Instruction Manual
AVTM 651060
for the

SFL-2000 Secondary Cable/ Fault Locator

Catalog No. 651060

High-Voltage Equipment
Read the entire manual before operating.

Aparato de Alto Voltaje
Antes de operar este producto lea este manual enteramente.

AVO® ™
MULTI-AMP® BIDDLE™ MEGGER®

AVO INTERNATIONAL

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SECTION 1

INTRODUCTION

RECEIVING INSTRUCTIONS

Check the equipment received against the packing list to ensure that all materials are present. Notify AVO Biddle Instruments of any shortage. Telephone (215) 646-9200.

Examine the instrument for possible damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify AVO Biddle Instruments or its nearest authorized sales representative, giving a detailed description of the damage.

This instrument has been thoroughly tested and inspected to meet rigid specifications before being shipped. It is ready for use when set up as indicated in this manual.

GENERAL INFORMATION

The SFL-2000 is a portable, battery-powered test set designed to locate the path and depth of buried secondary cables with voltage ratings less than 600 V ac, and to test for and locate earth faults caused by damage to the cable. See Figure 1. The transmitter uses modern digital power conversion techniques and circuits which automatically maximize signal power delivered to a wide range of loads. The heart of the receiver is a microcomputer. This advanced feature allows simplified operating controls, efficiency of operation, and elimination of confusion. The benefit to the user is foolproof cable and cable earth fault location. The test set will identify, locate, and provide depth on all cables with a metallic conductor component such as copper cable, fiber-optic cable with gopher and lighting protection, fiber-optic cable with metallic stress strand, fiber-optic cable buried in armored duct, or fiber-optic cable buried with locator wire or tape.

The system locates and provides depth on cables without disconnecting ground bonding at either end of the cable and without disrupting service in any manner. The receiver alone may be used to detect and trace the 60 cycle field generated by current carrying power cables. The system also uses an audio frequency signal (7776.4 Hz) for cable tracing. This frequency provides maximum locking on the cable being traced. As a result, the signal induced on nearby conductors is minimized. This audio frequency signal will travel much greater tracing distances, such as is required on long cable runs.

The SFL-2000 comprises a transmitter, receiver, earth contact ground frame, coupler-clamp, direct connection cable assembly (test leads), ground cable assembly, ground stake, ground plate, battery charger, instruction manual, and carrying case. Both transmitter and receiver cases are made of tough, rigid plastic and aluminum. Both are water-resistant. The black, lower portion of the receiver probe is waterproof and may be immersed to locate cables in small streams, flooded streets and similar areas with shallow water.

Figure 1: SFL-2000

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SECTION 2

SAFETY

The SFL-2000 and the recommended operating procedures have been designed with careful attention to safety; however, it is not possible to eliminate all hazards from electrical test equipment or to foresee every possible hazard which may occur. It is therefore essential that the user, in addition to following the safety rules in this manual, also carefully consider all safety aspects of the test before proceeding.

The test set and the cable under test are sources of hazardous electrical energy and all persons making or assisting in tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and related circuits. Persons actually engaged in the test must stand clear of all parts of the complete circuit, including all connections, unless the test set is de-energized and all parts of the circuit are grounded. Person not directly involved with the work must be kept away from the test activities by suitable barriers, barricades, or warnings.

Treat all terminals of power equipment as a potential electric shock hazard. There is always the possibility of voltages being induced at these terminals because of proximity to energized high-voltage lines or equipment. Always disconnect test leads from the cable under test before attempting to disconnect them at the test set. The ground connection must be the first made and the last removed. Any interruption of the grounding connection can create an electric shock hazard. Safety is the responsibility of the user.

Observe the following safety precautions:

- Observe all safety warnings marked on the equipment. These warnings identify areas of immediate hazard which could result in personal injury or loss of life.

- Do not use this equipment to fault locate on any cable which is likely to be near enough to an energized cable to allow a burn through of the insulation of the energized cable. This situation may occur when the cables are located in a common trench, duct or tray (e.g., three-phase systems).

- Do not operate the equipment with protective covers removed. Operation without the protective covers presents an electric shock hazard.

- Use of this instrument is restricted to secondary cables with voltage ratings of less than 600 V ac.
- Use all practical safety precautions to prevent contact with energized parts of the equipment and related circuits.
- Use suitable barriers, barricades, or warnings to keep persons not directly involved with the work away from test activities.
- Use the recommended grounding and connection procedures.
- Refer to IEEE 510-1983 "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing" for additional information.
- Misuse of this equipment can be extremely dangerous.
- The purpose of this equipment is limited to use as described in this manual. Do not use the equipment or its accessories with any device other than specifically described.
- Never connect the test equipment to energized equipment or use in an explosive atmosphere.
- A qualified operator should be in attendance at all times while the test equipment is in operation.
- The safety ground jumpers must be properly connected (refer to Sections 6 and 7).

Make sure that the equipment is grounded properly. Any interruption of the grounding connection can create an electric shock hazard.

To avoid electric shock hazard, operating personnel must not remove the system protective covers. Component replacement and internal adjustments must be made by qualified service personnel only.

Refer fuse replacement to qualified personnel only. To avoid electric shock and fire hazard, use only a fuse which is identical in respect to type, voltage rating and current rating to that specified.

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This instrument uses rechargeable batteries. Replace only with sealed lead-acid batteries as specified in Section 3, Specifications. Danger of explosion can result when the wrong batteries are used.

If the equipment is operated in accordance with the safety precautions described, and if all grounds are correctly made, rubber gloves are not necessary. As a routine safety procedure, however, some users require that rubber gloves be worn, not only when making connections to the high-voltage terminals but also when manipulating controls. AVO Biddle Instruments considers this an excellent safety practice.

Users of high-voltage equipment should note that high-voltage discharges and other sources of strong electric or magnetic fields may interfere with the proper operation of heart pacemakers. Personnel having heart pacemakers should obtain expert advice on possible risks before using this equipment or being close to equipment while it is in operation.

The following warning and caution notices are used in this manual where applicable and should be strictly observed

WARNING

Warning, as used in this manual, is defined as a condition or practice which could result in personal injury or loss of life.

CAUTION

Caution, as used in this manual, is defined as a condition or practice which could result in damage to or destruction of the equipment or apparatus under test.

AVO Biddle Instruments has made formal safety reviews of the initial design and any subsequent changes. This procedure is followed for all new Biddle products and covers areas in addition to those included in applicable ANSI standards. Regardless of these efforts, it is not possible to eliminate all hazards from electrical test equipment. For this reason, every effort has been made to point out in this instruction manual the proper procedures and precautions to be followed by the user in operating the system and to mark the system itself with precautionary warnings where appropriate. It is not possible however to foresee every hazard which may occur in the various applications of this system. It is therefore essential that the user, in addition to following the safety rules in this manual, also carefully consider all safety aspects of the test before proceeding.

SECTION 3

SPECIFICATIONS

TRANSMITTER

Operating Modes:

Inductive Integral, high-efficiency ferrite antenna provides indirect coupling of signal to target cable.

Direct A) Test Leads
B) Coupler-Clamp

Cable Locate Output Power: Two ranges, front panel selectable.

HI power	2.5 to 3 W; 10 to 2500 Ω load 80 V ac, rms, open circuit 1 A ac rms, short circuit
LO power	0.5 W; 10 to 10,000 Ω load 35 V ac, rms, open circuit 0.5 A ac rms, short circuit

Fault Locate Output Power: Two ranges, front panel selectable.

HI power	1 W; 10 to 2500 Ω load 120 V ac, rms, open circuit 1 A ac rms, short circuit
LO power	0.5 W; 10 to 10,000 Ω load 95 V ac, rms, open circuit 0.5 A ac rms, short circuit

Load Matching: Automatic. Provides maximum power into specified range of loads; allows foolproof operation regardless of load conditions.

Output Frequency: 7776.4 Hz ±0.002%; for superior range and target discrimination. Fault location 11.11 Hz. Crystal clock controlled for accuracy.

Battery:	Rechargeable, 6 V, maintenance-free, sealed lead-acid. System includes separate 120 V ac charger that fully recharges the transmitter overnight. The charger will not overcharge the battery and may be left on indefinitely.
Operating Time:	8 hours @ HI power cable locate 50 hours @ LO power cable locate 7 hours @ HI power fault locate 35 hours @ LO power fault locate
Battery Life:	300 to 1200 recharge cycles
Fuse:	3 A/250 V fast-blow fuse
Readout:	Ruggedized, digital display provides multiple readouts of the voltmeter, ohmmeter, battery test, and relative power output.
Voltmeter:	Measures voltage using the direct connection cable. Range is 10 to 500 V ac or dc with 20% accuracy. Activated with direct connection cable jack plugged in and POWER PULL ON switch in off position.
Ohmmeter:	Measures resistance using the direct connection cable. Range is 10k to 5M ohm with 20% accuracy. Activated with direct connection cable jack plugged in, POWER PULL ON switch in on position and MODE SELECT in the FAULT OHMS position.
Output Power:	Continually confirms output power in all operating modes using an eight-segment bar graph. Activated when using Cable Locate or Fault Locate mode.
Battery Test:	Displays percentage of battery charge remaining whenever desired during operation. Checked by pressing % BATTERY button.
Weight:	5.6 lb (2.1 kg)

Dimensions:	

RECEIVER

Left-Right Accuracy:	
Depth Accuracy:	
	Accuracies dep ductivity, relati
Readout:	
Battery Test:	
Left-Right:	
Signal Power:	
Depth Indication:	
Lock Indicator:	
Audio Indication:	
Fault Indicators:	
Sensitivity:	

Dimensions:	5.13 x 8.13 x 5.39 in. (L x W x H) (13.0 x 20.7 x 13.9 cm)

RECEIVER

Left-Right Accuracy:	±0.5 in. (1.3 cm) to 40 in. (102 cm) depth; ±2.5% to full depth. Constant sensitivity regardless of depth.
Depth Accuracy:	±1 to 5% normal conditions

NOTE

Accuracies depend on coupling method and site conditions such as soil conductivity, relative utility density.

