass, with few echoes. No defective tubes could be found.

Equipment was restored to normal by re-adjustment of i-f OVERLOAD ADJUST and MAX AGC ADJUST controls.

A study of these failures and the steps taken to correct them would indicate that the following procedure should be followed by technical personnel.

Since the systems are left in standby a great percent of the time, they should be turned on full operation for at least an hour each day. During this period of operation the technician should check the adjustment of the controls mentioned above plus the AGC LEVEL and the CIRCLE CLOSURE ADJUST. This preventive-maintenance check will usually prevent a condition of reduced gain appearing when the equipment is needed for actual operation.

One solution advanced to this problem is that the Ken-Rad type 6AC7 tubes used in the i-f strip seem to lose gain rapidly and that the AGC circuits are very critical and apparently unstable. Some overloading of the last i-f stage was encountered but was overcome by proper balance of the adjustments concerned.

—*E.F.S.G.*

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INCORRECT RANGES ON MK 12 RADARS

Ensign J. P. Costas (Electronic Field Service Group) reports ranging difficulties with Mk 12 radars during target practice by the USS *Columbus* (CA-74). The practice was fired on a towed target, with main battery control by Mk 13 radars. Mk 12 operators reported differences in range as great as 600 yards from those of the Mk 13's. Ens. Costas, assisted by the ships CRT, checked the range units, zero set, and range transmission, finding everything in order.

At the suggestion of the ship's radar officer, Lt. Follien, the Mk 12's were switched from automatic to manual ranging. This immediately corrected the difficulty and the ranges checked very closely with those from the Mk 13's.

The explanation of the errors was that the target was being towed by a tug. On automatic ranging, the Mk 12 will give excellent range results from a single isolated target. However, the automatic circuit should be used with caution when two targets are being picked up at about the same range and bearing. The automatic circuit will tend to favor the stronger echo, which in this case was from the tug. This explained why both Mk 12's had the same range reading but with a 600-yard error as compared with the Mk 13's.

—*E.S.F.G.*

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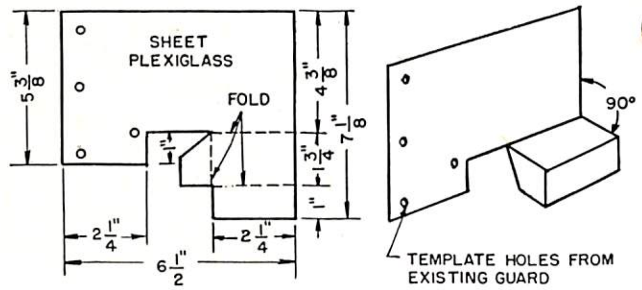
SAFETY SHIELDS FOR Mk 34

The transmitter in the Mk 34 Mod 2 systems is provided with a guard for preventing high-voltage injury to personnel engaged in tuning the TR and ATR boxes. Carelessness while making these adjustments can result in electric shock to the person engaged in the work.

Only one instance has actually been reported of personnel being injured as a result of coming in contact



with high voltage leads adjacent to these points of adjustment. However, to prevent a repetition of accidents of this nature, a plexiglass guard has been designed to be placed in these transmitters. The guard is made as shown in the figure and can be bolted to the frame replacing the guard now installed.

—*E.F.S.G.*

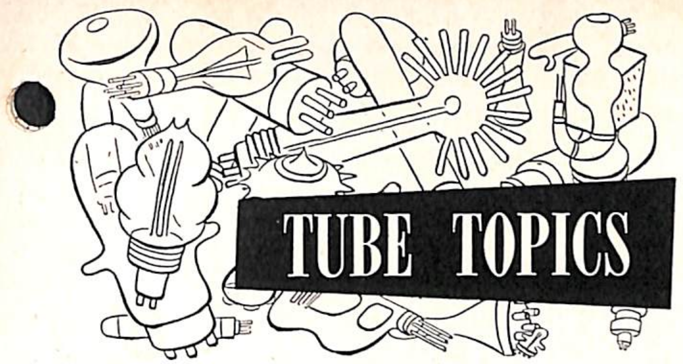
FSB Crystals

The formula for computing the crystal frequency as shown on page 10 of the Preliminary Instruction Book for the Model FSB Frequency Shift Keyer should be corrected to read as follows:

$$\text{Crystal frequency} = \frac{\text{assigned frequency} \pm 425 \text{ cycles}}{\text{multiplying factor}} - 200 \text{ kc}$$

Improved TR

An improved TR tube, type 721B, has been developed and has been stocked in all naval activities. The life expectancy is better than 1000 hours compared with the 300-hour safe limit established for the 721A. The 721B is completely interchangeable with the 721A except in new equipment designed for the 721B.



TESTERS MAY NEED TESTING

Over a period of time excessive rejection after checking types 6AB7, 6AC7, 6AK5, 6J6, 6Y6G, 7V7, 12SR7, and 9001 electron tubes on certain Hickok tube checkers has been reported to the Bureau. These testers include the Navy Model OZ-1, and Hickok Models 530, 540, and 550X. Special tests conducted at the Naval Research Laboratory by Airborne Coordinating Group engineers disclosed that when tested in accordance with instructions published by Hickok, the types 6AG5, 6AK5, and 6J6, are often ruined due to the grid wires being overheated, sometimes to the point of incandescence. Investigation carried out on the remaining types by the Electronics Section of NRL has shown that little correlation exists between the transconductance readings obtained on Hickok testers and satisfactory equipment performance or transconductance measurements taken in accordance with standard methods of testing as stated in JAN-1A Specifications. Additional tests on quantities of the tubes listed are now in progress at NRL and at the Hickok Electrical Instrument Company. Revised test settings and limits will be available in the near future.

In the meantime it would be well to test several new tubes, if available, of the same type as the one which is indicated to be faulty. If readings on the new tubes are approximately the same as those obtained on the one in question, it is likely that the tester is in error. As soon as the new data is made available, ELECTRON will publish the corrections.

TUBE DECLASSIFICATION

The Bureau of Ships advises that the following tubes together with all specifications and technical data pertaining to them are now "UNCLASSIFIED":

J-1	2C35	2KB72	5FP14
K-O series	2C36	2P21	5J21 thru -32
LVX	2C38 thru -47	2P22	5K34
1B22	2C49	2Q28	5K40
1B23	2J21 thru -34	3C22	6C21

TUBE DECLASSIFICATION—Cont'd.

1B24	2J36 thru -62	3C27	6C22
1B25	2J64	3C37	6C23
1B27	2JB49	3C45	6K4
1B29	2JB50	3D21A	6L4
1B31	2JB51	3E29	6Q4
1B32	2K21 thru -24	3HP12	HK7
1B34	2K25	3HP14	K-7 series
1B35	2K26	3J24	7BP12
1B37	2K27	3J25	7C22
1B38	2K28	3J26	7C23
1B40	2K29	3JP12	8B
1B42	2K30	3K21	8C22
1B43	2K31	3K22	8C23
1B44	2K34	3K23	L-14
1B50	2K35	3K27	15E
1B51	2K36	3K30	QK26
1B56	2K39	4C23	QK28
1B57	2K40	4C26	QK59-62
1B58	2K41	4C28	45 Special
1N21 thru -34	2K42	4C33	53A
1P24	2K43	4C35	98R
D-2 series	2K44	4J21 thru -65	A120
GY-2	2K45-46	HI5S	A124
Y2	2K47	5C22	X126B
2B22	2K48	5CP12	VT-127A
2B24	2K49	5D21	VT158
QF196	GL529	715A,B,C	1280-CT5
QF215	ZG529	718 series	1330M
227A	WL530	719A	1331
327A,B	ZG530	720 series	1380M
H350	GL541	721A,B	1382M
WL417	ZG541	722A	1391X
WL417A	ZG547	723A,B,C	1407XQ
417	559	724A,B	1429CT8
417A	ZG564	725A	1429CT9
417B	GL572	726A,B,C	1636
419	ZP572	727A	A2214
419A	GL579	728 series	A2304
419B	ZP579	729A	WE2779A
421	ZP584	730A	3092
421AA	GL590	826	WX-3199
434A	L600N	SD828	A5594A
WL441 series	ZG626	SD834	X6013
WL442	ZG629	SD835	X6030
WL443 series	GL645	SD846A,B	X6032
471A	ZG645	SD849A,B	X6033
GL484	ZP646	QK915A	R6210
GL485	700 series	QK915B	UX6653
GL486	701A	QK915C	C-7063
ZG489	702A,B	933	8014A
DRH505	706 series	936	38142
GL516	707A,B	NU-976	D161831
ZJ516	709A	1278-GY2	D164694
527	714 series	1280-CT	

The confidential status is being retained on tubes still in developmental status which were developed for military requirements and have no immediate commercial applications. The "*K*-band" types are all included in this category.

