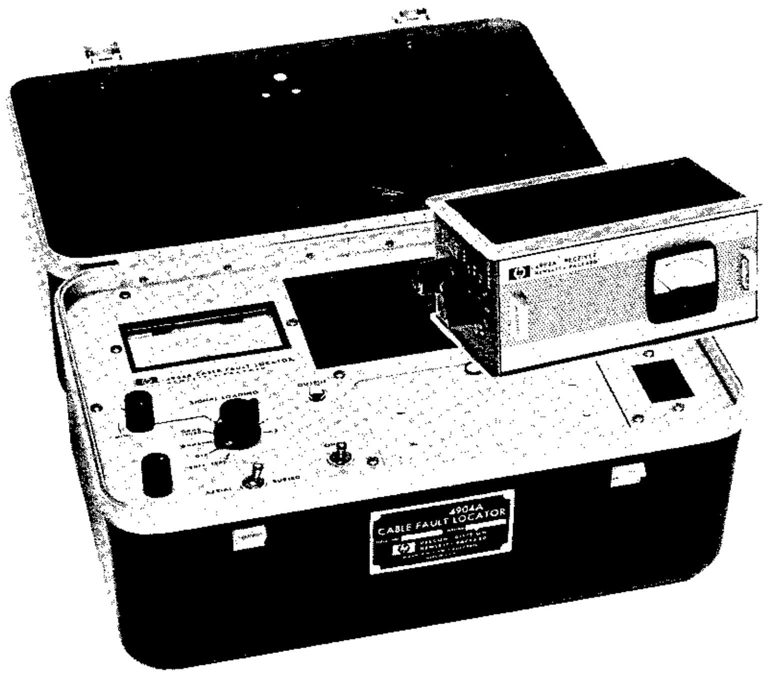
OPERATING MANUAL

CABLE FAULT LOCATOR

C4904A



COMMUNICATIONS TECHNOLOGY

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C4904A

CABLE FAULT LOCATOR

WARNING

DANGEROUS VOLTAGES ARE PRESENT AT VARIOUS POINTS ON CIRCUITRY.

THIS MANUAL RELATES TO A PRODUCT LINE THAT WAS PURCHASED FROM HEWLETT-PACKARD COMPANY BY COMMUNICATIONS TECHNOLOGY CORPORATION IN MAY 1984.

WHERE HP IS REFERENCED THROUGHOUT THIS DOCUMENT, CTC SHALL BE SUBSTITUTED.

MANUAL PART NO. D04904-90011

PRINTED: MARCH, 1977
REVISED: JANUARY, 1985

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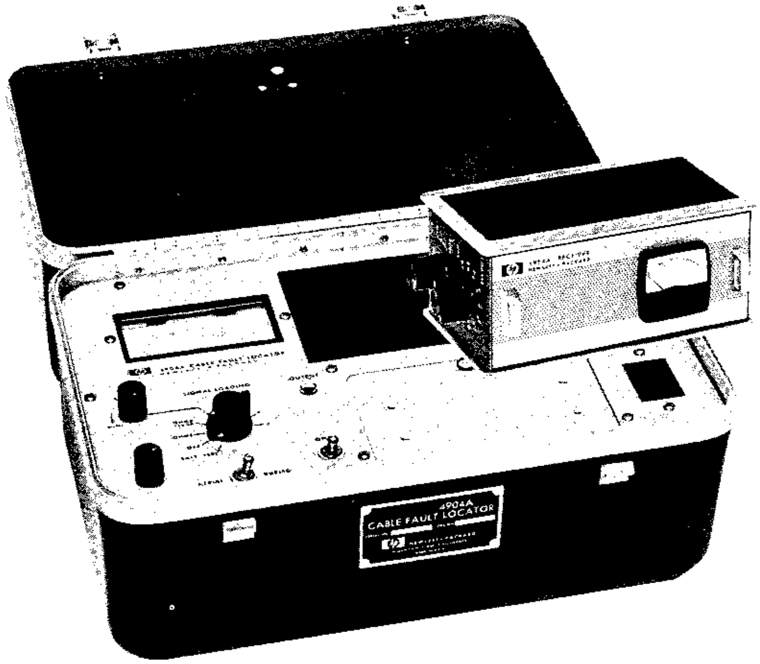


Figure 1-1. Model 904A/4994A Fault-Finding System

SYSTEM DATA

CABLE LAY: Buried, Underground, or Aerial

TYPES OF FAULTS: Grounds, Splits, Crosses, Shorts, and Some Combination Type Faults; also, Path and Depth Determination of Buried Cable and Pipe.

TRANSMITTED SIGNAL:
Standard Model (60-Hz Environment): 990 Hz (Buried) or 150 Hz (Aerial) Tone with 7-Hz Interruption Rate for Easy Identification

Option 001 (50 Hz Environment): 975 Hz (Buried) or 175 Hz (Aerial) Tone with 7 Hz Interruption Rate for Easy Identification

SIGNAL PICKUP: Inductive Probe or Voltage-Difference Contact Frame

RECEIVED SIGNAL:
Standard Model (60 Hz Environment): 990 Hz or 150 Hz in Tone Burst - beep-beep-beep-Sequence

Option 001 (50 Hz Environment): 975 Hz or 175 Hz in Tone Burst - beep-beep-beep-Sequence

OHMMETER (Built into Transmitter housing): Two Ranges - R X 1 and R X 1000; Polarity-Reversal Switch to Check for Foreign Voltage Sources

INPUT POWER:
Transmitter: Two 6-Volt Batteries (Eveready #744 or Equivalent)

Receiver: Two 9-Volt Batteries (Eveready E-126 or Equivalent)

DIMENSIONS:
Fiberglas Case: 11" High; 14-1/2" Wide; 10" Deep (279, 4 X 368, 3 X 254 mm)

4994A Receiver: 4-1/2" High; 7-3/4" Wide; 4" Deep (114 X 197 X 101, 6 mm)

Hand-Held Search Wand: 32 1/2" Long (826 mm)

Earth Contact Frame: 31-1/2" High; 21-3/4" Wide, 3/4" Diam. (800 X 552 X 19 mm)

Ground Rod: 12" Long (305 mm)

Transmitter Cord: Approximately 25-ft Long (760 cm)

Receiver Cord: When stretched, approximately 6-ft long (183 cm)

WEIGHT:
Encased System (Includes Transmitter, Receiver, and All Accessories, except Earth Contact Frame: Net 18 lbs. (8, 2Kg); Shipping 29 lbs. (11, 3Kg)

ACCESSORIES FURNISHED: 18046A Hand-Held Search Wand; 18005A Earth Contact Frame; 18009A Ground Rod; 18028A Transmitter Cord; and 18015A Receiver Coil Cord

ACCESSORIES AVAILABLE:
18017A 600 ohm Headset

SECTION I
BASICS OF YOUR INSTRUMENT

1-1. GENERAL INFORMATION

1-2. CLAIMS FOR DAMAGE. If the shipping carton is damaged, unpack the instrument in the presence of the carrier or his agent. If the instrument is damaged or fails to operate, immediately notify the carrier and TWX or call:

HEWLETT-PACKARD CO.
DELCON DIVISION
690 E. MIDDLEFIELD RD.
MOUNTAIN VIEW, CALIF. 94040
TELEPHONE: (415) 969-0880
TWX: 910 379-6490

1-3. Retain shipping carton and padding material for inspection by the carrier. Hewlett-Packard will repair or replace the damaged instrument without waiting for settlement of carrier claims.

1-4. REPACKAGING FOR SHIPMENT. To protect the instrument against the normal hazards of shipping, use the best available methods and packaging materials. The original shipping carton and packaging material, except for the accordion-pleated pads (if used), should be reused for shipment. If the original materials are unavailable or not reusable, the instrument should be packed as follows:

1. Use a double-walled carton that meets the requirements given in Table 1-1.

2. Protect all instrument surfaces with heavy paper, plastic, or sheets of cardboard. Use non-abrasive materials, such as foam rubber or soft cushioning paper, around all projecting parts.

3. Tightly pack at least 4" of industry-approved, shock-absorbing material around the top, bottom, and each side of the instrument.

4. Secure the outside of carton with heavy-duty shipping tape; mark "DELICATE INSTRUMENT" on each side of box.

Table 1-1. Shipping Carton Test-Strength

Gross Weight (lbs)	Carton Test Strength (lbs)
up to 10	200
10 to 30	275
30 to 120	350
120 to 140	500
140 to 160	600

1-5. Address the container as indicated in Paragraph 1-2. Enclose a note with the sender's name, address, and telephone number. Also, include the reason for return and if instrument is not under warranty as defined on inside front cover of this manual, a repair authorization.

1-6. CERTIFICATION AND WARRANTY. This instrument is certified and warranted as specified on the inside front cover of this manual. To avoid consequential damages, the operating instructions should be closely followed.

1-7. INSTRUMENT IDENTIFICATION. The serial number for all HP instruments are stamped into the identification plate. When applicable, option numbers are also shown on the plate. Refer to Paragraph 1-17 for options pertaining to this instrument. All inquiries regarding operation, calibration/adjustment, and service should be accompanied with the complete serial number and option number.

1-8. INSTRUMENT SUMMARY

1-9. SYSTEM DESCRIPTION. The basic fault-finding system (Figure 1-1) consists of a 4904A Transmitter; a 4994A Receiver, an 18042A Hand-Held Search Wand, an 18005A Earth Contact Frame, an 18009A Ground Rod, an 18015A Coil Cord, and an 18028A Transmitter Cable. In system configuration, grounds, splits, crosses, shorts, and other troubles in aerial or buried communications and power cables can be found. The system can also be used to trace the path and determine the depth of buried cable and pipe. The HP Model 4904A Transmitter generates a pulsed tone output and this signal is applied to the faulted cable for, path and depth determination, to the cable or pipe. An ohmmeter is an integral part of the transmitter. Also an approximate power match to the fault can be made at the transmitter front-panel; a flashing lamp tells the operator when the matching adjustments are correct. For buried cable (990 Hz), the receiving antenna is either the HP Model 18042A Hand-Held Search Wand or the HP Model 18005A Earth Contact Frame. The wand operates on the induced-voltage principle, whereas, the frame operates on conductive voltage difference principle. For aerial cable (150Hz), the transmitted signal is picked up with an HP Model 18034A Pole-Mounted Exploring Coil or with an HP Model 18035A Hand Coil. The 3-section collapsible search wand and the contact frame are furnished with the system; the other pickup devices are optional accessories. The HP Model 4994A is a very sensitive heterodyne receiver with two input channels. Both channels are fixed-tuned, one to 990 Hz and the other to 150 Hz. The receiver contains a loudspeaker and logging meter to monitor the input signal strength; a receptacle is also provided to connect a standard 600 ohm headset. Both receiver and transmitter are fully portable.

1-10. FUNCTIONAL THEORY. Figure 1-2 shows a typical hookup for locating a shield-to-earth fault. As signal current flows through the conductor, a magnetic field is established. Under ideal conditions, the field can be visualized as a series of concentric circles that radiate outward from any center point of the conductor. As shown, these magnetic lines of force are relatively strong near the current-carrying conductor and get progressively weaker as the distance increases. Because the field reflects all characteristics of the transmitted signal, it provides much useful information. The transmitter puts out a continuous series of 990 Hz tone bursts. During the burst interval, the field rises to a maximum and falls to a minimum at the 990 Hz rate. Since the field is continually changing, it is possible to induce a voltage by holding a coil nearby. The principle is identical to that used in a transformer; the circuit equivalent is shown in Figure 1-3. The conductor corresponds to a single-turn primary winding (View a), whereas, the pickup coil corresponds to a multiple-turn secondary winding. Just as a transformer requires mutual coupling between the primary and secondary windings, the pickup coil must be coupled to the magnetic field of the conductor. In most transformers, the coupling is fixed, but in the fault-finding system, the coupling can be varied by physically moving the pickup device. Figure 1-3 shows how the hand-held search wand is normally coupled to the primary field. View a shows the magnetic field associated with the faulted cable - the cable acting as a single-turn primary winding. Views b and c show physical positions of the wand and the equivalent mutual coupling for each position.

1-11. When the wand is connected to the receiver, the results become practical. With the wand directly over the cable (minimum coupling), the loudspeaker or headset signal is barely audible. As the wand is moved to either side of the underground conductor, the primary-to-secondary coupling is greater; likewise, the signal level is greater. By slowly swinging the wand back and forth and observing the peak-null-peak sequence, the cable path can be very precisely determined right up to the fault.

1-12. At the point where the shield is grounded, the signal currents return to the transmitter. With no current flow through the remainder of the cable, it would appear that the magnetic field would completely collapse. Yet the wand will still pickup the signal after the fault is passed; however, the change in signal strength is dramatic. What typically happens at the fault is shown in Figure 1-4. The signal begins to decrease as the fault is approached and continues to decrease as the fault is passed. A few feet past the grounded point, the signal levels off to some low value and remains essentially constant for the remainder of the underground lay. From the point where the signal first begins to drop to the point of level-off is typically 4-to-10 feet. The fault is considered to be at the center of the range. If, for instance, the distance between points is 6 feet, the fault is located approximately 3 feet from the signal drop off point.

1-13. For locating earth return faults, the conductive voltage difference method of the earth contact frame

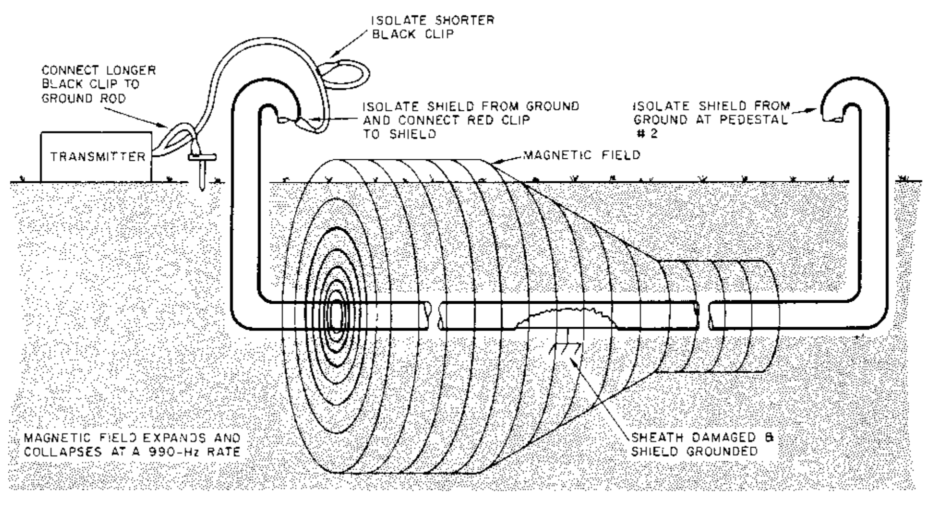


Figure 1-2. Connection of Transmitter to Find Shield-to-Earth Fault

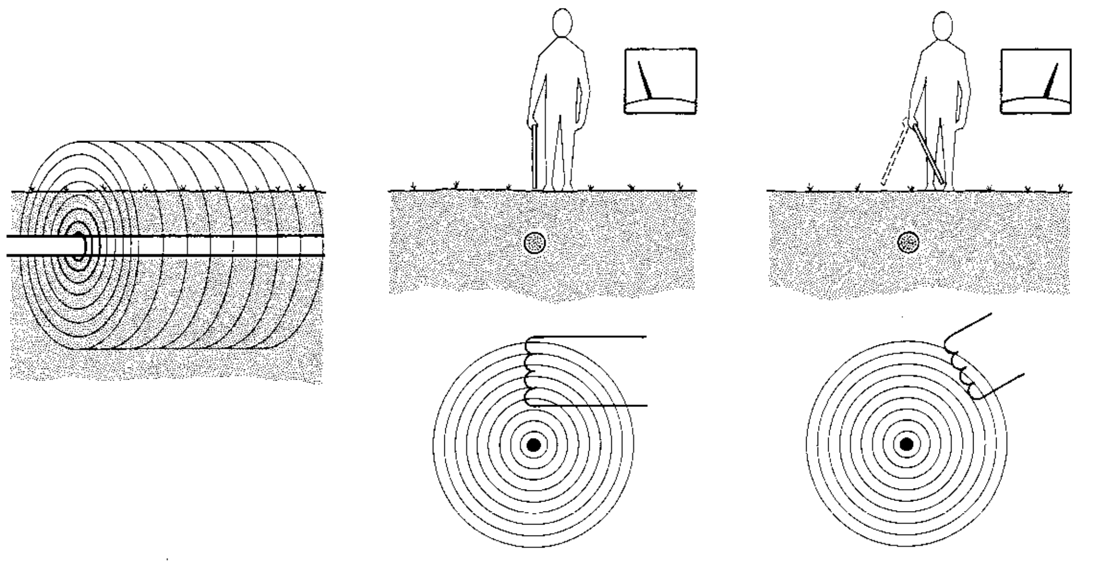


Figure 1-3. Transformer Equivalent of Faulted Cable and Pickup Device

complements the induced voltage principle of the search wand. After a very good approximation is made with the wand, the contact frame is used to pinpoint the fault location. The voltage difference principle of the contact frame is really nothing more than a practical application of Ohm's law. A typical shield-to-earth fault and its electrical equivalent is shown in Figure 1-5. Up to the fault, the cable represents a low resistance (R_c); thus, very little voltage is dropped along this path. The ground resistance (R_g) is

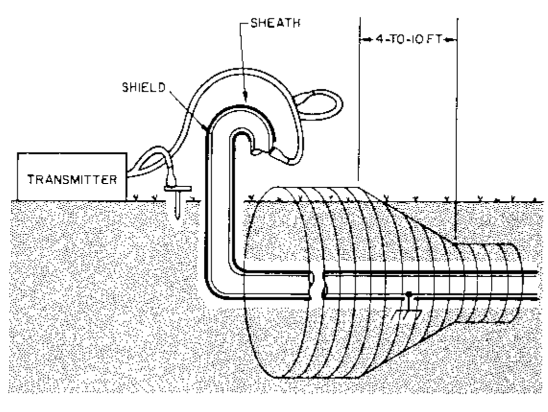


Figure 1-4. Field Intensity Drop-Off Past Shield-to-Earth Fault

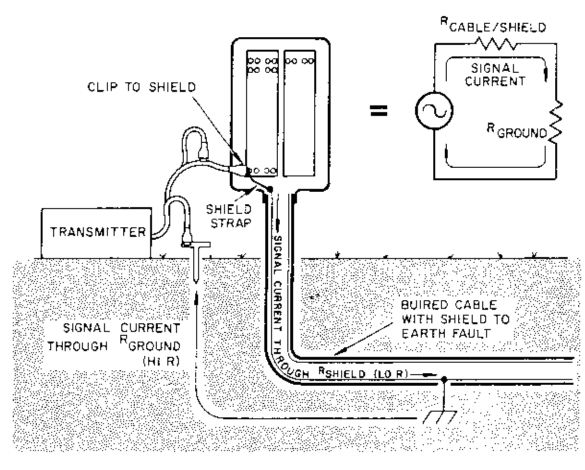


Figure 1-5. Shield-to-Earth Fault and Electrical Equivalent

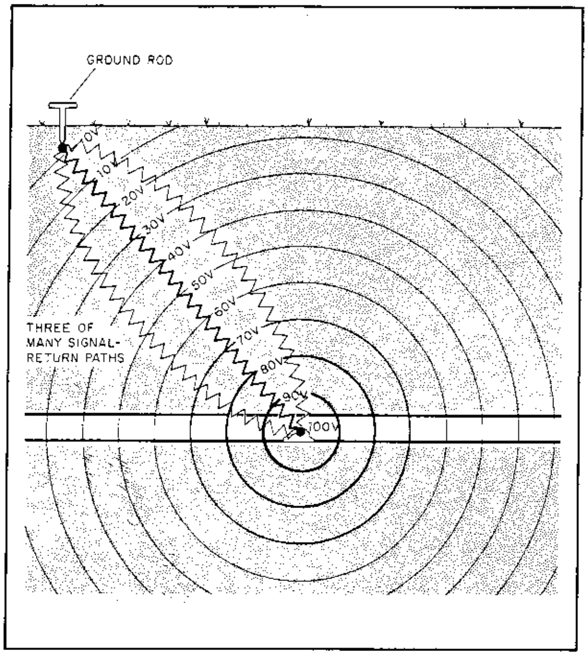


Figure 1-6. Plan View of Earth-Resistance Distribution

symmetrically distributed and is also very much higher than the cable resistance. For this reason most of the transmitter voltage appears at the juncture of R_c and R_g. Consider the case where 100 volts appears at the R_c/R_g junction. According to Ohm's law, all of this voltage must be dropped along the ground path between the fault and the ground rod. In effect, the earth acts as a large resistive sphere with the fault at the center; a plan view is shown in Figure 1-6. If the fault and ground rod are 100 feet apart, then 10 volts is dropped across every 10 feet of earth distance. Because voltage versus distance varies for different types of soil, these two values are sometimes plotted. The result is commonly called the earth voltage gradient.

