TM 11-1212

IAR DEPARTMENT TECHNICAL MANUAL

ECHO BOX

TS-207/UP

CONFIDENTIAL

DEPARTMENT

21 DECEMBER 1944

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-1212 [redacted]

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WASHINGTON 25, D. C., 21 December 1944

TM 11–1212, Echo Box TS-207/UP, is published for the information and guidance of all concerned. [redacted]

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For explanation of symbols see FM 21–6.

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LIST OF ILLUSTRATIONS

DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT—1. Smash—Resonant cavity, crystal, crystal adapter, tuning mechanism.
2. Cut—Cables and all wiring.
3. Burn—Calibration factor chart, all technical manuals, instruction books.
4. Bury or scatter—Any or all of the above pieces after destroying their usefulness.

DESTROY EVERYTHING

WARNING

HIGH VOLTAGE
is used in the operation
of the radio equipment.

DEATH ON CONTACT
may result if personnel fail
to observe safety precautions.

Be careful to avoid contact with high-voltage circuits or 115-volt a-c input connections while checking or servicing the radio equipment. Make certain that the power is turned off before disassembling any part of the radio equipment.

Dangerously high voltages are present in the power supplies of the radio equipment. Before making any service checks, manually discharge all high-voltage capacitors in these circuits after the a-c power has been removed from the components.

FIRST AID TREATMENT FOR ELECTRIC SHOCK

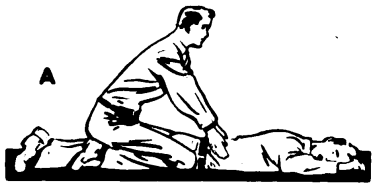
I. FREE THE VICTIM FROM THE CIRCUIT IMMEDIATELY.

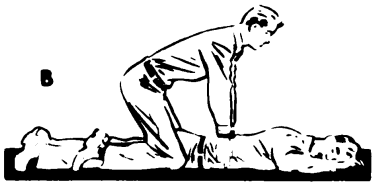
Shut off the current. If this is not immediately possible, use a dry nonconductor (rubber gloves, rope, board) to move either the victim or the wire. Avoid contact with the victim. If necessary to cut a live wire, use an axe with a dry wooden handle. Beware of the resulting flash.

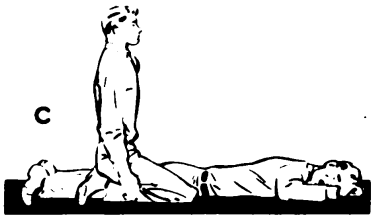
II. ATTEND INSTANTLY TO THE VICTIM'S BREATHING.

Begin resuscitation at once on the spot. Do not stop to loosen the victim's clothing. Every moment counts. Keep the patient warm. Wrap him in any covering available. Send for a doctor. Remove false teeth or other obstructions from the victim's mouth.

Resuscitation







POSITION

1. Lay the victim on his belly, one arm extended directly overhead, the other arm bent at the elbow, the face turned outward and resting on hand or forearm so that the nose and mouth are free for breathing (fig. A).
2. Straddle the patient's thighs, or one leg, with your knees placed far enough from his hip bones to allow you to assume the position shown in figure A.
3. Place your hands, with thumbs and fingers in a natural position, so that your palms are on the small of his back, and your little fingers just touch his lowest ribs (fig. A).

FIRST MOVEMENT

4. With arms held straight, swing forward slowly, so that the weight of your body is gradually brought to bear upon the victim. Your shoulders should be directly over the heels of your hands at the end of the forward swing (fig. B). Do not bend your elbows. The first movement should take about 2 seconds.

SECOND MOVEMENT

5. Now immediately swing backward, to remove the pressure completely (fig. C).
6. After 2 seconds, swing forward again. Repeat this pressure-and-release cycle 12 to 15 times a minute. A complete cycle should require 4 or 5 seconds.

CONTINUED TREATMENT

7. Continue treatment until breathing is restored or until there is no hope of the victim's recovery. Do not give up easily. Remember that at times the process must be kept up <u>for hours</u>.
8. During artificial respiration, have someone loosen the victim's clothing. Wrap the victim warmly; apply hot bricks, stones, etc. Do not give the victim liquids until he is fully conscious. If the victim must be moved, keep up treatment while he is being moved.
9. At the first sign of breathing, withhold artificial respiration. If natural breathing does not continue, immediately resume artificial respiration.
10. If operators must be changed, the relief operator kneels behind the person giving artificial respiration. The relief takes the operator's place as the original operator releases the pressure.
11. Do not allow the revived patient to sit or stand. Keep him quiet. Give hot coffee or tea, or other internal stimulants.

HOLD RESUSCITATION DRILLS REGULARLY

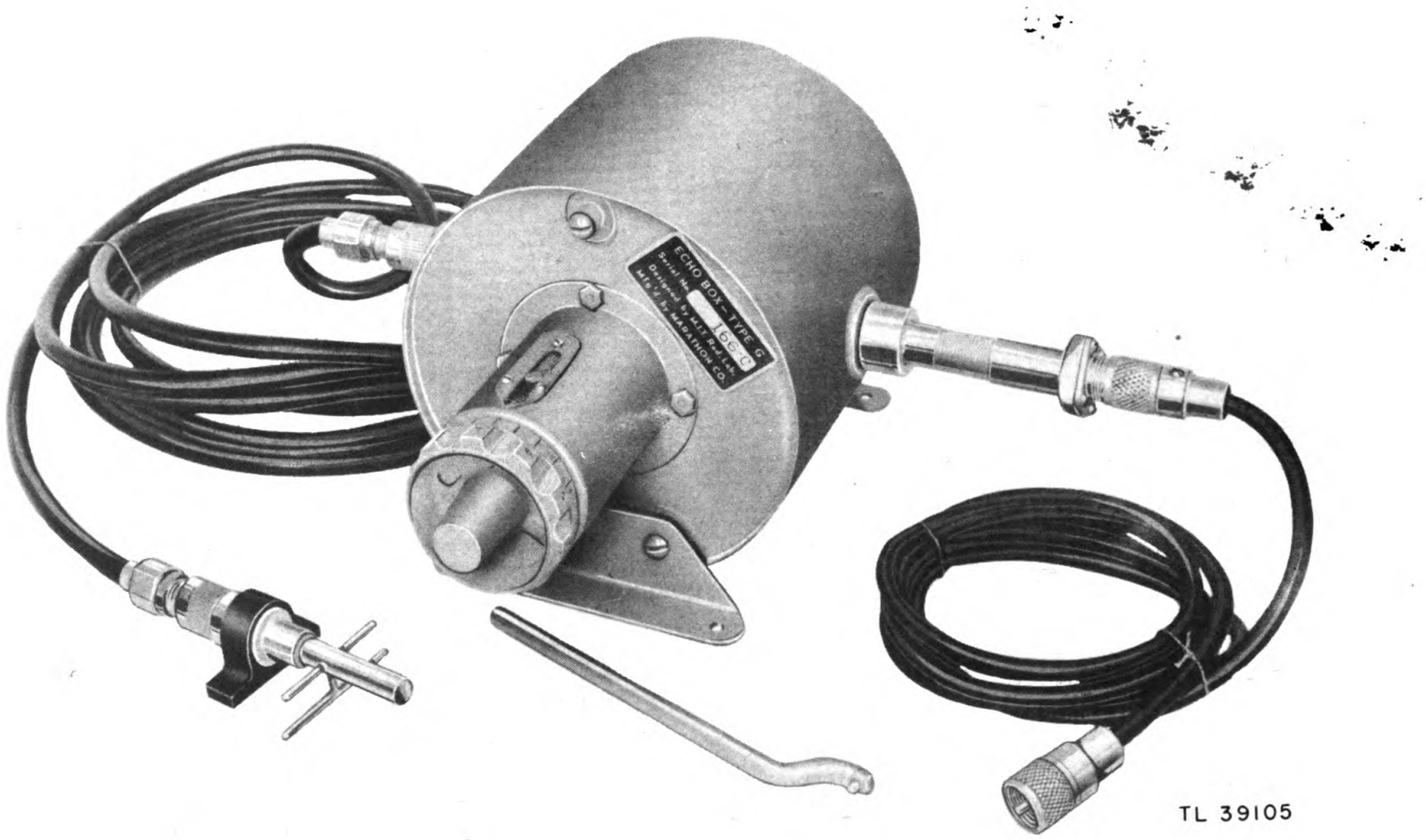


Figure 1. Echo Box TS–207/UP and associated equipment.

PART ONE

INTRODUCTION

1. GENERAL.

a. Purpose. The echo box (fig. 1) is a resonant-cavity device designed to simplify the tuning and checking of radar equipment as follows:
(1) It provides an artificial or "phantom" target which may be used in tuning the receiver to the transmitter if no real targets are available.
(2) It provides a clear, steady echo of known characteristics when such an echo is not obtainable from near-by ground targets.

b. Uses. The echo box may be used to perform a daily check on the same radar set to insure prompt discovery of any reduction in performance; but, in general, it cannot be used to make comparative measurements between the performances of two or more radar sets. The echo box, with its associated equipment, provides the following:

(1) A means of tuning the radar equipment.
(2) An over-all radio-frequency (r-f) performance check.
(3) An indication of transmitter power output.
(4) A measurement of transmitter frequency.
(5) An analysis of the transmitter frequency spectrum.
(6) A measurement of the local-oscillator frequency.
(7) A guide for trouble shooting.

2. COMPONENTS (fig. 2).

The list of echo box components varies depending upon the radar set with which the echo box is to be used. All of the equipments contain the basic Echo Box TS–207/UP, but additional components used for measuring r-f energy absorbed by the echo box and for transmission of r-f energy between the echo box and the radar system differ with each radar set. In general, the following list of components applies to all of the variations:

1 Echo Box TS–207/UP, complete with tuning knob, lucite scale, and mounting bracket.
1 crystal adapter (Crystal Adapter UG–119/UP in some cases).
2 coupling loops.
1 spare coupling loop.

