TM 11-1262

EPARTMENT OF THE ARMY TECHNICAL MANUAL

TEST SET
TS-172A/UP

QUARTERS, DEPARTMENT OF THE ARMY
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TEST SET TS-172A/UP

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INSTALLATION RECORD

Contract No. Date of Contract

*Serial number of equipment*____________________

*Date of acceptance by the Navy*____________________

*Date of delivery to contract destination*____________________

*Date of completion of installation*____________________

*Date placed in service*____________________

Blank spaces on this page shall be filled in at time of installation. Operating personnel shall also mark the "date placed in service" on the date of acceptance plate located below the model nameplate of the equipment, using suitable methods and care to avoid damaging the equipment.

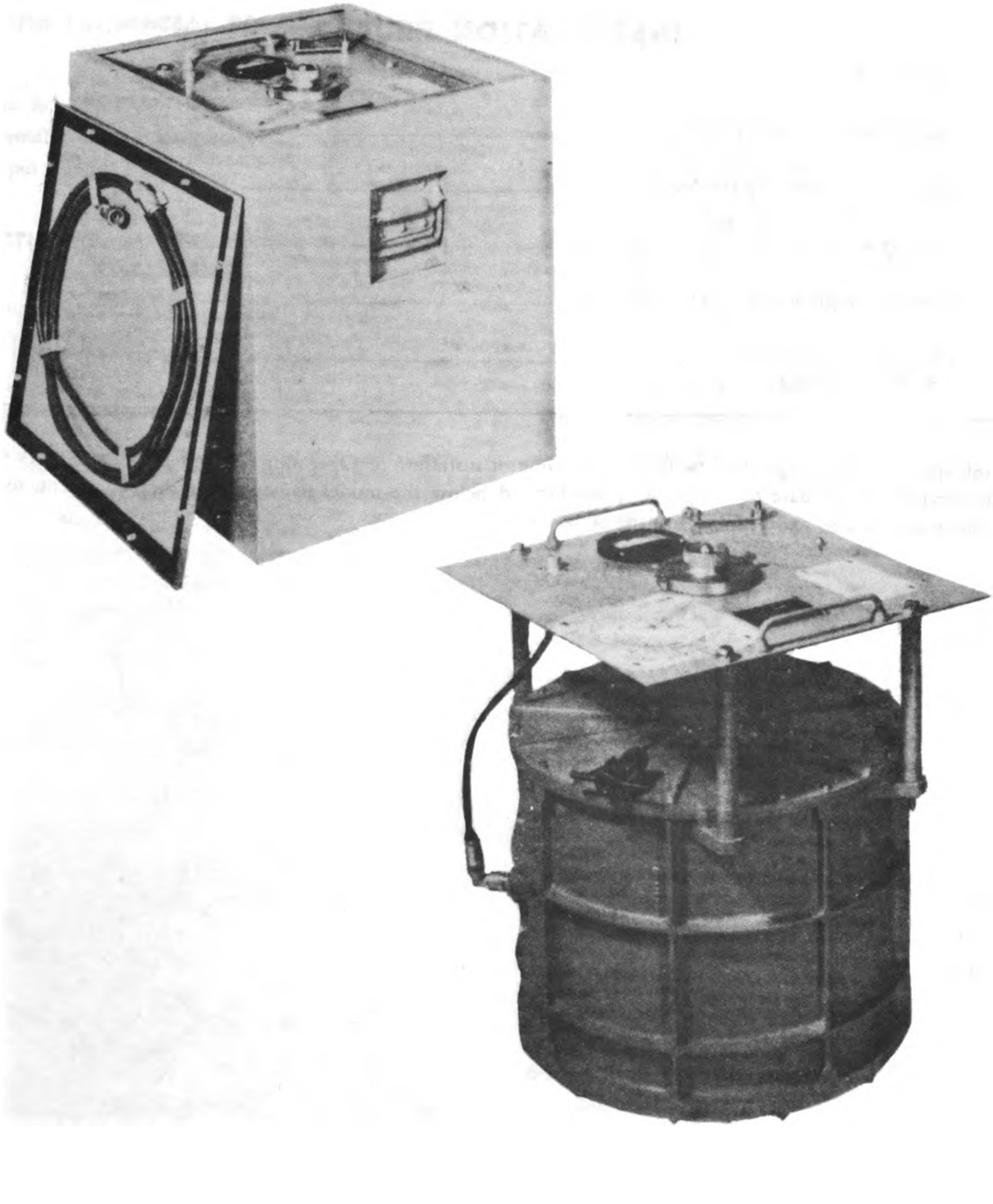


Figure 1-1. General View Echo Box — TS-172A/UP

SECTION I
GENERAL DESCRIPTION

1. PURPOSE AND PRINCIPLE OF OPERATION

The TS-172A/UP is a portable echo box test set designed to permit convenient field testing of the performance of radars operating in the frequency range 1215 to 1370 mc./sec. When properly used, this echo box is helpful in recognizing and localizing troubles. It should be used daily to measure the "ringtime" of the radar, and if this measured value differs from that predicted for the particular radar under test by more than five decibels, the radar should be repaired.

The test set, see Figure 1-1, consists of a hand-tuned resonator of high Q, excited by means of a loop which is connected by a flexible cable to the R-F test point of the radar. An auxiliary loop connected to a power meter serves as a tuning indicator. A transient oscillation is induced in the resonator by the radar pulse. As long as this oscillation lasts, a signal is fed back to the radar receiver. The time required for this signal to become imperceptible on the radar indicator is called "ringtime", and is usually expressed in yards or miles. The ringtime is a day-to-day, or relative, measure of the performance of the radar transmitter and receiver combined. This measured value may be compared with a value predicted according to this manual to find out whether the performance of the radar is up to standard. A meter attached to the box yields a rough relative measure of the output of the transmitter alone.

2. REFERENCE DATA

a. Nomenclature — Echo Box TS-172A/UP.

b. Contract NObsr-63469 dated 25 June 1953.

c. Contractor: Johnson Service Company, Milwaukee 2, Wisconsin.

d. Cognizant Naval Inspector: Inspector of Naval Material, Milwaukee, Wisconsin.

e. Equipment Shipped: One package (crate) per shipment. This contains echo box, two manuals, and accessories.

f. Cubic Contents: 10.1 cubic feet crated; 3.6 cubic feet uncrated, including accessories.

g. Total Weight: 120 pounds crated; 66 pounds uncrated, including accessories.

h. Frequency: 1215 to 1370 mc./sec.

i. Frequency Control: Hand tuned.

j. Connecting Cable: Ten foot RG-21/U cable with UG-18B/U connectors, furnished.

k. Typical Ringtime: Ten to fourteen miles: Exact value for a radar in good condition can be predicted with this manual.

3. DESCRIPTION OF ECHO BOX

The TS-172A/UP is shown in Figure 1-1. The unit is housed in splash-proof case. When the cover is removed, a panel is exposed which carries a tuning knob and dial, a microammeter, a switch, coaxial input terminals, a circular slide rule, and a data plate. An instruction card is attached to the box by means of a chain. Attached to the inside of the cover are a cable and two instruction manuals.

The tuning knob moves a plunger which changes the volume of the resonant cavity and thus changes the echo box frequency. Turning the knob also drives a train of gears; these gears drive only the outer dial. The microammeter is used principally to tell when the echo box is tuned to resonance. The switch actuates a loop which couples R-F energy from the echo box to the meter circuit; the meter reads only when the switch is in the "TUNE" position. A screwdriver adjustment inside the case permits the sensitivity of the meter to be regulated. The coaxial input terminals are connected to the radar directional coupler by means of the cable which is provided; this cable is a special resistance cable.

The circular slide rule is used for predicting the "expected ringtime", and for interpreting ringtime measurements in terms of "db down" in radar performance. These computations are explained on the instruction card; the basic use of the echo box is also explained on the instruction card. The data plate is used to record the expected ringtime, and the results of the last test.

4. EQUIPMENT SUPPLIED

Table 1-1 lists equipment supplied with Echo Box TS-172A/UP.

5. EQUIPMENT REQUIRED BUT NOT SUPPLIED

A directional coupler located in the transmission line to the radar antenna is required. This is normally a part of modern radars. A pickup dipole as described in Section 2 may be used as a substitute.

6. SHIPPING DATA

Table 1-2 lists shipping data for Echo Box TS-172A/UP.

7. SIMILARITY BETWEEN THE TS-172/UP AND THE TS-172A/UP

The TS-172A/UP is an improved version of the TS-172/UP. The TS-172A/UP can be used for replacement of the TS-172/UP. The TS-172A/UP performs all of the functions of the TS-172/UP but is simpler to use and is a quantitative instrument. The ringtime is equivalent, and the mounting is identical. The newer version is different in that:

a. The unit is more rugged.

b. A frequency scale has been provided.

c. The input loop adjustment has been eliminated as unnecessary.

d. The "OUTPUT" and "METER" jacks, together with the short patch cord connecting them, have been removed from the front panel. In the rare event that these terminals are needed for special test, they are available with standard BNC connectors under the panel.

e. The 0-20 microampere meter has been replaced with a more rugged 0-100 microampere meter.

f. Undesirable modes of resonance leading to spurious meter response have been suppressed.

g. The crystal has been removed from the front panel because experience has shown that the crystals used in echo boxes rarely fail. This permits a shorter connection to the crystal, with improved constancy of meter indication as a function of frequency.

h. The boxes are individually calibrated in ringing ability at the factory, and means are provided for predicting how much the echo box should ring, so that absolute performance measurements are possible.

i. A short set of instructions is provided on the front panel.

TABLE 1-1. EQUIPMENT SUPPLIED

Quantity per Equipment	Name of Unit	Navy Type Designation	Overall Dimensions			Volume	Weight
			Height	Width	Depth		
1	ECHO BOX	TS-172A/UP	19¾	17⅜	17⅜	3.45 cu. ft.	66 lbs.
1	Cable (W-103)						1 lbs.
1	Allen Wrench No. 6						
1	T-Handle Socket Wrench						
2	Instruction Book						

TABLE 1-2. SHIPPING DATA

Shipping Box No.	CONTENTS		Overall Dimensions			Volume	Weight
	Name	Designations	Height	Width	Depth		
1	ECHO BOX	TS-172A/UP					

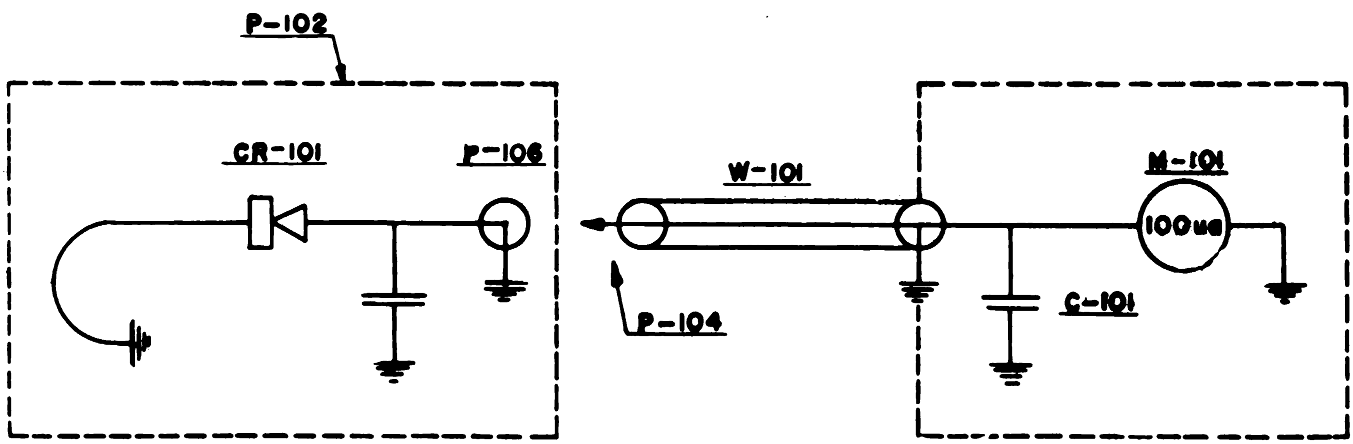


Figure 1-2.
Schematic Wiring Diagram of Output Circuit

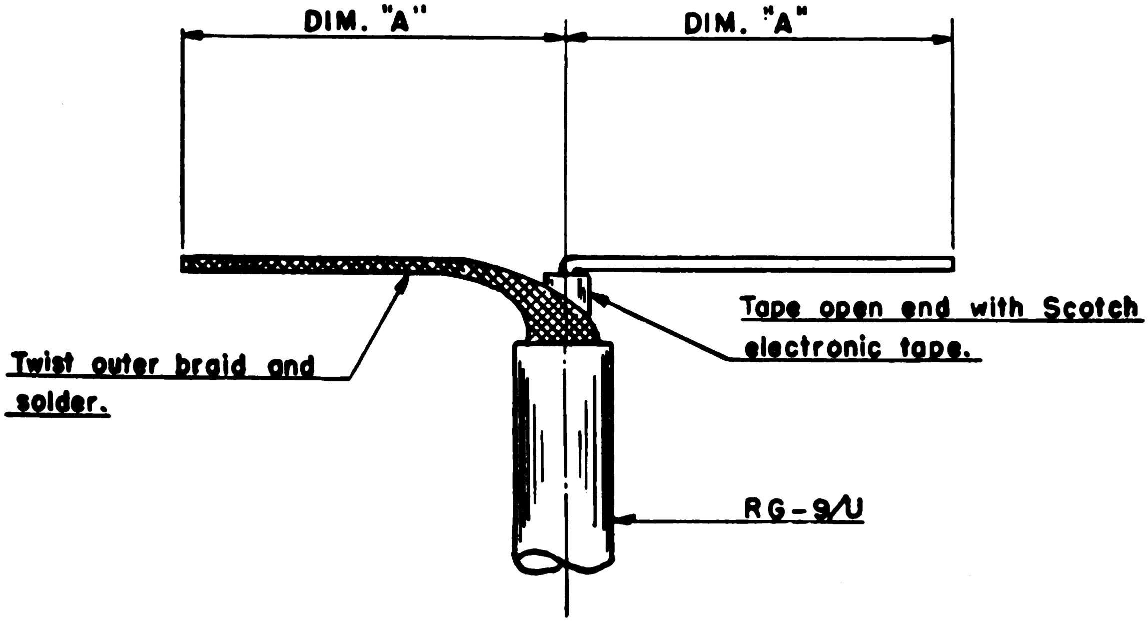
SECTION II
INSTALLATION AND ADJUSTMENT

1. INSTALLATION

a. DIRECTIONAL COUPLER — In use the echo box is connected to a directional coupler in the radar waveguide or coaxial line. A directional coupler will be found in all new radars; some of the older radars, such as the AN/TPS-1B and the AN/CPS-5, were not originally provided with one. In general, drawings are available for directional couplers for the older equipments, and it may be possible to requisition one. The use of the line probe provided in these sets is definitely not recommended, since the coupling of the probe is unknown, the impedance match is very bad, a response to standing waves in the main line is present, and since the power from any test instrument divides peculiarly between antenna and receiver when a test is made through a probe.

The coupling of the directional coupler used is not critical, but in general it should be between 25 and 35 decibels. The closer the coupling the greater will be the ringtime and meter reading of the echo box. No noticeable loss is introduced in the radar transmission line by the presence of the directional coupler.

b. PICKUP DIPOLE — If a directional coupler is not available, a satisfactory installation can be made using a pickup dipole. A pickup dipole can be made from RG-9A/U or RG-9/U cable, as shown in Figure 2-1; it should be cut to the length shown for efficient pickup. It is best to mount the dipole about one antenna diameter away from the large radar antenna reflector; it should be in the middle of the beam when the antenna is on the azimuth at which ground echos extend for the smallest distance. The coupling (when the antenna is at the proper azimuth) is about 10 log 10 S + 9 (in decibels), where S is the area of the radar antenna reflector in square feet. The dipole may also be mounted about two inches in front of the antenna reflector; however, in this position the coupling cannot be predicted, and the echo box can only be used for relative measurements. In either case, the dipole must be aligned with the radar polarization and may be left permanently in position without any effect on the operation of the radar.



f (mc)	"A"
1250	2.14"
1300	2.06"
1350	1.98"

Use UG-21B/U connector on long cable.

Figure 2-1. Construction of Pickup Dipole *c.* CABLE — It is desirable for impedance matching to have several decibels of attenuation between the echo box and the directional coupler or pickup dipole. For this reason a ten foot length of RG-21/U attenuating cable is supplied with the echo box, and the instruction card states that no other cable is to be used. If the echo box must be installed more than ten feet from the directional coupler or dipole, cable of lower loss such as RG-9A/U cable, should be used. A cable of RG-9A/U should be at least 25 feet long. Cables longer than 75 feet are not advisable, because the loss of RG-9A/U cable depends on temperature and on the age of the cable, and if the cable is long, these changes become noticeable. RG-9/U is inferior to RG-9A/U cable because the attenuation of RG-9/U increases badly with age. See Section 5, par. 4 for procedure for installing or replacing cable connectors.

d. If the echo box is used on a radar tower, it should be left on the tower ready for use, since the echo box is particularly useful for quick checks. Put the gasketed cover in place and cover the unit with a tarpaulin after use. The TS-172A/UP can also be placed in the mountings of the older TS-172 for storage on a radar tower, if such mountings exist, as it is mechanically interchangeable.

e. The expected ringtime should be computed when the echo box is installed, and this value should be written on the front panel data plate in the space provided. The method is described in Section 3, par. 1.

2. ADJUSTMENT

a. It will be necessary in some installations to adjust the echo box output loop to provide a proper meter reading. The meter should read quarter scale to half scale when the echo box is in tune. To adjust the meter reading:

(1) Put the radar in normal operation, and point the antenna at the pickup dipole if one is used.

(2) Connect the echo box to the directional coupler or pickup dipole.

(3) Place the "TUNE" "READ RINGTIME" switch in the "READ RINGTIME" position.

(4) By turning the large knob, tune the echo box cautiously from one end of the dial range to the other. If a high meter reading is encountered, the meter may be protected by adjusting screw H-157.

(5) To adjust the screw H-157, loosen the four captive panel screws H-116 and lift the echo box slowly out of the case, using care to avoid damaging the mechanism. Loosen the locking nut H-155, then adjust the meter reading to 25 to 50 with screw H-157 while the echo box is tuned to give maximum meter reading. Turn the screw in to decrease the meter reading or out to increase it. Tighten the locking nut.

(6) Continue to tune through the entire range, readjusting screw H-157 as required. Tune back to the highest meter reading encountered. If this maximum meter reading is between 25 and 50, the adjustment of the output loop is satisfactory.

(7) If no meter reading is observed, as might be the case when a pickup dipole is used in some locations, observe the radar indicator and tune the echo box for maximum ringtime, then adjust screw H-157 for proper meter reading.

(8) Use care in putting the echo box back in the case.

(9) Enter in the log the date of the initial adjustment and of any readjustment.

