LOCATING UNDERGROUND PIPES AND CABLES— HIGH FREQUENCY METHOD

CONTENTS PAGE

1. GENERAL

1.01 This section describes the method of locating, tracing the path, and determining the depth of underground conductors such as buried wires and cables, metallic gas and water pipes, and cable in conduit using the Metrotech Model P-440 and Model 480 pipe and cable locator. It can also be used to locate manhole frames and covers obscured during road surfacing operations or by snow and ice. It is not applicable to submarine cable.

1.02 This section is reissued to add the Metrotech Model 480 pipe and cable locator and to include information formerly contained in Section 106-350-113. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The methods outlined in this section are known as the high frequency methods since radio frequency of about 199 kHz is employed. The inductive method does not require metallic contact with the subsurface structure or the installation of ground rods for application of tracing current. It may also be used to trace the route of buried power cable in connection with construction or maintenance work. The conductive method requires metallic contact with the structure being located.

1.04 Buried cable, buried wire, cable in conduit, buried metallic gas or water pipe, etc, will be referred to as conductors in this section.

2. PRECAUTIONS

2.01 In choosing the location for the signal source, it is important to remember that cable is often buried adjacent to roads and highways. ***Wherever possible, the signal source should be placed where it will enable the operator to walk facing the oncoming traffic.***

2.02 ***Never connect the signal source to a conductor in the cable.***

2.03 Care must be exercised when using the pipe and cable locator in the inductive mode to avoid locating foreign or abandoned structures instead of working telephone plant.

3. DESCRIPTION

MODEL 480

3.01 The Metrotech Model 480 pipe and cable locator (Fig. 1) consists of a directional radio-type transmitter, a directional radio-type receiver, a ground plate, ground test cord, and a Metroclamp coupler. Optional accessories include a carrying case, headset, inductive probe, carrying handle, and handle case.

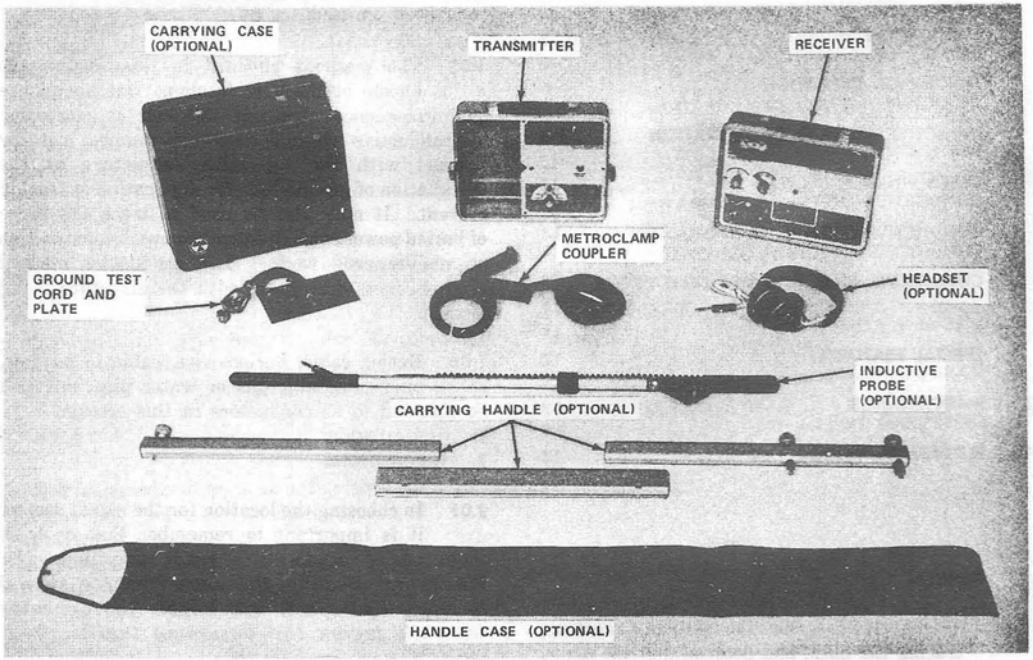


Fig. 1—Metrotech Model 480 Pipe and Cable Locator With Optional Accessories

3.02 The battery-powered directional radio-type transmitter assembly (Fig. 2) generates an electromagnetic field which surrounds the buried metallic object to be located. It is equipped with a tuned loop antenna, a storage compartment, and the following controls:

1. POWER On-Off Switch	Applies power to transmitter. This switch should be turned off to prolong battery life when not in use.
2. OUTPUT Jack	Provides receptacle for conductive ground cable assembly or Metroclamp 48 during tracing operations.
3. POWER TEST Indicator	Flashing light shows adequate battery condition and transmitter power output.
4. MODE Switch (4 positions)	CONDUCTIVE position should be used when transmitter is directly connected to the conductor being traced with the ground cable assembly or with the Metroclamp 48 (inductive coupler). INDUCTIVE position: Use for in-handle operation and induced (air) coupling to metal conductor. POWER TEST activates indicator when power is on. SIGNALATOR positions provide interrupted signal or tone for tracing operation in conductive and inductive modes. Not used for handle operation. Consistent use of signalator while tracing extends battery life.

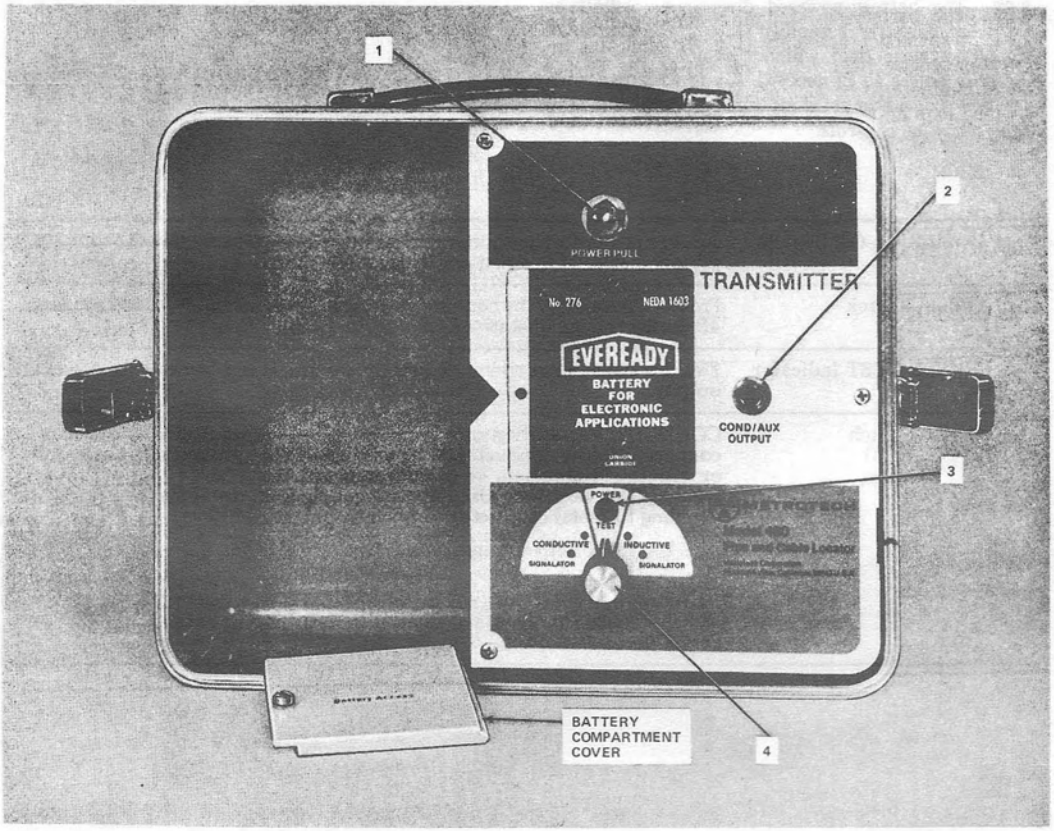


Fig. 2—Transmitter

3.03 The battery powered radio-type receiver assembly (Fig. 3) detects the transmitter induced electromagnetic field. It is equipped with a tuned loop antenna, visual indicator, and a depth level which is used when making depth determinations, and the following controls and switches:

(1) Visual indicator and battery test meter indicates the volume of signal being monitored by the headset or speaker and also indicates condition of receiver battery.