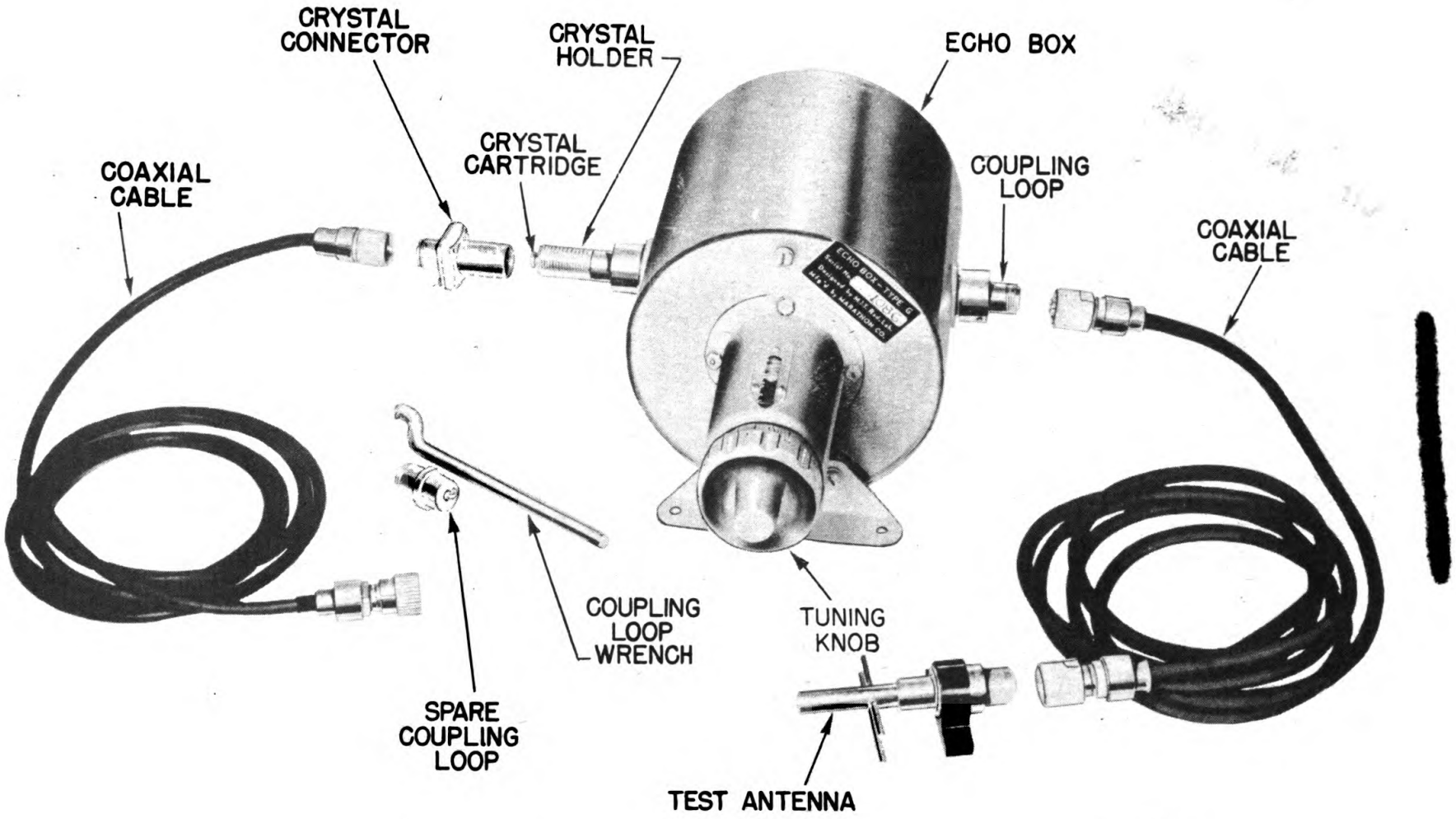


Figure 2. Echo box and associated equipment.

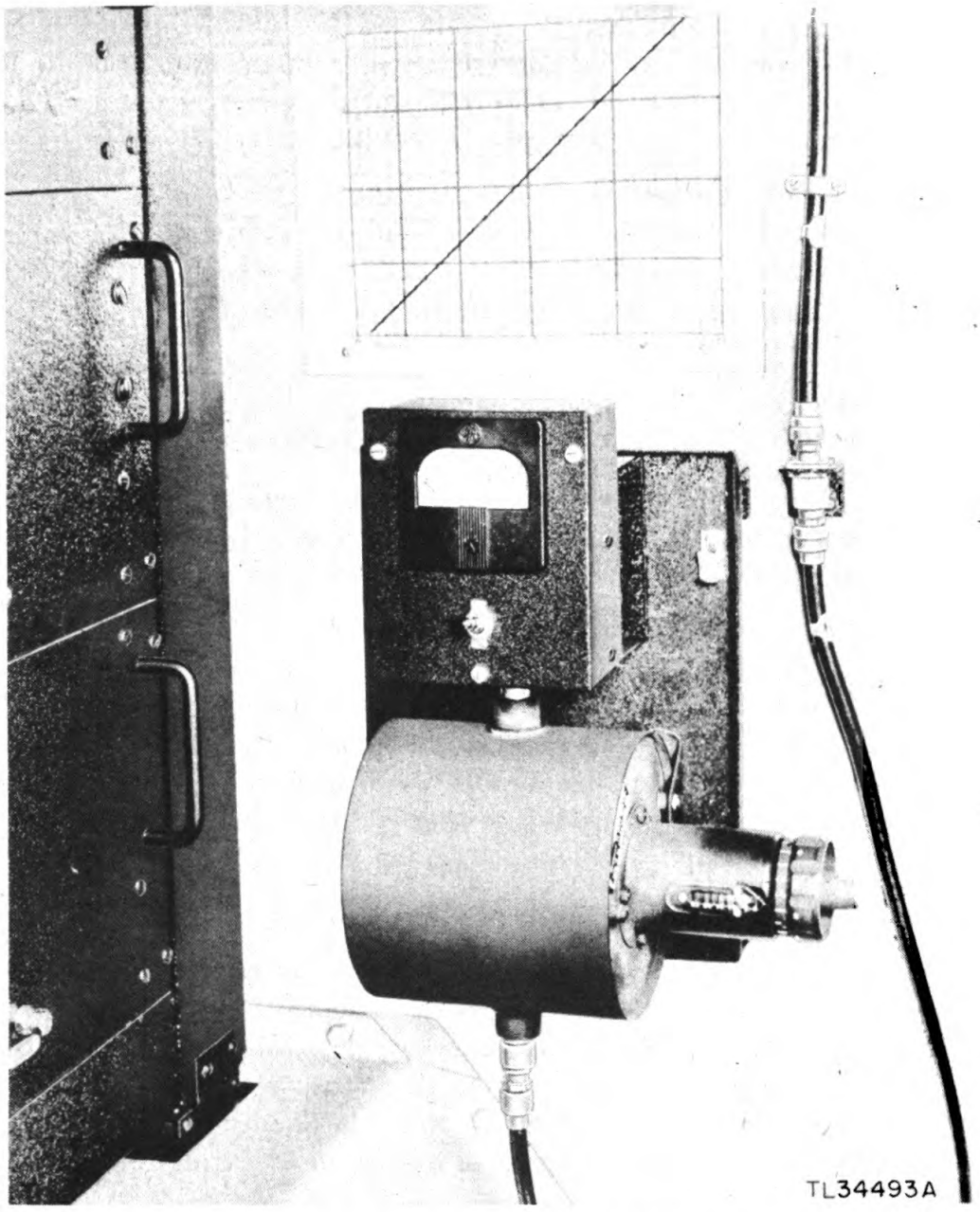


Figure 3. Echo box mounted on wall of trailer.

1 Cord CG–70/MPM.
1 Cord CG–71/MPM.
1 Antenna Assembly AS–23/AP or a directional coupler.
1 Terminal Box J–74/MPM.
1 Spanner Wrench MX–219/UP.
1 frequency calibration chart.

3. DIFFERENCES AMONG INSTALLATIONS.

a. At present there are four different installations of Echo Box TS–207/UP. Three of these require associated equipment; the fourth

installation is a complete unit which includes the associated equipment, and has the Signal Corps nomenclature Echo Box TS–238/UP (subpar. *e* below). Each of the first three installations (subpars. *b, c, d*) requires a microammeter (or analyzer set to read microamperes) when a visual indication of energy in the echo box is desired.

b. One installation uses the following associated equipment in conjunction with the basic Echo Box TS–207/UP: Antenna Assembly AS–23/AP, Cord CG–70/MPM for r-f transmission, Cord CG–71/MPM for video transmission, Terminal Box J–74/MPM, Crystal Adapter UG–119/UP, and Spanner Wrench MX–219/UP.

c. A second installation uses the same associated equipment as given in subparagraph *b* above except that a different crystal adapter is used.

d. A third installation uses the same associated equipment as that in subparagraph *c* except that a directional coupler is used instead of Antenna Assembly AS–23/AP.

e. The fourth set-up is Echo Box TS–238/UP (fig. 3). This installation consists of Echo Box TS–207/UP mounted on a metal plate together with a meter box containing a microammeter, capacitor, and switch. This unit uses a built-in crystal adapter. R-f energy is brought to the echo box from Antenna Assembly AS–23/AP through a special r-f cable, and a mounting rod is furnished with the equipment for mounting the test antenna.

4. INTERCHANGEABLE COMPONENTS.

Although the components of the echo box are interchangeable from a physical standpoint, the interchanged components will give differences in performance because of the differences in electrical characteristics of the interchanged parts. For this reason care must be taken to see that the components are not interchanged, since the identity of the system must be maintained to insure accurate repetition of testing results.

PART TWO

OPERATING INSTRUCTIONS

NOTE: For the destruction of the echo box and its associated equipment, see the DESTRUCTION NOTICE, page V.

5. INSTALLATION.

a. The method of installation of the echo box and its associated equipment varies, depending upon the type of radar unit with which it is being used. For installation instructions, refer to the technical manual describing the particular set. It is important that the use of a particular echo box and its accessories be restricted to a specific radar unit. The interchanging of components causes differences in performance (par. 4). System identity should be maintained to insure repetition of testing results.

b. In some radar equipment the echo box is permanently installed on the inside wall of the cab. In this case the dipole is attached to a support rod on the outside (fig. 4). On other equipment the echo box is portable and the dipole may be attached to a bracket on the inside of the paraboloid or mounted approximately one diameter of the paraboloid in front of the radar set antenna. In these cases the antenna assembly must be returned to exactly the same position for further measurements. On sets using the directional coupler, the coupler is permanently connected into the transmission line to the antenna and the echo box is connected with Cord CG–70/MPM to the directional coupler.

6. PREPARATION.

a. Attach the pick-up dipole to its supporting rod or bracket, and connect the echo box in accordance with the instructions pertaining to the type of radar equipment being used (fig. 5). If the directional coupler is supplied with the equipment, connect Cord CG–70/MPM to the coupler output.

b. On sets where the pick-up dipole is not mounted within the paraboloid or where the directional coupler is not used, move the paraboloid manually so that it points in the direction of the pick-up dipole.

c. When the directional coupler is not used, the pick-up dipole must be parallel with the radar set dipole for the maximum transfer of r-f energy. Orient the pick-up dipole so that the reflector portion (the

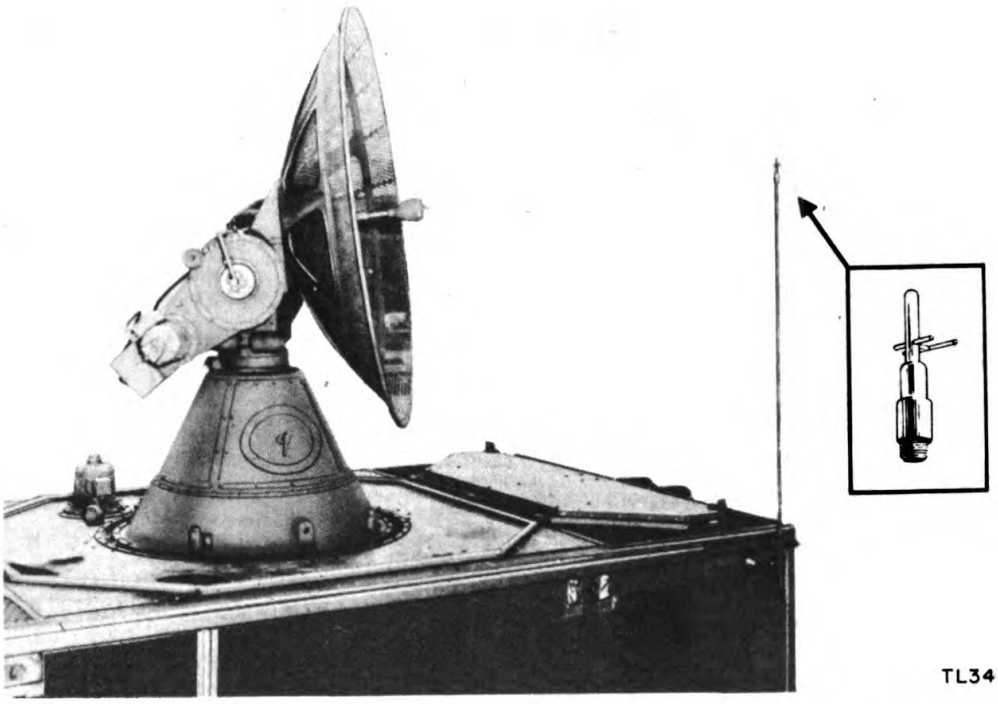


Figure 4. Echo box pick-up dipole attached to mounting rod.