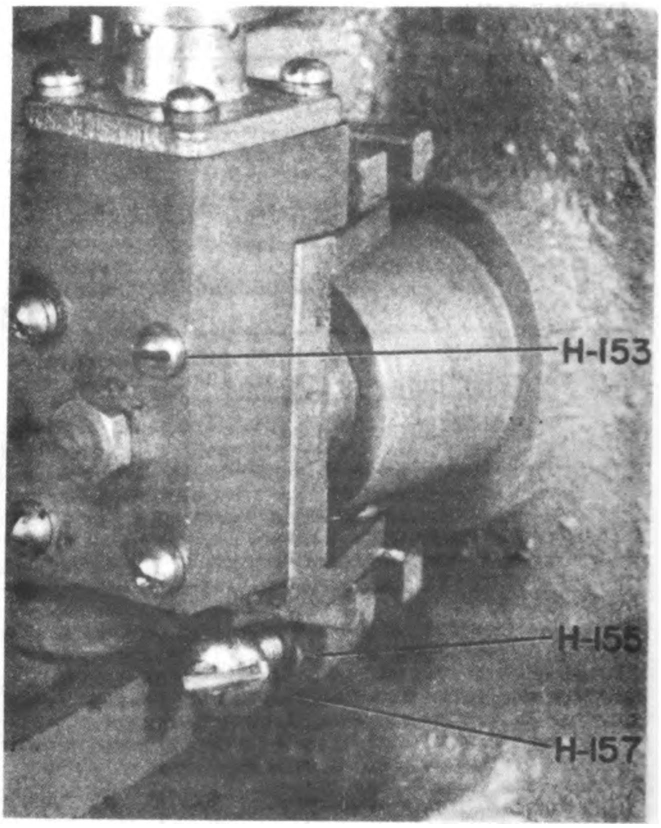


Figure 2-2.

SECTION III
OPERATION

1. RINGTIME PREDICTION

a. If one knows how long the echo box should ring under the particular conditions of the test (this is called the "expected ringtime") one can compare the ringtime observed with the expected ringtime to determine whether the radar is performing well. THIS IS THE MAJOR USE OF THE ECHO BOX.

b. EXPECTED RINGTIME — The expected ringtime is found in two steps. First the "uncorrected ringtime" is found, and then this is corrected to yield the "expected ringtime". The uncorrected ringtime depends on the type of radar, on the directional coupler, and, in radars with two different pulse lengths, on the pulse length in use. This value is corrected by allowing for the particular frequency of operation, for the ringing ability of the echo box, and for temperature effects.

Table 3-1
TABLE OF RADARS AND RINGTIME

RADAR	DIRECTIONAL COUPLER db	RINGTIME (yards)
AN/CPS-5D (long pulse)	32	22400
AN/CPS-5D (short pulse)	32	20300
AN/FPS-3 (long pulse)	35	26900
AN/FPS-3 (short pulse)	35	24900
AN/MPS-7 (long pulse)	35	26900
AN/MPS-7 (short pulse)	35	24900
AN/TPS-1D	28	22100
AN/TPS-15	28	22100
SR-6	25	26900

(1) HOW TO FIND THE UNCORRECTED RINGTIME. — Look in Table 3-1 and see if there is a value given for your particular radar. Be sure that the directional coupler on your radar is like that specified in the table, if this coupler is a field modification, and pick a value appropriate for the pulse length and receiver bandwidth in use on the radar.

If your radar is not listed in this table, to find the uncorrected ringtime go to the radar manual and find these facts about the radar:

(a) How long is the radar pulse, in microseconds? (This can also be measured with the echo box, as described in Section 3, Par. 5.b.)

(b) What is the power of the radar pulse, in kilowatts? (This is also called "peak power".)

(c) What is the bandwidth of the receiver, in megacycles?

(d) What is the "coupling" of the directional coupler, in decibels? (This value should be marked on the directional coupler itself.)

You must also know the attenuation of the echo box cable. If the 10-foot, RG-21/U cable furnished with the echo box is used, the attenuation is 5 decibels. See Table 3-2 if another cable is used.

Table 3-2
CABLE ATTENUATION

RG-9A/U	Attenuation (db)
25 feet	2 db
50 feet	4 db
75 feet	6 db
RG-21/U	**Attenuation (db)**
10 feet	5 db
12 feet	6 db

The uncorrected ringtime can be found by substituting these numbers in the formula below, or it can be found with the nomogram type chart, Figure 3-1 without using algebra. The result is exactly the same, but some users may prefer one method and some the other, so both are given. In the event that two different pulse lengths or two different receiver bandwidths can be used on the radar, calculate an uncorrected ringtime for each condition.

FORMULA FOR THE UNCORRECTED RINGTIME — (This value must be corrected, as described in (2) below, to get the expected ringtime).

$$R = 35{,}000 + 300\left(10 \log_{10} \frac{Pt^2}{B} - 2A\right) + 164t$$

Where:

R = Uncorrected ringtime, in yards, for a good radar

P = Power during transmitter pulse, in kilowatts

t = Transmitter pulse length, in microseconds

B = Receiver bandwidth, in megacycles

A = Attenuation between echo box and radar, in decibels. This value is the sum of the attenuation of the cable and the coupling of the directional coupler, both expressed in decibels.

Sample calculation:

Suppose we have a radar with a transmitter having 500 KW pulse power, a two microsecond pulse, a receiver with an eight-tenths megacycle pass band, and a directional coupler having 25 decibels coupling. The standard echo box cable, having an attenuation of 5 decibels, is used. Thus P=500, t=2, B= 0.8, and A=25+5 or 30.

The formula gives: Uncorrected ringtime.

$$R = 35{,}000 + 300\left(10 \log \frac{(500)(2)^2}{0.8} - (2)(30)\right) + (164)(2)$$

$$R = 35{,}000 + 300\ (10 \log 2500 - 60) + 328$$

$$R = 35{,}000 + 300\ (34 - 60) + 328$$

$$R = 35{,}000 - 7800 + 328$$

R=26,928 yards, or, to the nearest 100 yards, 26,900 yards.

(2) HOW TO FIND THE EXPECTED RINGTIME — A circular slide rule is provided on the panel

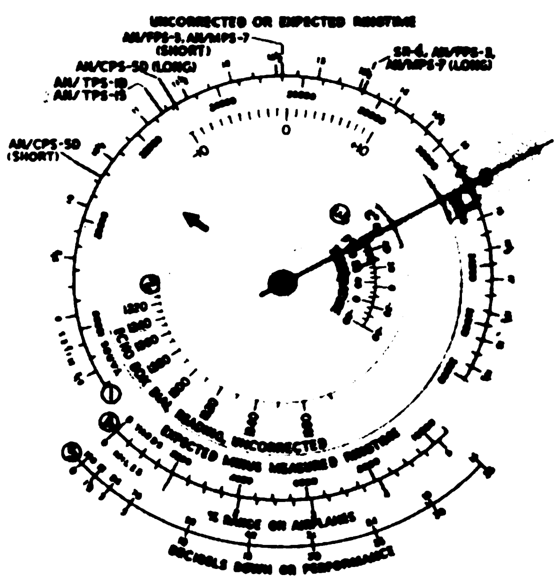


Figure 3-2.

of the TS-172A/UP echo box to correct the uncorrected ringtime to find the expected ringtime. The instructions for using it appear on the instruction card. Figure 3-2 shows the slide rule.

The individual echo boxes vary slightly in their ringing ability. This has been measured at the factory, and the position of the red index mark on the slide rule on each box has been set to correct for this. Do not interchange these slide rules between echo boxes, nor use the slide rule of another echo box for the prediction.

The ringtime depends on the frequency of the radar, and the slide rule corrects for this.

Tests may be made in the field under conditions of temperature which vary widely. The ringtime increases slightly if the echo box is cold, and decreases slightly if it is warm, because the electric resistance of the silver surface of the echo box changes with temperature. The ringtime change is small — one per cent for ten degrees F. change in temperature. The slide rule corrects for this. It is sufficiently accurate to guess the temperature. Unless the temperature changes very much, it is not necessary to calculate a new expected ringtime every time the echo box is used.

c. RADAR PERFORMANCE MEASUREMENT — The expected ringtime is the ringtime that would be had if the radar were operating satisfactorily. The difference between the ringtime measured and the expected ringtime tells how well the radar is working.

EXAMPLE:

Expected ringtime 26,500 yards
Measured ringtime 23,500 yards
3,000 yards short

Every 300 yards of ringtime short corresponds approximately to one decibel of radar performance lost; thus the radar is 3000÷300, or ten decibels down in performance. This is as though the transmitter were operating at one tenth of the proper power output or the receiver at one tenth proper sensitivity, corresponding to almost 50 percent reduction in range.

The slide rule can also be used to convert yards short in ringtime into decibels down in performance. A scale is also provided for interpreting the reduced performance in terms of per cent of the radar range possible on airplanes.

2. FREQUENCY CALIBRATION

a. The echo box dial is read under the left-hand transparent index. The outer dial number is read, followed by the inner dial number. Figure 3-3 shows the dial with a reading of 1291 5 (outer dial reading 129; inner dial reading 1.5).

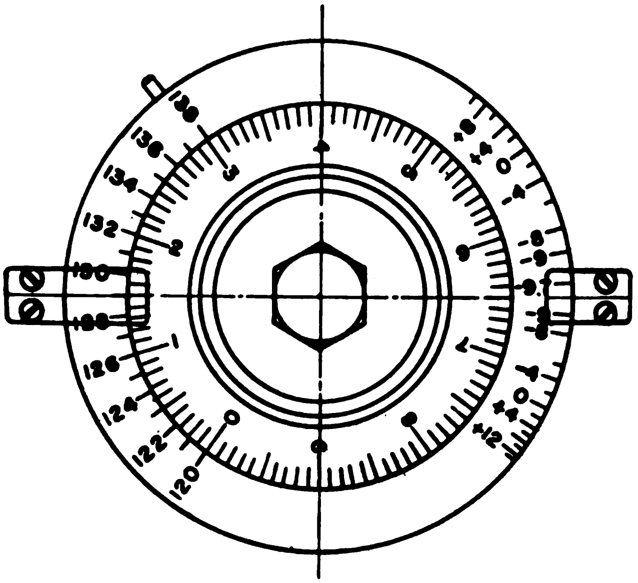


Figure 3-3.
Dial at a Reading of 1291.5

JPLING

1

2

ECTED
TIME

b. The echo box dial reading is the approximate resonant frequency of the echo box, accurate to 12 mc./sec. or better. A second scale is provided on the dial for the correction of the dial reading to obtain the exact frequency. The reading of the second scale, read under the right index, is added algebraically to the reading of the first scale, to obtain the exact frequency. ("Added algebraically" means add the reading if its sign is plus and subtract it if its sign is minus). The exact frequency on the dial shown in Figure 3-3 is 1291.5 minus 9.3, or 1282.2 mc./sec.

3. RINGTIME MEASUREMENT: RADAR PERFORMANCE MEASUREMENT

The following instructions assume that a directional coupler is to be used. When using the pickup dipole, locate the dipole in standard position as indicated in Section 2, par. 1. *b.*

a. PRELIMINARY PROCEDURES.

(1) Place the radar equipment in operation and allow it to warm up to its normal operating temperature (fifteen to thirty minutes for most radars).

(2) Check to be sure that the radar antenna is not pointed toward any large reflecting surface within a few hundred yards, as this might cause the transmitter frequency to be "pulled". Point the radar antenna in the direction in which fewest ground echoes are seen, to produce a place relatively free of echoes at the appropriate range in which the ringtime can be seen. It will help to point the antenna upward if possible.

(3) Connect the input of the echo box to the directional coupler of the radar by means of the ten-foot cable furnished, or by other means as described in Section 2, par. 1. *c.*

(4) Turn off any anti-jamming circuits and the sensitivity time control if provided on the radar.

(5) Check the calibration of the accurate ranging circuit of the radar if provided.

(6) Throw the switch in the upper right-hand corner of the echo box panel to the "TUNE" position and use the large knob to tune the echo box to the transmitter frequency. If the approximate transmitter frequency is known this may be used as a rough guide. The echo box has been tuned to the correct frequency when the meter reading is at a maximum. If the echo box has been adjusted properly (see Section 2, par. 2 above) the maximum meter reading should be between 25 and 50. The meter should not be allowed to go off scale; keep the reading on scale by adjusting screw H-157 as described in Section 2, par. 2. On each side of the correct frequency and occasionally at other points in the tuning range, there are small peaks in the meter reading. Be careful to get the main peak and not one of these smaller peaks.

(7) Tune the radar local oscillator, if automatic frequency control is not in use, so that the maximum ringtime is seen on the radar indicator.

(8) Adjust the I-F gain control of the radar until the noise is at about one-third to one-half of the highest signal level. (In the event that "grass" or "snow" cannot be seen on the scope, the radar I-F amplifier has inadequate gain and should be repaired.

(9) Check to see that the echo box is still in exact tune (radar sets have a tendency to drift in frequency, particularly until they are thoroughly warm).

(10) Throw the switch to the "READ RINGTIME" position and immediately read the ringtime as directed in *b.* or *c.* below.

b. MEASUREMENT OF RINGTIME ON AN A-SCOPE.

(1) The appearance of a typical ringtime on an A-scope is illustrated in Figure 3-4. The ringtime is to be measured, in units of radar range, to the last point at which any evidence of the ringing can be seen. Do not measure ringtime at the bottom of the "grass" nor at the end of the saturated top portion, because these are changed by the receiver gain setting and by other factors.

(2) Repeat each ringtime measurement on an A-scope at least four times and average the result, since there is an element of judgment involved and this method will reduce the error. Individual measurements may differ by 300 to 500 yards, but the average is more accurate. Practice is very important in reading ringtime. With practice one can detect the weak end of the ringtime which runs out into the "grass". The operator who obtains the greatest ringtime measurement is usually the most nearly correct.

(3) Ringtime measurements should be recorded to the nearest hundred yards or tenth of a mile. Both "yards" and "miles" scales are provided on the slide rule.

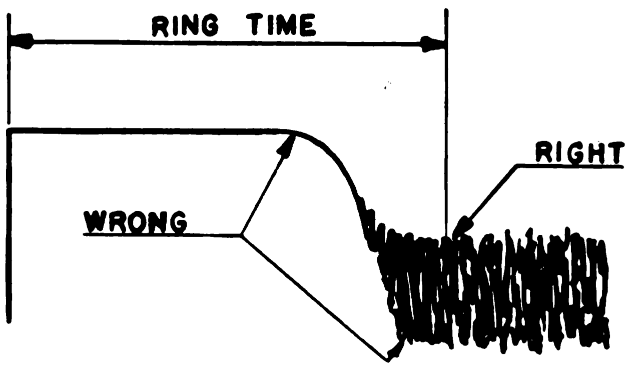


Figure 3-4. Ringtime Pattern A-scope

c. MEASUREMENT OF RINGTIME ON A PPI—If it is not possible to use an A-scope for measurement of the ringtime, a somewhat less accurate measurement may be made with a PPI. The following procedure should be followed:

(1) With the radar antenna in rotation, set the receiver gain at minimum and adjust the intensity (bias) so that there is a very slight radial trace on the PPI indicator.

(2) Increase receiver gain until the PPI area seems to be just half covered with flecks of "snow".

(3) PPI ringtime patterns, with proper receiver gain adjustment (and with radar antenna rotating), are shown in Figure 3-5. The pattern on the left is typical of the result when the echo box is used with a directional coupler, or a dipole two inches from the antenna; that on the right is typical of the result when the echo box is used with a pickup dipole that does not rotate with the antenna.

If the radar antenna is stopped (for convenience in tuning the radar), the PPI ringtime pattern will be brighter, but more difficult to read correctly. The PPI ringtime will then have the general appearance illustrated in Figure 3-6.

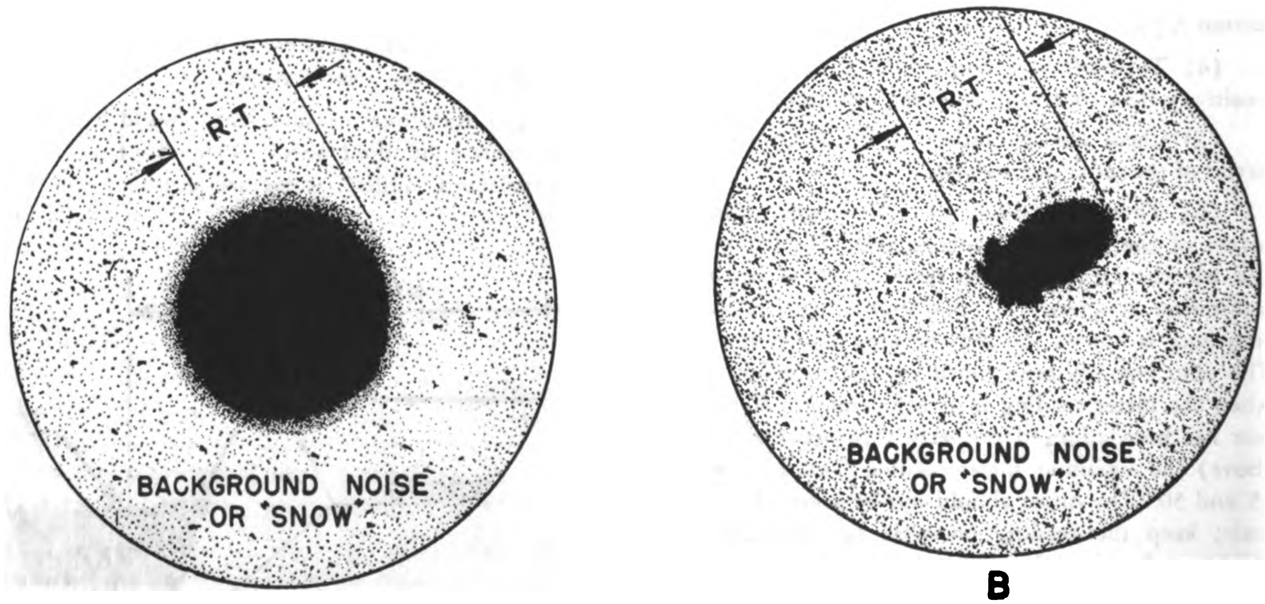
d. RECORDING OF RINGTIME MEASUREMENTS — Every ringtime measurement should be recorded either in the radar log or in the log in the back of this manual. Frequency measurements and meter readings should also be recorded. Such records are valuable for many reasons; in particular, comparison of the ringtime measurement on a particular day with the measurements made on the several preceding days may make it possible to detect troubles while they are developing.

(1) The end of the ringtime is not at the place where the bright or saturated part of the signal ends, but where the fainter portion of the signal disappears into the background noise. Therefore, when reading ringtime on a class PPI indicator, be sure to observe to the extreme tip of the pattern, and not just to the end of the bright portion of the pattern. Read to the last point at which the "snow" is brighter than the background.

(2) See the comments under A-scope measurement on repeating measurements and on the accuracy with which measurements are to be made. There is a particularly strong tendency to read the ringtime too short on a PPI if the radar antenna is in rotation.

e. COMMENTS ON RINGTIME, RADAR PERFORMANCE, AND RADAR RANGE.

When a radar under test shows less than the expected ringtime, it is an indication that the operating or service range of the installation is below par. Ringtime is not directly proportional to radar range. A SMALL LOSS IN RINGTIME REPRESENTS A GREAT LOSS IN EFFECTIVE SERVICE RANGE. Ringtime must, therefore, be measured as carefully and as accurately as possible, and prompt steps must be taken to repair the radar if the performance is poor. The radar definitely should be fixed if it is over five decibels down in performance, or over 1500 yards short in ringtime.



Using a Directional Coupler

Using a Fixed Dipole

Figure 3-5. Ringtime Pattern PPI-scope.