(2) Built-in speaker provides audible signal corresponding to visual indicator readings on meter.

(3) Range switch provides for LO, MED or HI receiver power. BATT position tests BATTERY when POWER switch is ON.

(4) AUX INPUT is receptacle for optional accessories and discontinues receiver loop operation.

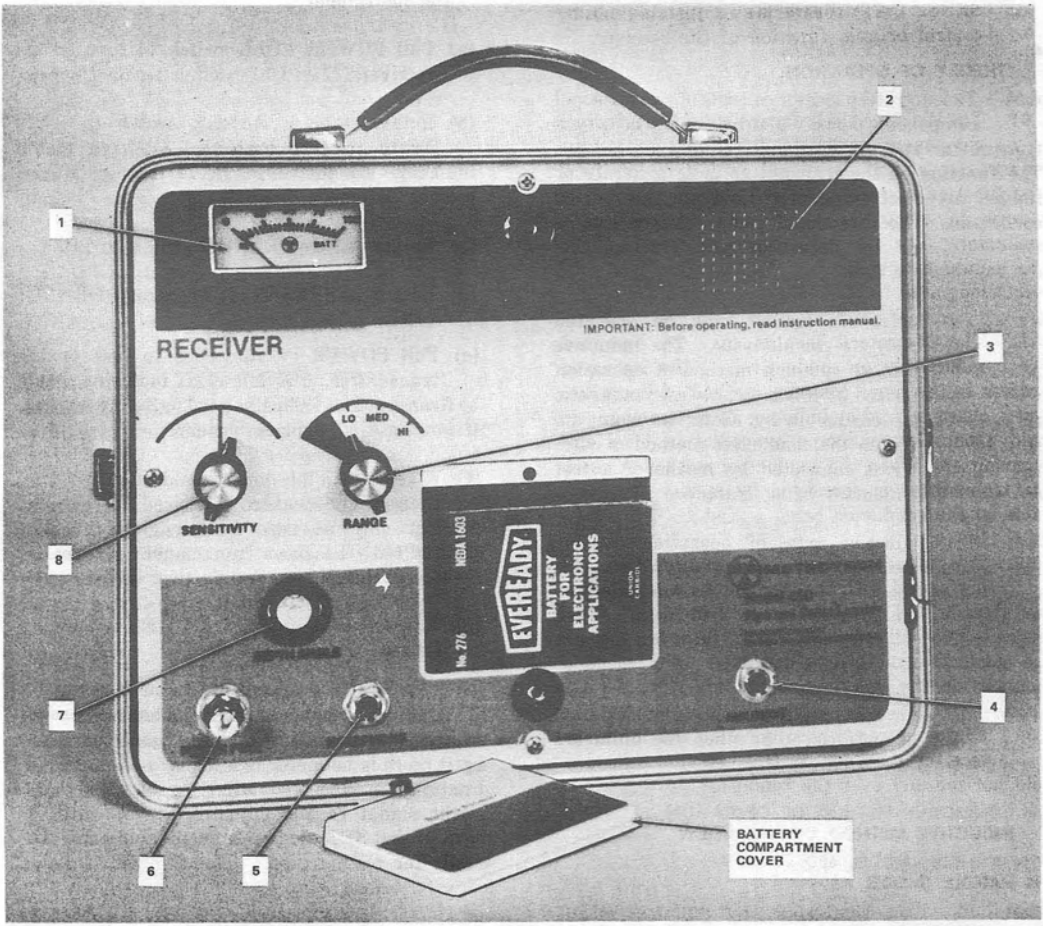


Fig. 3—Receiver

(5) HEADPHONE jack transfers audible signals from speaker to headphones.

(6) POWER PULL is ON/OFF switch. Should be OFF when not in use to prolong battery life.

(7) DEPTH ANGLE provides a quick and accurate method of measuring the depth of the conductor. A 45 degree tilt of the receiver for triangulation is used to determine the depth of a buried conductor.

(8) SENSITIVITY control is an adjustable volume control or gain function of the receiver.

4. THEORY OF OPERATION

4.01 The Metrotech locator consists of two principal component parts: a directional radio-type transmitter and a directional radio-type receiver. The function of the transmitter is to generate or induce an electromagnetic field in the buried conductor. The directional radio receiver locates the conductor by detecting and tracing this electromagnetic field.

4.02 The Metrotech locator may be operated inductively or conductively. The inductive process is the more common method of operation and is characterized by inducing an electromagnetic field about the conductor by radiation from the transmitter. When the conductive method is used, the transmitter is connected by means of a test cable to the conductor being traced.

4.03 The inductive type of operation can be performed with the transmitter and receiver mounted on the carrying handle (***on handle***) or with the two units separated (***off handle***). When the conductive method is used, the units are not mounted on the carrying handle.

4.04 Minimum transmitter induction and minimum receiver response occur when the units are held horizontally over the conductor.

5. INDUCTIVE METHOD OF OPERATION

ON HANDLE (MODEL 480)

5.01 Assemble the transmitter and receiver on the ends of the carrying handle as shown in Fig. 4. The transmitter is secured to the carrying handle with one knurled head screw. The receiver is secured to the handle with a knurled head mounting screw and adjusting screw. The adjusting screw permits adjustment of the receiver with respect to the transmitter to obtain an electrical balance. Make sure that the mounting screws are tight. Rotate adjusting screw 10 to 12 full turns clockwise to compress spring tension.

5.02 Adjust the receiver and transmitter for operation as follows:

Note: Adjustments should be made over a neutral area and at least 15 feet away from cars, wire fences, or other metal objects; otherwise, it will be impossible to balance the instrument.

(a) Pull POWER PULL switch to turn on the receiver.

(b) Rotate receiver RANGE switch to BATT TEST to test battery. Observe meter, indicator should be in BATT region; if not, replace battery.

(c) Rotate receiver RANGE switch to LO.

(d) Rotate the SENSITIVITY control to ORANGE LINE.

(e) Pull POWER PULL switch to turn on the transmitter. POWER TEST indicator should be flashing. This indicates good battery condition. If not flashing, replace battery.

(f) A steady audible tone should be heard from the receiver speaker. If desired, the optional headset may be used by plugging into the HEADPHONE jack on front panel. (***Note:*** If no tone is heard, set is defective; do not use.)

(g) Rotate transmitter MODE switch to INDUCTIVE.

(h) To adjust for balance, hold coupled instrument at arm's length with carrying handle parallel to ground. Rotate adjusting screw counterclockwise until there is no meter reading or audible signal. Continue to turn the adjusting screw until a slight signal is heard and meter indicator is within the SET region. The test set is now ready for testing.

(i) If the test set appears to be over-sensitive or it is not possible to obtain the adjustment balance above, it may be necessary to reduce the SENSITIVITY setting by rotating it in a counterclockwise direction.

