BUSHIPS

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ELECTRON

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"... today this type of interference may mean "targets" missed or lost; tomorrow it may mean the destruction of your ship by an alert enemy you don't detect."

SEE OUR FEATURE STORY ON PAGE 1.

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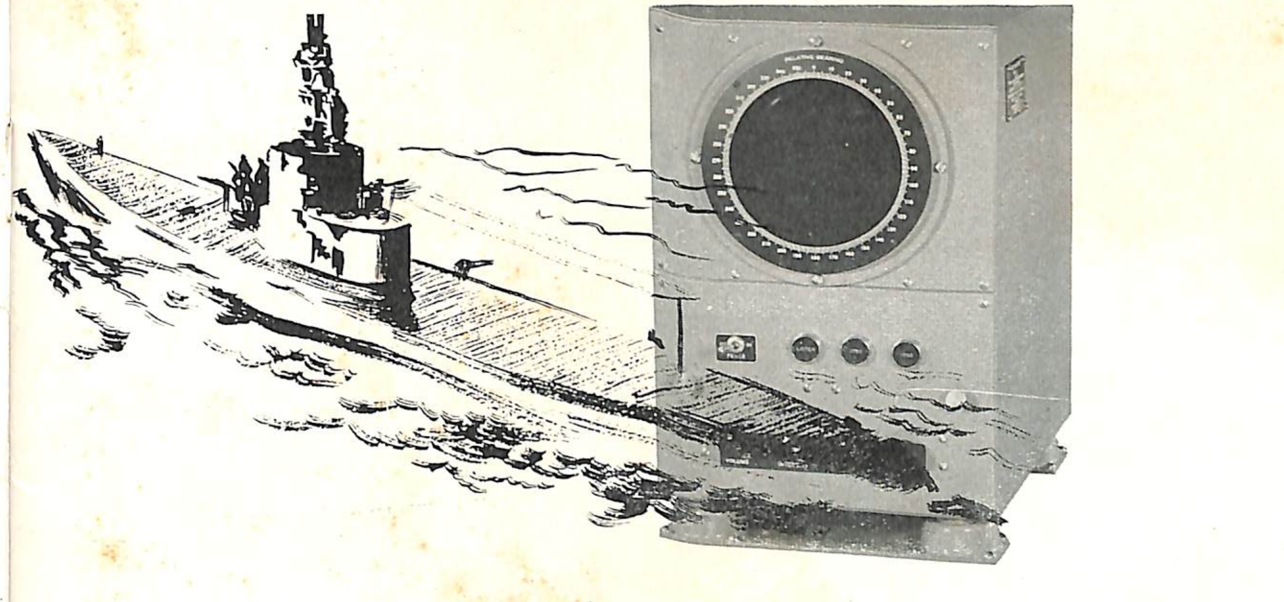
what you can do about electronic interference on board ship



by
Lt. G. P. Steele, II, U.S.N.
EO, Staff, Commander Submarine Squadron Eight

If you will look at Figure 1 you will see electronic interference literally tying a QHB sonar up in knots. On the scope of the QHB you can *see* and recognize what you probably would not be able to recognize when you *listened* to sonars such as the JT, WFA, QJB, and others. On these "listening" sonars, this type of interference could easily be mistaken for or passed off as water noise, or perhaps as just "poor sound conditions." Your ear couldn't tell the difference between interference produced by gear on your own ship and actual water noise.

Figures 1 and 2, when compared with Figure 3 show how interference produced by the torpedo data computer, the radar, or the general announcing system of a submarine can affect a sonar receiver—and unless you know what to look for, and what to do about it, plenty of this type of interference is probably being produced right on your own ship. Today, this interference may mean "targets" missed or lost; tomorrow it may mean the destruction of your ship by an alert enemy you don't detect.

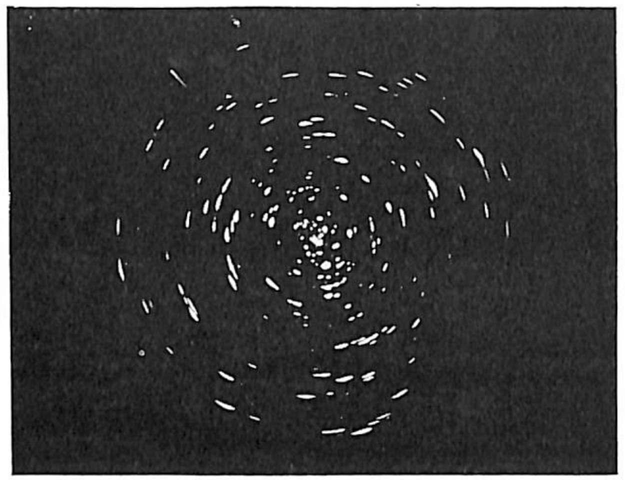
Naturally, interference picked up by sonar receivers is only one part of the overall problem of interference. Electrical and/or electronic interference produced right on your own ship can "deafen" or reduce the sensitivity of all kinds of receivers, be they sonar, radio, radar, loran, or RADCM. For example, on a recent fleet exercise the navigator of one ship found that he had to have the air-search radar secured in order to get a loran fix. Take your choice: a bomb or torpedo from an undetected enemy, or a rocky shoal.

There are some interference conditions which test the highest degree of engineering skill, experience, and ability, such as the precision measurement of interference, and the running down and correcting of complex problems which involve design changes or major alterations. These problems properly belong to the engineer or specialist in the field. To cope with such situations, the Bureau of Ships will make available to your ship the services of contract engineers who have the equipment, instruments, experience, and knowledge to do the job. You can obtain this assistance by submitting a request to BuShips through normal channels.

However, there is another, and equally important phase of the interference problem which particularly concerns *you*. It is the problem of maintenance or "housekeeping" defects which lead to increased interference levels in your equipments. This problem can usually be solved by the forces afloat, with the equipment generally available on board ships.

It is the purpose of this article to show you how you can detect, measure, and correct typical examples of interference caused by often unsuspected conditions resulting from poor maintenance. It is based on actual "case histories" of such work performed on numerous submarines.

FIGURE 1—Model QHB scope, as it appeared with torpedo data computer operating.



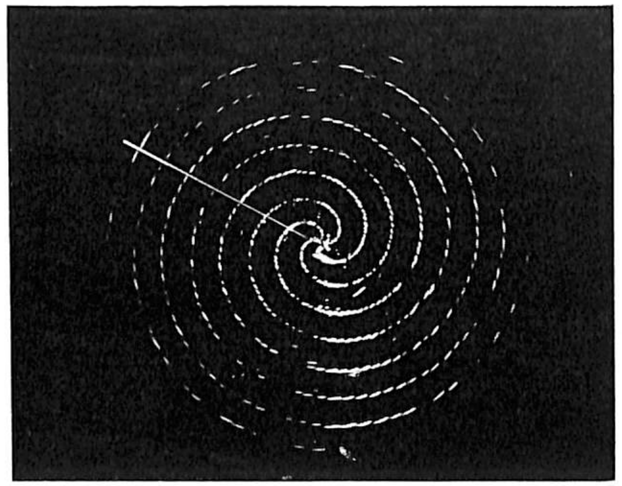


FIGURE 2—Model QHB scope, showing spirals produced by combined interference from QHB indicator lights, 1-Mc and 7-Mc battle announcing systems (with mike keys closed), and ST and SV radars.

A striking example of harmful interference which was corrected by a relatively simple measure, occurred during a recent fleet exercise. The radioman on a submarine was copying the NSS FOX broadcast. The signal was barely readable above high background noise. Then a few sunspots caused fading, or reduction of signal intensity, to the extent that it was no longer readable above the same background noise level. A check with other submarines in the vicinity indicated that while they too were troubled by weak signals, they were still able to copy. To the radioman, this fact indicated that his receiver, which he knew to be in very good shape, must be picking up a higher level of electrical noise (noise produced on his own ship) than were the receivers on the other ships. Obviously, if he could reduce this interference noise level he would be effectively increasing the sensitivity of his receiver to a weak signal.

SUBRON 8 has had the responsibility of dealing with radio and electronic interference problems on all submarines operating from Atlantic Coast bases. As Electronics Officer, personally directing this activity of Squadron 8, Lt. Steele has been able to accumulate a large volume of information on practical interference reduction measures—information which the Bureau has felt should be made available to electronics and communication personnel aboard ships. It is believed that this article by Lt. Steele presents a maximum of practical and usable information about a subject which is of vital concern to personnel aboard many types of ships.

A quick check disclosed that the antenna-lead shield was not grounded (see Figure 4). When this shield was connected to the ground terminal of the receiver, interference was reduced by almost 40 db. Later, when this unarmored lead-in was replaced with an armored, shielded cable, with armor and shield properly terminated and grounded (as described later), interference was reduced to about 1 db above normal receiver noise level.

Another example of harmful interference and its correction, involves an ECM intercept receiver which was picking up radar interference throughout the band. An investigation revealed that this ECM receiver was installed at the exact distance from the radar transmitter to permit it to pick up standing wave interference from the transmitter. This was realized when it was found that when the receiver was slid out of its case for only a few inches the interference level from the radar transmitter dropped to zero. The interference built up again as the receiver was moved further out of its rack and through another standing wave peak. When the receiver was moved over in the rack for only a short distance the interference from standing waves was eliminated entirely.

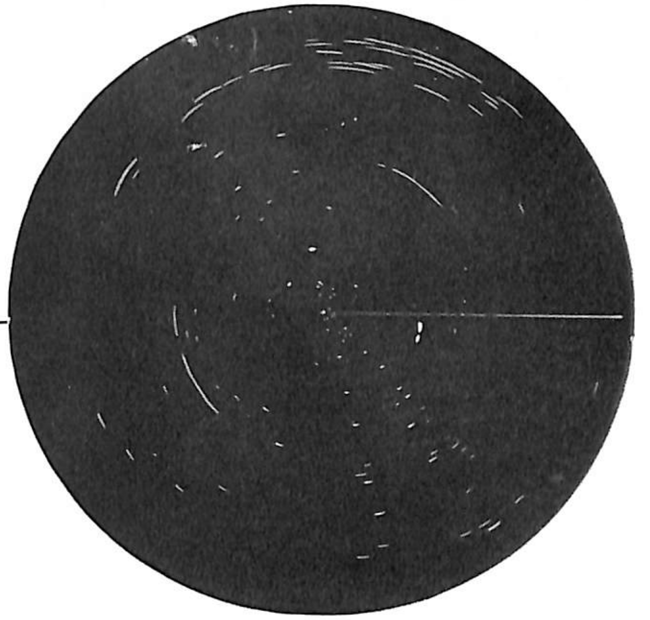


FIGURE 3—Model QHB scope, as it appeared with all interfering devices secured.

"So, I'll admit that electronic interference can be bad," you may say, "but how can I *find* it, let alone do anything about correcting it?"

We will first concern ourselves with the reduction of interference in *radio-type receivers*. These include those types of receivers which are designed primarily to produce an audible output, and which are not sensitive to acoustic noise or vibration; radio receivers, ECM receivers, and loran receivers. Other types of receivers such as sonar, which are subject to acoustic as well as electrical noise, and radar receivers, which are intended primarily for the production of a video or scope output, will be discussed later.

Interference reduction work with these receivers will be facilitated if you can work out a way to measure interference levels above background noise. In this manner you can make before and after checks as to the efficiency of your work. You

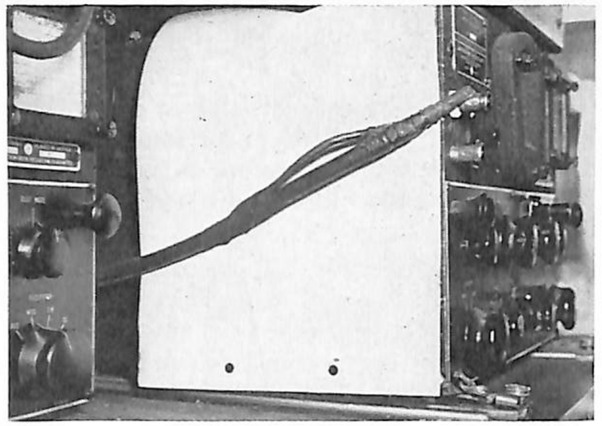


FIGURE 4—Shielded antenna lead (not armored) with shield ground lead not connected to ground terminal of receiver. When this lead was connected, interference was reduced by almost 40 db.

can also make approximations as to whether or not any particular receiver has an objectionably high interference level before you begin work, as it is generally agreed that a tolerable interference level is 3 db or less, above background noise.

Practical Interference Level Measurements

You can make reliable measurements of interference levels with any of several types of output indicators, such as:

1—A decibel (db) meter.

2—Any good multimeter (volt-ohm-milliammeter) which has a db scale.

If the multimeter you have available does not have a db scale, you can use an appropriate a-c voltage scale and convert your voltage differences to db values, as outlined further on. In many instances, you can use the output meter which is incorporated into some receivers. You can make a suitable patch cord which will permit you to patch the meter into the receiver output patch box or into the receiver output jack.

You will also need some form of checksheet for recording your readings of noise levels as they exist before any corrective measures are taken, and as they may be after you have cured some of the causes of interference. A check list which has been found adequate is shown in Figure 5. Besides offering you a comparative basis for evaluating your own work, this sheet, when completed, will serve as a permanent record. When new interference appears you will know it, and will be able to base your remedy on past experience.

Procedure

If possible, make your check for interference when your ship is moored, with most operating gear secured. Secure all of your own radio-electronic equipment but the receiver under test.

1—Connect your output meter to the output of the receiver you wish to check for interference.

2—Adjust the receiver to its most sensitive and broadest response condition, with the noise limiter secured, and the r-f gain control set to maximum. Tune the receiver to one of the channels on which it is worked (if it is a tunable receiver, such as a radio receiver).

3—Set the receiver audio gain control so that the output meter reads on the lower portion of the scale. For example, with the meter set on zero to 10-volt range, a gain control setting which would permit the meter to indicate 2 volts would be satisfactory; or, if you are using a db scale you could set the a-f gain so that the meter indicated zero db, or even some minus value of db.

Bear in mind that what you are doing in Step (3) above is establishing a *receiver output reference level.* With all possible interfering devices secured, this reference level will correspond to the output level of that receiver, at that particular a-f gain setting, and with no interference present.

> If for any reason you can't secure all possible sources of interference, you can still make useful tests as to interference level by (1) disconnecting the receiver antenna lead, (2) establishing a zero or reference level for receiver noise, then (3) reconnecting the antenna lead to measure total interference level above receiver noise level.