4. TUNING THE RADAR

An echo box is a convenient aid in tuning a radar. The method is simple: follow the procedures outlined above in Section 3, par. 3, Ringtime Measurement, as far as item (7); then, after tuning the local oscillator, proceed to adjust the other tuning adjustments of the TR and ATR to obtain the most ringtime. (The local oscillator injection level should not be set by reference to ringing, but rather by the radar crystal current meter. No antenna matching adjustments should be attempted by echo box meter reading or ringtime criteria, as the load on a self-excited oscillator should not be set for maximum power output but for a compromise between output and stability).

When using an A-scope, which is much better for this purpose than a PPI, it is helpful to mark a vertical line through the sloping portion of the pattern (near the end of the ringing). As the tuning proceeds, the pattern appears to wave back and forth, but its intersection with the vertical line moves up and down. If maximum target echoes and maximum ringtime occur at different settings of the local oscillator, the echo box is not in exact tune with the radar; if this happens, retune the echo box.

An echo box is particularly convenient to use when the radar is far out of tune, because the echo box signal is strong and can be seen much sooner than ordinary echoes as the radar begins to approach proper tuning.

It is quite desirable to record the ringtime before and after a routine tune up. One frequently finds that one has not made as large an improvement in performance as it seems, so that measuring ringtime is a desirable check on the progress of the tuning. Comparison with the expected ringtime can, of course, show that no tuning is needed, or tell when a proper adjustment is accomplished.

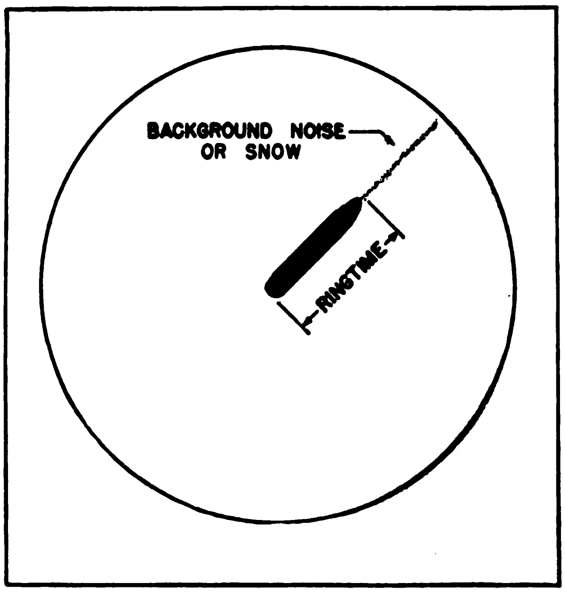


Figure 3-6. Ringtime Pattern PPI-scope, Antenna Stopped

A new use for an echo box has been found in tuning an MTI radar. The frequency of the coherent oscillator or "coho" can be set very conveniently, and with better accuracy than on clutter echoes, if the ringtime is observed on the uncancelled video. When the coho is out of tune a sine wave pattern is seen on the A-scope. As the coho frequency is varied the wavelength of this pattern changes. The pattern is adjusted until it becomes a horizontal line, indicating zero beat.

CAUTION

Since the echo box radiates on an extremely narrow frequency band compared with the spectrum of the transmitter, it is an error to attempt tuning of the receiver I-F stages by means of the echo box. This is especially true in "stagger-tuned" I-F amplifiers, in which a wide I-F is made by tuning the I-F stages to different frequencies. If such tuning is attempted, the receiver bandwidth may be narrowed; the ringtime will then increase, indicating apparently improved radar performance. Actually such I-F tuning will have impaired the operation of the radar set.

5. OTHER TESTS

a. TRANSMITTER POWER OUTPUT — If the ringtime is low, use the echo box to determine whether the fault lies in the transmitter or in the receiver. If the highest echo box meter reading is normal (i.e. equal to that obtained previously when the radar was in good condition) the transmitter is operating properly and the fault must be with the receiver. If the transmitter is faulty, the meter reading will be low.

The echo box meter reading is roughly proportional to the average power output of the radar and also to the pulse length in use. If the radar has more than one pulse length be sure that the meter readings compared were taken at the same pulse length and the same PRF. The echo box meter reading changes somewhat as the radar frequency is changed, so that readings made at different frequencies should not be compared without allowance for this effect.

In order to have a standard for comparison, the echo box meter reading, the frequency, and the ringtime should be entered into the radar log or into the log in the back of this manual every time they are measured. For the same reason, the latest reading should always be put on the data plate on the echo box panel.

b. SPECTRUM ANALYSIS — All of the energy of a radar pulse is not at one frequency; instead, it is contained in a band of frequencies whose center is the operating frequency of the radar. The frequencies on each side of the center frequency are called side bands. The distribution of energy among the operating frequency and the various side bands is called the "spectrum". A fairly wide spectrum with much energy in the side bands, is an inevitable result of pulsing the energy. It is possible to tell something about how the magnetron is operating during the pulse from the shape and width of the spectrum.

To record the transmitter spectrum, connect the echo box as for ringtime measurement (Section 3, par. 3. *a.*), and throw the TUNE-READ RINGTIME switch to the "TUNE" position. Turn the echo box dial to a point about a quarter turn below the position of maximum meter reading, then turn toward the position of maximum meter reading and well beyond this point. Call off the readings of the meter at each small division of the dial to another man to record. There will be roughly 15 to 25 readings on each side of the maximum; from these readings make a graph like Figure 3-7. Blank graph paper for this purpose will be found in the back of this manual.

Interpretation of the spectrum curve may be done by comparison with Figure 3-8, although most radars in the frequency band in use today do not give as good a spectrum as Figure 3-8a. A good spectrum should be symmetrical and have deep, narrow minima (dips) on each side of the maximum. If no other troubles are encountered, a poor spectrum is probably acceptable if it is narrow enough so that most of the energy is within the receiver pass band. If the spectrum is wider than this, some loss of signal strength will result, and also a decrease in ringtime will occur.

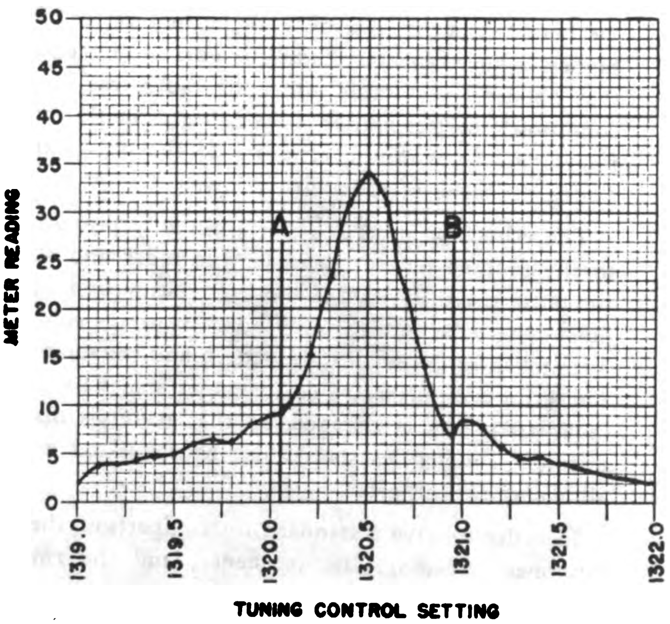


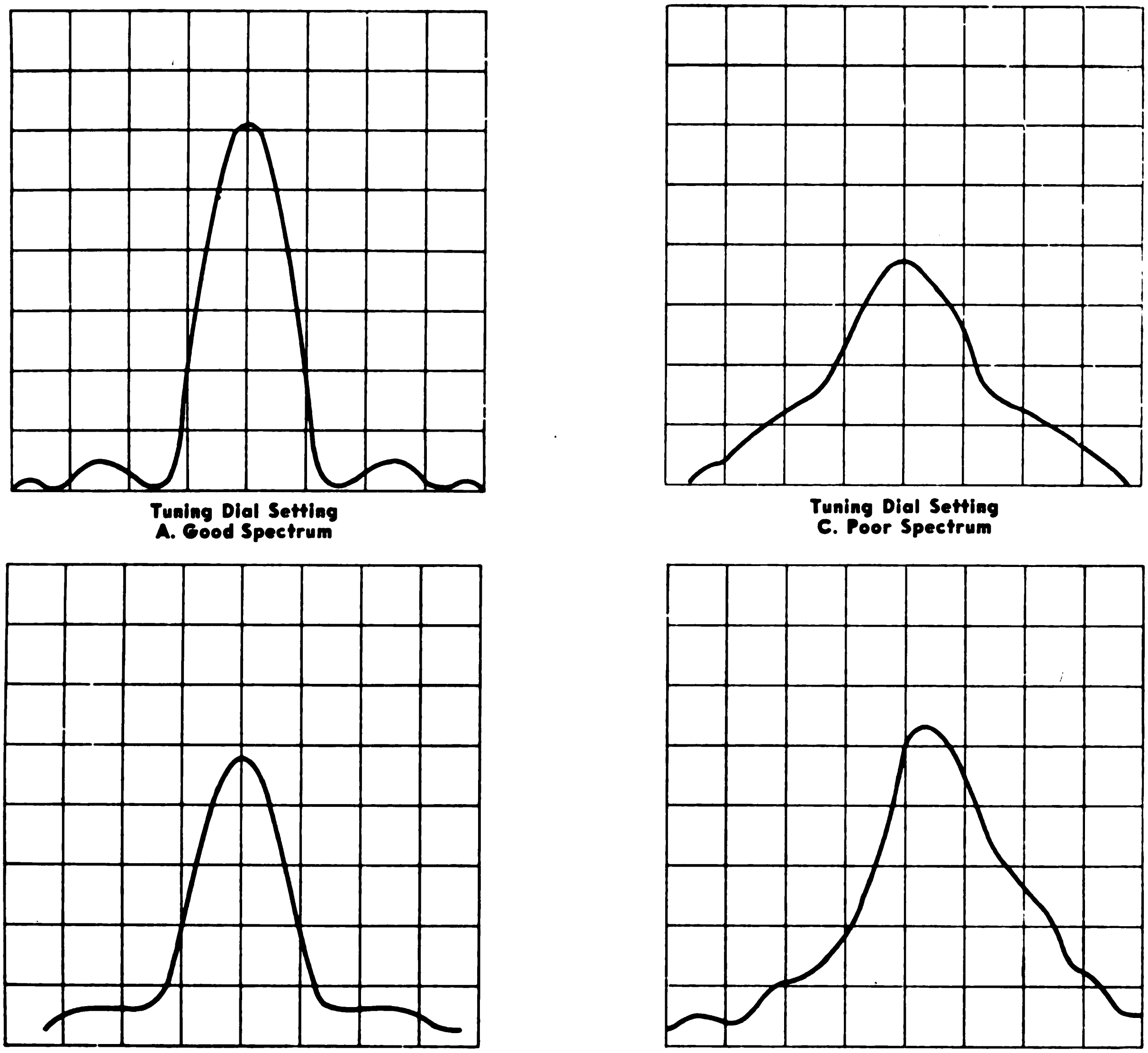
Figure 3-7. Typical Spectrum

AFC troubles can be caused by a bad spectrum, and a bad spectrum can indicate that the magnetron is operating into a load with a bad standing wave ratio or being operated with an improper magnetic field or pulse voltage. The pulse voltage and the magnetron frequency may be varied in an attempt to get a better spectrum. Sometimes it helps to reverse the magnetic field on the magnetron. Magnetrons vary in their ability to put out a good spectrum. A bad spectrum is usually basically due to frequency modulation of the magnetron during the transmitted pulse. A good spectrum indicates pure amplitude modulation. A major cause of poor spectra is change in voltage of the pulse during its duration, but it is usually not possible to do much about the modulator pulse shape. If a radar which has had an acceptable spectrum develops a bad spectrum over a period of days or weeks, it is a strong indication that something has happened to the modulator or magnetron. It is probable that the pulse voltage or pulse shape has changed, or that there is trouble with the magnetron. Check the modulator pulse shape and voltage, the power supply voltage, and the magnetron current for further clues.

The pulse length can be found from the graph of the spectrum. Mark the first two points of minimum meter reading found on each side of the maximum meter reading, such as A and B in Figure 3-7. Count the number of small dial divisions between these two points; each such division is one-hundredth of a dial revolution. Figure 3-9 shows how many megacycles of tuning result from each dial revolution, depending on what the dial setting is. Note the dial reading at the peak of the spectrum and find the tuning rate for this dial setting from Figure 3-9. Multiply this rate by the number of dial divisions between the minima and divide by one hundred; the result is the number of megacycles between the two minima. Divide two by this number of megacycles, and this result is the R-F pulse length in microseconds.

Example:

There are 9.0 small dial divisions between A and B in Figure 3-7. The dial reads 1320.5 at the peak of the spectrum. From Figure 3-9 the tuning rate is 13.25 megacycles per revolution. $(13.25 \times 9)/100 = 1.19$ megacycles between the minima. $2/1.19 = 1.68$ microseconds, the length of the pulse.



Tuning Dial Setting
A. Good Spectrum

Tuning Dial Setting
C. Poor Spectrum

Tuning Dial Setting
B. Fair Spectrum

Tuning Dial Setting
D. Bad Spectrum

Figure 3-8. Spectrum Analysis Diagram

With practice it will not be necessary to make a graph to recognize the quality of the spectrum, or to measure pulse length. Spectrum analysis can be done very easily, in the course of tuning up the echo box for a ringtime check. The pulse length can be found by reading the dial at the minimum and maximum positions. A graph is still a worthwhile record for future reference.

c. TEST FOR ERRATIC OR UNSTABLE RADAR OPERATION — Tune the echo box to the maximum meter reading (Section 3, par. 3. *a.*), reduce the receiver gain somewhat to eliminate noise, and observe the A-scope. If the sloping portion of the ringing trace is multiple or erratic, it shows that the radar is not operating in the same fashion in each pulse cycle. Such erratic operation can be a symptom of trouble which is just developing. This can lead to faulty operation of automatic tracking circuits and to bad MTI operation.

It is possible to use the echo box to localize the cause of erratic operation. First tune the echo box slightly from side to side. Discount the inevitable shortening of the ringing as the echo box is brought out of tune; but if the erratic behavior increases as the echo box gets out of tune, it is a sign that the transmitter is at fault, and is putting out an erratic spectrum. Fluctuating meter readings also indicate a faulty transmitter. Most radars show some erratic transmitter operation, so a slightly fuzzy trace is normal when the echo box is out of tune. Radars with spark-gap modulators are normally somewhat erratic. This normal behavior should not be mistaken for trouble. (A fuzzy echo box trace during ringtime measurement thus suggests to the experienced user that the echo box is slightly out of tune.)

To get positive proof that the trouble is or is not in the transmitter, remove the echo box from the case and

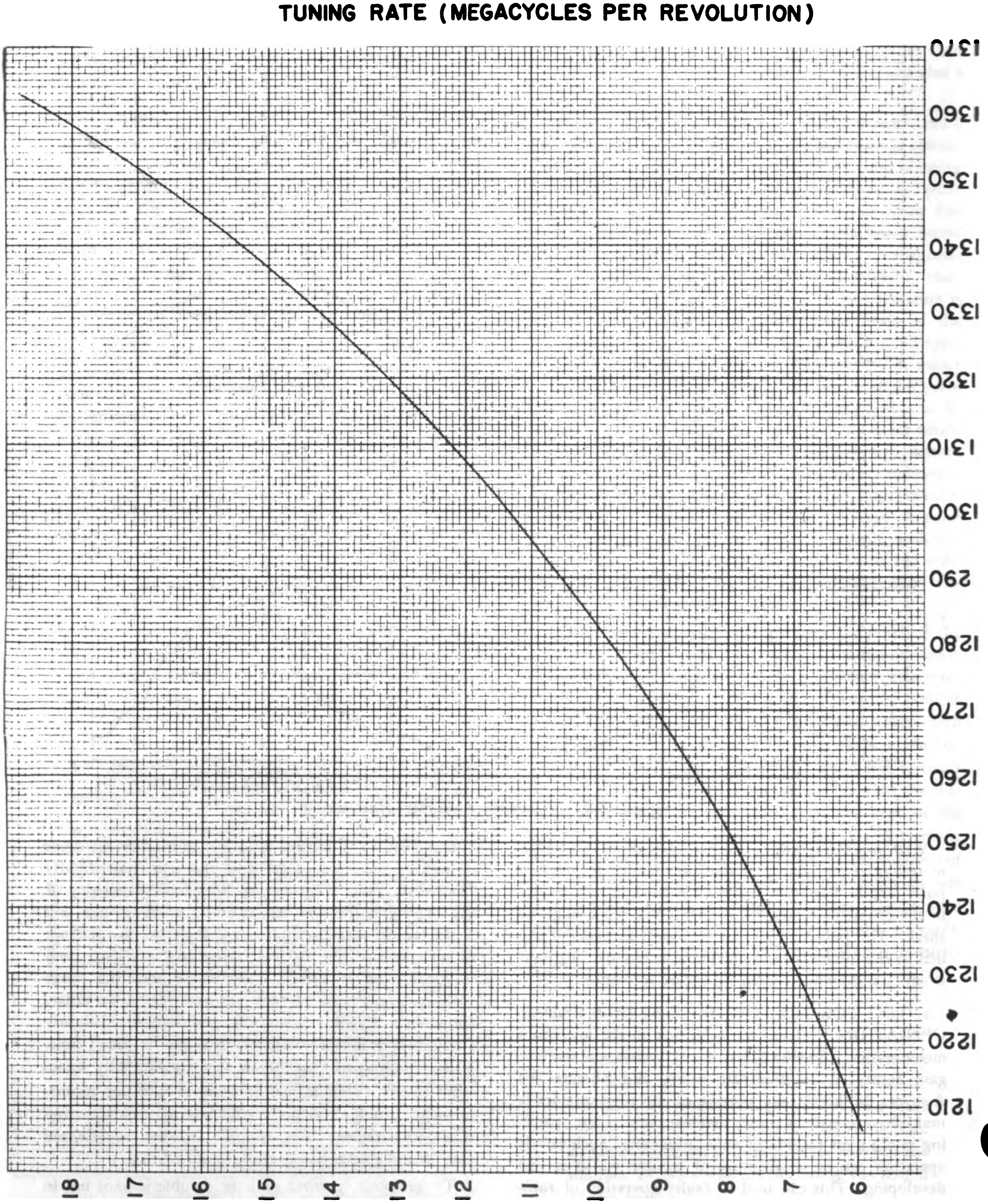


Figure 3-9. Tuning Rate vs. Dial Reading

connect an oscilloscope to plug P-106 with a coaxial cable having BNC connectors. A terminating resistor for DC return should be provided at the oscilloscope. The trace so seen is due to the transmitter energy alone, since the receiver is not in the circuit. Any erratic behavior seen here is due to the transmitter alone.

Trouble in the receiver can be suspected if the trouble is not found to be in the transmitter. To check for erratic operation of the local oscillator, turn off the AFC, tune the echo box to the peak of the spectrum, and then watch the A-scope while the local oscillator is tuned slowly from one side to the other. Discount the inevitable shortening of the pattern as the oscillator gets out of tune; if the pattern becomes more erratic or less erratic as the local oscillator is tuned, it is evidence that the local oscillator is modulated. AFC circuits can introduce erratic receiver operation, so one should note whether the trouble disappears when the AFC is turned off to perform this test.