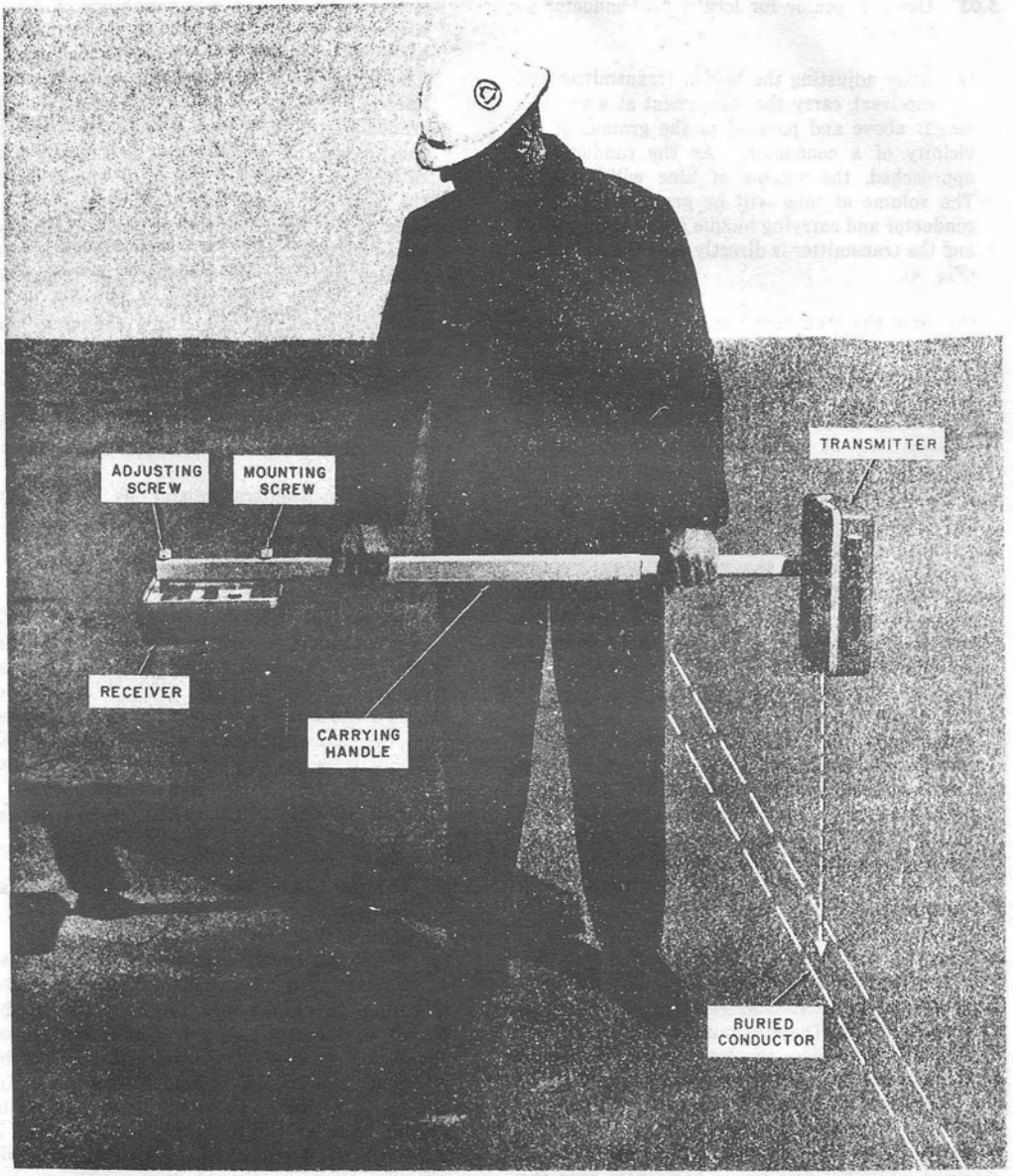


Fig. 4—Inductive Method of Operation—ON Handle

5.03 Use the locator for locating a conductor as follows:

(a) After adjusting the locator (transmitter and receiver), carry the instrument at a uniform height above and parallel to the ground in the vicinity of a conductor. As the conductor is approached, the volume of tone will increase. The volume of tone will be greatest when the conductor and carrying handle are at right angles and the transmitter is directly over the conductor (Fig. 4).

(b) Once the conductor has been located, it may be necessary to adjust the SENSITIVITY control on the receiver. For best results, the sensitivity should be set as low as practical. If in crossing the path of the conductor, the change in sensitivity at the new setting of the control is not satisfactory, it may be necessary to take the locator some distance from the conductor and readjust the plus null setting.

(c) The setting of the receiver may require adjustments from time to time along the route because of changes in soil conditions, changes in earth resistivity due to presence of minerals, or difference in water content of the soil, type of road surfaces, etc.

(d) The cable route can be followed by carrying the set by the handle with its axis at right angles to the conductor route (Fig. 4). It is advisable to cross and recross the conductor from time to time as a check on the tracing and to determine whether readjustment is necessary because of changes in ground conditions.

OFF HANDLE

5.04 In the ***off handle*** method of operation the transmitter and receiver are operated as separate units. The maximum energy is induced in the conductor when the transmitter is parallel and vertical to the conductor to be located (Fig. 5). The maximum response in the receiver is obtained when the receiver is parallel and vertical to the conductor to be located; the minimum response is obtained when the receiver is horizontal over the conductor to be located.

Note: If the transmitter and receiver are too close together and are lined up with both units on edge, there is a possibility of direct air coupling (transmittal of the signal through air without the presence of a buried conductor). To prevent this, it is necessary to maintain adequate distance between the receiver and transmitter. For example, with the RANGE control on the receiver set to LO and the SENSITIVITY control turned all the way up, the receiver and transmitter should be at least 35 feet apart. With the RANGE control set to MED or HI, the distance between the receiver and transmitter should be increased up to 150 feet. However, it is possible to shorten these distances by reducing the SENSITIVITY control with each position of the RANGE control.

5.05 Operate the locator inductively without the carrying handle as follows:

(a) Turn on the transmitter by pulling the POWER PULL switch.

(b) Rotate MODE switch to INDUCTIVE.

(c) Rotate MODE switch to INDUCTIVE SIGNALATOR position if interrupted signal is preferred. The interrupted signal is preferred in areas where there is a large amount of electrical interference due to overhead power lines, noisy transformers, etc. SIGNALATOR MODE will also prolong battery life of transmitter.

(d) Pull POWER PULL switch to turn on the receiver.

5.06 Use the locator for locating a conductor as follows:

(a) Place the transmitter unit on the ground directly over the conductor to be traced (Fig. 5). To ensure that the conductor to be traced is located and not some foreign or abandoned structure, the transmitter should be placed at a point where the conductor can be visually identified. When it is not possible to visually identify the conductor to be traced, it is desirable to expose the plant by digging. This will allow the transmitter to be correctly coupled to the conductor to be traced. The transmitter should be placed on edge with the handle up so its long dimension is parallel to the direction of the conductor.