Your next step is to turn on a single item of electrical or electronic gear and note the increase, if any, in the receiver output as measured with your output meter. It might be necessary to switch to a higher meter range to prevent the meter pointer from going off scale at the upper end, but *do not change any of the receiver settings.* Allow the device to reach a steady-state operating condition and note the reading on the output meter. This reading will be the *practical nuisance* value of interference produced by that device as far as that particular receiver, tuned to that particular frequency, is concerned. If you are using a meter having a db scale, and if you had previously set the receiver reference level, as outlined in Step (3) above, so that the meter read zero db, then the new reading in db will be the actual db level of your interference with respect to your receiver output with no interference present. Record this reading in the appropriate space in your check list. Turn off this piece of equipment and proceed to check every other item of electronic equipment for interference with the receiver you are checking. As a final step, turn on all items of electronic equipment to get the overall interference level resulting from all possible sources of interference operating at once.

If the receiver under test is a tunable receiver, such as a radio receiver, you then proceed to run the same series of checks on other channels, being sure to establish your reference, or "no interference" first, as outlined in Step (3) above.

> NOTE: If the output meter you are using does not have a db scale, you can convert voltage readings to db by means of the following formula:
>
> Interference level in db $= 20 \log E_2/E_1$ in which E_1 = meter reading (volts) with all interfering devices secured, and E_2 = meter reading (volts) with interfering devices operating. Or, if you have a db table (included in many radio handbooks) you can divide E_2 by E_1 to get the voltage ratio, and then find the corresponding db value in the table.

Example

In tests being made with a RAL receiver, a meter with a db scale was used. The reference (no interference) was established by adjusting the a-f gain until the meter pointer was on zero db, as described in Step (3) above. When the motor-generator set to the TBL transmitter was turned on, the receiver output increased to the extent that the meter indicated +30 db. Thus, the practical nuisance value of the interference produced by this MG setting was 30 db; a very high value.

Another Example

In another test with a RAL receiver, a multimeter which did not have a db scale was used. With all interference-producing devices secured, the receiver output was set to 0.5 volts on the meter. When a d-c heater fan was

	NOISE SOURCES									
EQUIPMENT INTERFERED WITH	TBL M–G Set	TCZ	SV	SS	D-C Fans	TDC	A-C Line Hash	D-C Line Hash	Water Noise	Loose Deck Structure
RBS-1										
RBS-2										
RAK										
RAL										
AN/APR-1										
AN/SPR-2										
Echo Ranging Sonar										
JT										
SCR-624										
AN/UQS-1										
Loran										

REMARKS

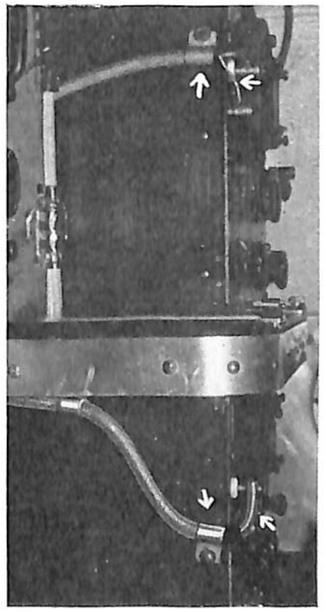
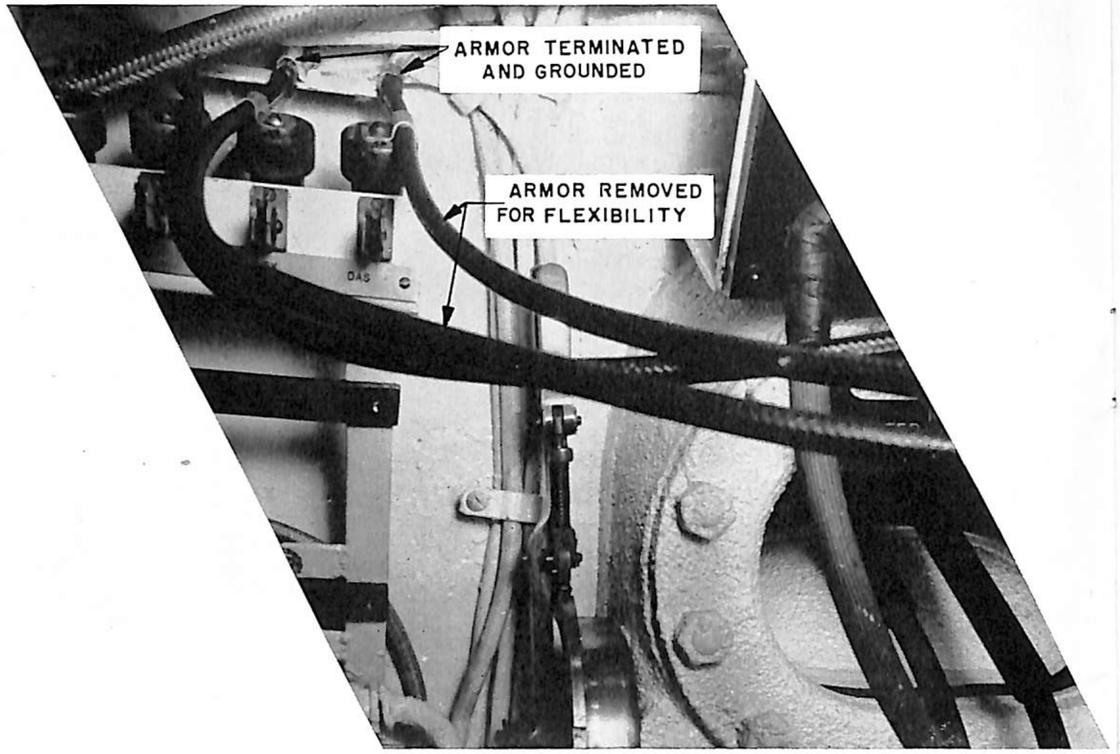


FIGURE 6—Examples of good antenna lead-in cable termination.

FIGURE 7—Example of good antenna lead termination at knife switch end of leads.



plugged in, in the radio compartment, the output reading went up to approximately 7.0 volts. This was a voltage ratio of 7.0/0.5 = 14. Reference to a db table showed that a voltage ratio of 14 was equal to approximately 23 db. Thus, when this particular fan was in use the receiver noise level was increased by the very high value of 23 db.

Corrective Procedures

After you have evaluated and logged the interference levels produced by various devices, you are ready to begin eliminating the holes that let the interference into your receivers. You could start with the interference sources, but it is usually easier to plug the holes in a screen door than it is to swat all the flies out of doors. Following, are typical corrective methods as gathered from "case history" files.

Radio Receivers

The most common type of interference is line hash from such sources as d-c fans, centrifugal regulators, and sparking brushes in transmitter motor-generators. Hash usually enters the receiver by radiation to the antenna leads which are often inadequately protected against such interference.

It has been found that an effective remedy for such interference is to replace cables of the antenna distribution system, in the radio compartment, with adequately shielded cables, such as type RG–10/U, which are properly terminated. A good example of such cable termination is shown in Figure 6.

Note that the outer armor of each cable is effectively grounded to its receiver case by means of a clamp. The inner shield braid is grounded to the receiver case by means of a short jumper, connecting it to the receiver ground binding post. The receiver is, of course, grounded through its case to the metal mounting shelf via a low-impedance braid jumper. The shelf is welded to the ship structure. At the other end of the lead-in cable (antenna knife switch end) the inner shield is left unconnected. Also, in the interest of flexibility, the armor does not continue right up to the knife switch but is terminated and grounded by clamps to a bracket attached to the overhead (see Figure 7). This leaves about 36 inches of unarmored, shielded cable between the overhead and the knife switch. The inner shield braid is continued right up to the knife switch, but is not connected to the knife switch, or to anything else at the switch end of the cable.

ECM Receivers

These receivers (formerly called RADCM or RCM) are often mounted cheek-by-jowl with radar transmitters, which doesn't help any. Neither do the long, unarmored antenna leads, and other unarmored cables which are often found in these installations (see Figure 8). Video intercabling is highly sensitive to interference. Often the receivers are found to be improperly grounded.

Typical remedies include scraping the receiver mounting racks clean of paint in order to maintain a large ground contact area, paying particular attention to the rack grounding strap. Clean the rack and individual unit shields to make better contact. Replace the power leads with MCOS–2, and ground the shields via the plugs provided on the individual units. Replace the video patching coaxial cables between units with RG–10/U, or RG–9/U, and keep them as short as practical. Ground the armor on the RG–10/U (if used) at both ends, even though it may be a short run. Best of all, an aircraft type harness may be installed, using short direct runs of cable as shown in Figure 9. Also, the antenna lead-ins should be replaced with RG–10/U cable, with the arms grounded in numerous places (See Figure 10).

A not uncommon type of interference is shock-excitation from standing waves in the mounting rack itself. This form of interference can be identified by sliding the receiver out of its rack for a few inches and noting if the interference increases or decreases. A permanent measure is to move the receiver over a few inches in its rack to get it away from the standing wave peaks. In cases where the receiver was in close proximity to a radar transmitter or waveguide flange, it is possible to install sheet copper shielding. Such shielding is installed to line the receiver rack on back, top, bottom, and ends, but not on the front. This shielding must be bonded to make an electrically solid "box," and must have large areas grounded to the rack. Make sure that all paint has been scraped from those surfaces of the rack which will contact the shield, and install the copper panels with self-tapping screws, or with machine screws and nuts, spaced not greater than eight to ten inches apart, and one in each corner. *This shielding must be grounded to the rack with relatively large areas of contact at all edges.* It will usually be advisable to bend a "lip" at the lower edges of each panel.

Radar waveguide flanges can be prolific sources of interference if they are loose, misaligned, or

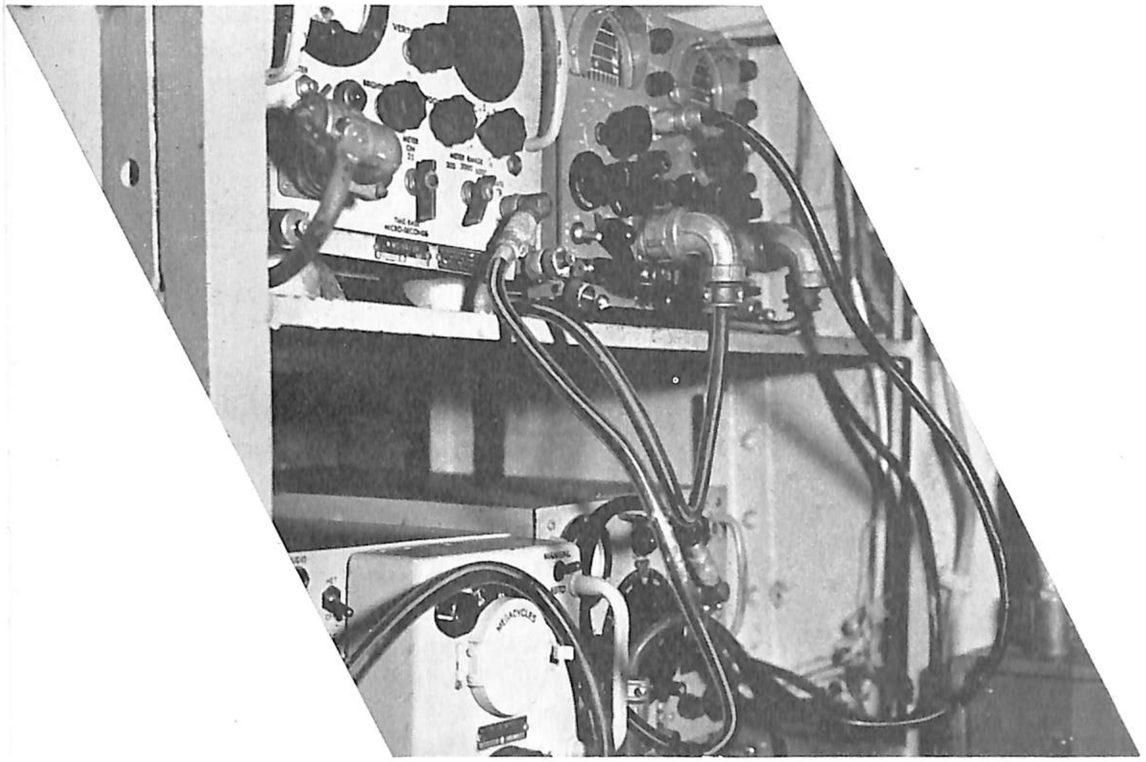


FIGURE 8—A typical example of bad cabling in an ECM installation. Note the excess of unarmored cables. Also, the rear of this rack is open to the radar transmitter.

have foreign substances (dirt, paint, chromate, etc.) between mating flanges. Therefore, check the various flanges for *any* misalignment and for good mating surfaces. The band of copper braid on the flange atop the SV transmitter-receiver units on submarines should be firmly affixed, in bare-metal-to-bare-metal contact, to both flanges.

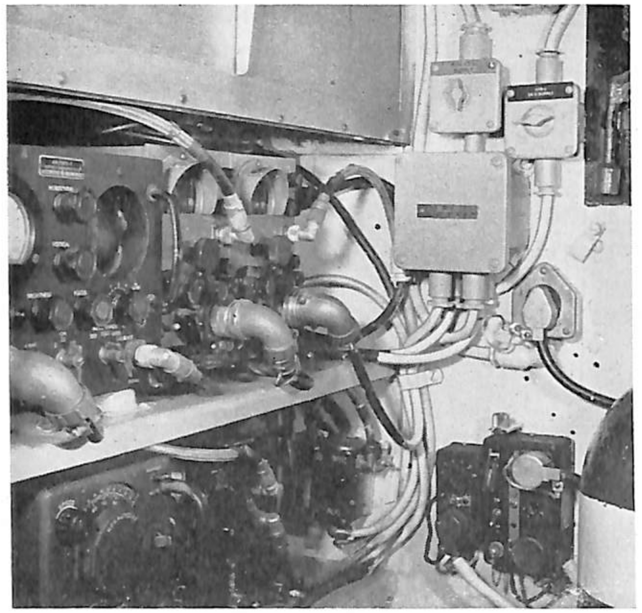
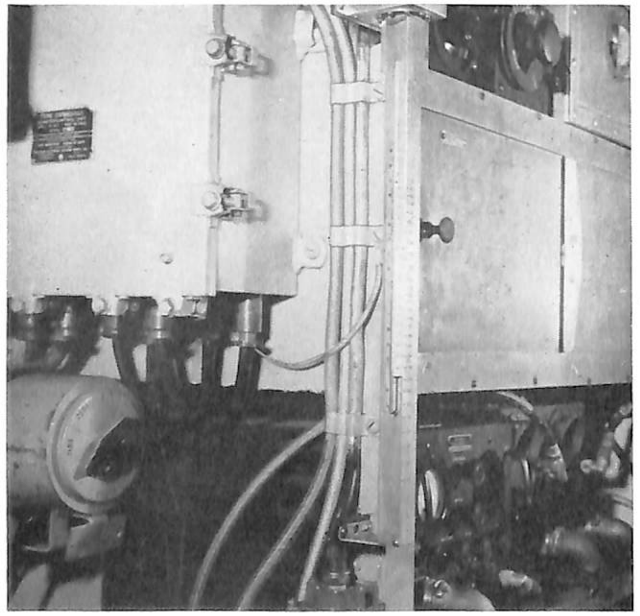


FIGURE 9—A shipshape and relatively interference free ECM cable installation. Note the short, direct runs, and the aircraft-type fittings.