Echo box echo should cancel in an MTI system. If any appreciable evidence of ringing is seen when MTI is used, this is also an indication of erratic operation and the above tests may help to localize the fault. If no signs of erratic operation are seen when MTI is not used, the MTI components should be suspected.

d. TRANSMITTER FREQUENCY PULLING — For this check the echo box must be connected to the transmitter through a directional coupler, or a pickup dipole mounted on the radar antenna, so that the coupling to the echo box will remain constant while the antenna rotates. Slew the antenna to an azimuth where there are no nearby obstructions and tune the echo box for maximum meter reading. Allow the antenna to rotate slowly and observe the meter reading. If the reading changes, the transmitter is probably being pulled in frequency. To confirm this, stop the antenna at the azimuth where the meter reading is most changed, and retune the echo box. If pulling is taking place, the maximum meter reading will occur at a changed echo box dial reading. If there are not extensive ground echoes, it may be possible to spot pulling by looking for notches in the ringing time pattern on the PPI. Pulling is due to a change in the load impedance on the magnetron; this change may be due to nearby obstructions or to trouble in the rotating joint.

e. AUTOMATIC FREQUENCY CONTROL CHECKS.

(1) AFC FOLLOWING — When the transmitter is pulled in frequency it is important to know whether the local oscillator is following in frequency, thus keeping the receiver in tune. If pulling has been found, make the following test:

Stop the antenna in a direction in which there is no pulling and tune the echo box. Now measure the ringtime in this direction on the PPI with the antenna rotating. Then stop the antenna in the direction in which there is maximum pulling and again tune the echo box. Now measure the ringtime in this second direction with the PPI rotating. If the ringtime is shorter in the second direction than in the first, it is evidence that the AFC is not following.

(2) AFC LOCKING — This check will show whether the AFC is locked on the proper frequency. Stop the radar antenna and tune the echo box for maximum meter reading. Turn off the AFC and tune the local oscillator for maximum ringtime in the same oscillator reflector mode, as judged by the radar crystal current. If the ringtime decreases, even slightly, the AFC is locking on the wrong frequency or is failing to lock. The probable causes of AFC trouble are a bad spectrum, local oscillator tuned on the wrong side of the transmitter, or an incorrect local oscillator adjustment. It is not advisable to realign the AFC circuit until it has been found, by eliminating other possible causes, that this is necessary.

f. T-R BOX RECOVERY — Some time is required for the T-R to recover from the transmitter pulse. During this time, and up to the corresponding radar range, the radar performance is much reduced. As a T-R tube approaches the end of its useful life, the recovery time increases. The T-R tube should be replaced for radars in this frequency band when their recovery time exceeds two miles. Anti-T-R tubes have a very long life and rarely need replacement.

To measure the recovery time of the T-R, stop the radar antenna and adjust the echo box tuning for maximum meter reading. On the radar A-scope a ringtime pattern such as curve A in Figure 3-10 should be seen. Slowly start to reduce the receiver gain setting or to detune the echo box. A pattern will result such as curve B, which has the same shape as A but is shorter. Further slight reduction in gain setting will produce another pattern such as curve C, again similar in shape

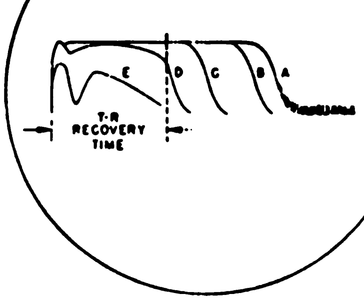


Figure 3-10. T-R Recovery.

to curve A. Continue until a change occurs in the slope of the curve, as in curve D. The point of change in shape marks the T-R recovery time of the radar.

If the gain control is reduced still further, a greatly distorted pattern will appear, such as curve E in Figure 3-10. If the above procedure does not produce a series of curves of identical shape (as indicated) giving a T-R recovery point, and if the ringtime is short, then it is probable that the T-R recovery time is much too high and is greater than the ringtime. If T-R tubes age too rapidly, excessive keep-alive current may be responsible.

g. RECEIVER RECOVERY — Adjust the echo box tuning control for maximum meter reading. Stop the radar antenna. Then detune the echo box, and adjust the radar receiver gain control until the indicator shows a pattern similar to the example illustrated at the left of Figure 3-11. Now retune the echo box to maximum meter reading and again observe the indicator pattern. If the receiver recovery time is normal, the background noise will reappear immediately after the end of the ringtime pattern, and this noise will be approximately as strong as the noise previously observed with the echo box detuned. If the receiver recovery is slow, the noise will be weak and will not reappear for some time after the end of the ringtime pattern (see the right-hand portion of Figure 3-11). In extreme cases of receiver non-recovery, normal background noise may not reappear on the indicator at all. Receiver non-recovery is usually an I-F tube or video defect, and one which will make the radar susceptible to enemy jamming.

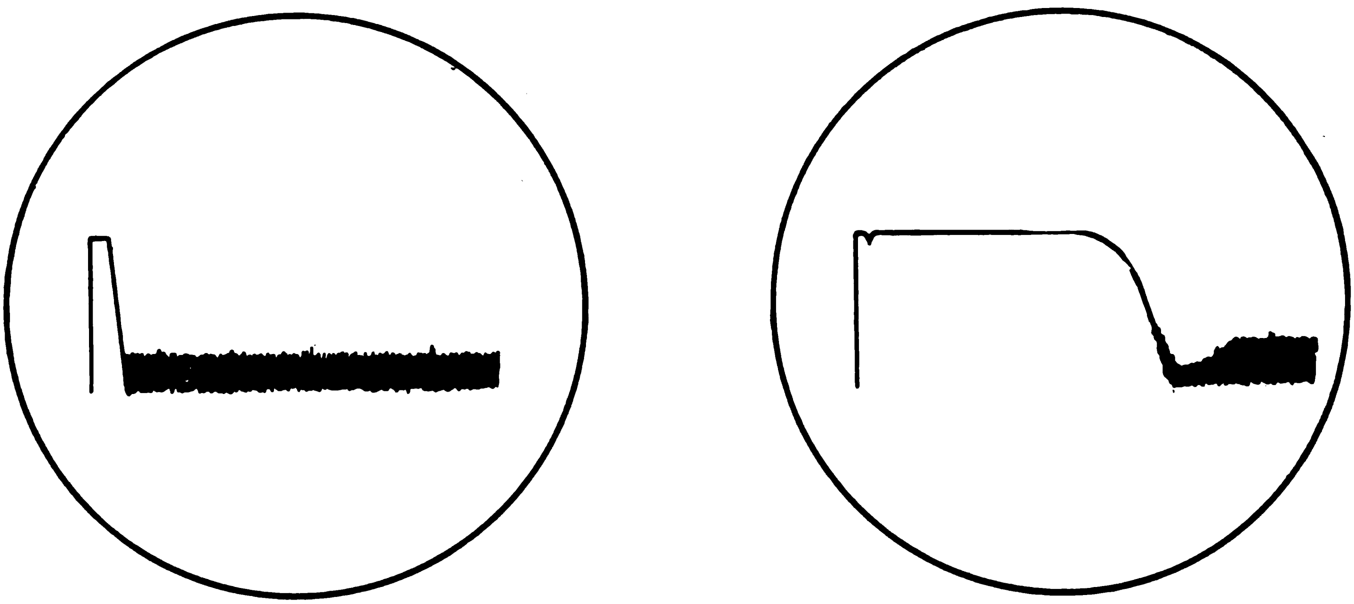


Figure 3-11. Receiver Recovery

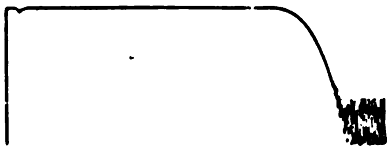
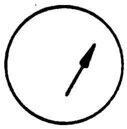
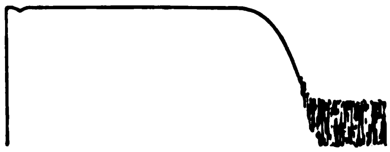
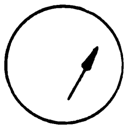
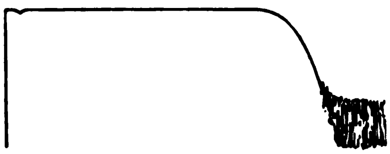
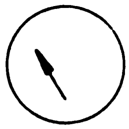
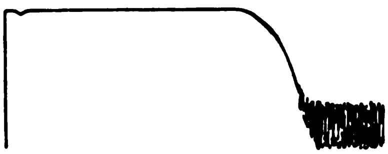
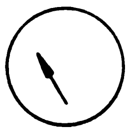
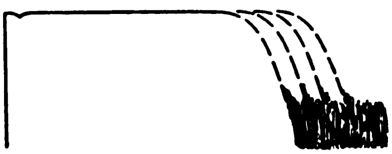
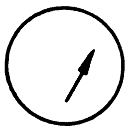
EFFECT	APPEARANCE ON RADAR INDICATOR	APPEARANCE ON TEST SET METER	PROBABLE CAUSE
Ringtime satisfactory, test set output reading satisfactory.			Radar performance satisfactory.
Ringtime low, test set output reading satisfactory.			Receiver trouble: detuned mixer or local oscillator, bad crystal, excessive i-f noise from first pre-amp stage, adjustment of coupling loops or probes in mixer cavity. Detuned T-R box.
Ringtime low, test set output reading very low.			Low power output. Check spectrum.
Ringtime low, test set output reading low.			Trouble probably in transmitter and receiver and/or trouble in transmission line, if dipole is being used.
Ringtime erratic, test set output reading steady.			Test set slightly detuned. Faulty pulsing, double moding transmitter, or local oscillator power supply trouble. Check spectrum.

Figure 3-12. Quick Trouble Shooting Chart

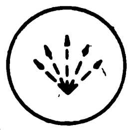
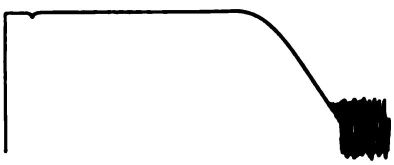
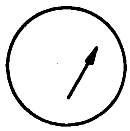
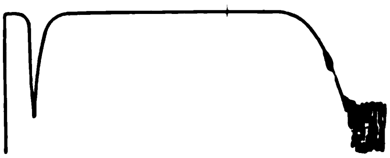
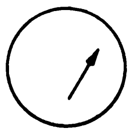
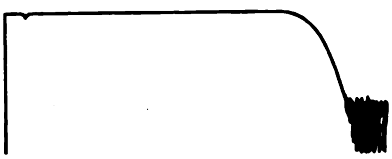
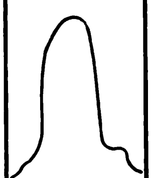
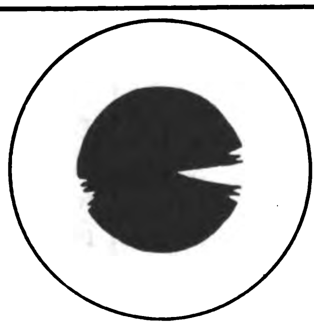
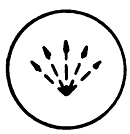
EFFECT	APPEARANCE ON		PROBABLE CAUSE
	RADAR INDICATOR	TEST SET METER	
Ringtime erratic, test set output reading erratic.			Faulty transmission line or poor connections — condition worse when line is rapped.
End of ringtime not steep but slopes gradually; perhaps even excessive ringing. Grass appears coarse. Test set output reading steady and satisfactory.			Oscillating i-f and or narrow band receiver.
Pronounced dip in ringtime at end of pulse.			Bad T-R tube.
Ringtime very slightly low, poor or bad spectrum.			Transmitter trouble.
Blank spaces or rough pattern on PPI ringtime indicator, test set output reading varies as radar antenna is rotated.			Frequency pulling of transmitter due to bad rotating joint or to reflecting object near radar antenna.

Figure 3-12. Quick Trouble Shooting Chart

SECTION IV

THEORY

1. HOW THE ECHO BOX WORKS

a. The echo box can be represented by the equivalent circuit shown in Figure 4-1. The high Q cavity resonator of the echo box is represented as a parallel resonant circuit. The input and output circuits are link-coupled to this resonator with half-turn loops. The output circuit contains an R-F bypass condenser, an audio bypass condenser, and a crystal rectifier together with a meter for reading its current. The coupling of the output loop is adjustable. The resonator is a large round waveguide which is short circuited at one end with a fixed plate and which is effectively short circuited at the other end by a movable plate that does not make contact with the cavity wall. As the dial is turned clockwise the movable plate is moved out and the resonator is made longer. The increased length lowers the resonant frequency, just as though the coil and condenser in the equivalent circuit were made larger.

b. Every time the radar transmits a pulse, some of the R-F energy is picked up by the directional coupler and fed to the resonator through the coaxial cable and the input loop. If the echo box is tuned to the frequency of the radar, R-F oscillations will build up in the resonator during the pulse. These oscillations contain energy. After the pulse ends these oscillations remain but gradually die out as stored energy is used up.

Most of the energy is lost in the resistance of the resonator, but some is sent back through the input loop cable, and directional coupler, to the radar receiver where it produces a ringing signal. To prevent loss of energy into the output circuit, this circuit is disconnected by decoupling the output loop during ringtime measurement.

Figure 4-2 shows the nature of the oscillations in the echo box. This figure has been simplified to show only a few cycles of oscillation during both the pulse interval and the ringing. Actually there are very many cycles of oscillation during each.

During the greater part of the ringing the signal returned to the radar receiver is extremely strong and the receiver is saturated. This explains the flat top on the pattern shown on the A-scope. Later, as the oscillations die down and the signal gets weaker, the trace slopes down from the flat top and disappears into the background noise of "grass". The point at which the ringing signal finally disappears in the "grass" is considered to be the end of the ringing. The ringtime is

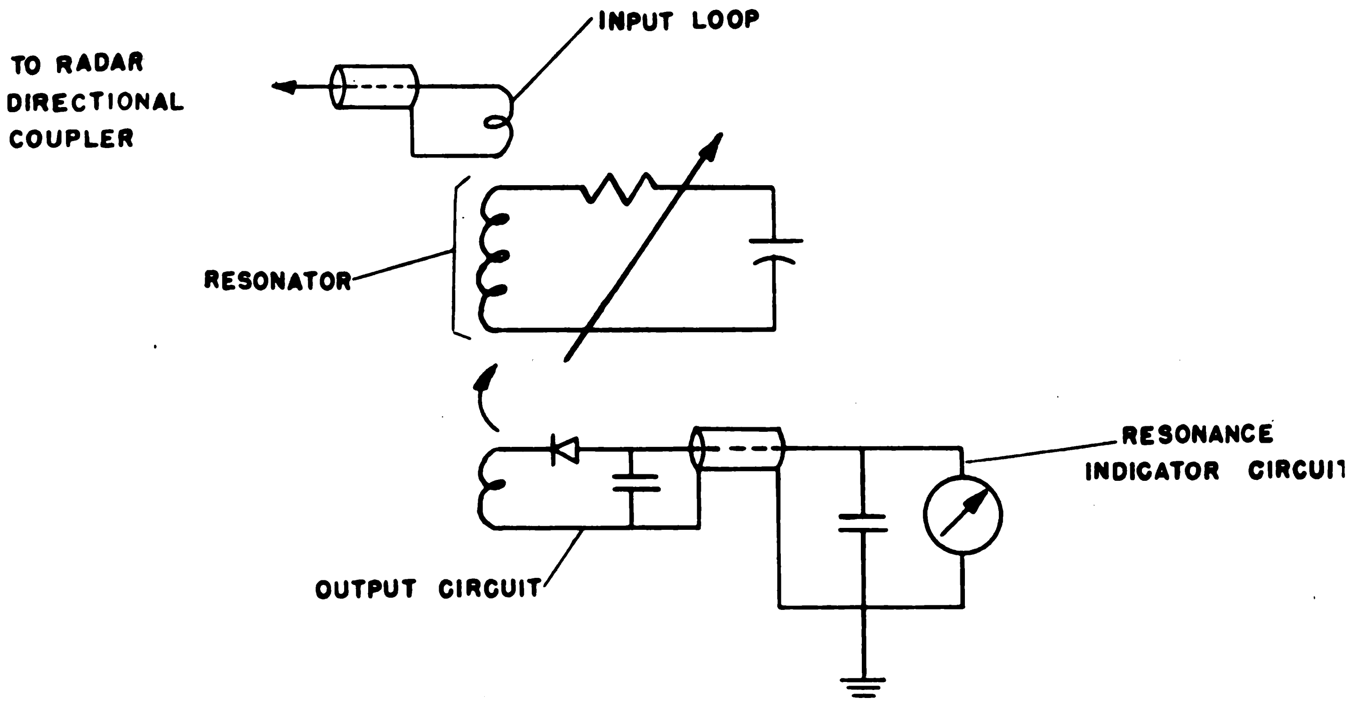


Figure 4-1.
Equivalent Circuit of TS-172A/UP Echo Box

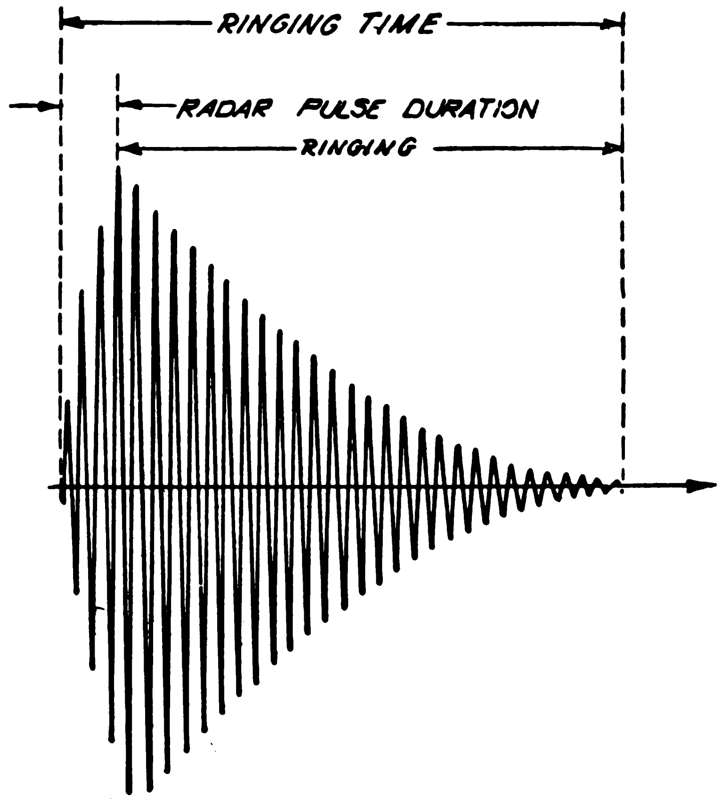


Figure 4-2. Oscillations In Echo Box

defined as measured from the beginning of the pulse to the point at which the ringing can last be seen in the "grass".

2. RADAR PERFORMANCE AND THE USE OF DECIBELS

a. RADAR PERFORMANCE — The efficiency of a radar in seeing targets under given external conditions depends on the radar performance. Radar performance consists of two main factors:

(1) The power in the pulse sent out from the antenna, measured when the pulse has correct frequency distribution.

(2) The receiver sensitivity, measured by the power of the smallest signal that will produce a pip on the indicator that is just discernible above the noise level.

The radar performance is defined by the following formula, which applies when the transmitter spectrum and receiver bandwidth match (see Section 4, par. 3. *b.*)

$$\text{Radar Performance (as a ratio)} = \frac{\text{Pulse Power Output}}{\text{Minimum Discernible Signal}}$$

Radar performance, like other power ratios, is often measured in decibels according to the following equation: Radar Performance (in decibels) = (10) $\left[\log_{10} \frac{P_2}{P_1}\right]$ where P_2 and P_1 are the powers being compared.

The decibel affords a convenient means of indicating performance in simple figures, avoiding the difficulty of expressing large numbers. For a radar in good condition, a typical value of performance is 100,000,000,000,000,000, which is more conveniently expressed as 170 db.