Tubes still "Classified" are listed below:

Restricted:

4AP10

Confidential:

1B26	2K33	3J31	Z594
1B36	2K50	5J33	Z597
1P25	3J21	6J21	Z599
1P25A	3J30	Z-556	Z647

Classifications drop again

■ The October ELECTRON listed certain equipments which had been declassified. Classifications have been changed again, with many more dropped to restricted or unclassified. In the tables below you will find the latest classifications, which apply to instruction books as well as to the equipments, but they do *not* apply to the *military applications* of the equipments.

Army-Navy Equipment

MODEL	Cassification	MODEL	Classification	MODEL	Classification
AN/AGA-1	U	AN/APG-15B•	U	AN/APS-4♦	U
AN/AIA-2	U	AN/APG-15C	U	AN/APS-4A♦	U
AN/AIA-2A	U	AN/APG-15-T1•	U	AN/APS-4T1	U
AN/AIA-4	U	AN/APG-16•	C	AN/APS-4T2	U
AN/AIC-4	U	AN/APG-17( )	U	AN/APS-6	U
AN/AIC-5	U	AN&APG-18( )♦	R	AN/APS-6A	U
AN/AIC-6	U	AN/APG-19( )	C	AN/APS-6T1	U
AN/AKT-1	U	AN/APG-20( )	R	AN/APS-6T2	U
AN/AMQ-1	U	AN/APG-22	C	AN/APS-6T3	U
AN/AMQ-1D	U	AN/APG-25	C	AN/APS-6T4	U
AN/ANQ-3	U	AN/APN-1	U	AN/APS-10•	U
AN/APA-1	U	AN/APN-1A	U	AN/APS-10-T1•	U
AN/APA-1A	U	AN/APN-1B	U	AN/APS-11(XN)	U
AN/APA-5	R	AN/APN-1X	U	AN/APS-13•	U
AN/APA-5A	R	AN/APN-T1	U	AN/APS-15♦	U
AN/APA-6	U	AN/APN-4•	U	AN/APS-15A♦	U
AN/APA-6A	U	AN/APN-7♦	U	AN/APS-15AM	R
AN/APA-6X	U	AN/APN-9•	U	AN/APS-15B♦	U
AN/APA-7•	U	AN/APN-11( )	R	AN/APS-15BM	R
AN/APA-8	U	AN/APN-13	U	AN/APS-15-T1	U
AN/APA-10•	U	AN/APN-22(XN-)♦	U	AN/APS-15-T3	U
AN/APA-11•	U	AN/APN-23(XN-)	C	AN/APS-16•	U
AN/APA-12	U	AN/APN-24(XN-)	C	AN/APS-17( )•♦	U
AN/APA-12A	U	AN/APN-31(XN-)	C	AN/APS-18	U
AN/APA-13	U	AN/APN-32(XN-)	C	AN/APS-19( )	R
AN/APA-13A	U	AN/APN-33	U	AN/APS-20	R
AN/APA-13B	U	AN/APN-41	U	AN/APS-20A	R
AN/APA-14	U	AN/APQ-1•	R	AN/APS-21(XN-)	C
AN/APA-14A	U	AN/APQ-2•	U	AN/APS-25	C
AN/APA-15	U	AN/APQ-2A•	U	AN/APS-30	R
AN/APA-15A	U	AN/APQ-2B	U	AN APS-30-T1	R
AN/APA-16	R	AN/APQ-5•	U	AN/APS-31	R
AN/APA-16B	R	AN/APQ-5B•	U	AN/APS-32	R
AN/APA-16-T1	R	AN/APQ-5-T1A•	U	AN/APS-33	R
AN/APA-17	U	AN/APQ-7•♦	U	AN/APS-34	R
AN/APA-17A	U	AN/APQ-7-T1•	U	AN/APS-35	R
AN/APA-18	U	AN/APQ-15•♦	R	AN/APT-1•	U
AN/APA-19	U	AN/APQ-19	C	AN/APT-2•	U
AN/APA-20	U	AN/APQ-20( )•	R	AN/APT-3•	U
AN/APA-21	U	AN/APQ-21•	R	AN/APT-4•	U
AN/APA-22	U	AN/APQ-27•	R	AN/APT-5•	U
AN/APA-23•	U	AN/APR-1	U	AN/APT-6( )•	U
AN/APA-24	U	AN/APR-1A	U	AN/APT-9	U
AN/APA-26	U	AN/APR-1B	U	AN/APT-10	U
AN/APA-27•	R	AN/APR-1X	U	AN/APT-16	R
AN/APA-30	U	AN/APR-2•	U	AN/APT-17	R
AN/APA-30A	U	AN/APR-4•	U	AN/APW-4(XN-1)	C
AN/APA-31	U	AN/APR-4-T1•	U	AN/APW-4(XN-2)	C
AN/APA-32	U	AN/APR-5	U	AN/APX-T1	R
AN/APA-38	U	AN/APR-5A	U	AN/APX-1	R
AN/APA-41•	U	AN/APR-5AX	U	AN/APX-1A	R
AN/APA-43(XN-)	R	AN/APR-5AY	U	AN/APX-1AM	R
AN/APA-44•	C	AN/APR-6	U	AN/APX-1AX	R
AN/APA-45	U	AN/APR-7A	U	AN/APX-1B	R
AN/APA-48	U	AN/APR-7B	U	AN/APX-1X	R
AN/APA-50	R	AN/APR-9	R	AN/APX-2	R
AN/APA-53	R	AN/APS-T1	U	AN/APX-2A	R
AN/APA-56	C	AN/APS-T1A	U	AN/APX-2B	R
AN/APA-57	C	AN/APS-T2	U	AN/APX-6( )	C
AN/APD-1	U	AN/APS-2♦	U	AN/APX-7( )	C
AN/APG-4	U	AN/APS-2A♦	U	AN/APX-8	R
AN/APG-4AX	U	AN/APS-2B♦	U	AN/APX-8A	R
AN/APG-4X	U	AN/APS-2C♦	U	AN/APX-12	R
AN/APG-5•	U	AN/APS-2D♦	U	AN/APX-13	R
AN/APG-6	U	AN/APS-2E♦	U	AN/APX-13A	R
AN/APG-9( )	U	AN/APS-2F♦	U	AN/ARA-3	U
AN/APG-12( )	U	AN/APS-2G♦	U	AN/ARA-4•	U
AN/APG-13•	U	AN/APS-2T1	U	AN/ARA-6( )	U
AN/APG-13A•	U	AN/APS-3♦	U	AN/ARA-7	U
AN/APG-13B•	U	AN/APS-3A♦	U	AN/ARA-8•	U
AN/APG-13-T1	U	AN/APS-3AM♦	U	AN/ARA-13	U
AN/APG-15A•	U	AN/APS-3T1	U	AN/ARA-15	R

• Indicates an item sponsored and developed by the Army.
♦ Indicates an item containing British influence. No technical disclosure on these items may be made to the public.
♦ Dome and Retracting Gear.

Army-Navy Equipment—Cont'd.