1-14. Just as the magnetic field is used for voltage induction, the earth voltage gradient is used to detect a voltage difference between two points. Figure 1-7 shows how this is possible.

1-15. In the preceding discussion, ideal conditions are assumed; such conditions do not always exist. More often than not, finding the fault is complicated by at least one of the following problems;

a. Signal carry-by.

b. Difficulty in isolating the shield.

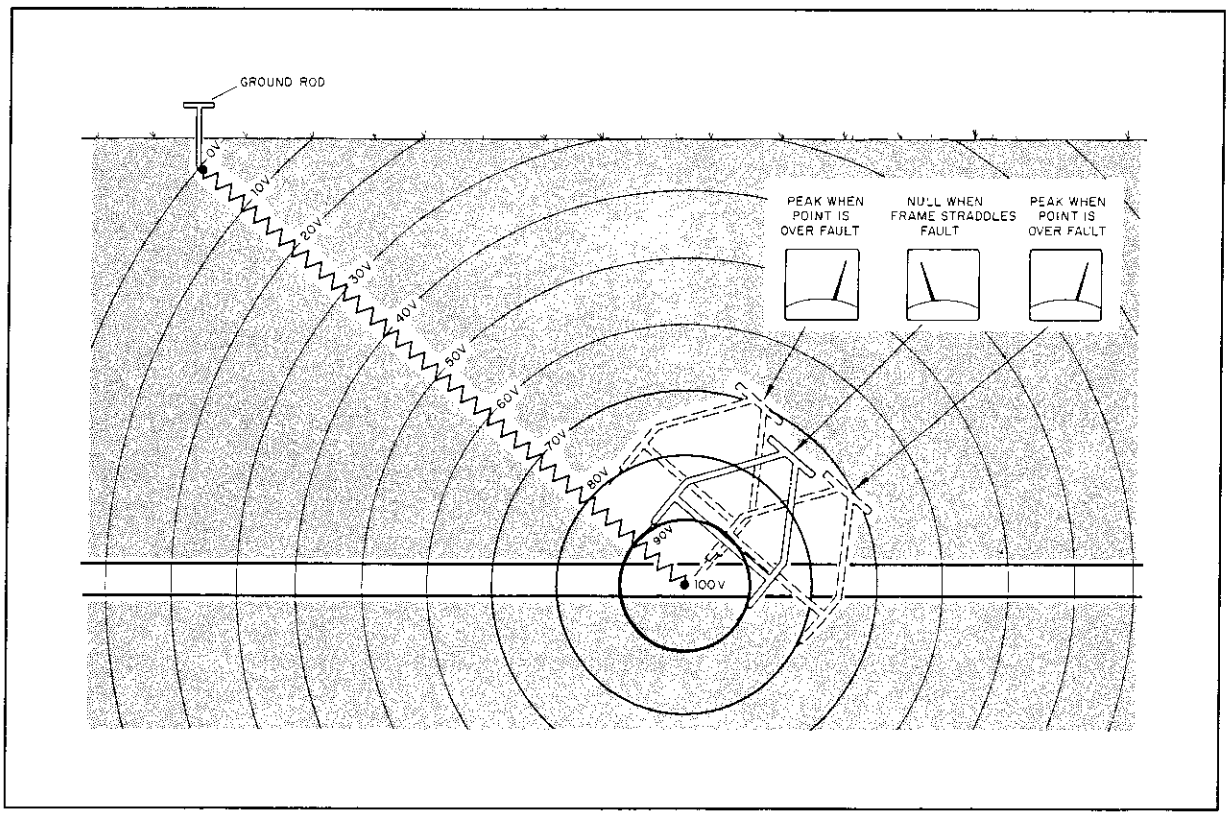


Figure 1-7. Fault-Finding Using Voltage-Difference Principle

c. Locating and predicting the effects of underground hardware.
d. Coupling into adjacent circuits.
e. Inaccessibility.

1-16. For the most part, all of the aforementioned problems can be overcome. The solutions are nearly always the same - good equipment, knowing how to use it, common-sense analysis, and the patience to keep trying after one or more failures. Sections III, IV, V, and VI describe the recommend solutions for those problems most likely to be encountered.

1-17. OPTIONS

1-18. The 4904A with its 4994A is available with an option designated 001. These instruments are identical to the standard 4904A and 4994A except that they are made to be used in areas where the power line frequency is 50 Hz. Therefore, the aerial tone frequency is 175 Hz and the buried tone frequency is 975 Hz. In all other respects and in the method of operation, the Option 001 unit is identical to the standard 4904A and 4994A.

SECTION II
OPERATION
(GENERAL)

2-1. INTRODUCTION

2-2. This section contains instructions on the operation of the Model 4904A. It is recommended that this section be read thoroughly to become familiar with the capabilities and limitations of the 4904A prior to putting it to work. Since the location of cable faults is mostly interpretive, an awareness of the results that might be attained with different soil conditions, cable characteristics, etc., is essential.

2-3. Appendix A, located in the back of this manual, contains a short training course to help familiarize an operator with the operation of the 4904A. It is excellent practice and a good opportunity to check out the performance of the 4904A.

2-4. In addition, Hewlett-Packard Co., Delcon Division offers a comprehensive course in telephone cable troubleshooting. For more information on this school, write or call the local Delcon field engineer or the Delcon Division Sales Department.

2-5. OPERATING CONTROLS AND LOCATION

2-6. Figure 2-1 and Table 2-1 describe the functions of the operating controls and other features on the Model 4904A; Figure 2-2 and Table 2-2 provide similar information for the 4994A.

2-7. USE OF THE SIGNAL LOADING SWITCH

2-8. Success in locating faults is dependent to a great extent on the proper setting of the transmitter SIGNAL LOADING switch. Excessive signal on the circuit under test will cause "carry-by" and will noise up other circuits, making the fault extremely difficult to pinpoint. Conversely, not enough signal may result in a very weak indication at the fault which could be missed altogether.

2-9. Best performance can be obtained with the smallest amount of signal necessary to provide a usable indication on the receiver logging meter, with the receiver GAIN controls set to Step 6 or greater.

2-10. The OUTPUT lamp is set so that it flashes when the transmitter is operating into an underload or into a matched load. The transmitter is overloaded when the lamp does not flash.

2-11. In most cases it is desirable to use less than maximum output power. Best performance can be obtained with the smallest amount of power that will provide a reference setting of 60 on the receiver, with the coarse gain control set to Step 6 or above.

NOTE

Sometimes it may be necessary to use a higher position to get lower output power. For example, if the light flashes only on Position 1, settings higher than this will provide progressively less power, since power decreases with increased overloading. Overloading will not harm the transmitter, however, it does increase battery drain.

2-12. A LEVEL control permits adjusting the transmitter output down to zero output when the SIGNAL LOADING switch is in Position 1.

2-13. Occasionally when fault locating in power cable it may be necessary to use maximum power output and low receiver gain in order to reduce interference from unusually strong power line harmonics.

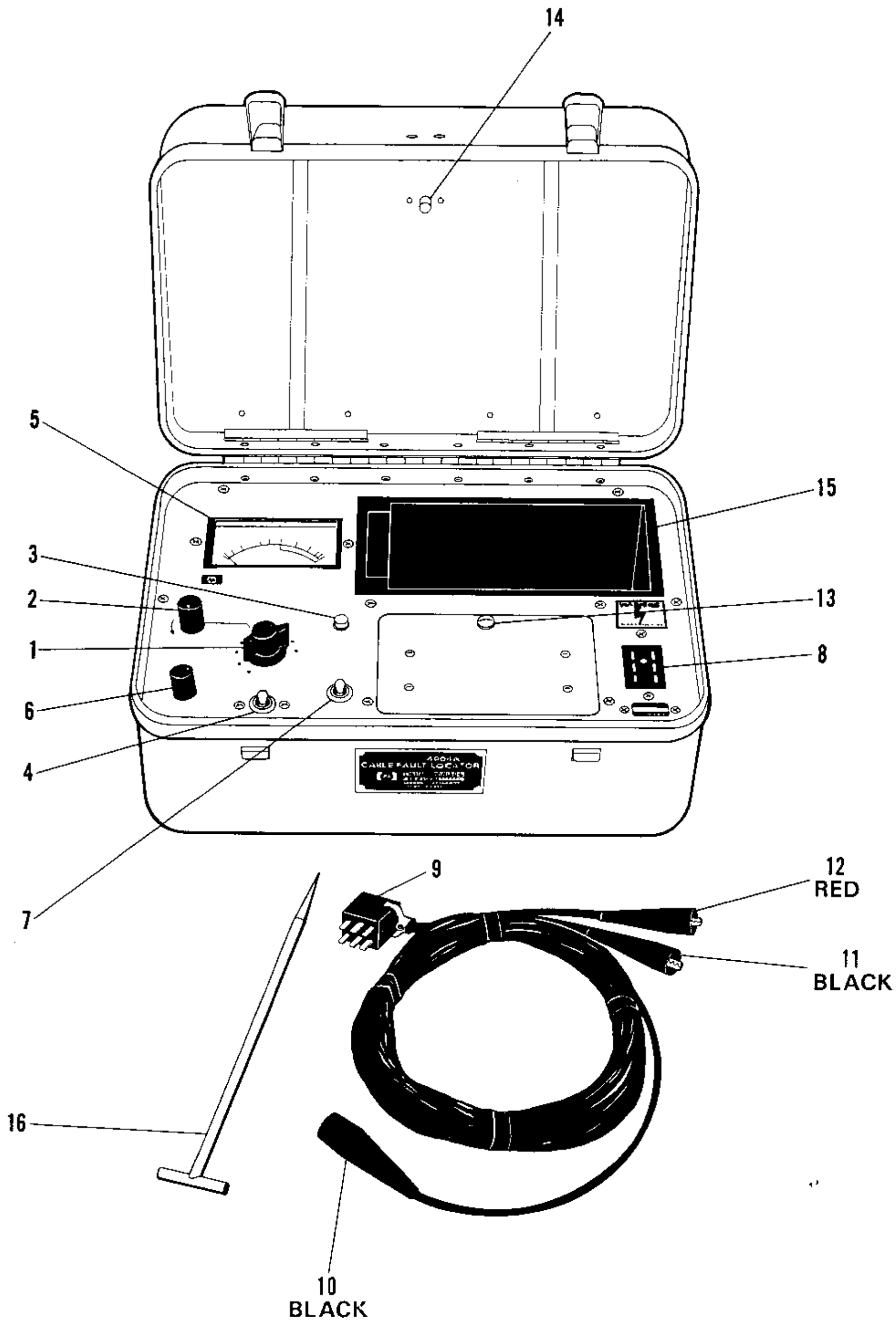


Figure 2-1. Transmitter Controls and Locations

Table 2-1. 4904A Transmitter Controls and Locations

1. SIGNAL LOADING Switch. Controls output power by approximately matching source impedance to fault impedance. (Refer to Paragraph 2-7 for information on the adjustment of this control.)

2. SIGNAL LEVEL Control. Variable adjustment of output signal when SIGNAL LOADING switch 1 is in Position 1. Output can be adjusted down to zero with this control.

3. OUTPUT Lamp. Flashes when transmitter is operating into underload or matched load. Does not flash when transmitter output is overloaded.

4. AERIAL-BURIED Selector Switch. Selects the proper output tone for aerial or buried fault locating. Provides 150 Hz tone bursts in AERIAL position; 990 Hz tone bursts in BURIED position.

5. Ohmmeter. Reads resistance of fault when Transmitter Cable is properly connected across fault. Reads directly in ohms when SIGNAL LOADING Switch 1 is in OHMS position. Reading must be multiplied by 1000 when switch is in OHMS X 1000 position.

6. OHMS ADJ. Control. Adjusts meter pointer electrically to zero when clips 11 and 12 are shorted together. This adjustment should be made each time prior to use of Ohmmeter.

7. OHMS-REVERSE Switch. Reverses transmitter cord clips 11 and 12 so that check for foreign battery can be made. If there is any significant difference in the ohmmeter reading between the two settings of this switch, there is foreign battery on the circuit.

8. Output Cable Receptacle. Connects transmitter output to cable 9. Cable plug is keyed to receptacle for proper connection. When cable is disconnected, transmitter batteries are automatically disconnected to prevent accidental battery drain.

9. Transmitter Output Cable. Connects transmitter to circuit under test. When SIGNAL LOADING Switch 1 is in OHMS or OHMS X 1000 position, cable becomes ohmmeter input.

10. Ground Clip A. Clips to ground rod 16 or other sufficient ground. Used only for tracing path and depth and for locating earth return faults.

11. Ground Clip B. (Black Clip). Clips to shield or to one side of metallic fault. Used only for locating metallic faults.

12. Signal Output Clip (Red Clip). Clips to faulted conductor or to either side of metallic fault.

13. Battery Access Screw. Cover unlatches by turning screw counterclockwise 1/4 turn.

14. Storage Compartment Access Knob. Cover unlatches by turning knurled knob counterclockwise 1/4 turn.

15. Receiver Storage Compartment. For storage of receiver when not in use. Receiver cannot be inserted unless it is turned off.

16. Ground Rod. Driven ground rod for connection of ground clip "A" 10 when tracing cable path and depth or locating earth return faults.

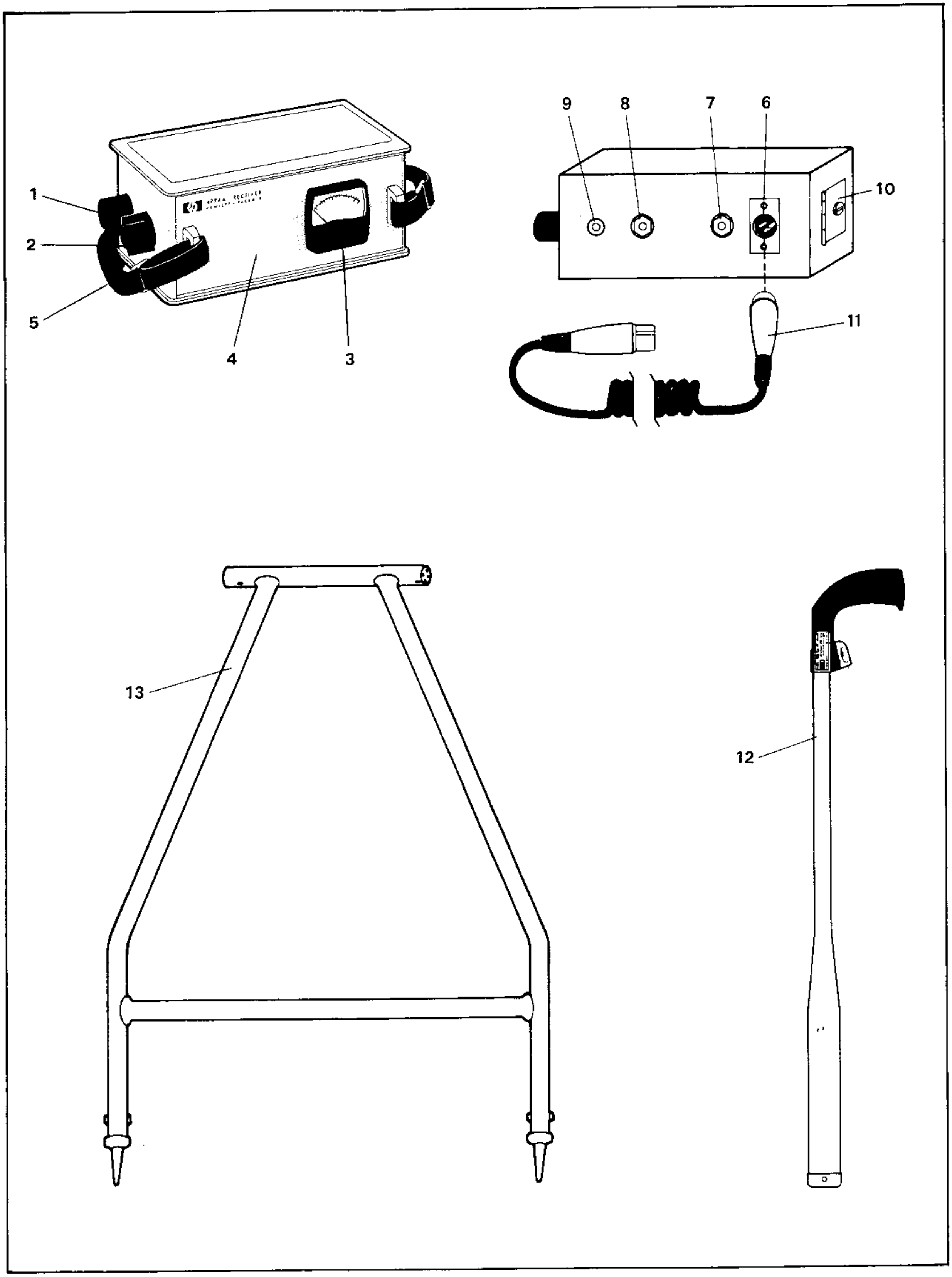


Figure 2-2. Receiver Controls and Included Accessories

Table 2-2. 4994A Receiver Controls and Locations

1. FINE GAIN Control/Power Switch. Pull knob to turn receiver on. Turn knob counterclockwise to increase volume. Works in conjunction with COARSE GAIN Control 2.