A drop of 3 db in performance (often stated as "3 db down") equals a decrease to ½ in the power ratio — that is, a 50% drop in transmitter output or a 100% increase of receiver input noise. A gain of 3 db in performance equals a rise to twice the power output or a halving of the receiver noise. Similarly, a drop of 10 db equals a decrease to 1/10 in power ratio, a drop of 20 db equals a decrease to 1/100 in power ratio, a drop of 30 db equals a decrease to 1/1000 in power ratio. Decibels are added where ratios would be multiplied; hence, 13 db down is 10 db plus 3 db, equivalent to a drop in power ratio of 1/10 times 1/2, or 1/20.

b. All radars with equal performance do not see the same targets equally well. Radars are not always designed for the same purposes nor are they similarly installed; in addition, the weather has a large effect upon the ability of a radar to see targets. Radar performance is a measure of that part of the ability to see targets which is under the control of the maintenance man.

3. FACTORS INFLUENCING RINGTIME

Outlined below, with explanation, are the factors which determine how long the echo box will ring. The first two of these determine the radar performance; the next two are related to radar characteristics; the remainder relate to the echo box, the installation of the echo box, and the circumstances of the test.

a. TRANSMITTED PULSE POWER — If all other factors are constant, the higher the power of the transmitted radar pulse, the higher the oscillations in the echo box will build up during the pulse. Since the gradual dying out starts from the level at the end of the pulse, a longer time is taken for the echo box signal to die down to the receiver noise level. The ringtime is increased by 300 yards for each increase in transmitter power of one db.

b. RECEIVER SENSITIVITY (NOISE LEVEL) — If all other factors are constant, the lower the apparent receiver-input noise level is made, the longer will be the measured ringtime, since one is enabled to see the weaker signal which comes from the echo box at a slightly later time. The apparent receiver-input noise level is the result of two principal factors: the receiver noise figure and the receiver bandwidth. The noise figure is the apparent input noise power per unit bandwidth in a receiver, in db above that which would be present in a theoretically ideal receiver. Noise figure is the general figure of merit of receivers, and is the quantity which one is trying to maintain. Each db increase in noise figure produces a 300-yard reduction in ringtime.

The bandwidth, which does not ordinarily change, also contributes to the noise level. The greater the bandwidth, the more noise is permitted to pass. Hence, a decrease in the bandwidth causes an increase in ringtime, but does not improve the ability of the radar to detect targets. The bandwidth of the radar receiver has been chosen by the designer to match the pulse length; hence reduction in the bandwidth is not desirable even though it produces an increase in ringtime.

c. PULSE LENGTH — Pulse length affects ringtime, because during a long pulse the echo box "charges up" to a greater extent than during a short pulse. Doubling the pulse length yields a 6 db or 1800-yard increase in ringtime. In radars in which the pulse length may be changed, different ringtimes will be obtained on each pulse length as explained before. The pulse length may be determined with the echo box as shown in Section 3, par. 5. *b.*

d. SPECTRUM — A bad transmitter spectrum reduces ringtime; it also reduces performance, though generally not as much. The spectrum may be determined with the echo box as directed in Section 3, par. 5. *b.*

e. The remaining things which influence the ringtime pertain to the echo box and its installation. The effect of these factors is taken care of in the process of predicting the expected ringtime.

(1) COUPLING — The coupling of the directional coupler or the coupling to a pickup dipole tells what fraction of the transmitter power appears at the coupler terminals, or what fraction of power applied there from the echo box will reach the receiver. The coupling of the directional coupler reduces the ringtime by 600 yards for each db of coupling; 600 yards because a 300-yard loss occurs "going" and another 300 yards "coming back".

(2) CABLE — The loss in the cable which connects the echo box to the pickup dipole or directional coupler also occurs twice, and shortens the ringtime by 600 yards per db loss. Some loss here is desirable.

(3) The ringing ability of the particular echo box, and the temperature of the echo box, also determine how long the echo box will ring. These factors, unlike those above, cause a certain *percentage* increase in the ringtime.

4. USUAL CAUSES OF POOR RADAR PERFORMANCE

The usual causes of radar performance faults lie in the radar receiver. The radar transmitter is not the usual cause of radar performance troubles. Most troubles which cause seriously reduced transmitter power output will show up in obvious symptoms such as arcing in the radar lines or improper readings on the transmitter meters.

Troubles in the radar receiver are not indicated in an obvious fashion unless echo box or other performance tests are made. Low ringtime with satisfactory power output observed on the echo box meter indicates probable trouble in the radar receiver. Reduction of radar receiver sensitivity may be caused by:

a. Loss of signal before the crystal rectifier by mistuned or defective components, or transmission line.

b. Impaired conversion gain of the crystal rectifier, as by reduced local oscillator power applied, or because of a defective crystal.

c. Excessive noise in the crystal rectifier which would tend to conceal signal, due to a bad crystal or to excessive local oscillator power applied.

d. Mis-match between the crystal rectifier and the first I-F stage which causes a loss of signal power.

e. Excessive noise in the first or second I-F tube.

Trouble, other than reduced gain causing loss of "grass" or snow, in I-F stages beyond the second, does not affect radar performance. It is not advisable to alter I-F tuning adjustments.

5. GUESSING RADAR PERFORMANCE

Judging radar performance "by eye" is very inaccurate and unreliable. One series of actual field checks made with an echo box showed that most operational radars were down 10 to 20 db or even more in performance, although the operators and maintenance men believed they were operating perfectly. Such mistakes may occur because the performance of the set is being judged by the strength of certain "standard" signals that can be picked up. The signals usually relied on are those from distant ground targets. Whether or not a large, fixed, distant target can be seen on a particular day depends primarily on weather conditions, and very little on radar performance.

It is the experience of every radar operator that under certain weather conditions such surface targets are seen at extremely long ranges. This happens because the atmosphere acts as a lens to the rays and bends them around the surface of the earth, or because the air contains a "trapping layer" which prevents the radar beam from spreading in a vertical direction and so concentrates it on the surface. It is less well known that such effects can make detection ranges on aircraft larger or smaller than average as well, and that less drastic effects of the same sort happen very often. It takes very little bending of this sort to change the strength of distant ground echoes. Such targets are very unreliable as standards.

Because of strong ground and water reflections at this frequency band, the attempts to estimate radar performance by practical tests against controlled aircraft meet serious difficulties. It is not at all hard to find combinations of range and altitude which will make a target plane totally invisible, and these combinations change from day to day. Careful study of the results will show that nulls due to ground reflection, plus the effects of earth curvature, have a very pronounced and regrettable effect. An echo box test will tell in a very few minutes what costly flight tests cannot: the performance on a day-to-day basis.

It is of course true that improved performance will increase the strength of all echoes. After the repair of severe cases of impaired performance, this increase is evident to the users of the set in the form of increased clutter. Such clutter should not be a cause for complaint, as it can be eliminated by temporary receiver gain reduction if necessary for some tactical purpose, or it can be handled with the STC circuits. It represents a new capacity for the detection of small objects, the echoes from which were formerly lost in the noise.

SECTION V

MAINTENANCE

FAILURE REPORTS

A FAILURE REPORT must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report, form NAVSHIPS 383, which has been designed to simplify this requirement. The card must be filled out and forwarded to BUSHIPS. Full instructions are to be found on each card.

Use great care in filling the card out to make certain it carries adequate information. For example under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T-803, in the case of a transformer, or R-207, for a resistor. Do not substitute brevity for clarity. Use the back of the card to completely describe the cause of failure and attach an extra piece of paper if necessary.

The purpose of this report is to inform BUSHIPS of the cause and rate of failures. The information is used by the Bureau in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The cards you send in, together with those from hundreds of other ships, furnish a store of information permitting the Bureau to keep in touch with the performance of the equipment of your ship and all other ships of the Navy.

This report is not a requisition. You must request the replacement of parts through your Officer-in-Charge in the usual manner.

Make certain you have a supply of Failure Report cards and envelopes on board. They may be obtained from the nearest District Printing and Publication Office.

1. TAKING THE ECHO BOX APART AND PUTTING IT TOGETHER

a. Any operation that might change the mechanical shape of the echo box or damage the silvered surface of the cavity must be avoided, as this may change the ringing ability of the box. It is certainly inadvisable to subject the echo box to unnecessarily rough handling. IT IS INADVISABLE TO TAKE THE CAVITY OF THE BOX APART BECAUSE THE RINGING MAY BE CHANGED BY A SMALL PERCENTAGE WHEN THE BOX IS REASSEMBLED. Therefore, the cavity should not be opened except for very good reason.

b. Large changes in ringtime will not be caused by *careful* disassembly and reassembly of this echo box, which is of rugged and precise construction. In the event that it becomes necessary to take the cavity apart (for example, to replace a damaged part), the ringing ability of the reassembled box may be recalibrated by comparing its ringtime on a particular radar with that of another echo box which retains the factory calibration. There is a scale underneath the red arrow on the computer on which one can read the percentage by which a particular box differs from the factory standard in ringtime. Each division on this scale stands for one per cent. If for example the box used for the comparison is marked with a red arrow at 4% and the ringtime of this echo box is 24,000 yards under the circumstances of the comparison, one can figure the ringtime of the factory standard as $24{,}000 \div 1.04 = 23{,}077$ yards. If the ringtime of the reassembled box is 22,500 yards, then $22{,}500 \div 23{,}077 = .98$. Thus the reassembled box rings 98% as much as the factory standard, or two percent low. If the red arrow on the computer is not at −2% it should be scraped off and a new one painted on.

c. TAKING THE ECHO BOX APART — See Figures 5-4, 5-5.

CAUTION

Never test the echo box meter with an ohmmeter. The movement is sensitive enough to be damaged by the current from the battery in the ohmmeter.

(1) Loosen the four captive panel screws H-116 and lift the echo box slowly out of the case, using care to avoid damaging the mechanism.

(2) Remove lever O-111 by loosening the Allen set screw with the Allen wrench, H-140, which is to be found behind the panel.

(3) Unscrew the cable W-102 from the input loop P-101.

(4) Unfasten the cable W-101 from the output loop P-102.

(5) Remove four nuts A-119 from the bottom of the stand off posts H-118.

(6) Lift off the complete front panel assembly.

CAUTION

Nuts H-102 and H-104 in the center of the dial are not to be removed except as directed below. If they are while the echo box is right side up, the plunger will fall inside the cavity and may cause severe damage to itself, to the echo box surface, and to the coupling loops.

(7) Loosen the twelve screws holding the front plate A-103 to the cylinder A-102.

(8) Lift off the complete front plate, plunger, and dial assembly, and place on a flat, soft surface, plunger down.

(9) Loosen nuts H-102 and H-104 in center of dial, using wrench H-139 (found under the panel), and a screwdriver. Lift off dial assembly O-118 being careful not to lose the shims, H-138, and then lift front plate A-103 and assembly off of plunger.

(10) Remove eight screws holding dial housing A-107 to the front plate, and lift housing off front plate. The plunger plate A-104 cannot be removed from the plunger shaft.

(11) The ball bearings O-101 may be removed from the housing assembly by removing four screws and retainer ring A-105.

(12) The input loop P-101 may be removed by taking off nut H-109.

(13) To remove the output loop, P-102, loosen two Allen head set screws from part O-110, and remove shaft O-108.

(14) Loosen twelve screws on back of cylinder and remove end plate, A-101.

(15) Remove three screws around face of meter M-101 and cautiously lift out meter.

(16) Remove two soldering lug screws on back of meter, and remove meter.

(17) Remove three screws around meter hole, and remove meter can, A-113.

d. PUTTING THE ECHO BOX TOGETHER.

(1) Put a light coating of silicone grease (Dow Corning DC-33 or equivalent) on the plunger shaft A-104 and push it back through the sleeve O-107. Make sure to align the keyway.

(2) Screw the plunger drive screw O-103 into nut H-108 about three turns. Push down so as to compress springs O-106 and screw in about ten turns.

(3) Replace dial housing A-107, shims H-138, and dial assembly O-118. Be careful to mesh the gears O-102 and O-104 before tightening nut, H-104.

(4) Replace gasket H-101 neatly in cylinder groove.

(5) Lower front plate and plunger assembly into cylinder, being careful not to damage the Teflon shoes on the plunger edge. Replace the 12 screws and lockwashers holding front plate to the cylinder. Measure the distance from the bottom edge of the cavity cylinder to the plunger with an accurate steel rule or a depth micrometer. Set this distance to 9-55/64 inches by turning the dial; loosen nut H-104 and turn dial to a reading of 1230 (uncorrected). Then readjust dial so that prick punch mark on dial lines up with point on dial washer N-102. Tighten nut H-104 and replace acorn nut H-102.

(6) Place rear gasket H-113 neatly in groove and replace end plate A-101. Make sure lip in cylinder A-102 and edge surface of end plate are free of all dirt or paint.

(7) Replace meter can A-113 and meter M-101, making sure the positive side of the meter is attached to the ground terminal.

(8) Replace front panel assembly, lever O-111, reconnect cables W-101 and W-102.

2. PRECAUTIONS IN HANDLING CRYSTALS

a. Crystal cartridges will stand only a limited amount of mechanical shock and should be handled with the same care as vacuum tubes.

b. In many cases the body of the person handling the crystal unit is not at ground potential. This is particularly likely to be the case when the humidity is low, as on a dry, cold day, or in heated quarters. The static charge carried by the body might accidentally be discharged through the crystal unit if it is held by the base and the tip is brought into contact with grounded equipment. Similarly, a static discharge might take place if the crystal is handed from one person to another. In order to avoid damage, precautions should always be taken in order to equalize any static charge.

(1) Touch the equipment with your bare hand before attempting to insert the crystal.

(2) If you want to hand the unit to another person, first touch his bare hand with a finger.

c. Crystals also are apt to be damaged by voltages in connecting wires induced by neighboring electrical equipment. In this way, voltage shocks may be delivered to the crystal by the opening and closing of nearby electrical circuits. Such damage should be avoided by careful shielding of the connecting wires, and by keeping the crystal cartridge always wrapped in metal foil or in a metal box when not in use.

d. If a crystal is exposed to a strong R-F field, it can easily absorb enough energy to damage it. Since it may be necessary to remove a crystal from the holder when near a radar transmitter or other source of radio or radar energy, the transmitter should be shut down before opening the crystal holder or unwrapping a new crystal. If it is impossible to shut down the transmitter, the echo box should be taken some distance from the transmitter before the crystal is changed.

e. REPLACING A CRYSTAL — Refer to Figure 5-1.

(1) Remove four screws H-153 and lift off top, A-116.

(2) Using a knife edge or fingernails pull out sleeve E-101.

(3) Push new crystal, spacer H-128 and sleeve E-101 back into crystal holder body A-117.

(4) Replace top assembly A-116, making sure wire W-106 is in the top groove of spacer H-128.

(5) Replace and tighten four screws H-153 with lockwashers.

3. THE ECHO BOX METER

The part of the echo box least resistant to damage by mechanical shock is the meter. This is inevitable with all sensitive meters of present design. One should thus use reasonable care in handling the echo box.

If there is reason to suspect that the meter has been damaged, disconnect the meter from the crystal and connect it in series with a 20,000-ohm resistor and a single 1.5 volt dry cell. The meter should read approximately 75. It is not necessary that this exact reading be obtained.

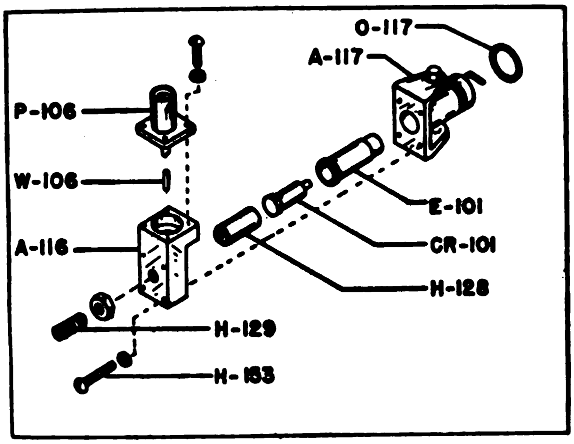


Figure 5-1.
Drawing of Output Loop for Crystal Change

CAUTION

Never test the echo box meter with an ohmmeter. The movement is sensitive enough to be damaged by the current from the battery in the ohmmeter.

4. REPLACING CABLE CONNECTORS

a. Radio frequency cables for use with microwave test equipment should be made up with more than ordinary care, because a connector which has been put on a cable poorly is a source of reflection that will make the measurements inaccurate. It pays to inspect cables and connectors at frequent intervals to see that the fingers are not bent or loose, and to see that the tip of the center conductor bullet comes just to the end of the outer conductor fingers. In making up the cables one should see that the dielectric is cut sharply and squarely; that the cable dielectric is in good contact with the connector bead; that the dielectric is not melted in soldering; that the bullet just touches the dielectric; that surplus solder is carefully filed off; and that when assembled the bullet tip neither projects beyond the outer conductor fingers nor fails to reach the plane of the outer conductor fingers. The more experience a microwave technician has had in such matters the more careful he is to see that the cables he uses are carefully made.

b. TO REPLACE A CONNECTOR ON RG-21/U cable follow this procedure:

Figure 5-2 shows the steps needed to replace a connector on RG-21/U cable. Do not make another such cable over 15 feet long or an undue loss of ringtime will be noticed. See Section 2, par. 1. *c*.

To ensure correct results, follow this procedure exactly, and step by step:

(1) Cut back the vinylite jacket square and even as shown.

(2) Push back braid and cut off 1/4 inch of cable dielectric.

(3) Pull braid forward and taper toward center conductor.

(4) Insert cable into clamping nut (a), thin metal washer (b), rubber washer (c), and clamping sleeve (d) in the order shown. Be sure that the clamping sleeve (d) clears all braid wires and that its internal shoulder rests squarely against end of vinylite jacket.

(5) Unbraid the wires of the inner shield, spread them open, and cut off excess wire. Each wire must end before reaching the rear shoulder of part (d). Cut off the dielectric 1/4" from the wires on the front face of part (d). Cut off the center conductor 1/8" from end of dielectric.

(6) Make a shield of sheet metal to protect the dielectric. Wrap the dielectric with a wet cloth.

(7) Silver solder "tin" the end of the center conductor. Use a hot flame, being careful to deflect most of the heat away from the dielectric. Work as rapidly as possible for best results.

(8) Remove the shield and cut off the dielectric 3/16" from the wires on the front face of part (d). Make the cut square and even, and do not nick the center conductor.

(9) Place the bullet (e) on the center conductor so that it just touches the dielectric and soft solder it in place. Feed solder through the hole in part (e). Wipe off excess solder while hot. Do not get solder or flux on the dielectric, and work quickly to avoid melting the dielectric.

(10) Insert cable into plug as far as it will go. Push rubber washer (c) and thin metal washer (b) into body and tighten clamping nut (a). Hold body with wrench and tighten clamping nut (a). Do not allow body or cable to rotate during this operation.

c. Figure 5-3 shows the steps in making up a cable of RG-9A/U cable for use with this echo box. Such a cable should not be under 25 feet long, nor over about 75 feet long. Follow this exact procedure step by step:

(1) Cut back the vinylite jacket square and even as shown.

(2) Push back braid and cut off 1/4 inch of cable dielectric.

(3) Pull braid forward and taper toward center conductor.

(4) Insert cable into clamping nut (a), thin metal washer (b), rubber washer (c), and clamping sleeve (d) in order as indicated. Be sure that clamping sleeve (d) clears all braid wires and its internal shoulder rests squartly against end of vinylite jacket.