MODEL	Classification	MODEL	Classification	MODEL	Classification
AN/ARC-T1•	U	AN/ARW-20	U	AN/GPS-T1A•♦	U
AN/ARC-1	U	AN/ARW-20X	U	AN/GPX-2	R
AN/ARC-1A	U	AN/ARW-21	U	AN/GSQ-1•	R
AN/ARC-2	R	AN/ARW-21X	U	AN/MKR-1(XN)	U
AN/ARC-4	U	AN/ARW-22	U	AN/MPQ-1	S
AN/ARC-4A	U	AN/ARW-22X	U	AN/MPN-1•	U
AN/ARC-4X	U	AN/ARW-23	U	AN/MPN-1A•	U
AN/ARC-5	U	AN/ARW-24	U	AN/MPN-2	R
AN/ARC-5X	U	AN/ARW-25	U	AN/MPN-3	R
AN/ARC-6( )•	U	AN/ARW-26•	U	AN/MPS-4(XN)	C
AN/ARC-9•	U	AN/ARW-26A	U	AN/MPX-1	C
AN/ARC-11( )	C	AN/ARW-27	U	AN/MPX-2	C
AN/ARC-12( )	R	AN/ARW-28	U	AN/MPX-13	C
AN/ARC-13( )	R	AN/ARW-29	U	AN/MRC-5•	U
AN/ARC-14	C	AN/ARW-30	U	AN/MRC-6•	U
AN/ARC-15	C	AN/ARW-31	U	AN/MRC-7	U
AN/ARC-16	C	AN/ARW-32	U	AN/MRC-8	U
AN/ARC-17	C	AN/ARW-34	U	AN/MRN-1•	U
AN/ARC-19	R	AN/ARW-35	U	AN/MRN-3•	U
AN/ARC-25	R	AN/ARW-37	U	AN/PPN-1	U
AN/ARC-28	R	AN/ARW-45	U	AN/PPN-2	U
AN/ARD-3	U	AN/ARW-46	U	AN/PPN-3	U
AN/ARD-4	U	AN/ARW-47	U	AN/PPN-8( )	C
AN/ARN-T1	U	AN/ARW-47X	U	AN/PPS-1( )•	C
AN/ARN-1	U	AN/ASA-1	U	AN/PRT-1	R
AN/ARN-5•	U	AN/ASA-1A	U	AN/SPA-1	U
AN/ARN-5A•	U	AN/ASA-3•	U	AN/SPN-1	C
AN/ARN-6( )•	U	AN/ASA-5(XN)	R	AN/SPQ-1	R
AN-ARN-7•	U	AN/ASA-6(XN)	R	AN/SPR-1	U
AN/ARN-8	U	AN/ASG-10	R	AN/SPR-2	U
AN/ARN-12	U	AN/ASG-10A	R	AN/SPR-3	R
AN/ARQ-1•	U	AN/ASG-10B	R	AN/SPT-1	U
AN/ARQ-4	U	AN/ASG-10(XN)	R	AN/SPT-1A	U
AN/ARQ-5•	U	AN/ASR-1(XN)	C	AN/SPT-2	U
AN/ARQ-5X•	U	AN/ASR-2	C	AN/SPT-3	U
AN/ARQ-6•	U	AN/ASW-8	C	AN/SPT-4	U
AN/ARQ-7	U	AN/ASW-9	C	AN/SPT-5	U
AN/ARQ-8•	U	AN/AXA-1(XN)	U	AN/SPT-6	U
AN/ARQ-9•	R	AN/AXR-1	U	AN/SPT-6A	U
AN/ARQ-10	R	AN/AXR-2(XN)	U	AN/SPX-1	C
AN/ARQ-11•	U	AN/AXR-3	U	AN/SPX-2( )	C
AN/ARQ-12	U	AN AXR-4(XN)	U	AN/SRQ-1	U
AN/ARR-1•	R	AN/AXS-1	U	AN/SRQ-2	U
AN/ARR-2	R	AN/AXT-2	U	AN/TPQ-T1•	U
AN/ARR-2A	R	AN/AXT-2A	U	AN/TPQ-T2•	U
AN/ARR-2AX	R	AN/AXT-2B•	U	AN/TPQ-1	R
AN/ARR-2B	R	AN/AXT-2C•	U	AN/TPS-1B	R
AN/ARR-2X	R	AN/AXT-4( )	C	AN/TPS-9	U
AN/ARR-3	U	AN/AXT-5	U	AN/TPX-8	C
AN/ARR-3A	U	AN/AXT-6	U	AN/TPX-11	C
AN/ARR-3B	U	AN/CPA-2	U	AN/TPX-12	C
AN/ARR-4	U	AN/CPN-3	U	AN/TPX-14	C
AN/ARR-5•	U	AN/CPN-3A	U	AN/TPX-15	C
AN/ARR-7•	U	AN/CPN-6	U	AN/TRA-1	R
AN/ARR-8	U	AN/CPN-8•	U	AN/TRC-1/3/4•	U
AN/ARR-9	U	AN/CPN-11•	U	AN/TRQ-1	U
AN/ARR-11•	U	AN/CPN-12•	U	AN/UIQ-2•	U
AN/ARR-14	U	AN/CPN-13	C	AN/UIQ-2A•	U
AN/ARR-16	R	AN/CPN-14	U	AN/UMQ-3	R
AN/ARR-16A	R	AN/CPN-15( )	C	AN/UPA-1	U
AN/ARR-16B	R	AN/CPN-16•	U	AN/UPA-2	C
AN/ARR-17	U	AN/CPN-17	U	AN/UPA-3	C
AN/ARR-18	U	AN/CPT-1•♦	S	AN/UPA-4	C
AZ/ARR-19	U	AN/CPT-2•♦	U	AN/UPA-5	C
AN/ARR-21	U	AN/CPT-3	U	AN/UPA-6	C
AN/ARR-22	R	AN/CPX-3	C	AN/UPA-7	C
AN/ARR-23•	U	AN/CPX-4	C	AN/UPA-8	C
AN/ART-2	U	AN/CPX-11	C	AN/UPA-9	C
AN/ART-3•	U	AN/CPX-15	C	AN/UPA-10	C
AN/ART-3A	U	AN/CPX-16	C	AN/UPA-11	C
AN/ART-7•	U	AN/CRC-7	U	AN/UPA-12	C
AN/ART-9•	U	AN/CRC-9	U	AN/UPA-13	C
AN/ART-10•	U	AN/CRN-1•	U	AN/UPA-14	C
AN/ART-11•	U	AN/CRN-1A•	U	AN/UPA-15	C
AN/ART-13•	U	AN/CRN-2•	U	AN/UPA-16	C
AN/ART-13A•	U	AN/CRN-3•	U	AN/UPA-17	C
AN/ART-17	U	AN/CRN-10•	U	AN/UPA-18	C
AN/ART-18	U	AN/CRT-1•	U	AN/UPA-19	C
AN/ART-21	U	AN/CRT-1A	U	AN/UPA-20	C
AN/ART-22	U	AN/CRT-1B	U	AN/UPN-1•	U
AN/ART-23	U	AN/CRT-2•	R	AN/UPN-2•	U
AN/ART-24	U	AN/CRT-3•	U	AN/UPN-3•	U
AN/ART-25	R	AN/CRT-4	R	AN/UPN-4•	U
AN/ARW-2	U	AN/CRT-6	U	AN/UPN-5( )	C
AN/ARW-2X	U	AN/FGC-1A	U	AN/UPN-6	C
AN/ARW-3	U	AN/FMQ-1	U	AN/UPT-T1	U
AN/ARW-11	U	AN/FPN-1(XN-1)	R	AN/UPT-T3	U
AN/ARW-12	U	AN/FRT-1	U	AN/UPT-1	R
AN/ARW-13	U	AN/GMQ-2•	U	AN/UPX-T1	C
AN/ARW-14	U	AN/GMQ-5	U	AN/URA-T2	U
AN/ARW-17( )	U	AN/GPN-1	R	AN/URA-T2A	R
AN/ARW-19	U	AN/GPN-2	R	AN/URQ-1	R
AN/ARW-19X	U	AN/GPS-T1•♦	U	AN/VRW-1	U

Airborne Equipment—A Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
ABA	U	ARD-2	U	ASJ	U
ABA-1	U	ARE	U	ASV♦	U
ABD♦	U	ARF	U	ASVC♦	U
ABD-1♦	U	ARG	U	ATA	U
ABD-2♦	U	ARH	U	ATB	U
ABD-3♦	U	ARJ	U	ATC	U
ABE♦	U	ARK	U	ATC-1	U
ABF	R	ARQ	R	ATD	U
ABF-1	R	ARR	R	ATE	U
ABJ	R	ASA	U	ATF	U
ABK	R	ASB	U	ATG	U
ABK-1	R	ASB-1	U	ATH	U
ABK-2	R	ASB-2	U	ATJ	U
ABK-3	R	ASB-3	U	ATK	U
ABK-4	R	ASB-4	U	ATM	R
ABK-5	R	ASB-5	U	ATM-1	R
ABK-6	R	ASB-6	U	AYA	U
ABK-7	R	ASB-7	U	AYA-1	U
ABL	R	ASB-7A	U	AYB	U
ABM	R	ASB-7B	U	AYB-1	U
AIA♦	U	ASB-8	U	AYC	U
AIA-1♦	U	ASC♦	U	AYD	U
AMA	U	ASC-1♦	U	AYD-1	U
AMD	R	ASD♦	U	AYD-2	U
ARA	U	ASD-1♦	U	AYD-3	U
ARA-1	U	ASE♦	U	AYD-4	U
ARA-2	R	ASE-1♦	U	AYD-5	U
ARB	U	ASF	U	AYF	U
ARC-1	U	ASG♦	U	AYF-F1	U
ARC-2	U	ASG-1♦	U	AYJ	U
ARD-1	U	ASH♦	U		