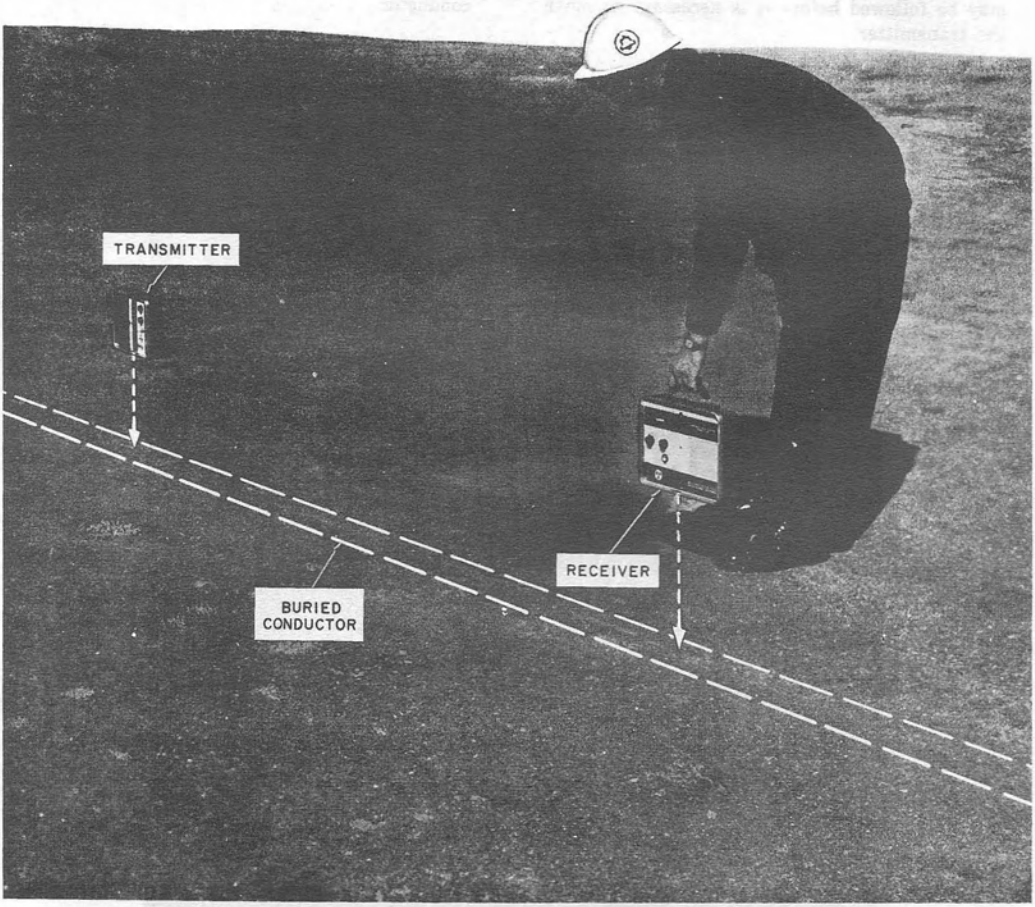


Fig. 5—Inductive Method of Operation—OFF Handle

(b) Carry the receiver so its long dimension is parallel to the assumed direction of the buried conductor (Fig. 5). In this manner the path of the buried conductor can be followed by keeping the audible tone at a maximum. Under normal conditions, up to 500 feet of conductor may be followed before it is necessary to move the transmitter.

(c) To determine the exact location of any point, turn the receiver from the vertical position to the horizontal and carry it back and forth across the conductor (Fig. 6). When the tone heard in the receiver drops to the null point, the center of the receiver will be above the conductor.

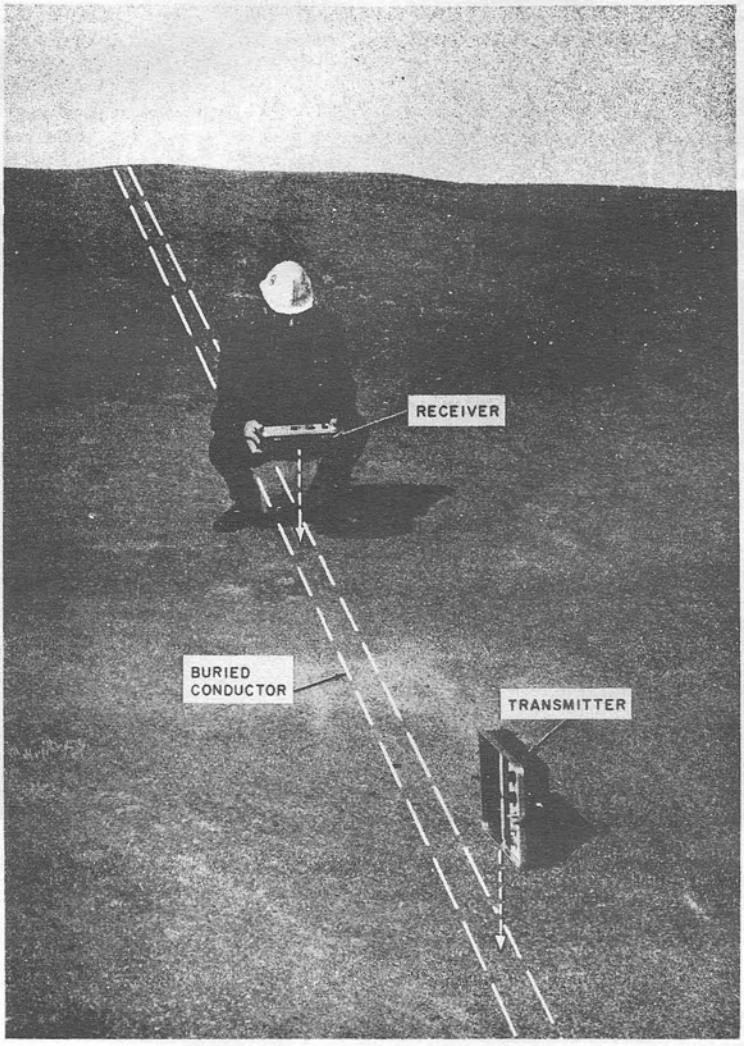


Fig. 6—Pinpointing Exact Location of Conductor

(d) The receiver SENSITIVITY control is used to vary the sensitivity of the locator. If the control is turned down, the effect is to widen the space in which the conductor can be detected; at the same time the receiver becomes less sensitive and conductors of small diameter might be overlooked. If the control is turned up, the effect is to shorten the space through which the conductor can be detected; at the same time the receiver becomes more sensitive and small conductors deep in the ground can be detected. The best setting for the volume control should be determined at each location. If the SENSITIVITY control is turned to maximum, the receiver may produce a continuous noise and will be unable to function properly until the volume is lowered to a usable value.

5.07 The reverse method of tracing is used to trace the conductor giving the weaker signal when two parallel conductors are closely spaced, (1 to 5 feet apart). Perform the reverse method as follows:

(a) Place the transmitter in the upright position above the conductor giving the stronger signal.

(b) Place the receiver above the conductor giving the stronger signal and about 100 feet from the transmitter.

(c) Tilt the receiver and block it in the position which gives the minimum signal. The receiver will then be neutral to the conductor giving the stronger signal.

(d) Pick up the transmitter and carry it across the route. When the transmitter is vertically above the second conductor, maximum tone will be heard at the receiver.

(e) Leave the transmitter in upright position over the second conductor to be traced. Pick up the receiver and carry it in a vertical position across the route of the conductor until a maximum tone is heard at the receiver. With the second conductor located, it can now be traced following normal procedures.

6. DEPTH FINDING

6.01 The off handle inductive method is used to determine the depth of a buried conductor.

6.02 After the center of a conductor has been located and marked, hold the receiver at a 45 degree angle parallel to line of conductor and move it away from the conductor at right angles to the conductor line until a new null point or minimum signal is obtained (Fig. 7).