2. COARSE GAIN Control. Maximum receiver volume when set to position 9 (MAX). Works in conjunction with FINE GAIN Control 1.

3. Logging Meter. Displays strength of tone picked up by Search Wand 12, Earth Contact Frame or Exploring Coil. The top scale, which is used for most fault locating indicates relative signal strength on a 0 to 100 linear scale.

4. Speaker. Makes the received tone audible for listening to its relative strength. 150 Hz and 990 Hz is translated to approximately 1300 Hz for easier listening.

5. Carrying Strap. Receiver can be slung from the neck or shoulder for ease of viewing and carrying. Strap is adjustable with two buckles.

6. BURIED - 990 Hz Receptacle. Connects Search Wand 12 or Earth Contact Frame 13 to receiver with Coil Cord 11. Used for locating path and for locating faults in buried and underground cable, only. Transmitter AERIAL-BURIED Selector Switch must be in BURIED position when connected to this receptacle.

7. AERIAL - 150 Hz Receptacle. Connects exploring coil to receiver. Transmitter AERIAL-BURIED Selector Switch must be in AERIAL position when connected to this receptacle.

8. PHONES Jack. For connection of external speaker or headphones. Headphone impedance should be 600 ohms for best performance.

9. BATT. TEST Button. Tests condition of batteries when depressed and when Power Switch 1 is on. A reading of over 70 on the top scale of meter 3 indicates adequate voltage for proper operation.

10. Battery Compartment. To open, turn screw fastener counterclockwise. Insert batteries with polarity as indicated.

11. Coil Cord. For connecting Search Wand 12 or Earth Contact Frame 13 to receiver. To remove cord from receptacle, press release button on side of connector and pull.

12. Search Wand. Inductive device for picking up signal from buried or underground cable or pipe. Receptacle for connecting to coil cord 11 is located in one end of the wand.

13. Earth Contact Frame. Voltage gradient pickup device for pinpointing earth return faults. Receptacle for connecting to coil cord 11 is located in one end of the frame.

NOTE

The Contact Frame can only be used to locate earth return faults such as shield-to-earth, conductor-to-earth, or phase-to-earth. It cannot be used to locate conductor faults.

SECTION III

OPERATION

(LOCATING PATH AND DEPTH OF BURIED AND UNDERGROUND CABLE AND PIPES)

3-1. LOCATING PATH OF BURIED AND UNDERGROUND CABLE

3-2. Tracing the exact path of buried and underground cable is an important preliminary step prior to locating any faults. In addition, the 4904A can be used to determine path and depth of cable in areas of excavation and construction.

3-3. SETUP: Plastic Insulated (PIC) and Coaxial Cable. On plastic insulated cable (PIC), isolate shield at near end and connect red clip to shield. Clip black clip "B" behind the red clip so that it does not touch ground, as shown in Figure 3-1.

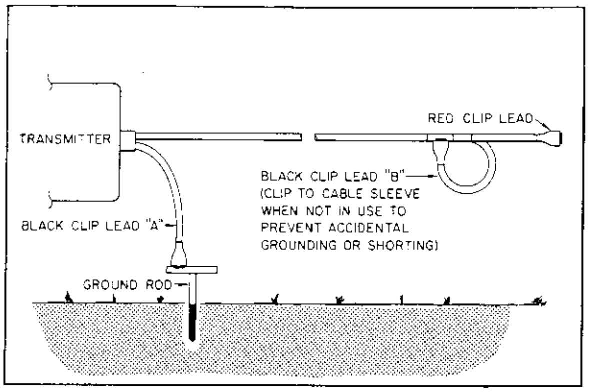


Figure 3-1. Ground Lead Isolation

3-4. Move the transmitter 15 to 20 feet perpendicular to the path of the cable and drive the ground rod so that the black ground lead "A" can be clipped to it. In certain instances of dry or sandy soil, a longer rod such as a reinforcing bar must be used.

NOTE

It is important that the transmitter and ground rod always be placed as far away from the cable path as possible (see Figure 3-2). Never use water pipes or other distributed grounds. Insulated guys perpendicular to the cable path make excellent grounds, however.

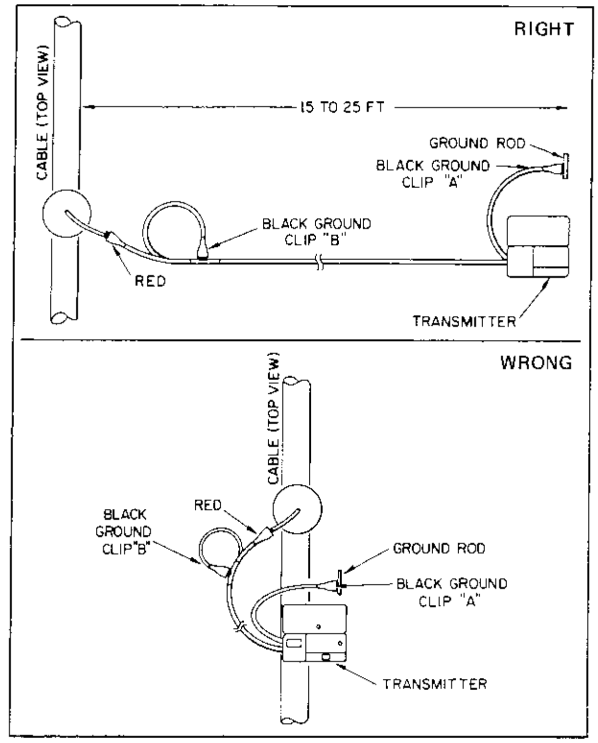


Figure 3-2. Proper Ground Rod Placement for Locating Path and Depth and for Locating Earth Return Faults

3-5. SETUP: Lead Sheath Cable. When tracing short sections (less than 1000 ft.) of lead sheath cable, connect the red clip directly to the sheath. When tracing longer sections, it is necessary to isolate an unused conductor in the cable at the near-end and ground it at the far-end. Connect the red clip to this conductor at the near-end. Clip black clip "B" behind the red clip so that it does not touch ground. Move the transmitter 15 to 20 feet off the cable path and connect black clip "A" to the driven ground rod.

3-6. SETUP: Power Cable. De-energize the circuit and isolate one conductor at the near-end and ground it at the far-end through a ground rod. Connect the red clip to the conductor at the near-end. Clip black clip "B" behind the red clip so that it does not touch ground. Move the transmitter 15 to 20 feet off at right angles to the cable path and connect black clip "A" to the driven ground rod.

3-7. SETUP: Metallic Pipe. Connect the red clip directly to the pipe. If the utility uses dielectric unions, make sure that the red clip is connected to the street side of the union. Clip black clip "B" behind the red clip so that it does not touch ground. Move the transmitter 15 to 20 feet off at right angles to the cable path and connect black clip "A" to the driven ground rod. Do not ground to another pipe or distributed ground.

3-8. PROCEDURES FOR PATH DETERMINATION

3-9. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN control set to Step 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the path at least 10 feet from the near-end connections. Pointing the search wand at the cable (or pipe), will give a null (minimum) reading and swinging the wand to either side of the cable path will give a peak (maximum) reading. Carefully locate this peak and adjust the transmitter and receiver to the reference.

NOTE

Never use more transmitter output than absolutely necessary. Excessive signal on the cable will cause erroneous measurement results and will noise up working pairs. A good rule of thumb is to adjust the output (signal loading) to provide a receiver reading of approximately 60 with the receiver COARSE GAIN control set on Step 6 or above. In other words, best results are obtained with low transmitter output and high receiver gain.

3-10. The cable (or pipe) can now be traced. (Refer to Figures 3-3 and 3-4.) Slowly swing the wand back and forth across the cable path. The signal from the speaker will decrease to almost nothing as the wand passes over the cable (or pipe) and increase to maximum on either side of the path. At the same time, the meter will indicate a null when the wand is pointed at the cable and approximately 60 when pointed to either side of the path.

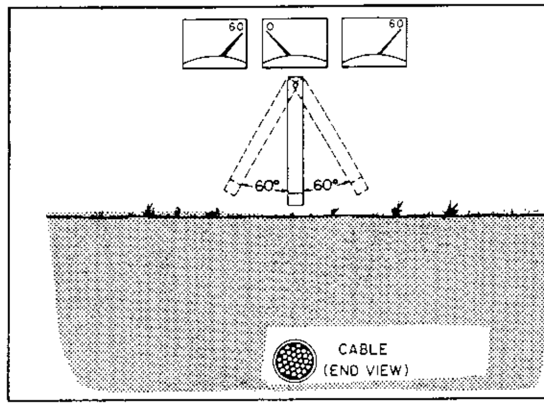


Figure 3-3. Tracing Cable Path

3-11. If the exact path of the cable or pipe is wanted, stake or mark the path every few feet and more often in areas where the path curves.

3-12. If there is a sudden decrease in the signal on each side of the cable, it may indicate a ground fault or a depth change. If the signal strength is insufficient to continue tracing the path either, (1) clear the fault, or (2) move the transmitter to the far end of the cable and proceed to trace back to the fault. Never increase the transmitter output in an attempt to "brute force" the fault as this may noise up other conductors and make tracing past the fault difficult and inaccurate.

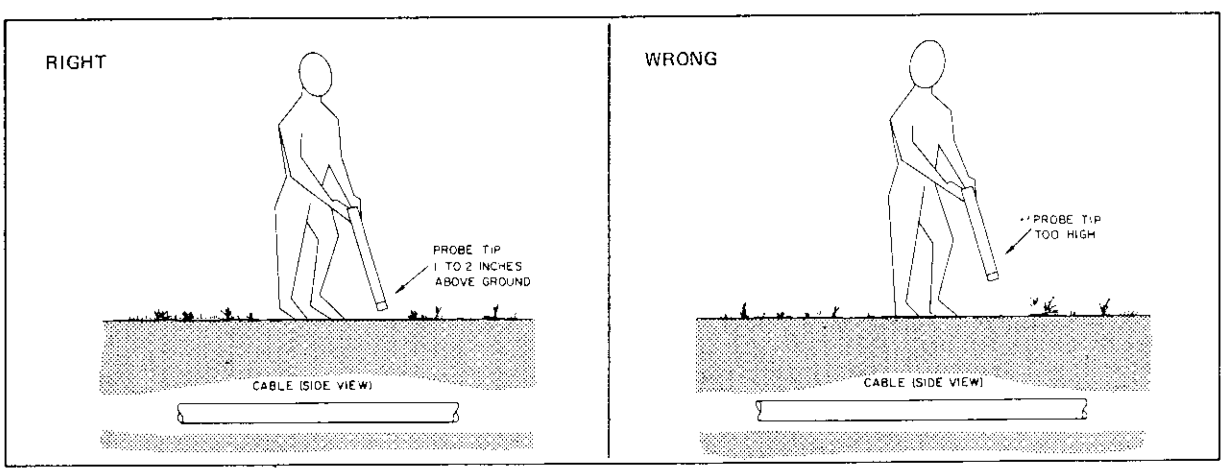


Figure 3-4. Proper Position of Search Wand

3-13. Loops, turns, butt-ends, legs, drops, etc., will cause characteristic changes in meter readings. It is suggested that these characteristics become familiar by running through the training exercise in Appendix A, in the back of this manual.

3-14. DETERMINING DEPTH OF BURIED AND UNDERGROUD CABLE AND PIPE

3-15. Depth of cable or pipe can be accurately determined using the same setup as with locating the path. Depth may be determined at any point along the cable path except within 5 or 6 feet of a ground fault and to within 10 feet of the transmitter connections.

3-16. Setup for Depth Determination. Transmitter hookup and reference settings are identical to those used to trace cable or pipe path.

3-17. Procedures for Depth Determination. Carefully locate the cable (or pipe) path and mark this spot. Next, holding the search wand at a 45° angle as shown in Figure 3-5a (the wand will be at a 45° angle when the handle of the wand is approximately 2 feet from the ground), move away from the path until the meter indicates a null (minimum) reading. Mark this spot. The distance between the two marks is equal to the cable depth.

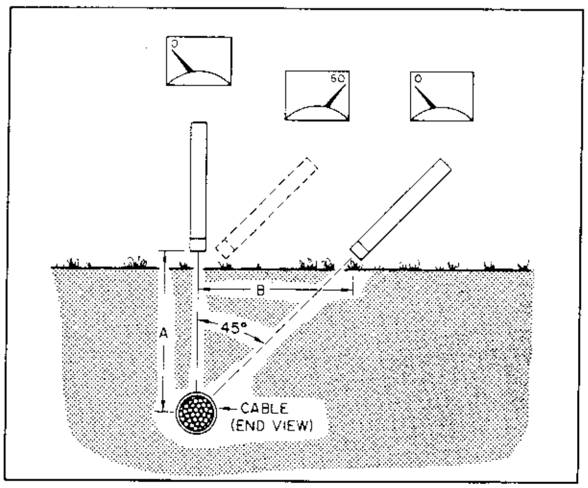
NOTE

When the cable under test is in the same trench as energized power cable, the depth reading will be accurate only on the side away from the power cable.

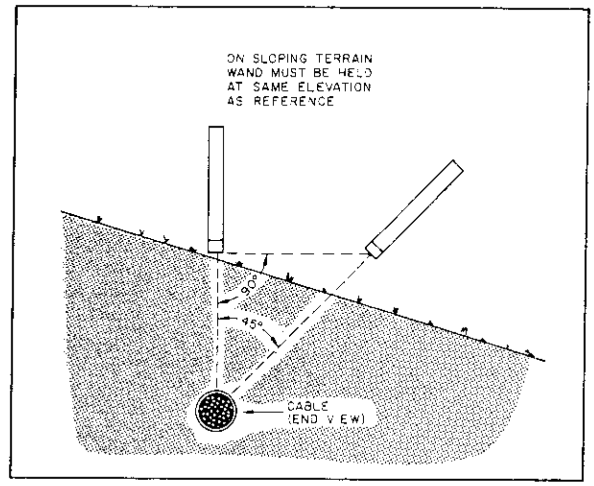
NOTE

Extremely rocky or loosely packed soil may cause an error in the depth measurement. However, this error will generally indicate that the cable is shallower than it actually is, thereby allowing a digging safety factor.

3-18. Care must be taken when measuring depth on a sloping terrain. The elevation of the wand tip must remain level, as shown in Figure 3-5b.



(a)



(b)

Figure 3-5. Determining Depth of Buried and Underground Cable and Pipe

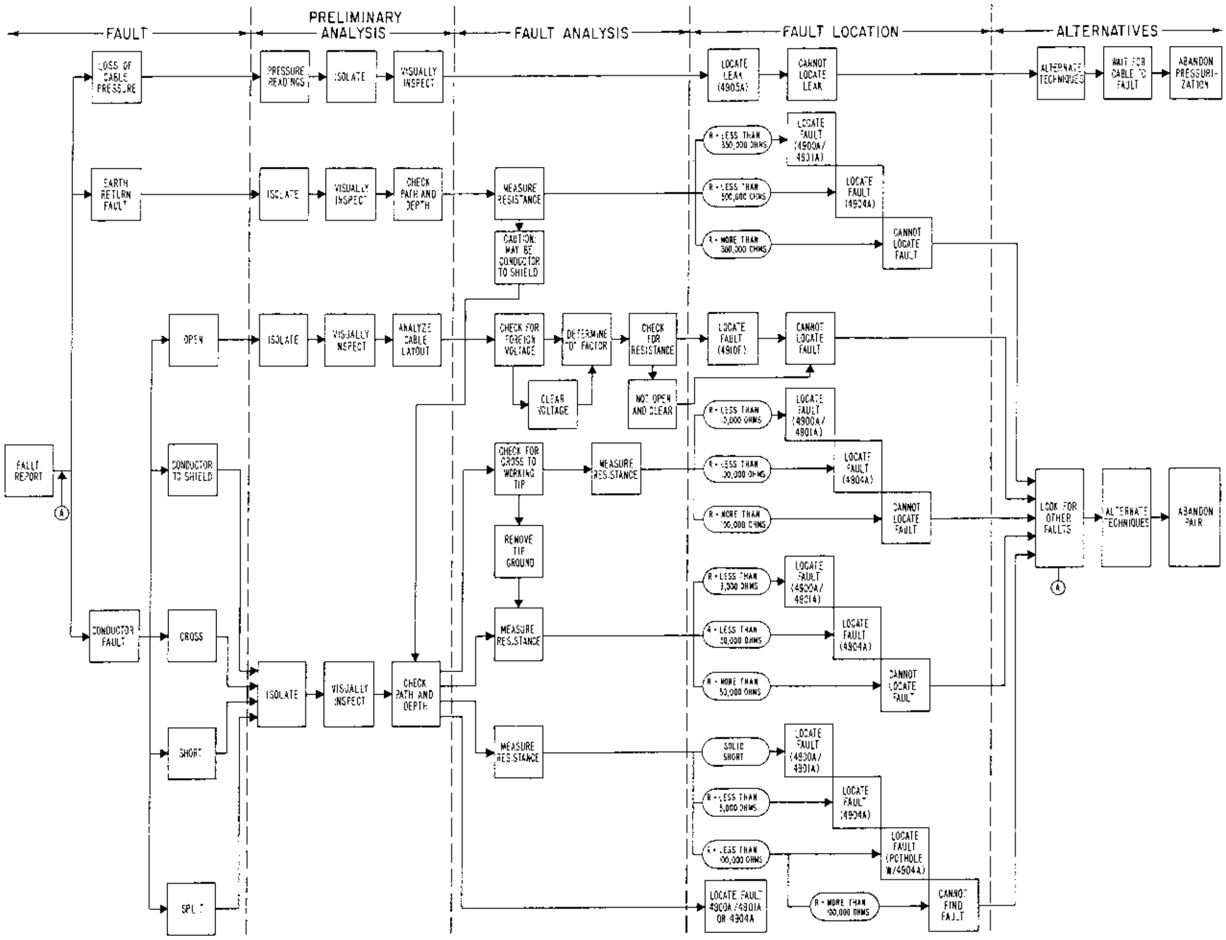


Figure 4-1. Fault Analysis Chart for Telephone Cables

SECTION IV
OPERATION
(LOCATING FAULTS IN TELEPHONE CABLE)

4-1. LOCATING FAULTS IN BURIED AND UNDERGROUND TELEPHONE CABLE

4-2. TECHNIQUES. There are Seven Cardinal Rules for Fault Locating. They are:

Rule 1. PRIMARY ANALYSIS. The most important step in troubleshooting a fault is the primary analysis. Always look for additional faults. When multiple faults exist, always test with an ohmmeter to see which will be easiest to find.

Rule 2. Use the minimum transmitter output signal. All that is needed is an output signal which will register 40 to 60 on the receiver. High transmitter settings will spill signals into other conductors and often will give false fault indications. It is better to have a high receiver gain and a low transmitter output.

Rule 3. Never allow the receiver gain to be set so high that the signal exceeds 70. The meter is electronically guarded so intense signals will not damage it. A meter reading of 95 may actually represent a signal strength of 200, so that even a 50 to 100 point decrease would barely register.

Rule 4. When the characteristic beep-beep-beep from the 7 pulses per second cannot be heard the fault cannot generally be run. If any repeatable reference signal can be established, it will be possible to attempt to locate the fault. The fault indication may not be what is expected or predicted in this manual. For example, if the tone changes substantially, the reason could be a change in depth, other metal objects in the ground, or a fault. In summary, a fault may be indicated by any substantial change in the tone.