Readout:	Ruggedized, easy-to-read digital display provides multiple functions
Battery Test:	Readout in percentage of remaining battery life
Left-Right:	Bar graph and directional arrows
Signal Power:	Readout from 0 to 999, expanded (SPI) range for better resolution and accuracy.
Depth Indication:	Reads to 155 in. (394 cm) (factory selected). Will locate cable path for cables buried up to 35 ft (10.6 m) deep.
Lock Indicator:	Assures user that operating signal is adequate for instrument operation.
Audio Indication:	Distinct audio tones for left or right direction to target; volume adjustable, weatherproof speaker.
Fault Indicators:	Forward and reverse arrows; multi-segment bar graph indicates relative intensity.
Sensitivity:	Automatically controlled

Power Sense:	Provides high sensitivity to current carrying 50 and 60 Hz lines. Location and tracing functions provided via the SPI readout and a unique audio tone with progressive volume.
Batteries:	Four alkaline, 9 V, transistor batteries.
Battery Life:	80 to 130 hr (depending on audio volume usage)
Weight:	4.5 lb (2.0 kg)
Dimensions:	7.5 x 31 x 11.75 in. (W x L x H) (19 x 78.7 x 29.8 cm) operating length
Probe Design:	Telescoping, locking at full extension, fully waterproof and compact lower section.

EARTH FRAME

This is a rigid, tubular aluminum frame supporting two stainless steel probes at a fixed separation of 22 in. (56 cm). Each probe is wired through a connecting cord to a plug. The frame is insulated for operator safety.

ACCESSORIES

Coupler Clamp:	4 in. (10 cm) clamp with a 15 ft (4.6 m) connecting cable terminated with a jack.
Direct Connect Cable:	Two conductor, 5 ft (1.5 m) cable, insulated to 1500 V ac, terminated with 50 A crocodile clips at one end and a jack at the other end.
Ground Cable:	4 ft (1.2 m) cable, insulated to 1500 V ac, terminated with 50 A crocodile clip at one end and a lug at the other end.
Ground Stake:	6 x 3/8 in. (15.2 x 0.95 cm) steel stake
Ground Plate:	4 x 6 x 1/16 in. (10 x 15 x 0.16 cm) aluminum plate

ENVIRONMENT

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Humidity:

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CHARGER

Input Voltage:

Power:

Output Voltage:

Output Current:

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Climate:

ENVIRONMENTAL

Operating Temperature Range:	-15 to 150°F
Storage Temperature Range:	-40 to 180°F
Humidity:	0 to 100% relative humidity noncondensing

Use prohibited in direct rain or snow.

CHARGER

Input Voltage:	120 V ac, 60 Hz
Power:	20 VA
Output Voltage:	6 V dc
Output Current:	1.35 A
Operating Temperature Range:	-40 to 180°F
Climate:	Indoor use only

SECTION 4

CONTROLS AND INDICATORS

TRANSMITTER CONTROLS AND INDICATORS (Fig. 2)

1. POWER PULL ON - Pulling the switch turns the transmitter on and pushing it turns the instrument off.

2. % BATTERY - With the POWER switch on, this push button, when pressed, indicates the percentage of battery charge available on the LCD. The display will show the percentage and the symbol BATT will be present.

3. MODE SELECT - This push button selects the desired mode of operation: CABLE LOCATE, FAULT OHMS, or FAULT LOCATE. This button only operates when the test leads are inserted in the DIRECT ACCESSORY and the POWER PULL ON switch is in the on position.

4. FAULT LOCATE - When illuminated, this LED indicates that the transmitter is operating in both the Locate and Fault Locate modes. Available when the direct connection cable assembly plug is inserted into the DIRECT ACCESSORY jack and the POWER PULL ON switch is in the on position. In this mode the word FAULT is displayed along with a bar graph indicating the output power.

5. FAULT OHMS - When illuminated, this LED indicates that the transmitter is in the ohmmeter mode and the LCD is in OHMS (either K OHMS or M OHMS). Available when the direct connection cable assembly plug is inserted into the DIRECT ACCESSORY jack and the POWER PULL ON switch is in the on position. In this mode the word FAULT is displayed along with a numeric indication of the fault resistance. If the fault resistance is greater than 5 megohms three dashes appear indicating over-range.

6. CABLE LOCATE - When illuminated, this LED indicates that the transmitter is only in the CABLE LOCATE mode. Available when the POWER PULL ON switch is in the on position. A bar graph is displayed indicating the output power.

7. VOLTS (POWER OFF) - When illuminated, this LED indicates that the transmitter is operating in the voltmeter mode, and the LCD is in volts. Operational when the direct connection cable assembly plug is inserted into the DIRECT ACCESSORY jack and the POWER PULL ON switch is in the off position.

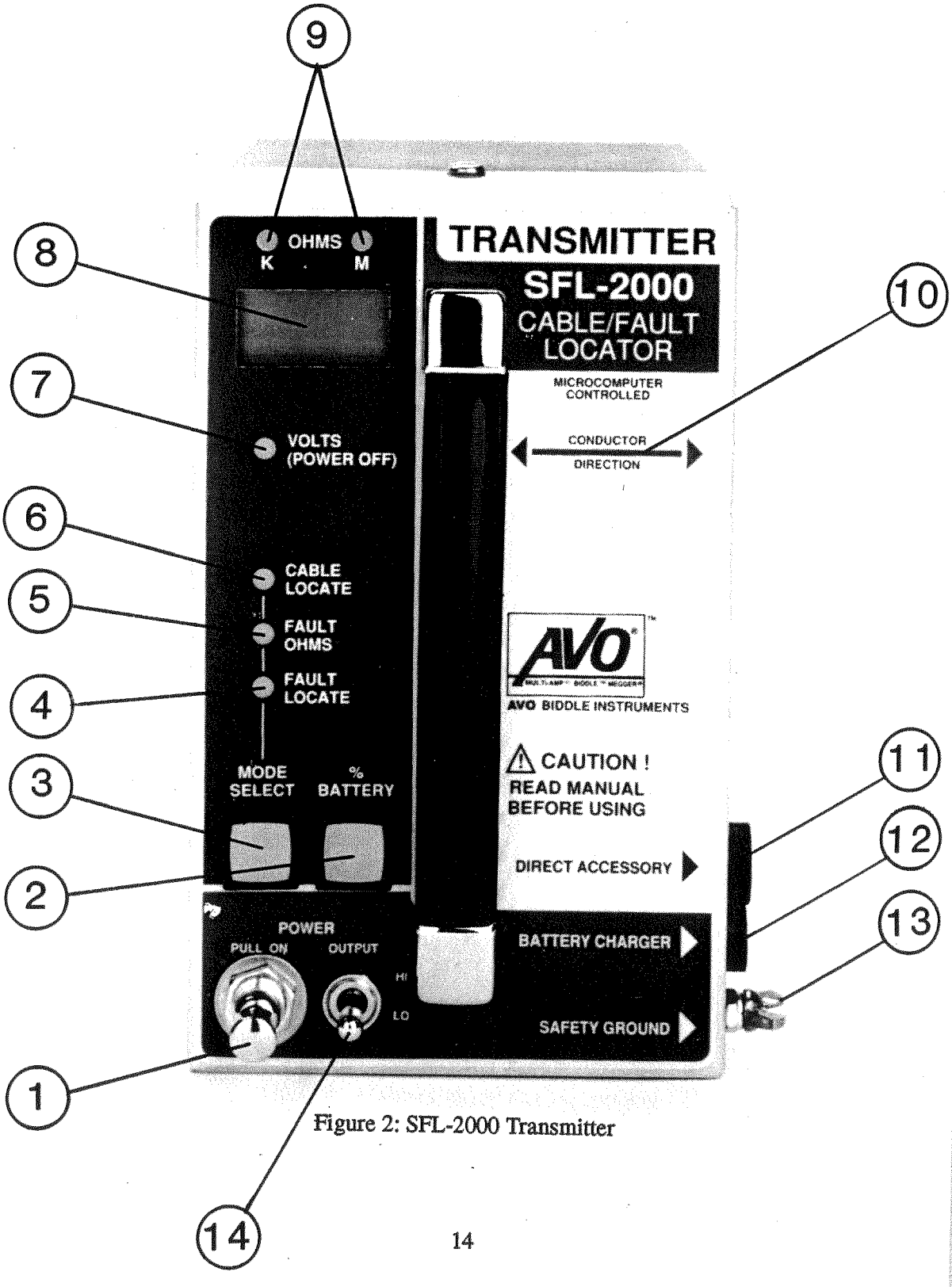

Figure 2: SFL-2000 Transmitter

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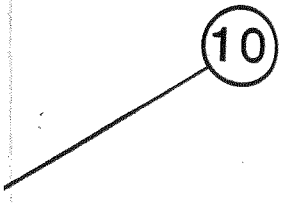
8. LCD - This window displays power output while in either the CABLE LOCATE or FAULT LOCATE modes. Voltage present on the cable under test is displayed when the VOLTS mode LED is illuminated. Fault resistance is displayed while in the FAULT OHMS mode.