(5) Unbraid the wires of the outer shield and cut them off square with the end of part (d). Unbraid the

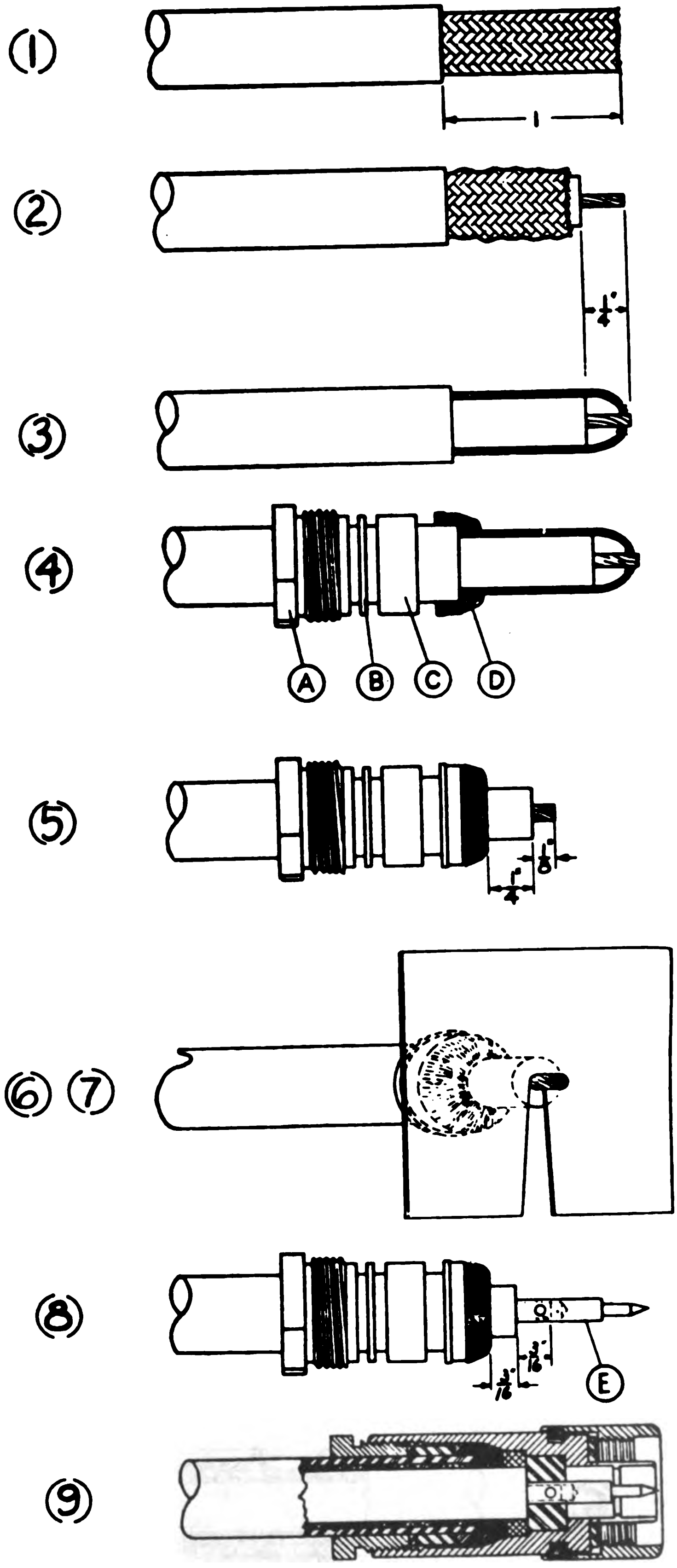


Figure 5-2.
Process of Attaching Connectors to RG-21/U Cable

wires of the inner shield, spread them open, and cut off excess wire. Each wire must end before reaching the rear shoulder of part (d). Cut off the dielectric 3/16″ from the wires on the front face of part (d). Make the cut square and even, and do not nick the center conductor. Cut off center conductor 3/16″ from end of dielectric.

Place the bullet (c) on the center conductor so that it just touches the dielectric, and solder it in place. Feed solder through the hole in (e). Wipe off excess solder while hot. Do not get solder or flux on the dielectric, and work quickly to avoid melting the dielectric.

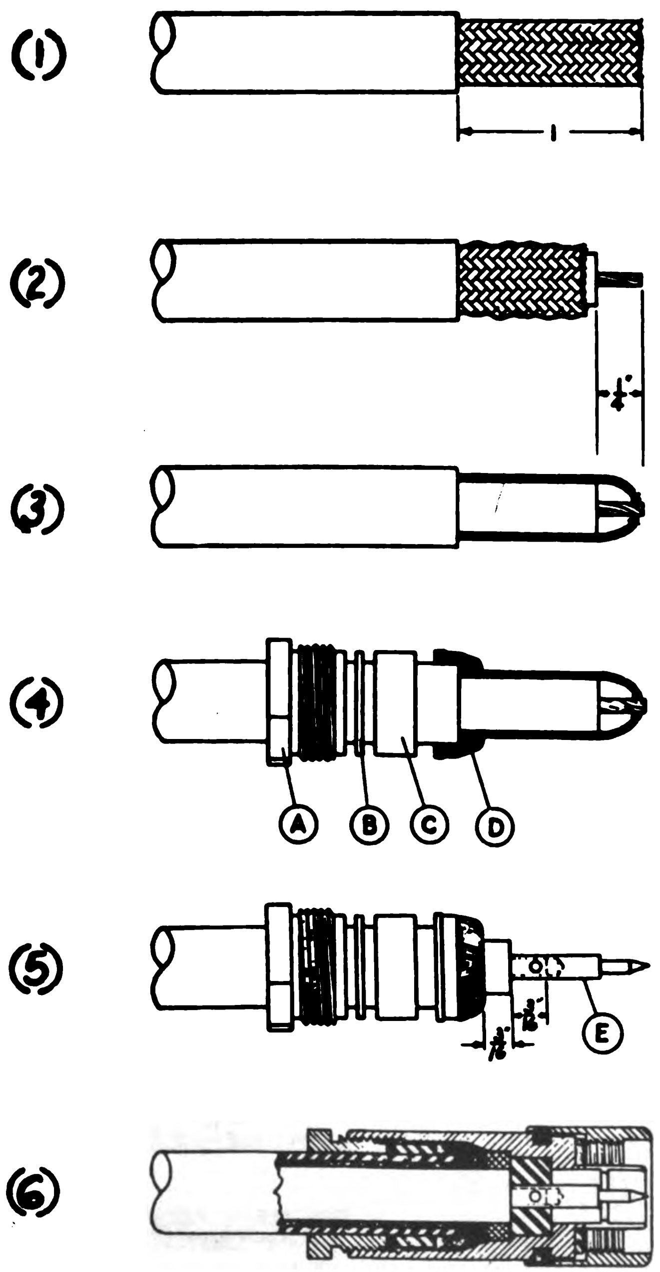


Figure 5-3
Process of Attaching Connectors to RG-9A/U Cable

(6) Insert cable into plug as far as it will go. Push rubber washer (c) and thin metal washer (b) into body and tighten clamping nut (a). Hold body with wrench and tighten clamping nut (a). Do not allow body or cable to rotate during this operation.

5. TROUBLES WHICH MAY BE ENCOUNTERED WITH THE ECHO BOX

a. LOW METER READING — The meter will read low when:

The radar peak power is low.
The spectrum of the transmitter is bad.
The pulse is shortened or the PRF lowered.

These include system faults which it is the purpose of the echo box to detect. When these conditions do not prevail, the echo box meter may read low due to the following causes:

(1) Echo box tuned to a side lobe of the transmitter spectrum or is in resonance in a minor mode. If the transmitter spectrum has large side lobes, it is possible unknowingly to maximize the meter on one of these lobes. This arises only by careless tuning and can be avoided by first tuning completely through the tuning range and then maximizing the meter by careful adjustment. Low meter reading due to this cause and to causes (4) and (5) below will always be accompanied by reduced ringtime.

(2) Output loop not properly adjusted at installation. See Section 2, par. 2. *a.*

(3) Burned out or damaged crystal in the echo box. Remove cable from output loop and check back and front resistance of crystal through the cable from center conductor to ground with a 20,000 ohm per volt multimeter, using the R×100 scale to avoid damage to the crystal. The low resistance should be roughly 400 ohms; and the high resistance should be ten or more times the low resistance.

(4) Damaged coaxial connectors or faults in the R-F cables.

(5) Directional coupler installed backward.

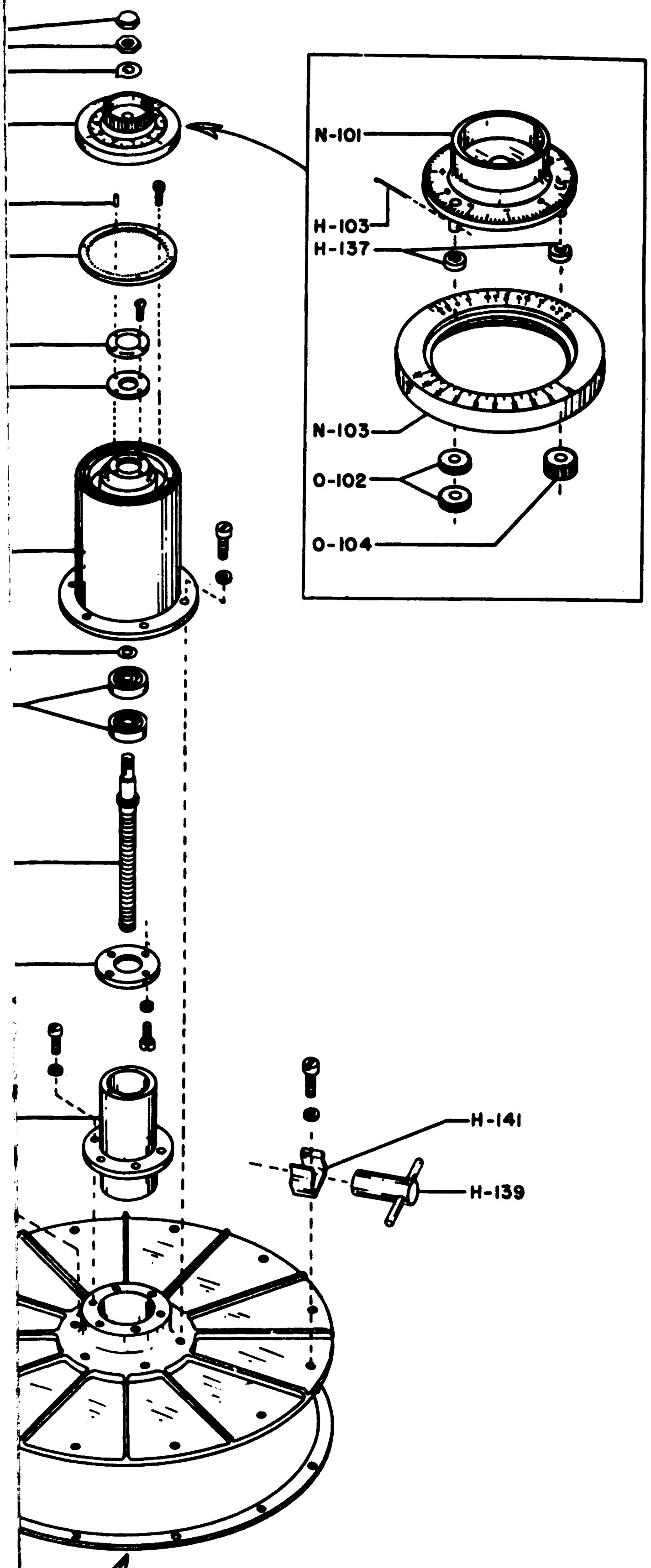
(6) Filter capacitor open or shorted.

(7) Output loop circuit broken. Remove cable from output loop and check from center conductor of jack to ground for crystal resistance as in (3). Check plastic crystal tension adjusting screw H-129.

(8) Meter damaged. Check as in Section 5, par. 3.

(9) "Tune-Read Ringtime" lever in wrong position or "Tune-Read Ringtime" lever failing to move the output loop.

b. LOW RINGTIME, METER READING NORMAL — If the radar receiver sensitivity and the T-R box recovery are normal, and the echo box meter reading is normal, a reduction in ringtime could be caused by echo box damage. Corrosion of the silver plating on



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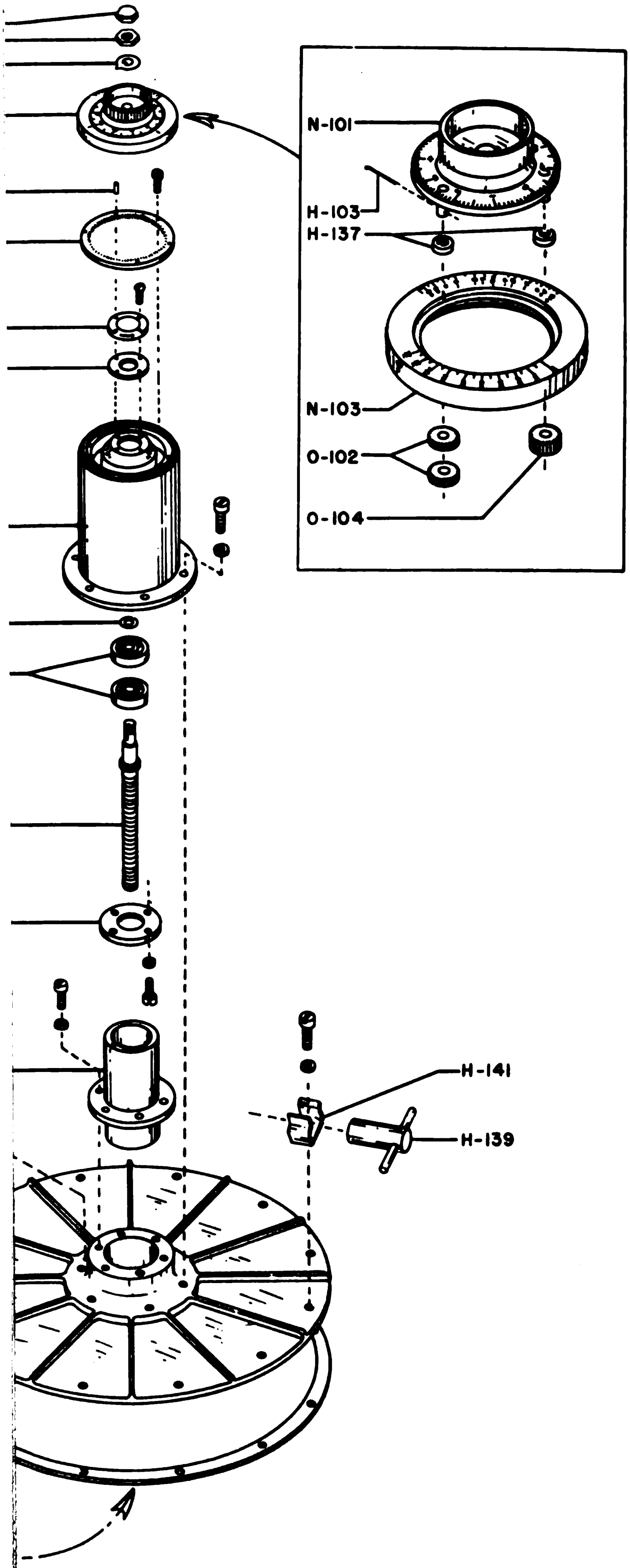
TS-172A/UP Echo Box



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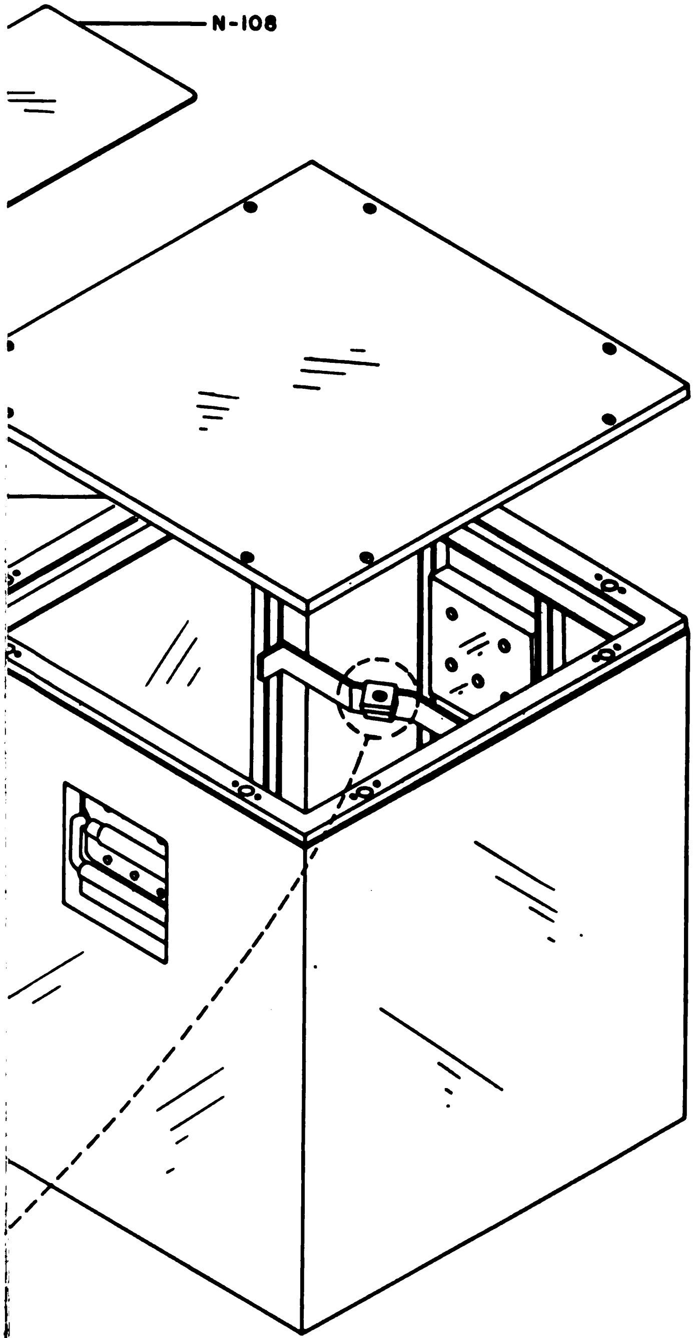
f TS-172A/UP Echo Box



re 5-5.
TS-172A/UP Echo Box
t panel and case)

the cavity wall over a considerable area could change the ringing ability of the echo box. This is not a likely cause of trouble. Compare the echo box with another if possible.

Note:

WHILE RADAR PERFORMANCE TROUBLES ARE USUALLY QUICKLY REMEDIED ONCE IT IS RECOGNIZED THAT TROUBLE EXISTS, THERE ARE CASES WHICH MAY LEAD AN EXPERT TO QUESTION THE TEST EQUIPMENT, AND WHICH, BECAUSE OF THEIR CHRONIC NATURE, IT IS PARTICULARLY IMPORTANT TO DETECT. THERE IS A NATURAL TENDENCY TO SUSPECT THE TEST EQUIPMENT ITSELF WHENEVER A PARTICULARLY RECALCITRANT CASE OF RADAR APPEARS. THIS ECHO BOX IS RELIABLE, AND INDEED WILL SELDOM FAIL TO OPERATE PROPERLY IF INTELLIGENTLY USED. THIS EQUIPMENT IS FUNDAMENTALLY SIMPLE, AND RUGGEDLY AND RELIABLY MADE. IT IS INTENDED TO SERVE AS YOUR GUIDE AND IS WORTHY OF YOUR CONFIDENCE.