Rule 5. When checking for a conductor-to-shield fault, completely isolate the shield from ground and analyze to make sure that it is not a cross to a working tip or grounded pair.

Rule 6. Isolate the unused ground clip A or B from making ground contact.

Rule 7. When using a separate ohmmeter, be sure that the transmitter connections are on the same circuit as those tested with the ohmmeter.

4-3. PRELIMINARY ANALYSIS. The most important step to successful fault locating is completely analyzing the trouble(s) in the cable before beginning to locate anything. No matter what sort of trouble is reported, always look for possible additional faults. Test with the ohmmeter to determine which fault is the easiest to find. For example, a sheath fault with a shield-to-earth resistance of 200,000 ohms, is easier to find than a conductor fault of 5,000 ohms. Refer to Figure 4-1.

4-4. When a conductor or pair is reported to be grounded, a careful analysis must be made to determine if the fault is conductor-to-shield, conductor-to-earth, or conductor to a working tip cross. When the fault is isolated to a section, the shield should be isolated from ground. Then, if the shield shows no resistance to ground, test the conductor to the isolated shield. If this also shows no fault, test for a cross to a working tip or another grounded pair.

4-5. Crosses and shorts in cable more than about three feet deep are very difficult if not impossible to locate in small cables. A solid short in a 24 or 26 gage cable at two feet deep is very difficult to locate but a cross in the same cable can be located with comparative ease. The higher the resistance of the fault the less current the transmitter will be able to force through the fault and the less signal will be received above the ground.

4-6. Shield-to-earth faults produce much larger fields because the shield is one side of the fault and has a large area; therefore, these faults may be located at much greater depths and with much higher fault resistances than shorts and crosses.

4-7. When a separate ohmmeter is used, be sure that the connections are the same circuit as tested. When testing a shield-to-earth fault the resistance from the shield to the ground rod to be used should be measured. If this resistance is much higher than that of shield to a good ground, use a longer ground rod or an insulated down guy if one is near. Do not use water pipes or any distributed ground. The types of buried faults are listed below in order of their fault locating ease:

1. Shield-to-earth
2. Conductor-to-shield
3. Cross
4. Short

4-8. LOCATING SHIELD-TO-EARTH FAULTS IN BURIED AND UNDERGROUND CABLE

4-9. A high percentage of buried cable trouble is associated with non-telephone company workmen, rodents or lightning. This results in sheath damage and continuity from shield to earth.

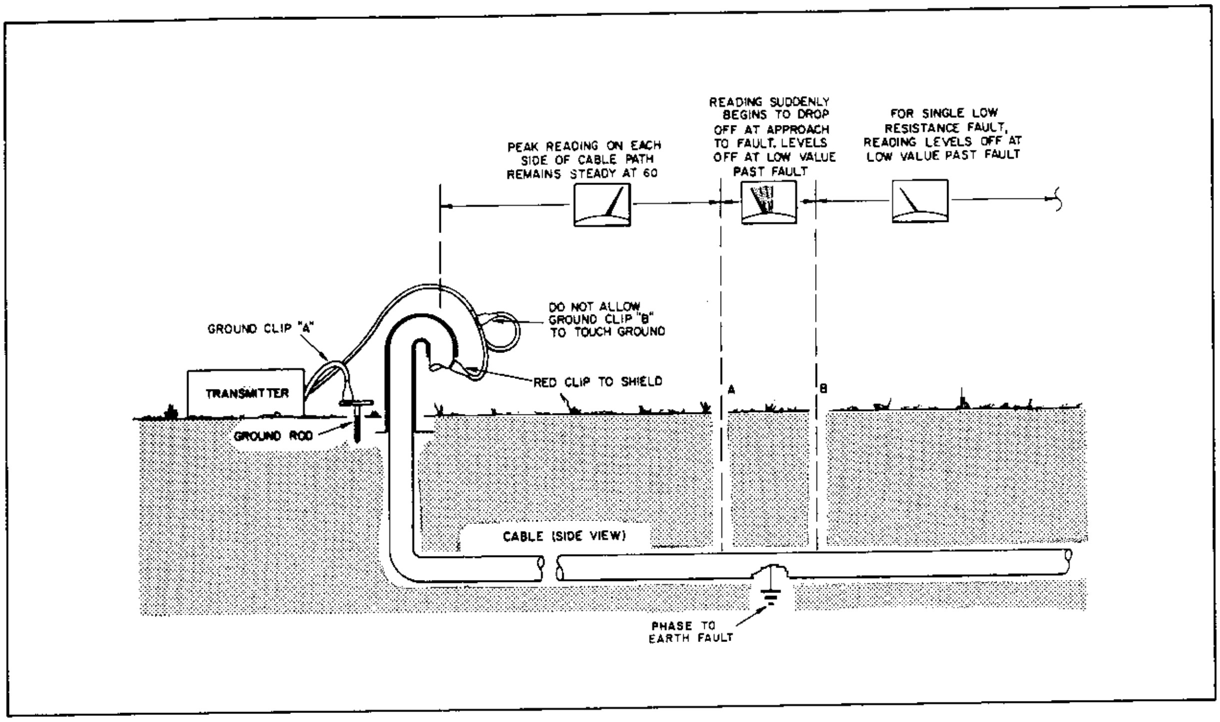


Figure 4-2. Locating Shield-to-Earth Fault Using Search Wand

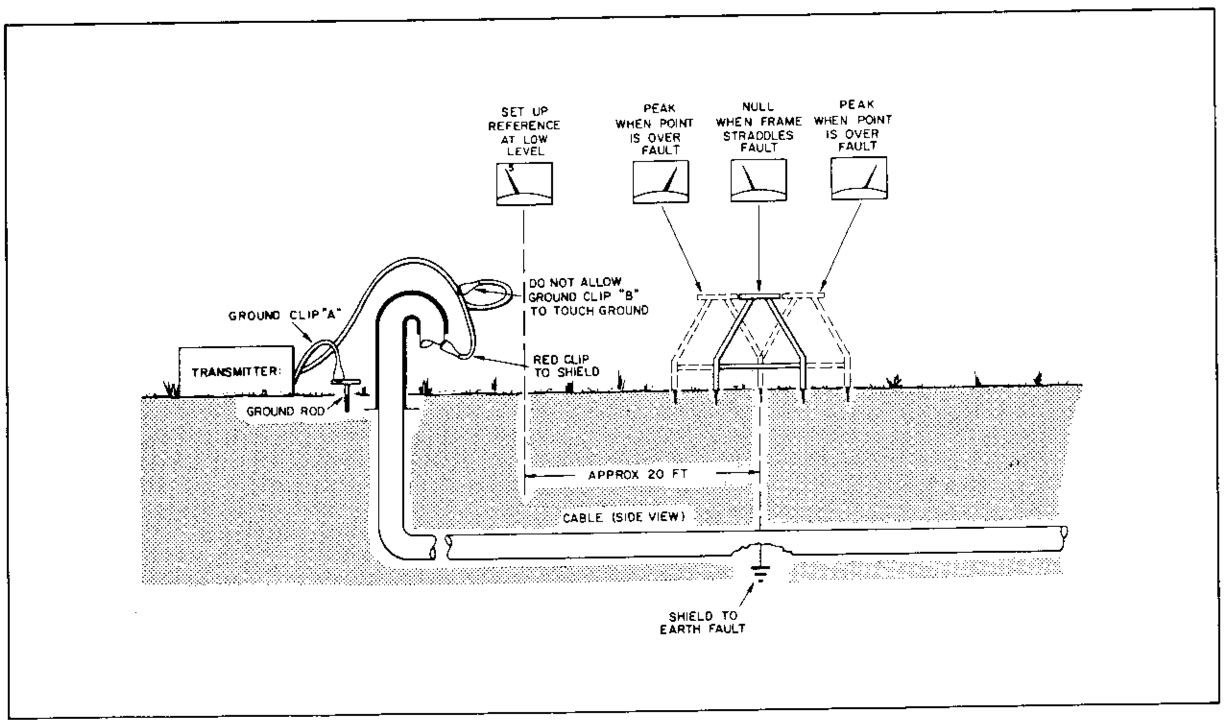


Figure 4-3. Pinpointing Shield-to-Earth Fault Using Earth Contact Frame

4-10. Isolate the shield from ground at each end of the section (Figure 4-2) and connect the red clip lead to the shield. Place the transmitter 15 to 20 feet off the cable path and connect black clip lead "A" to the driven ground rod. Make sure that black clip lead "B" is not grounded or shorted to the red clip lead.

4-11. To determine a shield-to-earth fault measure the resistance between the shield and ground rod. Make this measurement by throwing the ohmmeter lever switch to OHMS or OHMS X 1000.

NOTE

If the isolated section of cable contains buried splice cases that are bonded to the shield, the resistance measured will be that of the splice cases. Therefore, it is very difficult to locate shield-to-earth faults until these splice cases can be isolated from ground. However, it is possible to locate the precise location of buried splices by using the shield-to-earth fault locating technique.

4-12. If the shield-to-ground resistance is 500,000 ohms or less, the fault can generally be located with this instrument. If the resistance is over 500,000 ohms, try using a longer ground rod or an insulated down guy to lower the ground contact resistance.

NOTE

Occasionally what appears to be a sheath to earth fault is actually a sheath to tip(s) conductor ground. This usually is indicated when the tone slowly decreases along the cable section (transmitter at central office end). It is also indicated by the tone carrying past the isolated section toward the central office (transmitter at far end). In this case run the fault as a conductor to shield (Paragraph 4-27).

NOTE

If there is any foreign voltage on the shield this will cause an erroneous ohmmeter reading. To check for voltage, operate the REVERSE switch on the 4904A; or if a separate ohmmeter is being used, reverse the leads. Any significant difference in the reverse reading indicates that there is foreign battery or induced voltage present and the resistance reading is incorrect.

4-13. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control set to Step 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable path approximately 10 feet from the near-end connections. Pointing the search wand at the cable, will give a null (minimum) reading and swinging the wand to either side of the cable, will give a peak (maximum) reading. Carefully locate this peak and adjust the transmitter and receiver to the reference.

4-14. The fault locating procedure is the same as for locating the cable path except that the peak signal on each side of the cable will fall off sharply as the fault is approached and will disappear after passing the fault in the case of a single, low resistance fault. The higher the resistance of the fault and the more cable beyond the fault, the more signal "carry-by."

4-15. Proceed to walk the cable, observing the meter reading on both sides of the cable path. When a sudden decrease in the meter reading is observed, mark the spot where the reading starts to drop off. Proceed slowly and watch the meter for the point at which the decreasing reading levels out at a low value (usually 20 or less). Mark this point. The fault will be located halfway between the two marks (see Figure 4-2). For most single low resistance faults, the distance between marks will be 4 to 6 feet.

NOTE

Similar readings may result where the cable drops to a lower depth. If there is some doubt whether a fault or a depth change has been located recheck the cable depth. These checks should be made approximately 10 feet ahead of and 10 feet beyond the point where the meter dip was observed.

4-16. If the reading begins to drop gradually to zero, or a low value with no points of sharp drop, several points of sheath damage may be fairly close together, such as gopher damage. These faults can best be pinpointed with the Earth Contact Frame.

4-17. PINPOINTING SHIELD-TO-EARTH FAULTS WITH THE EARTH CONTACT FRAME

4-18. To pinpoint these faults (Figure 4-3) move back toward the transmitter about 20 feet from the fault area. With both prongs of the Contact Frame inserted over (parallel to) the cable path, adjust the receiver Gain Controls for a reference of 5 to 10 on the meter.

4-19. Proceed to walk along the path of the cable inserting the contact prongs into the earth over (parallel to) the cable path (Figures 4-4 and 4-5) about every 2 feet. As the first fault is approached the signal will increase sharply. Turn the receiver volume down as necessary to keep the meter below 60. Reduce probing intervals to about 6 inches and as the signal begins to drop off shorten the probing intervals further.

4-20. There will be a peak reading when the leading contact prong is inserted over the fault, a null when the contact frame is centered over the fault, and another peak when the trailing contact prong is inserted over the fault.

4-21. The first null should indicate the first fault. The fault is located halfway between the two prongs on the contact frame. To check that it is not a change in cable depth, rotate the contact frame with its center above the null and probe a circle around the fault. If it is a fault there should be a null completely around this spot.

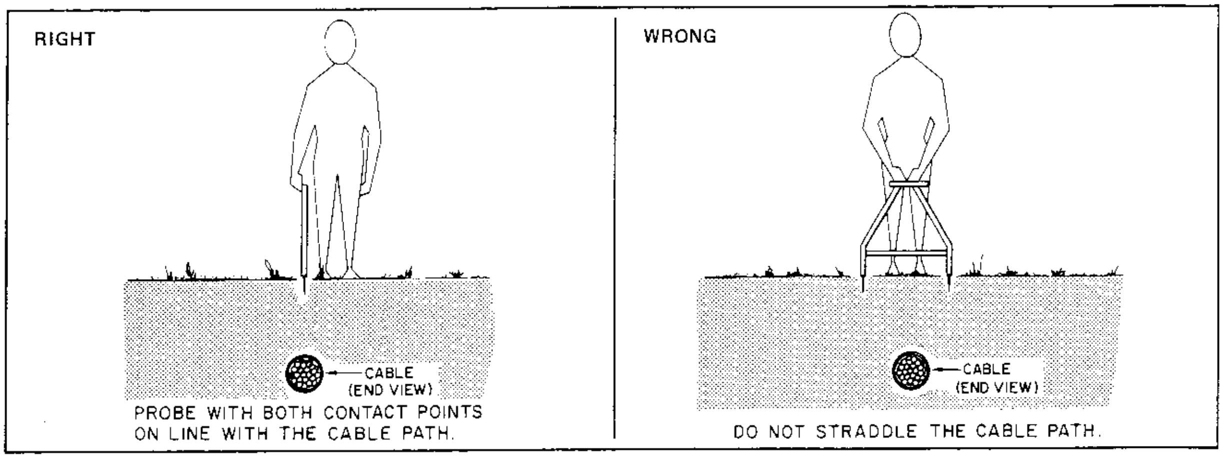


Figure 4-4. Using Contact Frame to Locate Earth Return Faults

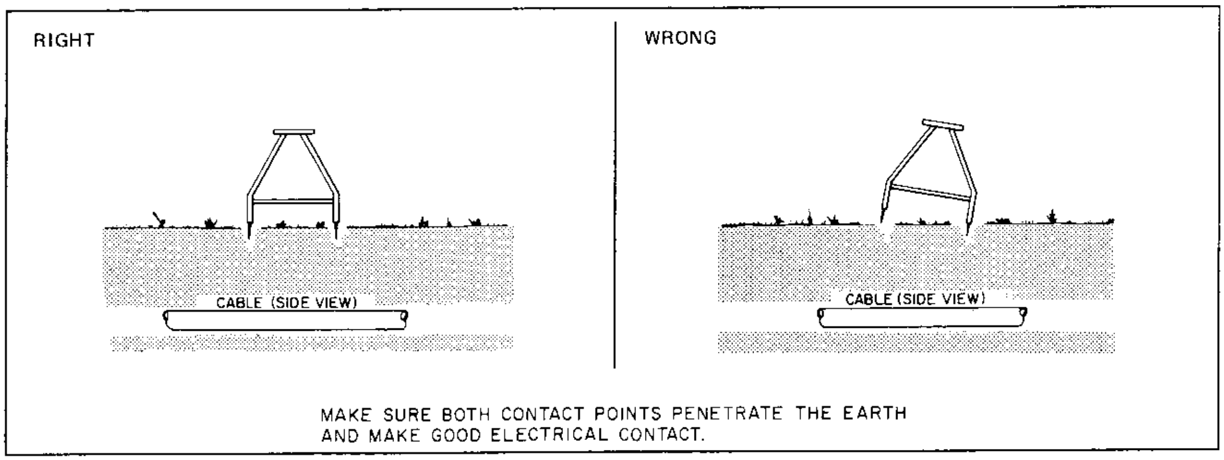


Figure 4-5. Proper Position of Earth Contact Frame

4-22. Proceed to locate the other shield-to-earth faults in a similar manner (see Figure 4-3). The characteristic peak-null-peak indication will be noticed as the fault is approached, located and passed.

NOTE

As the far-end of the faulty section is approached, it may become increasingly difficult to distinguish individual faults, depending upon the number of faults and the fault resistances. In this case, connect the transmitter to the far-end and shoot back to locate these faults.

4-23. If the apparent fault location as indicated by the search wand is under a hard surface it may be possible to approximately pinpoint the fault with the earth contact frame. As discussed in Paragraph 1-13 the earth gradient caused by an earth return fault extends a considerable distance from the fault. However, the strength of this earth gradient decreases with distance. If there are areas of earth within approximately 20 feet of the suspected fault location, these areas can be used for the contact frame.

4-24. Aligning the contact frame so that it points at the suspected fault location as shown at location "A" in Figure 4-6. Push the frame probes into the earth. Adjust the receiver COARSE GAIN and FINE GAIN for a reading of 60.

4-25. Rotate the contact frame a few degrees and again jab the probes in the ground. Note the meter reading. After rotating the frame through 180 degrees, the meter readings will be found to display a maximum and a minimum. The minimum reading will occur at right angles to the maximum reading. The maximum reading occurs when the frame is pointed directly at the fault. Sight down the frame and locate the point at which the line of sight crosses the cable path. Mark this spot.

4-26. Repeat the above procedure at one or two additional areas of earth. See location "B" in Figure 4-6. The spots marked on the cable path by this procedure should fall in a 2 to 3 foot distance. This will closely mark the fault location.

4-27. LOCATING CONDUCTOR-TO-SHIELD FAULTS IN BURIED AND UNDERGROUND CABLE

4-28. Analysis. When analyzing a conductor-to-shield fault, completely isolate the shield from ground. Quite often, a cross to a working tip or a cross to a grounded pair is mistaken for a conductor-to-shield fault, resulting in the signal "running wild" back to the central office. After isolating the shield, measure its resistance to see if it is faulted to ground. After determining that the shield is not grounded, measure the conductor resistance to ground to determine if it might be shorted to a working tip or grounded pair.

4-29. Sometimes the shield cannot be isolated because of a shield ground at a buried splice, making it impossible to completely analyze the fault. If it has been verified by other means that the fault is conductor-to-shield it can still be located as described under SPECIAL CASES.

4-30. Setup. (Refer to Figure 4-7.) Isolate the conductor and the shield from ground at both ends of the faulty section. Connect the red clip to the conductor and black clip "B" to the shield. Do not allow black clip "A" to touch ground. Measure the fault resistance. Normally conductor-to-shield faults up to 100,000 ohms may be located.

4-31. Set the transmitter selector switch to buried (990 Hz). With the receiver COARSE GAIN Control set to Step 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable, will give a null (minimum) reading and swinging the wand to either side of the cable will give a peak (maximum) reading. Carefully locate this peak and adjust the transmitter and receiver to the reference.

