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BUREAU OF SHIPS — NAVY DEPARTMENT

SP/SM Height Errors

By Lt. John A. Weber, U.S.N.R., E.F.S.G.

In fighter direction, a problem of combat in three dimensions, technicians carry the responsibility for the accuracy of the height information obtainable from fighter-director type radars. This responsibility does not end with the daily calibration of the height circuit, for the height circuit is just one small part of the mechanism of altitude determination and the easiest to test and adjust. Therefore it is important that all technicians understand fully the sources of error, how they are measured, and what can be done to correct them. This article tells that story with specific reference to the SP and SM radars using Westinghouse Mark 8 Mod 2 Stable Elements, but the principles and methods involved are applicable with minor modifications to other stabilized antenna systems.

In the Navy's polar-type plotting system, each ship carries its own zero-reference point for the three-variable fighter-direction system. Range zero is at the ship, bearing zero is a line from the ship to true north, and elevation angle zero is a plane horizontal with respect to the earth at the ship's position.

Range zero is provided internally by each radar. Auxiliary equipment external to the radar provides the zero references for bearing and elevation angle. These latter references both depend upon gyroscopic action; the gyro compass to provide bearing zero and the gyro-stable element to provide elevation-angle zero. Although the gyro compass is not the maintenance concern of the radar technician, the stable element is provided as part of the SP/SM, and the radar technician, unwittingly, has inherited a gyroscopic device.

THE HORIZONTAL REFERENCE

The simplest horizontal reference would be a plane perpendicular to the string of a plumb-bob. On shipboard a free plumb-bob would be subjected to many accelerations from the ship's movements in addition to the acceleration of gravity. The mean position of this simple reference plane would be horizontal, but instantaneously it might be in any position other than horizontal. By taking numerous altitude readings of a target, the average would be close to correct, but this is a far cry from the desired goal of a reading accurate within 500 feet every 15 seconds.

Once started, a simple gyroscope tends to remain with a fixed direction of its rotating axis, i.e. fixed in space, rather than with respect to the earth. A gyroscope started at the equator with its axis vertical at 0600 will have its axis horizontal at 1200. The axis has maintained fixed direction in space, but the earth has changed its position during the elapsed time.

A practical gyroscope has gimbal rings and bearings, none of which can be made weightless or frictionless, and which consequently exert continual forces on the gyroscope and tend to move it from its fixed direction in space. A practical gyroscope to be used as the basis for horizontal reference would require constant resetting to compensate for external forces and earth's rotation.

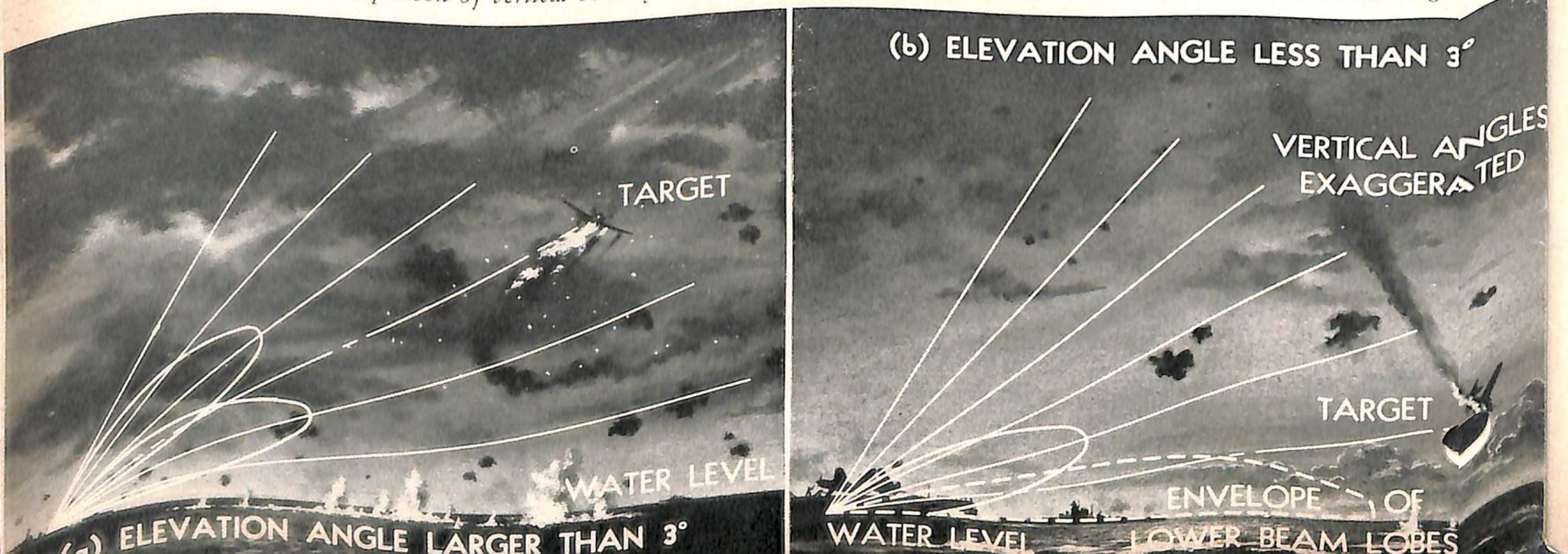
The stable element furnished with the fighter-director radar combines these simple systems. The prime reference is the plumb-bob, modified beyond recognition and emerging as an "erecting magnet". As before, the erecting magnet has considerable motion, but its average position is vertically below the center of rotation of its support. The actual reference plane is integral with the gyroscope, and is perpendicular to the gyro's axis of spin.

With every deviation of the erecting magnet from its correct vertical position, a magnetic force acts on the gyroscope tending to make it move from the vertical. Normal swings of the erecting magnet occur too rapidly for the gyroscope to follow anything but the magnet's average motion. In like manner, any tendency for the gyro-axis to deviate from its correct vertical position is counteracted by an average restoring force exerted by the erecting magnet and directed toward the point of mean motion or true vertical.

The restoring effect of the erecting magnet is dependent on the magnitude of the displacement, and consistent with all error-actuated devices there is ever present some small error. To keep this error a minimum, predictable disturbing forces on the gyroscope are compensated or eliminated. The known tendency of a gyro to remain directed in space was mentioned above. To keep the reference plane horizontal, then, the gyro must be made to follow the earth's rotation from west to east. By applying a northerly-directed force to the top of the stable element gyroscope, the gyro will precess in the direction of earth's rotation. However, a vertical line at the equator changes angular position in space 360° per day, whereas a vertical line at either pole remains fixed, necessitating that this precessing force be variable and proportional to the cosine of the latitude. This variable precessing force is provided by the *latitude correction mechanism*.

The same forces which cause loose gear to slither across the deck during violent ship's movement also act to deflect the erecting magnet. The greater the magnitude of these forces, the more detrimental is their effect on the accuracy of the stable element. By maintaining

FIGURE 1—*Comparison of vertical beam patterns for high- and low-angle targets. Axis of antenna directed at target.*



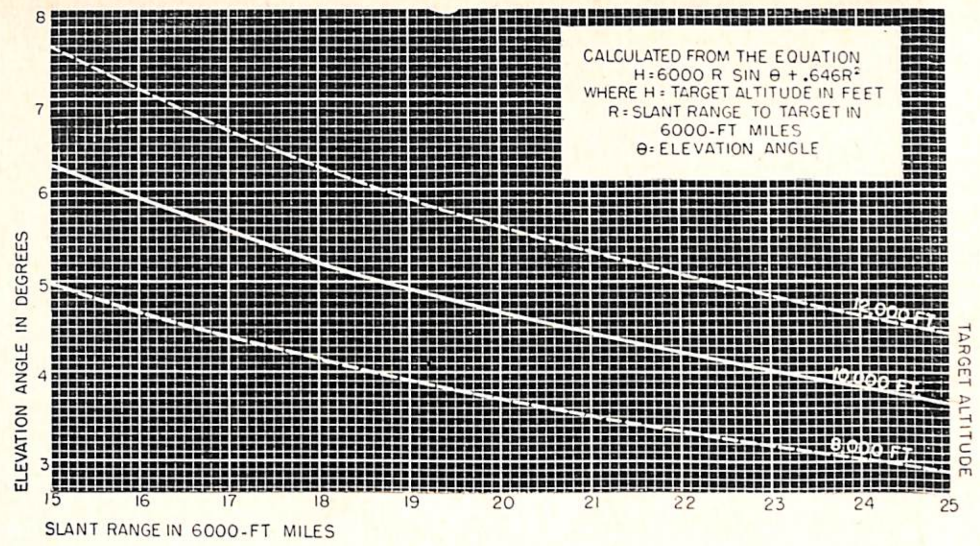


FIGURE 2—*Elevation angle as a function of slant range and altitude.*

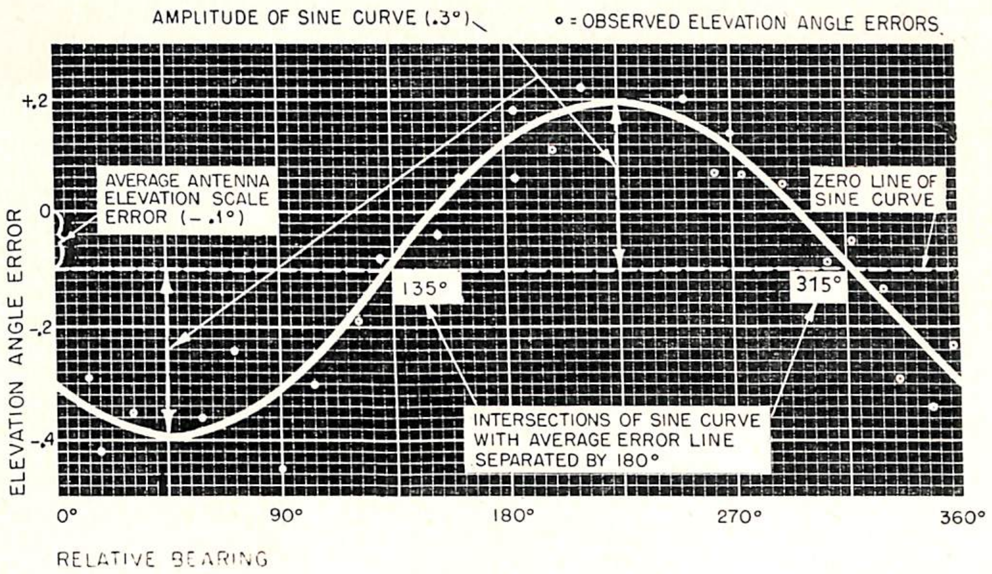


FIGURE 3 — *Elevation-angle errors plotted against relative bearing. The points fall about a full-cycle sine curve.*

the erecting magnet in a deflected position, the point of mean motion moves from the true vertical toward the deflected position, and through magnetic action, the gyro would tend to follow this point unless the magnetic action were removed. The *automatic turn cutout* is provided on some stable elements to de-energize the erecting magnet under conditions of prolonged violent maneuvers, thereby removing a known cause of error in the position of the horizontal reference plane.

The horizontal reference plane, as determined by the gyro, must be transferred to the antenna. This is accomplished through a series of reference planes: 1—a stable-element reference plane, 2—an antenna-pedestal reference plane, and 3—an antenna reference plane.

The stable-element reference plane is perpendicular to the train-rotation axis of the stable-element yoke. The antenna-pedestal reference plane is perpendicular to the azimuth-rotation axis of the antenna pedestal. The antenna-reference plane is the locus of the center of the (scanning) radar beam of zero-elevation angle. It is the sole purpose of the stabilizing system to keep this latter reference plane horizontal so that all elevation angles measured by the system will be with respect to the horizon.

The level and cross-level synchro systems measure the angle between the horizontal reference plane and the stable element reference plane, and duplicate this angle between the antenna-pedestal reference plane and the antenna reference plane. Stable-element synchros produce a zero signal when the horizontal reference plane and the stable-element reference plane are parallel. On

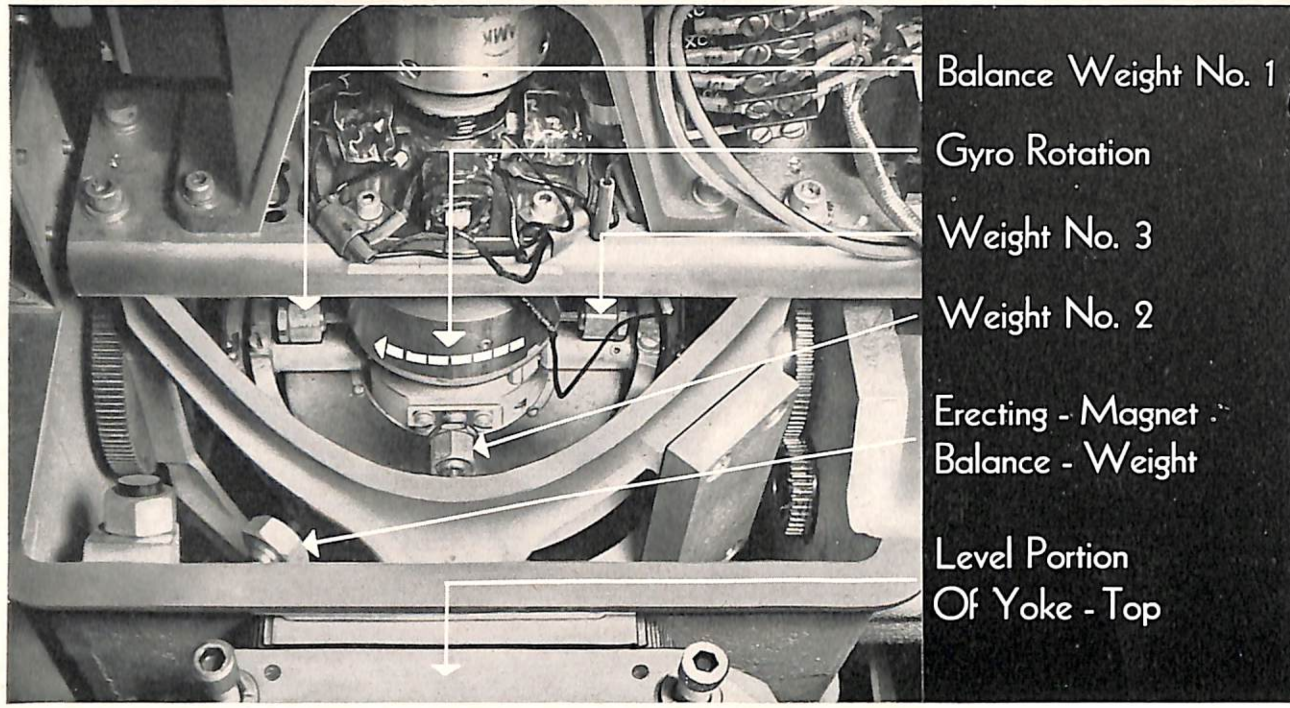


FIGURE 5—*Photograph of stable element showing location of gyro-balancing weights.*

receipt of a zero signal, the antenna reference plane should become parallel to the antenna-pedestal reference plane.

For the antenna reference plane to be horizontal requires not only proper duplication of angle, but also requires that the antenna-pedestal reference plane be parallel to the stable-element reference plane since these are the origins for measuring the angles of plane tilt. It may be said that whereas the angle is transmitted electrically through synchro wiring, the angle reference plane is transmitted mechanically through the structure of the ship, and the foundations and bases of the stable element and antenna pedestal.

SP/SM LIMITATIONS

With the overall picture in mind it is now possible to examine the system for possible causes of inaccuracy of height measurements. Before proceeding into the examination, however, a fundamental limitation of the equipment must be recognized to prevent misinterpreting the limitation as an inaccuracy.

Conical-scanning height-finding radars such as the SP and the SM (and also the Mark 12 and Mark 28) depend on the matching of echo strengths with the antenna beam pointing an equal angular distance above and below the target. This condition can be attained only when the radar beams are symmetrical for positions above and below the target. Distortion of one beam such as occurs due to water reflection changes the intensity pattern of the reflected beam and renders echo strength matching meaningless. Water reflection with its reinforcements and nullifications of echo strength will always affect the lower beam first, as shown in figure 1. For the frequency used in the SP/SM radars, the nulls formed in the lower beam are narrow and generally the water reflection results in an increased echo for the lower beam. To equalize the echo returns necessitates lowering the antenna to practically zero elevation.

Water reflection increases the ability of the set to pick up low flying targets at greater ranges, but prevents the determination of altitude of these targets until the lower beam is clear of the water. For the SM and the SP, the lower beam clears the water when the antenna elevation angle is equal to the beam width or approximately 2½° with the eight foot antenna dish.

The errors obtained in attempting to read target angles at elevation angles less than 2½° is therefore not due to misadjustment of the equipment, but represents the limit of usefulness of this type of radar. The Mark 22 has been furnished for use in the angle of limitation of the Mark 12, and similarly the SX is adapting the principle of the Mark 22 to the fighter-director radar to provide lower-angle coverage.

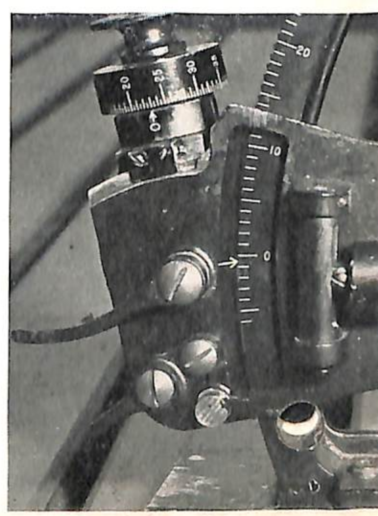


FIGURE 11—*Quadrant reads 359° 23′.*

ELEVATION SYSTEM ERRORS

The errors possible in the system may now be listed starting at the prime reference.

1—*Unbalanced erecting magnet*: The center of an unbalanced erecting magnet travels in a small circle about the vertical while scanning, averaging its position directly under the gyro center. Scanning stops while inspecting a target, thereby permitting the gyro to move toward this deflected magnet center and tilting the "horizontal" plane.

2—*Unbalanced gyro housing*: Being mounted in gimbal rings, the entire gyro will tilt under the influence of gravity unless the center of gravity coincides with the vertical axis. During scanning a tilting force due to unbalance would be applied to the gyro equally in all positions and would average out with each revolution. When not scanning, the unbalanced force would tilt the "horizontal" plane until the tilting force is matched by the restoring force of the erecting magnet.

3—*Erecting magnet de-energized*: With no actual magnetic field between erecting magnet and gyro flywheel, the prime reference for the "horizontal" plane is then a practical gyro free to move under all disturbing forces eventually resulting in an upset gyro.

4—*Improperly positioned latitude correction arm*: The latitude correction mechanism must apply its force in a northerly direction to produce eastward precession of the vertical axis. With the force applied in any other direction the "horizontal" plane will become tilted and cannot be leveled by scanning.

It then becomes obvious that the gyro plane will not normally be horizontal when the equipment is operated in relative bearing, for then the latitude corrector is positioned at ship's head instead of true north.