FIGURE 10—A good antenna lead-in installation, using RG–10/U, with armor grounded, via ground straps, at numerous points.



Loran Receivers

As is the case with radio receivers, a primary cause of interference in loran receivers is unprotected antenna leads. A typical example is shown in Figure 11. In some instances, antenna leads have actually been found draped over radar transmitter cases. As with radio receivers, the best remedy is to replace the antenna lead cable with RG–10/U *with the armor grounded at several points.* The inner shield should be grounded only at the loran receiver.

Sonar Receivers

Because Sonar receivers are highly sensitive to acoustic noise (often called "ship's own noise") the detection and measurement of interference is more complex than for radio-type receivers. Electronic type interference can be measured by plugging a suitable output meter into the a-f output, the same as for radio type receivers. Also, you should watch the scopes as possible interfering devices are turned on and off. This must be done when no acoustic or vibrational noise is reaching the sound heads. Otherwise, the meter and scope will register both types of noise, with no indication as to which is which. Fairly late at night, with the ship alongside a dock, is usually an acoustically quiet time for such measurements.

It sounds simple, but a poor choice of cable runs can be credited with being the cause of most electronic interference in sonar receivers. Line hash is contributed from power cables run alongside low-level, high-gain audio and transducer or hydrophone cables. Fire control instruments, such as the torpedo data computer, produce hash which is often reflected back through a common power supply with results as shown in Figure 1. Also it is not uncommon to find the inner shields of hydrophone cables grounded in too many places, resulting in circulating ground currents in this shield between the ground points. These cable shields should be grounded only in accordance with the manufacturers diagrams. Remove any grounds that may have been installed at other points. Unlike the inner shield, the armor should be grounded at several points throughout a run. In some instances, such armor has been found to be rotted off where the cables pass through a bilge. This condition can create an effect on the sonarman's eardrums that Gene Krupa might admire.

If you suspect that your hydrophone cables are run too close to power lines, there probably isn't much that you can do about it personally—rerunning them is usually a shipyard job. However, you can arrange for the services of a field engineer, who can make the necessary recommendations.

The same applies to noise from fire-control instruments, particularly the torpedo data computer. You can identify such noise by operating the instrument and listening to, or measuring, the noise output of the sonar. If the noise is appreciable, the engineer can recommend an effective filter for the power lines to the fire-control instruments.

You can correct grounding troubles, as mentioned above. Also, if you find any unarmored hydrophone cables you can usually pull Belden braid over them, and ground the braid at several places.

Radar Receivers

Radar receivers can be checked for interference much the same as radio-type receivers, with the exception that the effects of interference can best be observed on the radar scopes. Follow the policy of securing all possible interfering devices, and then turning them on, one by one, and observing the scopes for any change.

Actually, the cause of most interference in radar receivers is much the same as for sonar receivers—poor choice of cable runs. There isn't too much that you can do about this, except to obtain adequate engineering services in order to determine the necessary requirements for rerunning cables—particularly those cables to remote PPI scopes, which give the most trouble.

General Pointers

Here are some general pointers, applying to all types of electronic gear, that will help you make, and keep, your ship interference free.

Coaxial Plugs and Fittings

Make certain that *all* coaxial fittings and patch plugs are properly installed and always tight. Numerous cases of bad interference have been "cured" by tightening a fitting a final half turn. Replace all damaged or unduly worn plugs and fittings. Be careful when soldering. Use a large, hot iron, which reduces the time necessary for solder to flow, and consequently, the amount of "flow" of the insulation. While sharp bends in coaxial cable should be avoided for mechanical reasons, it is of extreme importance that each lead be as short and direct as is practical. Loops or "draping" cables are especially bad.

Cable Armor and Shield Grounds

The importance of good, low resistance and low impedance grounds cannot be stressed too much. Always use a suitable clamp when grounding cable armor. You can make satisfactory clamps if you don't have them. Terminate all armor as close as you can to junction boxes or equipments, and ground it via a clamp at the point of termination. *Always* ground cable armor at each end, and at as many points throughout the run as possible. You can not have "too many" grounds on cable armor. On the other hand, too many grounds on inner shield braid can be definitely bad. Therefore, ground inner shielding *only* at the fittings provided by the manufacturer, or in accordance with the manufacturer's installation prints.

Grounding Equipments

Again—the importance of good, low resistance, low impedance grounds can't be stressed too much. In grounding or checking grounds on equipments, you should clean all bulkhead buttons and grounding straps free of paint and chromate. A good metal-to-metal contact is important. Once installed properly, these may be painted. Where the r-f currents are high, as in radio transmitters, ground straps must have large surface area (to avoid high r-f resistance due to skin effects). For example, a strap 2 inches wide and *less* than a foot in length is considered satisfactory for transmitters. Such straps should run from the corners of the transmitter main chassis to the hull or compartment bulkhead.

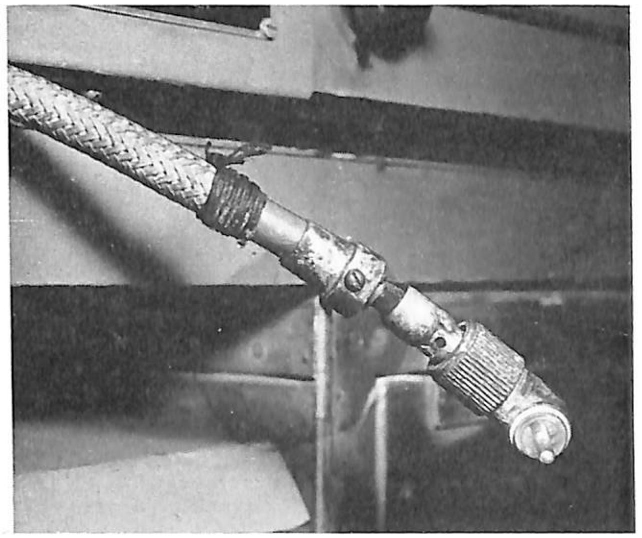


FIGURE 11—Model DAS loran antenna lead, actually damaged physically. Replacing this lead removed interference from the loran receiver.

In grounding radar r-f stacks, the possibility of using resonant lengths of ground straps, and the resulting formation of standing waves, is an added complication. For such items, the sheet-copper strap should be at least a half wavelength wide and just long enough to reach from the stack (near the magnetron or pulse network) to the hull or bulkhead. Such a ground strap must have good metal-to-metal contact over a large area at both its ends.

Belden braid may be used for grounding small, or low-powered units, such as receivers. Such braid must be at least ½ inch wide, and should be less than 6 inches long, and must run to the hull, a bulkhead, or to a metal structure which is welded to the hull or bulkhead. Decorative trim and cabinet work are *never* suitable as ground connections to the ship.

Soldering

There is only one form of soldering flux considered to be "corrosion-free" for use in soldering plugs, jacks, fittings, and other electronic connections—rosin (such as rosin-cored solders). All traces of rosin should be wiped off with an alcohol-soaked rag after soldering. Acid fluxes or acid-cored solders should never be used. It should be remembered that a poorly soldered joint can produce relatively high r-f impedance, even though it might show low d-c resistance. A soldered joint with even a little corrosion in it can become a highly effective noise generator in its own right, and will nearly always show an increasingly high r-f impedance as corrosion progresses.

Conclusion

There is plenty that you can do about electronic interference aboard ships. If you still have a problem after you have tried the methods outlined here, let BuShips in on your trouble. In correcting your difficulty the Bureau can not only make your ship a more effective unit of the fleet, but it will be able to improve future designs and installations in order to prevent similar situations.

GFCS MK 56 RADAR MK 35 MANUAL TROUBLES

by
Gerritt W. Van Velzen, ETC, USN
U.S.S. Epperson (DDE-719)

For a period of time there have been several intermittent troubles occuring in our GFCS Mk56. These troubles would show up during gunfire but a check immediately after would show the circuits functioning normally. In order to find the trouble the ship's electronics force conducted an extensive test of the equipment. The troubles found were of an unusual nature.

Synchronizer Unit: Trouble—Erratic notch on A/R scope during gunfire.

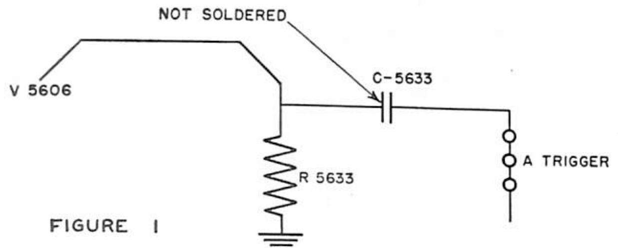


FIGURE 1

During gunfire it was noted that the notch on the A/R scope would jump and the target would appear to move. A check for the trouble immediately after would show normal operation. Test Set TS-34A/AP was employed to trace the circuits out. After tracing back through the synchronizer unit a bad connection was found where C5633 a .01-mf condenser connected to the cathode of V5606. An inspection of the joint brought to light that it had not been soldered at the factory. As the A-trigger is picked off on the other side of this condenser, vibration would cause an erratic notch on the A/R scope (See Figure 1). There are many connections in this unit that cannot be observed by the casual observer.

IF Unit: Trouble--Fading of signals during gunfire.

During gunfire it was noted that the target would intermittently fade. A routine check would show the i-f and video amp sections to be functioning normally. An OE was used to check voltages, and after several checks had been made an erratic voltage was noted on the screen of i-f amplifier V809 (6AK5). By tracing this down it was found that R842, a 470-ohm resistor, going to the screen of V809 was broken (See Figure 2). It did not show on a routine check as it is housed in a rubber grommet running through the chassis. The grommet kept the resistor together until vibration would cause it to intermittently make and break. Under normal conditions it would read a normal value.

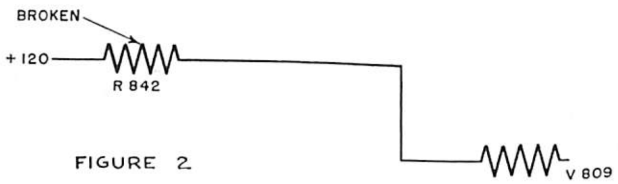


FIGURE 2

It was also found that vibration effected the 7F8's in chassis 65. These tubes are not rugged enough to take too much shock. V6901 and V6902 are 7F8's located in the range unit. They are hard to get at but should be checked often as these two tubes are very important. If V6902 goes out, the notch on the A/R scope will be lost. If V6902 is weak, the notch will be jittery and a target will not gate because this tube is an amplifier for the A-trigger. The operation of V6901 effects the tuning eye in the synchronizer as well as the phasing unit.

Maintenance Notes on Klystrons used as Radar Local Oscillators

by
Lt. H. Wellemeyer, USN
Maintenance Officer, GCA Unit No. 26

These tubes are not in any way mysterious and are not likely to fail without good reason or without giving definite indications. When handled correctly and not subjected to any mechanical or electrical strains they should last almost as long as a common receiving type vacuum tube. There is no reason in the world that technicians should select them as the first thing to yank out and throw away when a radar equipment begins to give trouble. Some of the earlier types of these tubes were a little troublesome, but it is impossible to ascertain what proportion of the trouble was due to the tube and what proportion was due to the limited training and knowledge of the maintenance personnel of that time. Such was the case of the "McNally" 707A, now obsolete and replaced by the 707B and 2K28.

Some failures of klystrons are identical to the failures of all other types of vacuum tubes, such as open filaments, shorted elements, broken sockets and broken envelopes. These are usually self-evident or can be tested for with an ohmmeter.

The glass klystrons, such as the 2K28 are also likely to be failures if the fins contacting the cavity in which the tube operates are allowed to get bent or broken, or if the tube is installed in the cavity with dirty, finger-printed or corroded fins. But, these cannot be considered failures through fault in the tube—only negligence on the part of the technician.

Clean gold-plated fins and uncorroded silver-plated fins with Trichloroethylene Stock No. 51T5751. This solvent is not so toxic as carbontetrachloride but *must* be used in a well-ventilated location. Wipe off with a clean dry cloth after cleaning. Clean silver-plated fins which are corroded or tarnished GENTLY with a neutral liquid silver polish, wash off the residue with mild soap and water, rinse with fresh water and *when dry* wipe off with a soft clean cloth. The glass area between the fins should be kept scrupulously clean. The cavity may need to be cleaned also and the same procedure should be followed. After cleaning, the fins, glass between them, and cavity interior should not be touched.

The reassembling of a glass klystron in its cavity should be carried out exactly as the instruction book specifies. Great care must be taken not to overtighten locking rings, screws, etc. Some types of cavities can be so distorted by too much tightening that they no longer resonate in the right frequency band. Placing a good glass klystron in a distorted cavity is likely to cause

With this issue, ELECTRON takes a new, bolder type face to improve "readability". For a while both the old and new faces will appear side by side. Comments from our readers are invited.

breakage of the glass-to-metal seals around the fins. Good glass klystrons are frequently "deep sixed" because of their failure to "put out," then later, a chagrined technician will discover that, in reassembling the cavity, the output coupling loop was not inserted deep enough to pick off the signal or was rotated out of the proper plane so little or no signal was coupled into it.