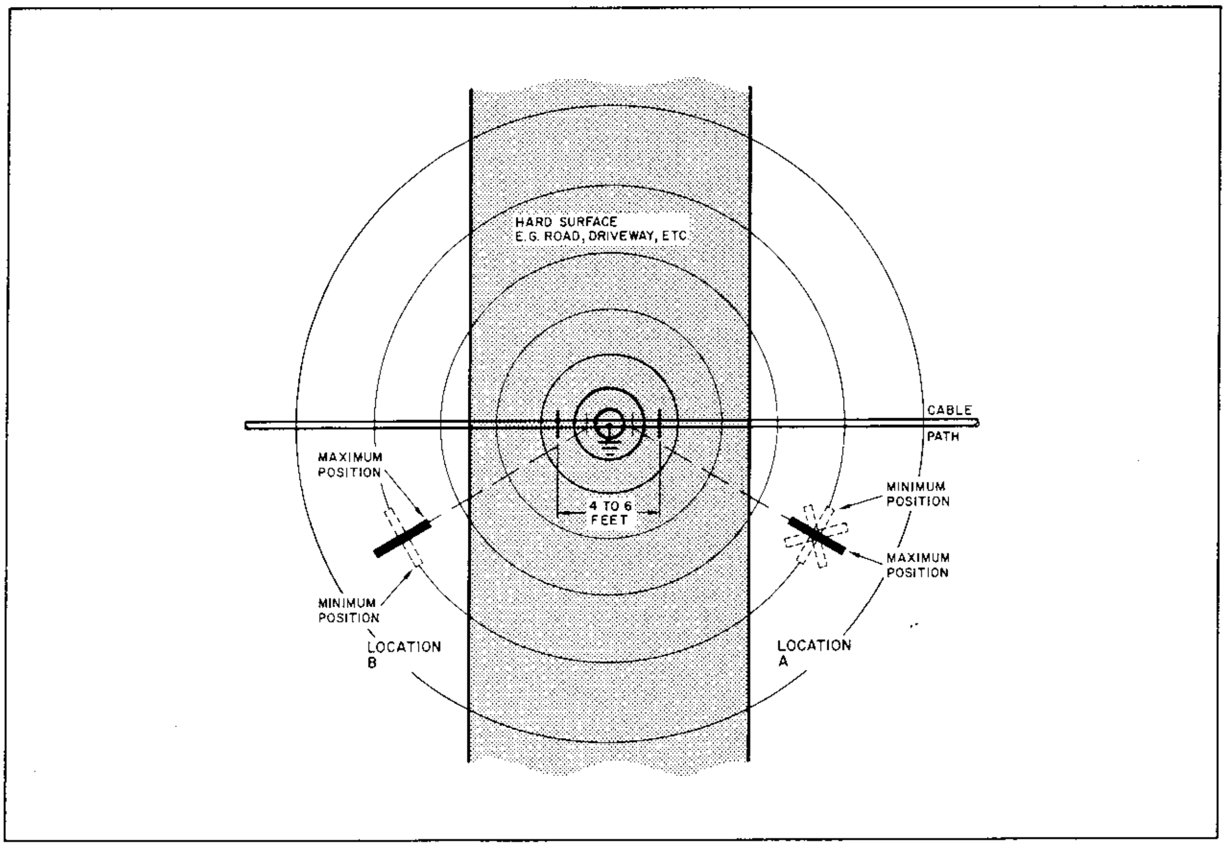
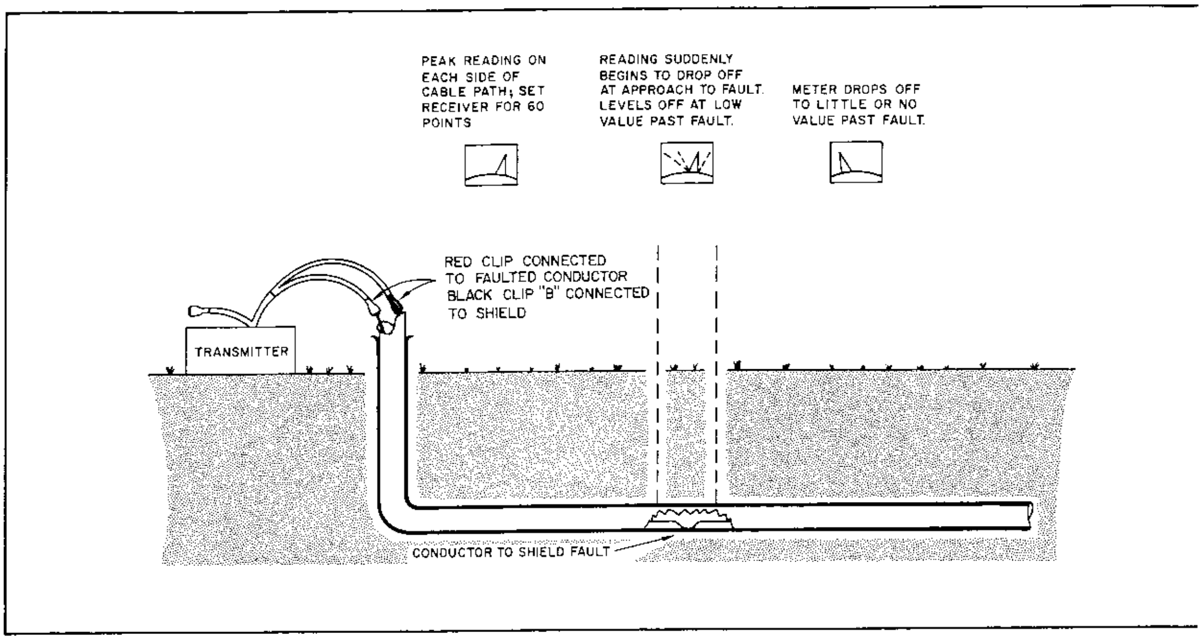
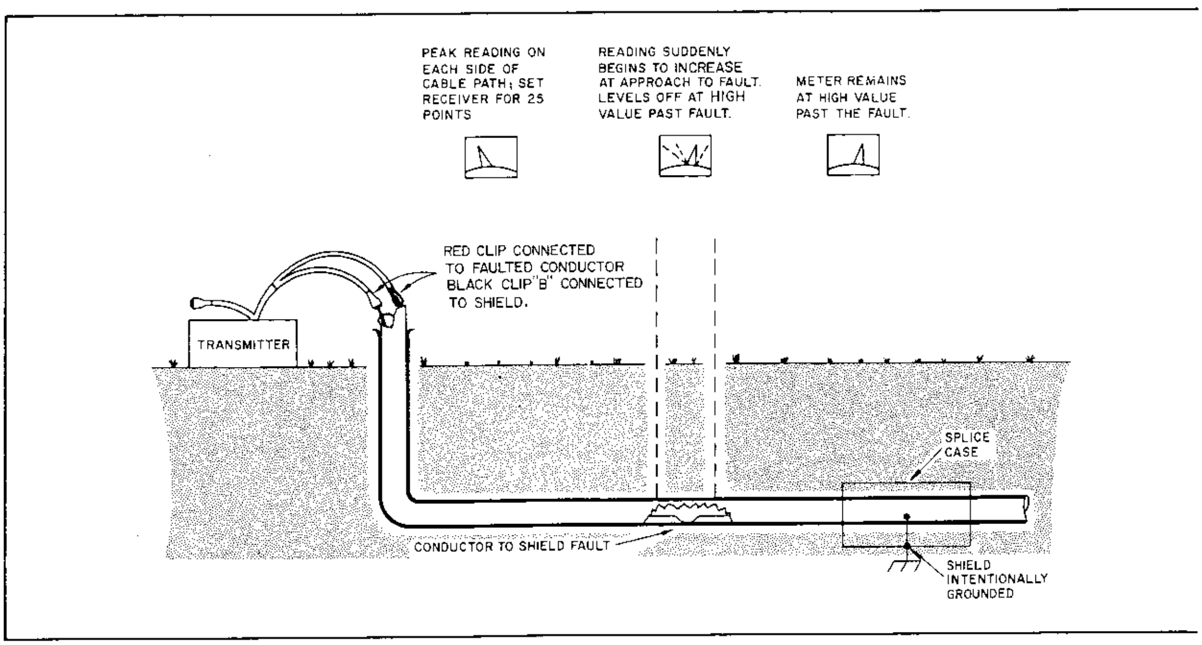


Figure 4-6. Locating Shield-to-Earth Fault with the Earth Contact Frame when the Fault is Under a Hard Surface



a. Shield Isolated from Ground Past Fault



b. Shield Intentionally Grounded Through Water-Tight Splice Case

Figure 4-7. Locating Conductor-to-Shield Fault in Buried and Underground Telephone Cable

4-32. Proceed to walk along the cable path, observing the meter reading. As the fault area is approached the signal will gradually increase or decrease. The change in signal will usually occur over a 6 to 8 foot distance. The fault is located between the start and end of the signal change.

4-33. Special Cases. If the shield is grounded at the far-end or in a buried splice beyond the fault, there will be a weak signal on both sides of the cable path until the fault area is approached. With the receiver COARSE GAIN Control set to Step 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference of 25 on the receiver with its FINE GAIN control. The indication in the fault area will be a sudden increase in signal over a 4 to 6 foot distance, followed by a leveling off at a high value. The fault is located halfway between the points where the signal starts to increase and where it starts to level off.

4-34. LOCATING CROSSES IN BURIED AND UNDERGROUND TELEPHONE CABLE

4-35. Analysis. Completely analyze the cable to determine whether there are also any shield-to-earth or conductor-to-shield faults that can be more easily located. Measure the resistance of the fault. If the fault is over 50,000 ohms, or if the cable is more than 3 feet deep, the fault may have to be located using the pothole technique. See Paragraph 4-44. In general, a cross of a conductor in one binder group to a conductor in another binder group will be easier to locate than crossed conductors in the same group.

4-36. Setup. (Refer to Figure 4-8.) Isolate both ends of the faulted conductors in as short a section as possible. Isolate the shield at both ends. Connect the red clip and black clip "B" metallically across the fault at the near-end. Do not allow black clip "A" to touch ground.

4-37. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control set to Step 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable, will give a varying peak signal reading and swinging the wand to either side of the cable will give decreasing signal reading. Carefully locate the peak signal over the cable and adjust the transmitter and receiver to the reference.

4-38. Procedure. Proceed to walk the cable, observing the meter reading over the cable path. A last peak signal will be observed, then the tone will decrease. The fault is located at the last peak.

4-39. LOCATING LOW RESISTANCE SHORTS IN BURIED AND UNDERGROUND TELEPHONE CABLE

4-40. Analysis. Very little signal is radiated from a shorted pair, making this type of fault very difficult to locate. Therefore, it is very important to completely analyze the fault to determine whether there is an easier fault to find. A 5,000 ohm short two feet deep

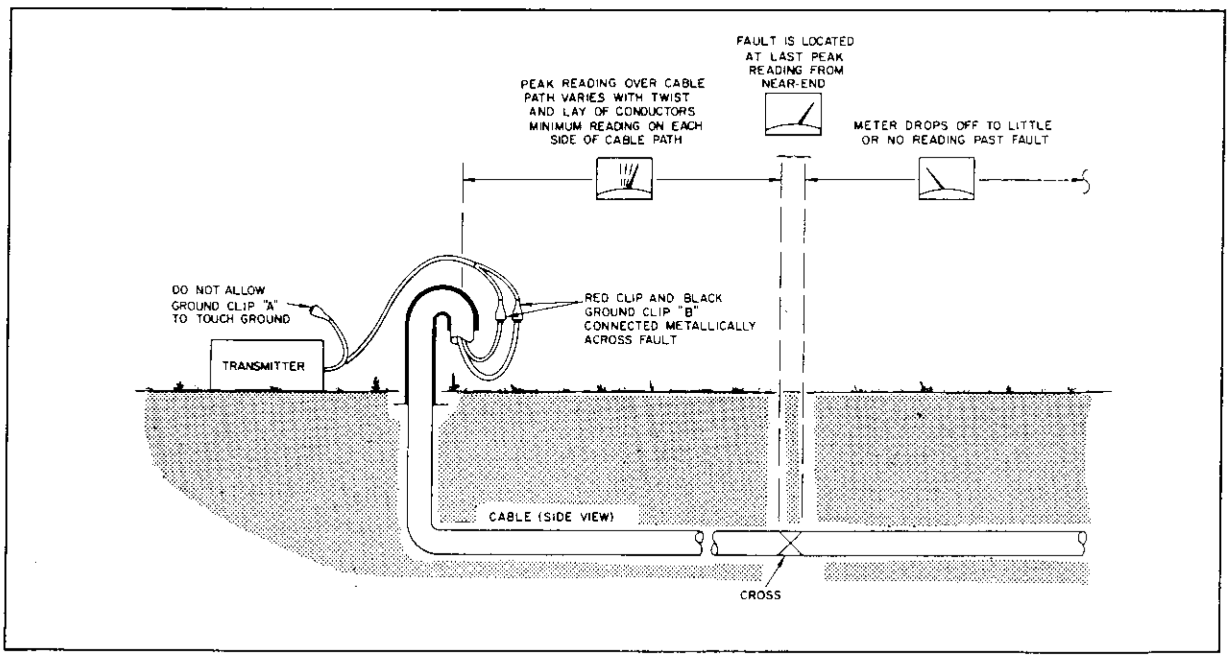


Figure 4-8. Locating a Cross in Buried and Underground Telephone Cable

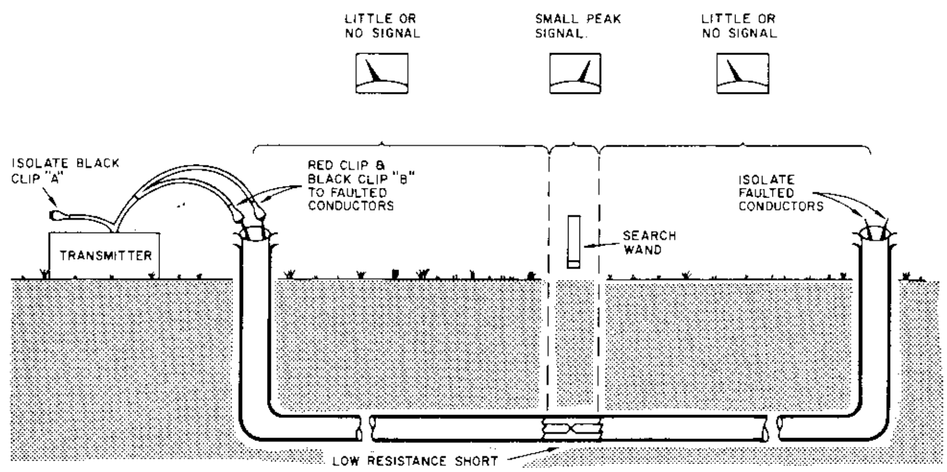


Figure 4-9. Locating Low Resistance Shorts in Buried and Underground Telephone Cable

in 50 pair cable can usually be located. Otherwise, if the short is higher resistance or the cable is buried deeper, or if the cable is smaller than 50 pair, the fault must be located by potholing, as explained in Paragraph 4-44.

4-41. Setup. (Refer to Figure 4-9.) Isolate both ends of the faulted conductors in as short a section as possible. Isolate both ends of the shield. A short cannot be located unless the shield is completely isolated from ground. Connect the red clip and black clip "B" metallically across the fault. Do not allow black clip "A" to touch ground.

4-42. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 10 or more on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable, will give a varying signal reading and swinging the wand to either side of the cable will give a diminishing signal reading. Carefully locate the peak over the cable and adjust the transmitter and receiver to the reference.

4-43. Procedure. Proceed to walk the cable, observing the meter reading over the cable path. There will be very little signal until the fault is approached. The signal will peak directly above the fault and decrease again past the fault.

4-44. LOCATING HIGH RESISTANCE SHORTS IN BURIED AND UNDERGROUND TELEPHONE CABLE-POTHOLE TECHNIQUE

4-45. Analysis. If a short is the only fault in the cable and it cannot be located by the preceding method, it is suggested that the potholing technique be used. In this way shorts up to 100,000 ohms can usually be located without cutting the cable and with a minimum of digging. Since the fault must be treated as an aerial short, it is necessary to refer to Figure 4-13 to determine the maximum allowable fault resistance and length of conductors beyond the fault.

4-46. Setup. (Refer to Figure 4-10.) Isolate both ends of the faulted conductors in as short a section as possible. (It does not matter whether the shield is grounded or not.) Connect the red clip and black clip "B" metallically across the fault. Black clip "A" must not touch ground.

4-47. Set the transmitter selector switch to AERIAL (150 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. Dig a pothole approximately 20 feet down the cable path from the near-end connections. Connect a hand exploring coil (such as the Bell System 105 or HP Model 18035A) to the receiver aerial jack and locate a peak signal on the cable. Since the signal varies, check all sides of the cable to locate a peak. Adjust the transmitter and receiver to the reference at the peak.

4-48. Procedure. Dig the first pothole halfway along the faulty section. The exploring coil can then be used to determine whether there is signal on the cable. If there is a healthy signal on the cable at the first pothole, then the fault is further toward the far-end. If there is little or no signal, then the fault has been passed.

NOTE

Because of the twist and lay of the conductors in the cable, there will be fluctuations in signal strength along the cable. When using the exploring coil, check all sides of the cable for a maximum signal. There may be some "carry-by" of the signal past the fault, but the level will be greatly deduced.

4-49. After determining which direction the fault lies from the first pothole, proceed to halve this section and repeat until the fault is precisely located.

4-50. LOCATING SIMPLE SPLITS IN BURIED AND UNDERGROUND TELEPHONE CABLE

4-51. Analysis. Since a split always occurs at a closure it is a relatively easy fault to locate. As a general rule, a split can be located under the same conditions that a 5,000 ohm short or a 50,000 ohm cross could be found.

4-52. Setup. (Refer to Figure 4-11.) After isolating the split to as short a section as possible, strap one pair at the far-end and connect the Fault Locator as shown. Black clip "A" must not touch ground.

4-53. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control set to Step 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable, will give a varying peak signal reading and swinging the wand to either side of the cable will give a decreasing signal reading. Carefully locate this peak over the cable and adjust the transmitter and receiver to the reference.

4-54. Procedure. Proceed to walk the cable, observing the meter reading over the cable path. When the closure containing the split is passed, the reading will drop off to approximately half or less.

4-55. LOCATING CORRECTED SPLITS IN BURIED AND UNDERGROUND TELEPHONE CABLE

4-56. Analysis. Occasionally an attempt will be made to correct a split at another closure, resulting in excessive crosstalk on the two pairs. Both the split and the correction can be located as easily as a simple split, since they both occur in closures.

4-57. Setup. (Refer to Figure 4-12.) After isolating the split and correction to as short a section as possible, strap one pair at the far-end and connect the Fault Locator as shown above. Black clip "A" must not touch ground.