IFF—B Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
BA	U	BL-1	R	BN-2	R
BE	U	BL-2	R	BO	R
BE-1	U	BL-3	R	BO-1	R
BF	U	BL-4	R	BP	U
BG	U	BL-5	R	BQ	U
BH	U	BL-6	R	BR	U
BI	U	BM(CXEM)	R	BR-1	U
BI-1	U	BM-1	R	BT	U
BK	R	BN	R		
BL	R	BN-1	R		

Radio Direction Finding Equipment and Loran Navigational Indicators—D Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
DA	U	DP-17	U	DAB	U
DB	U	DP-18	U	DAB-1	U
DC	U	DP-19	U	DAB-2	U
DF	U	DQ	U	DAB-3	U
DG	U	DQ-1	U	DAE	U
DH	U	DQ-2	U	DAE-1	U
DJ	U	DQ-3	U	DAE-2	U
DK	U	DQ-4	U	DAF	U
DL	U	DQ-5	U	DAF-1	U
DM	U	DQ-6	U	DAG	U
DN	U	DQ-7	U	DAG-1	U
DN-X	U	DR	U	DAG-2	U
DO	U	DS	U	DAH	R
DO-1	U	DT	U	DAH-a	R
DO-2	U	DT-1	U	DAH-1	R
DO-3	U	DT-2	U	DAH-2	R
DP	U	DU	U	DAH-3	R
DP-1	U	DU-1	U	DAJ	U
DP-2	U	DU-2	U	DAJ-2	R
DP-3	U	DV	U	DAK	U
DP-4	U	DW	U	DAK-1	U
DP-5	U	DW-1	U	DAK-2	U
DP-6	U	DY	U	DAK-3	U
DP-7	U	DY-1	U	DAK-4	U
DP-8	U	DY-2	U	DAL	U
DP-9	U	DY-3	U	DAM	U
DP-10	U	DY-4	U	DAN	U
DP-11	U	DZ	U	DAO	U
DP-12	U	DZ-a	U	DAP	U
DP-13	U	DZ-1	U	DAR♦	C
DP-14	U	DZ-2	U	DAS	U
DP-15	U	DZ-2a	U	DAS-a	U
DP-16	U	DAA	U	DAS-b	U

MODEL	Classification	MODEL	Classification	MODEL	Classification
DAS-1	U	DAY	R	DBN	U
DAS-1a	U	DAZ	R	DBO	C
DAS-1b	U	DBA	R	DBS	U
DAS-2	U	DBA-1	R	DBT	R
DAS-3	U	DBB	R	DBU	R
DAS-4	U	DBB-1	R	DBV	R
DAU	U	DBC	R	DBW	C
DAV	U	DBC-1	R	DXA	R
DAV-1	U	DBD	U	DXB	R
DAV-2	U	DBE	U	DXC	R
DAW	R	DBF	U	DXD	R
DAW-1	R	DBG	U	LRN-1	U
DAW-2	R	DBH	U	LRN-1A	U
DAW-3	R	DBM	U		
DAX	R	DBM-1	U	DAQ Series	U

Frequency Shift Keying Equipment—F Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
FRA	U	FRG	U	FSD	U
FRC	U	FRH	U	FSH	U
FRE	U	FSA	U		
FRF	U	FSB	U		

Aircraft Transmitting Equipment—G Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
GA	U	GH-X	U	GP-1	U
GA-1	U	GH-1	U	GP-2	U
GB	U	GI	U	GP-3	U
GC	U	GK	U	GP-4	U
GD	U	GK-1	U	GP-4a	U
GF	U	GL	U	GP-5	U
GF-1	U	GM	U	GP-6	U
GF-2	U	GN	U	GP-6a	U
GF-3	U	GO	U	GP-7	U
GF-4	U	GO-1	U	GQ	U
GF-5	U	GO-2	U	GR	U
GF-6	U	GO-3	U	GS	U
GF-7	U	GO-4	U	GS-1	U
GF-8	U	GO-5	U	GS-2	U
GF-9	U	GO-6	U	GS-3	U
GF-10	U	GO-7	U	GS-4	U
GF-11	U	GO-8	U	GS-5	U
GF-12	U	GO-9	U		
GH	U	GP	U		

Sound Listening (Receiving) Equipment—J Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
JA	U	JK-8	U	JN-1	U
JB	U	JK-9	U	JO	U
JC	U	JKA	U	JP	U
JD	U	JKA-1	U	JP-1	U
JE	U	JKA-2	U	JP-2	U
JF	U	JKA-3	U	JP-3	U
JG	U	JKA-4	U	JQ	U
JH	U	JKA-5	U	JR	U
JK	U	JKA-5a	U	JR-1	U
JK-1	U	JL	U	JR-2	U
JK-2	U	JM	U	JT	R
JK-3	U	JM-1	U	JAA	R
JK-4	U	JM-2	U	JAB	C
JK-5	U	JM-3	U	JBA	C
JK-6	U	JM-4	U	JCA	C
JK-7	U	JN	U		

Sound Transmitting Equipment—K Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
KA	U	KE	U	KE-4	U
KB	U	KE-1	U	KF	U
KC	U	KE-2	U	KG	U
KD	U	KE-3	U		

Combined Radio Transmitting and Receiving Equipment—M Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
MA	U	MO-1	U	MAN	U
MB	U	MO-2	U	MAO	U
MB-a	U	MP	U	MAQ	U
MB-b	U	MQ	U	MAR	R
MB-1	U	MQ-1	U	MAS	U
MB-2	U	MQ-2	U	MAW	U
MB-3	U	MR	U	MAX	U
MC	U	MR-1	U	MAY	R
MD	U	MS	U	MAZ	U
ME	U	MT	U	MBA	R
MF	U	MT-1	U	MBA-1	R
MF-1	U	MT-2	U	MBA-2	R
MF-2	U	MU	U	MBA-3	R
MG	U	MU-1	U	MBB	R
MH	U	MV	U	MBB-1	R
MI-X	U	MV-1	U	MBB-2	R
MJ-a	U	MW	U	MBB-3	R
MK	U	MW-1	U	MBC	R
ML	U	MX	U	MBD	R
ML-1	U	MX-1	U	MBE	R
ML-2	U	MY	R	MBF	U
ML-3	U	MZ	U	MBG	R
ML-4	U	MZ-1	U	MBK	R
MM	U	MZ-2	U	MBL	R
MM-1	U	MAA	U	MBM	U
MM-2	U	MAB	U	MBN	U
MM-3	U	MAC	U	MBO	U
MM-4	U	MAE	U	MBP	U
MM-5	U	MAE-1	U	MBQ	U
MN	U	MAF	U	MBR	R
MN-1	U	MAG	U	MBS	R
MN-2	U	MAH	U	MBT	R
MN-3	U	MAJ	U	MBU	C
MN-4	U	MAK	U	MBV	U
MN-5	U	MAL	U		
MO	U	MAM	U		