T-section which is fastened to the outer conductor) is away from the radar antenna. Turn the spinner motor on the radar antenna off if one is used, and rotate the radar antenna by hand until the dipole is horizontal.

d. Operate the radar set for a period of at least 10 minutes before attempting to tune the echo box.

7. R-F SYSTEM TUNE-UP PROCEDURE.

a. Echo Box Tuning. (1) After the radar set has been operated for at least 10 minutes, tune the echo box by rotating the control knob clockwise or counterclockwise, as necessary, until a deflection is observed on the microammeter.

(2) Tune the echo box until the meter needle shows maximum deflection. This tunes the echo box to the frequency of the transmitter. Read the scale and observe positions.

b. Receiver Gain Setting. (1) To measure the ringing time precisely, it is essential that the intersection of the descending (exponential) curve of the ringing-time indication with the upper level of noise indication be clear and easily discernible (fig. 6).

(2) To obtain a clear intersection, the receiver gain setting must be such that the indication of noise or "grass" appears on the screen at sufficient amplitude; but the receiver gain setting should not cause the

amplitude of the noise indication to approach the receiver saturation level.

c. Orientation of Paraboloid. (1) If AGC (automatic gain control) is used on the receiver, turn the AGC switch off; if such a switch is not on the equipment, reduce the AGC action to a minimum.
(2) With the receiver gain set high enough for the noise to be seen on the range scope, observe the ringing time (fig. 6).
(3) Move the paraboloid by manual control in azimuth and elevation until the ringing time is maximum as measured on the range scope.

d. Local Oscillator Setting. (1) Tune the local oscillator to maximize the ringing time.
(2) See if the ringing time can be increased by retuning the echo box. If so, the receiving system (principally the T/R box and the local oscillator) may not be tuned to the transmitter frequency (subpar. *e* below).

e. Check of Receiver-transmitter Tuning. (1) For correct tuning of the radar set, the maximum ringing time on the range scope should occur simultaneously with maximum deflection of the echo-box meter needle.
(2) Turn the echo-box tuning knob slowly so that the echo box is tuned

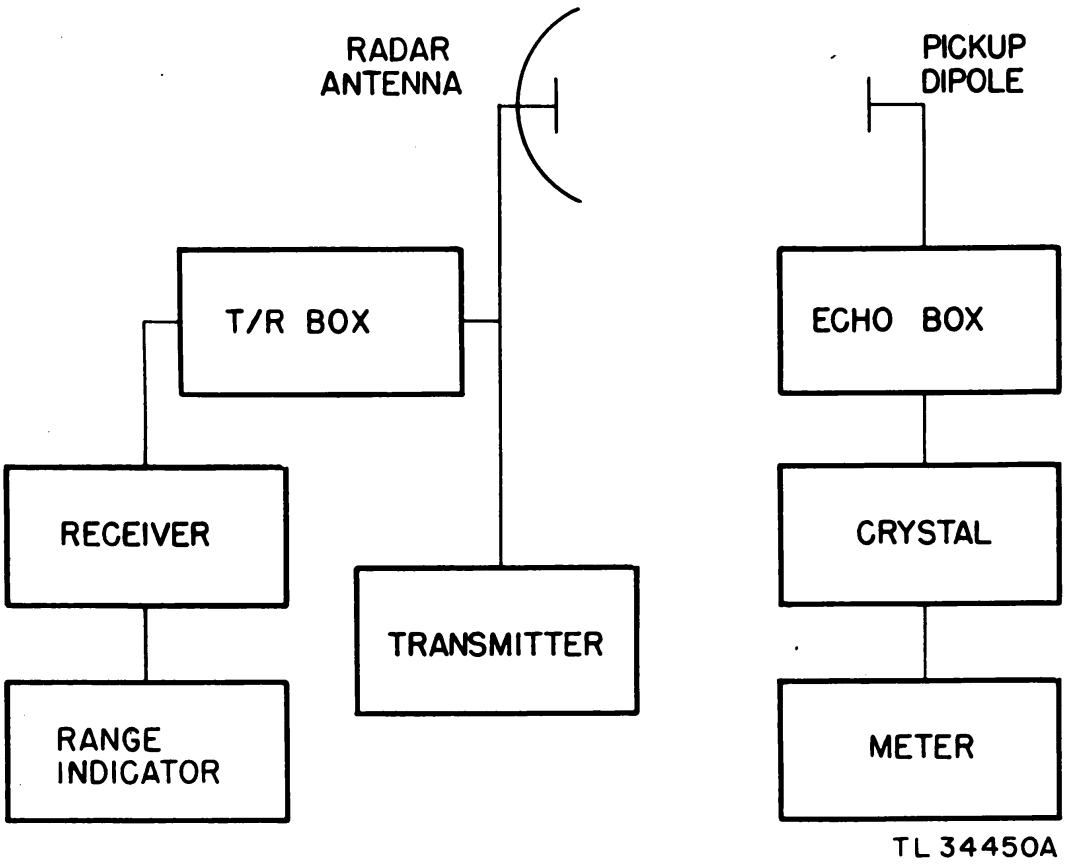


Figure 5. Block diagram for r-f system measurements.

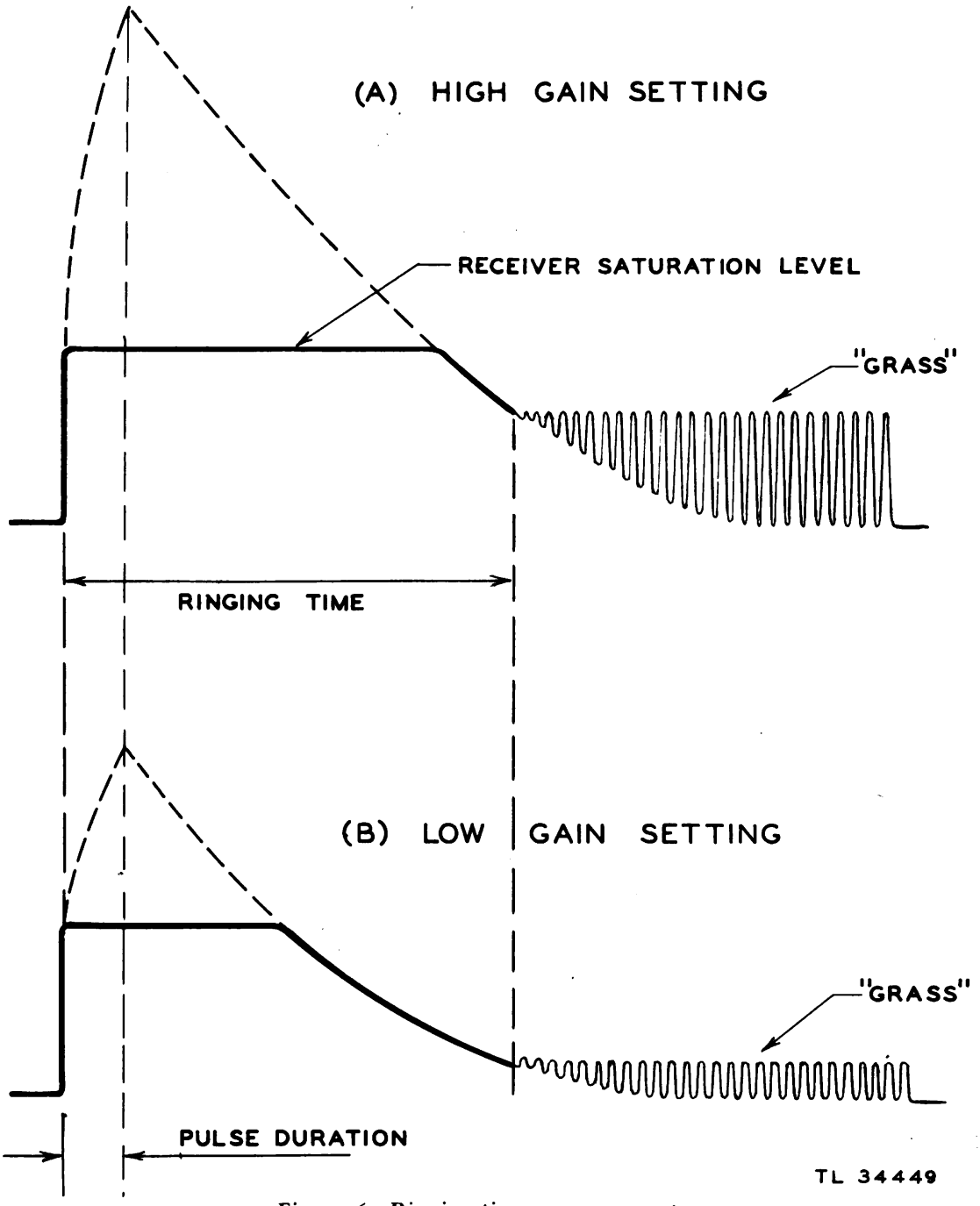


Figure 6. Ringing-time measurement.

through resonance, causing the meter needle deflection to increase to a maximum and then decrease.

(3) Observe the ringing time as indicated on the range scope to see that it is at its maximum value at the same setting that the echo-box meter needle is at a maximum. If it is, the receiving system is tuned correctly; otherwise, the longest ringing time observed on the range scope will occur when the echo box is tuned to a frequency between the transmitter and the receiver frequencies. In the latter case the local oscillator and the T/R box must be retuned.

f. Final Adjustments. (1) Adjust the local-oscillator tuning and the local-oscillator receiver voltage for maximum ringing time as observed on the range scope.

(2) Loosen the T/R box tuning-screw locknut and tune the T/R box for maximum ringing time.

(3) Lock the T/R box tuning screw in place carefully. Use Spanner Wrench MX–219/UP to tighten the locknuts.

(4) Check to see that the ringing time remains at the same value as observed in step *b* above.

g. Elimination of Outside-target Signals. (1) In measuring ringing time be sure that the indication on the range scope is caused by the echo box and not by signals received from outside targets.