SECTION VI

TABLE 6-1. WEIGHTS AND DIMENSIONS OF SPARE PARTS BOX

EQUIPMENT SPARES				
OVERALL DIMENSIONS			VOLUME	WEIGHT
HEIGHT	WIDTH	DEPTH		

Unless otherwise stated, dimensions are inches, volume cubic feet, weight pounds.

TABLE 6-2. SHIPPING WEIGHTS AND DIMENSIONS OF SPARE PARTS BOX

EQUIPMENT SPARES				
OVERALL DIMENSIONS			VOLUME	WEIGHT
HEIGHT	WIDTH	DEPTH		

Unless otherwise stated, dimensions are inches, volume cubic feet, weight pounds.

TABLE 6-3. LIST OF MAJOR UNITS

QUANTITY	NAME OF MAJOR UNIT	NAVY TYPE	DESIGNATION
1	Echo Box	TS-172A/UP	Radar Tester

Unless otherwise stated, dimensions are inches, volume cubic feet, weight pounds.

TABLE 6-4. TABLE OF REPLACEABLE PARTS

REFERENCE DESIGNATION	STOCK NUMBERS SIGNAL CORPS STANDARD NAVY AIR FORCE	NAME AND DESCRIPTION	LOCATING FUNCTION
A-101		Plate, rear end, aluminum casting alloy #195, irregular shaped, oxalic acid anodized, white nickel plated, silver plated glyptol coated, and zinc chromate and gray navy enameled. JSCo. Part #32884.	To cover rear end of cylinder.
A-102		Cylinder, aluminum casting alloy #195, 13.400" bore, 11.194" long, oxalic acid anodize, white nickel plate, silver plate all inside surfaces, zinc chromate and gray navy enamel all outside surfaces JSCo. Part #32958.	Resonant cavity
A-103		Plate, front end, aluminum casting alloy #195, heat treated, anodized, zinc chromate and gray navy enameled outside surfaces JSCo. Part #32920.	To cover front end of cylinder.
A-104		Plunger assembly; consists of spindle assembly, aluminum disc, bakelite absorber and Teflon guide pins, JSCo. Part No. 34120SA.	Plunger
A-105	3H305-388	Retainer, bearing; brass ½ hard, #10 (.101") B & S Ga. 2⅛" dia. 15/16" hole, 4-#31 holes zinc plated and clear iridite dipped JSCo. Part #33313.	To hold O-101 in place
A-106		Cover, gasket; cup shaped 1.406" dia. with 3/32" lip, ⅞" dia. hole #20 B & S Ga. sheet brass, zinc plate and clear iridite JSCo. Part #32998.	To retain H-105
A-107		Housing, aluminum casting alloy #195, heat treated, anodized, zinc chromate and gray navy enameled on outside only. JSCo. Part #32927.	To mount dial assembly and bearing.
A-108	6F207-115	Cabinet, case, aluminum #14 (.064") B & S Ga. alloy #52S-H34, 17-11/32" by 17-11/32" by 19¾", light gray navy enameled. JSCo. Part #34055. Part of JSCo. Part #33331.	To house echo box
A-109	6F1300-19	Cabinet, cover; aluminum #14 (.064") B & S Ga. alloy #52S-H34, 17-11/32" by 17-11/32" by ½", light gray navy enameled, JSCo. Part #34056. Part of JSCo. Part #33331.	To house echo box

A-110		Panel, aluminum #11 (.090") B & S Ga. alloy #52S-H34, 14⅞" by 14⅞", anodized per spec. #AN-QQ-A-696, light gray navy enameled, JSCo. Part #33526.	To mount echo box
A-111		Plate, washer; brass ½ hard #24 (.020) B & S Ga. 3/16" wide, ⅜" long, 2 holes .093 dia. spaced .218" JSCo. Part #31445.	To retain N-105 and N-106
A-112		Bracket, strip brass ½ hard #14 (.064") B & S Ga. ⅜" wide irregular shaped, zinc plate and clear iridite dipped JSCo. Part No. 28500.	To support N-105 and N-106
A-113		Housing; brass sheet #22 (.025") B & S Ga. dead soft, spun 2-13/16" dia. 3-7/16" long, 3½" dia. lip, zinc plated, clear iridite dipped, gray navy enameled external surfaces only. JSCo. Part #33316.	To protect rear of M-101 and support C-101
A-114		Bracket, aluminum, alloy #24S-T4 1¼" by 1¼" by 3/16" angle, clear anodized per spec. #AN-QQ-A-696. JSCo. Part #33328.	To support H-126
A-115		Bracket, steel, #16 (.059") U S S Ga. Sheet, irregular shaped, zinc plated, clear iridite dipped JSCo. Part #33317.	To retain H-126
A-116		Block, mounting; brass ½ hard, 1-5/16" long irregular shaped, silver plated. JSCo. Part #33310.	To support P-106 and A-117
A-117	3F3703-11.3	Loop, output assembly; consisting of a sleeve, pin, bracket and contact press fit and soldered, silver plated. JSCo. Part #33502-SA.	Housing for CR-101
C-101	3DB1-185 N16-C-48841-9420 3300-316958807	Capacitor, fixed, paper dielectric 1 mfd. 100 V dc W, hermetically sealed metal case, 1-13/16" long by 1" wide by ⅞" high, wax filled and impregnated, JSCo. Part #SPC 8783.	Capacitor shunt for M-101
CR-101	2J1N21B N16-T-51721-10	Crystal unit, rectifying, JAN-1N21B detector type, porcelain body with brass fittings, 27/32" long by 19/64" max. dia. JSCo. Part #SPC 8651.	Rectifier
E-101	3G2255-1.4	Insulator, polystyrene, 1⅛" long 7/16" overall dia. .299" dia. hole. JSCo. Part #33500.	Insulator between CR-101 and A-117

REFERENCE DESIGNATION	STOCK NUMBERS: SIGNAL CORPS STANDARD NAVY AIR FORCE	NAME AND DESCRIPTION	LOCATING FUNCTION
H-101	3F31510-6.3	Gasket, cylinder; Buna S rubber 14-23/32 outer dia., 13-31 32 inner dia. .064" thick. JSCo. Part #33318.	Seal for A-103
H-102	6L3746-24.2A	Nut, acorn; adj. post; brass, ⅜"-24 thread, ½" high zinc plated, clear iridite dipped. JSCo. Part #24874 IC.	To lock H-104
H-103	6L970-3-28	Pin, cotter, brass, 3/64" dia., ⅜" long, zinc plated JSCo. Part #SPC-8627ZN IC.	To hold O-102
H-104	6L3106-24-10	Nut, adj. post; brass, ⅝" hex, ⅜-24 thread, 7/64" thick, zinc plated, clear iridite dipped, JSCo. Part #24873 IC.	To secure O-118 to O-103
H-105	3F31510-6.2	Gasket, Buna S rubber .064" thick 1⅜" dia. ⅝" dia. hole, JSCo. Part #32995	To seal A-107
H-106	6L3941-5-15	Pin, brass ½ hard, #42 (.092") dia. .343" long. JSCo. Part #25876.	To secure O-105 to A-107
H-107	6L15006-5.10	Screw, shoulder; brass ½ hard, No. 6-32 5/16" long, overall length 1-3/32", zinc plated and clear iridite dipped. JSCo. Part #32997.	To secure H-108
H-108	3F32375	Nut; silicon bronze rod, 1½" dia., zinc plated and clear iridite dipped. JSCo. Part #32930.	To load O-103
H-109	2Z6900-182	Nut, clamping; 1⅛" hexagonal aluminum rod, alloy 17S-T4, 1"-16NS-2 thread, irregular hole, oxalic acid anodize and white nickel plate, silver plate JSCo. Part #30918.	To retain P-101
H-110	2Z4867.168 N33-W-312-7890	Gasket, Neoprene, .062" thick, .785" O.D. .625" hole. JSCo. Part #24890.	To seal P-101
H-111	6L3946-12-1	Pin; stainless steel type 303, ¾" long .1875" dia., ground and polished. JSCo. Part #29935.	To limit movement of O-110

H-112		Pin; brass rod #34 (.110") dia., .343" long zinc plated. JSCo. Part #24784.	To locate A-103 and A-107 on A-102
H-113	2Z4868.1396	Gasket; Neoprene, 14-47/64" outer dia., 13-25/32" inner dia., 1/8" thick. JSCo. Part #33363.	To seal A-101
H-114		Pin, brass rod, #34 (.110") dia., .343" long, zinc plated. JSCo. Part #33364.	To locate A-101 on A-102
H-115	6L50494	Washer; Nylon 1/32" thick, 7/16" dia. 1/4" dia. hole. JSCo. Part #33682.	Spacer for O-110
H-116	6L7918-126.81	Bolt; steel, hex head cap screw 8" by 5/16"-18 NC-2, zinc plated and clear iridite dipped. JSCo. Part #33305.	To retain echo box in case
H-117	2Z580-76	Bushing; aluminum rod, alloy #24S-T4 11/16" hexagonal, 17/32" overall length, clear anodized as per spec. #ANQQ-A-696. JSCo. Part #33306.	To support H-118 on A-110
H-118		Spacer; aluminum tubing, alloy 24 S-T 3/4" O.D. by 6 1/4" lg. .120 wall, clear anodized as per spec. #AN-QQ-A-696, zinc chromate and gray navy enamel exterior surfaces. JSCo. Part #33308.	To locate A-110 on echo box
H-119	2Z580-77	Bushing; aluminum rod, alloy #24S-T4 11/16" hexagonal, 7/8" overall length, clear anodized as per spec. #AN-QQ-A-696. JSCo. Part #33307.	To retain H-116 on echo box
H-120	6Z1900-4	Clip, cable; Nyloc cable clip, 1/4" I.D. type #3. JSCo. Part #SPC-13584.	To retain W-101 on echo box
H-121	2Z-1406-3	Bushing, with nut; panel bearing with nut for 1/4" shaft, size 7 16" overall length with 1/2" hex., 1/16" thick and 3/8-32 thread, nickel or cadmium plated. JSCo. Part #SPC-12850.	To guide O-108 in A-110
H-122	6L15440-5.7S	Screw, dial; brass 1/2 hard 1/8" dia. 11/32" long, 4-40 NC-2 thread 5/32" long. JSCo. Part #32946	Stop for dial assembly O-118
H-123		Handle, panel, 1/4" dia. aluminum alloy No. 52S-H34, U shaped, 5 3/8" long by 1" wide. No. 8-32 tapped hole on each bent end, clear anodized and gray navy enameled. JSCo. Part #31289.	To lift echo box from case

DESIGNATION REFERENCE	STOCK NUMBERS SIGNAL CORPS STANDARD NAVY AIR FORCE	NAME AND DESCRIPTION	LOCATING FUNCTION
H-124		Bushing, panel handle; aluminum alloy No. 17S-H32, ⅝" dia. by ⅜" thick, clear anodized, gray navy enameled. JSCo. Part #31296.	To locate H-123 on A-110
H-125	3F33226	Screw, stud; stainless steel rod type 303, ⅜" hexagonal, 1-11/32" overall length. JSCo. Part #33516.	To support O-116 on A-110
H-126	6L3425-18-10B	Nut, floating; brass ½ hard, 15/16" by ⅝" by 5/16" thick, 5/16-18 NC-2 tapped hole centrally located through narrow dimension zinc plated and clear iridite dipped. JSCo. Part #32994.	To secure H-116
H-127	6L3770-24-6B	Nut, acorn, brass, ⅜" hex. head cap nut tapped 10-24, zinc plated, clear iridite dipped. JSCo. Part #SPC-528ZN-IC.	To secure H-125 to A-110
H-128	2Z8552-174	Spacer; brass ½ hard, 9/32" dia. by 23/32" long silver plated. JSCo. Part #32993.	To provide electrical path between CR-101
H-129	6L18508-8.76	Screw, adjusting, nylon ½" long, 8-32 NC-2 thread. JSCo. Part #33301.	To adjust CR-101 and H-128
H-130		Nut; part of UG-262/U. Part of JSCo. Part #SPC-13590	Used with W-101
H-131		Washer; part of UG-262/U. Part of JSCo. Part #SPC-13590.	Used with W-101
H-132		Gasket; part of UG-262/U. Part of JSCo. Part #SPC-13590	Used with W-101
H-133		Clamp; part of UG-262/U. Part of JSCo. #SPC-13590.	Used with W-101
H-134		Nut; brass ½ hard, hexagonal, ⅛" thick ⅜"-32 NS-2 thread, silver plated. JSCo. Part #33000.	Used with W-101
H-135		Fitting; brass ½ hard, ½" dia. ⅞" long, silver plated. JSCo. Part #32999.	Used with W-101

H-136	6L58024-157	Washer; stainless steel type 303 #25 (.0209) USS ga. ⅜" dia. .257" dia. hole. JSCo. Part #31145.	To hold O-116 on H-125
H-137	6L50010-13 N16-W-180001-174	Washer, flat; brass, 11/32" O.D. by .189" I.D. by .087" thick, zinc plated, clear iridite dipped. JSCo. Part #24832	To line up pinions
H-138	2Z8320-16 N43-W-3173-294	Washer, shim; brass, 21/32" O.D. by .390" I.D. by .003" thick, zinc plated clear iridite dipped. JSCo. Part #24810.	To take up end play
H-139	6R57420.2 N41-W-2647-60	Wrench, socket; steel, zinc plated ⅜" hex; body 2½" long by ⅞" dia. T-handle 3" long by ¼" dia. JSCo. Part #SA-12651.	Tool
H-140	6R57400-6 G41-W-2445-2	Wrench, Allen; for No. 6 screw, L-shaped of 1/16" hex steel rod, zinc plated, 1-27/32" long leg, 11/16" short leg. JSCo. Part #SPC-11799.	Tool
H-141	3Z1013.16	Clip, socket wrench, fuse clip, nickel plated or zinc plated and clear iridite dipped. JSCo. Part #SPC-13671.	To hold H-139
H-142	2Z2712.254	Clip, Single Fahnestock; brass, 1-7/16" long, ⅜" wide, #8 hole. JSCo. Part #SPC-12726.	To hold H-140
J-101	2Z7390-19B N17-C-73108-6065	Connector, plug; JAN UG-19B/U, female contact, brass silver plated. Used with RG-21A/U cable. JSCo. Part #SPC-13181.	Used with W-102
M-101	3F871-35 N17-M-18968-6601	Meter, D.C. ruggedized microammeter, Burlington model 931 3½" dia. flanged flush mounted, O-100 micro-ampere range, 50 scale divisions, hermetically sealed case, internal resistance 1500 ohms or less. JSCo. Part #SPC-13716.	Tuning indicator
N-101	2Z3723-699	Dial assembly, inner; with pinion shafts brazed in place, etched and zinc plated. JSCo. Part #32928-SA.	Tuning assembly

REFERENCE DESIGNATION	STOCK NUMBERS SIGNAL CORPS STANDARD NAVY AIR FORCE	NAME AND DESCRIPTION	LOCATING FUNCTION
N-102	6L50156-N	Washer, dial, #20 B & S phos. bronze, zinc plated, clear iridite dipped. JSCo. Part #24875-IC.	Setting indicator
N-103	2Z3723-700	Dial assembly, outer; with dial gear pressed in place, etched and zinc plated. JSCo. Part #32948-SA.	Tuning assembly
N-104		Name plate, for contract NObsr-63469. JSCo. Part #33562.	Identification
N-105	2Z7258.161	Indicator dial; .060" thick transparent lumarith. JSCo. Part #28561.	To indicate dial reading
N-106	2Z7258.160	Indicator dial; .060" thick transparent lumarith. JSCo. Part #28562.	To indicate dial reading
N-107		Slide rule, circular, white opaque vinylite, 5¾" by 6" overall, flat rectangular, letters and numbers printed in black. 4 holes for mounting on panel. JSCo. Part #34053.	Used to determine uncorrected ringtime
N-108	3F2438	Sheet, instruction, printed sheet pressed between two sheets of clear vinylite, 6¼" by 8½" overall, flat rectangular, eyelet riveted in one corner for attaching safety chain. JSCo. Part #SPC-13736.	Instructions
N-109		Card, recording, white opaque vinylite, 2½" by 4" overall, flat rectangular, letters and numbers printed in black, 4 holes for mounting on panel. JSCo. Part #34054.	To record data
O-101	3H320-1 N77-B134-01202-6360	Bearing, ball; preloaded, single row angular contact, light duty, .4724" bore, 1.2598" O.D., .3937" wide, 8 balls, tight fit, ABEC-5 tol. JSCo. Part #SPC-11678.	To locate O-103
O-102	2Z4877-147 N16-G-431550-264	Pinion, brass; 33 teeth (external) 64 pitch, .516' pitch dia., .547" O.D. JSCo. Part #24958.	Support of outer dial

O-103	3F33400-5	Screw, plunger drive, Carpenter's stainless steel, #2-FM (type 420 F) 11/16" overall dia., 7-7/32" overall length. JSCo. Part #32909.	To operate plunger
O-104	2Z4877-148 N16-G-431558-101	Pinion, combination; brass, 33 teeth (external) 64 pitch, .516" P.D., .547" O.D. JSCo. Part #24959.	To transmit rotation
O-105	2Z4875-41 N16-G-422050-562	Gear, stationary; brass, 177 teeth (internal) 64 pitch, 2.766" pitch dia., 3.379" O.D. JSCo. Part #24954.	To rotate pinions
O-106	2Z8879-543	Spring, helical compression; #18 (.041") dia. music wire, 3/16" I.D. 19/32" free length, 6 coils, zinc plated clear iridite dipped. JSCo. Part #6484.	To load H-108
O-107		Sleeve, bearing, silicon bronze casting, 2¾" overall dia., 4-7/16" overall length, zinc plated and clear iridite dipped exterior surface only. JSCo. Part #32926.	To guide A-104
O-108		Shaft, stainless steel type 303, ¼" dia. rod, 15" long, JSCo. Part #33518.	To transmit motion from O-111 to O-109
O-109		Lever, aluminum casting alloy #195 irregular shaped, clear anodized. JSCo. Part #33494.	To transmit motion from O-108 to P-102
O-110		Segment, engaging, aluminum casting, alloy #195, clear anodized. JSCo. Part #33493.	To limit rotation of O-108
O-111	3F31480-1.1	Lever assembly; lever with collar and knob staked in place, zinc plate and clear iridite dip. JSCo. Part #33314-SA.	To rotate O-108
O-112		Lever, brass ½ hard, 2-7/16" long overall, irregular shaped, zinc plated, clear iridite dipped. JSCo. Part #33515.	To index O-108 clockwise or counterclockwise
O-113		Plate, lever; brass ½ hard, 2" long ½" wide. JSCo. Part #33514.	To retain O-114 in O-112