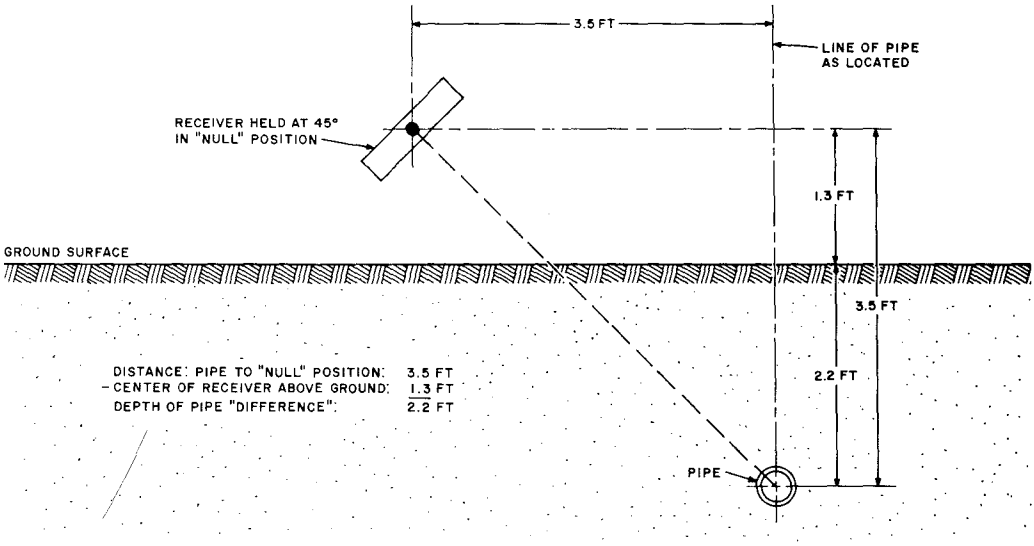


Fig. 7—Determination of Conductor Depth

Note: The receiver is equipped with a DEPTH ANGLE bubble which is used to determine the 45 degree angle. The receiver is at exactly 45 degrees when the bubble is centered between the outer edge of the center ring and the black border of the level.

6.03 The distance from the center line of the conductor, as previously determined, to the 45 degree null position is the same as the distance from the horizontal null position to the center of the conductor. This is illustrated in Fig. 7. It will be noted that a 45 degree right triangle has been formed in this operation. To prevent air coupling, the transmitter and receiver should be at least 35 feet apart during this operation.

6.04 ***An accurate depth measurement cannot be made if the electromagnetic field around the buried conductor is distorted by the presence of shield wire or other conductors within about 5 feet of the one being tested.***

6.05 Another method of determining the depth of a buried conductor is using the optional inductive probe. This probe provides greater accuracy in pinpointing a particular conductor in the presence of other nearby conductors or inside buildings.

6.06 To use the optional inductive probe, proceed as follows:

- Plug probe cord into AUX INPUT jack of the receiver.
- Rotate receiver SENSITIVITY control fully clockwise.
- Pull POWER PULL switch to turn on receiver and follow procedures outlined in paragraphs 5.02 through 5.06. Sensitivity will be controlled by the knob on the probe housing.
- Locate cable by achieving a null reading on the receiver meter. Mark the ground surface at location of conductor (Fig. 8).

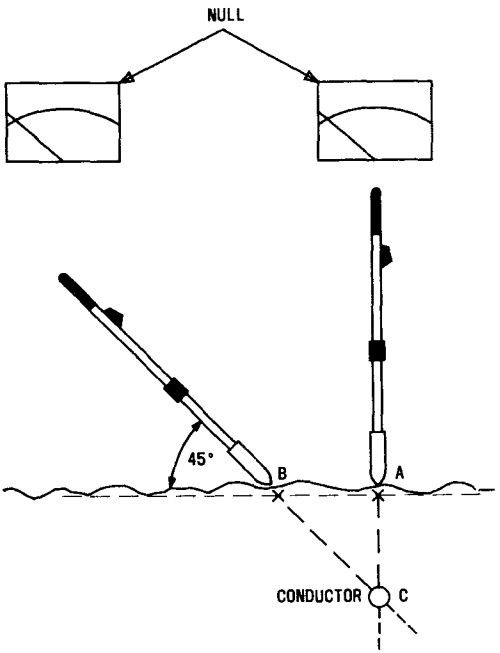


Fig. 8—Locating Cable With Probe

- Then place probe at 45° angle (Fig. 9) and move off to one side of the conductor until a null is achieved on the receiver meter.

The distance between the letter A and B in Fig. 8 is the depth of the conductor C.

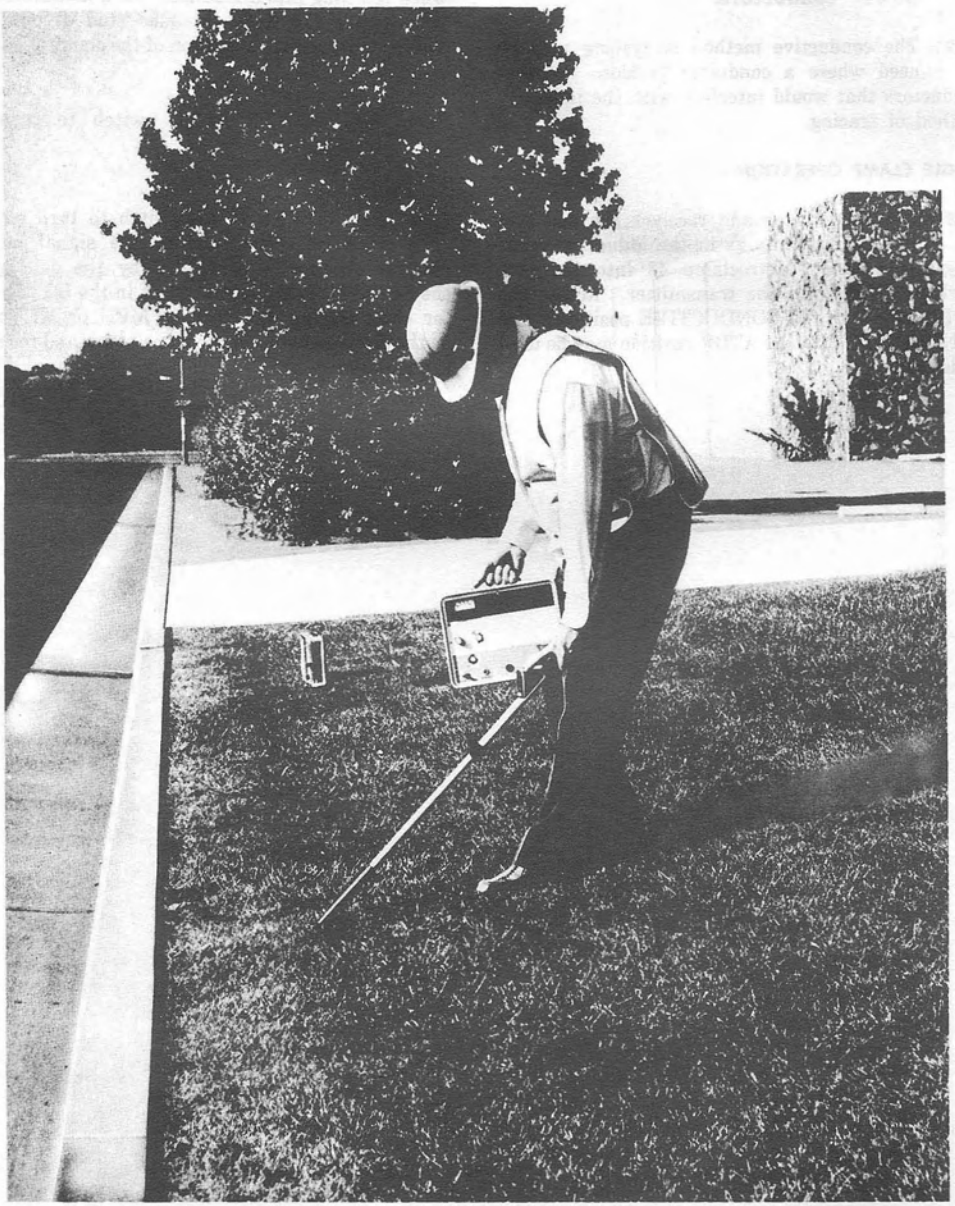


Fig. 9—Determination of Conductor Depth Using Inductive Probe

7. CONDUCTIVE METHOD OF OPERATION

7.01 ***This method must not be used on power conductors.***

7.02 The conductive method of tracing may be used where a conductor is close to other conductors that would interfere with the inductive method of tracing.