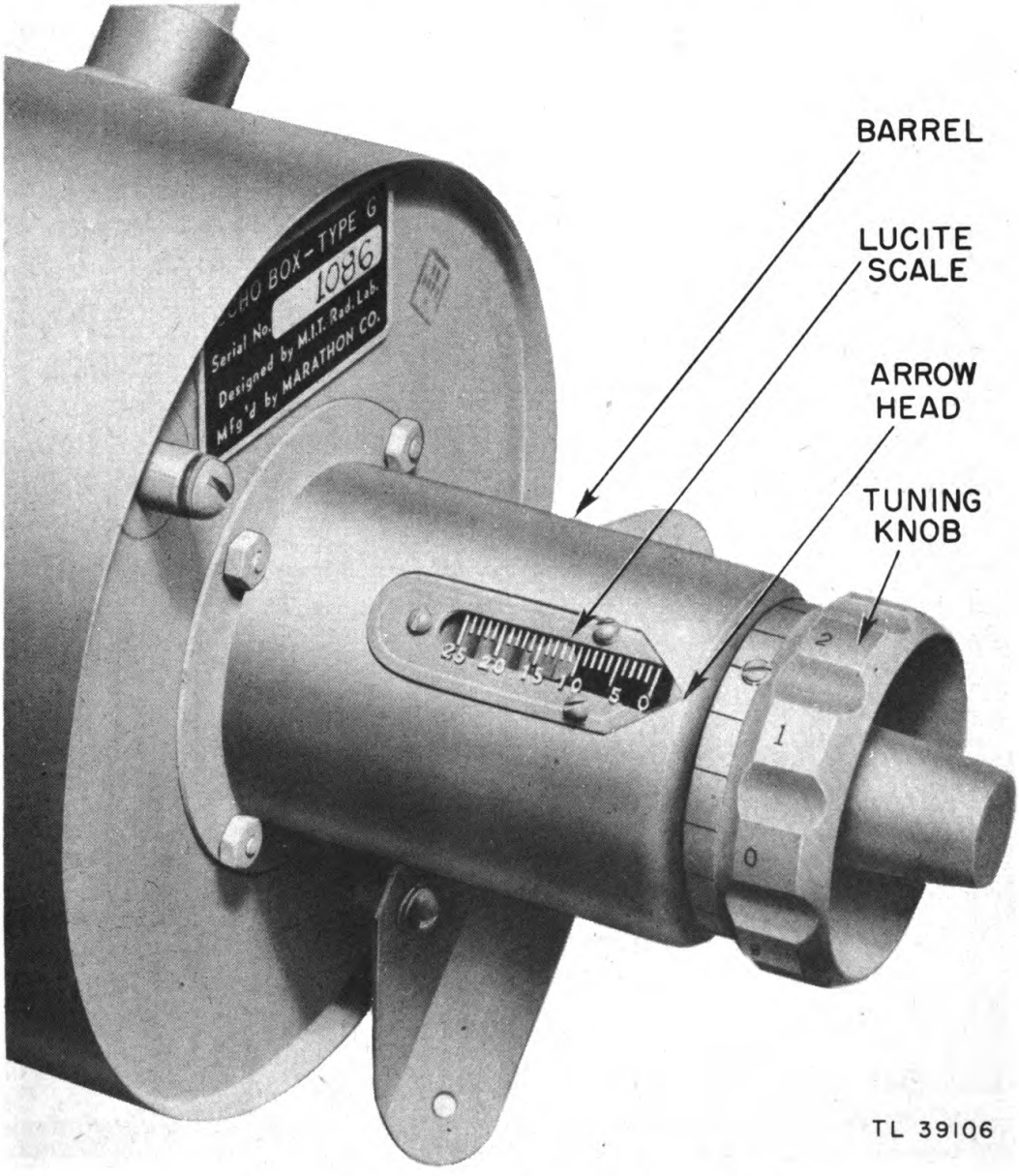


Figure 7. Tuning knob and scale markings.

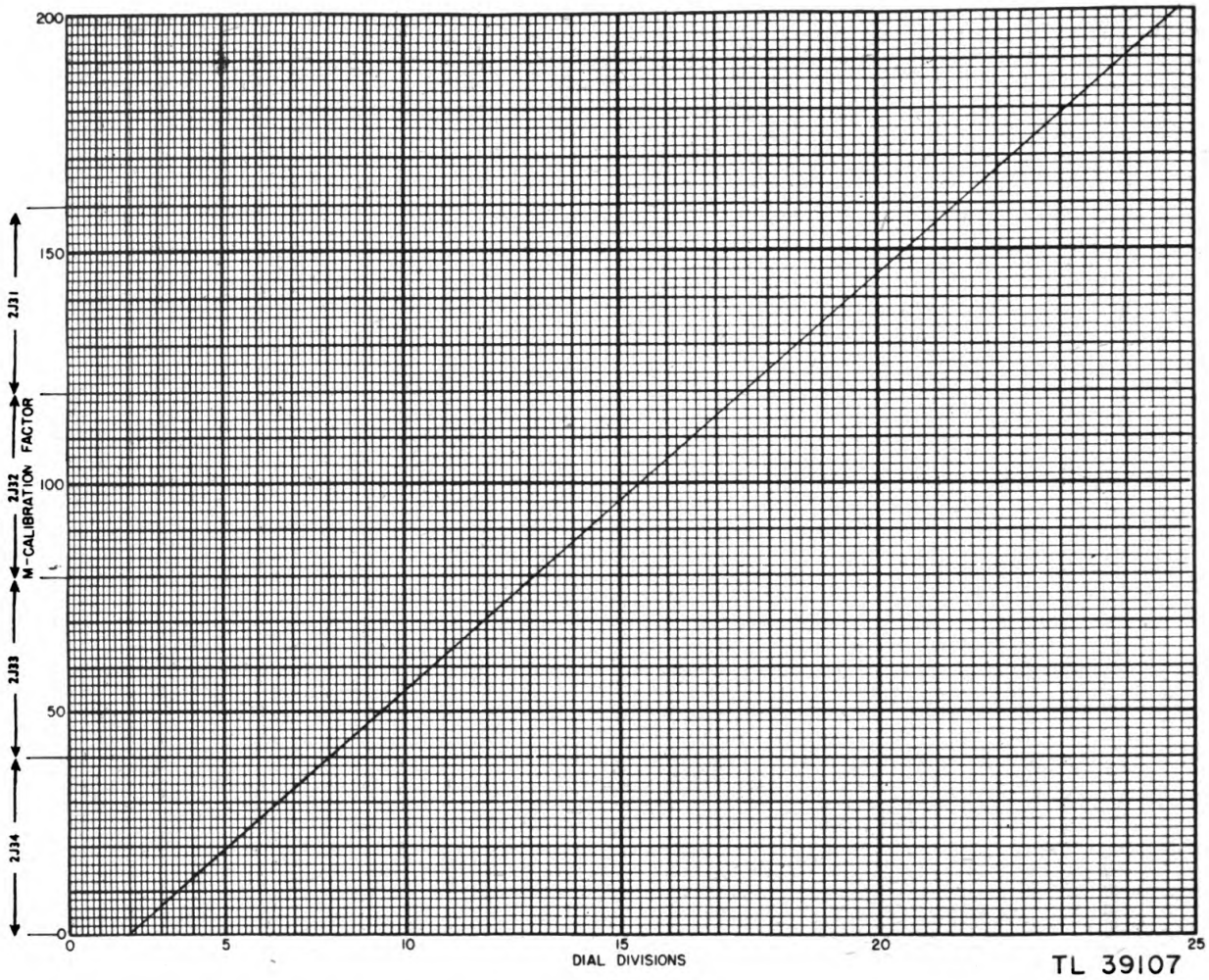


Figure 8. Dial division-calibration factor chart.

(2) If the pick-up dipole is located within the paraboloid or the directional coupler is used, the paraboloid should be elevated to prevent the reception of signals from near-by ground targets.
(3) When the pick-up dipole is fixed to some other part of the equipment, elevation of the paraboloid or antenna is not practicable. The presence of an outside signal indication may be discerned by tuning the local oscillator and noting whether or not the ringing time increases and decreases. Outside signal indications will change in amplitude but not in range, whereas the echo-box signal indication will change in range.

h. Measurement. (1) To determine the ringing time, measure the range to the point where the descending curve of the echo box signal begins to join the grass (fig. 6). As long as sufficient grass is visible, this measurement is independent of receiver gain.
(2) Ringing time should not be measured at the saturation level or by the length of the flat top, since this distance is dependent upon the receiver-gain setting (fig. 6).
(3) To obtain accurate results within ±100 yards, at least four readings should be taken and averaged to obtain the final reading.
(4) When echo-box tests are made by more than one person, the operators should practice together so that readings by any of the operators will give comparable results.

i. Detuning Procedure. Before proceeding with normal radar operation, the echo box should be detuned so that no signal (ringing time) from the echo box appears on the range scope, or the echo box should be disconnected from the dipole or directional coupler. On radar sets where the pick-up dipole is mounted within the paraboloid, the pick-up dipole and attached cable should be removed.

> **NOTE:** If the echo box is not detuned or disconnected, the set will be blocked in the direction of the outside pick-up dipole out to the range of maximum ringing time; if the pick-up dipole is installed within the paraboloid or the directional coupler is used, normal transmission will be interfered with in all directions.

8. R-F SYSTEM PERFORMANCE MEASUREMENT.

a. Set up the echo box as described in the instruction manual relating to the particular radar equipment being used.

b. Operate the radar set for 10 minutes.

c. Tune the echo box as outlined in paragraph 7, and orient the paraboloid, if necessary, for maximum ringing time. Record the value of ringing time (or range) in the log book. Check the value with those obtained in previous tests. Use an average of four readings.

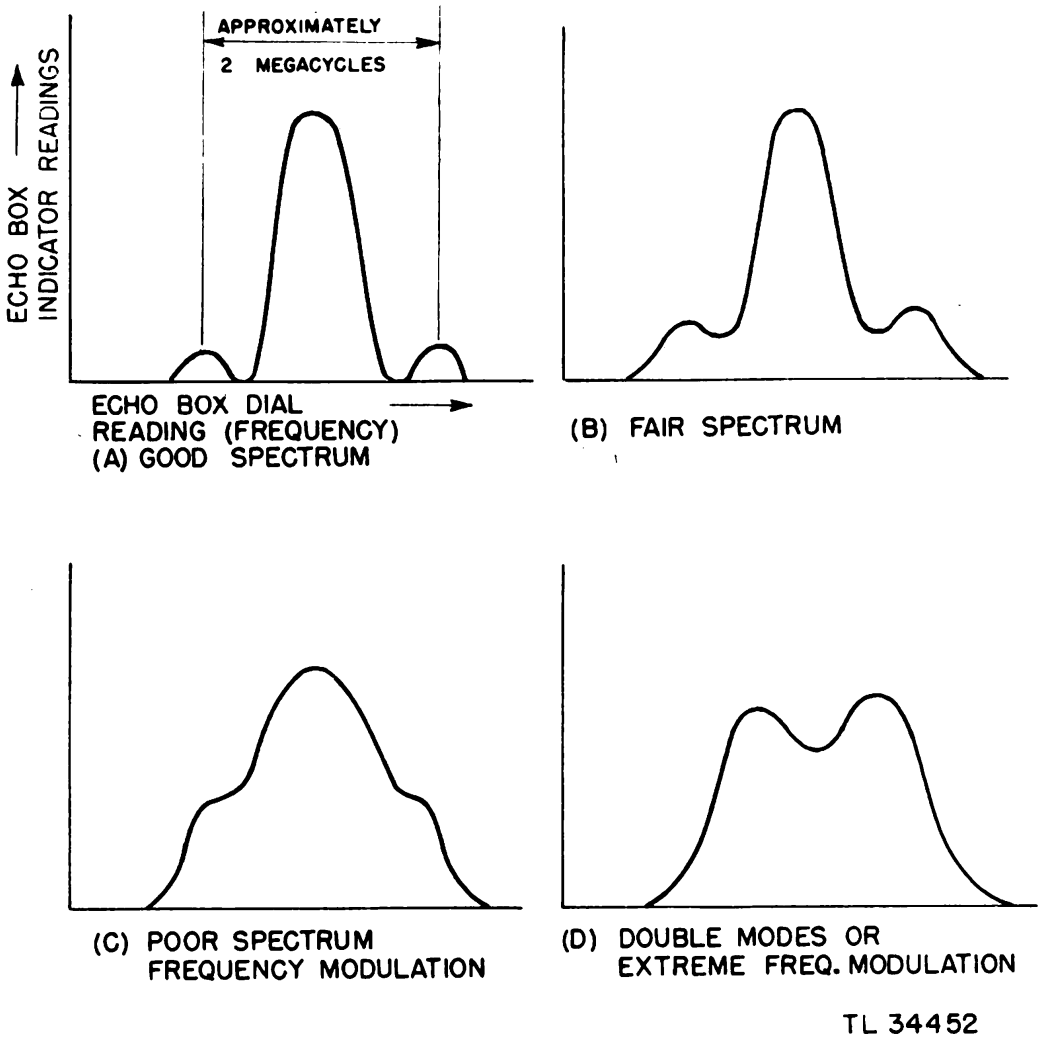


Figure 9. Frequency spectrums.

d. If the reading does not agree within 100 yards with previous readings, the system performance has changed.

e. If the average ringing time has decreased 200 yards, the system is down approximately 3 decibels in performance and only 80 percent of maximum range against aircraft is being obtained.