Fire-Control Equipment—MARK Series

MODEL	Classification	MODEL	Classification
Radar Mk 1(FA, FA-a) Mod 0	R	Radar Mk 34 Mod 1	R
Radar Mk 3(FC) Mod 0	R	Radar Mk 34 Mod 2	R
Radar Mk 3 Mod 1, 2, 3	R	Radar Mk 34 Mod 3, 4, 5	R
Radar Mk 4(FD) Mod 0, 1	R	Radar Mk 34 Mod 6, 7, 8, 9, 10	R
Radar Mk 4 Mod 2	R	Radar Mk 35 Mod 0, 1	C
Radar Mk 5 Mod 0, 1, 2	R	Radar Mk 36 Mod 0, 1	R
Radar Mk 6 Mod 0	R	Radar Mk 37 Mod 0	C
Radar Mk 7 Mod 0, 1	R	Radar Mk 38 Mod 0	C
Radar Mk 8 Mod 0, 1, 2, 3	R	Radar Mk 38 Mod 1	C
Radar Mk 8 Mod 4	C	Radar Mk 39 Mod 0, 1	R
Radar Mk 9 Mod 0	R	Radar Mk 39 Mod 2, 3	R
Radar Mk 10 Mod 0, 1	R	Radar Mk 40 Mod 0	C
Radar Mk 10 Mod 2-7 (inclusive)	R	Radar Mk 40 Mod 1	C
Radar Mk 11 Mod 0, 1, 2, 3, 4, 5	R	Radar Mk 41 Mod 0	C
Radar Mk 12 Mod 0, 1	R	Radar Mk 42 Mod 0	S
Radar Mk 12 Mod 2	R	Radar Mk 43 Mod 0, 1, 2, 3, 4	C
Radar Mk 12 Mod 3	R	Radar Mk 44 Mod 0	S
Radar Mk 12 Mod 4	R	Radar Mk 45 Mod 0	C
Radar Mk 13 Mod 0, 1	R	Radar Mk 46 Mod 0	C
Radar Mk 13 Mod 2	C	Radar Mk 47 Mod 0, 1, 2, 3, 4	C
Radar Mk 13 Mod 4	C	Radar Mk 48 Mod 0, 1	S
Radar Mk 14 Mod 0	R	Radar Beacon Mk 1 Mod 0, 1	R
Radar Mk 15 Mod 0, 1	R	Radar Beacon Mk 2 Mod 0, 1, 2	R
Radar Mk 16 Mod 0♦	U	Radar Beacon Mk 3 Mod 0	R
Radar Mk 18 Mod 0, 1	R	Radar Beacon Mk 4 Mod 0, 1, 2	R
Radar Mk 19 Mod 0, 1, 2, 3	R	Radar Beacon Mk 5 Mod 0, 1	R
Radar Mk 20 Mod 0, 1	U	Radar Beacon Mk 6	C
Radar Mk 21 Mod 0	R	Radar Trainer Mk 1 Mod 0, 1, 2	R
Radar Mk 22 Mod 0, 1	R	Radar Trainer Mk 2 Mod 0	R
Radar Mk 23 Mod 0	R	Radar Trainer Mk 3 Mod 0	R
Radar Mk 25 Mod 0, 1, 2	C	Radar Trainer Mk 4 Mod 0	R
Radar Mk 26 Mod 0, 1, 2, 3, 4	R	Radar Trainer Mk 5 Mod 0	R
Radar Mk 27 Mod 1	C	Radar Trainer Mk 6 Mod 0	R
Radar Mk 28 Mod 0, 2, 3	R	Radar Trainer Mk 7 Mod 0	R
Radar Mk 29 Mod 0, 2	R	Radar Trainer Mk 8 Mod 0	R
Radar Mk 29 Mod 5	R	Radar Trainer Mk 9	R
Radar Mk 30 Mod 0	R	SWOD Mk 1 Mod 1, 2, 3	C
Radar Mk 32 Mod 0, 1	R	SWOD Mk 2 Mod 0, 1	C
Radar Mk 33 Mod 0	R	SWOD Mk 3 Mod 0	S
Radar Mk 34 Mod 0	R		

Special Sonar Devices—N Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
NA	U	NJ-4	U	NK-9	U
NB	U	NJ-5	U	NM	U
NC	U	NJ-6	U	NM-1	U
ND	U	NJ-7	U	NM-2	U
NE	U	NJ-8	U	NM-3	U
NF	U	NJ-9	U	NM-4	U
NG	U	NK	U	NM-4a	U
NG-1	U	NK-1	U	NM-5	U
NG-2	U	NK-2	U	NM-5a	U
NH	U	NK-3	U	NM-6	U
NJ	U	NK-4	U	NM-6a	U
NJ-1	U	NK-5	U	NM-7	U
NJ-2	U	NK-6	U	NM-8	U
NJ-3	U	NK-7	U	NM-9	U

MODEL	Classification	MODEL	Classification	MODEL	Classification
NM-9A	U	NM-14c	U	NGA	R
NM-10	U	NM-15	U	NMA	U
NM-11	U	NM-16	U	NMB	U
NM-12	U	NAA	U	NMB-1	U
NM-13	U	NAB	U	NMB-2	U
NM-13a	U	NAC	C	NMC	U
NM-14	U	NAD	C	NMC-1	U
NM-14a	U	NAH	C	NMC-2	U
NM-14b	U	NAJ	C	NMD	R

Operator Training Equipment—O Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
OV	U	OAF	U	OAU	U
OW	U	OAH	U	OAV	U
OW-1	U	OAH-1	U	OAV-1	U
OW-2	U	OAH-2	U	OBC	U
OX	U	OAJ	U	OBJ	R
OY	U	OAJ-1	U	OCJ	R
OAB	U	OAS	U		
OAC	U	OAT	U		

Automatic Transmitting and Receiving Equipment—P Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
PA	U	PF	U	PN-1	R
PB	U	PG	U	PO	R
PC	U	PH	U	PO-1	R
PD	U	PJ	U	PO-2m	R
PDa	U	PL	C	PQ	U
PE	U	PM	U	PQ-1	U
PE-1	U	PN	R	PR	U

Echo Ranging Equipment—Q Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
QA	U	QCJ-1a	U	QCQ-3a♠♦	U
QC	U	QCJ-2	U	QCR♠♦	U
QC-1	U	QCJ-3	U	QCR-a♠♦	U
QC-1a	U	QCJ-3a	U	QCR-1♠♦	U
QC-2	U	QCJ-4	U	QCR-1a♠♦	U
QC-3	U	QCJ-4a	U	QCR-2♠♦	U
QC-4	U	QCJ-5	U	QCR-2a♠♦	U
QC-5	U	QCJ-5a	U	QCS♠♦	U
QC-5a	U	QCJ-6	U	QCS-a♠♦	U
QC-5b	U	QCJ-6a	U	QCS-1♠♦	U
QC-6	U	QCJ-8	U	QCS-1a♠♦	U
QC-6a	U	QCJ-8a	U	QCT♠♦	U
QC-7	U	QCJ-9	U	QCT-a♠♦	U
QF	U	QCJ-9a	U	QCT-1♠♦	U
QBA	U	QCK	U	QCT-1a♠♦	U
QBA-1	U	QCK-a	U	QCU♠♦	U
QBB	U	QCK-1	U	QCW♦	U
QBC♦	U	QCK-1a	U	QCX♦	U
QBC-1♦	U	QCL	U	QCY♦	U
QBD♦	U	QCL-1	U	QCZ♦	U
QBE	U	QCL-1a	U	QDA	C
QBE-1	U	QCL-2	U	QFA	R
QBE-1a	U	QCL-2a	U	QFA-b	R
QBE-2	U	QCL-3	U	QFA-c	R
QBE-3	U	QCL-3a	U	QFA-1	R
QBE-3a	U	QCL-4	U	QFA-2	R
QBE-3b	U	QCL-4a	U	QFA-2a	R
QBE-4	U	QCL-5	U	QFA-3	R
QBE-5	U	QCL-5a	U	QFA-4	R
QBF♦	U	QCL-7	U	QFA-5	R
QBG	U	QCL-7a	U	QFA-6	R
QBG-1	U	QCL-8	U	QFB♦	R
QBH♦	U	QCL-8a	U	QFB-1♦	R
QCA	U	QCM	U	QFC	R
QCA-a	U	QCM-1	U	QFD	R
QCA-1	U	QCM-2	U	QFE	R
QCA-1a	U	QCM-3	U	QFF	R
QCB	U	QCM-4	U	QFG	R
QCB-a	U	QCN	U	QFH	R
QCB-1	U	QCN-1	U	QFH-1	R
QCB-1a	U	QCN-1a	U	QFJ	R
QCB-2	U	QCN-2a	U	QFK	R
QCB-3	U	QCN-3	U	QFL	R
QCC	U	QCN-3a	U	QFM	R
QCC-1	U	QCN-4	U	QFN	R
QCD	U	QCN-4a	U	QFO	R
QCD-1	U	QCO	U	QGA	R
QCE	U	QCO-a	U	QGB	R
QCE-1	U	QCO-1	U	QGB-a	R
QCE-2	U	QCO-1a	U	QGC	R
QCE-3	U	QCO-2	U	QGD	R
QCF	U	QCO-2a	U	QCE	R
QCF-a	U	QCO-3	U	QGF	R
QCG	U	QCO-3a	U	QGG	R
QCH	U	QCP♦	U	QH Series	C
QCH-1	U	QCP-1♦	U	QJA	R
QCH-2	U	QCQ♠♦	U	QJB	R
QCH-3	U	QCQ-a♠♦	U	QLA	C
QCH-4	U	QCQ-1♠♦	U	QK Series	C
QCJ	U	QCQ-1a♠♦	U	QL Series	C
QCJ-a	U	QCQ-2♠♦	U	147B	C
QCJ-1	U	QCQ-3♠♦	U		