REFERENCE DESIGNATION	STOCK NUMBERS SIGNAL CORPS STANDARD NAVY AIR FORCE	NAME AND DESCRIPTION	LOCATING FUNCTION
O-114	3F34013	Bearing, nylon, ⅝" overall dia., 11/16" overall length. JSCo. Part 33512	To retain O-115 on O-116
O-115	2Z8879-542	Spring, helical compression; #16 (.037") dia. music wire, 7/32" I.D. 2¼" free length 17 active coils 2 inactive coils, zinc plated and clear iridite dipped. JSCo. Part #6486.	To index O-108
O-116		Rod; 2-13/16" long irregular shaped, stainless steel type 303. JSCo. Part #33513.	To support O-115
O-117	2Z4866.651	Gasket, O-ring, ⅜" I.D. by ½" O.D. by 1/16" dia. of cross section. JSCo. Part #SPC-12581.	To seal P-102
O-118	2Z3714-177	Dial, assembly, consists of 3—H-103 cotter pin, 4—O-102 pinion, 3—H-137 pinion spacer, 1—N-101 inner dial assembly, 1—O-104 combination pinion, 1—N-103 outer dial assembly; inner dial has 10 major divisions 0 to 10 clockwise and 100 minor divisions in 360°; outer dial has 19 divisions on 1⅜" rad in 108° arc. 25 divisions on outer diameter of dial in 91° 55′ arc. JSCo. Part #SA-18273.	Tuning assembly
P-101	3F32550	Probe, RF input; brass, silver plated, 1.687" long, 25/32" dia. excluding .355" long pick-up loop of .050" dia. brass wire. JSCo. Part #SA-18270	Input to echo box
P-102	3F32560	Probe, RF output; consists of 1—O-117 O-ring, 1—CR-101 crystal, 1—H-128 spacer, 1—A-116 mounting block, 1—P-106 UG-290/U receptacle, 1—H-129 screw, 1—W-106 brass wire, 1—E-101 insulator, 1—A-117 output loop sub-assembly, 8—#2 split lockwashers, 4—4⅜" by #2-56 machine screws, 4-5/16" by #2-56 machine screws, 1—#8-32 hex brass nut. JSCo. Part #SA-18272.	Output from echo box
P-103	2Z7390-18B N17-C-71412-8699	Connector plug UG-18B/U, male contact, brass, silver plated. Used with RG-21A/U cable. Part of JSCo. Part #SPC-13590 or SPC-13591.	Used with W-102 and W-103

P-104	2Z7390-260 N17-C-71408-3425	Connector plug UG-260/U, male contact, brass, silver plated, used with RG-59A/U cable. Part of JSCo. Part #SPC-13590.	Used with W-101
P-105	2Z7390-27B N17-C-67444-5090	Connector, angle cable; UG-27B/U, right angle adapter, brass, silver plated. JSCo. Part No. SPC-12643.	To connect W-102 to P-101
P-106	N17-C-73108-1267	Plug, UG-29OU; receptacle, female contact, 4 mounting holes drilled #42 (.093") brass, silver plated. JSCo. Part No. 32636.	Output connector
P-107	2Z307-263	Connector, consists of 1 nut Amphenol Part #31-983, 1 Washer Amphenol Part #43-192, 1 Gasket Amphenol Part #31-984, 1 Clamp Amphenol Part #31-982, 1 Fitting JSCo. Part #32999, and 1 Fitting Nut JSCo. Part #33000. JSCo. Part #34057.	To hold cable in meter housing
W-101	3E4001.361	Cable assembly output; consists of RG-59A/U cable, UG-260/U plug and modified UG-262/U jack. 16¾" long overall. JSCo. Part No. SPC-13590.	Rectifier output
W-102	3E4001.362	Cable assembly input; consists of RG-21A/U cable, UG-18 B/U plug, UG-19B/U jack, 14¼" long overall. JSCo. Part #SPC-13591.	RF input
W-103	3E4001.360	Cable assembly; consists of RG-21A/U cable, UG-18B/U plug at each end, 10 ft. long. JSCo. Part #SPC-13587.	To connect echo box to radar
W-104	1F425-21A N15-C-12160-640	Cable RG-21A/U Part of JSCo. Part No. SPC-13590 or SPC-13591.	Used on W-102 and W-103
W-105	1F425-59A N15-C-12201-528	Cable RG-59A/U Part of JSCo. Part No. SPC13590.	Used on W-101
W-106	G22-W-300	Wire, brass, #16 B & S Ga. soft tempered, JSCo. Part #SPC-9926.	To provide electrical path between H-128 and P-106

TABLE 6-5. MAINTENANCE PARTS KIT

KEY DESIGNATION	QUANTITY
C-101	1
CR-101	1
P-101	1
P-102	1

TABLE 6-6. CROSS REFERENCE PARTS LIST

JAN (or AWS) DESIGNATION	KEY SYMBOL
CP53B1-EB105V	C-101
1N21B	CR-101
UG-19B/U	J-101
MR36W100DCUA	M-101
UG-18B/U	P-103
UG-260/U	P-104
UG-27B/U	P-105
RG-21A/U	W-104
RG-59A/U	W-105

NAVY TYPE	KEY SYMBOL

ARMY-NAVY TYPE NO.	KEY SYMBOL

FEDERAL STOCK NO.	KEY SYMBOL

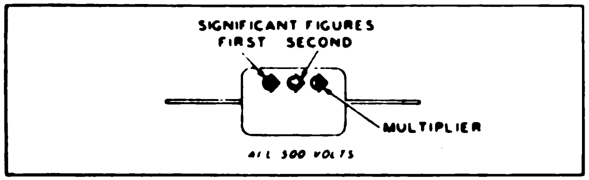
SIGNAL CORPS STOCK NO.	KEY SYMBOL
3H305-388	A-105
6F207-115	A-108
6F1300-19	A-109
3F3703-11.3	A-117
3DB1-185	C-101
2J1N21B	CR-101
3G2255-1.4	E-101
3F31510-6.3	H-101
6L3746-24.2A	H-102
6L970-3-28	H-103
6L3106-24-10	H-104
3F31510-6.2	H-105
6L3941-5-15	H-106
6L15006-5.10	H-107
3F32375	H-108
2Z6900-182	H-109
2Z4867.168	H-110
6L3946-12-1	H-111
2Z4868.1396	H-113
6L50494	H-115
6L7918-126.81	H-116
2Z580-76	H-117
2Z580-77	H-119
6Z1900-4	H-120
2Z-1406-3	H-121
6L15440-5.7S	H-122
3F33226	H-125
6L3425-18-10B	H-126
6L3770-24-6B	H-127
2Z8552-174	H-128
6L18508-8.76	H-129
6L58024-157	H-136
6L50010-13	H-137
2Z8320-16	H-138
6R57420.2	H-139
6R57400-6	H-140
3Z1013.16	H-141
2Z2712.254	H-142
2Z7390-19B	J-101
3F871-35	M-101
2Z3723-699	N-101
6L50156-N	N-102
2Z3723-700	N-103
2Z7258.161	N-105
2Z7258.160	N-106
3F2438	N-108
3H320-223	O-101
2Z4877-147	O-102
3F33400-5	O-103
2Z4877-148	O-104
2Z4875-41	O-105
2Z8879-543	O-106
3F31480-1.1	O-111
3F34013	O-114
2Z8879-542	O-115
2Z4866.651	O-117
2Z3714-177	O-118
3F32550	P-101
3F32560	P-102
2Z7390-18B	P-103
2Z7390-260	P-104
2Z7390-27B	P-105
2Z307-263	P-107
3E4001.361	W-101
3E4001.362	W-102
3E4001.360	W-103
1F425-21A	W-104
1F425-59A	W-105
G22-W-300	W-106

ITEM NO.	KEY SYMBOL

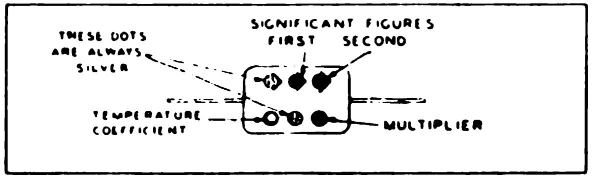
TABLE 6-7. APPLICABLE COLOR CODES AND MISCELLANEOUS DATA

CAPACITOR COLOR CODES

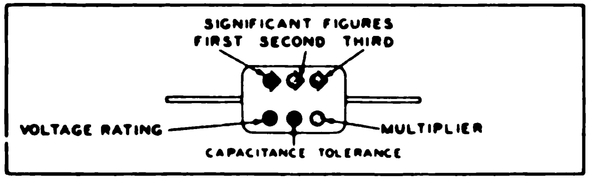
RMA 3-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



JAN 6 DOT COLOR CODE FOR PAPER DIELECTRIC CAPACITORS



RMA 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



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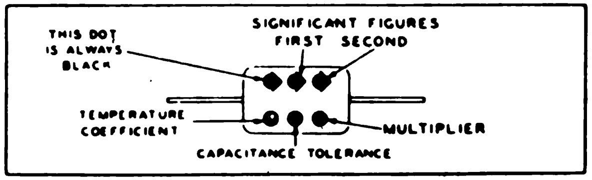
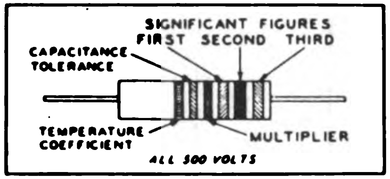
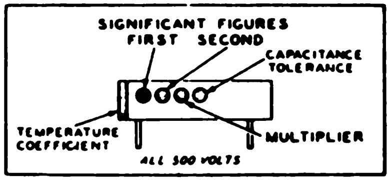


RMA COLOR CODE FOR TUBULAR CERAMIC-DIELECTRIC CAPACITORS

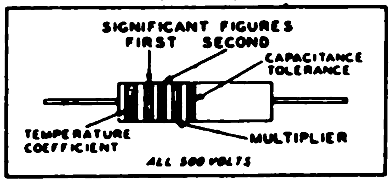


JAN COLOR CODE FOR FIXED CERAMIC-DIELECTRIC CAPACITORS

RADIAL TYPE NON-INSULATED



AXIAL TYPE INSULATED



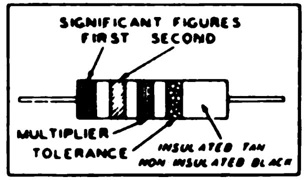
RMA RADIO MANUFACTURERS ASSOCIATION
JAN JOINT ARMY-NAVY

RESISTORS			CAPACITORS					
TOLERANCE	MULTIPLIER	SIGNIFICANT FIGURE	COLOR	MULTIPLIER: RMA MICA AND CERAMIC-DIELECTRIC	MULTIPLIER: JAN MICA AND PAPER-DIELECTRIC	MULTIPLIER: JAN CERAMIC DIELECTRIC	VOLTAGE RATING	TEMPERATURE COEFFICIENT
	1	0	BLACK	1	1	1		A
	10	1	BROWN	10	10	10	100	B
	100	2	RED	100	100	100	200	C
	1,000	3	ORANGE	1,000	1000	1000	300	D
	10,000	4	YELLOW	10,000			400	E
	100,000	5	GREEN	100,000			500	F
	1,000,000	6	BLUE	1,000,000			600	G
	10,000,000	7	VIOLET	10,000,000			700	
	100,000,000	8	GRAY	100,000,000		001	800	
	1,000,000,000	9	WHITE	1,000,000,000		0.1	900	
5	0.1		GOLD	0.1	0.1		1000	
10	0.01		SILVER	0.01	0.01		2000	
20			NO COLOR				500	

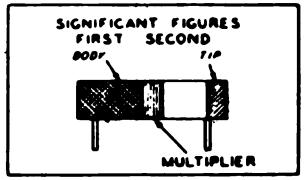
RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS

AXIAL TYPE

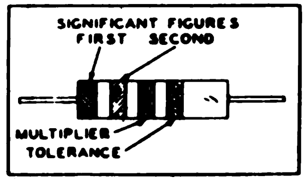


RADIAL TYPE



JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS

AXIAL TYPE INSULATED



RADIAL TYPE NON-INSULATED

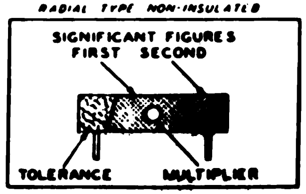


TABLE 6-8. LIST OF MANUFACTURERS

MFGRS. PREFIX	NAME	ADDRESS
	Allied Radio Co.	Chicago, Illinois
CPH	American Phenolic Corporation	Chicago, Illinois
	American Screw Company	Willimantic, Connecticut
	Bauer, R. J., Supply Company	Milwaukee, Wisconsin
	Burlington Instrument Company	Burlington, Iowa
	Chase Brass & Copper Co., Inc.	Waterbury, Connecticut
	Crane Packing Company	Chicago, Illinois
	Elastic Stop Nut Corporation	Union, New Jersey
CIE	Industrial Condenser Corporation	Chicago, Illinois
CABV	Johnson Service Company	Milwaukee, Wisconsin
	Littlefuse, Inc.	Des Plaines, Illinois
	Pritzlaff, J. Hardware Co.	Milwaukee, Wisconsin
	SKF Industries, Inc.	Philadelphia, Pennsylvania
CHS	Sylvania Electric Products Inc.	New York, New York
	Weckesser Company	Chicago, Illinois

RADAR PERFORMANCE CHECK SHEET

RADAR MODEL ______________ SERIAL ____________ LOCATION __________

ECHO BOX TS-172A/UP, SERIAL __________ RADAR CONDITIONS:- PULSE LENGTH ______

TESTS MADE:- WITH DIRECTIONAL COUPLER ________________ REP. RATE ________

WITH TEST ANTENNA ________________ REC. BW. ________

LOCATION ______________________________ RINGTIME ________

DATE	TIME	OBSERVED RINGTIME	RADAR PERFORMANCE	RADAR METERS		CHECKED BY
				CRYSTAL CURRENT	TRANSMITTER CURRENT	
		YDS.	DB. DOWN			
		YDS.	DB. DOWN			
		YDS.	DB. DOWN			
		YDS.	DB. DOWN			
		YDS.	DB. DOWN			
		YDS.	DB. DOWN			
		YDS.	DB. DOWN			
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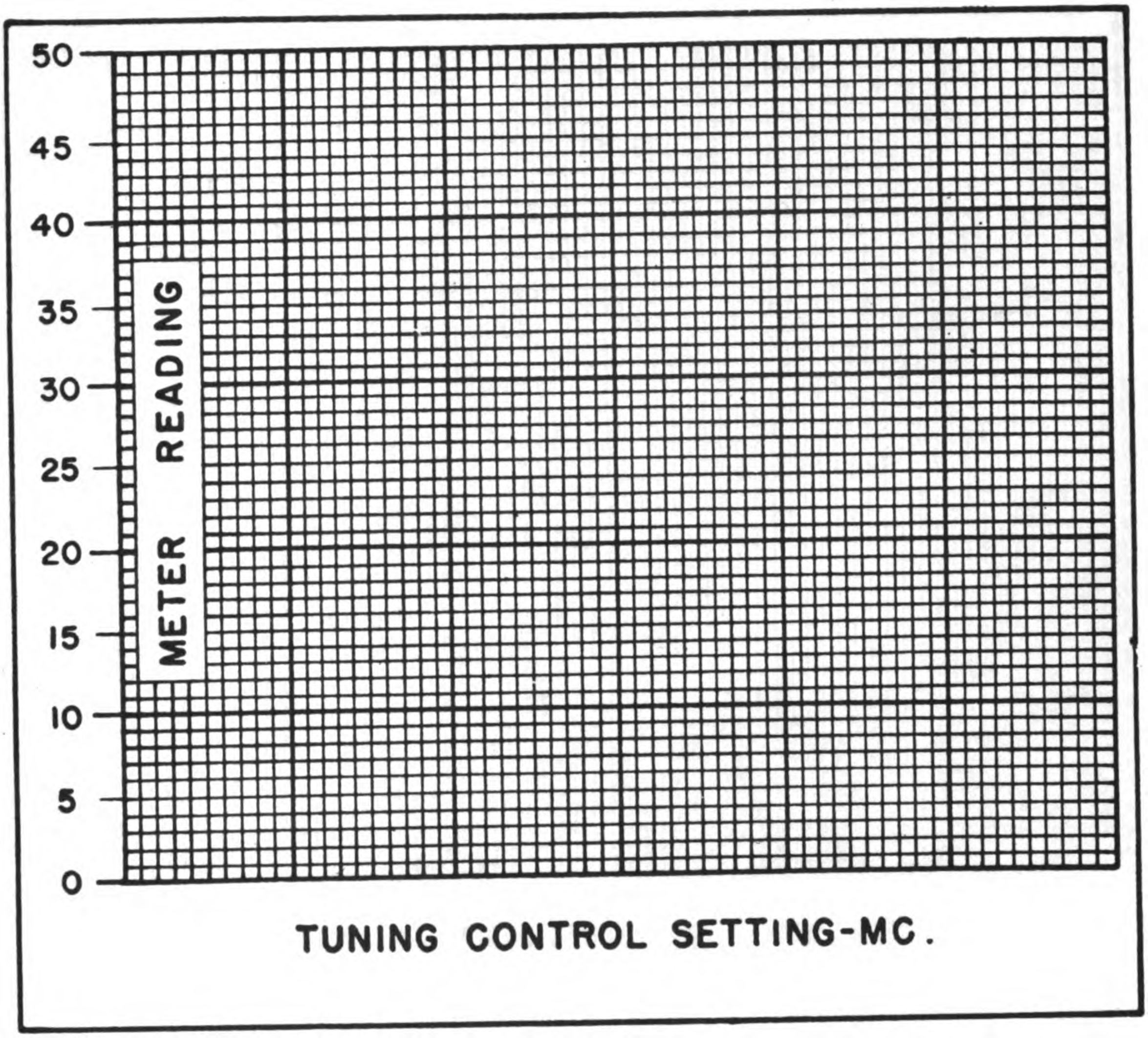
SPECTRUM ANALYSIS CHART



RADAR MODEL ______________________________

RADAR SERIAL ______________________________

ECHO BOX TS-172A/UP SERIAL ______________________________

SHIP OR STATION ______________________________

TESTED BY ______________________________

DATE ______________________________

RADAR CONDITIONS ______________________________

____

By Order of *Wilber M. Brucker*, Secretary of the Army:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

Official:
HERBERT M. JONES,
Major General, United States Army,
The Adjutant General.

Distribution:
Active Army:

ASA	Army Pictorial Cen	11-500 (AA-AE)
CNGB	WRAMC	11-557
Technical Stf, DA	AFIP	11-587
Technical Stf Bd	AMS	11-592
USA Arty Bd	Port of Emb (OS)	11-597
USA Armor Bd	Trans Terminal Comd	44-7
USA Inf Bd	Army Terminals	44-12
USA Air Def Bd	OS Sup Agcy	44-15
USA Abn & Elct Bd	USA Sig Pub Agcy	44-16
USA Avn Bd	USA Sig Comm Engr Agcy	44-17
USA Armor Bd Test Sec	USA Comm Agcy	44-25
USA Air Def Bd Test Sec	TASSA	44-26
USA Arctic Test Bd	USA White Sands Sig Agcy	44-35
USCONARC	Yuma Test Sta	44-36
USARADCOM	USA Elct PG	44-37
OS Maj Comd	Sig Fld Maint Shops	44-75
MDW	Sig Lab	44-76
Armies	Mil Dist	44-90
Corps	JBUSMC	44-101
Div	Units organized under following TOE's:	44-145
USATC		44-146
Ft & Camp	6-100	44-275
Svc Colleges	6-200	44-276
Br Svc Sch	6-300	44-315
Gen Depots	6-301	44-316
Sig Sec, Gen Depots	11-7	44-415
Sig Depots	11-16	44-416
Fld Comd, AFSWP	11-57	44-445
USA Sig Eqp Spt Agcy	11-127	44-446
Engr Maint Cen	11-128	

NG: State AG; units—same as Active Army.
USAR: None.
For explanation of abbreviations used, see AR 320-50.

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