SINGLE CLAMP OPERATION

7.03 The transmitter and receiver are operated as separate units as in the inductive mode. Plug the optional Metroclamp 48 into the jack marked OUTPUT on the transmitter. Rotate the MODE switch to the CONDUCTIVE position. The CONDUCTIVE SIGNALATOR position may be used if desired.

7.04 Clamp the Metroclamp 48 so that the jaws are completely closed around the cable to be tested. When overhead cables are present or when reaching into a manhole, use a nonconductive pole with a 1/4 X 20 threaded stud at one end. This permits remote operation of the clamp (Fig. 10).

7.05 Pull POWER PULL switch to turn on transmitter.

7.06 Pull POWER PULL switch to turn on the receiver. The level of the signal in the receiver speaker is controlled by the setting of the SENSITIVITY control. Start in the LO position for close tracing and then to MED or HI power as the distance between the transmitter and receiver is increased.

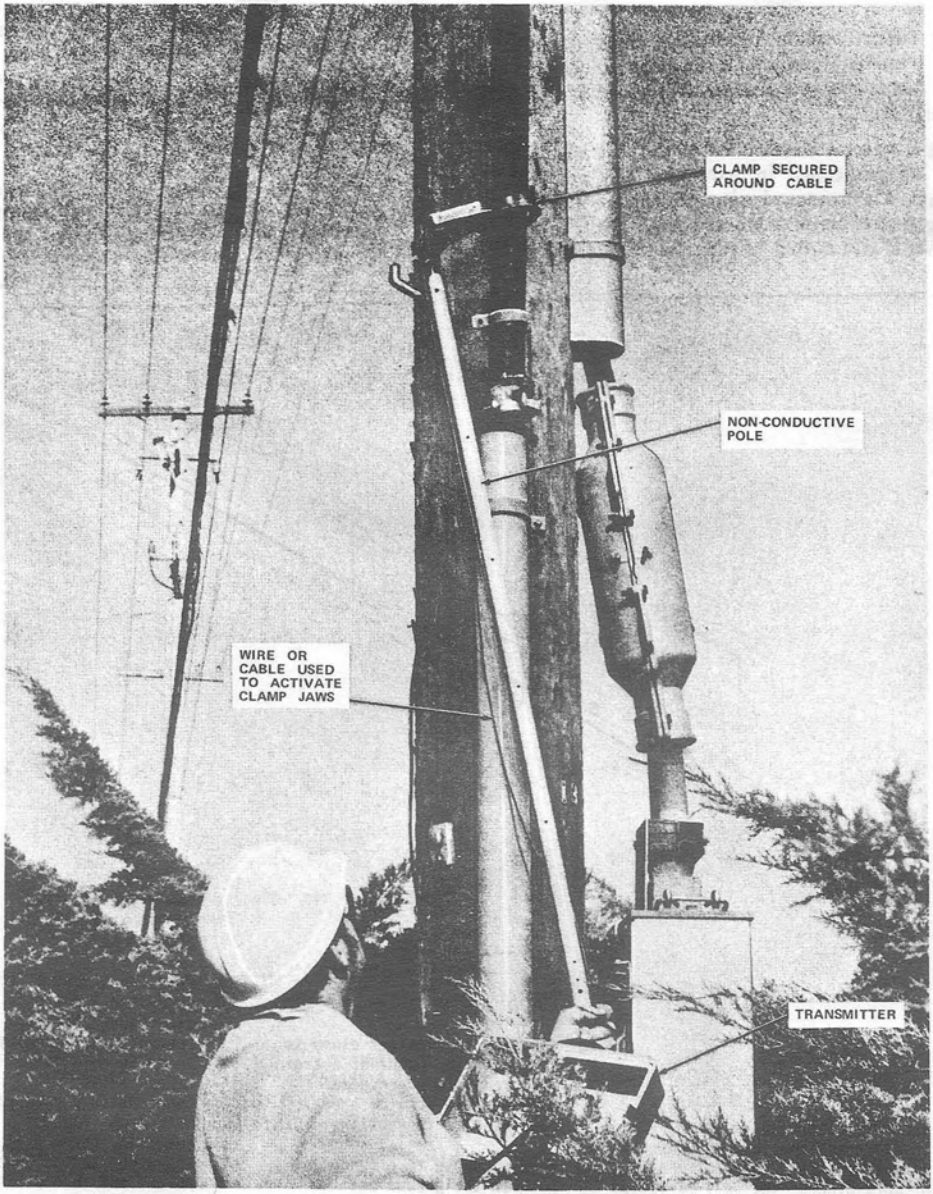


Fig. 10—Testing Conductor Using Metroclamp

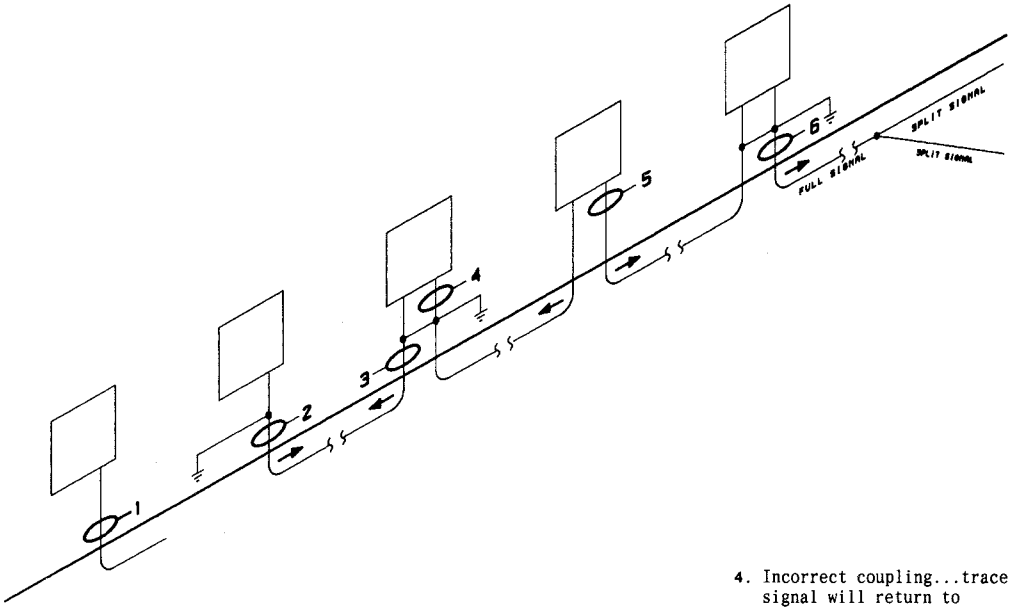
DUAL CLAMP OPERATION

7.07 Where certain conditions exist, such as manhole to manhole or drop to junction, two clamps may be used with the receiver and transmitter.

7.08 Connect a Metroclamp 48 to the transmitter as outlined in paragraphs 7.03 and 7.04. Connect the second clamp to the receiver by plugging into the jack marked AUX INPUT. Pull POWER PULL switch to turn on transmitter and receiver. Place RANGE switch in LO position and move to MED or HI as needed. Rotate SENSITIVITY control to desired signal level.

7.09 Locate the conductor by coupling the receiving clamp around each conductor to identify the one carrying the signal from the transmitter (Fig. 11).