9. OHMS K AND M - When the K LED is illuminated, the ohmmeter is measuring kilohms. When the M LED is illuminated, the ohmmeter is measuring megohms.



10. CONDUCTOR DIRECTION - While in the inductive mode of operation, the transmitter must be oriented such that the conductor direction arrows appear parallel with the cable to be traced.

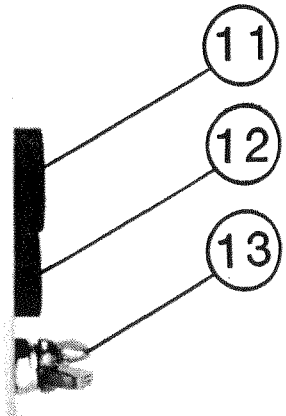
11. DIRECT ACCESSORY - This jack is used to connect the direct connection cable assembly or the coupler-clamp and when in use automatically disconnects the internal inductive transmitting antenna.

WARNING

Use only the specialized accessories in this jack.

12. BATTERY CHARGER - This jack allows connection of the charger unit.

13. SAFETY GROUND - This binding post is used to connect the chassis of the transmitter to earth ground when a direct connection to the specimen is required.



WARNING

Failure to connect the safety ground may result in an electric shock hazard.

14. POWER OUTPUT - Toggle switch selects the desired power output.

LO for 0.5 W operation or
HI for 2.5 to 3.0 W operation.

RECEIVER CONTROLS AND INDICATORS

Front Panel (Fig. 3)

1. Readout panel displays information and provides the operator with data concerning the exact location and depth of the conductor (or fault) that is being traced.

2. Depth Indicator push button (marked with an arrow) used to find the depth of the cable. When the depth indicator button is pressed and the receiver is aligned in a fully upright position directly over and in line with the intended conductor the depth, in inches (or centimeters), to the center of the conductor, will be displayed on the readout panel.

3. Four position switch used to set the receiver's mode of operation. This four-position switch may be set to:

BATT % - to perform a battery test and indicate the percentage of battery life remaining.

OFF - to turn the receiver off.

NORMAL - to select the Normal mode of operation for cable tracing or fault location.

POWER - to select the Power Sensing mode of operation for tracing power frequency signals.

4. Water-resistant speaker used to indicate cable location. In the NORMAL mode this speaker emits two distinct audio tones that correspond to the bar graph and directional arrows to direct the operator to the buried conductor. A solid or steady tone indicates that the conductor is to the right. An intermittent or broken tone indicates that the conductor is to the left. When the receiver is positioned directly over the conductor, the speaker produces no sound.

In the POWER mode the tone is intermittent, but at a faster rate than in NORMAL mode. The tone increases in intensity as the receiver is moved closer to the current carrying conductor.

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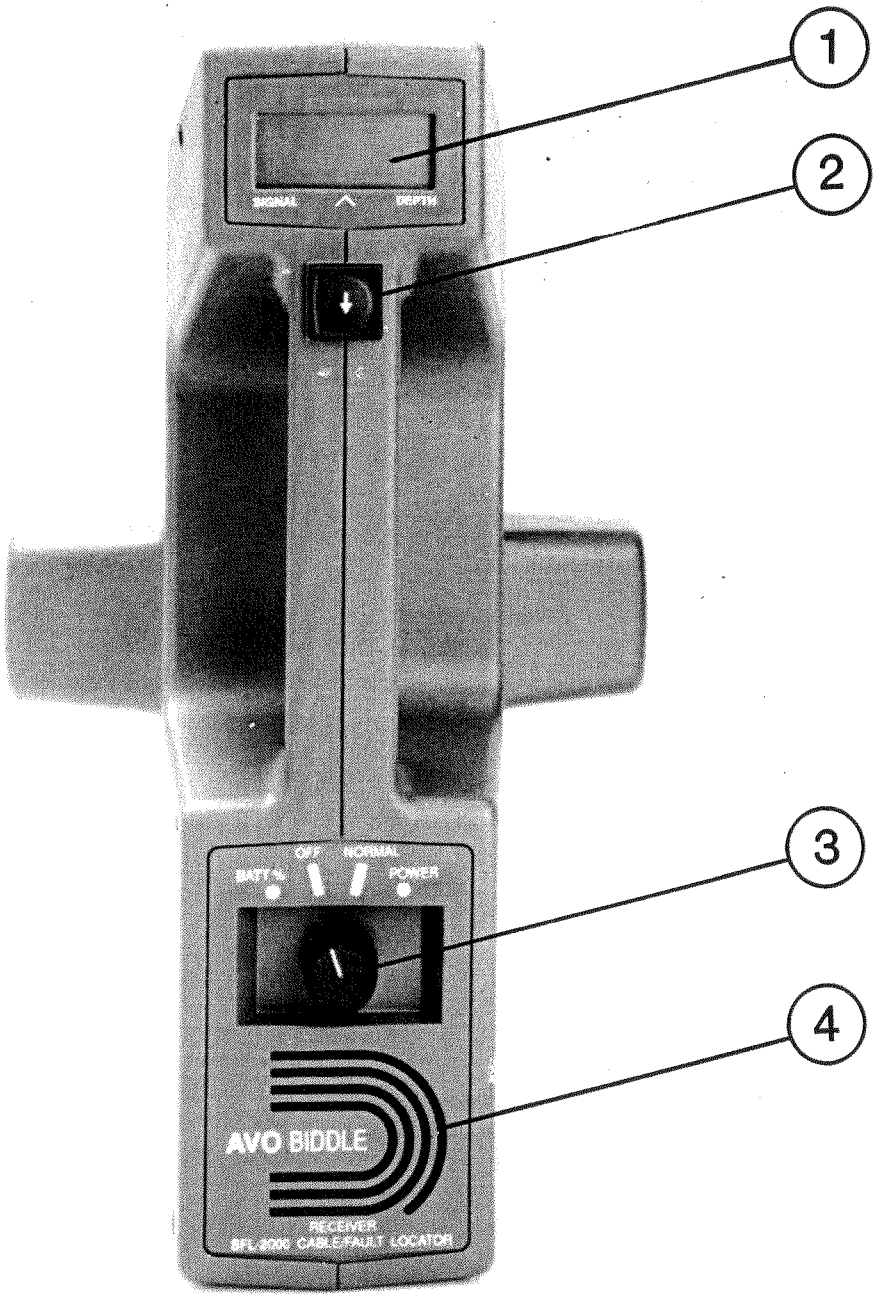

Figure 3: SFL-2000 Receiver (Front View)

Readout Panel (Fig. 4)

This display window readout panel provides the operator with the following information:

1. Battery % - Readout appears in percent (%) of the remaining receiver battery life along with the symbol BATT.

2. Signal Power Indicator (SPI) - The SPI provides the operator with a dual-purpose numerical readout, often referred to as "SPI" numbers, of the signal strength received. They are used in both the Normal audio signal tracing and Power frequency tracing modes of operation. SPI numbers range from 0 to 999. As the receiver gets closer to the buried cable, the numbers increase. As the receiver moves farther away, the numbers decrease.

3. Left-Right Indicators - A multi-segment bar graph and directional arrow indicate the direction and distance to the buried cable. As the receiver is moved nearer to the cable, less segments are visible. As the receiver is moved farther away from the cable, more segments are visible. When the receiver is positioned directly over the buried cable, all the segments and the directional arrow disappear from the readout panel, but the Lock Indicator (see 4 below) is still visible.

4. Lock Indicator - The Lock Indicator is a special feature of the Receiver. When the Lock Indicator, LOCK, appears in the readout panel window, the receiver is locked to the signal being generated by the transmitter. This indicator assures the operator that there is adequate signal strength for tracing the buried cable under test.

When the Lock Indicator becomes intermittent or disappears from the readout panel, the operator is approaching or has reached the limiting range of the transmitted signal. Depth determinations should not be attempted if the Lock Indicator is not steadily illuminated. In this case the transmitter should be repositioned to improve the signal strength if indirect coupling is used.

5. Depth Indication - When the Depth Indicator push button is pressed and the receiver is aligned in a fully upright position directly over and in line with the intended conductor, the depth, in inches (centimeters), to the center of the conductor, is displayed.