5—*Improperly set or calibrated latitude correction meter*: The force applied for altitude correction must

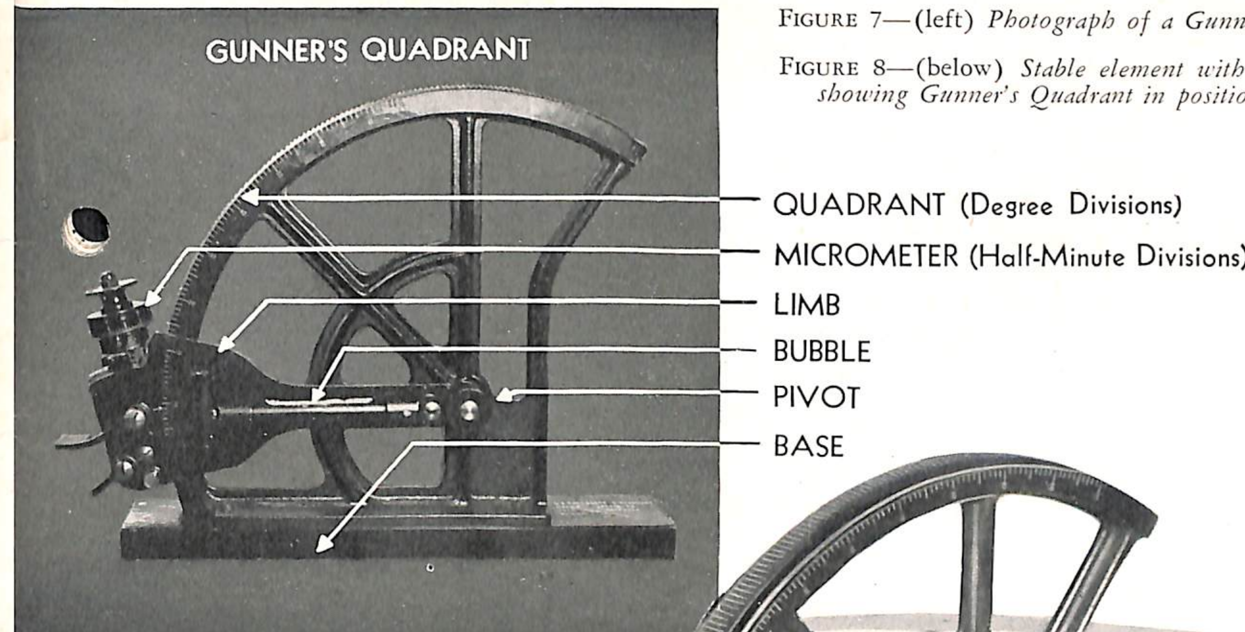


FIGURE 7—(left) *Photograph of a Gunner's Quadrant.*

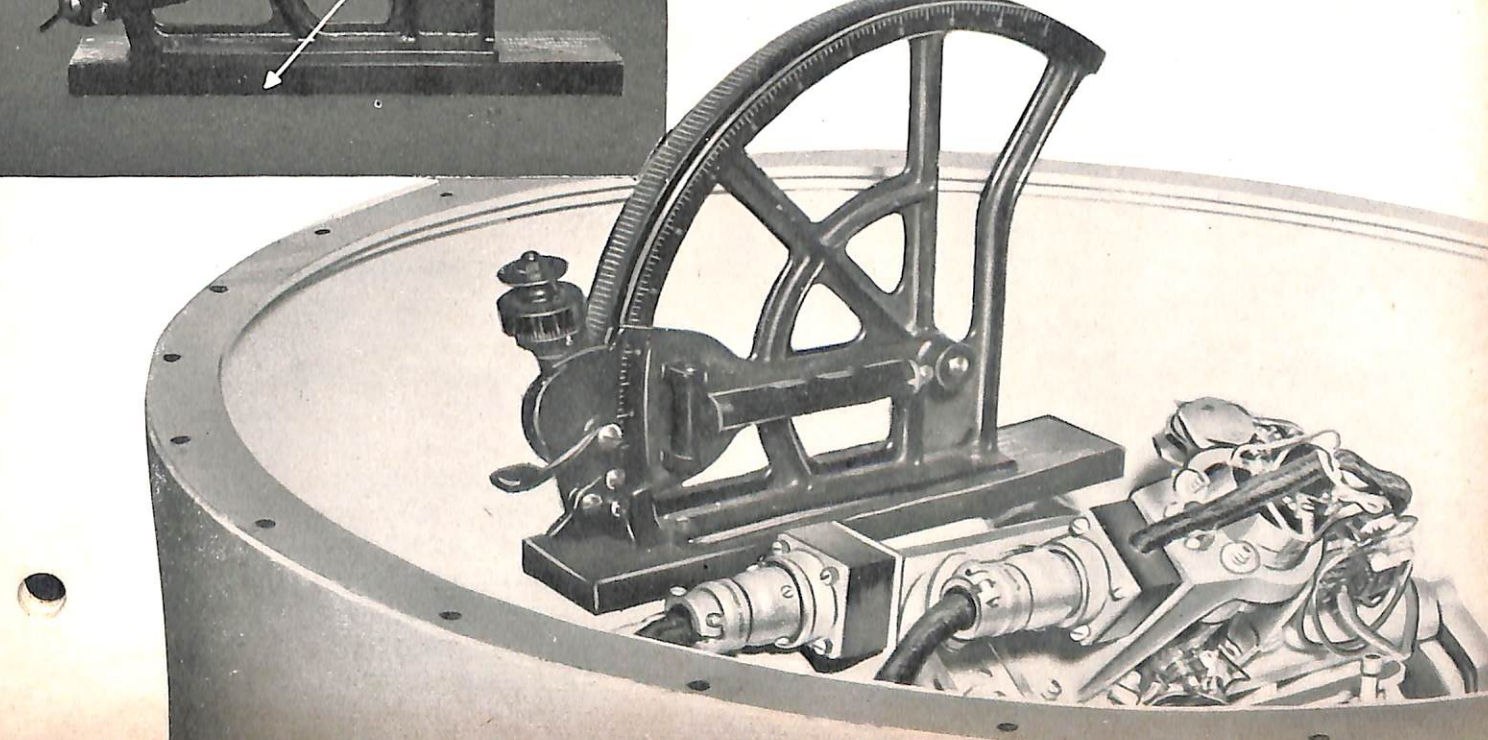


FIGURE 8—(below) *Stable element with top removed, showing Gunner's Quadrant in position on yoke.*

be just sufficient to cause precession equal to earth's rotation. Excessive force will depress the east portion of the "horizontal" plane, and insufficient force the opposite (west) portion.

6—*Weak servo amplifiers in stable element*: To measure the position of the horizontal plane, the stable-element synchros are driven into correspondence with the gyro by the level and cross-level servo amplifiers. Insufficient amplifier gain will result in the transmission of erratic tilt angles to the antenna.

7—*Improperly zeroed level synchros in stable element, console, and antenna*: Any errors introduced by the synchros are constant in all azimuth directions, and will not be cancelled by scanning.

8—*Stable-element train axis and antenna azimuth axis not parallel*: With axes not parallel, the reference planes used to transfer the gyro plane to the antenna will not be parallel. It would be presumed after leveling the mounting rings for stable element and antenna that the two axes would be parallel after installation. This presumption is by no means valid. Rough handling of the equipment may render the individual axis no longer perpendicular to its base. The mounting rings are machined and leveled in an unloaded condition, so that after installation, the weight of the equipment may tilt the mounting ring. A ship is not a rigid structure and major ship overhauls and additions involving welding, or even accidents, can distort the structure connecting the mounting rings. In a stationary ship, the effect of an intense sun shining on just one side of the antenna platform tripod has been measured and found to produce as much as 10 minutes of tilt between axes.

9—*Weak or improperly-adjusted servo amplifiers in antenna*: Some height-finding antennas are badly unbalanced around the elevation axis so that the servo-system error never drops to zero, for even under static conditions the error must compensate the gravitational forces. This ever-present servo error indicates a corresponding antenna-elevation error which is equal in all azimuth directions and should be kept a minimum by setting the elevation amplifier gain a maximum.

Normally the antenna is controlled by the high-speed synchro system, depending on the low-speed for positioning whenever more than 4° away from the correct elevation angle. Failure of the transfer relay to operate or improperly set "low-speed cut-in" may result in the antenna locking in with an elevation error of 10° or multiples, constant in all azimuth directions.

10—*Center of scanning radar beam not coincident with mechanical center of wobbler*: The center of the radiation pattern of the wobbler is coincident with the center line of the wobbler bearings, but after the radiation leaves the wobbler it is reflected by the splash plate and the parabolic reflector. The splash plate may not be perpendicular to the center line, or the axis of the paraboloid may not coincide with this center line. Either

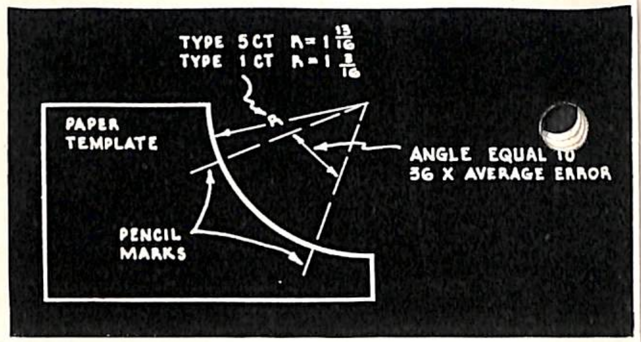


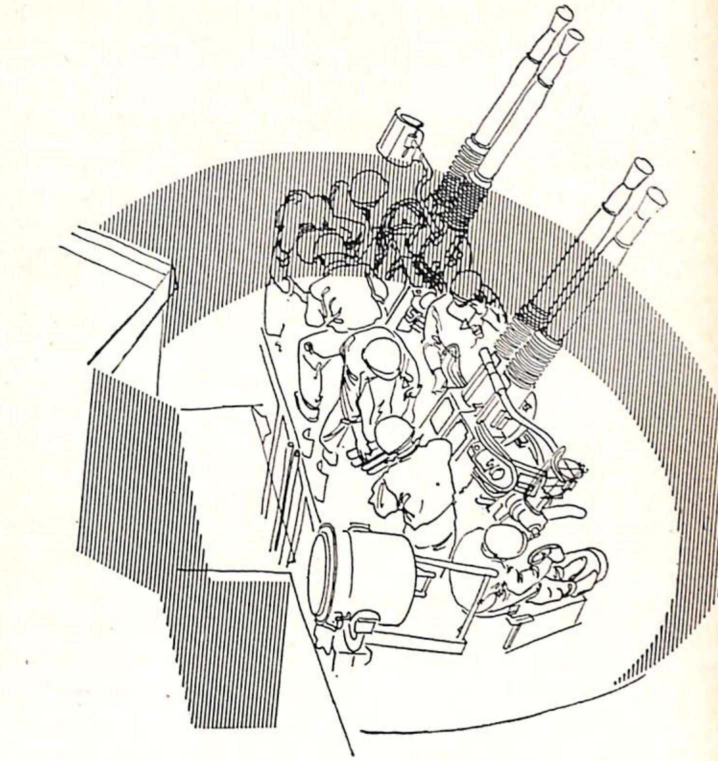
FIGURE 6—*Paper template for use in correcting constant error.*

condition deflects the scanning radar beam center from the mechanical zero. This error will be constant in all azimuth directions and is the reason for using a radar target for final calibration, as simple mechanical means cannot detect the error of the radar beam.

ELEVATION-CALIBRATION FLIGHT TEST

If a target plane were to fly completely around the ship, maintaining constant altitude and constant distance from the ship, a tracking SP/SM radar should require movement in azimuth only. Any movement in elevation required to remain "on target" would be due to the accumulation of errors introduced into the system by all causes listed above. Such a target plane flight is purely hypothetical, but a similar practical flight test using one JM or three TBM's has been developed and is recommended as a routine test to be conducted every few months.

FIGURE 9—*A second quadrant is placed on any smooth horizontal surface on the rotatable part of the antenna.*



The flight test requires cooperation between technicians, operators, FDO's and pilots for satisfactory results, and the roles played by the FDO and pilots during the actual test flight are most important, for the future accuracy and value of the SP/SM radar are determined solely by the constancy of altitude of the target plane.

It is essential that the calibration plane pilot fly steadily at a true altitude of 10,000 feet throughout the test flight. A deviation of not more than 200 feet may be allowable. The pilot should set the pressure altimeter at the sea level barometric pressure furnished by the FDO (Kollsman number) and should correct the indicated altitudes for temperature using standard Navy computers.

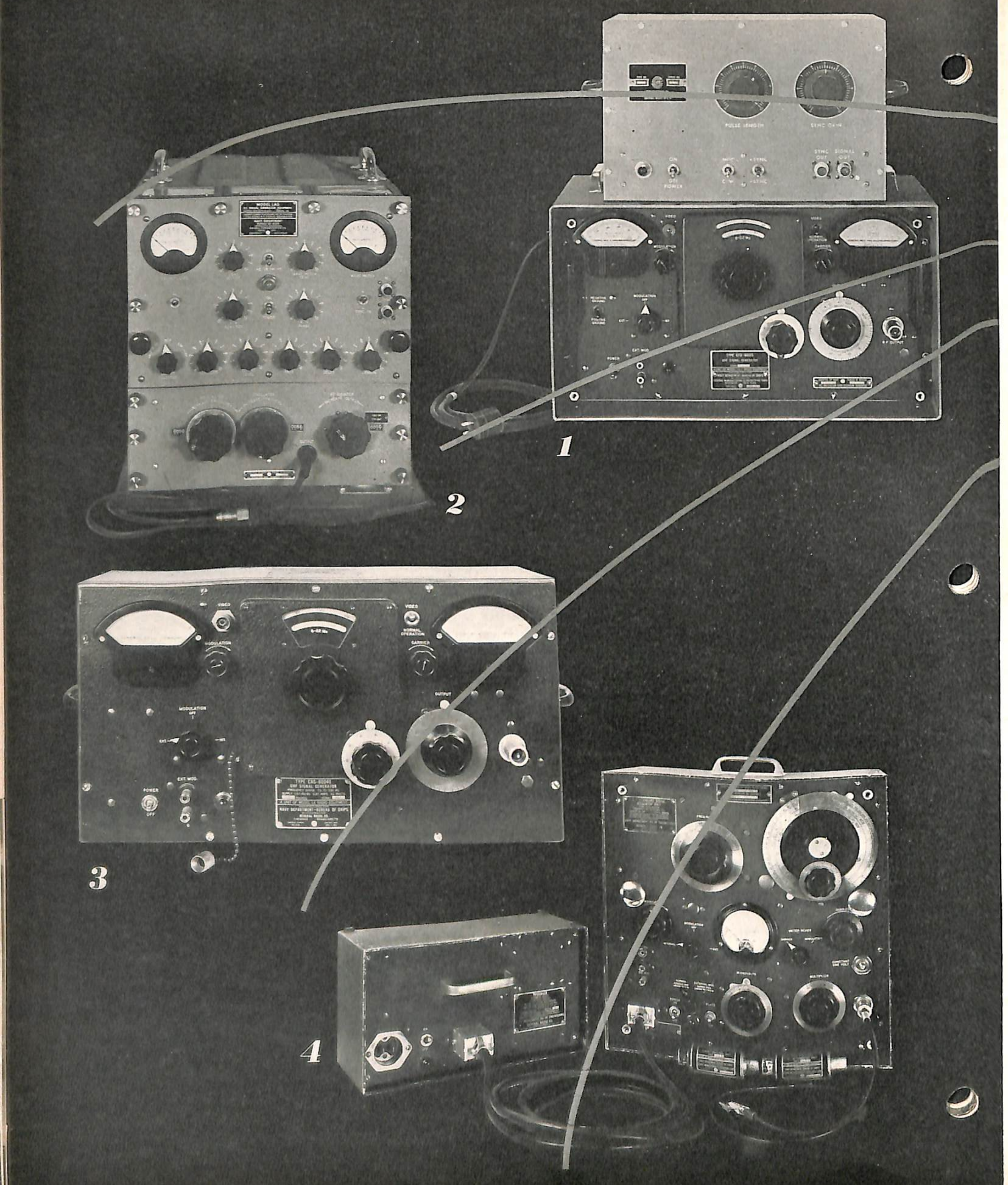
The FDO should vector the plane on various courses to complete a circular flight around the ship at a radius of 20 miles ±4 miles. During the hour period necessary for this flight the ship should maintain steady course, so that uniformly spaced observations will be obtained in all relative directions.

Prior to the test flight, technicians should make a routine check of the radar system, stressing the calibration of range and height-computing circuits and alignment of the precision circuits. The level servo amplifier of the stable element should be adjusted for best operation by turning the gain control clockwise until hunting begins or then backing down slightly until hunting stops. The elevation amplifier for the antenna should be adjusted for smooth operation with minimum elevation-error signal on the high-speed synchro system. The a-c voltage measured between terminals TB3351 (E1) 3 & 5 on SP and between terminals TB3351(E1) 5 & 6 on SM should not exceed 0.5 volts.

During the test flight, the best operating team should track the calibration plane with the SP/SM radar operating in the Stabilized-True-Bearing condition. Whenever on target the precisioning operator should call *"mark!"* and stop turning the handwheels. The range operator should then position the target at the left of the ranging ditch for an accurate range reading at the time *mark*. The following information should be read from the indicators and passed via sound-powered phone (23JS or 24JS) to a recorder for tabulation in Table A:

- Range (to tenths of miles)
- Altitude (to hundreds of feet, e.g. 9.8 thousand feet)
- Relative Bearing (to degrees)
- Elevation Angle (to nearest 5 minutes on SM, to tenths of degrees on SP).

Tracking, accurate positioning, and recording readings as rapidly as possible should permit the obtaining of about 100 readings distributed evenly at four-degree intervals of azimuth. (*continued on page 30*)



* Signal Generators

MODEL LP

The LP is a standard r-f signal generator covering a range from 9.5 kc to 30 Mc, and having a frequency accuracy of one percent. An additional range from 30 to 50 Mc is provided, having an accuracy of three percent. The instrument consists of two units, the radio-frequency oscillator proper, and a power-supply unit. Accessories, including a dummy antenna (simulating a standard antenna) and an attenuator unit, are also provided with each equipment.

The power supply unit furnishes heater and plate voltages for all stages in the r-f oscillator unit. The equipment may be operated from any 115-volt 60-cycle power source. It employs a type 84 full-wave rectifier with a flux-regulated transformer to compensate for line voltage fluctuations. In applications where no a.c. is available, the equipment may be modified to operate from batteries. For battery operation a 200-volt, 40-ma B supply and a 6-volt, 1.7-amp A supply is required.

The r-f oscillator unit contains a carrier oscillator, a buffer stage, a modulation oscillator, carrier and/or modulation VTVM, r-f filter, and an attenuator.

The carrier oscillator is of the conventional tuned-plate type and uses a -76 tube. Seven frequency bands are utilized to cover the range from 9.5 kc to 30 Mc. Seven trimming capacitors and adjustable cores in the coils are provided for resetting the maximum and minimum frequencies should they be known to be in error. These ranges are checked at the factory and normally will not require readjusting. The tuning capacitor dial has four scales. One covers an arc of 180 degrees on the outer ring and is calibrated from 0 to 300 divisions. To use this scale the operator must use the frequency calibration scales in the instruction book. The other outside scale provides a direct-reading frequency calibration accurate to 1 percent with a range from 9.5 kc to 30 Mc. The two inner scales provide direct reading of frequencies from 9.5 kc to 9500 kc. When the 30-50 Mc band is used, the frequency is set up by the use of a separate calibration graph provided in the instruction book. Accuracy is in the order of 3 percent.

The carrier oscillator output is applied to a type 89 tube, called the separator, which performs two functions. It operates as a buffer amplifier between the carrier oscillator circuit and all stages following the separator, and at the same time it is used as the stage where the carrier is modulated by the output of the modulation oscillator or by an external source. The separator has three outputs; one to the attenuator unit, one to the carrier VTVM, and a constant 1-volt output to a jack in the front of the unit. This high-level output voltage can be used for several tests such as receiver performance in strong electric fields, selectivity, etc.

The modulation oscillator is a conventional Hartley circuit employing a 76 tube. The frequency is 1000 cycles ±10%. The modulation voltage supplied to the separator is controlled by a knob on the front panel marked MODULATION.

The meter on the front panel of the r-f oscillator unit is for use as an indicator when setting the carrier to a point of pre-determined value, or when adjusting the percentage of modulation (up to 50%), from either the modulation oscillator or from an external modulation source. The carrier is adjusted to a point on the meter

(1) The LX-1 Signal Generator in metal case with front cover removed. (2) The LAG Signal Generator with output cable connected. (3) The LX Signal Generator in wooden carrying case. (4) The LP Signal Generator with power supply attached. Note dummy antenna unit and attenuator unit in front of main unit.

marked CARRIER SET. After the carrier has been set, the unit is then switched to modulation by appropriate controls on the front panel and the percentage of modulation adjusted, using the same indicating meter.

When using external modulation, care must be taken that the equipment is set up correctly. The unit is not suited for modulation frequencies greater than 1000 cycles per second when the carrier frequency is 300 kc or less. The unit will therefore be operated with the "Normal-External Mod" switch on "Normal". On higher carrier frequencies, the unit will operate satisfactorily with modulation frequencies greater than 1000 cycles but the "Normal-External Mod" switch must be set to "External Mod".

Before attempting to use the LP, the operator should read the instruction book carefully in order to make adjustments intelligently. This applies particularly to the attenuator and correct terminating impedances as described in Section 5.9.

LX

The LX and LX-1, manufactured by General Radio and Federal Manufacturing and Engineering, respectively, are designed and patterned along the same lines as the 804-B but have a few improvements which decrease r-f leakage.

The LX or LX-1 consists of four parts; a uhf signal generator, a 10:1 external attenuator, a jack connector, and a terminal unit. The entire LX equipment is contained in one case. It operates from any 115-volt, 60-cycle source and can be changed very easily to operate from 230-volts, 40-60 cycles. The power supply is a conventional full-wave rectifier using a 6X5GT tube. The power required is approximately 25 watts.