Radio Receiving Equipment—R Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
RA	U	RAK-4	U	RBL-3	U
RB	U	RAK-5	U	RBL-4	U
RB-1	U	RAK-6	U	RBL-5	U
RB-2	U	RAK-7	U	RBL-6	U
RC	U	RAK-8	U	RBM-Series	U
RD	U	RAL	U	RBN	U
RE	U	RAL-1	U	RBO	U
RE-a	U	RAL-2	U	RBO-1	U
RF	U	RAL-3	U	RBO-2	U
RF-a	U	RAL-4	U	RBO-3	U
RG	U	RAL-5	U	RBP	U
RG-1	U	RAL-6	U	RBP-1	U
RG-2	U	RAL-7	U	RBQ	U
RG-3	U	RAL-8	U	RBQ-1	U
RH	U	RAM	U	RBR	U
RH-1	U	RAN	U	RBR-1	U
RH-2	U	RAN-1	U	RBS-Series	U
RH-3	U	RAO	U	RBT	U
RH-4	U	RAO-1	U	RBT-1	U
RH-5	U	RAO-2	U	RBT-2	U
RI	U	RAO-3	U	RBU	U
RJ	U	RAO-4	U	RBU-1	U
RK	U	RAO-5	U	RBV	U
RL	U	RAO-6	U	RBV-1	U
RL-1	U	RAO-7	U	RBW	U
RL-1a	U	RAO-8	U	RBW-1	U
RL-1b	U	RAO-9	U	RBW-2	U
RL-2	U	RAP	U	RBW-2M	U
RM	U	RAQ	U	RBX	U
RN	U	RAR	U	RBY	U
RO	U	RAS	U	RBY-1	U
RO-1	U	RAS-1	U	RBZ	U
RO-2	U	RAS-2	U	RCB	U
RO-2a	U	RAS-3	U	RCB-1	U
RO-3	U	RAS-4	U	RCC	U
RQ	U	RAS-5	U	RCD	U
RS	U	RAT	U	RCE	U
RS-1	U	RAT-1	U	RCE-1	U
RT	U	RAU	U	RCF	U
RU	U	RAU-1	U	RCF-1	U
RU-1	U	RAU-2	U	RCG	U
RU-2	U	RAV	U	RCG-1	U
RU-2a	U	RAW	U	RCH	U
RU-3	U	RAX	U	RCJ	U
RU-3a	U	RAX-1	U	RCK	U
RU-4	U	RAX-2	U	RCL	U
RU-4a	U	RAY	U	RCM	U
RU-5	U	RAY-1	U	RCN	R
RU-5a	U	RAY-2	U	RCO	U
RU-6	U	RAY-3	U	RCP	U
RU-7	U	RAY-4	U	RCQ	U
RU-8	U	RAY-5	U	RCR	U
RU-9	U	RAZ	U	RCT	U
RU-10	U	RAZ-1	U	RCU	U
RU-11	U	RBA-Series	U	RCU-1	U
RU-12	U	RBB-Series	U	RCV	U
RU-13	U	RBC-Series	U	RCW	U
RU-14	U	RBD	U	RCX	U
RU-15	U	RBE	U	RCX-1	U
RU-16	U	RBF	U	RCY	U
RU-17	U	RBF-1	U	RCZ	U
RU-18	U	RBF-2	U	RDA	U
RU-19	U	RBF-3	U	RDB	U
RW	U	RBG	U	RDC	U
RAA	U	RBG-1	U	RDC-1	U
RAA-1	U	RBG-2	U	RDD	U
RAA-2	U	RBH	U	RDE	U
RAA-3	U	RBH-1	U	RDG	U
RAA-4	U	RBH-2	U	RDH	R
RAB	U	RBH-3	U	RDJ	U
RAB-1	U	RBH-4	U	RDK	U
RAB-2a	U	RBJ	U	RDL	U
RAB-3	U	RBJ-1	U	RDM	U
RAB-4	U	RBJ-2	U	RDO	U
RAB-5	U	RBJ-3	U	RDP	U
RAC	U	RBJ-4	U	RDS	R
RAC-1	U	RBJ-5	U	RDV	U
RAD	U	RBK	U	RDW	U
RAD-1	U	RBK-1	U	RDX	R
RAD-2	U	RBK-2	U	RDY	R
RAD-2a	U	RBK-3	U	RDZ	R
RAD-3	U	RBK-4	U	REA	U
RAE	U	RBK-5	U	REB	U
RAE-1	U	RBK-6	U	REB-1	U
RAE-2	U	RBK-7	U	REC	U
RAF	U	RBK-8	U	RED	R
RAG	U	RBK-9	U	REE	U
RAG-1	U	RBK-10	U	REF	U
RAH	U	RBK-11	U	REH	U
RAH-1	U	RBK-12	U	REJ	U
RAJ	U	RBK-13	U	REK	U
RAK	U	RBK-14	U	REM	R
RAK-1	U	RBL	U	REO	U
RAK-2	U	RBL-1	U	REP	U
RAK-3	U	RBL-2	U	REQ	R

Radar Equipment—S Series

SA	U	SC-a	U	SD	U
SA-1	U	SC-1	U	SD-1	U
SA-2	U	SC-2	U	SD-a	U
SA-3	U	SC-3	U	SD-2	U
SB	U	SC-4	U	SD-3	U
SC	U	SC-5	U	SD-4	U

MODEL	Classification	MODEL	Classification	MODEL	Classification
SD-5	U	SK-1M	U	SQ	U
SE♦	U	SK-2	U	SR	U
SF♦	U	SK-3	U	SR-1	R
SF-1♦	U	SL♦	U	SR-2	R
SG♦	U	SL-a♦	U	SR-3	R
SG-a♦	U	SL-1♦	U	SE-4	R
SG-b♦	U	SM	R	SR-5	R
SG-1♦	U	SN	U	SR-6	R
SG-1b♦	U	SO♦	U	SS	R
SG-c♦	U	SO-a♦	U	SS-1	R
SG-1c♦	U	SO-1♦	U	ST	R
SG-d♦	U	SO-2♦	U	ST-a	R
SG-1d♦	U	SO-3	R	ST-1	R
SG-e♦	U	SO-4	R	SU♦	U
SG-1e♦	U	SO-5	R	SU-1♦	U
SG-2S♦	U	SO-6	R	SU-2	R
SG-3	R	SO-7M/N♦	U	SU-3	R
SG-4	R	SO-8♦	U	SU-4	R
SG-5	R	SO-9♦	U	SV	R
SG-6	R	SO-11♦	U	SV-a	R
SH♦	U	SO-12M/N♦	R	SV-1	R
SJ♦	U	SO-13♦	U	SW	U
SJ-a♦	U	SP	R	SX(SC1)(CXHR)	R
SJ-1♦	U	SP-1M	R		
SK	U	SP-2	R		

Army Signal Corps Radio and Radar Equipment—BC and SCR Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
		BC Series			
BC-34A	U	BC-610	U	BC-1206( )	U
BC-312	U	BC-614	U	BC-103A	U
BC-342	U	BC-638♦	U	BC-103AZ	U
BC-348	U	BC-639♦	U		
BC-606	U	BC-640♦	U		
		SCR Series			
SCR-169	U	SCR-295	U	SCR-587♦	U
SCR-177	U	SCR-299-A	U	SCR-588-B♦	U
SCR-183	U	SCR-299-E	U	SCR-595♦	R
SCR-187	U	SCR-300	U	SCR-602-A♦	R
SCR-188-A	U	SCR-399	U	SCR-608	U
SCR-193	U	SCR-499	U	SCR-609	U
SCR-194	U	SCR-508	U	SCR-610	U
SCR-195	U	SCR-509	U	SCR-619	U
SCR-244	U	SCR-510	U	SCR-624	U
SCR-245	U	SCR-511	U	SCR-625	U
SCR-268	U	SCR-517♦	U	SCR-627♦	U
SCR-268-B	U	SCR-517-a♦	U	SCR-634	U
SCR-268-C	U	SCR-517-b♦	U	SCR-694	U
SCR-269F	U	SCR-517-c♦	U	SCR-695♦	R
SCR-269G	U	SCR-522♦	U	SCR-718A	U
SCR-270-B	U	SCR-527-A♦	U	SCR-718AM	U
SCR-270-D	U	SCR-528	U	SCR-718B	U
SCR-270-Da	U	SCR-536	U	SCR-718C	U
SCR-271-A	U	SCR-538	U	SCR-720A♦	U
SCR-271-D	U	SCR-542	U	SCR-720C♦	U
SCR-274-N	U	SCR-573	U	SCR-722	U
SCR-277	U	SCR-574	U	SCR-729A	R
SCR-283	U	SCR-578-A	U	SCR-808	U
SCR-284	U	SCR-578-B	U		
SCR-287	U	SCR-584	U		