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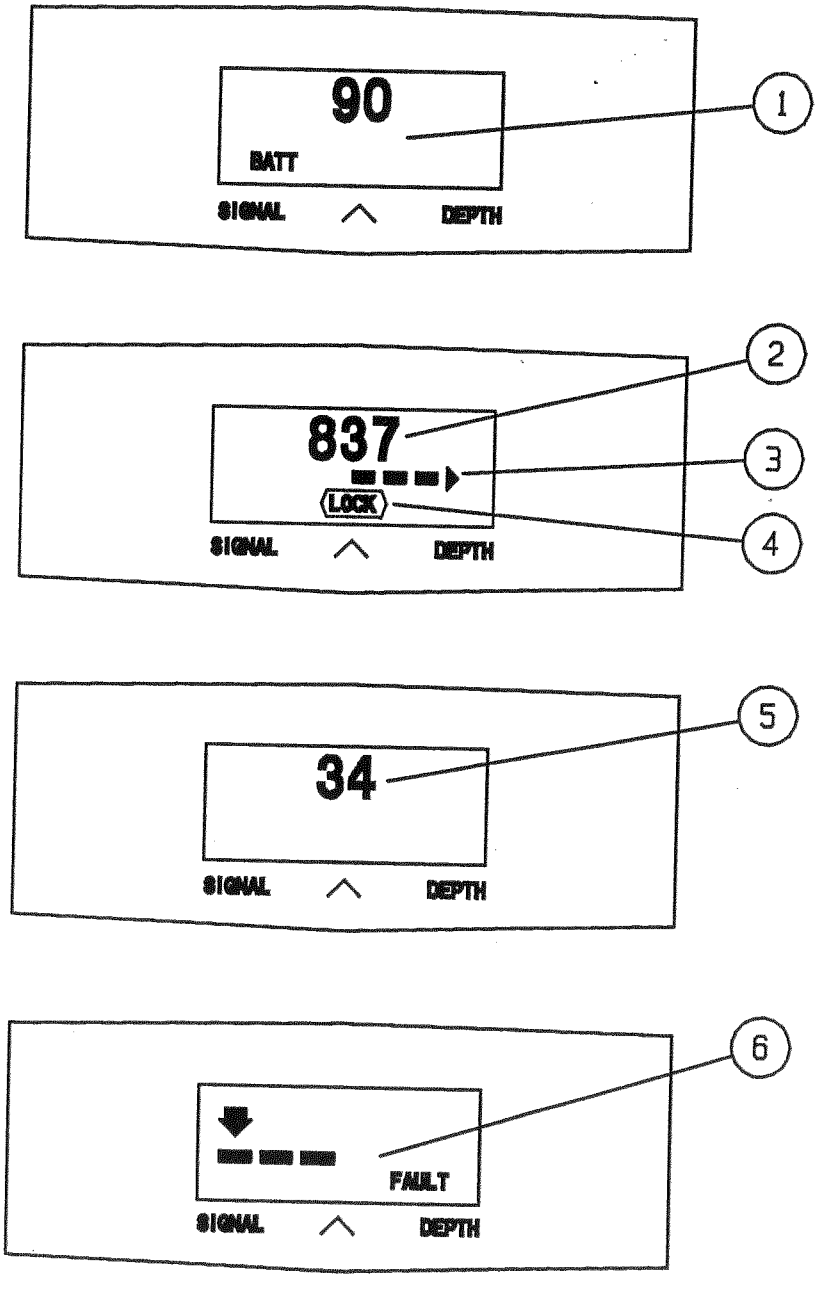

Figure 4: SFL-2000 Receiver (Readout Panel)

6. Fault Indicator - The forward/reverse indicator readout is a multi-segment bar graph with directional arrows that indicate the direction and distance to the fault to be located. The word FAULT is displayed to indicate the mode. As the operator approaches the fault, the multi-segment bar graph becomes shorter, and as the operator moves farther away from the fault, the bar graph becomes longer. When the earth contact ground frame is directly perpendicular to the fault, the directional arrows and multi-segment bar graph both disappear from the readout panel.

Rear of Receiver (Fig. 5)

1. ACCESS: This accessory jack is used to connect to a coupler-clamp. This jack is not used for applications outlined in this manual.

2. VOLUME - This control increases or decreases the volume of the audio tones from the speaker used as the Audio Left-Right Indicator.

3. FAULT - This jack is used to connect the earth contact ground frame.

4. Telescoping Probe - The telescoping probe provides for compact storage of the receiver in its carrying case. It is of rugged design and is waterproof up to the locking nut. Its design assures perfect alignment of the probe under all conditions and without having to take special precautions while extending or locking.

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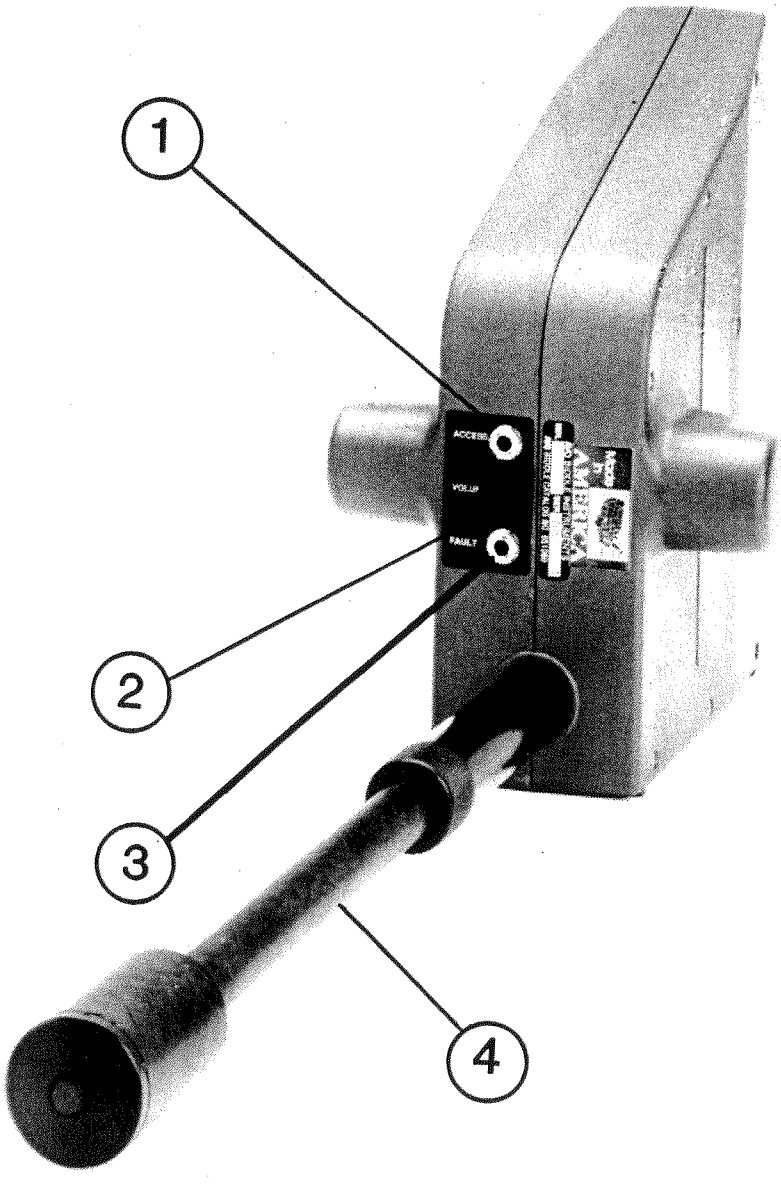

Figure 5: SFL-2000 Receiver (Rear View)

SECTION 5

GENERAL OPERATING PROCEDURES

TRANSMITTER OPERATION

The most important consideration in properly locating a non-energized buried cable or ground fault is to energize the cable with a suitable signal. The SFL-2000 transmitter transmits such a signal.

1. With the direct connection cable assembly plugged into the DIRECT ACCESSORY jack and the POWER PULL ON switch off, the transmitter is in the Voltmeter operation mode. The LED indicator for VOLTS (with power off) lights and the digits read ac or dc volts without respect to polarity. The transmitter reads voltage to 500 V. When more than 500 V (regardless of ac or dc) is present, the digital display will flash "HOT."

2. With the direct connection cable assembly plugged into the DIRECT ACCESSORY jack and the POWER PULL ON switch on, the transmitter is in the Locate operation mode and the test leads are energized. The signal is now coupled into the cable by directly connecting the test leads to the cable under test. The MODE SELECT button is used to select the desired mode and when selected, the LED indicator next to the selected mode label becomes illuminated.

3. Power output of "HI" or "LO" can be selected using the POWER OUTPUT switch while in either the CABLE LOCATE or FAULT LOCATE modes.

4. With the transmitter in any mode, pushing the % BATTERY switch displays the percentage of charge remaining as related to the mode of operation the transmitter is in. When the digital display shows LO in place of a number, operation is locked out until the battery is partially charged. BATT will always show on the digital display during battery testing.

5. With POWER PULL ON switch pulled on and nothing plugged into the DIRECT ACCESSORY jack, the digital display will indicate cable locate and the unit is operating in the Inductive cable locating mode. In this mode a self-contained antenna in the transmitter radiates the audio frequency tracing signal. Power output of "HI" or "LO" can be selected using the POWER OUTPUT switch. The MODE SELECT switch is disabled and only cable location and depth may be determined in this mode.

6. With the coupler-clamp plugged in, the self-contained antenna is disconnected. The signal is now coupled into the cable by placing the coupler-clamp around the cable. The MODE SELECT switch is disabled, and only cable location and depth may be determined in this mode of operation.

RECEIVER OPERATION

The receiver can be made operational by performing the following steps:

1. Loosen the lock nut on the probe and extend the probe to its fullest extent. Then, tighten the lock nut on the probe to secure the probe in its proper operating position.