In addition to the failures mentioned above, metal klystrons, "Shepheard-Pierce" type, are likely to be damaged by technicians screwing the mechanical tuning adjustment too far (bows too far open) thus permanently distorting the internal elements. Practically every instruction book for radar systems using this type of tube gives a tuning procedure, which, if followed closely, will lessen the possibility of such a casualty occurring. Care should be exercised in handling and installing metal klystrons so that the coaxial output probe is not bent or the polystyrene insulation cracked or broken off. After installing the tube check the "plate cap" to assure that it cannot get shorted to the body of the tube. In many radar systems the body of the tube is operated at other than ground potential, be careful that it isn't shorted to the chassis or shield can.

If a klystron is suspected of being bad and yet all points previously mentioned have been checked and found O.K., try tuning the klystron through its entire electrical and mechanical tuning range. (AFC, if provided in the radar equipment, should be "off.") If this gives no indication of crystal current regardless of the combination of tuning used and the crystal is known to be good, the klystron is likely to be bad—no emission. (This check can usually be made with radar transmitter high voltage down unless a mechanical protective crystal disconnect circuit is operated by turning down the transmitter high voltage.)

If there is some indication of crystal current, and perhaps signals, or echo box ringtime, but the full value of crystal current cannot be obtained the klystron is likely to be too weak for satisfactory service—low emission.

Remember, crystal current is almost 100% a function of klystron oscillation; received signals or transmitter radiation will not have a noticeable effect on it. So, if either signal crystal current or AFC crystal current is obtained it is a good indication that the klystron is oscillating.

If (with AFC "off") the proper value of crystal current is obtained but it is difficult to tune in signals (or the signal from an echo box) because the klystron seems "jittery" it may be that the klystron is unstable. Watch the crystal current, if it is also "jittery" then quite likely the trouble is in the klystron. Two exceptions to this rule are: (a) a worn out "noisy" repeller voltage potentiometer, (b) the technician doing the tuning is too nervous. Steady crystal current and "jittery" signals indicate that the klystron is probably good and something else in the receiver, transmitter or antenna circuits is acting up.

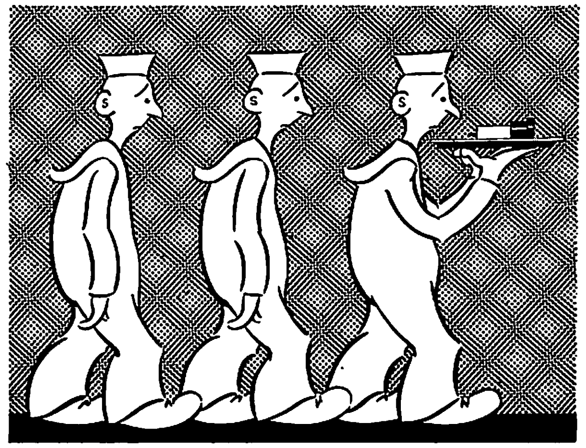
If the proper value of crystal current is obtained but it is impossible to tune in signals (or the signal from an echo box) the klystron may be too far off frequency and unusable.

However, before pronouncing such verdicts on a klystron and heaving it over the side try replacing it with a new one. If the same effects are noted as before, the old one was probably perfectly good and the trouble is somewhere else in the system. A radar system can have all the symptoms metioned above indicating a bad klystron and still the trouble is something entirely different, such as:

1—crystal loose in holder.

2—tiny mica insulator in some crystal holders lost or shorted.

3—crystal mixer cabling and connections loose, shorted or open.



All precautions for the handling of crystals should be adhered to religiously.

4—bad crystal current meter or test switch.

5—arcing waveguide joints, broken flexible waveguide, obstructions in waveguide.

6—open or short in the crystal current circuit in the i-f amplifier or pre-amplifier if provided. In the case of the SO–4, Mk. 29 and SU series radars, a test probe point broken off in the crystal current test jack holds the contacts of the test switch open.)

7—worn or "noisy" repeller voltage control.

8—dirty, corroded, loose or worn out r-f plumbing.

9—mechanical shutter or disconnect for protection of crystal defective.

10—wrong or varying voltages supplied to the klystron.

11—klystron or r-f plumbing subjected to vibration. (Faulty mounting, shockmounts, cooling blower, or, technician too nervous when tuning.)

12—bad connection to echo box or other test equipment.

13—faulty test equipment.[1]

14—magnetron (transmitter) bad or off frequency.

15—voltage supplies to transmitter or receiver wrong or varying.

16—"noisy" or erratic crystal.

17—bad i.f., detector or video amplifier stage.

AFC operation, or the lack of it, *is not especially* indicative of a good or bad klystron. AFC circuits develop "bugs" of their own that can be quite confusing. However, a good AFC circuit will "lock in" when the klystron is supplying only a small percentage of the required AFC crystal current. In general, if proper signal crystal current and good signals (or echo box ringtime) can be obtained from a radar system by manual tuning and yet the AFC circuit fails to operate, the trouble is in the AFC system, not the klystron. One hypothetical case which could be an exception to this rule is, for example: In a radar system in which the klystron frequency has to be 30 Mc. above the magnetron frequency for proper AFC action, the klystron fails to produce oscillations. However, the klystron will produce oscillations 30 Mc. below the magnetron frequency. The system can be tuned manually to 30 Mc. below and good targets and adequate crystal current will result. The klystron has either been damaged and won't tune to the higher frequency or is too weak to produce oscillations of sufficient amplitude at the higher frequency.

STC, FTC, AVC, AGC, IAVC, DAVC., etc., circuits usually have nothing whatsoever to do with the question of whether or not a klystron is operating properly! It is best to switch all these circuits "off" when testing or tuning up a klystron.

Repeated crystal failures in a radar are rarely if ever caused by a bad klystron! If repeated crystal failures are experienced, in all probability the T-R tube is weak or bad, or the magnetron is unstable or arcing. If this is not the case then perhaps the crystal current is set too high. (The crystal current meter can be bad and indicating less current than is actually being passed by the crystal.) In the case of radar systems equipped with AFC, the crystal current is likely to exceed safe values if the transmitter (magnetron) high voltage is turned down before the AFC circuit is switched off. This allows the AFC circuit to hunt over a wider range of the klystron. At some point in this range the crystal current is likely to exceed the safe limit. If the radar has been properly tuned manually before switching to AFC operation this is less likely to happen, but, as a general rule, AFC should be switched OFF before turning down the transmitter (magnetron) high voltage. *All precautions for the handling of crystals should be adhered to religiously.*

T-R tubes have been mentioned. The old (obsolete) Type 721A had a life expectancy of only 300 hours. The newer types such as 721B have a life expectancy of more than 1000 hours.[2] When computing the time on a T-R tube remember to include time that keep alive voltage was applied to the tube, even though the radar transmitter was off or in standby. T-R tubes usually go bad slowly making a day-by-day visual comparison of targets, or close in discrimination, difficult. A T-R tube which has been used over 600-800 hours should, therefore, not be retained as a spare except in an emergency but should be disposed of in accordance with radioactive safety precautions.[3] *The cleaning and care of T-R tube cavities, fins, glass windows and pick-up loops is just as important in their upkeep as it is in the case of klystrons.* Keep alive voltage should be checked frequently to assure that the proper value is always maintained on the T-R tube. If keep alive voltage falls below the specified low limit spurious oscillations set up in the T-R tube are likely to damage the crystal. It is difficult to get a true direct reading of T-R keep alive voltage due to the large series resistances encountered in most keep alive circuits. If a value of proper keep alive current for the tube is known it may be easier to check it.

This article was written with the assumption that the readers are familiar with the construction, theory and use of klystron oscillators. It may be well, however, to refresh a few memories on the cardinal points in tuning a klystron.

1—The optimum tuning of klystron oscillator will result in peak crystal current occurring simultaneously with maximum echoes (or echo box ringtime).

2—The maximum safe value of crystal current (usually .8 to 1 ma.) should never be exceeded.

3—The frequency coverage of a klystron is over the entire range of the cavity or mechanical adjustment. This adjustment is the "main tuning' of the klystron. It should be adjusted exactly for peak echoes (or echo box ringtime), not set approximately and "pulled" the last few megacycles with the repeller voltage control.

4—The repeller voltage control is a "phasing" control to adjust in-phase "feedback" of bunched electrons through the cavity for optimum, sustained oscillation and may have sufficient range to produce oscillation, crystal current and signals at as many as three or four different settings. These points are all the same frequency for any one setting of the mechanical or cavity

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[1] Don't be too suspicious of test equipment. If maintained and operated properly it is usually quite reliable. The author has found the X-band TS–191 and S-band LAD test equipment a valuable aid in tuning, trouble-shooting and checking sensitivity of radar systems.

[2] NavShips 900,096, Section 1, Page 5-4.

[3] NavShips 900,096, Section 1, Pages 5-7, 5-8, 5-9.

adjustment, but are different "modes" of klystron operation. (Three or four different velocities producing oscillation at the same frequency.) Use the "mode" which is broadest and which at the same time produces sufficient crystal current. Usually this will be the "mode" which produces the largest crystal current for a given setting of the crystal current adjustment. Use of a "sharp" mode is likely to result in the radar system being frequently out of tune. Adjust the repeller voltage control for peak crystal current, then retune the cavity or mechanical adjustment for peak echoes (or echo box ringtime), then re-adjust the repeller voltage control, etc., until the provisions of (1) are satisfied.

5—It is necessary to qualify the statement made in (4) about the function of the repeller voltage control. This control, when adjusted about the peak of a "mode" does have a tuning effect over a small range (at the rate of .5 Mc. per volt in the 707B and 2 Mc. per volt in the 723A/B) by "pulling" the natural f_r produced by the cavity. The range of this tuning effect is limited by the fact that the klystron drops out of oscillation a few volts on either side of the peak of the "mode". The Type 707B has a range of about 18 Mc. between half power points and the Type 723A/B has a range of about 34 Mc. between half power points. This tuning effect is made use of in most radar systems for AFC and for a "fine" or "operator's" tuning control. However, as the AFC or "fine" tuning control is operated and "pulls" the frequency, the provisions for optimum operation of the klystron (as specified in (1) and (4)) are violated. This is the reason that a radar system should be peak tuned manually and working properly before switching to AFC operation. Then the AFC will work closer to the set value.

6—When tuning through a "mode" with the repeller voltage control the frequency increases as the voltage is *increased negatively*. In a metal klystron, such as the 723A/B, the frequency increases as the tuning bows are screwed shut. In a glass klystron, such as the 707B, the frequency increases as the tuning plugs are screwed into the cavity. The final adjustment of these plugs should be made so they are all screwed in about an equal amount. In some of the S-band radars, klystron cavity tuning vanes were provided. These should all be set in the *same plane* during final adjustment with the main tuning plug about half way in.

7—There is no need for "cooking" a newly installed klystron by applying filament voltage for several hours before using it! In a tube this size any small amount of gas accumulated during storage will be absorbed by the elements in the first few minutes of operation. If a large amount of gas is present, or air has leaked into a tube, no amount of "cooking" will remedy the situation—the tube is bad. If a klystron refuses to operate and gas or air leakage is suspected look for excessive heating with only filament power applied. This can be judged by observing the color of the cathode in a glass klystron and by feeling the shell of a metal klystron. *In the latter case be sure that the voltage supply to the shell, if any, is secured.* Usually the filament in a contaminated klystron will operate for some time before burning out. These tubes get quite hot in normal operation; do not confuse this with excessive filament heating. Mention of these differences in heating is made mainly to aid in diagnosing a failure and reporting it properly on NBS–383. Experience is necessary for distinguishing between normal and abnormal heating of a klystron. *Do not use this alone as a reason for pronouncing a klystron a failure,* especially one which otherwise appears to operate normally.

If a klystron is operating with good stability, is producing the proper crystal current, and is tunable to the right frequency, *there is nothing wrong with it. All the klystron does is to produce a CW signal at a certain frequency. In a good klystron no one "mode" of operation results in any greater sensitivity of the radar system, as long as proper tuning and crystal current are maintained.*

MARK 25 MODS 2 AND 3 BEACON AFC UNIT

Reports from the field indicate that a small number of Field Change No. 28 kits have been found with condenser C15 incorrectly mounted on the chassis, and incorrectly connected in the circuit. This condenser has two pigtails: one is connected to the shell of the condenser, and the other to the high side. The condenser is mounted by a metal strap to the chassis so that, electrically, one pigtail is at chassis ground potential, and the other is above ground. In these few kits the condenser has been mounted end-for-end from the specified way, so that the grounded pigtail connects to cathode, pin 2, of V6, and the high side connects to ground. The effect is that this arrangement removes cathode bias from V6 and causes a distortion of the oscillator waveform. Since this 1000-cps a.c. frequency-modulates the local beating oscillator, and also controls conduction of the two phase detectors, V3 and V4, poor waveform can result in poor operation of the Beacon AFC Unit.

It is not known how many AFC Units have left the shop with the connections from C15 reversed, but each installation of MK 25–FC28 should be checked, and when this undesirable condition is found it should be corrected.—*W.E. Newsletter*

USN USL notes

PERISCOPE TARGET BEARING TRANSMITTER

The torpedo fire-control methods employed on the modern submarine require that the relative azimuth bearing of a periscope be repeated at several remote stations and be visible at the periscope itself. To effect this performance, it is necessary to couple the periscope shaft to a follower unit which will drive the remote bearing repeaters. The use of mechanical or electrical couplings between the follower unit of a periscope target bearing transmitter and the periscope leaves much to be desired.

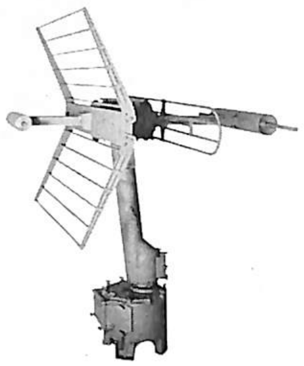
In the search for a satisfactory system of repeating periscope bearings, many obstacles had to be surmounted. One complication was the fact that during normal operation, a periscope may be raised, lowered, or maintained in various positions other than full extension. Another factor to be considered was the need for watertight fittings at the point where the periscope passes through the hull of a submarine.

As the result of a search for an improved system of bearing transmission, the Underwater Sound Laboratory has developed the Periscope Target Bearing Transmitter (PTBT), which follows the rotation of a periscope to an accuracy of approximately six minutes of arc without the need for mechanical or electrical coupling between the follower unit and the periscope. The PTBT operates on an a-c magnetic bridge principle in which a Mumetal bar mounted between the inner and outer tubes of a non-magnetic periscope creates a balance in two E-shaped transformers of varying permeability. This balance is detected, amplified, and fed into a servo motor which rotates the double bridge (mounted on the follower unit) around the periscope to equilibrium or zero total flux. The travel of the bridge is taken off by two synchros and recorded in terms of bearing. The relative target bearing is transmitted electrically to the Torpedo Data Computer, and to other stations as required. Azimuth bearings at the periscope control station are obtained from a Lucite dial provided with red night-lighting of adjustable intensity.