Radio Transmitting Equipment—T Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
TA	U	TW	U	TAJ-3	U
TB	U	TX	U	TAJ-4	U
TC	U	TY	U	TAJ-5	U
TD	U	TZ	U	TAJ-6	U
TE	U	TAA	U	TAJ-7	U
TF	U	TAB	U	TAJ-8	U
TG	U	TAB-1	U	TAJ-9	U
TH	U	TAB-2	U	TAJ-10	U
TJ	U	TAB-3	U	TAJ-11	U
TK	U	TAB-4	U	TAJ-12	U
TL	U	TAB-5	U	TAJ-13	U
TM	U	TAB-6	U	TAJ-14	U
TP	U	TAB-7	U	TAJ-15	U
TQ	U	TAC	U	TAJ-16	U
TR	U	TAD	U	TAJ-17	U
TS	U	TAD-1	U	TAJ-18	U
TS-1	U	TAD-2	U	TAJ-19	U
TS-2	U	TAE	U	TAK	U
TS-3	U	TAF	U	TAK-a	U
TS-4	U	TAF-1	U	TAL	U
TU	U	TAF-2	U	TAM	U
TU-1	U	TAG	U	TAN	U
TU-2	U	TAH	U	TAN-1	U
TU-3	U	TAJ	U	TAO	U
TU-4	U	TAJ-1	U	TAP	U
TV	U	TAJ-2	U	TAP-1	U

MODEL	Classification
TAQ	U
TAQ-1	U
TAQ-2	U
TAQ-3	U
TAQ-4	U
TAQ-5	U
TAQ-5a	U
TAQ-6	U
TAQ-6a	U
TAQ-6b	U
TAQ-7	U
TAQ-8	U
TAQ-9	U
TAQ-10	U
TAQ-11	U
TAR	U
TAR-1	U
TAR-2	U
TAS	U
TAT	U
TAT-1	U
TAU	U
TAU-1	U
TAV	U
TAV-a	U
TAV-1	U
TAV-2	U
TAV-2a	U
TAV-3	U
TAV-4	U
TAW	U
TAW-a	U
TAW-1	U
TAX	U
TAX-1	U
TAX-1a	U
TAX-2	U
TAY	U
TAY-1	U
TAZ	U
TAZ-1	U
TBA	U
TBA-1	U
TBA-1a	U
TBA-2	U
TBA-3	U
TBA-4	U
TBA-5	U
TBA-6	U
TBA-7	U
TBA-8	U
TBA-9	U
TBA-10	U
TBA-11	U
TBA-12	U
TBA-13	U
TBB	U
TBC	U
TBC-1	U
TBC-2	U
TBC-3	U
TBC-4	U
TBC-5	U
TBD	U
TBE	U
TBE-a	U
TBE-1	U
TBF	U
TBF-a	U
TBF-1	U
TBF-2	U
TBG	U
TBH	U
TBH-1	U
TBH-2	U
TBJ	U
TBJ-1	U
TBK	U
TBK-1	U
TBK-2	U
TBK-3	U
TBK-4	U
TBK-5	U
TBK-6	U
TBK-7	U
TBK-8	U
TBK-9	U
TBK-10	U
TBK-11	U
TBK-12	U
TBK-13	U
TBK-14	U
TBK-15	U
TBK-16	U
TBK-17	U
TBK-18	U

MODEL	Classification
TBK-19	U
TBK-20	U
TBL-Series	U
TBM	U
TBM-1	U
TBM-2	U
TBM-3	U
TBM-4	U
TBM-5	U
TBM-6	U
TBM-7	U
TBM-8	U
TBM-9	U
TBM-10	U
TBM-11	U
TBN	U
TBN-1	U
TBN-2	U
TBN-3	U
TBO	U
TBO-1	U
TBP	U
TBQ	U
TBR	U
TBR-1	U
TBS	U
TBS-1	U
TBS-2	U
TBS-3	U
TBS-4	U
TBS-5	U
TBS-6	U
TBS-7	U
TBS-8	U
TBT	U
TBU	U
TBU-1	U
TBU-2	U
TBU-3	U
TBU-4	U
TBV	U
TBW	U
TBW-1	U
TBW-2	U
TBW-3	U
TBW-4	U
TBW-5	U
TBX	U
TBX-a	U
TBX-1	U
TBX-1a	U
TBX-2	U
TBX-2a	U
TBX-3	U
TBX-3a	U
TBX-4	U
TBX-4a	U
TBX-5	U
TBX-6	U
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TBY	U
TBY-1	U
TBY-2	U
TBY-3	U
TBY-4	U
TBY-5	U
TBY-6	U
TBY-7	U
TBY-8	U
TCA	U
TCB	U
TCB-1	U
TCB-2	U
TCC	U
TCC-1	U
TCC-2	U
TCC-3	U
TCC-4	U
TCD	U
TCE	U
TCE-1	U
TCE-2	U
TCF	U
TCG	U
TCG-1	U
TCG-2	U
TCG-3	U
TCH	U
TCH-1	U
TCJ-Series	U
TCK-Series	U
TCL	U
TCL-1	U
TCL-2	U
TCM	U

MODEL	Classification
TCM-1	U
TCM-2	U
TCN	U
TCN-1	U
TCO	U
TCO-1	U
TCO-2	U
TCP	U
TCP-1	U
TCP-2	U
TCP-3	U
TCQ	U
TCR	U
TCS	U
TCS-1	U
TCS-2	U
TCS-3	U
TCS-4	U
TCS-5	U
TCS-6	U
TCS-7	U
TVS-8	U
TCS-9	U
TCS-10	U
TCS-11	U
TCS-12	U
TCS-13	U
TCS-14	U
TCT	U
TCU	U
TCU-1	U
TCU-2	U
TCV	U
TCW	U
TCX	U
TCY	U
TCY-1	U
TCZ-Series	U
TDA	U
TDB	U
TDB-1	U
TDB-2	U
TDC	U
TDC-1	U
TDD	U
TDD-1	U
TDD-2	U
TDE	U
TDE-1	U
TDE-2	U
TDE-3	U
TDF	U
TDF-1	U
TDG	U
TDG-1	U
TDH	U
TDH-1	U
TDH-2	U
TDH-3	U
TDH-4	U
TDJ	U
TDK	U
TDL	U
TDM	U
TDM-1	U
TDN	U
TDN-1	U
TDN-2	U
TDN-3	U
TDN-4	U
TDO	U
TDP	U
TDP-1	U
TDP-2	U
TDQ	U
TDR	R
TDT	U
TDU	U
TDV	U
TDW	U
TDX	U
TDY	U
TDY-a	U
TDY-1	U
TDY-1a	U
TDY-2	U
TDZ	R
TEA	U
TEB	U
TEC	U
TED	R
TEE	R
TEF	U
TEG	R
TEH	R
TEJ	R
TPA	U

Remote Control Equipment—U Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
UA	U	UE-1	U	UL	U
UA-1	U	UF	U	UL-1	U
UA-2	U	UG	U	UM	R
UB	U	UG-1	U	UN	U
UB-1	U	UH	U	UP	U
UC	U	UJ	R	UXA	U
UD	U	UK	R		

Radar Repeaters—Model V Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
VC	U	VE-1	U	VG-3	R
VC-1	U	VF	R	VH	R
VD	U	VF-1	R	VJ	R
VD-1	U	VG	R	VK	C
VD-2	U	VG-1	R		
VE	U	VG-2	R		

Combined Echo Ranging and Echo Sounding Equipment—W Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
WAA	U	WCA-1	U	WEA-2a	U
WAB	U	WCA-2	U	WEA-3	U
WAB-1	U	WDA	U	WEB	U
WAC	U	WDA-1	U	WFA	R
WBA	U	WEA	U	WFA-1	R
WBA-1	U	WEA-1	U		
WCA	U	WEA-2	U		

Aircraft and Navigational Aids—Y Series

MODEL	Classification	MODEL	Classification	MODEL	Classification
YA	U	YD	U	YG-2	R
YA-1	U	YD-1	U	YH	U
YA-2	U	YD-2	U	YH-1	U
YB	U	YD-3	U	YJ	U
YB-1	U	YE	R	YJ-1	U
YB-2	U	YE-1	R	YJ-2	U
YB-3	U	YE-2	R	YL	U
YC	U	YE-3	R	YN	U
YC-1	U	YF	U	YQ	R
YC-2	U	YG	R	YR	U
YC-3	U	YG-1	R		