2. Set the function switch to BATT % to verify that the receiver batteries contain sufficient power for operation. The battery test indication will read 0 to 100 indicating the percentage of available power in the batteries.

3. Set the function switch to NORMAL to select the Normal mode of operation. Plugging the earth contact ground frame into the FAULT jack places the receiver into the FAULT LOCATE mode. Unplugging the earth contact ground frame automatically returns the unit to the cable tracing and depth location mode using the audio signal produced by the transmitter.

4. Set the function switch to POWER to activate the Power Sensing mode of operation. In this mode the receiver is used for cable tracing of energized cables carrying power frequency currents.

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SECTION 6

CABLE PATH LOCATING/TRACING APPLICATIONS

USING THE TRANSMITTER FOR CABLE PATH LOCATING/TRACING

Before using the transmitter in any of the following applications, check that the transmitter has sufficient reserve charge to complete the test. To test the battery, press the BATTERY button and observe the percentage of battery charge on the LCD. This can be done while using any transmitter mode.

The transmitter transmits an audio frequency signal (7776.4 Hz) on the conductor to be traced. Because of the low frequency of the transmitter, high efficiency ferrite inductive antenna and fully automatic load matching system, there is little signal leakage to nearby cables.

The most important element in properly locating and tracing a buried cable is to energize the cable properly with the transmitter. There are three modes of operation that can be used to energize a conductor with the transmitter:

- Inductive or indirect (no direct connection to cable)
- Conductive or direct (direct connection to cable)
- Coupler-clamp (no direct connection to cable)

Operating in the Inductive Mode

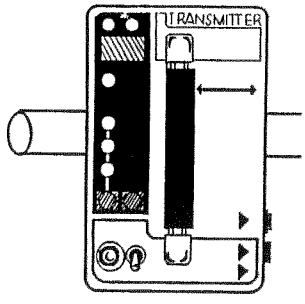
The inductive, or indirect, mode of operation is the easiest and simplest mode of using the SFL-2000 transmitter because no direct hook-up to the cable is needed. Be sure to keep at least 35 ft (10.6 m) between the receiver and transmitter at all times to avoid coupling through the air. When the transmitter is operating in the inductive mode, it is energizing the cable with an electromagnetic signal that is not only going onto the intended cable, but also being radiated through the air all around the transmitter. To operate the transmitter in the inductive mode perform the following steps:

1. Make sure that the direct connection cable assembly and the coupler clamp are disconnected from the DIRECT ACCESSORY jack. Turn the transmitter on by pulling the POWER PULL ON switch to the on position. After the transmitter performs a self-

test, the CABLE LOCATE LED illuminates, indicating that the unit is operating in the Cable Locate mode. Note that all other modes of operation are locked out because nothing is plugged into the DIRECT ACCESSORY jack.

2. Set the POWER OUTPUT switch to HI or LO. The appropriate power level is selected considering the depth of the cable and the length of the trace desired.

3. Push the % BATTERY switch to display the percentage of charge remaining in the battery. If the digital display shows LO in place of a number, operation is locked out until the battery is partially charged. BATT will always show on the digital display during battery testing.

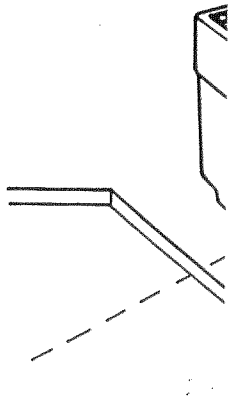


4. Position the transmitter directly over the top of the cable to be traced so that it is aligned with the path of the cable. This is accomplished by aligning the two-sided CONDUCTOR DIRECTION arrow in the upper right of the transmitter with the assumed run of the cable to be traced (see Fig. 6).

NOTE

The strongest signal will be placed on the cable when the transmitter is centered directly over the cable with the CONDUCTOR DIRECTION arrows aligned parallel to the path of the cable.

Other conductors in the area may be energized with the tracing signal. These other conductors might include overhead power or telephone lines, water pipes, chain link fences, guard rails, railroad tracks or other utilities in the area of the transmitter. A direct connection mode of operation should be considered in this case.



5. Refer to the topic "Using the Receiver for Tracing" for instructions on tracing the cable.

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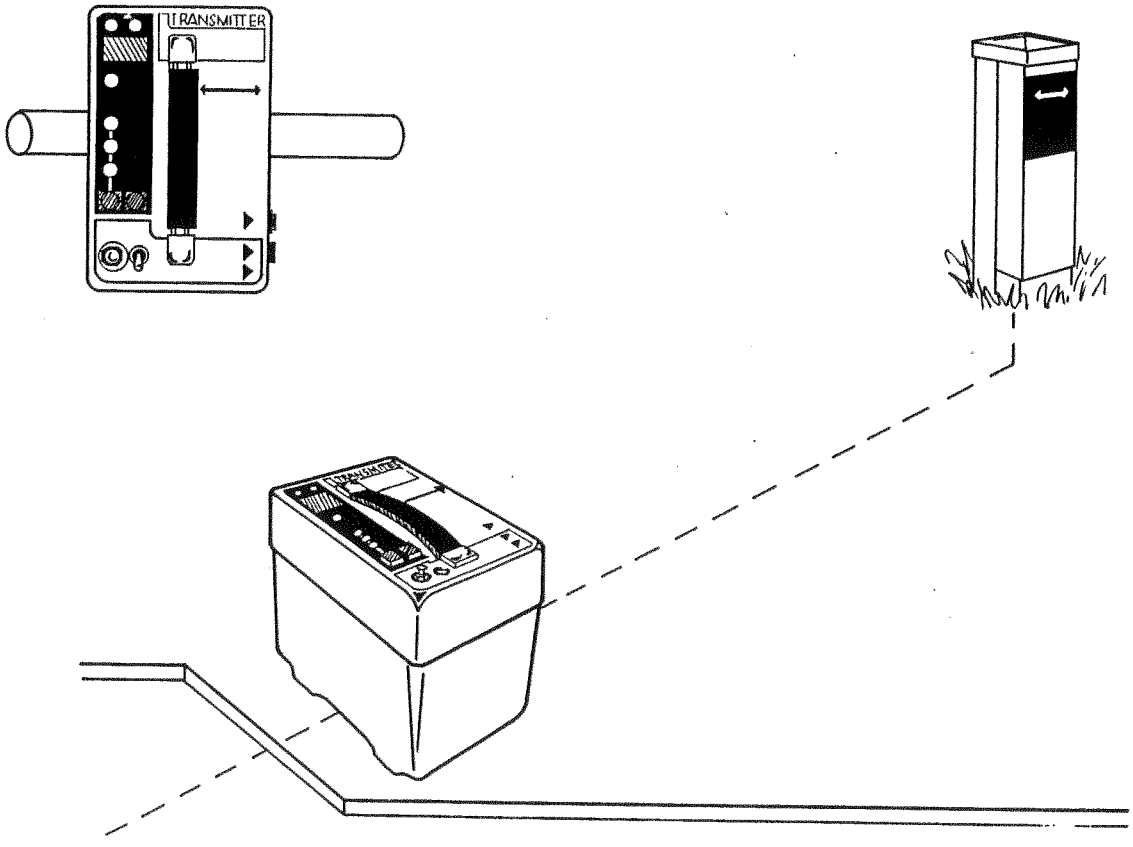

Figure 6: Transmitter Properly Aligned with Cable
(Inductive Mode of Operation)

Operating in the Conductive Mode

Before proceeding, read, understand, and observe all safety precautions contained in this manual. Refer to Section 2.

WARNING

Before conductively connecting the transmitter directly to any cables, test for the presence of voltage. All cables to be tested must be fully de-energized and grounded before conductively connecting the transmitter. Be certain that the transmitter output POWER PULL ON switch is off before touching the output clips on the test leads. The transmitter can deliver over 100 V of output signal.

WARNING

When operating in the conductive mode, be aware that signals applied to the cable will be present at the remote end(s) of the cable. To avoid inadvertent contact to hazardous live parts, always ensure that access to any exposed part of the cable or connected equipment is restricted, by using suitable barriers or barricades.

Whenever possible, the conductive (direct connection) mode is the preferred method for energizing the cable during tracing. By using a direct connection, the operator can eliminate mistakes often associated with inductive operation. The direct connection method is the most efficient because it helps to isolate the target cable from other cables in the area. Also, this method produces the strongest signal at the receiver for the most accurate results.

There are two ways to directly connect to the cable for tracing: a direct connection to the phase conductor or a direct connection to the neutral. When directly connecting to a phase conductor there is always the possibility that hazardous voltages may be present so it is more desirable to connect to the neutral conductor. When it is necessary to connect to the phase conductor extra steps are necessary to protect the equipment and operator. Different procedures are used depending on whether one connects to the phase conductor or neutral conductor.

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Direct Connection to a Neutral Conductor

The following steps serve as a general guide for setting up operation in the conductive tracing mode when directly connecting to the neutral conductor. Before proceeding, read, understand, and observe all safety precautions contained in this manual. Refer to Section 2.

WARNING

Even though testing involves connecting to the neutral conductor, often there are exposed conductors that have hazardous voltages on them. Only qualified personnel with the proper training should connect the instrument when exposed live conductors are present. In these situations individual company safety policies and procedures should be followed.