A prototype model of the PTBT was installed on a submarine and was employed in normal submarine operation for a period of approximately six months. During this time, the equipment was evaluated and several improvements were incorporated in the design.

The PTBT exhibits several advantages not found in other types of bearing transmitter. Unlike the Mark 11 Bearing Transmitter, it does not require keyways in the periscope, which cause leakage. Consequently, the associated mechanical difficulties caused by wearing and loosening of the key are eliminated. The Lucite drum dial lighting arrangement incorporated in the PTBT is more effective than that provided by the Mark 11 transmitter and facilitates azimuth readings at the periscope. The magnetic bearing transmitter is not affected by external ferrous material or by any other electrical equipment, and it will follow the periscope to a maximum rate of from 10 to 12 rpm while maintaining static position accuracy.

In addition, installation of the PTBT is no more involved than that of the Mark 11 Bearing Transmitter. With a minimum of additional instruction, submarine personnel can accomplish the necessary maintenance.



keep the RADCM gear ready

by

Edward J. Wirtz, Jr., & Roy Niemi
Service Force, U.S. Atlantic Fleet

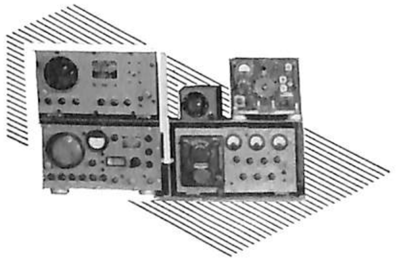
Since the middle of World War II, RADCM (Radar Countermeasures) has greatly increased in prominence. Today, it is as important as "radar silence" is to a ship in enemy infested waters. It should be of prime concern to every ET that his ship can count on ALL of the RADCM gear operating properly. Failure of just one unit can place many units or even the complete system out of operation, since they are inter-related.

In 1943, German U-boats were the first to employ radar countermeasures to detect the radar equipped ships of the Allied Fleet. Shortly thereafter, in July of 1944, the United States Forces successfully used countermeasure warfare against the Japanese fleet.

The purpose of the RADCM equipment is to intercept radar signals from other ships while still beyond the echo range of their radar receivers, and also beyond the range of your own radars. Then, after intercepting and studying the characteristics of their radar signals, to use this information to:

1—Aid your ship in evading detection by their radars.

2—Use your own ship's countermeasure jammers to prevent the enemy from making intelligent use of his radar.



3—Deceive him by creating false and misleading readings on his radar scope (through such methods as setting up false target indications).

Whatever use it is put to, RADCM is still the "early warning" gear that will allow you to outguess the enemy.

The equipment comprising the bulk of the RADCM installation includes: the low frequency Radar Search Receiver, Type RDO; the high frequency Radar Search Receiver, Type AN/SPR–2; the Panoramic Adaptor (used for viewing a wide band of frequencies), Type RDP; the Pulse Analyzer (used for determining the characteristics of the received signals), Type RDJ; and the Direction Finder (which covers both high and low frequency radar ranges), Type DBM.

Since the above RADCM equipment is that most frequently found (aboard a ship designated for countermeasure service) this article will be devoted to "hints and kinks" for the ET, to help him service it correctly and maintain it in peak operating condition.

DBM Service and Maintenance

Common Troubles

The most frequent trouble experienced with the DBM direction finder is in the antenna r-f rotary joint, E–202. Ironically enough, the majority of cases of this trouble can be blamed upon lack of proper maintenance by the ET. Bi-weekly cleaning and lubrication of this joint is required if the antenna is subjected to continuous duty. The contact fingers should be inspected for deformation and excessive wear. Proper technique for cleaning and lubricating this joint and also slip ring assembly, E–203, can be found in the instruction book.

The indications of a neglected r-f rotary joint are noise and intermittent signals in the receiver. As mentioned in Field Change #3 (applicable to DBM serials 1 through 252), signal attenuation and noise can often be attributed to the steel pin in the r-f rotary joint being in contact with a beryllium copper cup, causing uneven wear due to the relative hardness of the two metals. Field Change #3 contains a replacement for this pin made of soft brass and silver plated.

The antenna speed control variac (T–108) is another component requiring careful adjustment and frequent checking. Such symptoms as broken antenna counterweights and a shorted variac can often be attributed to improper settings of the variac stops. The first step in adjusting the antenna speed is to set the variac low speed mechanical stop so that the variac output voltage is approximately 30 volts and the high speed mechanical stop so that the output voltage is approximately 87 volts. The final setting of the low speed stop is determined by the starting torque of the antenna motor. The low speed stop should be set at the point where the output voltage from the variac is just sufficient to start the antenna motor rotating the antenna slowly from a still position. It must be remembered that the voltage necessary to cause the antenna motor to continue to rotate the antenna is less than the voltage necessary to start the antenna rotating. The low speed stop *must* be set at the point where the voltage is just enough to overcome the starting torque of the motor, causing the antenna to commence rotating from a still position. A setting of the low speed stop at a point where the variac output voltage is less than this voltage will result in excessive current through the variac and antenna motor, causing damage to either or both. When adjusting for high speed rotation, setting the variac to allow too high an output voltage will cause a centrifugal force to be created which will be in excess of the physical strength of the counterweight mounting. The result of the excessive speed will be another one of those equipment failure reports stating, "antenna counterweight broken and dragging on the radome".

The antenna spinner should be checked for proper seating on the driveshaft. Improper seating may result in excessive antenna vibration; loss of signals at the indicator due to lack of continuity in the r-f line between the antenna and the antenna internal connector (E–201); the antenna becoming loose, shearing off leads from the r-f relay (K–201), placing an excessive strain on the antenna internal connector (E–201), and possibly causing damage to the antenna and radome.

Less Common Troubles

Proper adjustment of the beam modulator control (R–137) will usually take care of the common complaint of "dim radial trace with intense center spot brilliancy".

The following cases of equipment failure, and corrective measures taken, are recent troubles but of a less frequent nature!

The bias control potentiometer (R–160) in the grid circuit of the video power amplifier (V–104) had no effect. This was due to a shorted cable between the —90 volt supply and R–160.

The trace was off-center. This was caused by defective vertical and horizontal restorers, V–106 and V–107. Following replacement of these tubes it was necessary to readjust the scanning capacitor trimmer (C–141).

The video gain was low. Only a faint trace was visible with bias and gain controls in their maximum clockwise positions. The lead to the input capacitor (C–106) was found to be open.

Pattern on the cathode-ray tube off center and distorted. Visual inspection showed the cap was off the lower vertical deflection plate of the cathode-ray tube (V–112).

Switches which have been replaced due to mechanical failure include the main power switch (S–101); the horizontal-vertical relay switch, antenna #2 (S–102A); the horizontal-vertical relay switch, antenna #1 (S–102B); the battle short switch (S–103); the antenna motors power supply switch (S–104) and the aural search switch (S–105).

Fuses F–101 and F–102 were blowing when the equipment was turned on. This was caused by a partially shorted power input buffer capacitor (C–148).

The video gain control potentiometer (R–101), when varied, caused random flashes on the screen. This potentiometer was worn and required replacement.

The true bearing indication was displaced 180°. This was caused by reversal of the gyro input at Terminals 38 and 39 on the main terminal panel.

Erratic signals due to damaged fingers in the right-angle connector assembly (E–202). This was caused by incorrect seating of the cable assembly (E–201).

The high frequency antenna measured open in both the vertical and horizontal positions. This was caused by defective contacts on the transfer relay (K–201).

The low frequency antenna was inoperative. The collar on the antenna mounting plate was found to be broken. This was corrected in accordance with instructions contained in C.E.M.B., Section 4, Page DBM–3, Supplement No. 31.

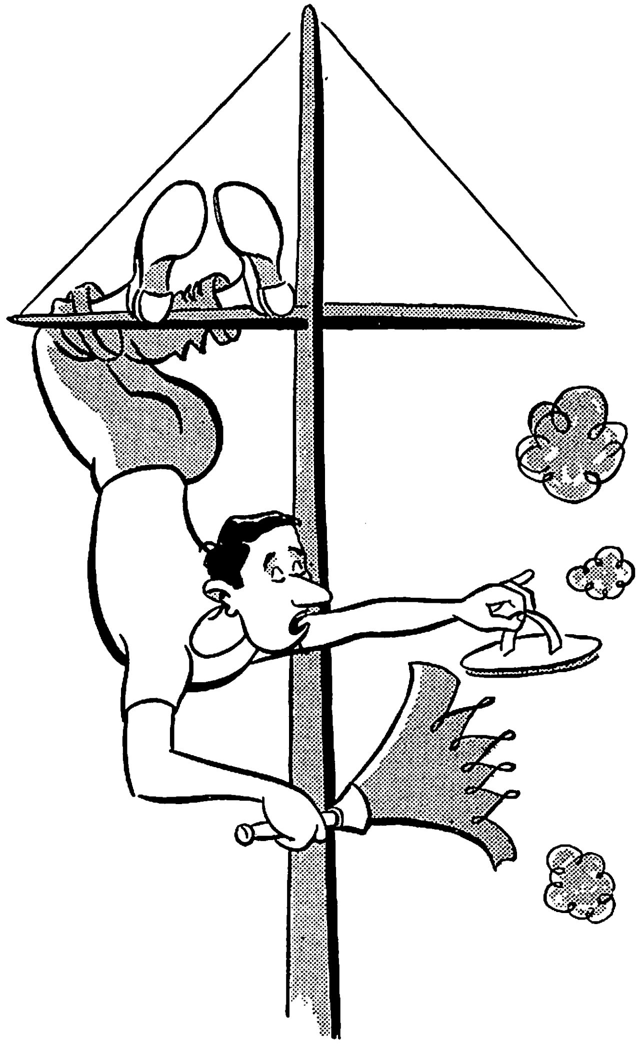
Main line fuses (F–101 & F–102) were blowing. The trouble was traced to the slip ring assembly (E–203) on the antenna spinner. The slip ring assembly was mounted approximately 1/16″ too high on the shaft, allowing the upper brush to ride on the lower edge of the upper slip ring and arc over to the lower slip ring. The line fuses would blow at the time arcing took place. The r-f relay (K–201) was passing excessive current during the arcing, causing damage to the antenna speed control variac (T–108).

The fiber gear on the drive motor (B–201) was stripped. Since the equipment spares did not include a replacement part, this gear had to be fabricated by a tender. The cause of this gear being stripped was excessive torque applied by the drive motor due to too high a setting of the antenna speed control variac (T–108) for high speed rotation.

AN/SPR–2 Service and Maintenance

Common Troubles

The most common trouble with the AN/SPR–2 radar search receiver is low sensitivity due to a defective 1N21 crystal (Y–501). The C.E.M.B., Section 11, Page AN/SPR:1, Supplement No. 31 contains information on the construction details, electrical details, and instructions on checking and changing this crystal.



The cavity oscillator tube (2C40) in the tuning unit often fails to oscillate and requires replacement.

The oscillator cavity in the tuning unit has given more than its share of trouble. There are no facilities available for replating the cavity and spares are not available for replacement. When the oscillator cavity is suspected of giving trouble it would be wise to check all other associated components before this unit is disassembled. If definitely determined to be the cause of the trouble, the oscillator cavity should be very carefully disassembled and handled while it is being cleaned.

Erratic operation of cavity oscillator is caused by dirty track and roller. Both the track and roller should be kept clean.

Erratic signals and loss of signals when the AN/SPR–2 is used with one of the antennas while reception remains good on the other antenna can usually be attributed to a faulty coaxial cable or antenna. Routine megging of the antennas and coaxial cables should be a part of the preventive maintenance program.

RDP Service and Maintenance

Common Troubles

In the RDP panoramic radio adaptor one of the common troubles is that the high voltage filter resistor (R–181) changes value due to overheating. Excessive overheating and ripple in the horizontal trace on the scope are indications that this resistor has changed value.

Signals and grass appearing only at the right side of the sweep. This was corrected by alignment of the r-f and oscillator sections and adjustment of the screwdriver front panel controls. These front panel controls should be adjusted only if complete adjustment can be accomplished.

Less Common Troubles

RDP was inoperative. The d-c blocking capacitors C–116, C–117 and C–120 were shorted.

The RDP was causing interference in the RDO receiver when the "center frequency" and "sweep" controls were advanced. Upon checking the alignment, it was found that the FM oscillator coil (Z–101–09) was improperly adjusted. When the frequency was varied by the reactance modulator at 30 cps, the oscillator would pass through 30 Mc (the intermediate frequency of the RDO receiver) causing spurious oscillations. The trouble was corrected by adjusting the local oscillator.

The local oscillator was not functioning properly. The FM oscillator coil (Z–101–09) had a shorted turn.

The RDP was inoperative. Fuse F–101 was blowing due to a shorted 2X2 tube.

The sweep was just visible above the lower edge of the scope mask. Operation of the vertical positioning control (R–124) would not permit raising the sweep to the correct position. R–126 in the cathode circuit of the push-pull video amplifier (V–107) had changed value from 750 ohms to 680 ohms.

Intensity was too brilliant and could not be adjusted with the brilliance control (R–177). This was caused by improper resistance values in the high voltage bleeder circuit. R–175 had increased from 300,000 to 500,000 ohms. A 2-megohm and 3-megohm parallel resistor combination was found in place of R–173 and R–184. These resistors were replaced with resistors of the correct values and the circuit functioned properly.

RDJ Service and Maintenance

Common Troubles

No elliptical sweep throughout all or a portion of the range when the "Elliptical Sweep Range" control was set on the 25-180 position. The oscillator frequency determining resistor (R–140), a 985,000-ohm precision resistor, was open. Any one of the precision resistors, R–140 through R–147 and R–149 through R–156, opening up will cause the above indications.

The linear (slave) sweep was unstable. This was caused by a dirty "pulse amplitude" potentiometer (R–101).

The elliptical sweep frequency dial was incorrectly adjusted (when the "Elliptical Sweep Tuning" crank knob was rotated counterclockwise until the knob stopped, the Figure 170 did not appear under the hairline on the mid-frequency band). Excessive torque had been applied to the "Elliptical Sweep Tuning" knob and had bent the dial stop pin and loosened the flexible coupling. It was necessary to tighten the coupling and reposition the dial stop pin.