9. TRANSMITTER FREQUENCY MEASUREMENT.

a. Set up the echo box as described in the instruction manuals relating to the equipment.

b. Make sure that the radar set has been operated for at least 10 minutes.

c. Tune the echo box and, if necessary, orient the paraboloid for maximum ringing time.

NOTE: When tuning the echo box by means of the indicator needle, be sure that the center of strongest maximum is read. Usually one small peak is found on either side of the main peak.

d. Read and record the scale and tuning-knob position as follows:
(1) The first two significant figures (0-25) are found by noting the position of the indicator under the lucite scale of the tuning-knob barrel (fig. 7).
(2) The fractional divisions are read by observing the reference mark or figures on the circumference of the knob opposite the arrowhead on the lucite scale.

e. Determine the calibration factor by using the dial division-calibration factor chart (fig. 8).

f. Determine the correct frequency in megacycles by adding the constant 2,700 to the calibration factor as follows:

Correct frequency = 2,700 + calibration frequency.

10. TRANSMITTER FREQUENCY SPECTRUM MEASUREMENT.

a. Set up the echo box as described in the instruction manuals relating to the particular equipment being tested.

b. Operate the radar set for at least 10 minutes.

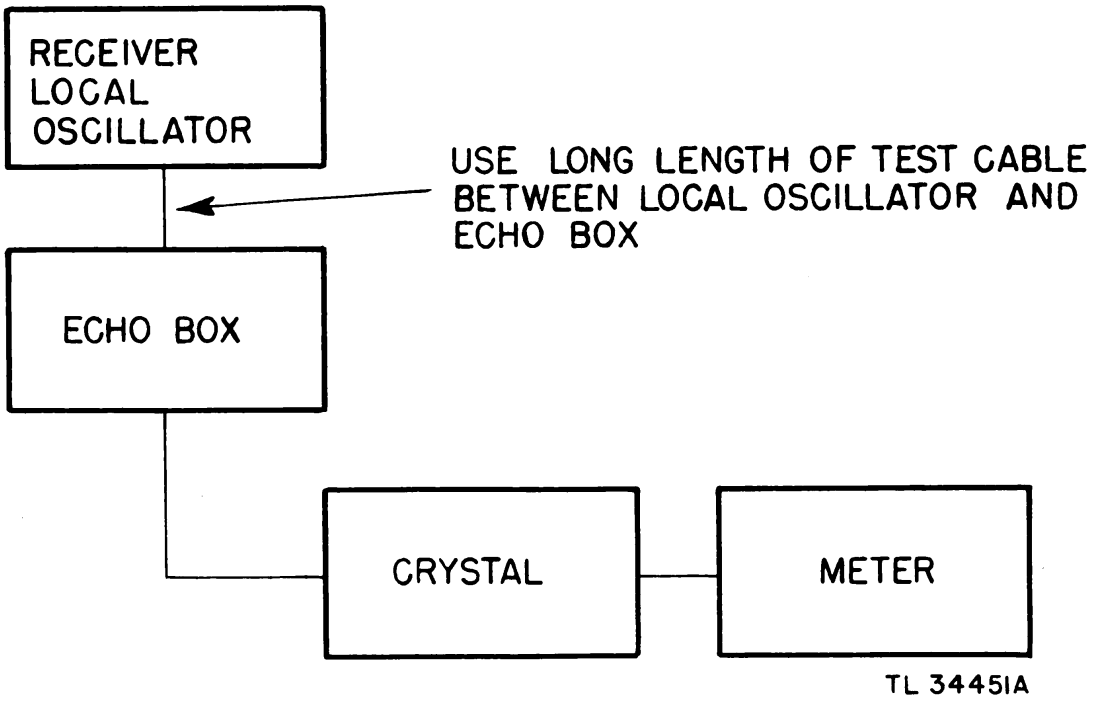
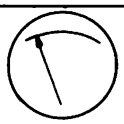
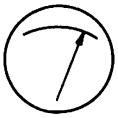
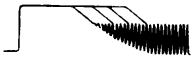
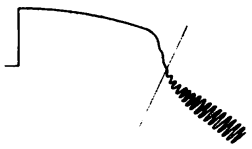
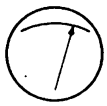
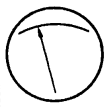
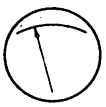
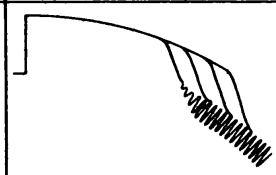
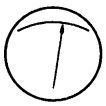
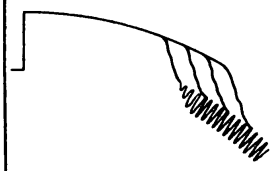
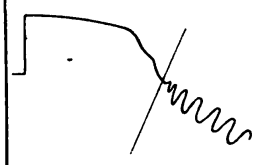
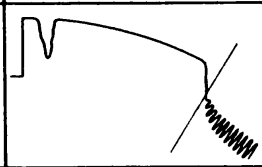


Figure 10. Block diagram for measurement of receiver local-oscillator frequency.

EFFECT	APPEARANCE ON		CAUSE AND PROBABLE REMEDY
	RANGE SCOPE	ANALYZER METER	
RINGING TIME SATISFACTORY			SYSTEM PERFORMANCE SATISFACTORY
RINGING TIME VERY LOW, CRYSTAL CURRENT SATISFACTORY			RECEIVER TROUBLE: LOCAL OSCILLATOR; BAD CRYSTAL, EXCESSIVE I-F NOISE AND/OR PICKUP FROM MOTORS; DETUNED T/R BOX; T/R TUNING PLUGS NOT LOCKED TIGHTLY
RINGING TIME LOW, CRYSTAL CURRENT EQUALLY LOW			LOW POWER OUTPUT, CHECK SPECTRUM
RINGING TIME VERY LOW, CRYSTAL CURRENT LOW			TROUBLE PROBABLY IN TRANSMITTER AND RECEIVER; AND/OR TROUBLE IN TRANSMISSION LINE. CHECK FOR EXCESSIVELY HOT STUBS ON TRANSMISSION LINE, WATER IN LINE, CORRODED OR POOR CONNECTIONS
RINGING TIME ERRATIC, CRYSTAL CURRENT STEADY			SPINNER MOTOR ON, OR FAULTY PULSING; DOUBLE MODING TRANSMITTER, OR LOCAL OSCILLATOR TROUBLE. CHECK SPECTRUM. INTERMITTENT CONTACTS IN CABLES OR RECEIVER
RINGING TIME ERRATIC, CRYSTAL CURRENT ERRATIC			FAULTY TRANSMISSION LINE OR POOR CONNECTIONS, CONDITIONS WORSE WHEN LINE IS RAPPED
END OF RINGING TIME IS NOT STEEP, SLOPES GRADUALLY; PERHAPS EVEN EXCESSIVE RINGING "GRASS" APPEARS COARSE AND SAWTOOTH RATHER THAN FINE AND NEEDLE-LIKE			OSCILLATING I.F. AND/OR NARROW BAND RECEIVER
DIP IN RINGING TIME AT END OF PULSE			BAD T/R TUBE
POOR SPECTRUM			TRANSMITTER TROUBLE

TL 39108

Figure 11. Cause and effect chart for A-scope.

EFFECT	APPEARANCE ON 32,000 YARD RANGE SCOPE	APPEARANCE ON ECHO BOX METER	CAUSE AND PROBABLE REMEDY
RINGING TIME SATISFACTORY			SYSTEM PERFORMANCE SATISFACTORY
RINGING TIME VERY LOW, CRYSTAL CURRENT SATISFACTORY			RECEIVER TROUBLE: LOCAL OSCILLATOR; BAD CRYSTAL; EXCESSIVE I-F NOISE FROM IST PRE-AMP STAGE AND/OR PICKUP FROM MOTORS; DETUNED T/R BOX; T/R TUNING PLUGS NOT LOCKED TIGHTLY.
RINGING TIME LOW, CRYSTAL CURRENT EQUALLY LOW.			LOW POWER OUTPUT CHECK SPECTRUM
RINGING TIME VERY LOW, CRYSTAL CURRENT LOW.			TROUBLE PROBABLY IN TRANSMITTER AND RECEIVER; AND/OR TROUBLE IN TRANSMISSION LINE: CHECK FOR EXCESSIVELY HOT STUBS ON TRANSMISSION LINE, WATER IN LINE, CORRODED OR POOR CONNECTIONS
RINGING TIME ERRATIC, CRYSTAL CURRENT STEADY.			SPINNER MOTOR ON, OR FAULTY PULSING; DOUBLE MODING TRANSMITTER, OR LOCAL OSCILLATOR TROUBLE. CHECK SPECTRUM INTERMITTENT CONTACTS IN CABLES OR RECEIVER.
RINGING TIME ERRATIC, CRYSTAL CURRENT ERRATIC			FAULTY TRANSMISSION LINE OR POOR CONNECTIONS, CONDITION WORSE WHEN LINE IS RAPPED.
END OF RINGING TIME IS NOT STEEP, SLOPES GRADUALLY; PERHAPS EVEN EXCESSIVE RINGING.			OSCILLATING I.F. AND/OR NARROW BAND RECEIVER. "GRASS" APPEARS COARSE AND SAWTOOTH RATHER THAN FINE AND NEEDLE-LIKE.
DIP IN RINGING TIME AT END OF PULSE.			BAD T/R TUBE
POOR SPECTRUM			TRANSMITTER TROUBLE

TL34469

Figure 12. Cause and effect chart for J-scope.

c. Tune the echo box for maximum needle deflection; orient the paraboloid if necessary.

d. With the system tuned up, record echo-box scale, tuning-knob reading, and echo-box meter needle deflection as the echo box is tuned slowly through the transmitter spectrum.

e. Plot the meter reading against the dial reading (fig. 9) to obtain the frequency spectrum.

f. Since the radar transmitter output is modulated in the form of pulses, energy will be transmitted in the sidebands—that is, in frequencies above and below the carrier frequency.