7.10 The single clamp and dual clamp operation permits conductor tracing without making metallic contact.



1. The Metroclamp can be used in **all** trace applications where conductors are exposed at one or more places. The only exception is at a terminated end that is an open circuit.
2. Coupling transmitter clamp to a terminating point of a trace item requires a grounded conductor to provide proper current flow through the ground.
3. Always couple to a conductor between the ground and the point where the conductor enters earth.
4. Incorrect coupling...trace signal will return to ground.
5. Coupling around a long conductor feeding in two directions creates a current flow allowing trace in **both** directions.
6. Coupling to a conductor with drop lines or laterals, feeds full trace signal up to the junction point, and then divides the signal strength into each branch.

Fig. 11—Dual Clamp Operation

8. CONDITIONS AFFECTING USE OF LOCATOR

8.01 When the locator is properly adjusted, no difficulty will be encountered under normal conditions in locating a metallic conductor which is 2 inches in diameter, buried at depths of as much as 8 feet. Small diameter metallic conductors such as shield wires can be identified at plowing depths.

8.02 Subsurface pipes of iron or steel will sometimes give a stronger signal than lead or other nonferrous metallic structures of the same size.

8.03 A water pipe which parallels a buried cable will give the stronger signal. In this case it may be necessary to use the reverse method which is described in paragraph 5.07.

8.04 Short lengths of iron or steel pipe such as cast-iron bends, underground pipe dips, etc, may shield the conductor from the locator.

8.05 Hum from power lines does not affect this locator although the metal in the lines will have an effect depending on the distance of the lines from the locator.

8.06 Shield wires plowed in with the buried cable usually do not affect the accuracy of location.

8.07 Depth measurements will be affected by the presence of shield wires. Where they are present, the locator will indicate a shallow reading and the actual depth must be obtained by careful excavation if the digging or trenching is done over the cable.

8.08 Nonmetallic conduit cannot be identified with this locator. A method of using an induction coil to locate vacant or dead-ended nonmetallic conduit is described in Section 634-220-500.

9. SPECIAL FEATURES

9.01 ***Signalator Circuit:*** The circuit provides at the operator's option a distinct pulsing note to the transmitter signal for use during inductive or conductive tracing where there is heavy outside electrical interference. It should not be used when transmitter and receiver are used for ordinary on handle operation. The use of the pulsator increases transmitter battery life four times.

9.02 ***Battery Test Circuits:*** Both the transmitter and receiver have built-in battery testers. When testing the batteries the units must be turned on so the batteries will be operating under their normal load.

10. MAINTENANCE

10.01 ***Batteries:*** The batteries should be tested before each operation of the locator and at any other time when their condition is doubtful.

10.02 The batteries for the transmitter and receiver are located in a compartment on the front panel (Fig. 2 and 3). When installing new batteries, make certain that no leads are shorted or incorrectly connected.

10.03 Replace the batteries in the transmitter and receiver with either of the batteries listed in Table A.

10.04 No maintenance in the field other than replacement of the batteries is recommended.

TABLE A

9-VOLT BATTERIES

MANUFACTURER	PART NUMBER
Burgess	D6
Eveready	276
RCA	VS 306
Mallory	M-1603
Neda	1603

11. SUPERSEDED TYPES

11.01 While this section describes the Metrotech Model 480 cable and pipe locator, the methods described may also be used with the superseded Metrotech Model P-440.

11.02 A description of the superseded Model P-440 is included due to the number of test sets still in the field.

11.03 The Metrotech Model P-440 pipe and cable locator (Fig. 12) consists of a directional radio-type transmitter, a directional radio-type receiver, a carrying handle, headset and cord with case, ground test cord, and a pipe cable test cord. A carrying case for housing the transmitter and receiver and a bag for storage of the carrying handle are furnished with the test set.

11.04 An optional plug-in speaker, Metrotech No. 110, may be ordered for use in place of the headset and cord.

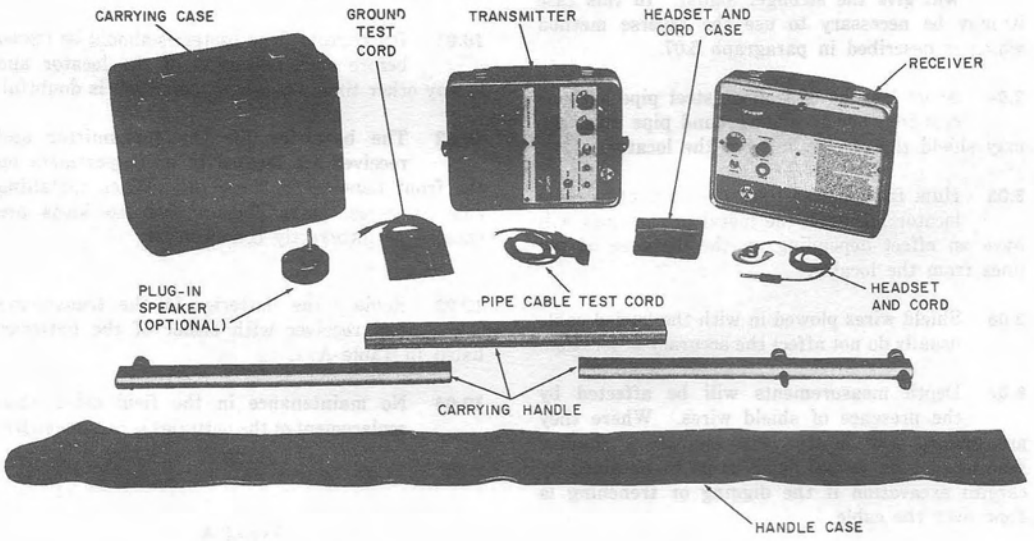


Fig. 12—Metrotech Model P-440 Pipe and Cable Locator

11.05 The battery-powered directional radio-type transmitter assembly (Fig. 13) generates an electromagnetic field which surrounds the buried metallic object to be located. It is equipped with a tuned loop antenna, a storage compartment, BATTERY TEST meter, and the following controls and terminals:

(a) The PULL-POWER switch is used to turn the transmitter on and off. When the transmitter is not in use, push the switch in to prolong battery life.