The power transformer (T–102) had shorted in a few reported cases.

Less Common Troubles

The PRF meter (M–101) was inoperative. This was caused by a defective meter tube (V–107). After replacing the tube it was necessary to recalibrate the meter on all scales.

The PRF meter (M–101) would not calibrate correctly. The plate meter resistor (R–134) in the plate circuit of the meter tube (V–107) had increased from 33,000 ohms to 38,000 ohms.

The PRF meter (M–101) would not indicate on a received pulse. The meter fuse (F–101) was open.

The PRF meter (M–101) was reading off-scale. The meter tube (V–107) was shorted.

The linear (slave) sweep was erratic. This was caused by an intermittent third video amplifier tube (V–103).

Erratic operation of the "calibrate" sine wave. The sweep length determining capacitors C–122, C–123 and C–124 had a poor ground connection.

RDO Service and Maintenance

Common Troubles

The input meter (M–201) was not functioning properly. This is a common trouble and is caused by the meter input bleeder resistor (R–265) changing value.

Less Common Troubles

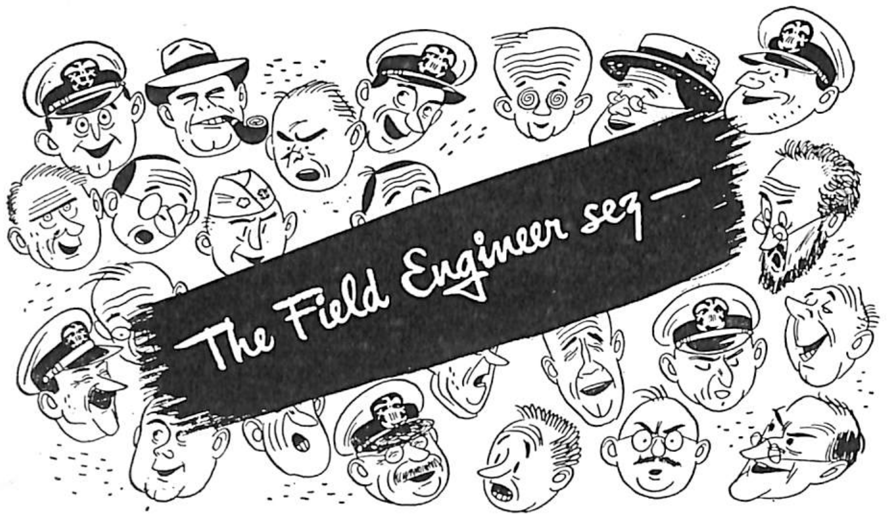
The receiver output was low as indicated on the output meter (M–202). This was caused by an open V–211 screen filter resistor (R–276).

No signals were being received on the DBM indicator from the RDO receiver. The RDO video output coaxial cable had a recessed center pin.

When the RDO receiver is functioning normally but no signals are being received from it at the DBM indicator, the most common causes are: cables accidentally connected to the wrong position, defective cables and coaxial connectors, and defective coaxial switches.

Afterthoughts about the over-all picture . . .

The above article has been prepared for every ET whose job it is to service and maintain RADCM gear. It contains important data from actual failures. Use it wisely as a guide for finding present and future "weak spots" in your equipment so that you may anticipate many troubles before they actually happen. Never forget that each unit is merely a link in your RADCM chain, and if one unit is inoperative the rest are of much less value, if not totally useless. Think twice about the value of RADCM, then you'll be a step ahead of your enemy and his radar.



MARK 25 MOD 2

D–153671 Balanced Converter

The Equipment was not capable of tracking planes out beyond 20,000 yards. Believing that low current from the crystal CR (3F)4, Type 1N23B, might be a contributing factor, it was replaced. Negligible improvement was observed after this replacement.

D–153567 Radar Antenna Assembly

Continuing on the assumption that poor power output might be responsible for the poor performance reported, an investigation was made of the entire waveguide run. In the scanner it was found that the choke flange on the end of the scanner waveguide section was badly deformed. It appeared as though the end might have been hammered, or dropped repeatedly, so that the quarter-wave trap had been flattened out and then bent back into a semblance of proper shape with some tool, possibly a screwdriver. The trap was actually a series of short irregular chords rather than a true arc of exact dimensions as it should be. Knowing that some loss of power was inevitable from such a trap, the ship's spare scanner was installed by ship personnel. Again subsequent tests proved disappointing as performance was but slightly better than before.

D–153556 Range Error Detector

A number of tracking runs had been made by the time the above work was completed. It had become apparent that the equipment sensitivity was normal but that the automatic following circuits were not capable of holding in as they should. Rebalancing of the ATI circuits was indicated. After replacement of tube V(12M)7 (6SN7), which was necessary in order to get a null point with switch Test #1 held down, the circuit was adjusted. Again only negligible changes in operation were noted.

D–153541 Range Unit Assembly

After considerable checking and testing it was found that the trouble was in mechanical binding of the range unit drive mechanism. At the separable coupling assembly, Drawing BL–72171, the upper half coupling was slightly loose on its shaft due to loosening of the Allen screws. The coupling would shift its position on the shaft with vibration, change of range, or especially as a result of high-speed slewing. At some positions operation was about normal while at others a very appreciable amount of drag could be felt. After re-aligning the parts in their proper relationship the set screws were carefully tightened. One tracking test was then made out to beyond 47,000 yards. Additional tests would have been desirable but there was an absence of planes because of very inclement weather conditions. However, it is believed that the equipment will operate normally as a result of the above corrective maintenance.

A. J. Jones
W. A. Withers
F. C. Zimmerman

U.S.S. Moale (DD–693)

The bearing and elevation sweeps on the indicators of this equipment were jumping aperiodically. The trouble was finally traced to the terminal connections in Connection Box #1. Several lugs were coming loose as a result of the nuts securing them slacking off. The result in the case of one connection was intermittent circuit continuity. It was found that only one nut per terminal was used, instead of the four nuts which are provided for. It is suggested that this practice, if it is such, be discontinued, and that other connection boxes be investigated for similar conditions.—V. G. Popof

U.S.S. Des Moines (CA–134)

It was noted that operation of the AFC unit was erratic as evidenced by the fact that the multivibrator would lock in on one side instead of changing over at ten-second intervals. It was discovered that if the AFC input cable was removed at the balanced converter output, J(3F)2, the AFC unit would still lock in on one side, but if the input cable was removed from the AFC unit, J(3F)1, input the flip-flop circuit operated properly. The cable was inspected and it was found that the coaxial plug termination at P(3K)1 was improperly made in that there was no connection between the cable shield and the outside of the plug. The cable was reterminated and the trouble disappeared.—Roscoe M. Lewis, Jr., W. A. Withers.

U.S.S. Sumner (DD–692)

The modulator selector switch (S–8) on the console (Unit 4) was found broken due to mechanical interference with the radar indicator power plugs when stowed on the hanger bracket. The bottom deck of the switch jammed against the stowed plug when the control panel was lowered. The switch was replaced from ship's spares and to prevent repetition of this trouble the yard (Philadelphia Naval Shipyard) was requested to shorten the plug stowing hanger bracket. Other instances of this difficulty have been encountered.

—A. J. Elia

4C35 DIFFICULTIES IN MARK 25 MOD 2

Considerable difficulty has been experienced in the Fleet with Type 4C35 tubes used in the modulator of Radar Equipment Mark 25 Mod 2. In general, it has been necessary to make individual selections to find tubes which will operate satisfactorily. Recently the *USS Newport News* reported that Sylvania-made Type 4C35 tubes will not operate at all in the Mark 25 equipment even when new. However, the ship stated that after several hundred hours' use in Radar Equipment Mark 35, the tubes performed satisfactorily in the Mark 25 equipment. This holds true even after the tubes have become inoperative in the Mark 35 equipment. This discovery, the *Newport News* reports, has reduced the casualty rate of 4C35 tubes, from approximately 70% to 5%.

Pending development of a basic remedy for the above difficulty, it is suggested that ships experiencing trouble with the 4C35 Sylvania tubes follow the procedure indicated by the *Newport News*. This will result in obtaining many more hours' of operation from tubes which might otherwise be declared faulty and not be used at all.

Have you ever wondered about the frequency limits of the various sub-bands? See "Letters to the Editor" on Page 28 of this magazine.

Electronic Systems Installation Descriptions

A lot of water has rushed past the bows of U.S. Navy ships since the first shipboard electronics installation was completed in 1904. In those days electronics was barely out of the gadget stage, and few Naval strategists believed that it would become a significant factor in the design and operation of Naval vessels. Electronic communications were then a minor subdivision of a ship's engineering organization.

For many years, while radio increased in utility and importance in Naval warfare and communications, electronics remained a subordinate part of ships' engineering systems, and descriptions of electronic equipment were contained in the Electrical Machinery Installation Descriptions.

During the period immediately preceding World War II, the advent of radar, sonar, direction finding equipment and other navigational aids, together with the rapid expansion of radio communications, pointed up the need for a separate and more comprehensive installation description of electronic equipment for Naval vessels. The complexity and variety of electronic gear have multiplied so rapidly that electronics has grown from a stepchild of electrical engineering into a separate and vitally important phase of technology.

The Bureau of Ships was quick to recognize this rapid growth and its significance in Naval planning and tactics. The General Specifications for Machinery of the United States Navy, prepared during 1945, clearly delineate the format, contents and function for separate texts on Electronic Systems Installations to be prepared for each Naval vessel or group of vessels. For various reasons the preparation of such texts did not progress into a reality as soon as was to be desired. However, at the present time several books of this type are in various stages of preparation or completion and they will doubtless prove of great value in the organization of electronics activities on board ship. These systems descriptions have been designed to help achieve optimum efficiency in the operational use of electronic equipment and to facilitate prompt and correct maintenance.

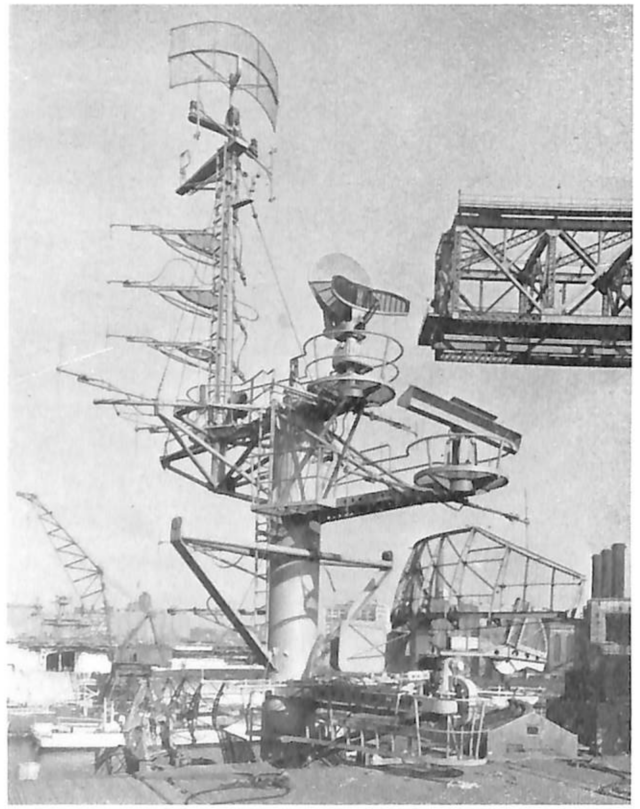


FIGURE 1—Arrangement of antennas on the CV–34. Mast is in stowed position for passing under Brooklyn Bridge.

This article is intended to acquaint Naval personnel responsible for the technical or operational use and application of electronic gear, with the general layout and purpose of the Electronic Systems Installation Descriptions. Reference is made to the first volume of the general description of electronic systems installation for the *USS Oriskany (CV–34)*, which represents a good example of this type of text and is one of the first to be prepared in compliance with the specifications. The General Description of Electronic Systems Installations for Aircraft Carrier CV–34, Volume 1, was compiled by the New York Naval Shipyard.

As shipboard electronics installations have grown in complexity and function, it has become increasingly difficult for the technical as well as non-electronics personnel, who must depend upon these equipments for tactical, navigational, and communications information, to maintain a working knowledge of their scope and limitations. What each piece of gear can and cannot do, its dependability, range, and many other factors must be understood to use electronic devices to the best advantage. Electronics personnel are becoming more and more specialized; some expert in radar, others in one or more of the various specialized equipments. The general description of electronic systems installation for a given vessel or type of vessel is designed to facilitate instruction of both electronics and non-electronics personnel in their ship's electronic equipments and layout. This general description is the first of two volumes dealing with the electronics installation system of the CV–34. The second volume, to be described later in this article, will contain test, calibration and performance data.

The General Description of Electronic Systems Installation for the Aircraft Carrier CV–34, provides through the use of text material, drawings and photographs, a description of each of the major units of the installation and their interrelation, and gives general information on each system as a whole. A concise description of the general purpose and function of the various systems is included, setting forth the fundamental operational and installation features. The interrelationship of the electrical and electronic systems on board the vessel is clarified. A study of the integrated electrical and electronic functions and requirements of the various pieces of gear, as presented in this instruction book, helps electronics personnel to know and understand their responsibility with respect to power supplies, cabling, intercommunications, etc., necessary for the proper operation of the electronic installations.

BuShips specifications for the general description of electronics system installations require descriptive material and illustrations for each of the following major electronic systems on board Naval vessels:

1—Radio.
2—Radar.
3—IFF.
4—Countermeasures.
5—Sonar.

The table of contents of the volume prepared by the New York Naval Shipyard for the *U.S.S. Oriskany (CV–34)* illustrates the complete coverage provided in this instance and gives some idea of the layout of this type of instruction book:

Section 1—Airborne Early Warning.
Section 2—Beacons.
Section 3—Carrier Controlled Approach.
Section 4—Countermeasures.
Section 5—Identification.
Section 6—Radio Communications.
Section 7—Radio (Navigational).
Section 8—Radiosonde Equipment.
Section 9—Radar (Fire Control).
Section 10—Radar Search.
Section 11—Sonar.