The equipment covers frequencies from 7.5 to 330 Mc in five ranges. The scales are changed by a front-panel control which masks all scales but the one in use. Each range scale is divided into units of 5 or less; for example, the 24-330 Mc band is marked off in divisions of ten Mc and each division is further divided by an indicating mark. When setting up a new frequency, the accuracy is about 2%. When resetting the unit to a previously-calibrated frequency the accuracy is approximately 0.03% provided the settings for the frequency have been properly marked beforehand.

The frequency adjustments are made by a front-panel control which has a 100-division vernier scale on the control knob. This control is geared to turn the frequency-indicating dial mentioned above, and also turns a second large dial which is marked in 15 uniform divisions, thereby providing 1500 effective dial divisions. In this manner great accuracy can be realized when resetting the unit to a previously-calibrated frequency.

The uhf signal generator has only four tubes; a 6X5GT rectifier, a VR-150-30 voltage regulator, a 955 and a 6G6G. The 955 is used in a conventional Hartley oscillator circuit as the carrier oscillator. The tuning capacitor is permanently connected between grid and plate. Provisions are made for switching any one of the five coil assemblies into the circuit when changing ranges. The output of the oscillator is applied to a capacitive voltage divider which allows only about 10% of the total voltage to be available at the attenuator. The output of the attenuator can be varied from 1 microvolt to 20 millivolts by the output control on the front panel.

The attenuator is in the form of two variable capacitors connected in series and operated from the same shaft in such a manner that one increases while the other decreases, but the total capacity of the series combination remains constant in order to prevent changes in oscillator frequency. It acts as an ordinary capacity-type voltage divided, and the output jack is connected across one of the capacitors. On lower frequencies the output impedance of the circuit is about 75 ohms to match the coaxial cable supplied for the equipment.

The carrier setting is accomplished by a control on the front panel which effectively varies the plate voltage on the carrier oscillator. A micro-ammeter in the grid circuit is used for indication.

The 6G6G is used in a second Hartley oscillator circuit as the modulation oscillator. The frequency of oscillation is 100 cycles ±5% at about 70 volts. The percentage of modulation, as read on the modulation indicator, is varied by impressing the 70-volt output across a potentiometer. The output from the potentiometer is applied in series with the plate supply to the carrier oscillator. Facilities are also provided to externally modulate the carrier, using either video or audio frequencies. The external input must be approximately 7 volts in amplitude to obtain 50% modulation.

LAG

The LAG is a general-purpose, ultra-high-frequency signal generator for use aboard ship or in the laboratory for general service work, such as checking the sensitivity and alignment of uhf receivers. It covers the range 1200 to 4000 Mc, and is essentially a bench-mounted instrument as it weighs about 125 pounds. It may be used as a portable in an emergency, however. A total of 18 tubes are required, 11 of these being in the various power supplies. The equipment draws approximately 2 amperes from a 105-125-volt, 60-cycle line.

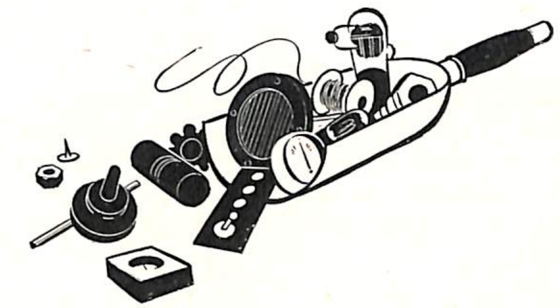
An un-modulated, pulse-modulated, or frequency-modulated signal may be selected for the output by means of a switch on the front panel. The voltage at the end of the six-foot 50-ohm output cable is 40,000 microvolts or greater for all frequencies covered by the oscillator. An attenuator unit can be used to reduce this voltage to approximately 100 db below the existing zero-level voltage. The attenuator is calibrated in db below 1/10 volt across a 50-ohm load. For continuous checks on the r-f output level, a bolometer with an indicating meter is provided. Calibration curves are furnished to determine corrections to be applied to the output level as indicated by the bolometer circuit, at different frequencies.

The oscillator used is of the velocity-variation reflex-type with an adjustable cavity. Two controls are provided, one for setting cavity length and the other to set the repeller voltage accurately in order to peak the oscillator tube to the desired mode. A calibration curve, with approximate dial settings for the complete frequency range, is provided.

The carrier may be either frequency-modulated or pulse-modulated. If frequency modulation is desired, a switch and control are provided so that 60-cycle frequency modulation may be obtained, the amplitude of which may be changed to produce a varying carrier shift. By means of a PHASE control, the phase angle of the frequency-modulated signal may be varied with respect to the 60-cycle supply. If pulse modulation is desired, a pulsing circuit is provided which gives a 1- to 30-microsecond pulse at a repetition rate from 60 to 2500. A pulse delay of from 3 to 300 microseconds is also available.

On the front panel is a SYNC OUT jack. This jack may be used to facilitate taking a pulse from the LAG to synchronize an oscilloscope or to introduce a synchronizing pulse into the LAG from an external source.

Equipment Spares



■ The eventual plan to bin-stock common electronic components aboard all tenders has so much in its favor that it may be extended to equipment spares on individual ships. The plan has worked out exceptionally well aboard fleet electronic ships.

Before delving into the matter too deeply, however the Bureau of Ships desires to get as many suggestions on equipment spares as possible from the fleet as well as from service forces.

It is no secret that existing equipment spares are too bulky, weigh too much, and involve too much fumbling in order to find the right part at the right time. There is in some cases a tremendous duplication of parts aboard ship, and in other instances a serious shortage of badly needed parts. This condition was to be expected during the stress and strain of war, although there is no excuse for perpetuating the difficulties. It is believed that a more suitable plan for spares can be worked out which will be adaptable to peacetime use and economy as well as war-time expansion and necessity.

There may be a need for two classes of equipment spares; a large one for ships of the battleship, cruiser, and carrier types, and a small one for ships of the destroyer and smaller types.

Standardization and interchangeability of electronic units will go far towards reducing the need for so many varieties of parts, and is being accomplished as rapidly as possible.

Proper cataloging has to date reduced the number of different manufacturers parts from 600,000 down to 30,000. A careful analysis has been necessary in order to determine that items are electrically and mechanically alike. Eventually, it would seem that all armed services must arrive at a common cataloging system.

Actual "use-rates" will be employed in determining the required quantities of spare parts, making use of valuable failure reports submitted during the war.

A standard box of common parts (or utility spares, so to speak) might be kept ready at each location containing electronic equipment so that the necessity for access to spare parts boxes or bins during general quarters would be reduced.

Spares supplied with equipments could be reduced to peculiar items only, which could be suitably stored near the equipment. These items are, in general, the heaviest.

Common components could be issued to ships as a set, based upon the electronic allowances. Such parts would not accompany the equipment, if transferred, and would be binned, to facilitate withdrawal.

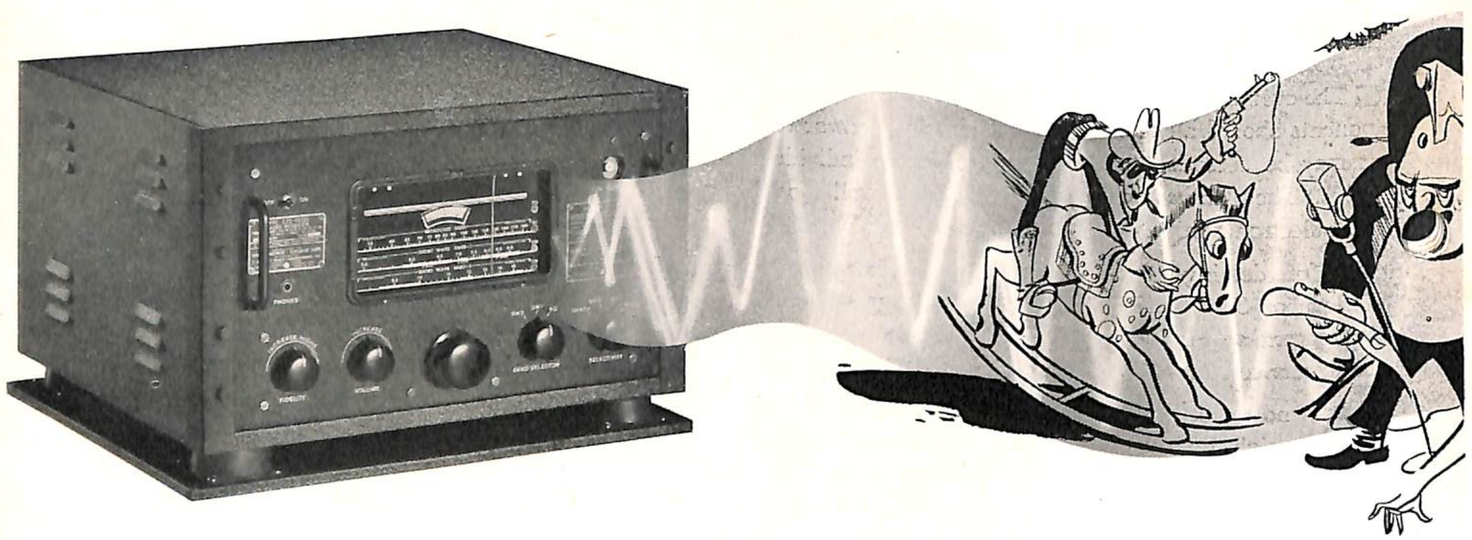
The above suggestions are offered merely as a starter. It is hoped that all activities dealing with the problem of equipment spares will give the Bureau of Ships the benefit of their experience and suggestions. Direct such material to the Bureau, attention Code 980.

Getting the most out of your RBO

The information in this article was obtained from CRE Eldridge A. Helwick, USNR, who repaired some five hundred RBO receivers in the Pacific. Data concerning new speaker-amplifiers was furnished by Mr. Otis A. Anderson, Receiver Design Section, Bureau of Ships.

■ Radio broadcast programs, including the corny singing commercials, have become a definite part of the American way of living. While at sea, being able to enjoy favorite programs and newscasts not only provides entertainment but is a great boost for morale. The Navy has always recognized the value of the broadcast receiver and prior to the war usually permitted the use of personal sets.

During the early stages of the war it became necessary to ban this practice as the majority of such sets transmitted its own oscillator signal, thereby permitting the



enemy to detect movements of our forces. However, the Bureau initiated immediate action to obtain suitable equipment for entertainment purposes, and the Model RBO equipment was the result of this effort.

In view of the fact that the RBO entertainment system is the most-appreciated piece of electronic equipment aboard ship, radio technicians have managed to keep it in some sort of operating condition. It is hoped that this article may help you maintain the equipment at its best.

The equipment proper is of good design and, if properly installed, operated, and maintained, will out-perform the average broadcast set. Unfortunately, being parallel to all electronic developments encountered at the beginning of the war, such complications as priorities, shortage of materials and production facilities, made it imperative to employ certain items and units that were already available or in quantity production. The Navy Type 49131 series of speaker-amplifiers employed in the RBO distribution system was the result of such necessity.

This speaker-amplifier was originally designed as a rugged, blast-proof, general-purpose speaker for voice communication circuits. Consequently the resulting reproduction cannot rightfully be classified as high fidelity. The Navy Type 49545 speaker-amplifier, which will eventually replace the 49131 in the RBO distribution system, has been designed specifically for use with the RBO and should do justice to the capabilities of the equipment.

The major complaints and criticism received by the Bureau in regard to the RBO system has not, however, been the direct result of the limitations of the 49131 speaker-amplifier. Poor installation, authorized and unauthorized modifications, and attachment of additional speakers, microphones, electric megaphones, and phonograph attachments, with little or no regard to impedance matching, has been the greatest factor in creating the distortion and generally unsatisfactory operation encountered in many of the RBO installations.

It is not the purpose of this article to criticize the many mistakes that have been made in this premise, but rather to outline some procedures whereby such errors may be tracked down and corrected so that the best possible performance may be obtained from the RBO receiver.

One of the most common faults found in the RBO installation is the improper connection of the receiver to its output load or speaker distribution system. The output circuit of the RBO contains an output transformer having three secondary windings to match a load impedance of either 5000, 600, or 60 ohms. One leg of each of these secondary windings are connected together internally and brought out to a common terminal which is connected to the chassis and ground. The input transformer of the 49131 speaker-amplifier has a center-tapped primary and, as supplied to the Navy, has the center tap grounded for balance-line inputs. Connecting the 49131 speaker-amplifier to the RBO results in shorting out half the primary of the input transformer in the speaker-amplifier which, in turn, causes distortion, frequency discrimination, and loss of power. Many technicians recognized this trouble and corrected the condition by simply removing the jumpers in each of the 49131 speaker-amplifier units connected in the system.

Due to cross-talk encountered in many installations having two or three RBO receivers operating into a single distribution system, an erroneous modification was inadvertently authorized by Radio Installation Bulletin 58 of 26 February 1945. This modification consisted of removing the common terminal of the RBO output transformer from ground, insulating the phone jack from the chassis, and shunting the 600-ohm winding with two 300-ohm resistors, the junction of the resistors being connected to ground. This modification eliminated the difficulty of cross-talk and the possibility of removing the load from the RBO when all speakers were switched

This Model CRV-49545 speaker-amplifier will replace units now being used with the RBO receiver. Fidelity is improved by the use of a "bass-reflex" cabinet, larger speaker, and tone control.

to another circuit, but also presented a full load to the output tube with the result that the addition of any speaker-amplifier units caused mis-matching of impedances, distortion, and loss of power. Distortion in music reproduction was minor compared with the unintelligibility that resulted due to reduction in high-frequency response. This was corrected later in RIB 124 of 2 June 1945 wherein it was outlined that the two 300-ohm resistors should be connected across the 60-ohm winding rather than the 600-ohm winding as previously stated. This modification presents only a 10% loading of the output tube, obviates the possibility of removing the load from the receiver when all the speaker-amplifiers are switched from the circuit, and provides a balanced output circuit for elimination of cross-talk between equipments. The necessary parts and instructions to facilitate this modification have been supplied to the fleet in RBO Modification Kit #3. It has been noted that in many cases where the above modification has been made, the phone jack was not insulated from the chassis. Fiber insulating washers or bushings for insulating this jack are included in the kit.

Some recently inspected installations will show that impedance matching is entirely ignored. Two particular installations with receivers having the 600-ohm winding modified for balanced-line operation (100% loading) had twenty 49131 speaker-amplifiers (equivalent load of 30 ohms) and a 4-ohm monitor speaker all connected across the 60-ohm winding.

The basic laws of impedance matching state that in order to keep frequency and harmonic distortion at a minimum in audio circuits, the impedance of the load must match the impedance of the source. The combined total loading should at all times present to the output tube the recommended loading and under no circumstances a lower impedance loading. If this cannot be done, it is much better to feed into a higher impedance with some loss in power than into a lower impedance which results not only in a loss of power but increased distortion. This mis-match should never exceed about 2-to-1, however.

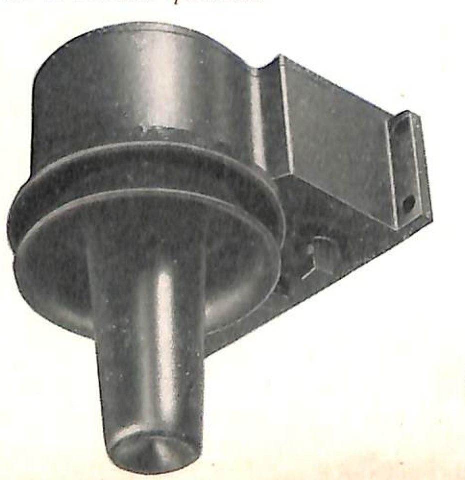
The introduction of negative feed-back or degeneration in the design of audio amplifiers has helped to compensate for any slight mis-matching. This feature is included in the design of the 60-ohm output circuit of the RBO receiver. Theoretically, the correct loading for the RBO is ten 600-ohm speaker-amplifiers connected in parallel to present a 60-ohm load to the receiver. However, good results are possible by feeding one to ten speaker-amplifiers from the 60-ohm winding.

For any installation, only *one* of the three output windings should ever be employed at a time for supplying audio power to loudspeaker circuits. However, this does not preclude the use of a head telephone set for monitoring while the loudspeaker system is in operation.

COMMON FAILURES

6X5-GT rectifier tubes with their heaters grounded or at chassis potential were used in the early RBO's. This practice had the advantage of eliminating the need for a rectifier filament winding on the power transformer, but the tubes were subjected to a high cathode-heater potential difference. This resulted in reduced tube life and, due to shorted tube elements, considerable damage to power transformers and other components. Tubes were usually subjected to vibration and shock encountered aboard ship and in many instances to fluctuating or abnormally high a-c voltages that contribute largely toward breakdown failures.

The Model CRV-49456 is weather-proof and very rugged in construction. This speaker will be standard for all outside installations and will replace all former and ad interim speakers.



Blowing of the 2-ampere line fuses F-101 usually resulted from breakdown of 6X5-GT tubes. Although there is a notice on the rear of the RBO receiver chassis cautioning the technician that the fuse rating should *not* be increased, some 20- and 30-ampere fuses have been found in sets where the power transformers were burned to a crisp. If your set employs 6X5-GT rectifier tubes, check them occasionally and insist on 2-ampere fuse protection. Also check the a-c line voltage. Recent 6X5-GT tubes are of better design and construction, and should therefore prove satisfactory.

For some time a replacement transformer incorporating a 5-volt secondary winding for converting over to 5Y3-GT rectifier tubes has been available at navy yards and radio pools. It is known as RBO Modification No. 2, and has been approved by BuShips. It is covered in RIB No. 123 of 26 May 1945 (Vol. 5).

Failure of the 680-ohm, 2-watt bias resistor for V-109 (6K6-GT in early models and 6V6-GT in later models) was common. Most failures were caused by gassy or shorted power tubes, though any abnormal plate current would cause this trouble. A ten-watt resistor can be used for more satisfactory results.

The RCA Voltohmyst Jr., or any electronic d-c voltmeter, is handy for checking voltage in high-resistance audio circuits. With a good power tube in socket X-109, and normal a-c line voltage, the voltage drops across the cathode bias resistor should be approximately 21 volts. The control grid voltage with respect to the cathode should be the same, and any lower voltage would indicate a gassy power tube or leakage in the .005 μf coupling capacitor C-127.

In a few cases R-131, the 470 k plate-load resistor for V-108, has increased in value causing low volume. In some sets the 470 k screen-dropping resistor R-138 has also increased in value. These resistors should be checked and replaced if necessary.

The .02 μf tone-control capacitor C-118 connected from the plate of the first audio tube V-107 through the variable 250,000-ohm tone-control unit to the chassis sometimes fails. Capacitor leakage can be checked with an electronic d-c voltmeter by turning the tone control fully clockwise and noting if there is any d-c voltage present at the tone-control side of C-118. If any d-c voltage is present, the capacitor should be replaced.

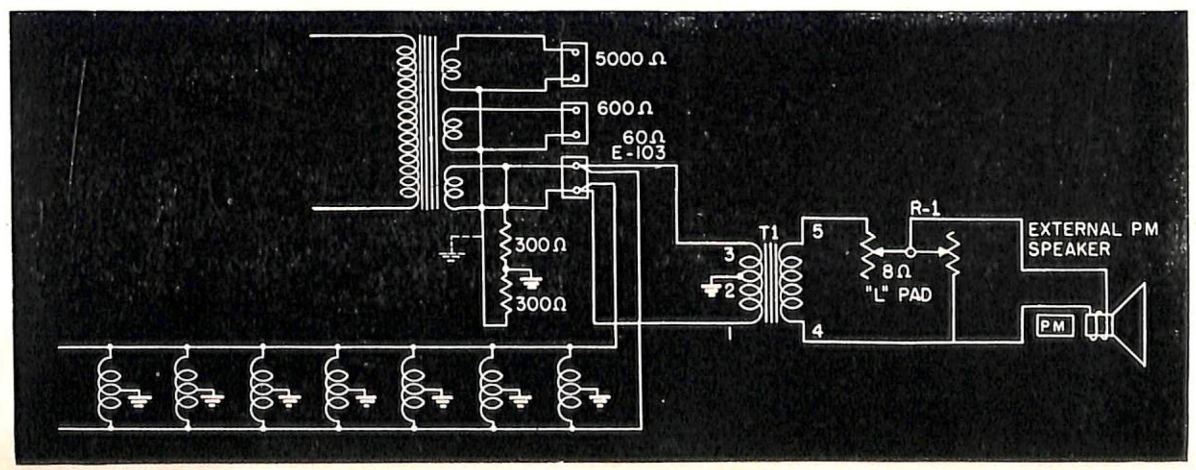
If the 6E5 magic-eye tube V-110 is good but does not close on strong signals R-150, the target load resistor, may be open or increased in value. It should be replaced, if necessary, with a new resistor and R-148 readjusted for desired operation. A dull screen is the usual indication of a weak or worn out tube which should be replaced if a brighter image is desired.