SU-1 Motor Generator Servo

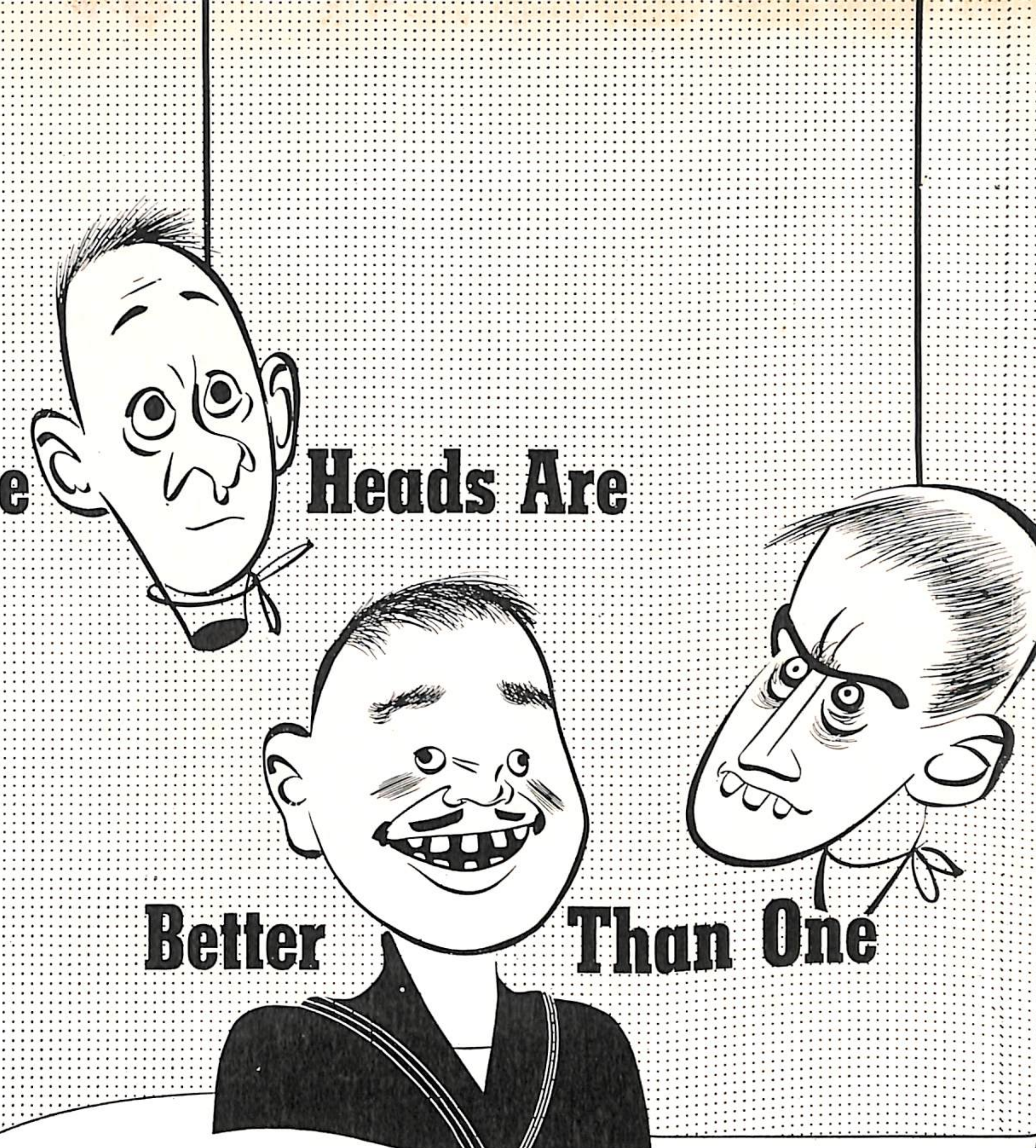
Due to its very high speed of rotation the SU-1 motor generator servo B-405 must be given special attention to insure long life. Both brushes on the generator end should be replaced after each 1000 hours of operation. After each 2000 hours the machine should be disassembled and cleaned thoroughly with carbon tetrachloride.

—*Sub Signal*

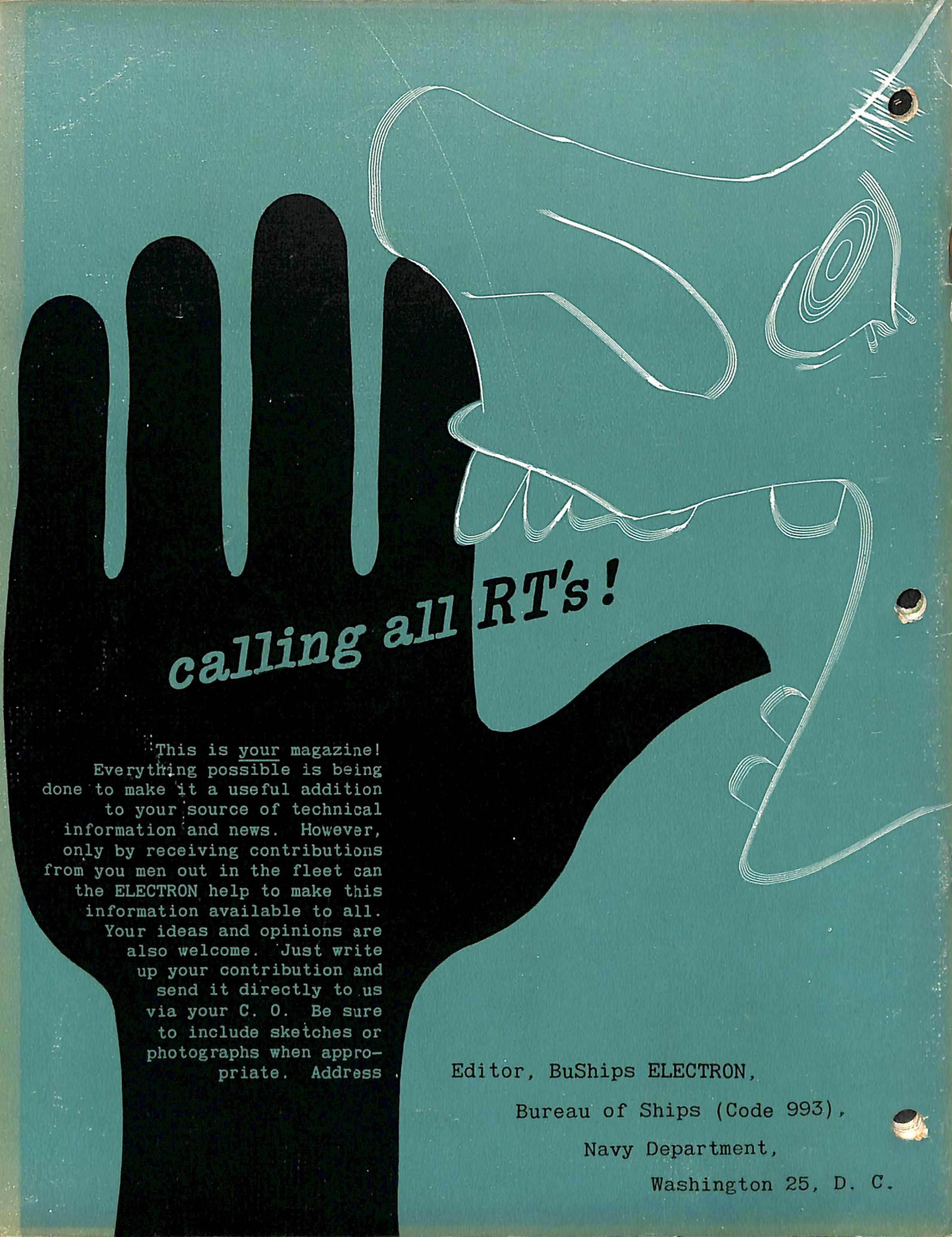
CORRECTION

November ELECTRON, p. 28: Figures 1 and 2 are transposed.

Three Heads Are Better Than One



YES, three heads are sometimes better than one. This is particularly true in the case of some of our complicated electronic gear. The radio technician is an expert on circuits, but he may be a little confused by some of the mechanical and electrical gadgets that get tacked on to his equipment. So don't be ashamed to call on your shipmates for a little help. Electrician's Mates may help you with a gyro attachment or a Machinist's Mate may know the answer to your sonar retracting gear problem. You'll probably be able to return the favor by giving them a lift on some headache that's right up *your* alley.



calling all RT's!

This is *your* magazine! Everything possible is being done to make it a useful addition to your source of technical information and news. However, only by receiving contributions from you men out in the fleet can the ELECTRON help to make this information available to all. Your ideas and opinions are also welcome. Just write up your contribution and send it directly to us via your C. O. Be sure to include sketches or photographs when appropriate. Address

Editor, BuShips ELECTRON,
Bureau of Ships (Code 993),
Navy Department,
Washington 25, D. C.