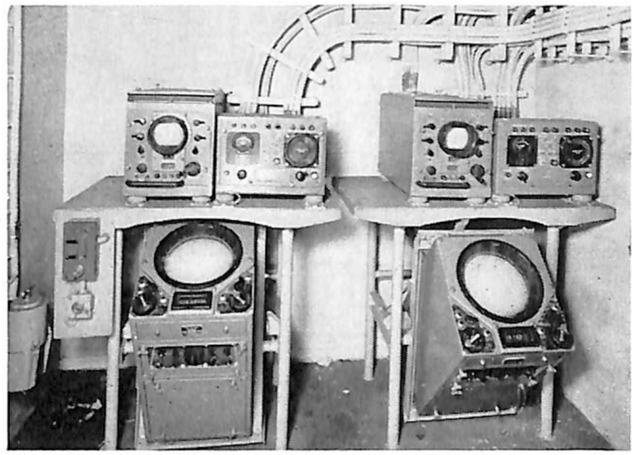


FIGURE 2—Search radar control room on the CV–34.

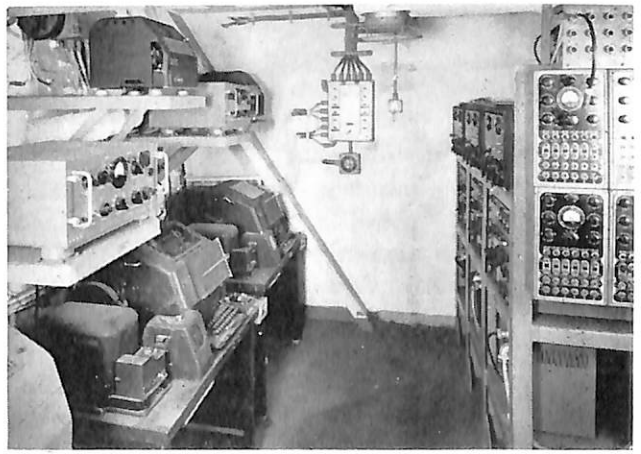


FIGURE 3—Radio Central (Radio I) on the CV–34.

Together with descriptive text material, functional diagrams of each system and of the major equipments which make up those systems are included in the instruction book. Lists of electronic circuit designations, electronic equipments installed, and the locations of individual units are also included.

Figures 1 and 2 are representative of the many photographs showing orientation of individual equipments and various electronic systems.

The combat information center, search radar control room, captain's plot and message center, radio transmitter room forward, and radio central locations are shown in photographs such as Figures 3 and 4.

Each electronic circuit is adequately described through text material and general isometric and elementary wiring diagrams. Plans showing the arrangement of equipment are also shown for the major electronic spaces.

A master plan, showing the arrangement of all electronic spaces on shipboard, is provided, and in this volume, as in all those to be prepared for major combatant vessels, each radio, radar, sonar, iff and countermeasures space is shown in detail on a separate plan.

Profile drawings and plans used for the following electronic systems are also included:

Radio Receiver Extension System.
Radio Transmitter Remote Control System.
Radiophone System.
Teletype System.
Radar Repeater System.
Power Supply System (between distribution centers and electronic equipments, and between units of these equipments).

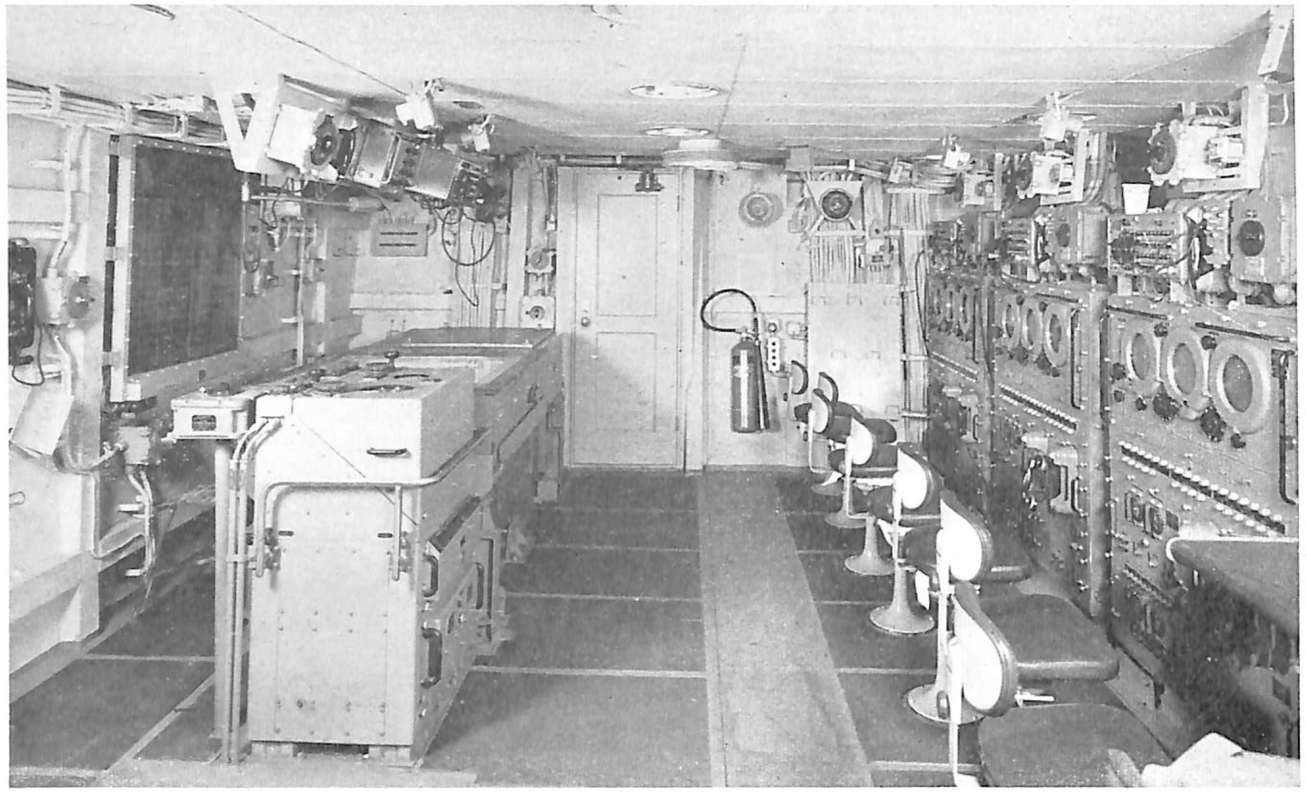


FIGURE 4—Combat Information Center on the CV–34.

The second volume of the electronic systems installation instruction book will contain the calibration, performance and test data required for maintenance of the electronic equipment and systems. All information necessary to keep gear properly aligned and in operating condition will be provided. This volume will also contain instructions for calibration of the various electronic equipments and pertinent test data indicating performance characteristics of the system as a whole. Diagrams, charts, graphs, reduced size plans and other descriptive matter to enable personnel to properly orient, test and calibrate all the installed electronic equipments are included in this second volume.

While the calibrations, records of performance and test data which will be provided will, of necessity, be information obtained prior to delivery and acceptance of the vessel by the Navy, they will provide information that will be useful in shipboard tests and operational use. This information will include:

1—Radio-frequency characteristics of various radio receiving and transmitting antennas.

2—Antenna calibration and pattern measurements as applicable in accordance with standardized procedures, techniques and report forms established by the Bureau of Ships.

3—Radar range calibrations, including descriptions of targets, together with charts showing actual latitude and longitude of the fixed targets employed and their location relative to the docking area.

4—Records—Initial calibrations of LF/DF, MF/DF, HF/DF and UHF/DF covering a typical set of conditions and frequencies plus a statement of overall characteristics and expected performance.

5—Calibrations of surface search radar bearings as compared with pelorus bearings.

6—Radar calibrations—Records of test point wave forms with the theoretical and actual wave forms indicated at each test point.

7—Records of field changes.

8—Records of transmitter performance.

9—Records of radio transmitter tuning.

10—Records of radio receiver tuning.

11—Sonar records:

a—Panel meter readings.
b—Resistance readings.
c—Voltage and current readings.
d—Monitor measurements.
e—Modifications and attachments.

System planning provides for the installation of equipment, which, while not readily available at the time of construction and delivery, may be installed with minimum displacement of existing installed facilities, since the plans for the equipment are integrated with the other electronics systems at the time of construction and before preparation of the book.

This instruction book provides a comprehensive listing of available electronics facilities and their potentialities for ready reference in planning communications, radar, sonar and other electronics functions in any ship, unit, task force or fleet action. Officers will be able to learn readily the functions, utility and operation of electronic gear under their cognizance.

The easily referenced catalogue of equipments and systems, and their functions and requirements, together with the diagrams provided, will measurably speed appraisal of battle damage and rapid adaptation of remaining operating equipment to the maintenance of optimum combat efficiency.

These tests on the electronics systems installation will provide a means for speeding the orientation of electronics and non-electronics personnel insofar as the functions, needs, scope and limitations of electronic equipments are concerned. New personnel may use it to become familiar with the ship's electronics installation.

The many drawings and plans located together in one source, make it possible to plan shipboard changes with a minimum of confusion.

The present plan is for the home shipyard of each vessel to retain the original of both the text and illustrations for the book and have the responsibility of maintaining the book current. In this way the book will be kept up to date and the ship will be provided with the latest drawings, text, instructions and organizational material for the equipment currently installed on board.

Through the various diagrams provided, the maximum use of cabling facilities may be obtained, minimizing the number of cables and cabling changes required.

Similarly, the optimum use of antenna facilities, in routine operations and after battle damage, may be quickly planned by reference to the applicable text and illustration information in the systems installation instruction book.

Interference between equipments or from outside sources will be subject to analysis with considerably greater facility than was possible without this reference on the entire electronics installation, and corrective measures may therefore be developed and action taken more efficiently.

The electronic systems installation instruction books will be a very welcome addition to a ship's instruction book library and a useful tool in learning and using the ship's electronics installations to their best advantage. Those whose supervisory duties require knowledge of the broad phases, purposes and functions of the various electronics systems installed, as well as the electronics personnel, who will doubtless make good use of this compendium of information, will find this text a real help.

The systems instruction book is not designated to supplant the present type of equipment instruction book. Rather, it is intended to supplement it, aid in system planning and further the most efficient integration of electronic facilities under the changing conditions of shipboard activity. As represented by the General Description for Electronic Systems Installation for the Aircraft Carrier CV–34, this type of instruction book will serve well in shipboard electronics.

MAGNETOSTRICTIVE HYDROPHONE

Rochelle salt crystals become unserviceable at temperatures in excess of 116° F. and were superseded by ADP (ammonium dihydrogen phosphate) type crystals. The ADP type crystals are serviceable up to temperatures of approximately 212° F. Since the production cost of the magnetostrictive transducer is lower than that of the crystal type, a design has been completed by the Ordnance Research Laboratory, Pennsylvania State College, which is an exact electro-acoustic and mechanical replacement of the crystal type for use in the above torpedoes.

In the commonly used piezoelectric or crystal hydrophone[1], the crystal elements produce voltages when they are alternately stretched and compressed by the acoustic waves striking them.

In general principle, magnetostrictive hydrophones are similar to the crystal type, consisting essentially of a number of active elements actuated by the vibrations of a diaphragm in contact with the water.

In a magnetostrictive hydrophone, however, the core of each element is a length of magnetic material which changes in degree of magnetization when it is stretched or compressed. Each of these cores is surrounded by a pick-up coil through which the magnetic lines of flux pass, so that as the sound vibrations cause the magnetization of the bar to fluctuate, the changing lines of flux induce corresponding voltages in the coil.

The most sensitive crystal substances deteriorate at temperatures that may be reached on a ship's deck in the hot sun or beneath an airplane near the engine exhaust. Magnetostrictive transducers, on the other hand, are constructed to endure temperatures very much higher. Additional advantages of magnetostrictive hydrophones are their greater mechanical ruggedness and their previously mentioned lower production cost.

Like piezoelectricity, magnetostriction is a reversible phenomenon. If voltages are applied to the coils surrounding the magnetostrictive elements, the resulting changes in magnetization of the elements will set up stresses which may be used to produce acoustic signals. The hydrophone then becomes a projector.

The commonly used magnetostrictive materials are nickel, nickel-iron alloys, and iron-cobalt-vanadium alloys.

Both magnetostrictive and piezoelectric transducers are inherently well suited to receiving the high pressures and low amplitudes encountered in underwater signals (contrasted to the much lower pressures and much higher amplitudes which impinge on a receiver of air-borne sound, such as a telephone receiver). Conversely, they are also well suited to producing underwater signals because, furnishing high forces with little amplitude they are able to operate efficiently when loaded with water.

Since all transducers operate most efficiently at the natural or resonant frequencies of their vibrating elements, magnetostrictive and crystal elements are useful principally at ultrasonic frequencies because units resonant in the audible range are usually too large to be practical. Magnetostrictive transducers have a smaller range of useful frequencies than do crystal hydrophones because their efficiency of conversion between electrical and acoustic energy (in either direction) decreases more rapidly at frequencies off the resonant frequency. An additional high-frequency limitation is imposed on magnetostrictive transducers by the difficulty of constructing very small elements.

The performance of a hydrophone is usually expressed in terms of its sensitivity, or the voltage it develops in a given sound field. However, since this voltage is dependent on the electrical impedance of the hydrophone, the impedance must be specified before a sensitivity figure is meaningful. Crystals have extremely high impedance, and the sensitivities of piezoelectric hydrophones are, therefore, generally higher than those of magnetostrictive hydrophones. Direct comparison between hydrophones of the two types can be made only when the sensitivities are converted to efficiencies, or when one hydrophone is fitted with a tuning device to make its impedance equal to that of the other. Magnetostrictive hydrophones designed to replace crystal ones are provided with such tuning devices so that the same electronic panels may be used without redesign, and the resulting sensitivities are almost identical to the original.