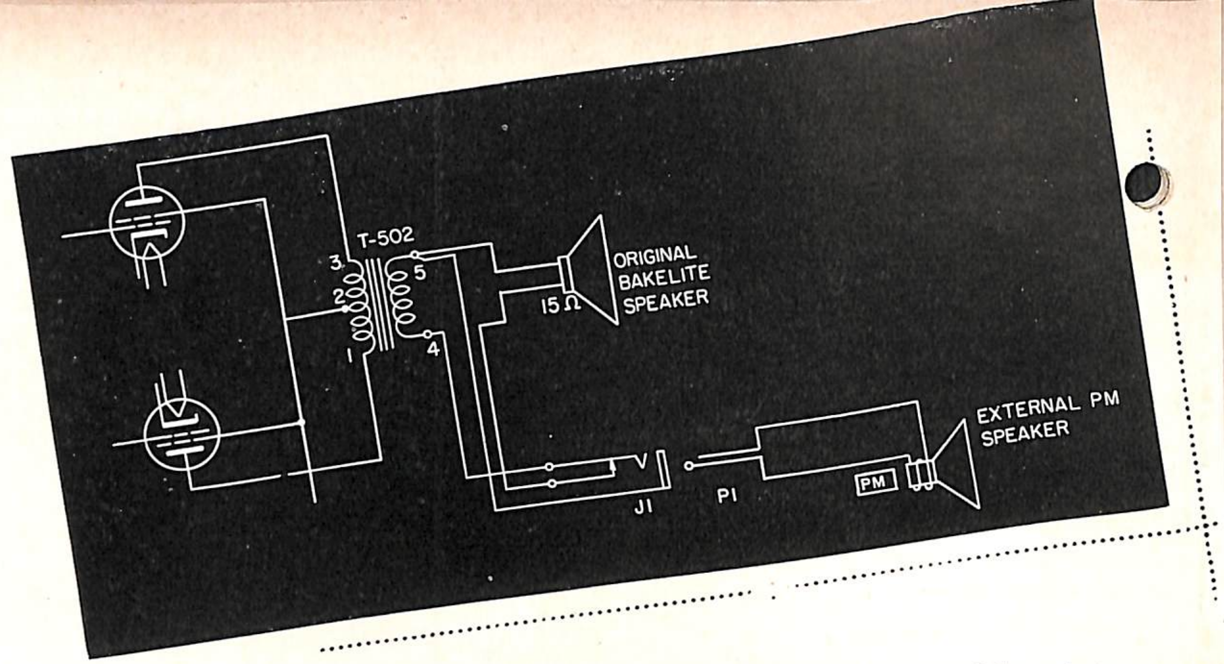
SERVICING THE RBO

One of the most important steps toward keeping any piece of electronic equipment in good operating condition and reducing failures to a minimum is a regular cleaning routine. A small paint brush, rags, a bottle of carbon tetrachloride, an air hose or bellows, and a little energy are the only things necessary. After dust has been loosened with the brush it can be removed with air or rags as appropriate.

All tubes should be checked on an OZ or similar tester every month. A flickering of the meter pointer while

An external speaker may be used at low volume levels if an amplifier unit is not available, but an 8-ohm L- or T-pad should be inserted as shown for control of the volume.





The addition of a jack to the speaker-amplifier unit permits use of a better-quality speaker. When plug is inserted, the original speaker is automatically disconnected.

tapping or thumping tubes under test will indicate any intermittent shorts.

The Hallicrafters PM-23C with a 5000-ohm matching transformer is an excellent speaker for use in testing operation of the RBO, though any good PM speaker with a 5000-, 600-, or 60-ohm transformer will serve the purpose.

The i-f amplifier, second detector, and audio amplifier tubes should be checked for intermittent shorts and microphonics. Either a modulated or an unmodulated i-f signal may be used. Slightly noisy tubes can easily be located by using a strong unmodulated signal, since any tubes with loose elements will modulate the carrier.

The Navy Model LP is probably the best signal generator for use in aligning the RBO, but is by no means the only one that can be used. Any stable signal generator covering the frequency range will be satisfactory.

Instruction books suggest that the generator be connected to the control grid (terminal #8) of the first detector V-103. Experience has shown, however, that it may just as well be connected to the terminal on the stator section of the tuning capacitor, thereby eliminating the possibility of disturbing critical circuit constants. If the signal generator is connected in the latter position, a slightly higher output will be required because coupling capacitor C-123 will be in series with the i-f signal.

The dummy antenna should always be used with the LP, even at i-f frequencies, as its internal capacitor will protect the r-f attenuator from exposure to any possible d-c voltages. Several attenuators have been burned out in the field by carelessness in attempting to connect the LP output leads directly to some tube terminal, and touching the lead against a d-c voltage on another terminal.

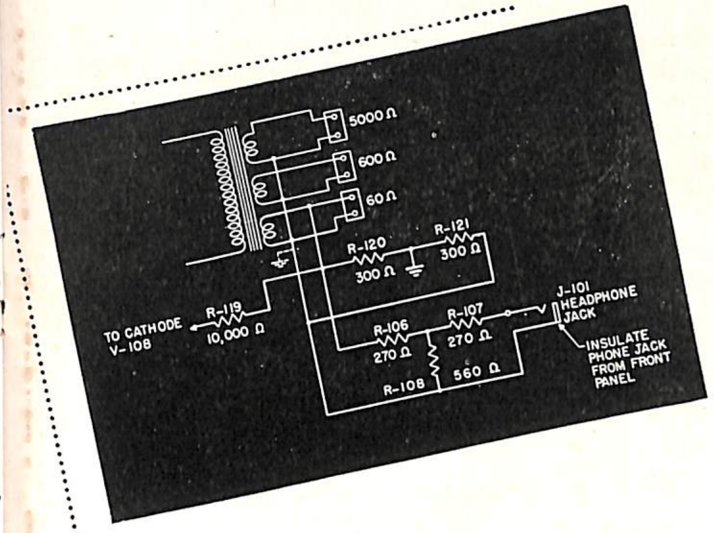
The use of an electronic voltmeter, RCA Voltohmyst Jr. or Hickok Model 202, connected to the automatic volume control system is strongly recommended for all receiver alignment operations. It has many advantages over the old system of using an output meter or db meter for resonance indication. When using an audio output indicator (db meter) it is necessary to keep the signal level from the r-f signal generator below the threshold of the receiver's automatic volume control system. Severe electrical interference (ABK, BL and most radar equipment undergoing test) or static background noise usually present, make correct alignment a tedious, nerve-racking job. Compromises are made in some cases by using a stronger r-f carrier level which usually results in overloading and double-hump resonance misalignment. Close observation has revealed that many technicians and engineers use alignment methods that need correction.

With the automatic volume control method it is possible to use an r-f signal level that is above the background noise, operate the r-f and i-f amplifier tubes at a more nearly normal operating point on their characteristic curve, secure more rapid alignment with stable meter indication, and finally obtain a noiseless condition if desired by turning the volume control down or using an unmodulated r-f signal.

A convenient connection point for the electronic voltmeter is to the grid-return lug on the first i-f transformer T-110.

The three i-f transformers should be aligned according to standard procedure, using AVC and an electronic voltmeter for resonance indication. An r-f signal strong

Schematic diagram shows correct modification for balanced-line output.



enough to produce five to seven volts AVC is satisfactory.

Complete alignment to the antenna, first detector, and oscillator circuits should be done following the procedure outlined in the RBO instruction book. The 6K7, 6SA7, and 6J5 tubes in the r-f and oscillator compartment should be thoroughly checked for intermittents, microphonics, or other noise, before proceeding with the r-f and high-frequency oscillator circuit alignment. Some tubes that check very well in tube checkers do not perform very well at higher frequencies. Several new tubes should be tried in these sockets, noting sensitivity and noise. Extreme care should be exercised in all alignment operations. Proper tracking is not always attained and a common mistake is that of tuning the oscillator to the high-frequency rather than to the low-frequency side of the incoming carrier on bands 2 and 3. It is highly advisable to re-align each band several times, using the trimmer capacitors at the high-frequency end and the iron-core inductor adjustments at the low-frequency end to obtain best results. Good sensitivity, tracking, and dial calibration can be secured. A sensitivity of two microvolts throughout bands 2 and 3 can be obtained, while band 1 should be about 5 to 7 microvolts at 600 kc and 2 microvolts at 1500 kc.

This extreme sensitivity may never be utilized aboard ship as the average electrical interference noise level is usually over 20 microvolts and many small vessels have a noise level of 100 or more.

Considering the fact that the useful sensitivity of the RBO or any receiver is limited only by the prevailing noise level, all electrical interference encountered aboard ship should be reduced to a minimum by shielding, bonding, etc. The receiver is a program or amusement receiver, and the necessity for interference suppression is not as great as for communication receivers. However, eliminating interference will greatly enhance the entertainment value of the system.

SPEAKER AMPLIFIERS

The Type 49131-A, -B, and -C speaker-amplifiers which generally have been used with the RBO were designed to withstand sea spray, concussion from gunfire, and general shock conditions experienced aboard combatant vessels of all types. Due to the speaker cone construction these speakers are unsuitable for the reproduction of music or for full utilization of the receivers' high-fidelity characteristics.

These speaker-amplifiers have required only general servicing and replacement of such parts as noisy volume controls, broken or noisy channel selector switches, open filter chokes, and burned-out input and output transformers. Several cases of input transformer failures were traced to experimenters or unqualified personnel exchanging the audio input cable with the 120 volt a-c or d-c power cable while attempting to make quick temporary repairs to a dead or weak speaker-amplifier. This condition was usually noted aboard small vessels that used DHFA-3 cable for both audio and power supply. An a-f signal generator is helpful in servicing the amplifier and especially in locating resonant speaker cone rattles. Noisy speaker cones should be replaced with new cones after removing the old cone and cleaning the magnetic air gap of iron filings and other foreign matter. In the event a new cone is not available for this replacement, cleaning the voice coil structure and re-cementing any loose voice coil turns will remove most rattles.

Bakelite speaker cones have a peak at approximately 3000 cycles, which makes the Type 49131 series speaker-amplifiers good for intelligibility of speech but inadequate for music.

Because there are many areas aboard ship where the blast-proof and water-resistant protection of the 49131 speaker-amplifier is not required, and because of the general interest in better sound reproduction, the newer Type 49620 speaker-amplifier, incorporating a soft paper cone speaker of slightly larger dimensions, has been made available as an interim unit. The improvement in frequency response makes this model a suitable replacement.

The production of the 49131 series and 49620 speaker-amplifiers has ceased and deliveries of these specific units have been completed. Future production of speaker-amplifiers is being limited to units now under development which will become standard for ship-board installation on radio communication and on broadcast entertainment circuits.

The Type 49620 speaker-amplifier is intended primarily for use on the broadcast entertainment circuit pending the availability of the completely new Type 49545 speaker-amplifier unit which will be standard for this circuit. The 49545 unit will be available early next summer, and is of an entirely new design using the "bass-reflex" principle to achieve improvement in low-frequency response over that of all previous units.

Due to the unavailability of the new 50210 audio amplifier now under development for use with the Type 49546 speaker, it has also been necessary to use the 49620 speaker-amplifier on radio communication circuits for an interim period. The 49546 speaker is a weather-proof and blast-proof unit which is presently intended only for open-bridge and other exposed locations. Eventually it is contemplated that the 49546 speaker with the 50210 audio amplifier will supersede all presently employed speakers and speaker-amplifiers for all shipboard communication circuits. The 49546 is a diaphragm-type driver unit coupled to an air-column horn of the radial reflex type and is radically different from the cone-type of direct radiator speaker which has prevailed in ship-board radio installations for a number of years. The radial feature permits mounting this unit in many locations heretofore impracticable.

All RBO installation plans approved by the Bureau of Ships incorporate a TTHFA-5 cable for audio distribution, spare channels being available for phonograph record programs.

A record player capable of playing both 78 and 33⅓ rpm broadcast transcription recordings has been available through the Bureau of Naval Personnel and the Welfare and Recreation departments of the Navy.

Connecting the output of the record player amplifier directly into the spare audio channel at the RBO output distribution box has been covered in RIB No. 85 of 2 September 1944. The 10-ohm, 10-watt resistor may be used for a dummy load, but it is suggested that the speaker be retained in the circuit of the phonograph amplifier for a monitor while playing recordings. Omit the load resistor in this case.

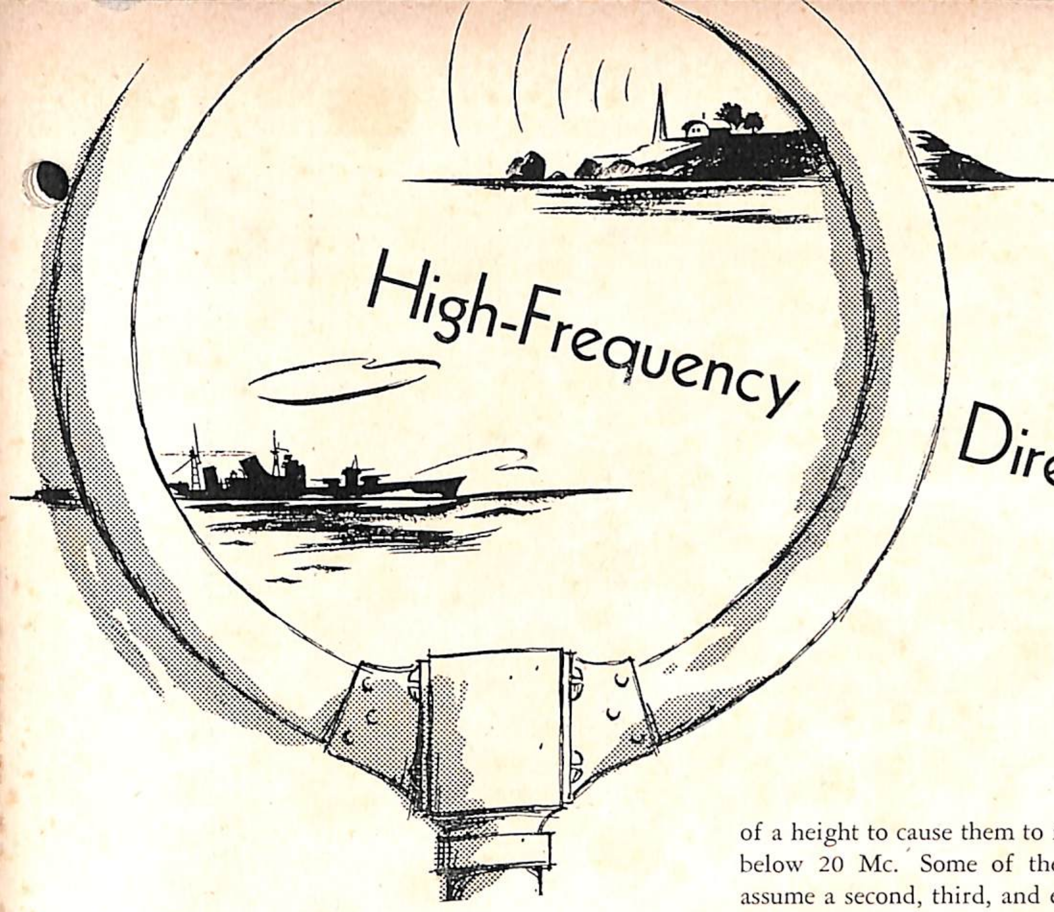
The importance of maintaining approximately the same relative audio level from all receivers and the phonograph channel cannot be overemphasized. The audio volume control of the RBO receiver should be adjusted up to but not beyond the level necessary to drive each 49131 or 49620-type speaker-amplifier to maximum volume level with its volume control in the extreme clockwise position.

The RBO receiver was designed for headphone monitoring, but many installations include a local loudspeaker for monitoring and entertainment of the radio personnel. Impedance matching has been totally disregarded in most instances, and it is not uncommon to find a 4-ohm voice coil connected across the 60-ohm or 600-ohm output terminals! An additional 49131 or 49620-type speaker-amplifier should be used, although a speaker alone could be used at low volume levels if connected so as to add only a slight load of ten to fifteen percent. Volume should be controlled by a low-impedance 6 to 8-ohm L or T pad volume control.

Intermittent Azimuth Marks on VF's

■ When a VF is repeating a radar with a 60-cycle repetition rate, the azimuth marks on the *B*-tube may skip at random intervals. This results from the fact that the duration of the flash from the azimuth-marks amplifier (V-1203) as well as the time constant of the coupling between this amplifier and the *B*-tube are shorter than the repetition period of the radar. Thus the azimuth mark may occur completely between repetitions of the radar. This condition is greatly accentuated by low-intensity azimuth marks which may result from either a weak azimuth-marks amplifier (V-1203), weak photo cell (V-1202), improper positioning of exciter lamp (I-1210), or dust in the slots of the drum or aperture.

Since the shape of the azimuth-mark pulse is in the form of an inverted V, any factor which reduces its amplitude will automatically reduce its duration. Therefore, if a VF is found to be skipping azimuth marks seriously, an attempt should be made to increase the amplitude by investigating the items listed above. Ordinarily, if the unit is in good operating condition otherwise, the azimuth-mark skipping will be infrequent and will not be sufficient to eliminate the appearance of the marks on the tube. —*Raytheon*



High-Frequency Direction Finders

■ The provision of accurate and reliable high-frequency direction finders in Naval ships for a continuous frequency coverage of 3 to 30 Mc is one of the most difficult technical problems in the whole field of Navy direction finders. The results obtainable even after elaborate precautions have been taken are, for instance, very much inferior to those which are obtained in ships on MF and under some circumstances in the VHF frequency ranges.

In general, accurate and reliable direction finding in ships is only possible when the DF antenna can be placed in such a position that the secondary fields caused by metallic objects in the vicinity are small compared with the main incident field. It is also necessary, for accurate results over a band of frequencies, that any secondary field present should not vary greatly for a small change in frequency.

In the 1-30 Mc range a number of parts of the ship's structure and rigging will successively assume the quarter-wave resonant condition as the wave length is progressively decreased. First the masts, approximately 100 ft above the water line, will resonate at a frequency of about 2.5 Mc. The various radio antennas may have resonances at about the same frequency. The bridge superstructure will resonate at about double this frequency (5 Mc), and the stacks standing about 30 ft above the deck will be in resonance at about 7 Mc. There are also numerous other small parts of the ship which are of a height to cause them to resonate at other frequencies below 20 Mc. Some of the structures mentioned will assume a second, third, and even higher mode of oscillation within the working frequency band.

It is seen that any position in a ship where HF/DF may be installed is under the influence of a complex secondary field caused by re-radiation from a large number of oscillators resonant to different frequencies within the working range.