(1) For square pulse modulation, the frequency spectrum should be similar to that labeled "good spectrum" (fig. 9 (A)). Since the crystal current of the echo box is not linear over the entire range, the secondary peaks will be exaggerated. This characteristic will be an advantage, since deep minimum points adjacent to the main peak and a fairly symmetrical curve indicate a good spectrum.

(2) For a 2-megacycle bandwidth receiver, the distance between minima should not be much greater than 2 megacycles, or power will be wasted outside of the bandwidth.

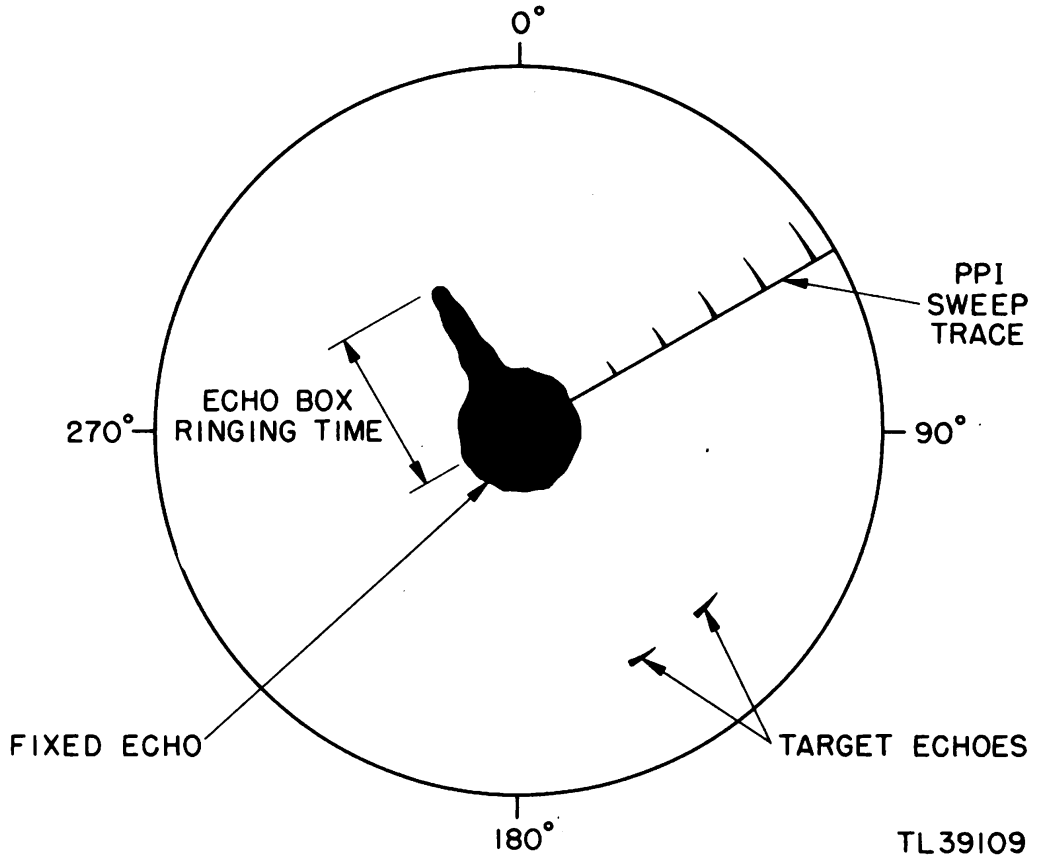


Figure 13. Normal indication of echo box on PPI scope (fixed pick-up dipole).

(3) A good spectrum with a low-peak (low-power) meter reading may indicate low voltage or an old transmitter tube.
(4) A spectrum without deep minima adjacent to the main peak indicates a frequency modulation of the transmitter output. This can be caused by a voltage pulse whose sides are not steep and whose top is not flat.
(5) If two distinct maxima are observed, the transmitter is "double moding" by being "pulled" in frequency as a result of standing waves in the transmission line. Double moding does not occur frequently with new-model tubes. The spacing between the two peaks indicates the amount of frequency scattering, while the height of the peaks indicates the amount of power radiated in each peak. Double moding may often be remedied by the adjustment of the line voltage or the input voltage to the transmitter.

11. LOCAL-OSCILLATOR FREQUENCY MEASUREMENT.

a. General. The measurement of local-oscillator frequency generally is unnecessary, since the tubes are preset to operate within the bandwidths of the radar set. If measurement is desired, however, the preliminary instructions below should be followed:
(1) Precautions should be taken to see that the echo box does not "pull" the frequency of the local oscillator. To prevent this from occurring, use a long piece of test cable, or join two lengths so that there is considerable attenuation between the local oscillator and the echo box.
(2) It may be necessary to use a short cable to determine the approximate frequency or determine whether or not the tube is oscillating, and then change to the longer cable for actual measurement.
(3) In any case, the deflection of the meter needle should be about one-fourth of full scale, or less when the indicator meter switch is in the most sensitive position and the echo box is tuned for maximum deflection.

b. Procedure. (1) If the echo box is permanently attached to the radar unit or trailer, remove the echo box.
(2) Connect the input of the echo box to the output of the local-oscillator by means of the test cable. (See figure 10 for the block diagram.)
(3) Tune the echo box for maximum deflection of the meter needle.
(4) Record the scale and knob reading of the echo box.
(5) Determine the frequency by consulting the dial division-calibration factor chart (par. 9).
(6) When the test is complete, remove the connection from the local-oscillator output.

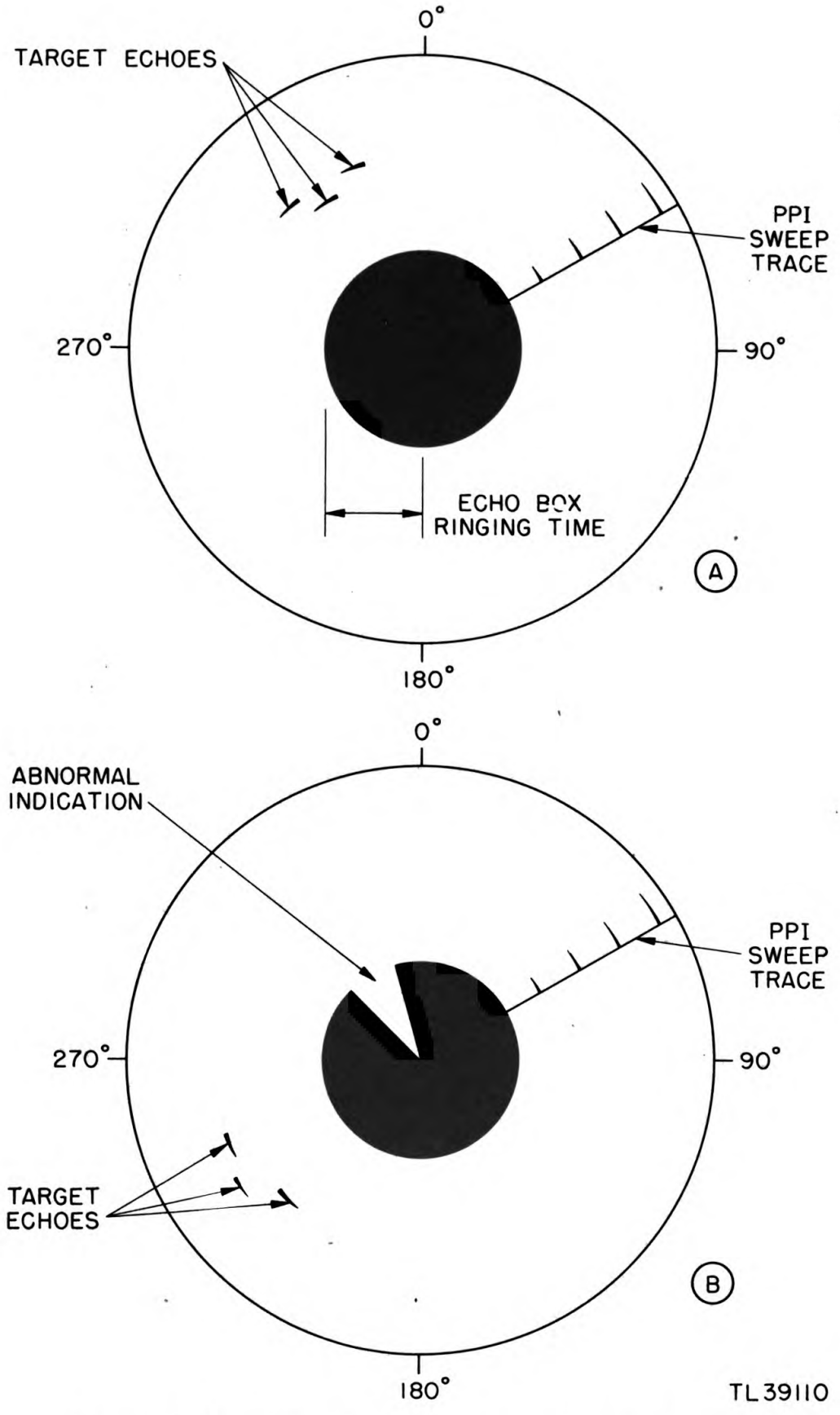


Figure 14. PPI indication of an echo box using a directional coupler.

12. RADAR TROUBLE SHOOTING.

a. Many malfunctions of the radar equipment may be detected rapidly by the use of the echo box. In making the checks, the appearance and measurement of the ringing-time indication on the range scope should be combined with the echo-box ammeter reading for complete analysis. The cause and effect charts (figs. 11 and 12) should be used in connection with these tests.

b. Although more information can be obtained by observing the effects of the echo box on an A-scope or equivalent, a PPI scope will also show a characteristic echo box indication. If the pick-up dipole is mounted as shown in figure 4, the normal PPI indication is shown in figure 13. Figure 14-A is the normal PPI indication if the echo box is energized from a directional coupler or if the pick-up dipole is mounted on the paraboloid. Figure 14-B is an abnormal indication of the latter installation caused by a frequency shift at a particular azimuth due to a poor magnetron or "pulling" due to a bad transmission line or near-by targets. The cause of this abnormal indication is localized to some extent due to the fact that it occurs only at the azimuth indicated by the blank sector.

PART THREE

PREVENTIVE MAINTENANCE

13. MEANING OF PREVENTIVE MAINTENANCE.

Preventive maintenance is a systematic series of operations performed at regular intervals on equipment to eliminate major break-downs and unwanted interruptions in service, and to keep the equipment operating at top efficiency. To understand what is meant by preventive maintenance, it is necessary to distinguish between preventive maintenance, trouble shooting, and repair. The prime function of preventive maintenance is to *prevent* break-downs and, therefore, the need for repair. On the other hand, the prime function of trouble shooting and repair is to locate and correct *existing* defects. The importance of preventive maintenance cannot be overemphasized. The readiness and operating efficiency of a radar set depends on the condition of readiness and operating efficiency of its test equipment.

14. DESCRIPTION OF PREVENTIVE MAINTENANCE TECHNIQUES.

a. General. Echo Box TS–207/UP and its associated equipment requires the application of the preventive maintenance operations of *inspect, tighten, clean,* and *adjust.*

b. Inspect. Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook the evidences of minor trouble. Although these defects may not interfere with the performance of the equipment, valuable time and effort can be saved if they are corrected before they lead to major break-downs. Make every effort to become thoroughly familiar with the indications of normal functioning, in order to be able to recognize the signs of a defective echo box. Inspection consists of carefully observing all parts of the equipment, noticing their color, placement, state of cleanliness, etc. Inspect for the following conditions:

(1) Placement, by observing that all leads and cabling are in their original positions. Check the position of the pick-up dipole, if used.