1. Observing all safety precautions, identify the cables to be traced and erect barriers.

2. Choose a location that meets the following conditions:

   a. The neutral conductor of the cable to be tested must be accessible.

   b. A secure low-resistance ground (less than 5 Ω) must be located near the cable under test. A driven ground is often used; this ground is called the local earth ground.

   c. Set up suitable barriers to protect the operator from traffic hazards and to prevent intrusion by unauthorized personnel. Warning lights or beacons are recommended.

3. After a satisfactory location for the transmitter of the SFL 2000 has been selected, connect the ground cable between the SAFETY GROUND (instrument chassis) wing nut on the SFL 2000 transmitter and the local earth ground (refer to step 2b).

WARNING

The transmitter chassis must be earth grounded to prevent an electric shock hazard.

4. Be sure that the POWER PULL ON switch on the transmitter is set to OFF.

5. Connect the test leads into the DIRECT ACCESSORY jack on the side of the transmitter. The VOLTS LED will illuminate indicating the unit is in the Volts mode.

WARNING

Before connecting the output test leads, make sure that the transmitter power is turned off.

6. Extend the black cable as far away from the path of the buried cable as its length will allow. The path of the black lead should be perpendicular to the cable under test.

7. Install a suitable signal ground, such as the spike or grounding plate provided. Drive the spike firmly into the soil, the ground plate may be pushed vertically into the soil or laid flat on the ground if soil penetration is not possible, such as when working over concrete. If the plate is laid flat on concrete or blacktop, it is advisable to wet such surfaces to obtain a good ground. See Fig. 7. This ground is the return path for the tracing signal.

NOTE

A good signal ground is essential to cable tracing. It is generally advisable to ground perpendicular to the cable being traced.

8. Connect the black lead of the output test leads to the ground stake or plate.

WARNING

When exposed live conductors are present it is recommended that insulated rubber gloves be worn when making any connections to prevent inadvertent contact with hazardous voltages.

9. Connect the red test lead to the sheath (neutral conductor) below the ground bond of the cable that is to be traced. A good connection to the sheath is essential for a clear, strong signal.

10. Verify that the conductor under test is not energized by observing the voltage reading on the LCD Display of the transmitter. If the cable is energized and it is less than 500 V (ac or dc) a voltage will be displayed. If the voltage is greater than 500 V

the word HOT will be flashing on the display. If any voltage is present, immediately disconnect the test leads, determine the source of the voltage and de-energize the conductor before proceeding with the test.

WARNING

The test leads and the cable will have hazardous voltages on them while in the CABLE LOCATE mode.

CAUTION

Turning the transmitter on with any voltage present on the conductor under test may damage the transmitter.

11. Pull the POWER PULL ON switch of the transmitter to the on position. After the transmitter performs a self-test, the CABLE LOCATE LED illuminates, indicating that the unit is now operating in the Cable Locate mode and voltage is present at the output red lead and the neutral conductor of the cable under test.

12. Set the POWER OUTPUT switch to HI or LO. The appropriate power level is selected considering the depth of the cable and the length of the trace desired.

13. Push the % BATTERY switch to display the percentage of charge remaining in the battery. If the digital display shows LO in place of a number, operation is locked out until the battery is partially charged. BATT will always show on digital display during battery testing.

14. Refer to the topic "Using the Receiver for Tracing" for instructions on tracing the cable.

15. During a temporary or permanent shutdown, push the POWER PULL ON switch of the transmitter to the off position.

16. Remove the test leads from the neutral conductor and from the signal ground.

17. Remove the safety ground lead from local earth ground.

Direct Connection to a Phase Conductor

The following steps serve as a general guide for setting up operation in the conductive tracing mode when directly connecting to the phase conductor. Before proceeding, read, understand, and observe all safety precautions contained in this manual. Refer to Section 2.

WARNING

Testing involves a connection to the phase conductor and there is always the possibility that this conductor could be energized. Furthermore, there may be other exposed conductors that have hazardous voltages on them. Only qualified personnel with the proper training should connect the instrument when exposed live conductors are present. Personnel involved in this testing should follow the individual company safety policies and procedures.

1. Observing all safety precautions, be sure all equipment and cables are de-energized. Identify the cables to be traced and erect barriers.

2. Discharge the cable under test by applying a ground using a safety grounding stick (not supplied). Connect a safety ground jumper (not supplied) from the phase conductor of the cable under test to the neutral conductor (the ground conductor of the cable under test).

WARNING

Failure to apply a safety ground jumper to the cable under test prior to connection of the transmitter can be extremely dangerous.

3. Choose a location that meets the following conditions:

   a. Both the phase conductor and the neutral conductor of the cable to be tested must be accessible.

   b. A secure low-resistance ground (less than 5 Ω) must be located near the cable under test. A driven ground is often used; this ground is called the local earth ground.

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c. Set up suitable barriers to protect the operator from traffic hazards and to prevent intrusion by unauthorized personnel. Warning lights or beacons are recommended.

4. After a satisfactory location for the transmitter of the SFL 2000 has been selected, connect the ground cable between the SAFETY GROUND (instrument chassis) wing nut on the SFL 2000 transmitter and the local earth ground (refer to step 3b).

WARNING

The transmitter chassis must be earth grounded to prevent an electric shock hazard.

5. Be sure that the POWER PULL ON switch on the transmitter is set to off (pushed in).

6. Connect the test leads into the DIRECT ACCESSORY jack on the side of the transmitter. The VOLTS LED will illuminate indicating the unit is in the Volts mode.

WARNING

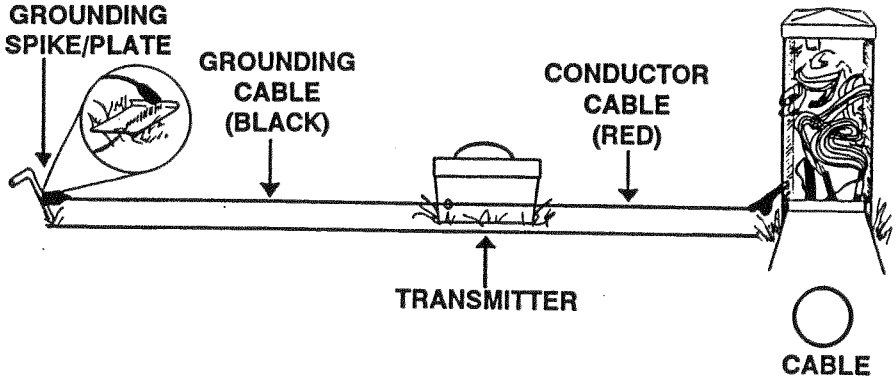
Before connecting the output test leads, make sure that the transmitter power is turned off.

7 Extend the black cable as far away from the path of the buried cable as its length will allow. The path of the black lead should be perpendicular to the cable under test.

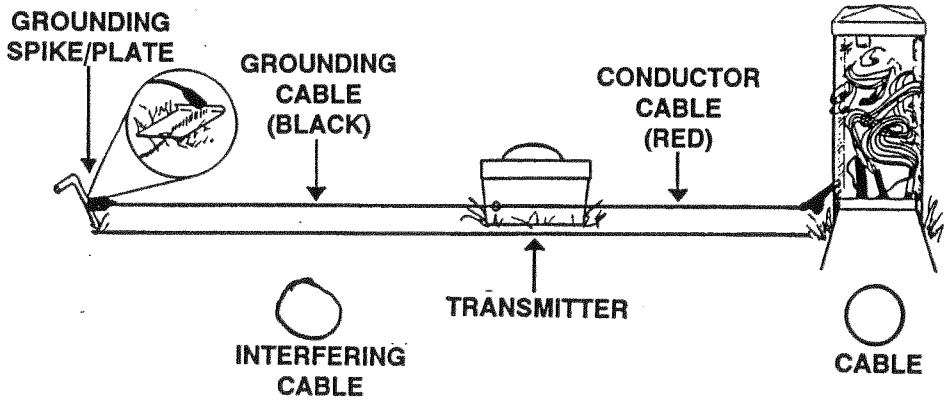
8. Install a suitable signal ground, such as the spike or grounding plate provided. Drive the spike firmly into the soil, the ground plate may be pushed vertically into the soil or laid flat on the ground if soil penetration is not possible, such as when working over concrete. If the plate is laid flat on concrete or blacktop, it is advisable to wet such surfaces to obtain a good ground. See Figure 7. This ground is the return path for the tracing signal.

NOTE

A good signal ground is essential to cable tracing. It is generally advisable to ground perpendicular to the cable being traced.



CORRECT GROUNDING



INCORRECT GROUNDING

FOR ILLUSTRATION ONLY; SAFETY
GROUND AND BARRIERS NOT SHOWN

Figure 7: Correct and Incorrect Grounding Applications

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9. Connect the black lead of the output test leads to the ground stake or plate.

WARNING

When making connections, it is recommended that insulated rubber gloves be worn to prevent inadvertent contact with hazardous voltages. Make sure that the safety ground jumper is still in place before connecting to the cable.

10. Connect the red test lead to the phase conductor for tracing. It is essential to make a good connection to the phase conductor for a clear, strong signal.

11. Remove the safety ground jumper.

12. Verify that the conductor under test is not energized by observing the voltage reading on the LCD Display of the transmitter. If the cable is en ergized and the voltage is less than 500 V (ac or dc) a voltage will be displayed. If the voltage is greater than 500 V the word HOT will flash on the display. If any voltage is present, immediately disconnect the test leads, determine the source of the voltage and de-energize the conductor before proceeding with the test.