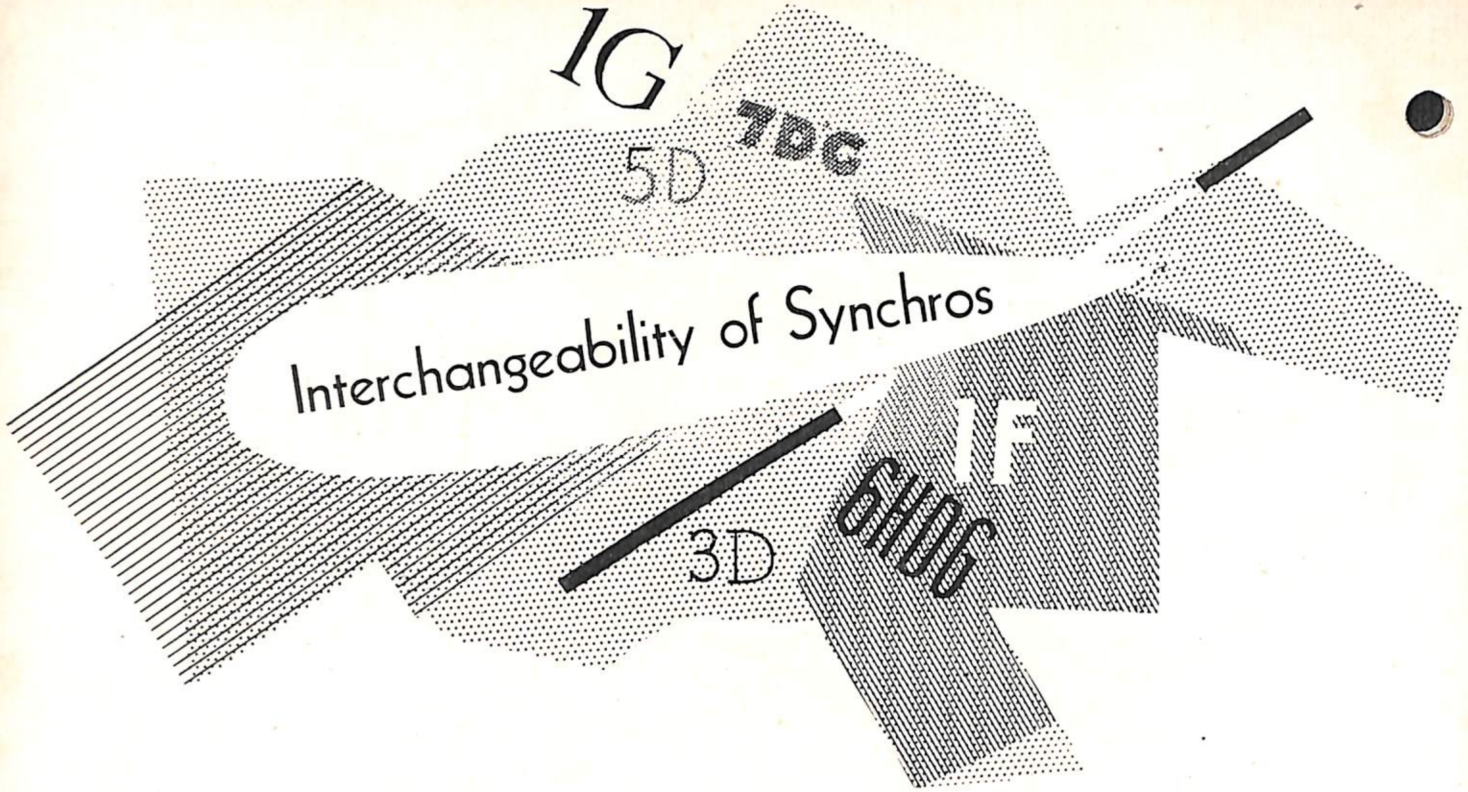
It is to be noted that for a slight departure from the resonance frequency of each of the structures there will be a large change in the re-radiation and therefore in the deviation it produces.

To avoid harmful effects by re-radiation from the mast on which the antenna assembly is mounted, complete symmetry of the antenna about the vertical axis of the mast and its rigging is essential.

The antenna assembly must be fixed exactly co-axially with its supporting mast. The smallest asymmetry even amounting to a fraction of an inch may produce considerable error, amounting to many degrees.

It is preferable to have the bottom of the mast welded to the main deck itself (riveting may not give sufficiently good contact) and the cables from the DF antenna assembly must not be supported on conduit or channelling enroute to the direction finder room.

In view of the above, every effort should be made to keep the secondary fields at a minimum, and the importance of proper alignment of the antenna assembly cannot be overemphasized.



Interchangeability of Synchros

■ Supply activities report enough confusion on requisitions for ordnance type synchro[1] units that perhaps a word of explanation won't hurt anyone.

Requisitions too often specify both Mark and Mod numbers. This is unnecessary because when a synchro unit has a Mark number—and nearly all types do—all Mods of the same type and Mark are interchangeable. It is only when a unit has a *Mod number only* that interchangeability does not exist.

For example:

(a) 5SB Mod 1 is not interchangeable with 5SB Mod 2 (*no Mark numbers*).

(b) 5F Mk 4 Mod 1 is interchangeable with 5F Mk 4 Mod 2 (*Mark numbers*).

In the case of certain special synchros of early manufacture, Mark numbers were not assigned, nor will they be assigned in view of the task such action would entail in stamping the numbers on the nameplates. However, all new types of synchro units will carry Mark and Mod designations.

The Model indicates the manufacturer as follows:

- Mod 1—Arma Corporation
- Mod 2—General Electric Co.
- Mod 3—Ford Instrument Co.
- Mod 4—Bendix Aviation Corporation
- Mod 5—Central Instrument Co.
- Mod 6—Diehl Manufacturing Co.
- Mod 7—Bennel Machine Co.

The letters A, B, etc. indicate minor design changes (as Mod 1, Mod 1A, Mod 1B) but the units are still interchangeable.

Recently some improved types of synchros have been designed and will soon be available for replacement. In most cases the improved type has the letter "H" prefixed to the type designation of the unit. The H denotes *high speed,* and shows that the newer unit has had incorporated in its design better bearings and brushes and improved lubrication. This design is essential where high rotational speed is encountered, and it furthermore affords longer life where the synchro application is of a general nature and is not being used for a specialized purpose. An example of this type of synchro is the 5HG Mk 6. In most cases a synchro of the new "high-speed" type can be used as a replacement for its low-speed counterpart. However, instruments of recent design, whose designs have been based on the capabilities and longer life of the high-speed type of Synchro should not use the low-speed counterpart as a replacement. An example is shown by the fact that a 5HG Mk 6 can be used as a replacement for the 5G Mk 1, but the 5G Mk 1 should not be used as a replacement for the 5HG Mk 6.

In the following tables interchangeable synchros are shown. Note that the first choice for replacement is not always the same as the original unit. This is because newer types may be preferable. It should also be pointed out that not every synchro listed in this table is immediately available. Some of the newer ones, mostly of the high-speed type, have not yet gone into production.

Installed Synchro			Replace with First Choice			Replace with Second Choice			Remarks
Type	Mk	Mod	Type	Mk	Mod	Type	Mk	Mod	
GENERATORS									
1G	5	any	1HG	14	any	1G	5	any	
1HG	14	any	1HG	14	any	......	......	......	
1HG400	13	any	1HG400	13	any	......	......	......	400 cycles.
3HG	10	any	3HG	10	any	......	......	......	
5G	1	any	5HG	6	any	5G	1	any	
5HG	6	any	5HG	6	any	......	......	......	
5HG400	12	any	5HG400	12	any	......	......	......	400 cycles.
6G	2	any	6HG	7	any	6G	2	any	
6HG	7	any	6HG	7	any	......	......	......	
7G	3	any	7HG	9	any	7G	3	any	
7HG	9	any	7HG	9	any	......	......	......	
7SG	8	2	7SG	8	2	7G	3	any	Special windings.
MOTORS									
1F	8	any	1HF	14	any	1F	8	any	
1HF	14	any	1HF	14	any	......	......	......	
1F400	7	any	1F400	7	any	......	......	......	400 cycles.
3F	9	any	3F	9	any	......	......	......	
3HF	15	any	3HF	15	any	......	......	......	
5F	4	any	5F	4	any	......	......	......	
5HF	11	any	5HF	11	any	......	......	......	
5F400	12	any	5F400	12	any	......	......	......	400 cycles, standard.
5SF	......	3 or 4	5F400	12	any	5SF	......	3	400 cycles, special.
5B	5	any	5B	5	any	......	......	......	When Mods are interchanged, brush block supplied with spare synchro unit must also be changed.
5SB	......	1	5SB	......	1	......	......	......	Special high torque.
5SB	......	2	5SB	......	2	......	......	......	Special high accuracy.
5N	6	any	5N	6	any	......	......	......	
5SN	......	1	5SN	......	1	......	......	......	Special high torque.
5DB	9	any	5DB	9	any	......	......	......	
DIFFERENTIAL MOTORS									
1D	1	any	1D	1	any	......	......	......	
1HD	5	any	1HD	5	any	......	......	......	
3D	3	any	3D	3	any	......	......	......	
5D	7	any	5D	7	any	......	......	......	
5D400	4	any	5D400	4	any	......	......	......	400 cycles.
DIFFERENTIAL GENERATORS									
1DG	1	1	1HDG	13	any	1DG	1	1	Mk 1 Mod 1 must be used for Stable Elements and Stable Verticals, in order to avoid interference.
1HDG	13	any	1HDG	13	any	......	......	......	
1HDG400	15	any	1HDG400	15	any	......	......	......	400 cycles.
3HDG	8	any	3HDG	8	any	......	......	......	
5DG	4	any	5HDG	9	any	5DG	4	any	
5HDG	9	any	5HDG	9	any	......	......	......	
5HDG400	14	any	5HDG400	14	any	......	......	......	400 cycles.
6DG	5	any	6HDG	10	any	6DG	5	any	
6HDG	10	any	6HDG	10	any	......	......	......	
7DG	6	any	7HDG	11	any	7DG	6	any	
7HDG	11	any	7HDG	11	any	......	......	......	

[1] *Synchro* is the general term for these units; not Selsyn, which is a General Electric Co. trade name.

Installed Synchro			Replace with First Choice			Replace with Second Choice			Remarks
Type	Mk	Mod	Type	Mk	Mod	Type	Mk	Mod	
CONTROL TRANSFORMERS									
1CT	......	2	1CT	......	2	......	......	......	Special mounting and shaft.
1CT	......	3	1CT	......	3	......	......	......	Special low impedance.
1CT	5	any	1HCT	11	any	1CT	5	any	1CT no Mk Mod 3 third choice.
1HCT	11	any	1HCT	11	any	......	......	......	
1HCT400	9	any	1HCT400	9	any	......	......	......	400 cycles.
3HCT	7	any	3HCT	7	any	......	......	......	
5CT	1	3	5HCT	6	any	5CT	1	3	Mk 1 Mod 3 must be used for 36" Sperry Searchlight.
5CT	3	any	5HCT	6	any	5CT	3	any	
5HCT	6	any	5HCT	6	any	......	......	......	
5HCT400	10	any	5HCT400	10	any	......	......	......	400 cycles.
5SB1	......	2	5CTB	8	any	5SB1	......	2	Bearing mounted control transformer.
5CTB	8	any	5CTB	8	any	......	......	......	
5SDG	......	1	5SDG	......	1	......	......	......	Special low impedance control transformer.
5CTB	......	1	5CTB	......	1	......	......	......	Special bearing mounted low impedance control transformer.
6CT	2	2	6CT	2	2	......	......	......	
5SCT	......	2 or 4	5SCT	......	2 or 4	......	......	......	90/22.5 volts.
CAPACITORS									
....	1	any	....	1	any	....	......	......	
....	2	any	....	2	any	....	......	......	
....	3	any	....	15	any	....	3	any	
....	4	any	....	4	any	....	......	......	
....	5	any	....	1	any	....	5	any	
....	6	any	....	2	any	....	6	any	
....	7	any	....	15	any	....	3	any	
....	8	any	....	4	any	....	8	any	
....	9	any	....	9	any	....	......	......	
....	10	any	....	10	any	....	......	......	
....	11	any	....	11	any	....	......	......	
....	12	any	....	12	any	....	......	......	
....	13	any	....	13	any	....	......	......	
....	14	any	....	14	any	....	......	......	
....	15	any	....	15	any	....	3	any	

NEW FIELD-CHANGE POLICY

The Bureau desires that the following policy be applied in respect to accomplishment of field changes to electronic equipments (sonar, radio, radar, etc.).

Active Fleet: All field changes which are applicable to equipment installed in vessels of the active fleet shall be made. Vessels of the active fleet shall have priority over vessels of the reserve and inactive fleets. All field changes shall be made on vessels of the active fleet as soon as availability and materials permit.

Reserve Fleet: Only field changes which can be accomplished by the vessels RT's should be made on vessels of the reserve fleet. Other field changes may be requisitioned and stowed in a safe place aboard ship under the following conditions:

(a) The kits are available in adequate quantities, i.e., enough to take care of all active vessels and then supply the reserve fleet.

(b) The bulk of the field change is not so great as to cause stowage difficulty.

A complete and accurate list should be kept of all stowed field changes and their exact location. This list should be kept in a place where it can be easily found by the man who relieves you.

Inactive Fleet: No field changes shall be stowed or accomplished on vessels of the inactive fleet as long as they remain in that status.

Lightweight Loran Model DBS

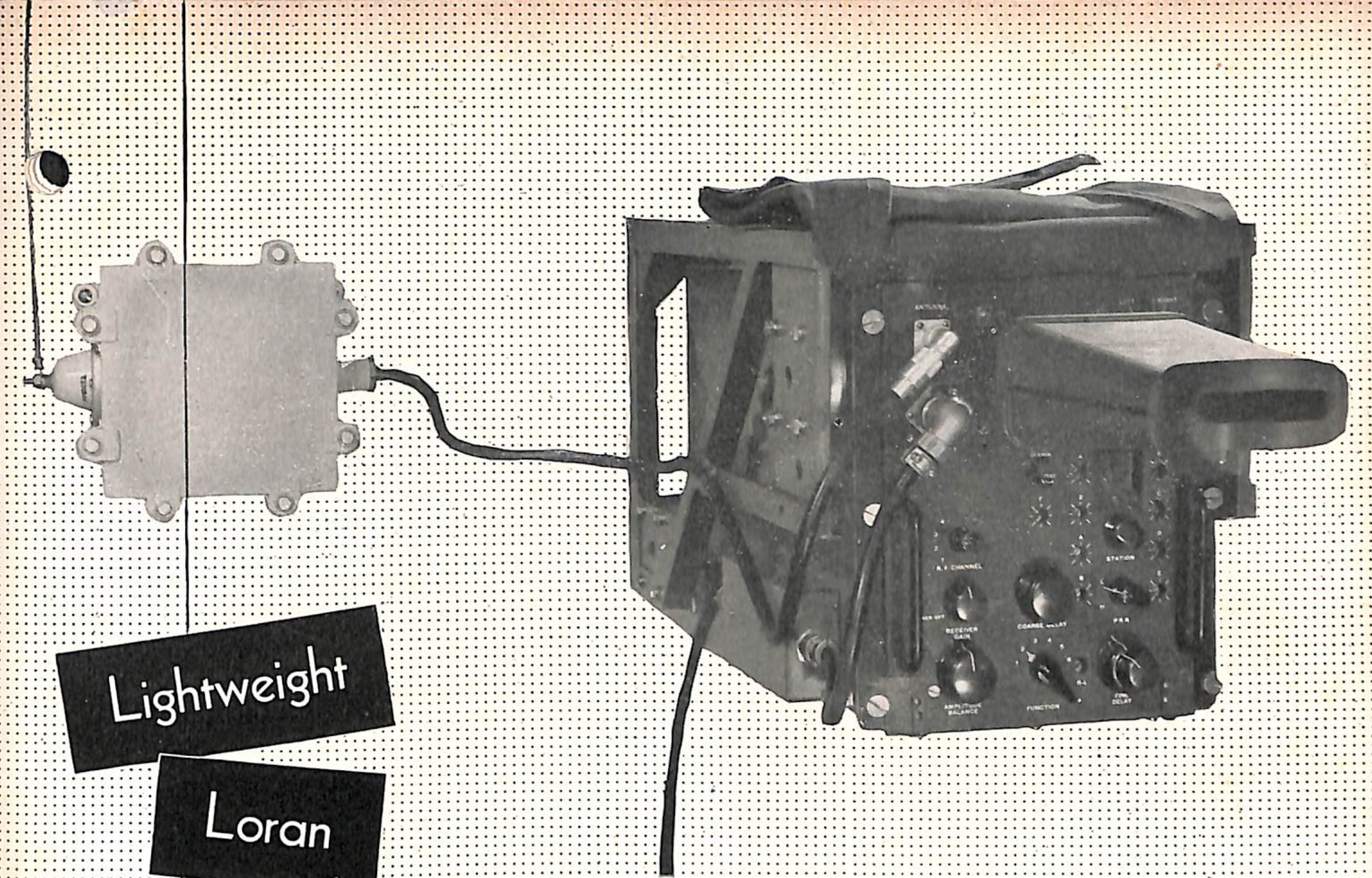
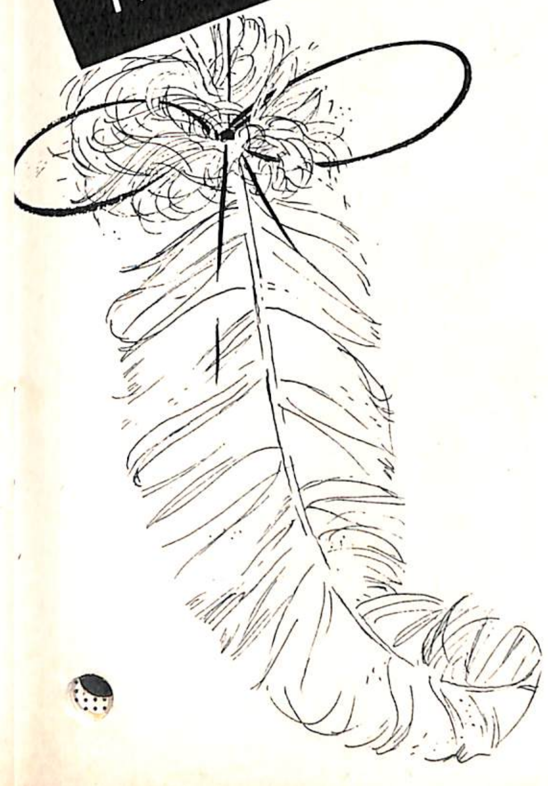


FIGURE 1—*Model DBS Loran Receiving Equipment, consisting of type CG-47335 Antenna Loading Coil and type CRM-46286 Receiver-Indicator Unit.*



For applications where a very compact light-weight set is required, the Bureau is procuring a number of model DBS Loran Receiving Equipments. The DBS is basically an AN/APN-9 aircraft loran modified for 60-cycle 115-volt operation (instead of 400 cycles) and provided with shipboard-type shock mounting and accessories. The complete equipment weighs 97 pounds, including the bulkhead mounting bracket and antenna coupling unit. It is much smaller than any previous loran set. The overall dimensions of the receiver-indicator unit, excluding the removable visor, are 13⅜" x 13⅞" x 26".

One of the methods of simplifying the AN/APN-9 (and therefore DBS) circuits is the use of a new type of sweep presentation as shown in figure 2. Notches are used instead of the pedestals as in other equipments, and only one fast sweep is provided, with a medium-fast portion at the right and a very fast portion at the left. All trace presentations are selected by a single FUNCTION switch. Switch positions 4 and 5 remove the signals and substitute time-markers so that the Loran time-difference may be read. These markers are in multiples of 10, 100 and 1000 microseconds to simplify counting, and with a little practice it is possible to "sight-read" the time difference at a glance, without laboriously counting each interval. In this respect, as well as in the provision of a single function switch, the presentation is a distinct improvement over the DAS, but not comparable to the DBE. The AN/APN-9 and DBS use a 3-inch cathode ray tube with a magnifying glass instead of the 5-inch tube used in other models.