4-58. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control

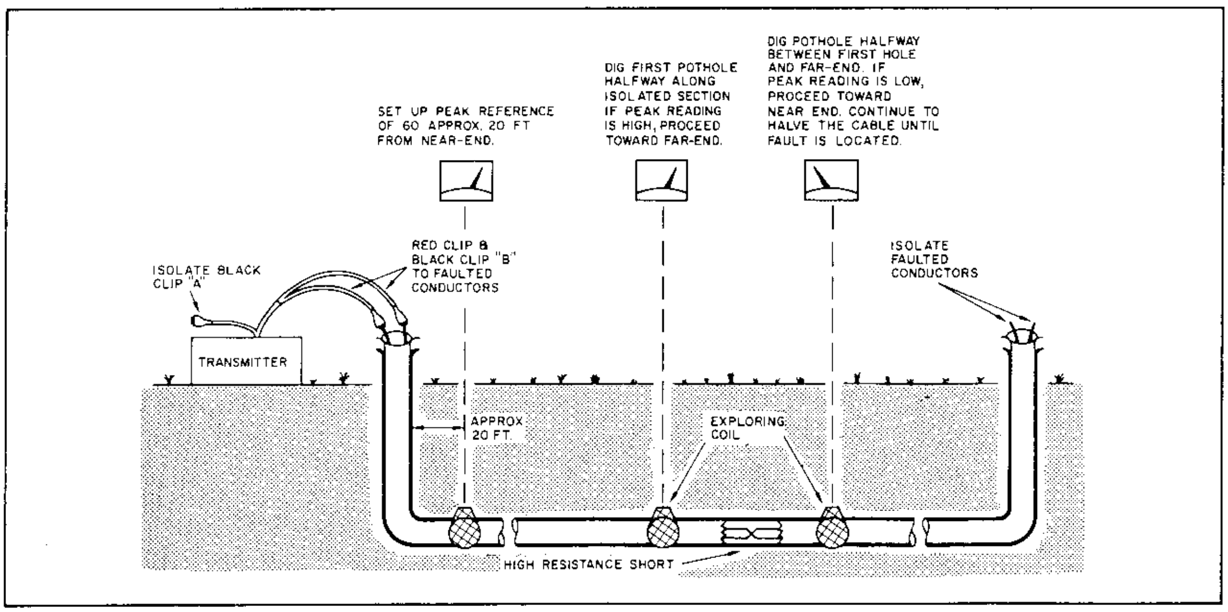


Figure 4-10. Locating High Resistance Short in Buried and Underground Telephone Cable by the Pothole Method

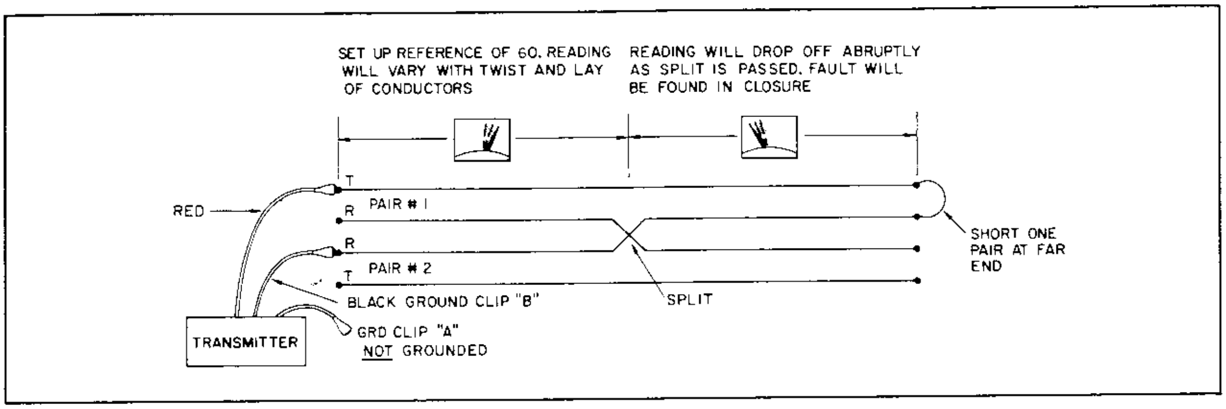


Figure 4-11. Locating Simple Splits

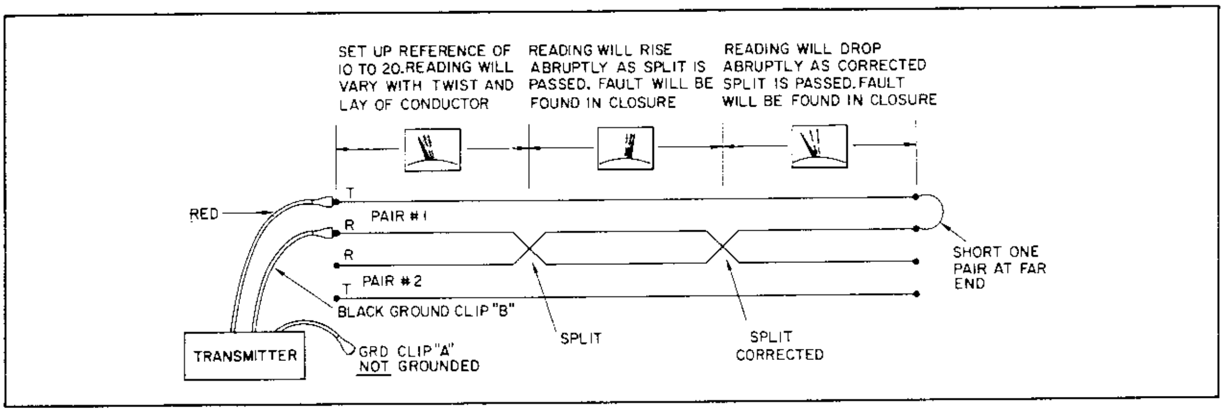


Figure 4-12. Locating Corrected Splits

set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 25 on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable, will give a varying peak signal reading and swinging the wand to either side of the cable will give a decreasing signal reading. Carefully locate this peak over the cable and adjust the transmitter and receiver to the reference.

4-59. Procedure. Proceed to walk the cable, observing the meter reading over the cable path. The signal will rise abruptly after the split is passed and will drop off again as the split correction is passed.

4-60. LOCATING FAULTS IN AERIAL AND BLOCK TELEPHONE CABLE

4-61. TECHNIQUES. The techniques for fault locating in aerial cable differ somewhat from those used on buried and underground cable because of the small amount of transmitter signal that is radiated into the air. For this reason, a pole mounted exploring coil (such as the Bell System 105 or HP Model 18034A) must be used in lieu of the search wand.

4-62. The six cardinal rules for fault locating in buried and underground cable also apply to aerial and block cable. To these rules, add this rule for tracing faults on aerial and block cable:

> The exploring coil should always be held against the cable sheath with the center groove on the cable. If the exploring coil is held away from the cable very little signal will be received and false trouble indications may result.

4-63. PRELIMINARY ANALYSIS. The most important step to successful fault locating is completely analyzing the trouble(s) in the cable before attempting to locate anything. No matter what sort of trouble is reported, always look for possible additional faults. Testing with the ohmmeter to determine which fault is easiest to locate. The ease of locating types of aerial faults is listed in order below:

1. Cross
2. Short
3. Conductor-to-shield

4-64. There are two major factors that determine the ease of locating a fault in aerial cable: (1) the resistance of the fault, and (2) the length of the faulted conductors beyond the fault. Since the conductors have their own signal return paths due to cable capacitance, part of the return circuit will be through this capacitance and part through the fault. Therefore, it is important that at least half the signal be returned at the fault in order to detect a distinct drop in the signal at fault point. In other words, the fault resistance must be at least equal to the cable resistance (i. e.; impedance) past the fault in order for the meter to register a 50% drop (60 to 30). The longer the conductors beyond the fault, the more signal "carry-by".

4-65. Figure 4-13 is a graph which should always be referred to in analyzing whether the fault can be located within the isolated section. After measuring the fault resistance, refer to the graph to determine the maximum allowable conductor length beyond the fault. The diagonal line indicates the point at which the fault resistance is equal to the cable impedance.

EXAMPLE #1

Suppose a 5,000 ohm fault is isolated to a 1,000 foot section of cable. Referring to the graph, find that the 5,000 ohm line intersects with the 1,000 foot line in the "can find fault" area. This fault should be easy to locate.

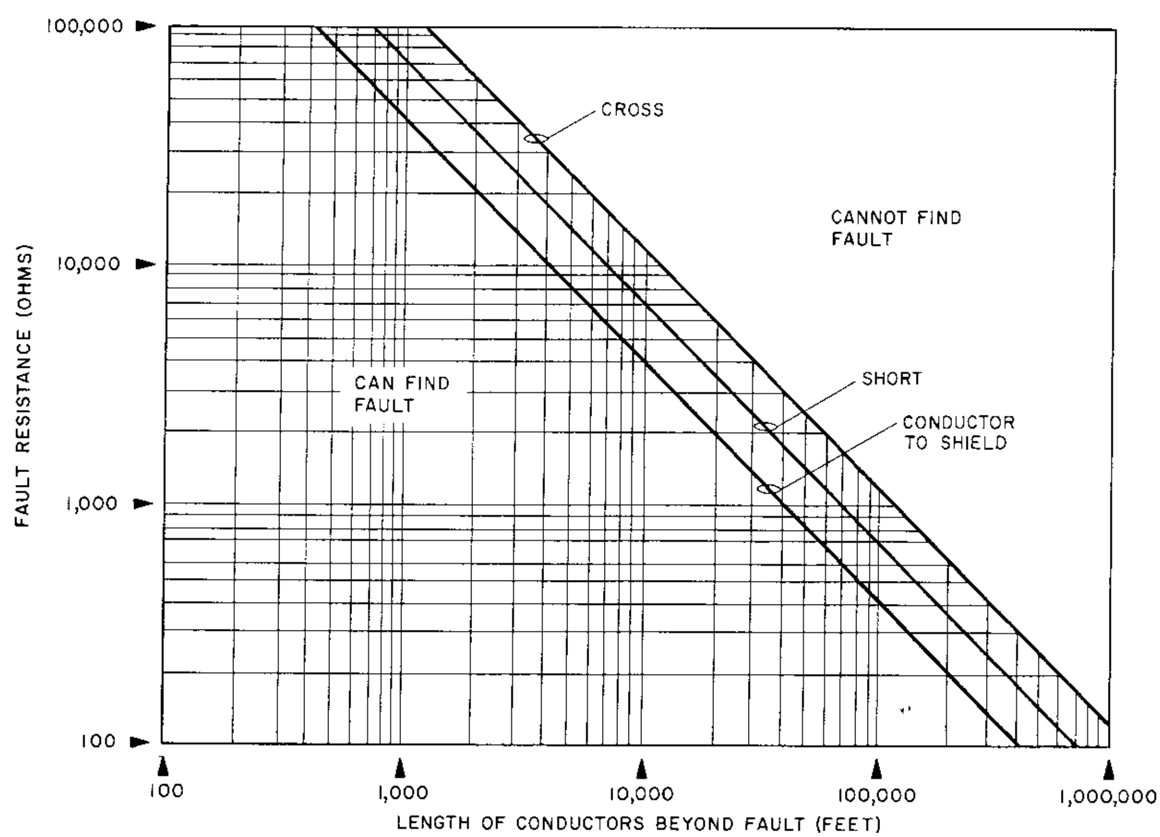


Figure 4-13. Resistance-Versus-Distance Chart for Aerial Cable Fault Location

EXAMPLE #2

There is a 10,000 ohm short in a 10,000 foot section of cable. These lines intersect in the "cannot find fault" area. In this instance, it would be very difficult to locate a fault close to the near-end. It would be necessary to shoot the trouble from both ends or isolate to a 8,000 foot section.

4-66. LOCATING CROSSES IN AERIAL CABLE

4-67. Analysis. After determining that the fault is a cross, measure the fault resistance and refer to Figure 4-14 to determine within how long a section the fault must be isolated.

4-68. Setup. Connect red clip and black clip "B" metallically across the fault. Ground clip "A" must not be allowed to touch ground.

4-69. Set the transmitter selector switch to AERIAL (150 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable at least 10 feet from the near-end connections. Holding the exploring coil against the cable; notice that the reading varies as the coil is moved along the cable. Carefully locate a peak and adjust the transmitter and receiver to the reference.

4-70. Procedure. Rather than explore the entire length of isolated cable, it is suggested that the cable be spot checked to see if the signal has dropped off. For example, check first at the halfway point to determine which half of the section the fault is in; and continue to halve the cable until the fault has been localized. As the exploring coil is moved along the cable notice a periodic fluctuation in signal due to the twist and lay of the conductors. However, there will be an abrupt drop in the peak signal level past the fault.

NOTE

A change in cable size may affect the signal intensity. A larger cable may decrease the signal and a smaller cable may increase the signal because of the position of the coil to the faulted pairs.

4.71. LOCATING SHORTS IN AERIAL CABLE

4-72. Analysis. A solid or near solid short is as easy to find as a cross. However, a high resistance short (30,000 ohms or higher) is more difficult to pinpoint and therefore carefully analyze all trouble to see if there are any easier to locate faults. Isolate the faulted conductors at both ends in as short a section as possible and measure the fault resistance. Refer to Figure 4-14 to determine whether the fault is locatable. If the chart indicates the "cannot find" area, try locating the fault from both ends of the isolated section anyway, since the fault may be near one end of the section.

4-73. Setup. Connect red clip and black clip "B" metallically across the fault. Ground clip "A" must not be allowed to touch ground.

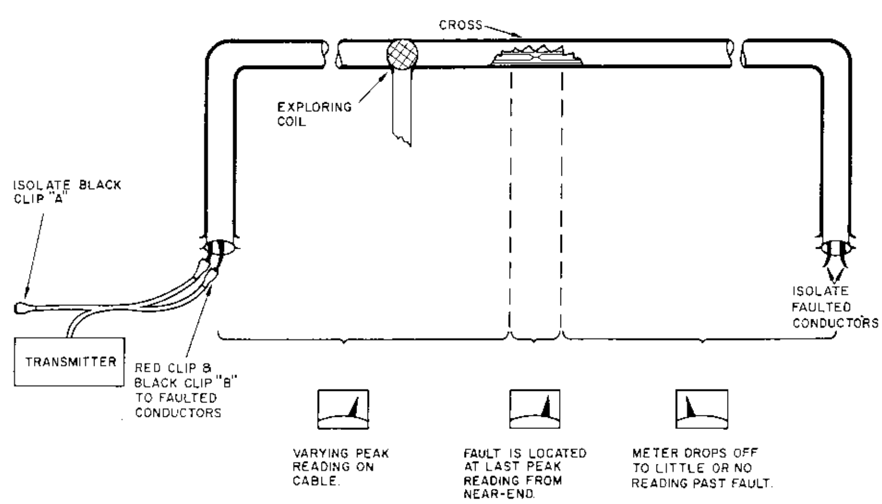


Figure 4-14. Locating Cross and Short in Aerial Telephone Cable

4-74. Set the transmitter selector switch to AERIAL (150 Hz). With the receiver COARSE GAIN set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable at least 10 feet from the near-end connections. Holding the exploring coil against the cable, notice that the reading varies as the coil is moved along the cable. Carefully locate a peak and adjust the transmitter and receiver to the reference.

NOTE

In setting up the receiver reference, locate a peak reading on the cable at least 10 feet from the transmitter connections. Note the value of this peak reference very carefully as the signal beyond the fault may drop only 30 to 40 points on a high resistance fault with a maximum allowable length of cable beyond the fault.

4-75. Rather than walk the entire section of cable, first check the signal at the midpoint in the isolated section. In this way, the fault will be isolated to half of the cable. For example, if the peak signal has dropped considerably, the fault has been passed. Continue to "halve the cable" until the fault is isolated to a short section.

NOTE

Because the signal will vary every 2 to 4 feet with the twist and lay of the conductors, explore several feet of cable to locate the peak.

4-76. When the fault is passed, the peak signal will drop abruptly. This drop may be only 30 points, or it may drop all the way to zero, depending on the fault resistance and the length of the conductors beyond the fault. The lower the resistance of the fault and shorter the length of cable beyond the fault, the less "carry-by" signal.

NOTE

A change in cable size may affect the signal intensity. A larger cable may decrease the signal and a smaller cable may increase the signal because of the position of the coil to the faulted pairs.

4-77. LOCATING CONDUCTOR-TO-SHIELD FAULTS IN AERIAL CABLE

4-78. Analysis. Carefully analyze the fault to determine that it is not a cross to a working tip or to a grounded pair. These faults will usually result in the tone "running wild" back to the main frame. Isolate the faulted conductor and the shield at both ends in as short a section as possible and measure the fault resistance. Refer to Figure 4-13 to determine whether the fault is locatable. If the chart indicates that the fault is in the "cannot find" area, try locating the fault from both ends of the isolated section anyway, since the fault may be near one end of the section.

4-79. Setup and Procedure. Connect red clip to the conductor and black clip "B" to the shield. Ground clip "A" must not be allowed to touch ground.

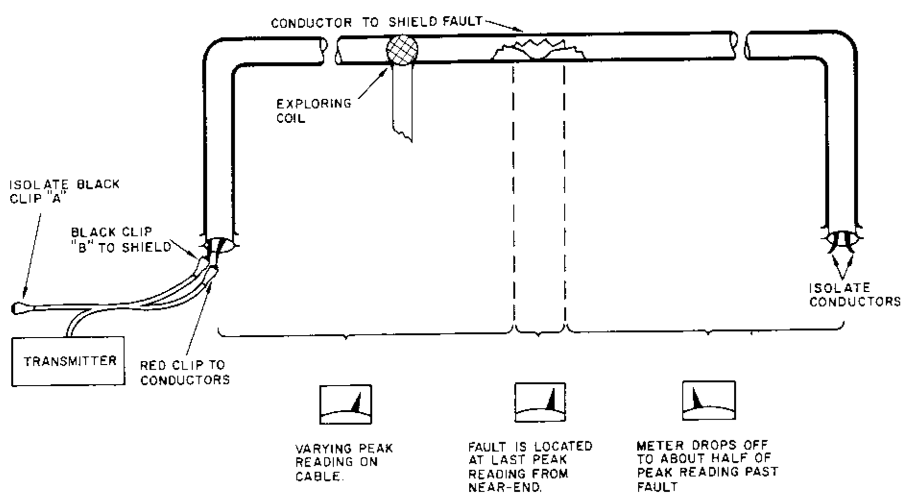


Figure 4-15. Locating Conductor-to-Shield Faults in Aerial Telephone Cables

4-80. Set the transmitter selector switch to AERIAL (150 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable at least 10 feet from the near-end connections. Holding the exploring coil against the cable, notice that the reading varies as the coil moves along the cable. Carefully locate a peak and adjust the transmitter and receiver to the reference.

NOTE

In setting up the receiver reference, locate a peak reading on the cable at least 10 feet from the transmitter connections. Note the value of this peak reference very carefully as the signal beyond the fault may drop only 10 to 20 points on a high resistance fault and a maximum allowable length of cable beyond the fault.

4-81. Rather than walk the entire section of cable, first check the signal at the midpoint in the isolated section. In this way, the fault will be isolated to half of the cable. For example, if the peak signal has dropped considerably, the fault has been passed. Continue to "halve the cable" until the fault is isolated to a short section.

NOTE

Because the signal will vary every 2 to 4 feet with the twist and lay of the conductors explore several feet of cable to locate the peak.