CABLE

WARNING

The test leads and the cable will have hazardous voltages on them while in the CABLE LOCATE mode.

CAUTION

Turning the transmitter on with any voltage present on the conductor under test may damage the transmitter.

13. Pull the POWER PULL ON switch of the transmitter to the on position. After the transmitter performs a self-test, the CABLE LOCATE LED illuminates, indicating that the unit is now operating in the Cable Locate mode and voltage is present at the output red lead and the phase conductor of the cable under test.

14. Set the POWER OUTPUT switch to HI or LO. The appropriate power level is selected considering the depth of the cable and the length of the trace desired.

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15. Push the % BATTERY switch to display the percentage of charge remaining in the battery. If the digital display shows LO in place of a number, operation is locked out until the battery is partially charged. BATT will always show on the digital display during battery testing.

16. Refer to the topic "Using the Receiver for Tracing" for instructions on tracing the cable.

17. During a temporary or permanent shutdown, push the POWER PULL ON switch of the transmitter to the off position.

18. To disconnect the setup, manually ground the phase conductor with a safety ground stick and then apply safety ground jumpers.

WARNING

Never assume that the output test leads or the cable under test are completely discharged, even after following the above procedures. Always use a safety grounding stick to ground any conductive part of the circuit and then apply safety ground jumpers before touching any connections.

19. Remove the test leads from the phase conductor and from the signal ground. Remove the safety ground lead from local earth ground.

20. As the final step, remove the safety ground jumper.

USING THE COUPLER-CLAMP

Another means of inductively energizing the buried cable is with the coupler-clamp. The coupler-clamp is the most accurate means of tracing conductors, when it can be applied, because it keeps the signal away from interfering conductors.

The following steps serve as a general guide for setting up operation in the coupler tracing mode. Before proceeding, read, understand, and observe all safety precautions contained in this manual. Refer to Section 2.

WARNING

Even though testing does not involve a direct connection to any conductor, often there are exposed conductors that have hazardous voltages on them. Only qualified personnel with the proper training should connect the instrument when exposed live conductors are present. In these situations, individual company safety policies and procedures should be followed.

1. Observing all safety precautions, identify the cables to be traced and erect barriers.

2. Choose a location that meets the following conditions:

   a. The neutral conductor of the cable to be tested must be accessible.

   b. A secure low-resistance ground (less than 5 Ω) must be located near the cable under test. A driven ground is often used; this ground is called the local earth ground.

   c. Set up suitable barriers to protect the operator from traffic hazards and to prevent intrusion by unauthorized personnel. Warning lights or beacons are recommended.

3. After a satisfactory location for the transmitter of the SFL 2000 has been selected, connect the ground cable between the SAFETY GROUND (instrument chassis) wing nut on the SFL 2000 and the local earth ground (refer to step 3b).

WARNING

The transmitter chassis must be earth grounded to prevent an electric shock hazard.

4. Plug the coupler-clamp into the DIRECT ACCESSORY jack on the transmitter.

5. Pull the POWER PULL ON switch to the on position. With the coupler-clamp inserted into the DIRECT ACCESSORY jack, the inductive antenna is automatically disconnected. After self-test, the CABLE LOCATE LED will light and the unit is locked in the Cable Locate mode.

6. Set the POWER OUTPUT switch to HI or LO. The appropriate power level is selected considering the depth of the cable and the length of the trace desired.

7. Push the % BATTERY switch to display the percentage of charge remaining in the battery. If the digital display shows LO in place of a number, operation is locked out until the battery is partially charged. BATT will always show on the digital display during battery testing.

WARNING

Before clamping the coupler-clamp around a cable, use all necessary safety precautions to prevent inadvertent contact with exposed live conductors that may be in the vicinity.

8. Attach the coupler-clamp around the neutral conductor of the cable to be traced, making sure that the jaws of the clamp are fully closed.

9. Refer to the topic "Using the Receiver for Tracing" for instructions on tracing the cable.

10. During a temporary or permanent shutdown, push the POWER PULL ON switch of the transmitter to the off position.

11. Remove the coupler-clamp from the neutral conductor.

12. As a last step, remove the safety ground lead from local earth ground.

USING THE RECEIVER FOR TRACING

Once the conductor is properly energized, the receiver can be made operational. Perform the following steps:

1. Loosen the lock-nut on the probe and extend the probe to its fullest extent, then tighten the lock-nut on the probe to secure the probe in its operating position.

2. Set the four-position switch on the receiver to BATT % to perform a battery test on the receiver to verify that sufficient charge is available for operation. The battery test indication will read from 0 to 100% of available power in the batteries. BATT will always show on the digital display during battery testing.

3. Set the four-position switch on the receiver to NORMAL.

4. Slowly sweep with the receiver to search for the cable. Observe the following visual and audio indications on the LCD and from the built-in speaker:

LOCK INDICATOR ... as the operator enters the "Signal Field," the lock indicator will appear on the LCD. This feature assures that the receiver is locked onto the signal being generated by the transmitter.

AUDIO/VISUAL LEFT-RIGHT INDICATOR ... a multi-segmented bar graph will appear on the screen with directional left/right arrows which will guide the operator to the conductor. In conjunction with the directional left/right arrows, there will be tones coming from the speaker. A steady tone indicates that the conductor is to the right; an intermittent tone indicates that the conductor is to the left.

SIGNAL POWER INDICATOR (SPI) ... numbers will appear on the display screen, these numbers range from 0 to 999. As the operator nears the conductor, the numbers increase; as the operator moves away from the conductor, the numbers decrease. The numbers are the highest when the operator is directly over the conductor, and the receiver is lined up with it. See Figure 8.

When the operator has pinpointed the exact location of the cable (using the above indicators) and the receiver is positioned directly above the cable, the following will occur:

- The lock indicator will remain on the display screen.
- The left-right arrows and multi-segmented bar graph will disappear from the display screen.
- The audio left-right tones will produce no sound indicating no directional movement is required.
- The SPI will show the highest relative number on the display screen.

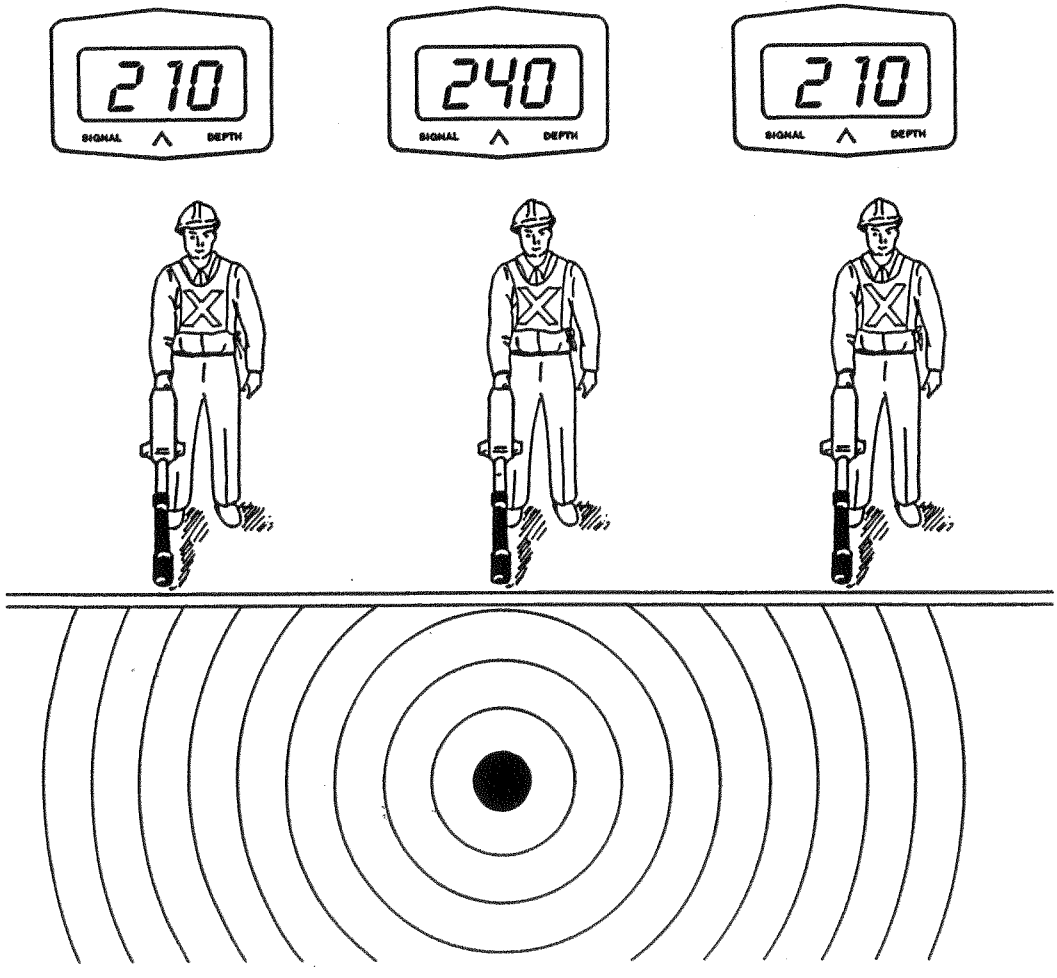

Figure 8: SPI Numbers Illustrated

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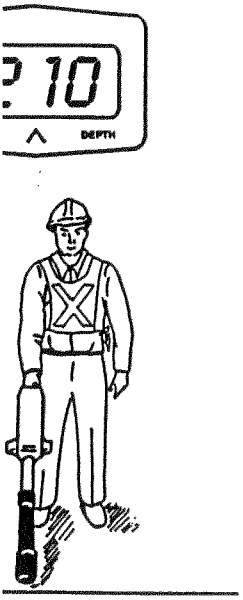

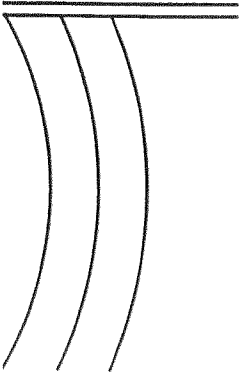

To Determine Depth of the Conductor

Once the cable has been pinpointed, the operator may obtain a depth reading. Proceed as follows:

1. Hold the receiver in a vertical position. For accurate depth readings it must not angle away from the operator, toward the operator or to either side.