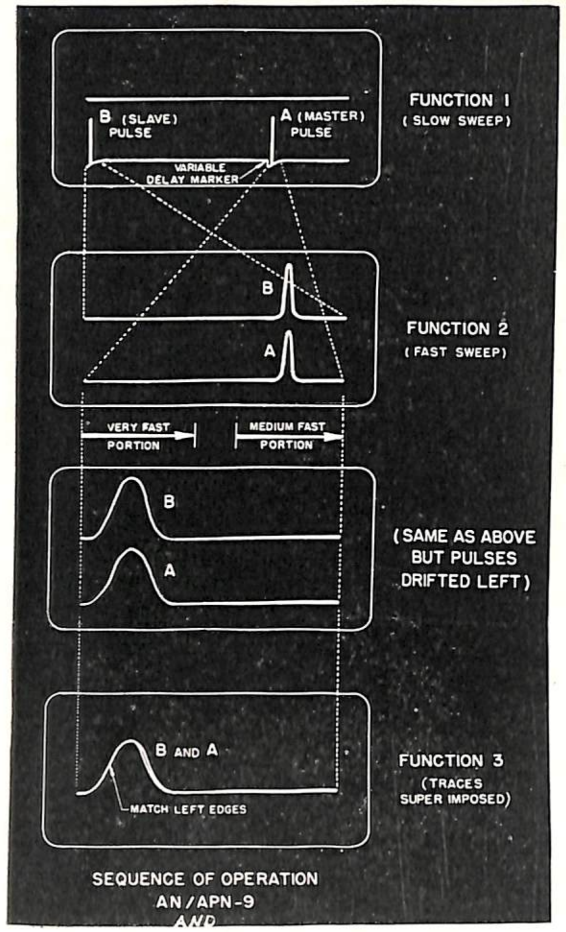


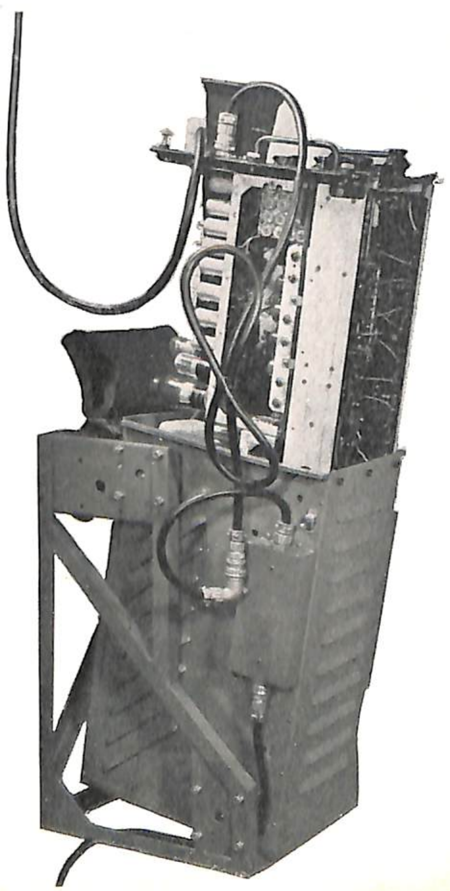
FIGURE 2—*Trace presentation on AN/APN-9 (part of DBS) showing sequence of operation.*

The modification of the AN/APN-9 receiver-indicator unit to the DBS consists of the substitution of a somewhat larger power-supply sub-chassis, a heavier and slightly larger cabinet, and the provision of a bulkhead mounting bracket which supports the cabinet through its center of gravity. An a-c power-line filter is mounted on one side of the cabinet, and a compartment for a power-line extension cord is mounted on the other side. The chassis is held in place by panel-mounted thumbscrews. Slide-rails and catches are provided to hold the chassis in an extended position for servicing. A canvas cover is provided to protect the front panel when the equipment is not in use.

The mounting bracket has been carefully designed and tested to provide adequate stiffness for the rather long projecting length of the cabinet. The mounting bracket extends over the top of the cabinet to provide maximum clearance beneath in case the equipment is mounted over a chart table. This method of construction also facilitates suspension from the overhead, and by securing the front shock mounts in another set of holes in the mounting bracket, the equipment may be mounted vertically on a bulkhead, as shown in figure 3, with the panel at a slight tilt for operating convenience. Another feature of the mount is that the cabinet may be removed from the bracket by loosening bolts inside the cabinet. Thus, the equipment may actually be easily installed in a space no larger than the overall dimensions of the bracket.

For its field of application, the Model DBS is superior to other models of loran receiving equipment, and may extend the use of loran to previously impractical conditions.

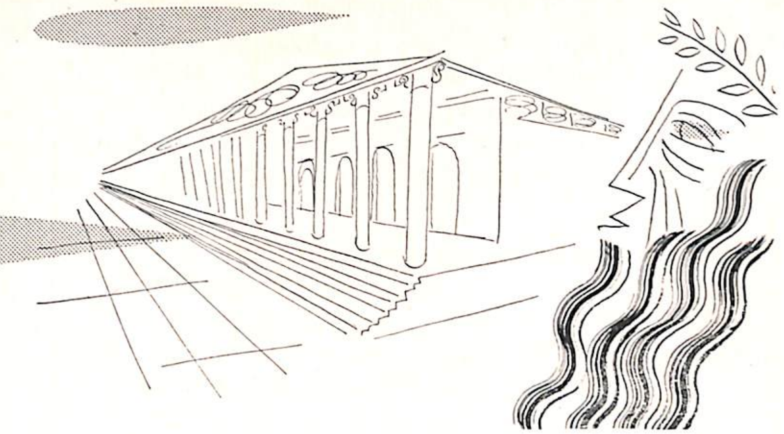
FIGURE 3—*Vertical mounting arrangement of Model DBS showing chassis partially withdrawn for servicing, with power-line extension in use. Chassis is held extended by latches.*



LORAN DECLASSIFICATION

In accordance with recent directives from the Chief of Naval Operations, all loran receiving equipments, charts, tables, operational reports, and other publications pertaining to this subject issued to date are reduced to *unclassified*. This will permit the commercial air and steamship lines to take advantage of loran, thereby adding another system to promote safety in travel.

THE FORUM



KINKS ON LINKS

Naval Supply Depot, Mechanicsburg, Pa.

An unwarranted number of maintenance calls have been experienced on Link Type 5-FRX Transmitter-Receivers installed in the security and industrial control nets at NSD, Mechanicsburg. Approximately 85% of the failures were attributable to faulty capacitors. Endeavoring to reduce the number of maintenance calls, the following steps were taken, which resulted in a reduction of approximately 75%:

(1) C40 and C43 were replaced by a Cornell-Dubilier Type UP-7D-J54, 4 x 10 μf, 450-volt dry electrolytic can-type capacitor. Two sections in parallel were used to replace C43 (the cathode bypass of the 6K6GT audio output tube) and one section to replace C40, the cathode bypass of the 6SL7GT first audio tube. The fourth section remains unwired as an installed spare. This type capacitor fits exactly in the chassis mounting hole of the capacitor replaced.

(2) C78 and C79 were replaced by Cornell-Dubilier Type KR-588A, a 2 x 8 μf, 450-volt dry electrolytic can-type capacitor in the rectifier filter. This replacement also exactly fits the replaced capacitor.

(3) Block 952D, a 6 x .05 μf paper capacitor, was replaced by two Aerovox Type 430-400, 3 x .05 μf, 400-volt capacitors stack-mounted on the chassis. These comprise C22, the meter bypass of the first limiter grid circuit; C24, the screen bypass of the first limiter; C28, the meter bypass of the second i-f grid circuit; C30, the screen bypass of the second i-f amplifier; C38, the cathode bypass of the squelch generator; C39, the plate bypass of the squelch amplifier.

(4) The fiber wafer-type sockets of the 6X5GT rectifier are being replaced by a phenolic wafer-type since a number of instances of voltage leakage and eventual arcing across the fiber socket have been experienced.

These maintenance replacements have proven so satisfactory that all equipments are in the process of being serviced accordingly.

Bureau Comment: The Bureau has no objection to these replacements where activities are experiencing failures of the components discussed. The Bureau is always interested to learn of ways of nipping trouble in the bud.

*

E.F.S.G. INFORMATION

The Electronic Field Service Group is maintained to assist both shipboard and shore activities. For full information on this organization see the March issue of CIC.

*

TDE RADIATING WHEN NOT KEYED

By M. R. Lambert, RT 2/c—USS Scribner (APD-122)

When the TDE transmitter of this ship was tuned to any frequency within its range, an audio tone could be heard in a receiver tuned to this same frequency. The tone persisted when the transmitter was not being keyed or modulated, and blocked all reception from other stations. The i-f amplifier grid current meter indicated 3 ma. This condition exists whenever the transmitter is turned on, except when the tune-operate switch is in the adjust-frequency position.

After checking several components, C-301, a capacitor between the cathode of V-302 and ground was found to be leaky. In the tune or operate position of the tune-operate switch, plate voltage is applied to the tubes, and since they are keyed by grounding the cathodes, the high-resistance short to ground caused the oscillator and i-f amplifiers to draw a reduced current when not keyed. Thus, a weak signal was radiated. This signal was strong enough to be picked up by the receiving antenna.

Replacement of C-301 remedied the trouble and it is hoped that the above information will be of value to other technicians.

Nomograms for use with SG/SL Radars

■ The Commanding Officer, Fleet Training Center, Oahu, T.H. reports that visits to many ships of the Pacific Fleet revealed generally poor microwave radar performance existed without recognition by the technicians. The OBU echo box test equipment, installed aboard most of the ships visited, was not used or was used improperly.

Calculation of expected ringing time for most of the newer types of echo boxes is not considered a difficult problem but requires reference to the instruction book, particularly the radar test sheets in the back of the book. Then following the example given in the book, refer to the charts as called for on these test sheets. Regardless of the fact that this calculation is a comparatively simple problem, it appears that most operators and technicians are seldom determining expected ringing time.

For simplification of this problem, Mr. J. M. Wolf, of Radiation Laboratory Test Equipment Group and formerly of Operational Research Section at U. S. Armed Forces, Middle Pacific, has prepared a series of charts. These charts, in the form of nomograms, effectively do all the calculating and table reading necessary in determining expected ringing time. They do not cover the use of the OBU on all types of radars with which it should be used, nor are they applicable to the SG-3, SG-4, SG-5, or SG-6 because they do not use the OBU.

The instructions printed on the nomograms are self-explanatory, but for purposes of further clarification the following steps are recommended

1. Have radar running for at least fifteen minutes and properly tuned before starting the tests.

2. Check to assure that the attenuation (coupling) figure marked on your directional coupler is "27 db". This figure is stamped on the coupler in the r-f waveguide line. These nomograms assume a 27 db coupler since, as far as is known, all directional couplers installed with these radars are of the 27 db variety. If other than 27 db coupler is installed do not use these nomograms but follow the instruction book which shows how to compute the expected ringtime for any value of coupling.

3. Measure the length of cable furnished with your particular OBU.

4. Note temperature in the vicinity of the echo box and log it. (It should be known within 10°F but it is not critical.)

5. Look on the glass on front of the echo box meter for a number. This number is called the "box factor" for want of a better name.

6. Place a ruler edge on a point on the left-hand line of the nomogram for the type of echo box you have. Run the ruler edge through a point on that line which is the length of your cable as measured in (3) above.

7. Swing the ruler around on this point until the edge is on the point of the box factor on the next line to the right.

8. Draw a line along the ruler's edge through these two points and crossing the first "pivot line".

9. Now move the ruler around, keeping the edge on the point where the line just drawn meets the first pivot line, until the edge goes through the proper temperature as recorded in (4) above.

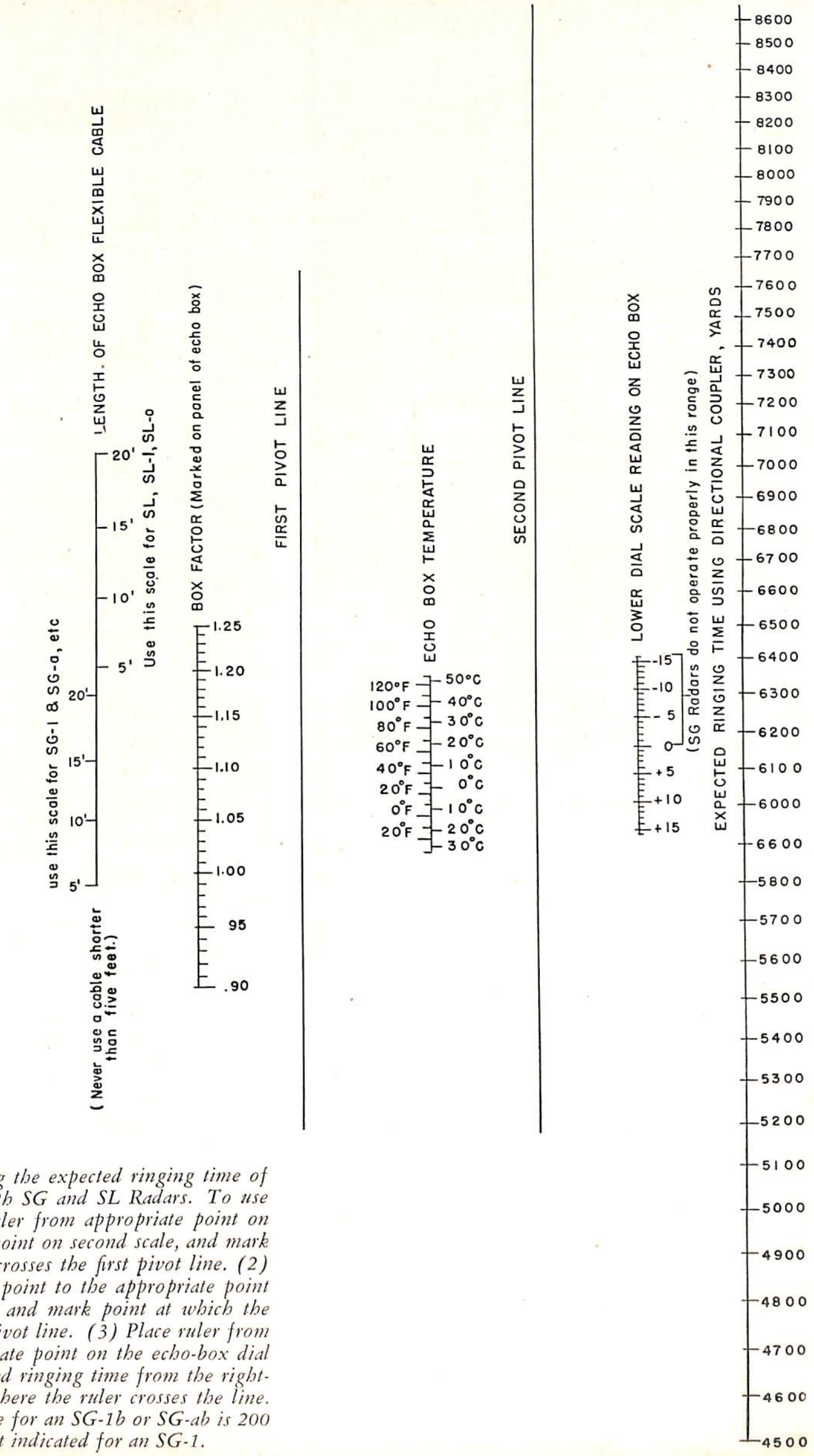
10. Draw a line along the ruler's edge through these two points and through the second pivot line.

11. Assure that the echo box is connected to the directional coupler by means of the RG-8/U cable and turn the knob on the echo box to give the maximum meter reading on the echo-box meter. Be careful that you choose a time for this test when the equipment will not be required to range on targets less than about 8000 yards as they will be blanketed by the ringtime. Log the echo-box lower-dial reading (not the meter reading).

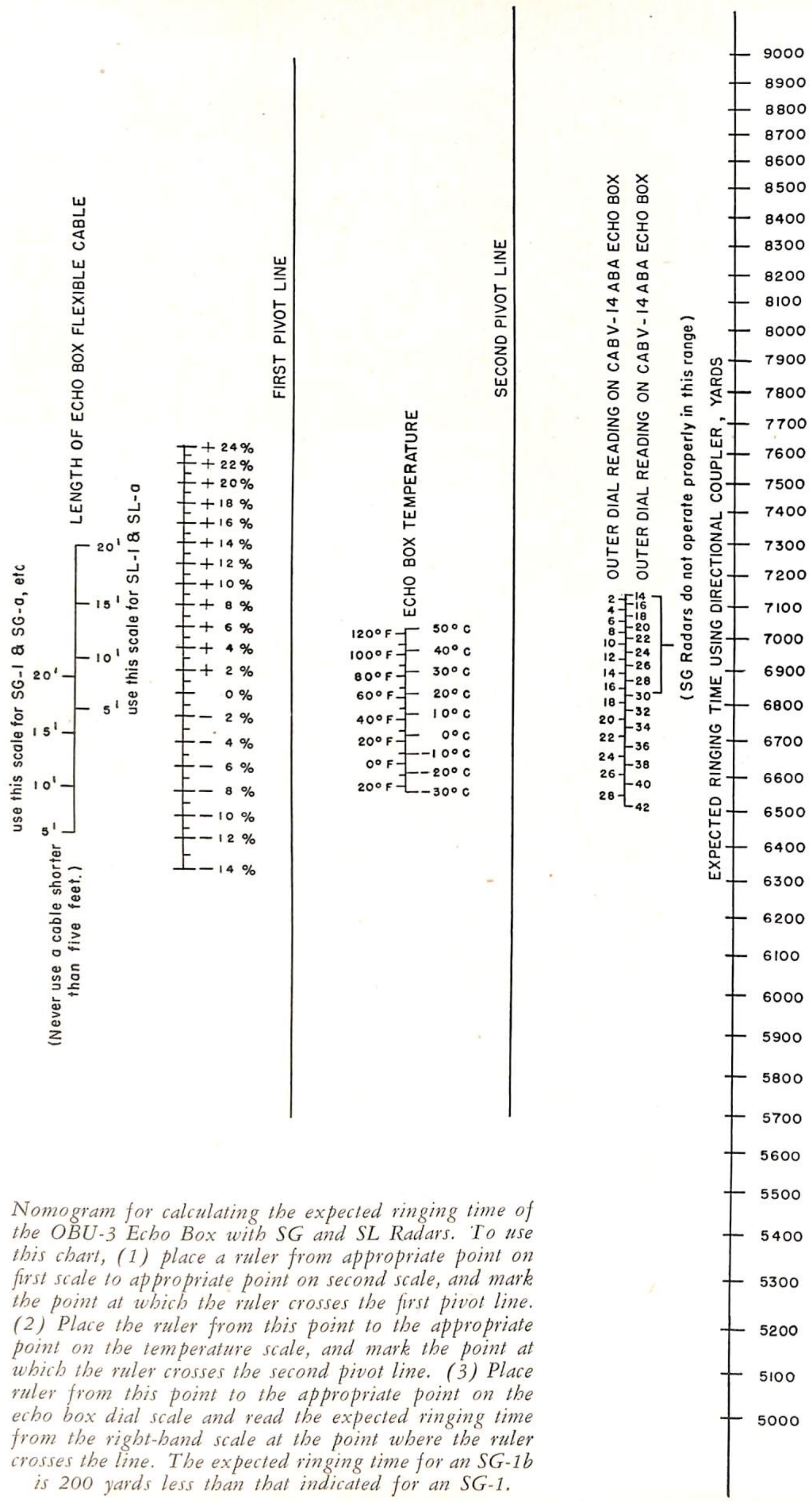
12. Draw another line on the nomogram, this time through the point of the crossing of the last line drawn with the second pivot line and the point on the lower-dial scale corresponding to the dial reading just noted in (11) above. Extend this line until it crosses the expected ringing time curve.

13. Read the value from the expected ringing time scale where the last line drawn crosses it. This is the corrected ringing time except for an SG-1b or SG-ab. In those equipments the correct time can be determined by subtracting 200 yards from the value read above. The expected ringing time value should be recorded for future reference.

After determining the correct ringing time by the above procedure the performance expected of your radar is evident. Next measure your radar ringing time in the usual fashion. If this does not closely approximate the value determined in the procedure outlined above, the radar performance is low. It follows that tuning, cleaning the TR box, and/or inserting a good crystal is immediately necessary. Other troubles are probably less usual and additional techniques will be necessary to give proper performance.



Nomogram for calculating the expected ringing time of the OBU-2 Echo Box with SG and SL Radars. To use this chart, (1) place a ruler from appropriate point on first scale to appropriate point on second scale, and mark point at which the ruler crosses the first pivot line. (2) Place the ruler from this point to the appropriate point on the temperature scale, and mark point at which the ruler crosses the second pivot line. (3) Place ruler from this point to the appropriate point on the echo-box dial scale and read the expected ringing time from the right-hand scale at the point where the ruler crosses the line. The expected ringing time for an SG-1b or SG-ab is 200 yards less than that indicated for an SG-1.



Nomogram for calculating the expected ringing time of the OBU-3 Echo Box with SG and SL Radars. To use this chart, (1) place a ruler from appropriate point on first scale to appropriate point on second scale, and mark the point at which the ruler crosses the first pivot line. (2) Place the ruler from this point to the appropriate point on the temperature scale, and mark the point at which the ruler crosses the second pivot line. (3) Place ruler from this point to the appropriate point on the echo box dial scale and read the expected ringing time from the right-hand scale at the point where the ruler crosses the line. The expected ringing time for an SG-1b is 200 yards less than that indicated for an SG-1.

TS-239/UP Oscilloscope

■ At a recent demonstration the Naval Research Laboratory introduced the latest in test oscilloscopes, the TS-239/UP. This is probably the best oscilloscope ever made available for bench use, especially where short-duration transients and pulses are to be examined. It is a portable unit displaying a plot of the variation with respect to time of a voltage pulse or waveform, with self-contained means for measuring it's duration and instantaneous magnitude. The unit was designed by Bell Laboratories and will be built by the Western Electric Co. It weighs 60 pounds and measures 21½" x 16½" x 13½". A carrying case is also provided which is very light in weight, being constructed of balsa wood covered with aluminum sheeting.