4-82. When the fault is passed, the peak signal will drop abruptly. This drop may be only 10 points, or it may drop all the way to zero, depending on the fault resistance and the length of the conductors beyond the fault. The lower the resistance of the fault and shorter the length of cable beyond the fault, the less "carry-by" signal.

4-83. A solid (zero ohm) conductor-to-shield fault will usually produce a field from the cable that can be detected with the search wand from a distance of about 50 feet. This fault may then be found by holding the wand out the window of a car or truck and noting the location where the signal disappears. Pinpointing the fault can then be done with an exploring coil.

4-84. LOCATING SIMPLE SPLITS IN AERIAL TELEPHONE CABLE

4-85. Analysis. Since a split always occurs at a closure it is a relatively easy fault to locate.

4-86. Setup. (Refer to Figure 4-11). After isolating the split to as short a section as possible, strap one pair at the far-end and connect the Fault Locator as shown above. Black clip "A" must not touch the ground.

4-87. Set the transmitter selector switch to AERIAL (150 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable at least 10 feet from the near-end connections. Holding the exploring coil against the cable, notice that the reading varies as the coil moves along the cable. Carefully locate a peak and adjust the transmitter and receiver to the reference.

4-88. Procedure. Rather than explore the entire length of the isolated cable, spot check only at the closures. Carefully check the signal level for 3 to 4 feet on each side of the closure. As the closure containing the split is passed, the reading will drop off to approximately half or less.

NOTE

A change in cable size may affect the signal intensity. A larger cable may decrease the signal and a smaller cable may increase the signal because of the position of the coil to the faulted pairs.

4-89. LOCATING CORRECTED SPLITS IN AERIAL TELEPHONE CABLE

4-90. Analysis. Occasionally an attempt will be made to correct a split at another closure, resulting in excessive cross talk on the two pairs. Both the split and the correction can be located as easily as a simple split, since they both occur in closures.

4-91. Setup. (Refer to Figure 4-12.) After isolating the split and correction to as short a section as possible, short one pair at the far-end and connect the Fault Locator as shown above. Black clip "A" must not touch ground.

4-92. Set the transmitter selector switch to AERIAL (150 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 25 on the receiver with its FINE GAIN control. The reference should be set up down the cable at least 10 feet from the near-end connections. Holding the exploring coil against the cable, notice that the reading varies as the coil moves along the cable. Carefully locate a peak and adjust the transmitter and receiver to the reference.

4-93. Procedure. Rather than explore the entire length of the isolated cable, spot check only at the closures. Carefully check the signal level for 3 to 4 feet on each side of the closure. As the first closure is passed containing a split, the reading will rise abruptly to approximately double. As the second closure is passed containing the split correction, the reading will drop off to about its original value again.

NOTE

A change in cable size may affect the signal intensity. A larger cable may decrease the signal and a smaller cable may increase the signal because of the position of the coil to the faulted pairs.

4-94. SUMMARY TABLES

4-95. For the experienced craftsman, Tables 4-1 and 4-2 provide fault-finding information in capsule form. Table 4-1 pertains to Buried and Underground Telephone Cable and Table 4-2 pertains to Aerial Telephone cable. The summary information is a particularly useful reference tool for those who have mastered the fundamental details described earlier.

Table 4-1. Fault-Finding Summary of Buried and Underground Telephone Cable

Type of Fault	Fault Resistance Level	Isolation	Reference Setting	Fault Indication
Shield-to-earth using the wand	500,000 ohms	Isolate shield at both ends	Step 6 or above; 60 pts wand to the side.	Signal will slowly decrease over a 4-6 ft distance. The signal will then level out to a low level. The fault is approximately in the middle of the 4-6 ft. area.
Shield-to-earth using the Contact Frame	500,000 ohms	Isolate shield at both ends	Any step to give 5-10 pts over the cable.	Signal will peak when the leading probe of the contact frame is at the fault and will null when the frame is over the fault. Note: The null will be very narrow, probably not more than an inch or two wide.
Conductor-to-shield. Case 1	100,000 ohms	Isolate shield at both ends. Check to see if grounded to working tip.	Step 6 or above; 60 pts with wand to the side.	Signal will slowly decrease over an area 4-6 ft. distance to a constant low level. Fault is approx. in the middle of the 4-6 ft. area.
Conductor-to-shield. Case 2	100,000 ohms	Isolate conductor and shield at near end. Isolate the conductor at far end. Shield grounded at far end or past fault.	Step 6 or above; 25 pts wand to the side.	Signal will slowly increase over a 4-6 ft. distance to a constant high level. Fault is approx. in the middle of the 4-6 ft. area.
Cross	50,000 ohms	Isolate fault conductors and the shield at both ends.	Step 6 or above; 60 pts wand pointing at cable.	Signal will vary over the cable giving a peak valley peak signal. Tone will peak and return to a low level signal after the fault. Fault is located at the last peak from the transmitter.
Short	5,000 ohms 2 ft. deep	Isolate the faulted conductors and the shield at both ends.	Setting 6 or above; 10 pts or more. Wand pointing at cable.	The signal will vary along the cable, peak-valley-peak. The last peak from the transmitter end will be the fault.

Table 4-1. Fault-Finding Summary of Buried and Underground Telephone Cable (Cont'd)

Type of Fault	Fault Resistance Level	Isolation	Reference Setting	Fault Indication
Short Pothole technique	100,000 ohms	Isolate fault conductor at both ends. Isolate the shield.	Step 6 or above; 60 pts coil close to the cable. Use 150 Hz signal.	Signal will drop sharply at the fault. Location can be pinpointed by using the halving technique.
Simple Split	None	Strap one pair at the far end. Isolate the shield.	Step 6 or above; 60 pts wand pointing at cable.	Run the signal on the strapped conductors. At the closure with the split the signal will decrease as the conductors change from a simulated cross to a short.
Corrected Split	None	Strap one pair at the far end. Isolate the shield.	Step 6 or above; 25 pts wand pointing at cable.	Run the signal on the strapped conductors. At the first closure with a split the signal will increase (simulated short to a cross). At the second closure with the split correction the signal will decrease.

Table 4-2. Fault-Finding Summary of Aerial Telephone Cable

Type of Fault	Isolation	Reference Setting	Fault Indication
Cross	Isolate faulted conductors at both ends.	Step 6 or above; 60 pts.	Varying peak signals along the cable. Fault is located at last peak reading, little or not signal beyond the fault. In setting the 60 pt. ref., be sure to find the peak signal.
Short	Isolate faulted conductors at both ends.	Step 6 or above; 60 pts.	Varying peak signals along the cable. Fault is located at last peak reading, little or no signal beyond the fault. In setting the 60 pt. ref., be sure to find the peak signal.
Conductor-to-Shield	Isolate faulted conductor and shield at both ends. Check to be sure not crossed to a working tip.	Step 6 or above; 60 pts.	Varying peak signals along the cable. Fault is located at last peak reading. Varying low level signal past the fault.
Simple Split	Strap one pair at the far end.	Step 6 or above; 60 pts.	Run the signal on the strapped conductors. At the closure with the split the signal will decrease as the conductors change from a simulated cross to a short.
Corrected Split	None	Step 6 or above; 25 pts. wand pointing at cable.	Run the signal on the strapped conductors. At the first closure with a split the signal will increase (simulated short to a cross). At the second closure with the split correction the signal will decrease.

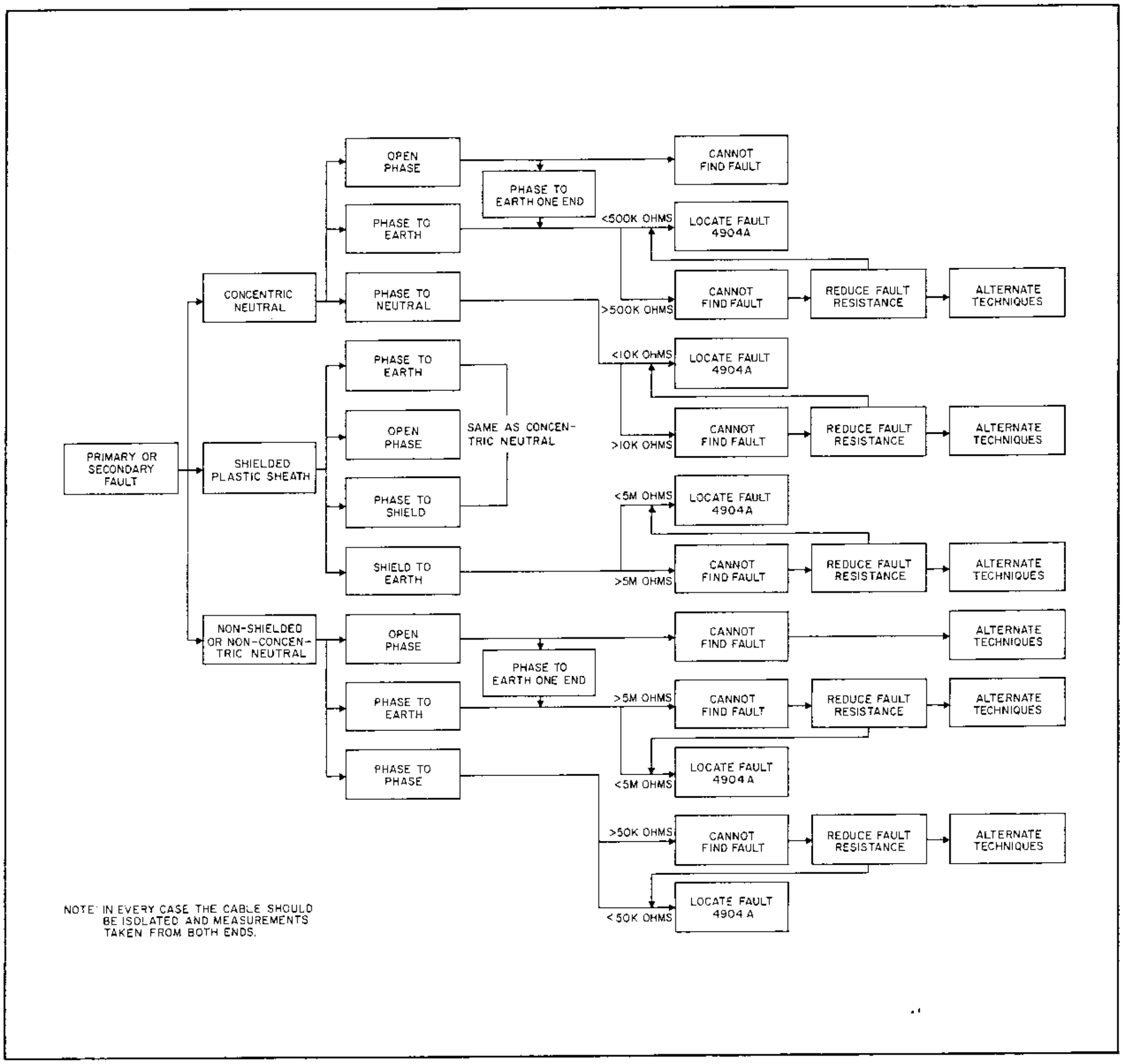


Figure 5-1. Power Fault Analysis Chart

SECTION V
OPERATION
(LOCATING FAULTS IN POWER CABLE)

5-1. GENERAL

5-2. There are eight cardinal rules for locating faults in power cable. They are:

Rule 1. PRIMARY ANALYSIS. The most important step in troubleshooting a fault is the initial analysis. Always look for additional faults. When multiple faults exist, always test with an ohmmeter to see which will be easiest to find. Refer to Figure 5-1.

Rule 2. Isolate the fault to the shortest possible section before trying to pinpoint the fault. This practice not only saves time and leg work, but also makes the fault much easier to pinpoint. By isolating both ends of the faulty section, there is less chance of signal "carry-by" past the fault and erroneous indications.

Rule 3. Measure the fault resistance from both ends. Sometimes a fault will measure a very high resistance from one end and much lower from the other end. This can be caused by the current at the time of fault forming a high resistance path around one side of the fault. Always locate from the low resistance end.

Rule 4. Never use more transmitter signal than necessary. Normally, this consists of a SIGNAL LOADING switch setting which will give a receiver reading of 60 with the gain turned high. However, in cases where there is exceptionally high induced voltage (1020 Hz power line harmonic) it may be necessary to use high transmitter output and low receiver gain. In this case, set the SIGNAL LOADING switch to the highest position on which the OUTPUT lamp flashes.

Rule 5. When the characteristic beep-beep-beep from the 7 pulses per second cannot be heard, the fault cannot be run. If any repeatable reference signal can be established, it will be possible to attempt to locate the fault. The fault indication may not be what is expected or predicted in this manual. For example, if the tone changes substantially, the reason could be a change in depth, other metal objects in the ground, or a fault. In summary, a fault may be indicated by any substantial change in tone.

Rule 6. Never allow the receiver gain to be set so high that the meter reads above 60. The meter is electronically guarded so intense signals will not damage it. A meter reading of 95 may actually represent a signal strength of 200, so that even a 50 to 100 point decrease would barely register.

Rule 7. Isolate the unused ground clip A or B from making ground contact.

Rule 8. When using a separate ohmmeter, be sure that the transmitter connections are on the same circuit as those tested with the ohmmeter.

5-3. DETERMINING PATH AND DEPTH OF BURIED AND UNDERGROUND POWER CABLE

5-4. Locating the precise path and depth of the cable is an essential first step. Often, a deviation in the cable path, or an abrupt cable depth change will give an indication similar to that of a fault. A good rule to follow is: Before digging double check the cable path and that the indication is not the result of a depth change.

5-5. Refer to Section III of this manual for detailed instructions on determining path and depth. However, for power cable, it will be necessary to ground the far end of the cable to an isolated ground rod.

5-6. LOCATING PHASE-TO-EARTH FAULTS IN BURIED AND UNDERGROUND POWER CABLE

5-7. Analysis. De-energize the circuit and isolate both ends of the faulted conductor in as short a section as possible. Measure the fault resistance. Phase-to-earth faults as high as 500,000 ohms can be located with the Model 4904A.

NOTE

If there is any foreign voltage on the conductor this will cause an erroneous ohmmeter reading. To check for voltage, operate the OHMS-REVERSE switch on the transmitter. Any significant difference in the reverse readings indicates that there is induced or leakage voltage present and the resistance reading is incorrect.

5-8. Setup. (Refer to Figure 5-2.) Connect the red clip to conductor and isolate black ground clip "B" so that it does not touch ground or short to the red clip.

5-9. Move the transmitter 15 to 20 feet perpendicular to the path of the cable and drive the ground rod so that the black ground lead "A" can be clipped to it. In certain instances of dry or sandy soil, a longer rod, such as a reinforcing bar, must be used.

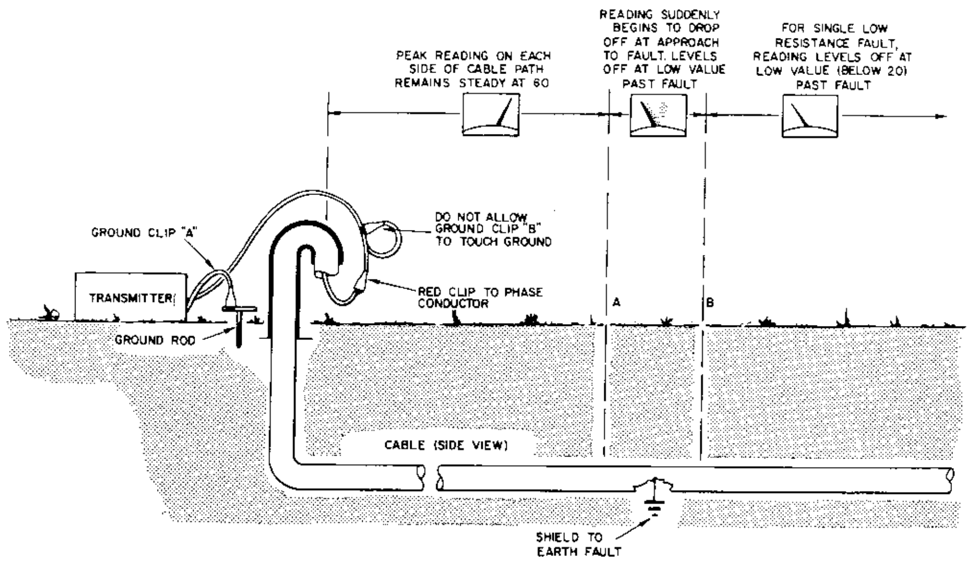


Figure 5-2. Locating Single Phase-to-Earth Fault Using Search Wand

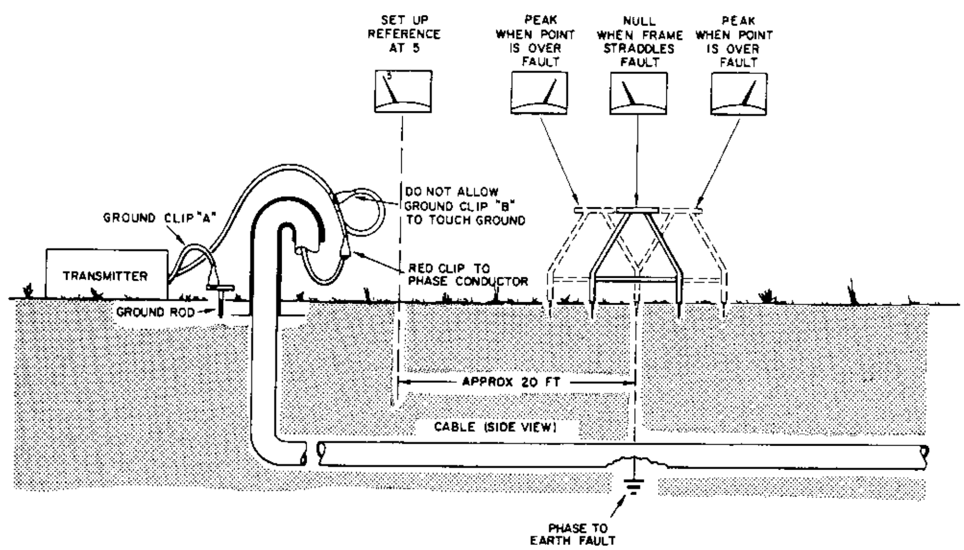


Figure 5-3. Locating Phase-to-Earth Fault with Earth Contact Frame

NOTE

It is important the transmitter and ground rod always be placed as far away from the cable path as possible (see Figure 3-2). Never use water pipes or other distributed grounds. Insulated guys perpendicular to the cable path make excellent grounds, however.

5-10. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable path approximately 10 feet from the near-end connections. Pointing the search wand at the cable, will give a null (minimum) reading and swinging the wand to either side of the cable will give a peak (maximum) reading. Carefully locate this peak and adjust the transmitter and receiver to the reference.

5-11. Procedure. The locating procedure is the same as for locating the cable path except that the peak signal on each side of the cable path will fall off sharply as the fault is approached and will become weaker beyond the fault. The higher the resistance of the fault and the more cable beyond the fault, the greater the signal "carry-by."