(2) Cleanliness, by carefully examining all recesses in the units for accumulation of dust, especially between connecting terminals. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

c. Tighten. Tighten all mounting bolts, screws, and cable connections.

CAUTION: Screws, bolts, and nuts should not be tightened beyond the pressure for which they are designed, or they will be damaged or broken.

d. Clean. Clean the exterior of the echo box. Pay particular attention to the tuning knob and the lucite scale. Clean the cable connectors, the crystal holder, and the pick-up dipole if used. Use a clean cloth and Solvent, Dry-cleaning (DS), Federal Specification P–S–661a. Clean the cables with a clean dry cloth.

NOTE: Leaded gasoline is not to be used as a cleaning fluid for any purpose. Dry-cleaning solvent (DS) is available as a cleaning fluid through established supply channels. Oil, Fuel, Diesel, U. S. Army Specification 2–102B, may be used for cleaning purposes when dry-cleaning solvent is not at hand. Since unleaded gasoline is available only in limited quantities and only in certain locations, it should be used for cleaning purposes only when no other agent is suitable. Carbon tetrachloride or fire-extinguishing liquid (carbon tetrachloride base) may be used, if necessary, *only on contact parts of electronic equipment.*

e. Adjust. Adjust the position of all the cables and the position of the pick-up dipole if used.

15. SCHEDULE.

Perform the preventive maintenance outlined above at least once a month.

16. LUBRICATION.

Lubrication is not necessary.

17. MOISTUREPROOFING AND FUNGIPROOFING.

Moistureproofing and fungiproofing treatment is not required.

PART FOUR

AUXILIARY EQUIPMENT

(NOT USED)

PART FIVE

REPAIR INSTRUCTIONS

NOTE: Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report). If Form No. 468 is not available, see TM 38–250. Failure or unsatisfactory performance of equipment used by Army Air Forces will be reported on Army Air Forces Form No. 54 (Unsatisfactory Report).

18. GENERAL THEORY.

a. Resonant Frequency. (1) The echo box consists of a variable cylindrical cavity about 6 inches in diameter and 5½ inches long (fig. 15).

(2) A movable piston or plunger, located inside the echo box (fig. 15),

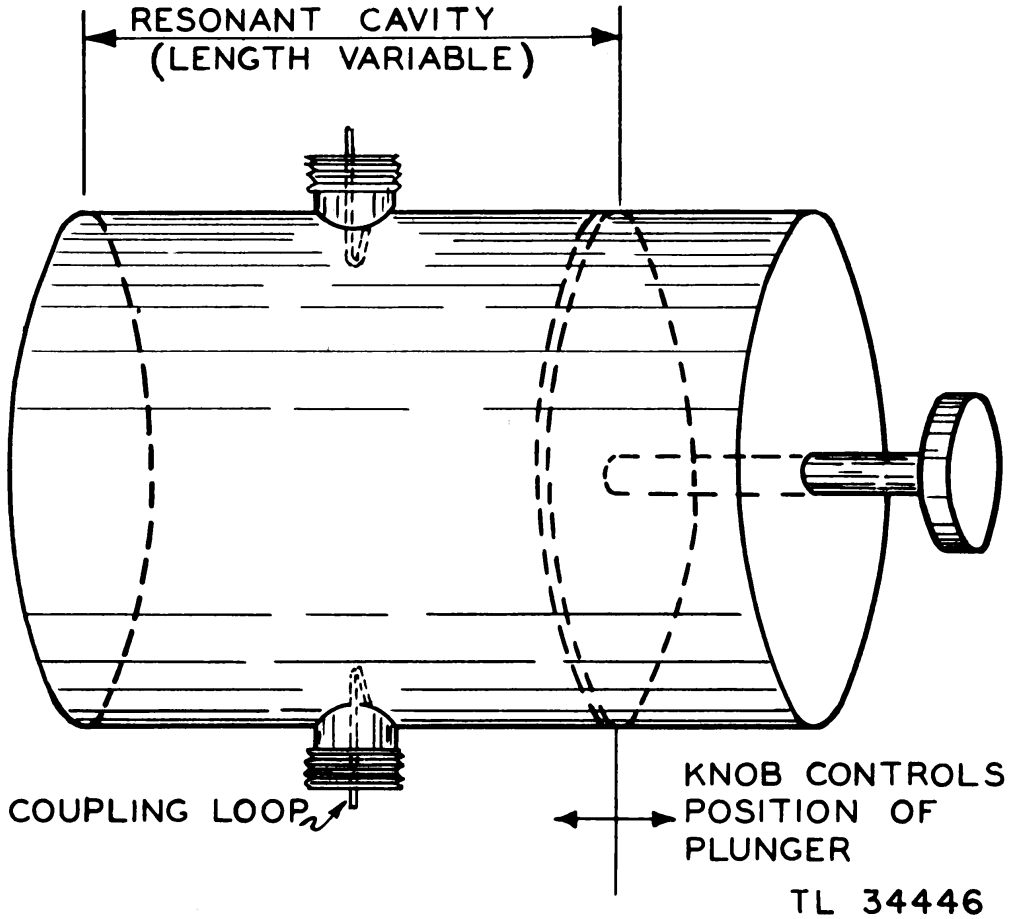


Figure 15. Outline drawing of echo box.

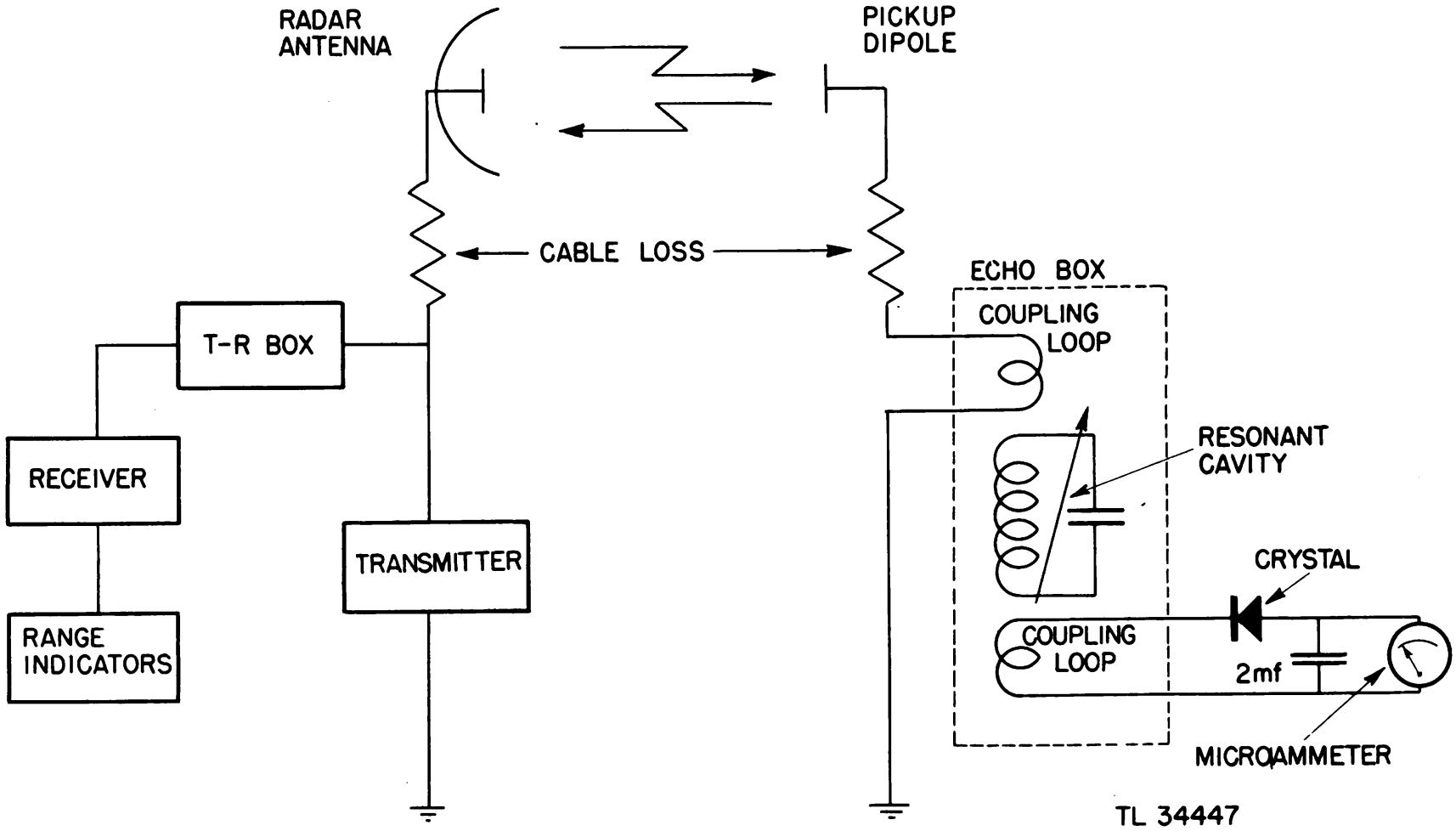


Figure 16. Equivalent echo-box circuit.

may be moved back and forth by means of a tuning knob to vary the length of the cavity as desired. The position of the plunger determines the resonant frequency of the cavity.

(3) The position of a scale and marker and the position of the tuning knob are used in conjunction with a calibration chart to determine the resonant frequency of the cavity.

b. Radio-frequency Coupling. (1) Two coupling loops, parallel to the ends of the box, are attached to the sides of the echo box in order to couple, inductively, r-f energy into and out of the cavity. The interior surface of the cavity is silver-plated and highly polished to increase efficiency.

(2) To prevent the cavity behind the plunger from affecting the operation of the box, a small amount of r-f absorbing material (such as polyiron) is placed within this cavity.

c. Energy Indication. The energy accepted by the echo box is indicated by a microammeter connected through a crystal adapter to one of the coupling loops. This microammeter may be permanently attached to the echo box, or it may be part of an analyzer connected to the echo box by a coaxial cable and Terminal Box J–74/MPM.

d. Resonant Cavity of Echo Box. Electrically the echo-box cavity is equivalent to a sharply tuned inductance-capacitance (L–C) resonant circuit and will accept energy in a bandwidth of 0.085 mc (fig. 16). It is not correct, however, to consider any particular part of the box as either the capacitance or inductance of the equivalent circuit. The frequency to which the box is resonant is dependent upon the physical size of the resonant cavity, which may be changed by moving the plunger. When the length of the cavity is decreased, the resonant frequency is raised. When the length of the cavity is increased, the resonant frequency is lowered.

e. Echo Box as Small Transmitter. R-f energy from the radar antenna is picked up by the small test dipole or by the directional coupler and is fed into the echo-box cavity through r-f cable and a coupling loop. During the radar pulse, the resonant cavity of the echo box accepts r-f energy, and oscillations build up for the duration of the radar pulse. After the radar pulse, the oscillations in the echo box continue but gradually die out because some of the energy is dissipated in the resonant cavity, some is coupled out to the crystal rectifier and microammeter, and some is coupled out to the pick-up dipole or back to the directional coupler. The energy which is fed back to the receiving system is detected in the radar receiver, and appears on the oscilloscopes of the radar set. The echo box therefore acts as a miniature transmitter which begins to transmit immediately after the radar pulse has been transmitted (fig. 17).