Front panel of the TS-239/UP Oscilloscope. The CRO tube is not visible until the light shield, upper right, is lifted. The screens at three of the corners are for ventilation.

It will trigger from transients or sine waves from 10 cycles up to 5 Mc. The amplifier has very little phase shift and will permit observation of signals with amplitudes as low as 0.1 volt. External connections are available to horizontal and vertical plates, as well as the Z axis.

The instrument uses a 3-inch CRO tube inclined at an angle of 45° with respect to the front panel. An image of a scale may be made to appear at any desired brightness for measuring length and height. It is completely invisible when not desired and is of a contrasting color to the signal when appearing on the screen. There is no parallax since the image coincides with the fluorescent screen inside the CRO. Scope face reflection is at a minimum, thereby permitting ease of observation even in a lighted room. A continuously-variable sweep time of 0.5 to 50,000 microseconds per inch can be obtained. Any portion of the sweep may be delayed and expanded about 10 times for detailed examination of the signal. Timing markers synchronized with the sweep can be obtained at intervals of 0.2, 1, 10, 100, or 500 microseconds.

It has a trigger output 4 microseconds in duration with an amplitude of 25 volts at a repetition rate of 300, 800, or 2000 pulses per second. Also available is a sawtooth output of 150 volts for frequency modulating an oscillator by varying the repeller voltage. Another feature is a calibration-voltage generator which permits measurements of instantaneous signal voltages without reference to an external standard.

Broadcast Receivers

■ Since the cessation of hostilities the Bureau has received many inquiries from the field indicating a general belief that war-time restrictions on ship installations of commercial types of broadcast receivers has been or will be relaxed. This is not the case. On the contrary, the Chief of Naval Operations has recently broadened the scope of the directive which established maximum permissible communication receiver radiation to cover all shipboard receivers. This directive now specifies that all receiving equipments, including communication receivers, entertainment and non-Navy issue receiving equipments used aboard the vessels of the fleet, and operating in the 10-kc to 30-Mc band, shall not exceed 400 micromicrowatts oscillator radiation, measured across an optimum load resistance connected from the antenna input of the receiver to the receiver ground.

In general, present commercial types of broadcast receivers do not meet the above requirements. In view of this, and due to the above stringent requirements, the Bureau cannot approve of the shipboard installation of any commercial broadcast receiver or multiple antenna system until the specific type has been tested and passed by a Naval Laboratory.

SP/SM HEIGHT ERRORS

(continued from page 7)

After completion of the test flight, obtain from the curves of figure 2 the true elevation angle for each range reading and enter in column 5 of Table A. Compute each elevation-angle error by subtracting column 5 from column 4 and enter the error in column 6. Average the errors of column 6, taking into due account the sign of each error, and plot the errors of column 6 as a function of the relative bearings of column 3.

Under perfect conditions all the errors would be zero and all plotted points would fall on the zero-error line. Actually the plotted points will not present that picture.

In the first place, the points will be scattered due to natural operator's errors, an accumulation of the effects of errors 1, 2, 3, 6, and 9, and the presence of bearing friction in the gyro gimbals.

Secondly, the points will be scattered but will average about some line displaced from the zero line by the amount of the average error. This error, constant at all bearings, will be an accumulation of errors 1, 2, 7, 9, and 10, and is dependent for its accuracy on the pilot's maintenance of a true 10,000-foot altitude.

Lastly, the plotted error points may be distributed about the average error line in the shape of a full-cycle sine wave, as illustrated in figure 3. The average error line will be the base of the sine curve only if observations are distributed uniformly completely around the ship. This sinusoidal distribution of error is caused by an accumulation of errors 3, 4, 5, and 8.

Any improper tilt of a reference plane causes incorrect altitude readings for all relative bearings except the two directions along the axis of tilt. On one half the remaining bearings the errors are positive and the other half negative (see figure 4), the errors having a sinusoidal distribution.

If all the plotted error points fall between ±0.2°, the SP/SM radar calibration may be considered excellent. An average error and/or a sinusoidal amplitude greater than 0.1° necessitates additional tests to isolate the cause of the error and permit restoration of maximum accuracy.

The constant error can be corrected by rotating the antenna elevation synchro, but if the cause lies with the gyro, this method of correction merely doubles the number of errors in the system.

STABLE ELEMENT GYRO-BALANCE TEST

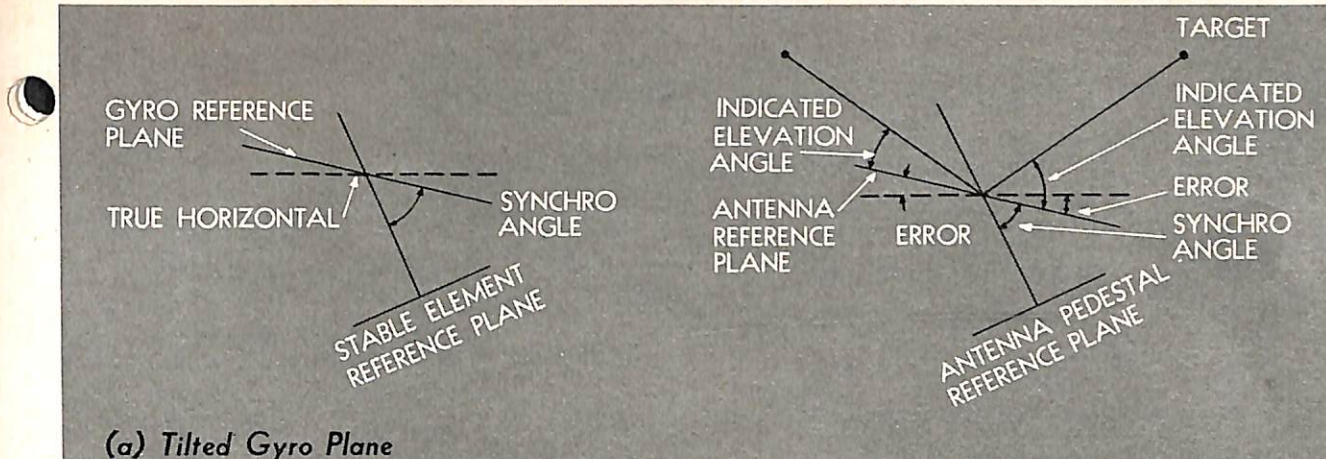
Remove the top of the stable-element housing. With the equipment energized and operating on true bearing, place the stable element on "local" control at the control panel and scan at maximum rate until the bubble atop the gimbal rings centers in the etched circle indicating an upright gyro. This test must be conducted when the ship is steady, so as to prevent extraneous accelerations affecting the steadiness of the bubble. If the bubble steadies, but not in the center, then errors 3, 4, or 5 may be present.

To test for error 3, stop the scanning, grasp the erecting magnet by hand and move slowly (excessive movement will cause physical contact between magnet gimbal and gyro gimbal causing false indications). With a properly energized erecting magnet, the gyro will slowly and smoothly follow the magnet, whereas the gyro will not move for a de-energized magnet. This test should be made with the erecting magnet switch on the control panel in both "on" and "automatic" positions.

The latitude correction arm should be checked for positioning on the true North of the gyro. When so positioned, any gyro tendency to tilt toward East or West indicates an error in latitude corrector current. A tilt to East indicates excessive current, whereas a tilt to West indicates insufficient current. It should be noted that the bubble position indicates a tilt in the opposite direction, i.e. the bubble to the West of center indicates the gyro top tilted to the East. On the latitude setting meter, current increases as latitude decreases, zero current occurring at 90° latitude.

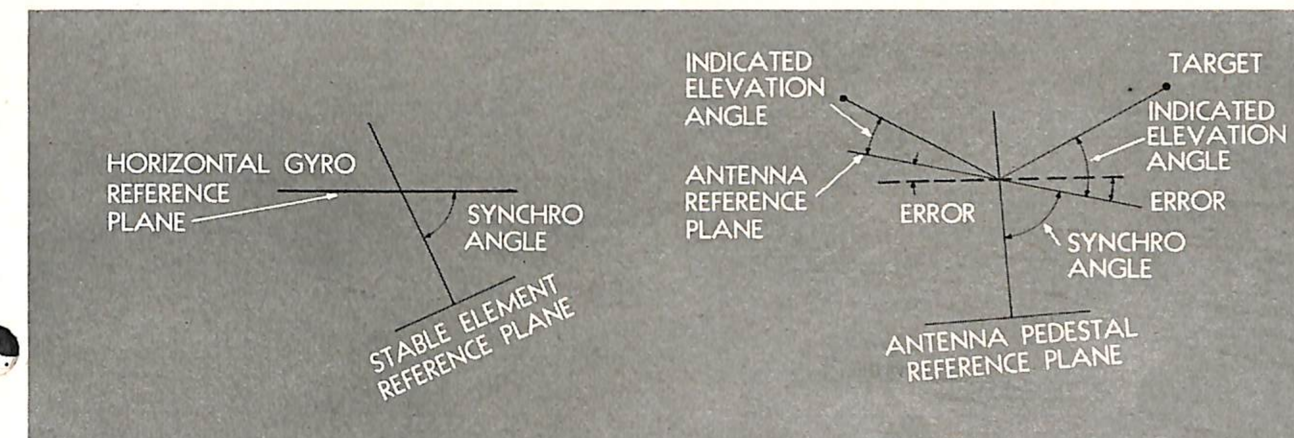
Table A—*Calibration Flight Data True Altitude of Aircraft*

1. Range (miles)	2. Altitude (thousands ft.)	3. Relative bearing (degrees)	4. Elevation angle (degrees)	5. True elevation angle (degrees)	6. Elevation angle error (Col. 4 —Col. 5)
		(Space for 100 Readings)			



(a) Tilted Gyro Plane

FIGURE 4—*Introduction of altitude errors due to tilting of the reference plane. Tilt axes are normal to page.*



(b) *Nonparallel Transfer Plane Errors Due to Reference Plane Tilt. Tilt Axes Normal to Page*

After elimination of errors 3, 4, and 5, the bubble should center after scanning for several minutes. Stop the scanning and immediately turn off the erecting magnet. If the gyro is unbalanced, the bubble will slowly drift from the center. The amount of angular tilt of the gyro may be judged by use of the small circle engraved on the bubble glass as follows:

Bubble tangent to inside of circle: 20 minutes gyro tilt
Bubble bisected by circle: 40 minutes gyro tilt
Bubble tangent to outside of circle: 70 minutes gyro tilt

If the gyro tilts more than 30 minutes within 3 minutes after scanning is stopped, rebalancing of the gyro is required.

There are four balancing weights provided on the gyro housing located as shown in figure 5 (only three weights are visible in the photograph). In balancing, the right-angle precession must be remembered, e.g. moving weight #1 outward causes weight #2 to elevate, moving the bubble toward weight #2.

After balancing the gyro, scan as originally with the erecting magnet ON until the bubble again centers. Stop the scanning, but this time leave the erecting magnet energized. The gyro tilt should not exceed 12 minutes in 3 minutes of time. Excessive tilt requires balancing of the erecting magnet by means of the three balance weights provided, one on the magnet gimbal ring and one on each side of the magnet, as shown in figure 5. Balancing is straightforward since precession does not enter into the erecting-magnet position.

SYNCHRO ZEROING

De-energize the stable element frequency changer, but leave the synchros energized. Scribe-mark the latitude 1F synchro position atop the gimbal rings and remove without disconnecting. Insert the zeroing jig and zero the level synchros in accordance with the instruction book. With the stable element level synchros zeroed, proceed to the radar console, set the elevation dials to 0°, and zero the elevation 5DG synchros if necessary.

Remove zeroing jig and replace latitude 1F synchro.

CONSTANT ERROR CORRECTION

Any adjustments required during the gyro balancing or synchro zeroing invalidates the average error obtained during the flight test, necessitating a second flight test. Where no adjustments are required, or after the second flight test, the average error indicates errors in the radar beam alignment or antenna elevation synchros. This combined error is corrected by shifting the antenna elevation synchros.

Lay off on a template an angle equal to 36 times the average error, as shown in figure 6.

Energize the radar equipment and operate in an unstabilized condition, if available.

Position the antenna for stowing and block the antenna elevation amplifier transfer relay in the de-energized or high-speed position.

Stow the radar antenna in all three axes and remove the cover which houses the elevation synchros. Scribe-mark the position of the 36-speed elevation synchro and loosen the clamping screws. Mechanically unstow the elevation axis only, and move the loosened synchro to determine relative elevation movements of the antenna.

A positive constant error requires elevating the antenna dish for correction, a negative constant error requires lowering the dish. Using the template and the scribe marks, move the synchro the required amount and direction and tighten the clamping screws.

Unblock the elevation amplifier relay and adjust the low-speed elevation antenna synchro to zero with the high-speed synchro.

SINUSOIDAL ERROR

A tilted "horizontal" reference plane caused by errors 3, 4, or 5 can be detected and corrected by the gyro balance tests outlined above.

To eliminate the errors caused by the non-parallel transfer planes (error 8) requires careful shimming of the stable element base until the train axis is parallel to the antenna azimuth axis.

An accurate determination of the amount of error requires the use of two gunner's quadrants, which are not usually carried aboard combat ships. As can be seen in figure 7, they are accurately calibrated levels. They may be obtained from Ordnance Shops in Navy Yards or from repair ships and tenders. The quadrants are sensitive pieces of equipment and a few minutes of instruction on their operation from an ordnance man will prevent incorrect results and damaged quadrants.

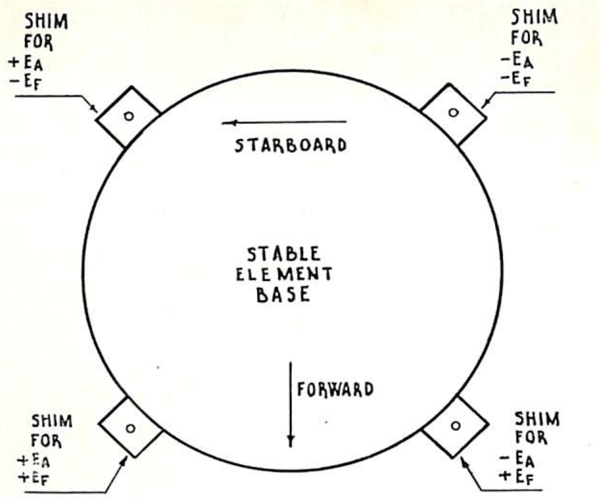


FIGURE 13—*Drawing showing placement of shims for various errors;* $+E_A$ *indicates positive athwartships error;* $-E_F$ *indicates a negative fore-and-aft error, etc.*

QUADRANT TEST OF TRANSFER PLANES

During the quadrant test, the ship must be relatively free from movement, a condition sufficiently met when tied to a pier and ideally met when drydocked. The test should be performed when the sun has minimum effect in distorting the metal structure; that is, early in the morning or on a cloudy day.

Test the two quadrants for relative sensitivity. The more sensitive quadrant, a pair of sound-powered phones and one technician will be required at the stable element. The less sensitive quadrant, a pair of phones, scotch tape or binding cord, and two technicians will be required at the radar antenna.

At the stable element, de-energize the equipment and remove the top cover. Place the quadrant atop the yoke (figure 8) in such position as not to be disturbed if the gimbal ring assembly should move. One portion of the yoke top is machined and unpainted for use as a level surface, as was observed in figure 5. Connect phones to circuit X6J to radar antenna.

At the radar antenna, de-energize the equipment using the safety switch and stow the antenna in elevation and cross level only. Place the quadrant on some smooth, relatively horizontal surface, such as wave guide, flat casting, etc., on the rotatable portion of the antenna as shown in figure 9. Fasten the quadrant in place with scotch tape or cord, but never use "C" clamps as these may damage the flatness of the quadrant base. Establish communication to the stable element.

This test is performed with the entire equipment de-energized, and the stable element and antenna need not be in corresponding azimuth positions. It is necessary that the quadrants be kept in corresponding positions, so that the bubbles will be leveled in the same vertical plane and angles measured in the same direction. Four positions of the quadrants are required.

Start the test readings with the quadrants athwartships and pivots at the port side as shown in figure 10. Keep both bubbles centered until the ships mid-movement is found on the stable element quadrant, when *mark* should be called from the stable element. Stop adjusting both bubbles. As the stable-element bubble passes through its center, *mark* to the antenna. At the antenna, note the bubble position at each *mark* and make adjustments as necessary until both bubbles pass the center simultaneously.

With steady ships, it may be possible to center both bubbles and have little motion, but this is the exceptional case. The antenna has additional motion, the swaying of the mast in the wind, necessitating the use of the least-sensitive bubble aloft.

When both bubbles center simultaneously, read the indicated angle to nearest half minute without moving the quadrants from position, and record in Table *B*.

Quadrants are calibrated in an increasing direction. The angle to be read for a depressed limb position will not be a negative value, but will be a positive value, such as 359° 23′. Do not try to convert at the quadrant, but read positive values direct. Convert later by subtracting from 360° to give the negative equivalent; e.g. the angle shown in figure 11 becomes —37′.

Repeat the above leveling procedure after rotating the antenna and stable element through 90° intervals until readings have been obtained in each of the four positions shown in figure 10.

If at any time during this process the quadrant base is shifted from its resting place, the prior observations are invalidated and the test run must be repeated.

In Table *B,* convert all depressed-limb readings to

Table B—Test Before (After) Shimming Stable Element

1.	Stable Element quadrant, pivot port, reads	..........;	converted	
2.	Stable Element quadrant, pivot stbd., reads	..........;	converted	
3.	Subtract line 2 from line 1			....
4.	Antenna quadrant, pivot port, reads	..........;	converted	
5.	Antenna quadrant, pivot stbd., reads	..........;	converted	
6.	Substract line 5 from line 4			....
7.	Subtract line 6 from line 3			....
8.	ERROR ATHWARTSHIPS (E_A)—One-half of line 7			______
9.	Stable Element quadrant, pivot aft, reads	..........;	converted	
10.	Stable Element quadrant, pivot fwd., reads	..........;	converted	
11.	Subtract line 10 from line 9			....
12.	Antenna quadrant, pivot aft, reads	..........;	converted	
13.	Antenna quadrant, pivot fwd., reads	..........;	converted	
14.	Subtract line 13 from line 12			....
15.	Subtract line 14 from line 11			....
16.	ERROR FORE-AND-AFT (E_F)—One-half of line 15			______

Basis of Table B:

$$\text{Error athwartships } (E_A) = \frac{\begin{pmatrix}\text{S.E. Pivot}\\ \text{Port}\end{pmatrix} - \begin{pmatrix}\text{S.E. Pivot}\\ \text{Stbd.}\end{pmatrix}}{2} - \frac{\begin{pmatrix}\text{Ant. Pivot}\\ \text{Port}\end{pmatrix} - \begin{pmatrix}\text{Ant. Pivot}\\ \text{Stbd.}\end{pmatrix}}{2}$$

$$\text{Error fore-and-aft } (E_F) = \frac{\begin{pmatrix}\text{S.E. Pivot}\\ \text{Aft}\end{pmatrix} - \begin{pmatrix}\text{S.E. Pivot}\\ \text{Fwd.}\end{pmatrix}}{2} - \frac{\begin{pmatrix}\text{Ant. Pivot}\\ \text{Aft}\end{pmatrix} - \begin{pmatrix}\text{Ant. Pivot}\\ \text{Fwd.}\end{pmatrix}}{2}$$

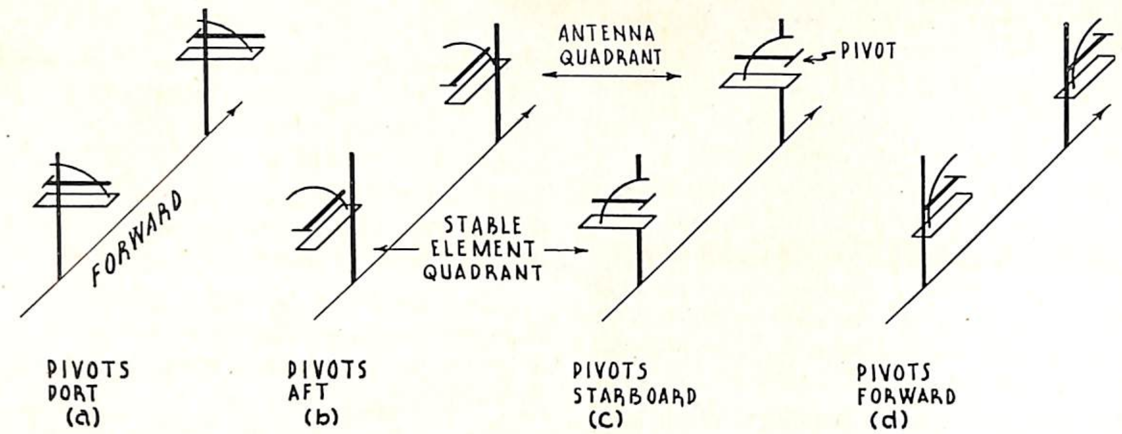


FIGURE 10—*Quadrant positions for test of transfer planes.*

negative equivalents. Insert elevated-limb readings directly in spaces marked "converted". Perform the operations indicated in the table to obtain the errors of tilt of the transfer planes.