5-12. Proceed to walk the cable, observing the meter reading on both sides of the cable path. When a sudden decrease in the meter reading is noticed mark the spot where the reading first starts to drop off. Proceed slowly and watch the meter for the point at which the decreasing reading levels out at a low value (usually 20 or less). Mark this point. The fault will be located halfway between the two marks. For most single, low resistance faults, the distance between marks will be about 4 to 6 feet.

NOTE

Similar readings may result where the cable drops to a lower depth. If there is some doubt whether a fault or a depth change has been located recheck the cable depth before digging. These checks should be made approximately 10 feet ahead of and 10 feet beyond the point that the meter dip was noticed.

5-13. If the fault resistance is too high or if there are multiple phase-to-earth faults, it may be difficult to pinpoint the fault(s) with the search wand. The earth contact frame can be used to precisely locate these faults, as explained in the following section. Faults up to approximately 5 megohms may be located using the contact frame. To closely locate suspected faults under hard surfaces refer to Paragraph 4-24.

5-14. PINPOINTING PHASE-TO-EARTH FAULTS IN BURIED POWER CABLE WITH THE EARTH CONTACT FRAME

5-15. Setup. (Refer to Figure 5-3.) After determining the general area of the fault with the search wand, as explained on the preceding page, connect the earth contact frame to the receiver and move back toward the near-end about 20 feet from where the signal started to drop off. With the contacts of the frame inserted over (in line with) the cable path, adjust the receiver gain for a reference of 5 to 10 on the meter. Refer to Figures 4-4 and 4-5 for correct use of the contact frame.

5-16. Procedure. Proceed to walk the cable path inserting the contacts into the earth over (in line with) the cable about every three feet. As the fault is approached the signal will increase sharply. Turn the receiver gain down as necessary to keep the meter below 60. Reduce probing intervals to a few inches.

5-17. There will be a peak reading when the leading contact probe is inserted over the fault, a null when the frame is centered over the fault, and another peak when the trailing contact probe is inserted over the fault.

5-18. Proceed to locate other phase-to-earth faults in a similar manner. Notice the characteristic peak-null-peak indication as the fault is approached, located and passed.

NOTE

As the far-end of the faulty section is approached it may become increasingly difficult to distinguish individual faults, because of the loss of signal. In this case, it is recommended that the transmitter be connected to the far-end and shoot back to locate these faults.

5-19. LOCATING PHASE-TO-PHASE AND PHASE-TO-NEUTRAL FAULTS IN BURIED AND UNDERGROUND POWER CABLE

5-20. Analysis. De-energize the circuit and isolate both ends of the faulted conductors in as short a section as possible. Measure the fault resistance. Phase-to-neutral and phase-to-phase faults as high as 100,000 ohms can be located with this instrument.

5-21. Setup. (Refer to Figure 5-4.) Connect the red clip to the conductor and black clip "B" to the neutral or other phase. Do not allow black clip "A" to touch ground.

5-22. Procedure. Set the transmitter selector switch to BURIED (990 Hz). With the receiver GAIN CONTROL set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable,

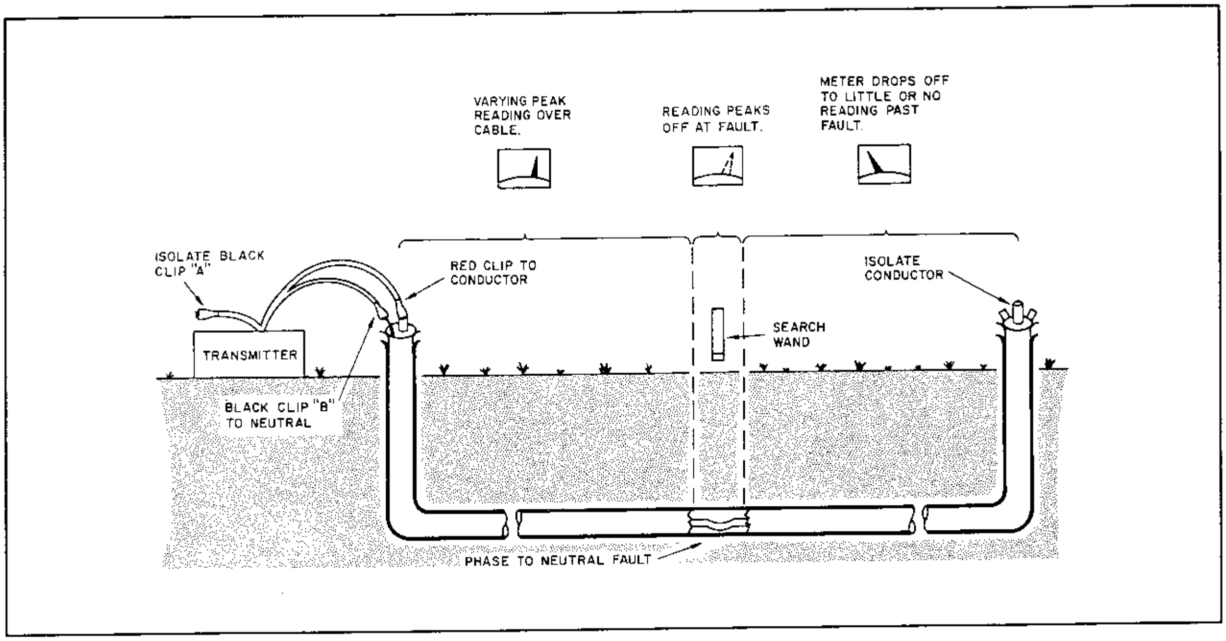


Figure 5-4. Locating Phase-to-Neutral and Phase-to-Phase Faults in Buried and Underground Power Cable

will give a varying peak signal reading and swinging the wand to either side of the cable, will give a decreasing signal reading. Carefully locate this peak and adjust the transmitter and receiver to the reference.

NOTE

The meter reading may vary along the cable path when tracing twisted triplex cables or random separation single conductors. When setting up the initial reference of 60 on the meter, walk a few feet along the cable path and set the receiver at the maximum point.

5-23. Walk the cable path with the search wand pointed over the cable. There may be a slight variation in signal as noted above.

5-24. As the fault is located a pronounced peak signal will be indicated followed by a sharp drop in signal past the fault. Proceed to trace the path for several feet past this peak to see if the signal strength increases again. If it does not increase, walk slowly back toward the near-end and locate the peak again. This pinpoints the fault.

5-25. SUMMARY TABLE

5-26. For the experienced craftsman, Table 5-1 provides fault-finding information in capsule form. The summary information is a particularly useful reference tool for those who have mastered the fundamental details described earlier.

Table 5-1. Fault-Finding Summary of Power Cables

Type of Fault	Fault Resistance Level	Isolation	Reference Setting	Fault Indication
Phase-to-earth using wand	500,000 ohms	De-energize circuit. Isolate the conductor at both ends.	Step 6 or above; 60 pts wand to the side.	Signal will slowly decrease over a 4-6 ft. area. The signal will then level out at a low level. The fault is approximately in the middle of the 4-6 ft. area.
Phase-to-earth using contact frame.	5,000,000 ohms	De-energize circuit. Isolate the conductor at both ends.	Any step to give 5-10 pts. Contact Frame over cable.	Signal will peak when the leading contact probe is at the fault and will null when the contact frame is straddling the fault. Note: The null may be very narrow; 1-2 in. wide.
Phase-to-Neutral and Phase-to-Phase.	100,000 ohms	De-energize circuit. Isolate the conductors at both ends.	Setting 6 or above 60 pts wand pointing at the cable.	Signal will peak abruptly at the faulted location, and drop off to a constant low level past the fault.

SECTION VI
OPERATION
(LOCATING FAULTS IN BURIED AND UNDERGROUND COAXIAL CABLE)

6-1. GENERAL

6-2. Faults to coaxial cable are generally caused by unknowing workmen damaging the cable or by water getting through a break in the polyethylene jacket and corroding the outer conductor and possibly the inner conductor.

6-3. The types of faults for buried coaxial cable are shield-to-earth, and short (center conductor to shield). The shield-to-earth fault may be caused by either a nick in the polyethylene jacket or by the cable being severed. A short will most likely be caused by water getting into the cable and causing a center conductor-to-shield fault.

6-4. Use the ohmmeter to measure the fault resistances. Isolate the shield from ground before measuring the shield-to-earth fault resistance.

6-5. If a shield-to-earth and a short exist on the same cable, attempt to locate the shield-to-earth fault first. It is easier to locate a 300,000 ohm shield-to-earth fault than a 50,000 ohm short.

6-6. Trace the cable path as outlined in Paragraph 3-1.

NOTE

Only 990 Hz BURIED tone can be used on coaxial cable. Coaxial cable path and depth can be determined using 990 Hz tone on the shield without disconnecting the system. The signal will not affect normal transmission.

6-7. LOCATING SHIELD-TO-EARTH FAULTS IN BURIED AND UNDERGROUND COAXIAL CABLE

6-8. Setup and Analysis. If the fault resistance is less than 500,000 ohms the fault may be located with the search wand. (Refer to Figure 4-2.) Isolate both ends of the cable in as short a section as possible. Connect the red clip to the conductor and black clip "B" to the shield. Make sure that black clip "A" does not touch ground.

6-9. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference reading of 60 on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable, will give a null (minimum) reading and swinging the wand to either side of the cable will give a peak (maximum) reading. Carefully locate this peak and adjust the transmitter and receiver to the reference.

6-10. Procedure. Proceed to walk the cable, observing the meter reading on both sides of the cable path. When a sudden decrease in the meter reading is noticed, mark the spot where the reading first starts to drop off. Proceed slowly and watch the meter for the point at which the decreasing reading levels out at a low value. Mark this point. The fault will be located halfway between the two marks. The distance between these two marks is usually 4 to 6 feet.

6-11. PINPOINTING SHIELD-TO-EARTH FAULTS USING THE CONTACT FRAME

6-12. Setup and Analysis. (Refer to Figure 4-3.) After determining the general area of the fault with the search wand, as explained above, connect the earth contact frame to the receiver and move back toward the near-end about 20 feet from where the signal started to drop off. With the contacts of the frame inserted over (in line with) the cable path, adjust the receiver gain for a reference of 5 to 10 on the meter. To closely locate suspected faults under a hard surface refer to Figure 4-6.

6-13. Procedure. Proceed to walk the cable path inserting the contacts into the earth over (in line with) the cable about every three feet. As the fault is approached the signal will increase sharply. Turn the receiver gain down as necessary to keep the meter below 60. Reduce probing intervals to a few inches.

6-14. There will be a peak reading when the leading contact is inserted over the fault, a null when the frame is centered over the fault, and another peak when the trailing contact is inserted over the fault.

6-15. Locate other shield-to-earth faults in a similar manner. The characteristic peak-null-peak indication will be noticed as the faults are approached, located and passed.

6-16. LOCATING CENTER CONDUCTOR-TO-SHIELD FAULTS IN BURIED CABLE

6-17. Analysis. In order to properly analyze a center conductor-to-shield fault, it is necessary to isolate the shield from ground. After completely isolating the shield at both ends of the faulty section, measure the shield-to-earth resistance to see if the shield is faulted to ground. If the shield is grounded refer to Paragraph 6-7. Center conductor-to-shield faults up to 100,000 ohms may be located.

6-18. Setup. (Refer to Figure 4-7.) Isolate the shield from ground at both ends of the faulty section. Connect the red clip to the conductor and black clip "B" to the shield. Do not allow black clip "A" to touch ground.

6-19. Set the transmitter selector switch to BURIED (990 Hz). With the receiver COARSE GAIN Control set to 6 or above, adjust the transmitter SIGNAL LOADING (or SIGNAL LEVEL) for just enough signal to set up a reference of 40 on the receiver with its FINE GAIN control. The reference should be set up down the cable path at least 10 feet from the near-end connections. Pointing the search wand at the cable, will give a null (minimum) reading and swinging the wand to either side of the cable will give a peak (maximum) reading. Carefully locate this peak and adjust the transmitter and receiver to the reference.

6-20. Procedure. Proceed to walk the cable path, observing the meter reading on both sides of the cable path: As the fault is approached, the signal will gradually increase or decrease. The change in signal will usually occur over a 6 to 8 foot distance. The fault is located between the beginning and end of the signal change distance.

SECTION VII
FIELD MAINTENANCE

7-1. GENERAL

7-2. This section contains routine maintenance information on Model 4904A that can be performed in the field.

7-3. Because special test equipment is required for aligning the circuits in these instruments, no attempt should be made to perform calibration and repairs not covered in this section. Hewlett-Packard (Delcon Division) maintains a complete repair facility at its Mountain View, California plant. Customers in the United States should send their instruments directly to this facility for repair. Customers outside the U.S. should consult their nearest Hewlett-Packard Sales and Service Office (listed in the back of this manual) for repair information.

7-4. BATTERY REPLACEMENT

7-5. Transmitter Section. To test battery, hold SIGNAL LOADING Switch in BAT TEST position. If the meter needle fails to deflect to BATT. OK region of meter, batteries must be replaced.

NOTE

If the transmitter fails the battery test after replacing the batteries, the transmitter is malfunctioning and must be repaired.

7-6. Replace batteries with Eveready No. 744 or equivalent (see Table 7-1).

Table 7-1

Replacement Batteries for Transmitter
Eveready 744 .... HP Part No. 1420-0067
Burgess F4P1
NEDA 6
RCA VS 345
Ray-o-Vac A6
Bright Star 646
Marathon 3006
Mallory M-6

7-7. Battery is located under the hatch below the receiver storage compartment. To open hatch, turn screw counterclockwise 1/4 turn.

7-8. Remove the battery plugs and the old batteries, being careful not to accidentally strip the insulation off the battery leads. Put the replacement batteries vertically in the battery well. Insert the battery plugs into the batteries. Replace the battery compartment cover.

7-9. Receiver Section. To test batteries, pull FINE GAIN switch to ON position and depress BAT. TEST button. If the meter reads below 70 on the upper scale, batteries must be replaced.

7-10. Replace batteries with Eveready E-126 mercury batteries, or equivalent (see Table 7-2).

Table 7-2

Replacement Batteries for Receiver
Eveready E-126 .... HP Part No. 1420-0033
Burgess H126
RCA VS 126
NEDA 1611M
Mallory TR 126
Ray-o-Vac 1611M

7-11. Unfasten battery compartment screw and open lid. Remove defective batteries. Replace the batteries, placing the positive end down as shown by the arrow. Replace the battery compartment lid.

NOTE

If the receiver fails the battery test after replacing the batteries, the receiver is malfunctioning and must be repaired.

7-12. METER ADJUSTMENT

7-13. With the 4904A transmitter off and sitting in its normal operating position the meter pointer should rest on the infinity (∞) mark. If the pointer does not point to this mark it should be adjusted. Refer to Figure 2-1 for the location of the mechanical meter adjustment.

7-14. Using a ballpoint pen or other sharp tipped object, carefully push the adjustment to the right so that the pointer is to the right of the ∞ mark. Then push the adjustment to the left until the pointer rests on the ∞ mark. If the ∞ mark is passed, repeat this procedure. The pointer must always approach the ∞ mark from the right to be properly adjusted.

7-15. CONSTRUCTION OF EXTRA LONG CONTACT FRAME POINTS

7-16. In extremely dry or sandy soil conditions, it is sometimes necessary to equip the Earth Contact Frame with extra long six-inch points.

7-17. Figure 7-1 shows the construction of these points. It is recommended that they be made of 412 or 416 stainless steel rod (.500 in. diameter).

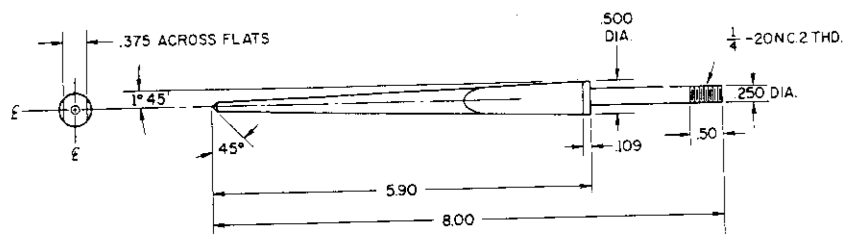


Figure 7-1. Pin - Contact, Long

APPENDIX A
A SHORT TRAINING COURSE

All craftsmen who use these instruments should practice tracing cable. Since there is usually a bit of uncertainty about the exact lie of the buried cable, it is important to be able to distinguish between cable turns, loops, butts, drops, etc. - and cable faults.

Figure 1 shows a suggested layout for a cable course. Take about 100 feet of insulated conductor and lay it out on top of the ground as shown. Connect the red transmitter lead to the conductor and ground clip lead "A" as far from the cable course as possible. Ground the conductor at the far end.

PROCEDURES:

Step 1 Set the SIGNAL LOADING switch to position #2.

Step 2 Standing over the cable path, notice that very little signal is received when the search wand is pointed at the conductor. Pointing the wand to either side of the cable path, a very strong signal is received. Adjust the receiver VOLUME control for a setting of 60 on the meter, with the wand pointing toward the strongest signal. This is the reference setting.

Step 3 Walk the course moving the search wand from side to side over the conductor. Notice that the conductor lies directly beneath the minimum signal (null) point on the straight section.

Step 4 Approaching 90 degree turn notice that there is a more pronounced signal on the inside of the turn than on the outside.

Step 5 The signal will increase considerably when the wand is directly over the loop and the signal will be spread out around the loop.

Step 6 At the tee, which represents a butt splice, the signal will extend out for a fraction of the tee and then drop off completely as the directional signals cancel.

Step 7 It may be desirable to simulate other cable situations on the cable course, such as drops and earth return faults. To ground the conductor, strip off about 2 inches of insulation, wrap the conductor around a 10 penny nail and drive the nail into the ground. This earth return fault will also provide good experience in the use of the Earth Contact Frame.

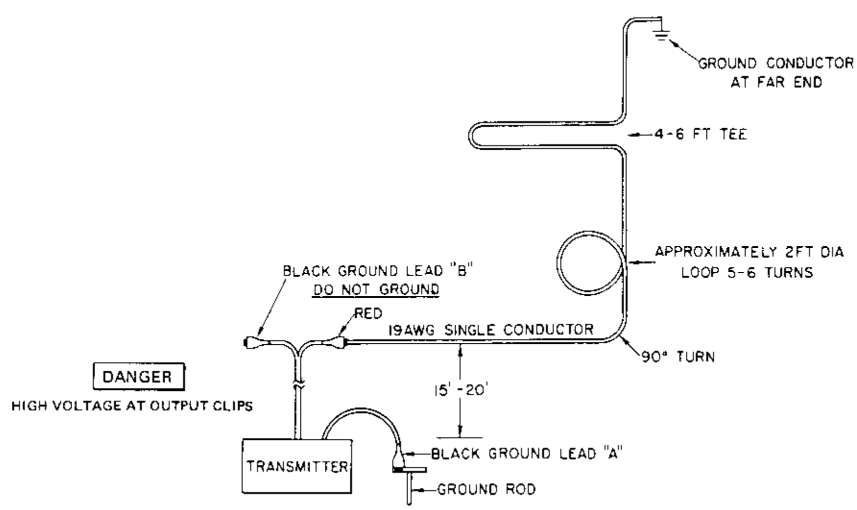


Figure 1. Recommended Layout for Cable Training Course