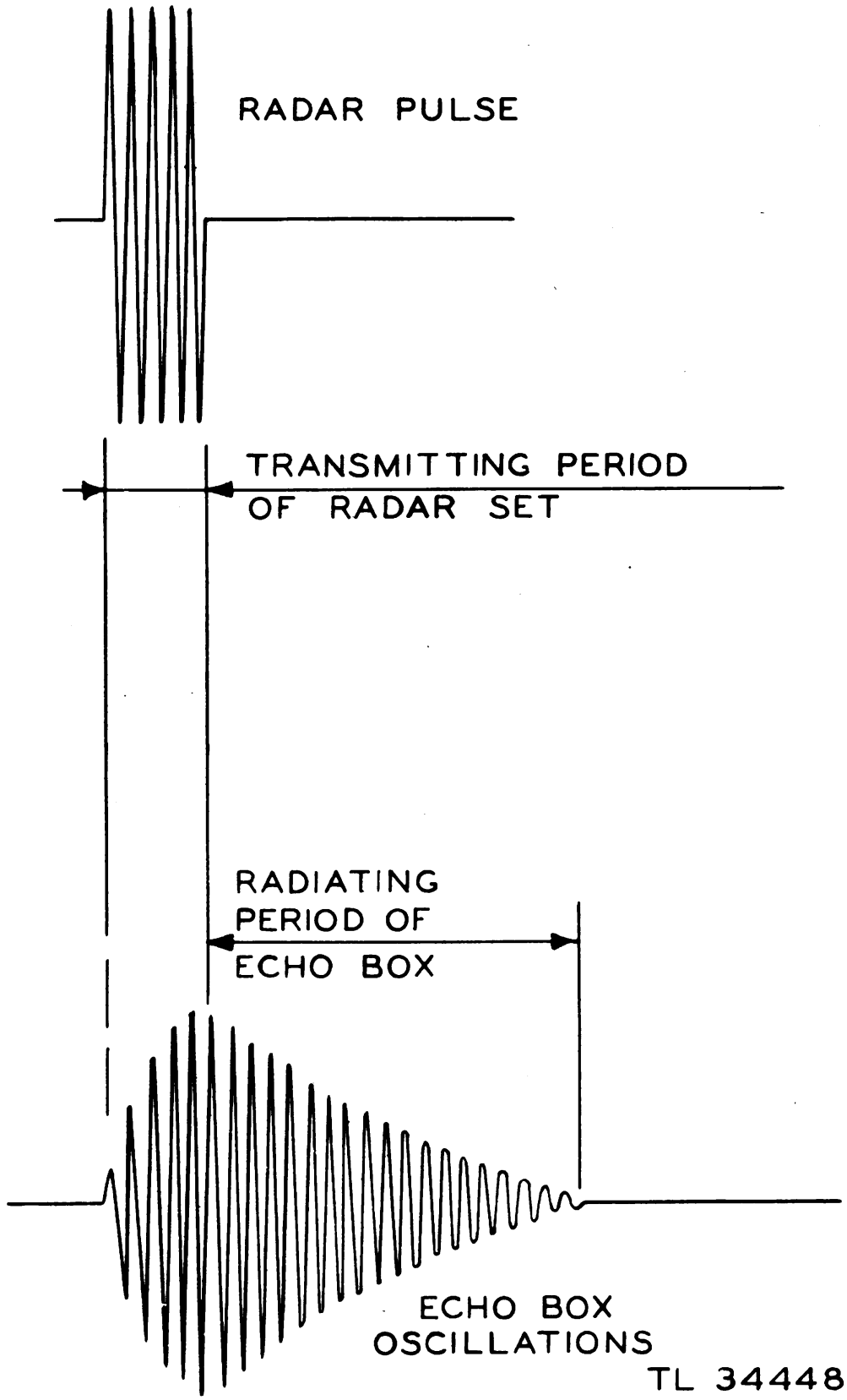


Figure 17. Echo-box oscillations.

f. Ringing Time. Because of the large amount of power received and returned by the echo box, the received signals will, for the most part, appear on the range indicators as a solid block with a flat top at the receiver-saturation amplitude, as shown in figure 18. The oscillations die out exponentially and this portion of the curve can be seen from the end of the flat top to the noise or grass level. The time from the beginning of the transmitted pulse to the point where the signal from the echo box fades into the noise level is known as the "ringing time" of the box. The ringing time is measured in terms of range in yards on the range scopes. On sets when the dipole is mounted on the paraboloid or the directional coupler is used, the ringing time of the echo box appears on the PPI scope as a solid circle out to the point where the signal from the echo box fades into the noise (fig. 14–A).

g. Output Indication. When the box is tuned to resonance, maximum energy is coupled out of the box and into the crystal rectifier. The crystal current, filtered by the capacitor in Terminal Box J–74/MPM, is measured by a microammeter. Because the amount of crystal current indicates the amount of energy absorbed by the echo box, the microammeter reading indicates the relative power output and tuning condition of the transmitter.

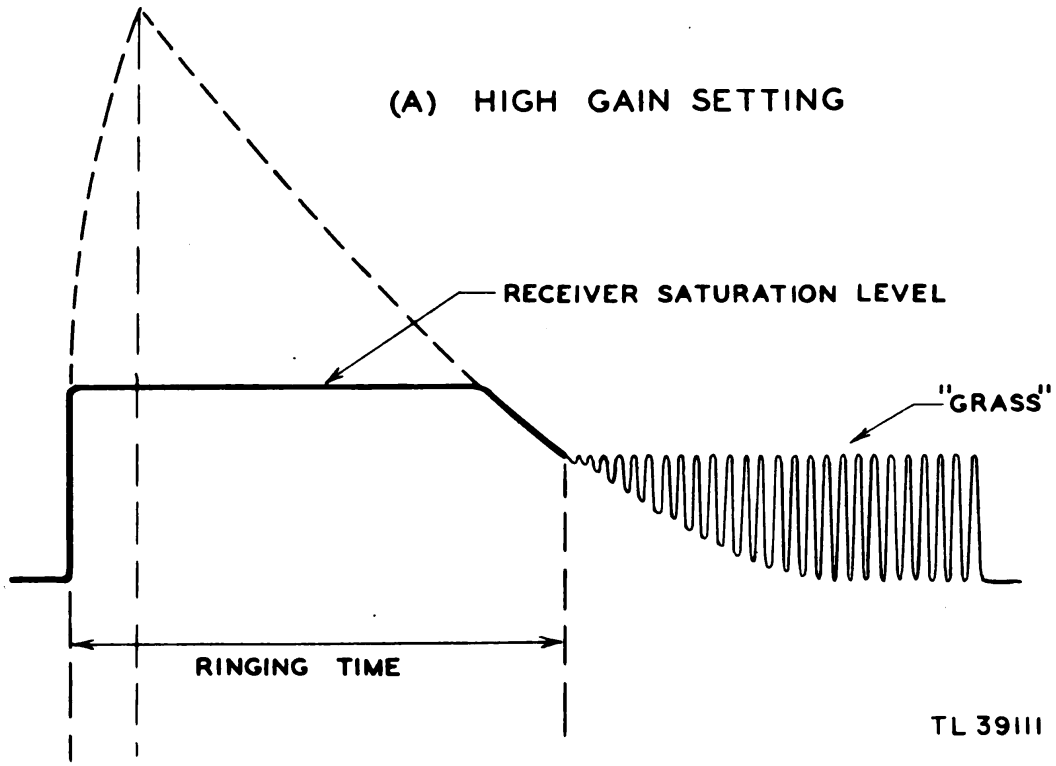


Figure 18. Ringing-time indication.

19. FACTORS AFFECTING RINGING TIME.

a. General. The factors affecting the ringing time may be divided into constant factors, radar system variable factors, and temperature variable factors.

b. Constant Factors. Since the constant factors are those that are dependent upon the construction of the particular radar set and the test circuit, they do not enter into any of the comparative measurements or indications. These constant factors depend on the characteristics of the following equipment:

(1) Echo box.
(2) Pick-up dipole.
(3) Cabling.
(4) Coupling loops.

c. Radar System Variable Factors. When all the constant factors (which are external to the radar system) are standardized, the ringing time will depend only upon the variable factors which affect the performance of the radar system. These variable factors are as follows:

(1) Power output of the transmitter.
(2) Pulse duration.
(3) Frequency spectrum.
(4) Receiver condition.
(5) Tuning of the radar set.

d. Temperature Variable Factor. (1) The temperature of the atmosphere in the immediate vicinity of the echo box affects the size and electrical resistance of the echo box thus changing the ringing time. If the echo box is installed in a trailer or cab, the temperature of the interior of the trailer (in degrees Fahrenheit) must be taken and the necessary correction made by means of the temperature effect table (table I). When the echo box is placed in the open, the outside temperature must be used.

(2) Do not leave dark-colored echo boxes in bright sunlight immediately before or during echo box tests, because the temperature rise within the box may be sufficient to lower the ringing time as much as 100 yards.

(3) Whenever the surrounding temperature varies from the normal 60°F, corrections should be made according to table I. The plus or minus sign before the correction indicates that the correction must be added to or subtracted from the ringing time as observed on the range indicator. Interpolations should be made for every 5°F variation of temperature.

TABLE I

VARIATIONS IN RINGING TIME WITH CHANGES IN TEMPERATURE

Temperature (degrees F)	Change in ringing time (yards)	Temperature (degrees F)	Change in ringing time (yards)
−20	+400	+ 60	0
0	+290	+ 80	− 70
+20	+180	+100	−150
+40	+ 70	+120	−210

20. ECHO BOX FAILS TO RING.

a. If the echo box fails to ring, make the following checks:
(1) Check the cables for continuity and shorting.
(2) Check the center conductor fingers of the cable connectors for spreading.
(3) Check the coupling loop at the end of the cable from the pick-up dipole. Remove this loop by means of the special wrench, but do not remove unless absolutely necessary.

b. Whenever the coupling loop is removed, care must be taken to prevent moisture, grit, sand, etc., from entering the echo-box cavity.

21. MICROAMMETER FAILS TO OPERATE.

If the echo box rings and shows the customary indication on the range scope, but the microammeter needle does not deflect, check as follows:

a. Remove the terminal box cover and examine the wiring.

b. Examine the test leads to the analyzer and the control positions on the analyzer.

c. Replace the crystal by unscrewing the connector on the inside of the echo box at the side next to the cavity. Be sure to take the precautions listed in paragraph 22 below.

22. CRYSTAL REPLACEMENT.

a. Care. (1) The crystals used with the echo box are extremely delicate, and must be handled carefully. Spare crystals should be wrapped in tinfoil and kept in metal boxes to protect them from burn-out.
(2) The crystal used in the echo box is Crystal 1N21–D, which is also used in the converter of the receiver. Noisy crystals which are no

longer satisfactory for use in the converter may be used in the echo box if their rectifying qualities are unimpaired.

b. Installation. (1) When the crystal is being installed, or is out of its holder for any reason, it should be kept away from the radar antenna if the latter is operating. Failure to observe this precaution may cause the crystal to burn out. Whenever crystals are to be removed from their capsules, turn the radar set off.

(2) When crystals are being installed during cold weather or in dry climates, static electricity should be grounded out by touching the finger to the echo box before installing the crystal. Crystals may be burned out by the static discharge if this precaution is not followed.

23. MAINTENANCE PARTS LIST FOR ECHO BOX TS–207/UP.

A maintenance parts list is not required.

Order No. 1510–MPD–44; 567 copies, December 44.