Two complete test runs should be made and corresponding errors should check within two minutes. A failure to check can usually be traced to incorrect readings so that additional tests must be run until a check within limits is obtained.

The average errors obtained from satisfactory runs may be converted into shim thicknesses required on the following basis for Westinghouse Mark 8 Mod 2 stable elements: .006 inches of shim per minute of error. Shims should be made of sheet brass or steel shaped in accordance with figure 12. It should be noted that any error of tilt will be corrected by shimming a maximum of three legs of the stable element; one leg should always remain unshimmed.

A positive value of athwartships error, $+E_A$, requires shimming the starboard legs of the stable element for correction (figure 13, at $+E_A$).

A negative value of athwartships error requires shimming the port legs (figure 13, at $-E_A$).

A positive value of fore-and-aft error requires shimming the forward legs (figure 13, at $+E_F$).

A negative value of fore-and-aft error requires shimming the after legs (figure 13 at $-E_F$).

After shimming, another test run is desirable to insure correction of the previous errors. Residual errors of less than five minutes are satisfactory.

It is obvious that in certain instances variation in the order of the above alignment procedure will effect a conservation of test flights, and the technician should feel free to vary the order as desired just so long as the interactions of the various causes of error are realized.

The flight test procedure was developed and reported in the enclosure to ComAirPac Confidential letter, Serial No. 05480 dated 30 July 1945; the gyro-balancing test was reported in BuShips Confidential letter, Serial No. C-982-802 of 29 August 1945, but to provide a complete elevation-system alignment, these two tests must be combined with the quadrant test of the transfer planes.

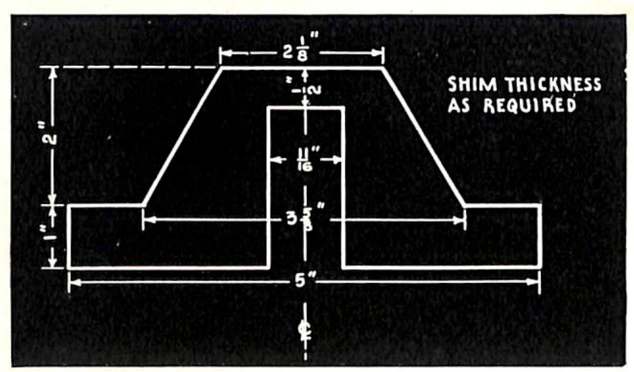
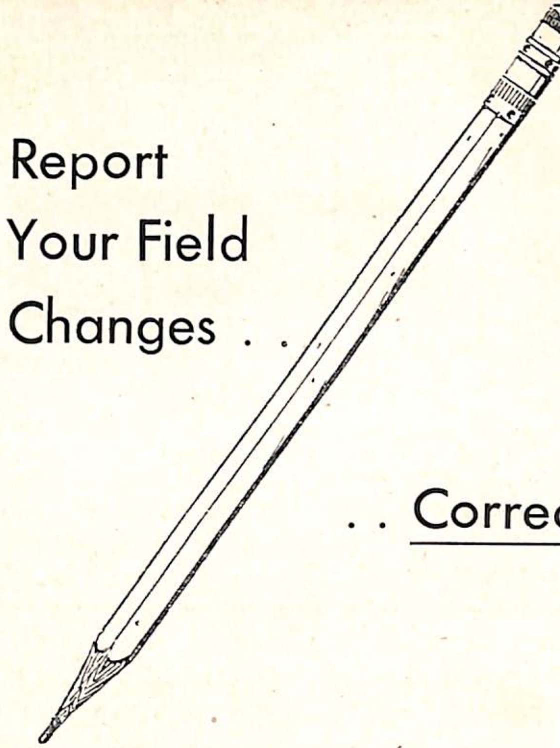


FIGURE 12—*Shape and dimensions of shims for stable element.*

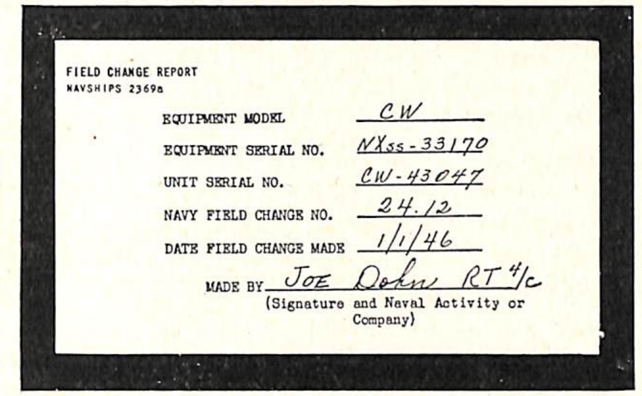
SPARE 323A's FOR TTY EQUIPMENTS

The Bureau has received reports that some radio teletype equipments have been received without spare type 323A tubes. These tubes are stocked at electronic pools, and vessels are requested to contact the Electronics Officer for a full complement of spares. Electronics officers are requested to ascertain that adequate spare tubes are supplied to vessels having radio teletype equipments.

Report Your Field Changes . . . . Correctly



■ That extra five minutes that it takes to go back to the ship and get the correct serial number of the equipment you just made a field change on may seem like a waste of time—but it isn't. An increasingly large number of Field Change Report cards are being received in BuShips with incomplete or incorrect information. An example, illustrating the type of errors generally made on the reports, is shown below:

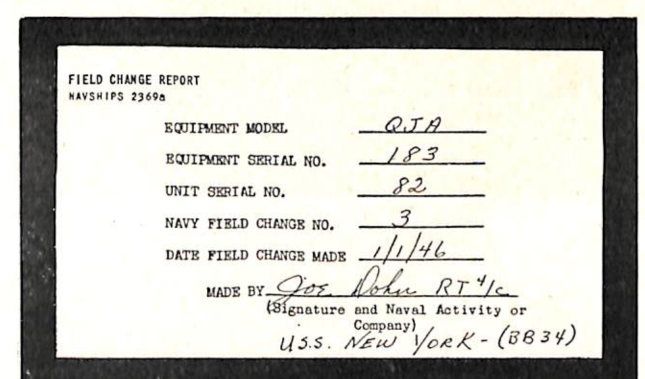


FIELD CHANGE REPORT
NAVSHIPS 2369a

EQUIPMENT MODEL	CW
EQUIPMENT SERIAL NO.	NXss-33170
UNIT SERIAL NO.	CW-43047
NAVY FIELD CHANGE NO.	24.12
DATE FIELD CHANGE MADE	1/1/46
MADE BY	Joe Dohn RT 4/c

(Signature and Naval Activity or Company)

In the above, it will be noted that "CW" is not an equipment model, but the prefix letters assigned to units manufactured by the Western Electric Company; "NXss-33170" is not a serial number, but the number of the contract under which QJA conversion equipments were purchased; "CW-43047" is not the serial number of the unit involved, but the type number of that unit; "24.12" is not the field change number, but the number of the paragraph in the Sonar Bulletin which gives instructions for making the change; and lastly, the signature should be followed by the name of the naval activity or company to which the person making the change is attached. The same report made out properly is shown below:



FIELD CHANGE REPORT
NAVSHIPS 2369a

EQUIPMENT MODEL	QJA
EQUIPMENT SERIAL NO.	183
UNIT SERIAL NO.	82
NAVY FIELD CHANGE NO.	3
DATE FIELD CHANGE MADE	1/1/46
MADE BY	Joe Dohn RT 4/c

(Signature and Naval Activity or Company)
U.S.S. New York - (BB 34)

Each entry on the Field Change Report card is important and must be accurate in order not to confuse the field change records maintained in BuShips. These records, kept by equipment serial numbers, show which changes have been reported as completed on each individual equipment together with indications of the ship in which the equipment is installed.

EQUIPMENT MODEL refers to the Navy model letters which identify the major equipment to which the change is made. This information is found on the equipment plate.

EQUIPMENT SERIAL NO. is the serial number which identifies the complete basic equipment and is also found on the model plate. Do not use the unit serial number.

UNIT SERIAL NO. is the serial number which identifies the major unit (receiver, indicator, antenna, etc.) to which the change is made. This number is found on the type plate for the individual unit involved.

NAVY FIELD CHANGE NO. refers to the complete, official number assigned to the field change by the Navy.

DATE FIELD CHANGE MADE is self-explanatory.

MADE BY should be followed by the signature of the person actually completing or checking the change. The ship or activity to which he is attached should be indicated.

Field Change Report cards (Navships 2369) are supplied with all field change kits and should be used in reporting completions. Changes not requiring kits should be reported on Failure Report cards (NavShips 383), indicating the field change number in the space for "Brief Description for Cause and Failure".

NEW TUBE-BASE MATERIAL

■ There appeared in the October issue of ELECTRON (p. 35) information concerning the characteristics of a new low-loss phenolic tube base material. JAN-1A specifications on the tubes listed below are being revised to insure that their bases are made from this material, and the letter "Y" will serve to identify them. The new type will supersede the prototype without the "Y"; for example, the 6AG7Y will replace the 6AG7.

The new designation, however, will not be added to tubes bearing the "W" suffix as all improvements are automatically added to tubes in this category.

6AB7Y	6SA7GTY	6V6GTY/G
6AC7Y	6SG7Y	12SA7Y
6AC7W	6SK7Y	12SA7GTY/G
6AG7W	6SK7GTY/G	12SG7Y
6L6Y	6SL7W	12SK7Y
6L6GAY	6SN7W	12SK7GTY/G
6SA7Y	6V6Y	

DISPOSAL OF MAGNETRONS

Since most magnetrons have been declassified, it is no longer necessary to follow any special disposal instructions for these tubes. Secret and confidential electron tubes of all types must still be disposed of in accordance with security regulations. No special reports indicating the destruction of any electron tube are required by the Bureau of Ships. The only form required is the regular failure report form (NBS-383) Failure Report—Electronic Equipment.

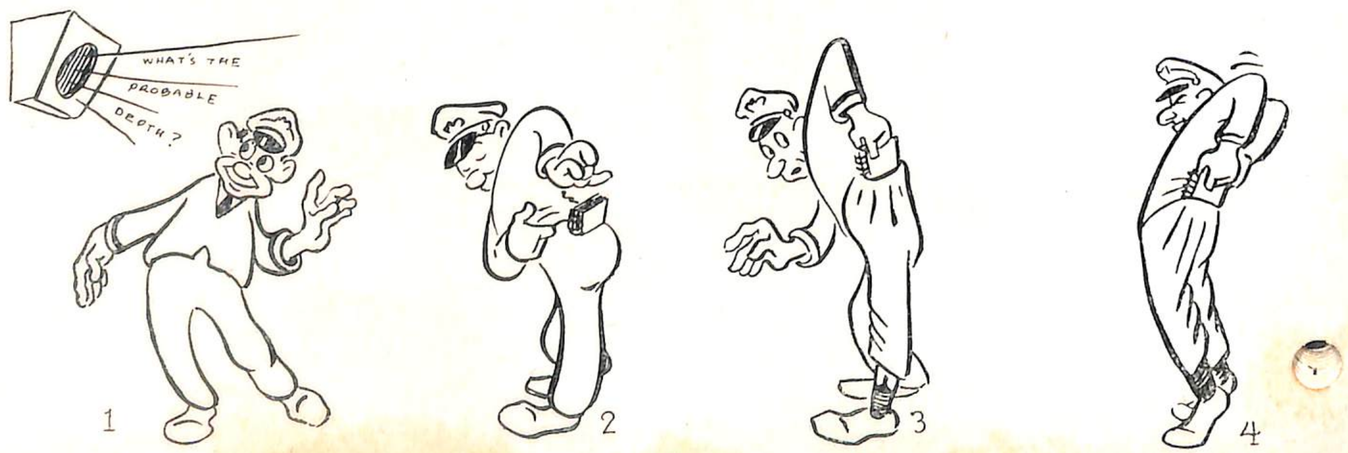
UNTUNED ECHO BOXES CRITICIZED

Reports from the field indicate that untuned echo boxes have lessened the enthusiasm over tuneable echo boxes. Perhaps those responsible for this criticism do not realize that results obtained from the untuned echo box are not expected to equal those obtained from the tuneable box, but that certain advantages of the former have warranted its production. The two types may be thought of as two different equipments designed for different purposes, even though their uses are similar.

In simple terms, the untuned echo box is a large cavity with reflecting walls. No tuning features are incorporated in the box, but it is capable of absorbing energy at almost any frequency. This energy is bounced around inside the box at random and delivers returning energy to the transmission line. Wave reflections inside the untuned box may for one frequency add together in amplitude at the coupling loop, while for another frequency, slightly higher or lower, subtract to produce an output frequency of lower amplitude. For this reason, relative ringing times, except at a particular frequency, are meaningless.

For fire control purposes, where a radar may cover a frequency band three times that of any tuned echo box, certain advantages of the untuned box are apparent. The radar may be quickly tuned without any test set tuning or manipulation. As stated above, however, the untuned box should not be used to tune the transmitter to another frequency for higher output, as relative ringing times for two different frequencies are of no value.

If power output, standing-wave ratio, and overall system performance data are desired, the tuneable echo box should be used, as it was designed especially for this purpose. Thus, every piece of test equipment has a certain function and should not be criticized because we expect results beyond its design capabilities.

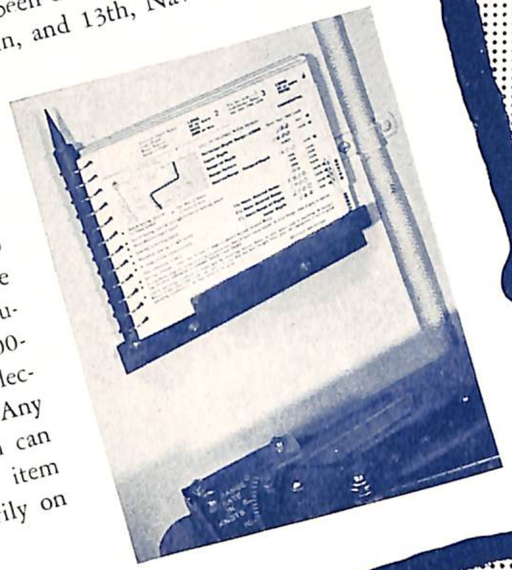


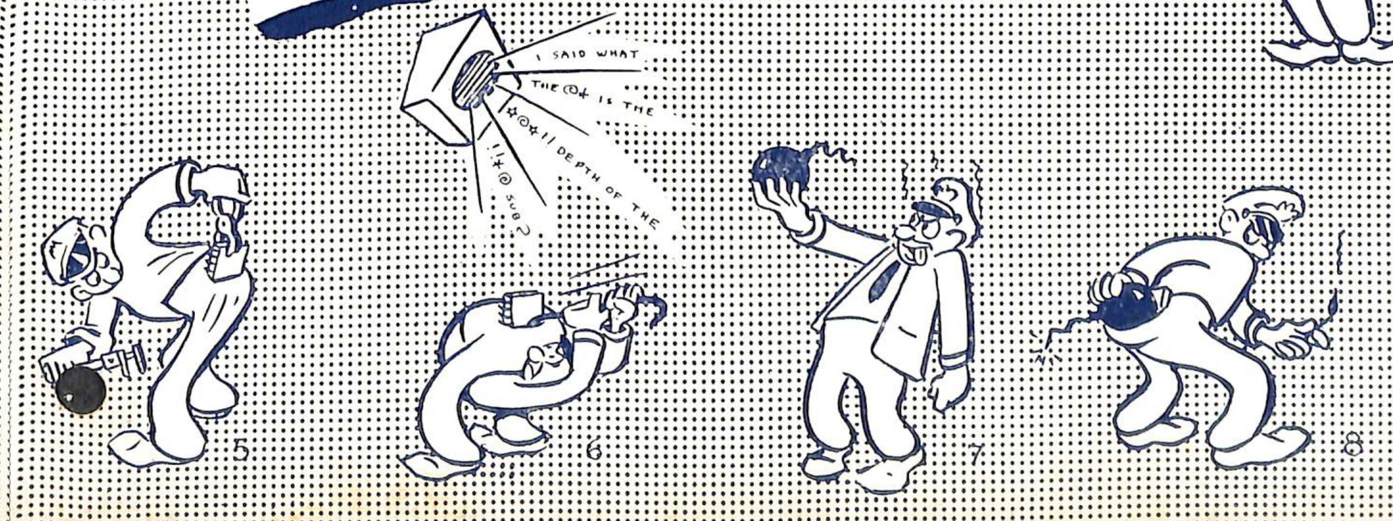
Sonar Range Book Mount

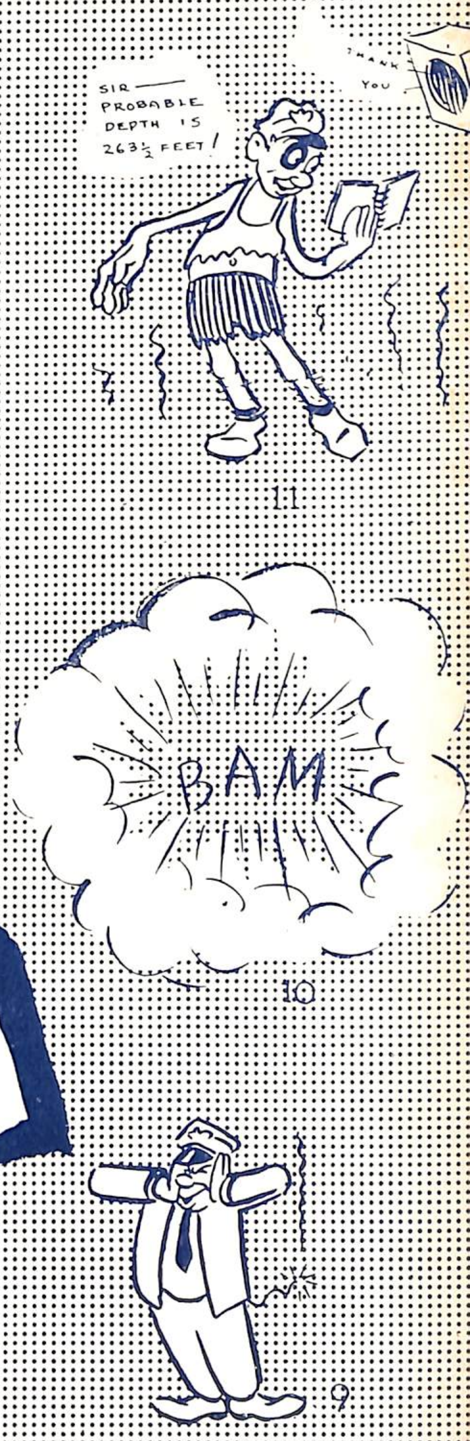
The Sonar Range Book (NavShips 900,040A) used by all ASW ships is a bit large for the Sonar Officer's hip pocket. Therefore, to make use of the booklet more convenient, the Mare Island Navy Yard has developed a small metal fixture, described on their plans under the somewhat misleading name of "Sonar Message Door".

This fixture may be fastened to a bulkhead in the sound hut, possibly just above the recorder, on the bridge, and in CIC. When a sonar message is received, the range book is folded open to the proper card and inserted in the fixture which holds it securely in this position, thereby making the data constantly and conveniently available. The fixture includes a built-in pencil holder,—an item sure to be appreciated by all in the sound room.

Supplies of these fixtures have been distributed by NYMI to Electronic Pools in the 11th, 12tn, and 13th, Naval Districts. Ships wishing mounts may obtain them on application to the pool officers and in many cases a ship's requisition will not be needed. Other ships may prefer to make their own based on the NYMI plan. Request BuShips Plan No. FSS 6800-152998 Alt. O, from Electronics Officer, NYMI. Any shipfitter or metalsmith can easily fabricate this item from material ordinarily on hand.







The old saw about an ounce of prevention never had a truer application than to electronic equipment. Many a tough repair job is avoided by a good system of preventive maintenance. Follow the procedures outlined in your instruction books, then make an entry in the proper equipment log to show that the work has been done. The extra time thus spent will pay dividends in gear that really works when it is needed most.