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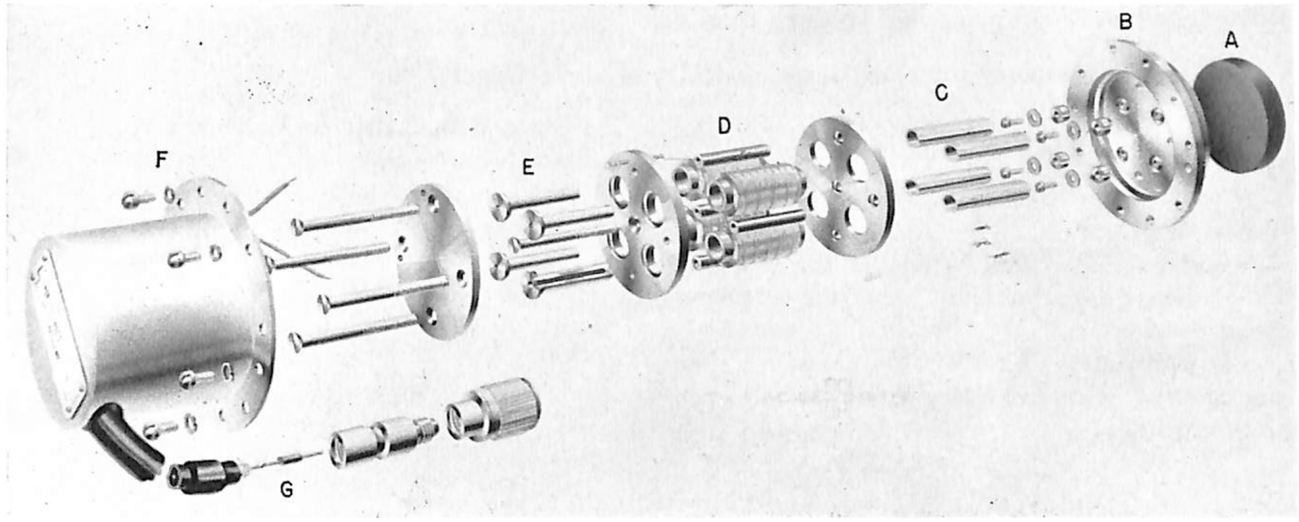
[1] In the terminology of underwater acoustics work, a "hydrophone" is an instrument used to transform acoustic signals into electrical signals, and a "projector" or "transmitter" transforms electrical signals into acoustic signals; a "transducer" performs either function or both.

Whereas in piezoelectricity, stretching corresponds to electrical polarization of one sign and compression to polarization of the opposite sign, in magnetostriction the sign of the force (tension is considered positive, compression negative) and the direction of magnetic polarization are independent. For example, if a bar of nickel is compressed, there is an increase in whatever magnetic polarization it already happens to have, and if the bar is stretched, this polarization decreases; conversely, if the polarization is increased by electrical means, the bar shortens, and if the polarization is decreased, the bar lengthens, regardless of the direction of polarization. If an alternating magnetic field is applied to an unmagnetized bar, the bar vibrates at twice the frequency of the applied field.

Some magnetostrictive materials undergo an increase in magnetization when they are stretched and a decrease when they are compressed; for others the change is the reverse. Regardless of the magnetostrictive characteristics of the material, however, applied forces can cause changes only in the existing magnetization of the material; no applied force can cause a reversal of the magnetic polarization. A completely unmagnetized bar would remain unmagnetized regardless of the magnitude and the direction of the forces applied. In fact, the degree of conversion between mechanical and electrical energy is very low anywhere near zero magnetization, reaching a maximum only when the magnetization is quite high.



Exploded view of four-tube magnetostrictive hydrophone developed at the Ordnance Research Laboratory. A—Rubber pad used between transducer diaphragm and shell of torpedo; B—Diaphragm; C—Tubular magnetostrictive elements; D—Coils; E—Polarizing magnets; F—Case; G—Cable to electronic panel.

For these reasons, magnetostrictive vibrators are given a steady magnetic polarization upon which the alternating field is superimposed. Provision of this polarization may be accomplished by sending direct current through the coil, by placing a permanent magnet in close proximity to the bar, or by using one of several magnetostrictive alloys capable of retaining a high residual magnetism.

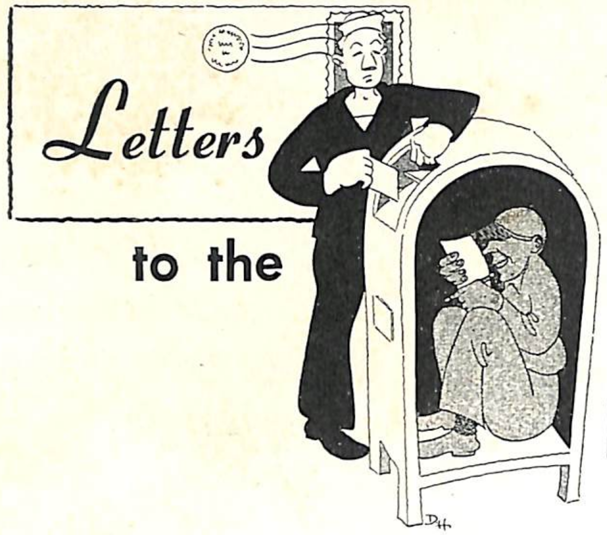
Although a solid bar of magnetostrictive material may be used as a vibrator, it is very inefficient because of energy losses due to eddy currents within the material. To eliminate eddy currents, the bar may be built up of laminations electrically insulated from one another, or a thin tube may be used instead of a bar.

Besides the longitudinally vibrating elements described above, radial magnetostrictive vibrators are also used. A radial vibrator may simply be considered as a longitudinal vibrator which has been bent to form a closed loop, the coil surrounding it becoming a toroid. As the loop changes in length, it also changes in diameter, and acoustic energy is radiated equally in all directions in the plane of the loop. Radial vibrators are usually built as stacks of ring laminations. They are used where non-directionality is desired, in such applications as artificial noise targets.

Because of their advantages, magnetostrictive hydrophones will probably completely supersede piezoelectric hydrophones in some applications. Crystal transducers will continue to be used where their inherent qualities make them most applicable, especially at high frequencies and where good response characteristics over a broad frequency range are desired.

—*Bulletin of Ordnance Information*

Letters to the EDITOR



This new feature is the answer to numerous suggestions and requests from fleet and shore personnel for a medium of presenting their individual problems, gripes and questions on electronics matters and obtaining answers to such queries.

As a matter of convenience, it is suggested you write directly to:

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

Editor
BuShips Electron
Sir:

We are unable to find in any of the technical publications on board a definition of the frequency sub-bands identified as S_g, X_b etc. We would appreciate your running a table of the frequency spectrum showing the frequency limits of all such bands and sub-bands.

Lt. J. D. A., U.S.N.

The requested information follows:

BAND	FREQUENCY (Kilocycles)
VLF	Below 30
LF	30 to 300
MF	300 to 3,000
HF	3,000 to 30,000
VHF	30,000 to 300,000
UHF	300,000 to 3,000,000
SHF	3,000,000 to 30,000,000
	(Megacycles)
A	157 to 187
G	194 to 212
P	225 to 390
L	390 to 1,550
S	1,550 to 5,200
X	5,200 to 11,000
K	11,000 to 33,000
L_L	510 to 725
L_S	900 to 950
L_X	950 to 1,150
L_K	1,150 to 1,300
L_Q	2,400 to 2,600
S_G	2,700 to 2,900
S_S	2,900 to 3,100
S_A	3,100 to 3,400
S_U	3,400 to 3,700
X_B	6,220 to 6,900
X_L	8,520 to 9,000
X_S	9,000 to 9,600
X_X	9,600 to 10,000
X_F	10,000 to 10,250
X_K	10,250 to 10,900

Editor

Editor
BuShips Electron
Sir:

Is it permissible for an ET to be put in the operations division rather than the engineering division? This question pertains to small craft.

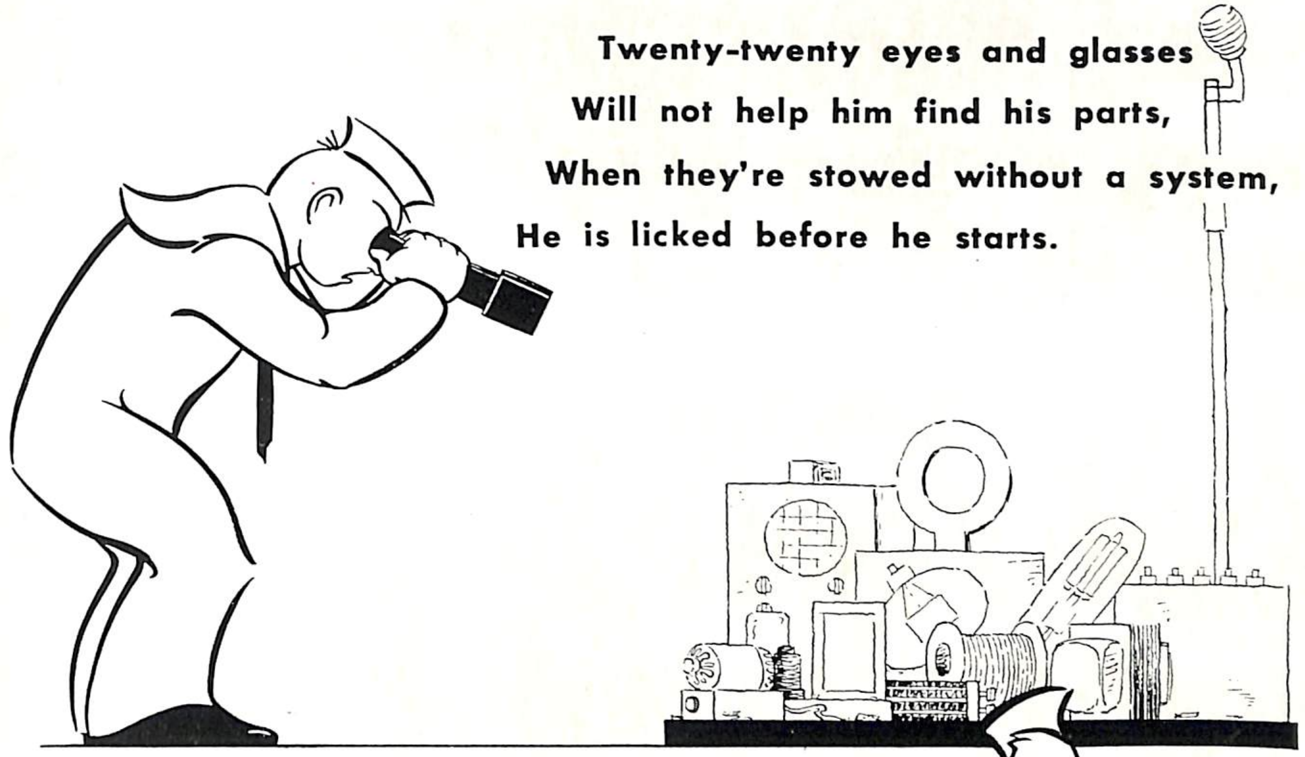
If so, can it be done at the discretion of the commanding officer or does he have to get permission from the Bureau?

R. L. D., ET 2, USN

This can be done at the discretion of the commanding officer, without permission from the Bureau.

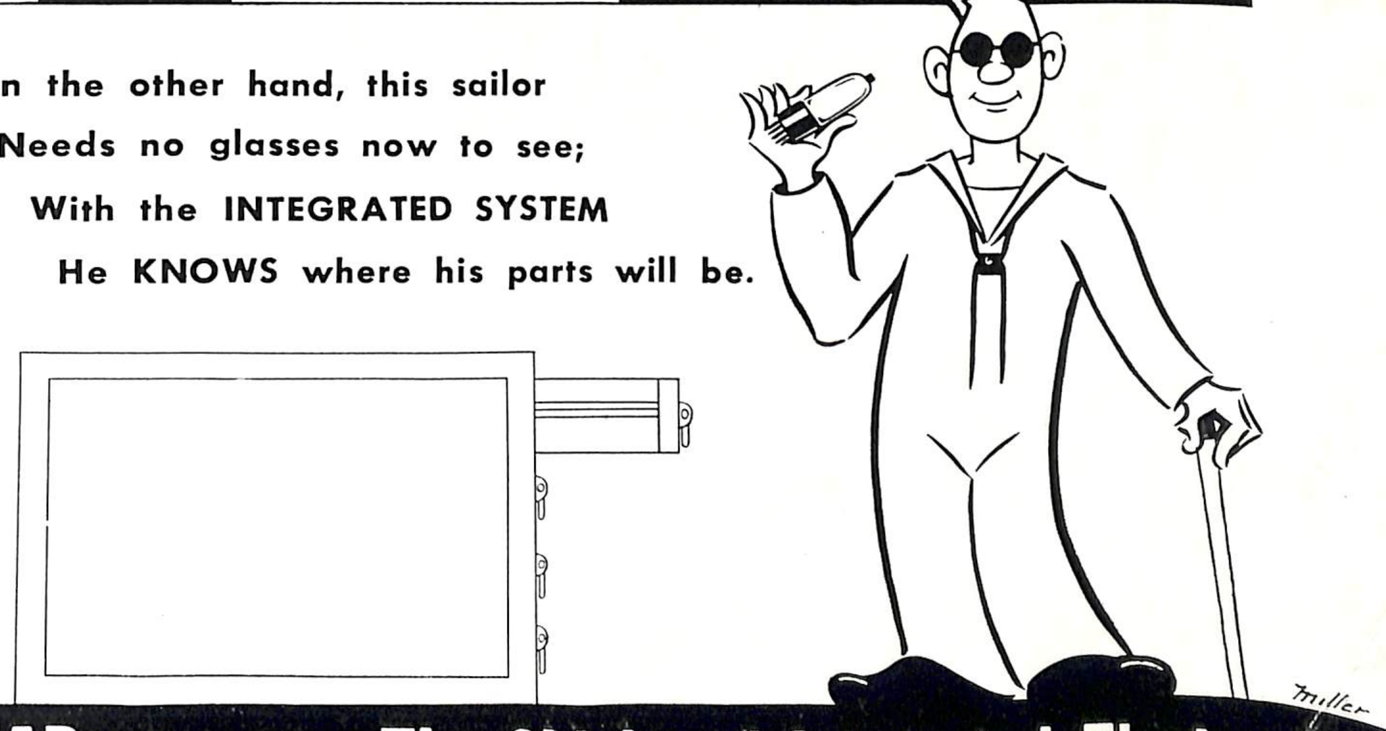
Editor

Make It Easy!



Twenty-twenty eyes and glasses
Will not help him find his parts,
When they're stowed without a system,
He is licked before he starts.

On the other hand, this sailor
Needs no glasses now to see;
With the INTEGRATED SYSTEM
He KNOWS where his parts will be.



READ: The Shipboard Integrated Electronic Maintenance Parts System - NAVSHIPS 900,168

"I shot an arrow into the air
It fell to earth, I know not where."
Henry Wadsworth Longfellow

Navy radar knows "where." It locates, identifies and destroys the enemy far beyond the horizon. Navy radar is bound to make a hit.