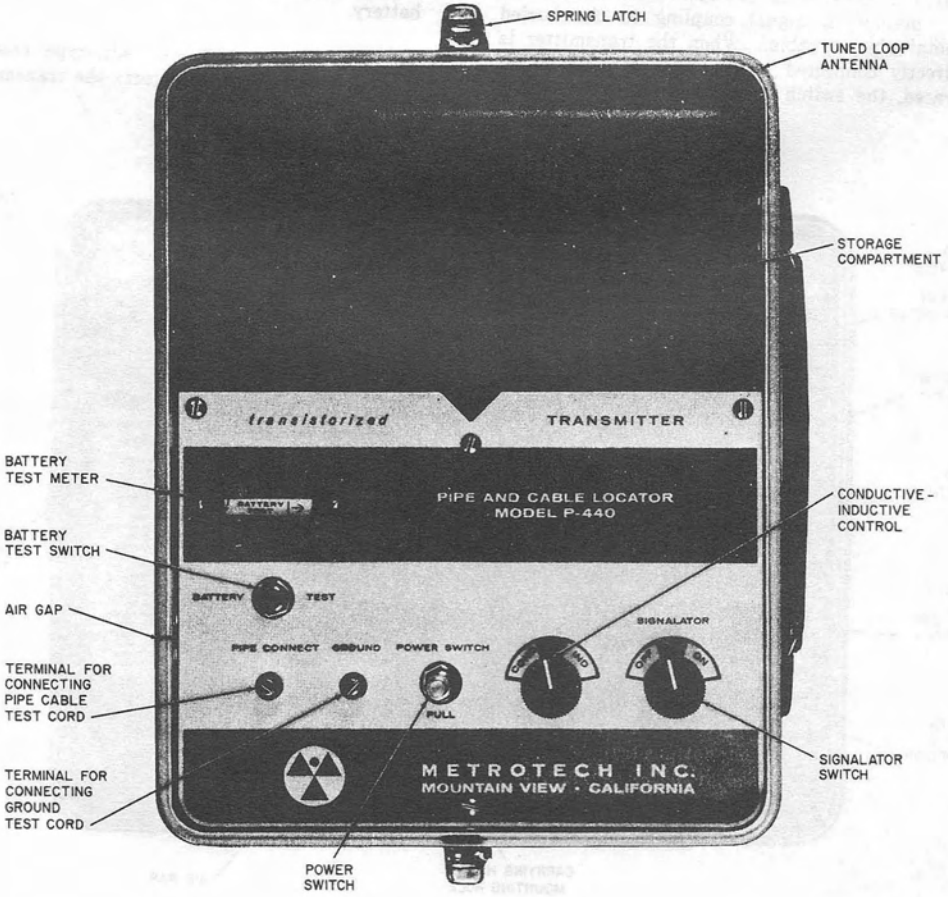


Fig. 13—Transmitter Assembly

(b) GROUND terminal is used in conjunction with the PIPE CONNECT terminal for ***conductive*** operations. The plate of the ground test cord is inserted in the ground or laid flat on the pavement and the other end of the cord is connected to the GROUND terminal.

(c) PIPE CONNECT terminal is used for connecting the pipe cable test cord for ***conductive*** operations. One end of the pipe cable test cord is connected to a pipe or cable and the other end is connected to the PIPE CONNECT terminal.

(d) The COND-IND control switch selects the method of signal coupling to the buried metal pipe or cable. When the transmitter is directly connected to the pipe or cable being traced, the switch should be set in the COND (conductive) position. In all other cases, set the control switch to IND (inductive) position. When the control switch is set to IND, the oscillator output is radiated from the tuned loop antenna.

(e) SIGNALATOR OFF-ON switch provides either continuous or interrupted output. The ON position provides an interrupted signal or tone for tracing operations. The OFF position provides a continuous signal or tone for inductive on-handle operations.

(f) BATTERY TEST switch provides a means for checking the condition of the transmitter battery.

11.06 The battery powered radio-type receiver assembly (Fig. 14) detects the transmitter

Fig. 14—Receiver Assembly

induced electromagnetic field. It is equipped with a tuned loop antenna, visual indicator, and a depth level which is used when making depth determinations, and the following controls and switches:

(a) HEAD-PHONE jack functions as an on-off switch for the receiver when the headset or speaker is inserted or withdrawn.

(b) DEPTH ANGLE provides a quick and accurate method of measuring a 45 degree tilt of the receiver for triangulation in determining the depth of a buried pipe.

(c) Visual indicator and battery test meter indicates the volume of signal being monitored by the headset or speaker and also indicates condition of receiver battery.

(d) T-L-M-H Range Switch—range switch for low, medium, or high power. The T position tests the receiver battery with the headset or plug-in speaker inserted in the HEAD-PHONE jack.

(e) SENSITIVITY control is an adjustable volume control or gain function of the receiver.

11.07 When the unit is not in use, the headset and test cords should be stored in the compartment provided in the transmitter.

MAINTENANCE

11.08 Battery replacement for the transmitter and receiver may be made by the operator as follows:

(a) Remove the four slotted head screws located on panel edges and carefully remove panel (Fig. 15 and 16).

(b) Remove the battery and replace with either of the 9-volt batteries listed in Table A.

(c) Replace the panel in its original position and secure with the four screws removed in (a).

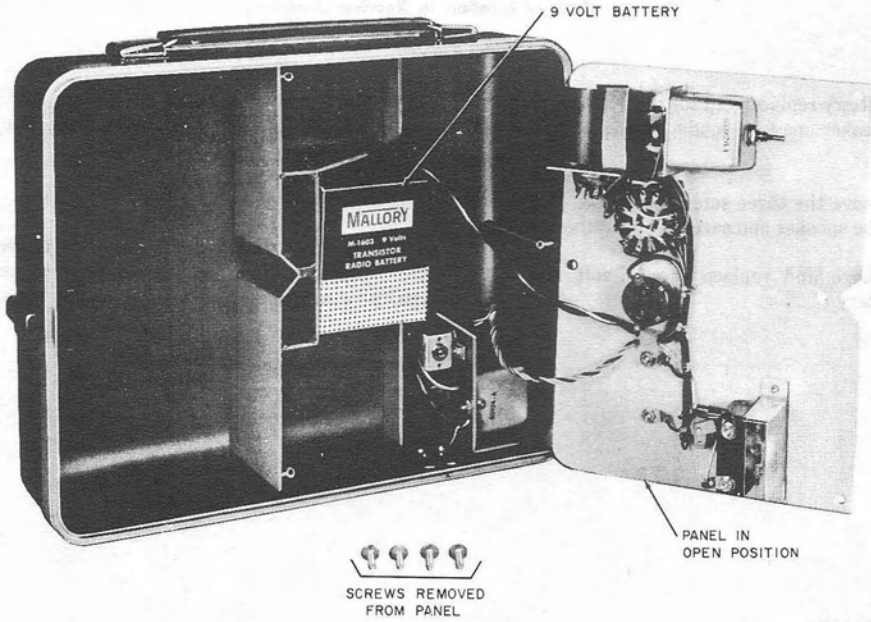


Fig. 15—Battery Location in Transmitter Assembly

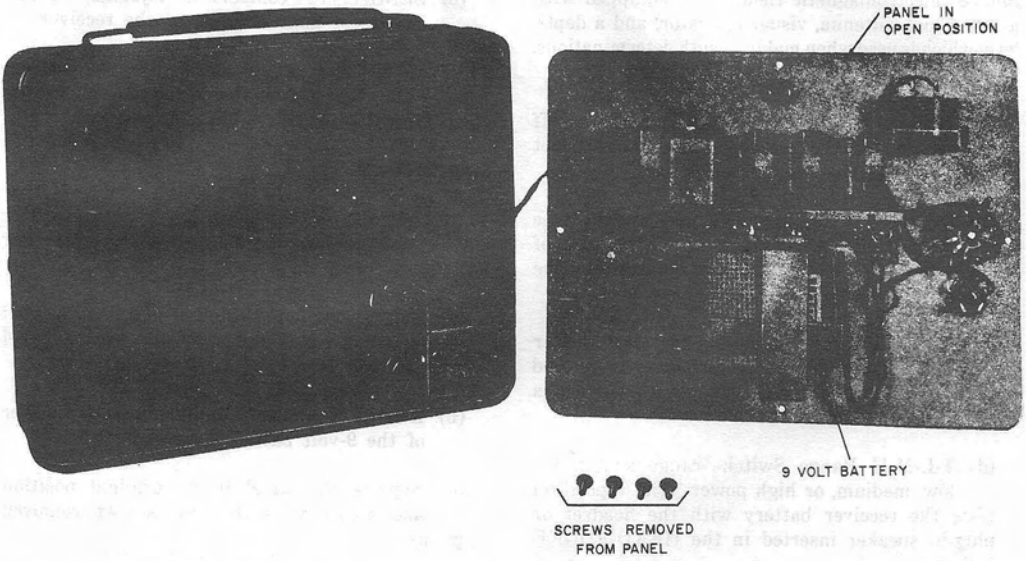


Fig. 16—Battery Location in Receiver Assembly

11.09 Battery replacement for the optional plug-in speaker may be made by the operator as follows:

(a) Remove the three screws from the plug side of the speaker and carefully open the speaker.

(b) Remove and replace the 1.5-volt size AA battery.

(c) Replace the plug side of the speaker in its original position and secure with the three screws removed in (a).

11.10 If either the transmitter or receiver becomes defective, the set should be returned for repairs in accordance with local instructions.