2. Rest the tip of the probe on the ground directly over the conductor.

3. Momentarily press the depth push button (marked with arrow) located below the display screen. The letters CLC (calculation) appear on the digital display showing the computer is sampling readings and calculating the depth.

4. Observe a number on the display screen; this number will remain on the screen for several seconds, unless the depth button is pressed again, which will restore left/right location. This number is an indication of the depth in inches (or centimeters) to the center of the conductor.

If a depth indication does not appear on the display screen or there is no logical sequence to the numbers, it usually means one or more of the following:

- A ghost signal is being traced
- The receiver is air-coupled to the transmitter
- Interference is present from other conductors
- The probe assembly is not fully extended
- The 155 in. (394 cm) depth limit is exceeded

Poor results may also indicate that the operator should reposition the transmitter (if in the indirect mode) or energize the cable with a different transmitter mode of operation.

Encountering Interfering or Multiple Conductors

The SFL-2000 has features that assist the operator in identifying the target cable when working in an area with parallel or interfering conductors present. There are two basic means to determine which of the conductors is the cable that has been energized.

The first means is the SPI. When the operator has the target cable energized with the signal from the transmitter, other conductors in the area may also be energized to some extent due to common grounding. When the target cable has been energized properly, it will have a higher SPI reading than the parallel or interfering conductor. If the operator is searching for a shallow buried cable, the operator should expect to see higher SPI readings. If the signal being traced is poor, with low SPI readings, it should alert the operator that there may be a problem.

The SPI gives the operator valuable information about the conductor being traced and other conductors in the area. Major factors affecting SPI readings are:

- Cable energizing and grounding method
- Depth of cable
- Distance from transmitter
- Type of cable (size, insulation, etc.)
- Poor or no ground connections or ground integrity problems.

The second means of differentiating between conductors is to take a depth reading over both conductors. If the operator knows that the approximate depth of burial for the target cable is 36 in. (91 cm) and one conductor reads 34 in. (86 cm) while the other conductor indicates 12 in. (30 cm) on the display screen, this is an indication that the 34 in. (86 cm) conductor is the target cable.

In an area where multiple utilities are encountered, it may be advisable for the operator to locate each conductor individually, and determine its depth. Knowing the location and depth of all conductors in a congested area is particularly helpful in differentiating one buried conductor from another (Fig. 9).

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Locating a Bend

To locate a bend, pay particular attention to the left/right audio tones coming from the receiver speaker. There is a distinct change in the tone from the usual solid-null-broken tone to a steady solid or broken tone. Stop at that point and sweep the receiver in a 180° sweep, to the left and to the right along the ground to determine the direction of the bend. To determine the exact bend, locate the line going into the bend and coming out of the bend and mark where the lines intersect. There will be a confused signal area at the exact point of the bend and exact pinpoint may be difficult (Fig. 10).

POWER FIELD SENSING

In this mode of operation, the receiver is used without the transmitter, and involves sensing the presence of power frequency currents existing in power systems. Because there is no control over the range of these sources, this mode should not be relied upon for accurate tracing operations. However, it can provide a means for identification and confirmation of the presence of power cables, and where such a signal is present on the conductor and is stronger than interfering power signals, it can be used to approximate the cables location.

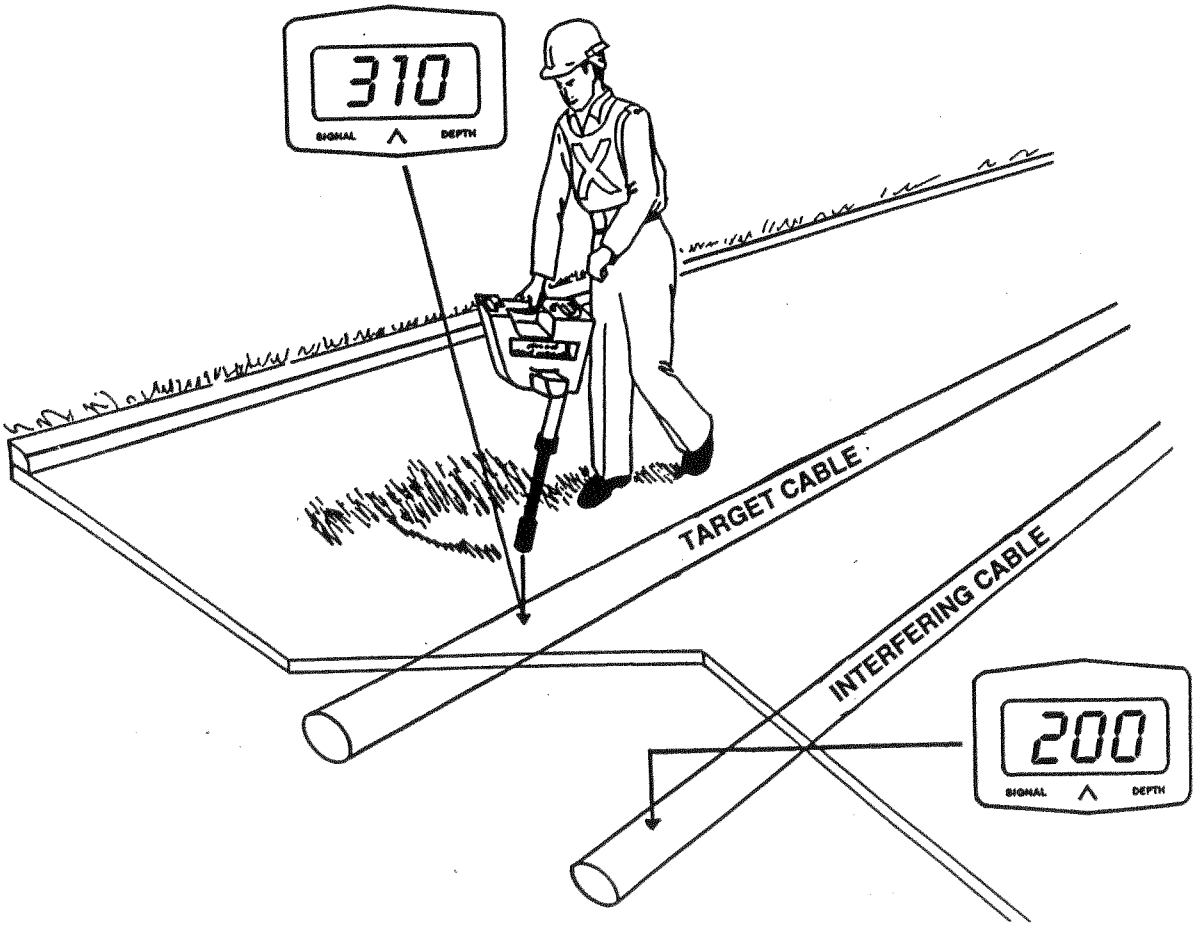
WARNING

Live power circuits can be extremely dangerous regardless of whether or not they are carrying current. Live power cables cannot be detected with this receiver unless they are carrying sufficient current to create a signal field. Do not use this unit to determine whether a power cable is energized or not.

Perform the following steps:

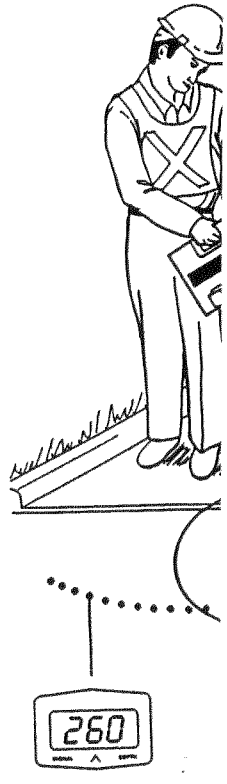
1. Loosen the lock-nut on the probe and extend the probe to its fullest extent, then tighten the lock-nut on the probe to secure the probe in its operating position.

2. Set the four-position switch on the receiver to BATT % to perform a battery test on the receiver to verify that sufficient charge is available for operation. The battery test indication will read from 0 to 100% of available power in the batteries. BATT will show on the digital display during battery testing.



NOTE: SPIs are for example only and will vary due to local conditions.

Figure 9: Relative SPIs Between the Target Cable and an Interfering Cable



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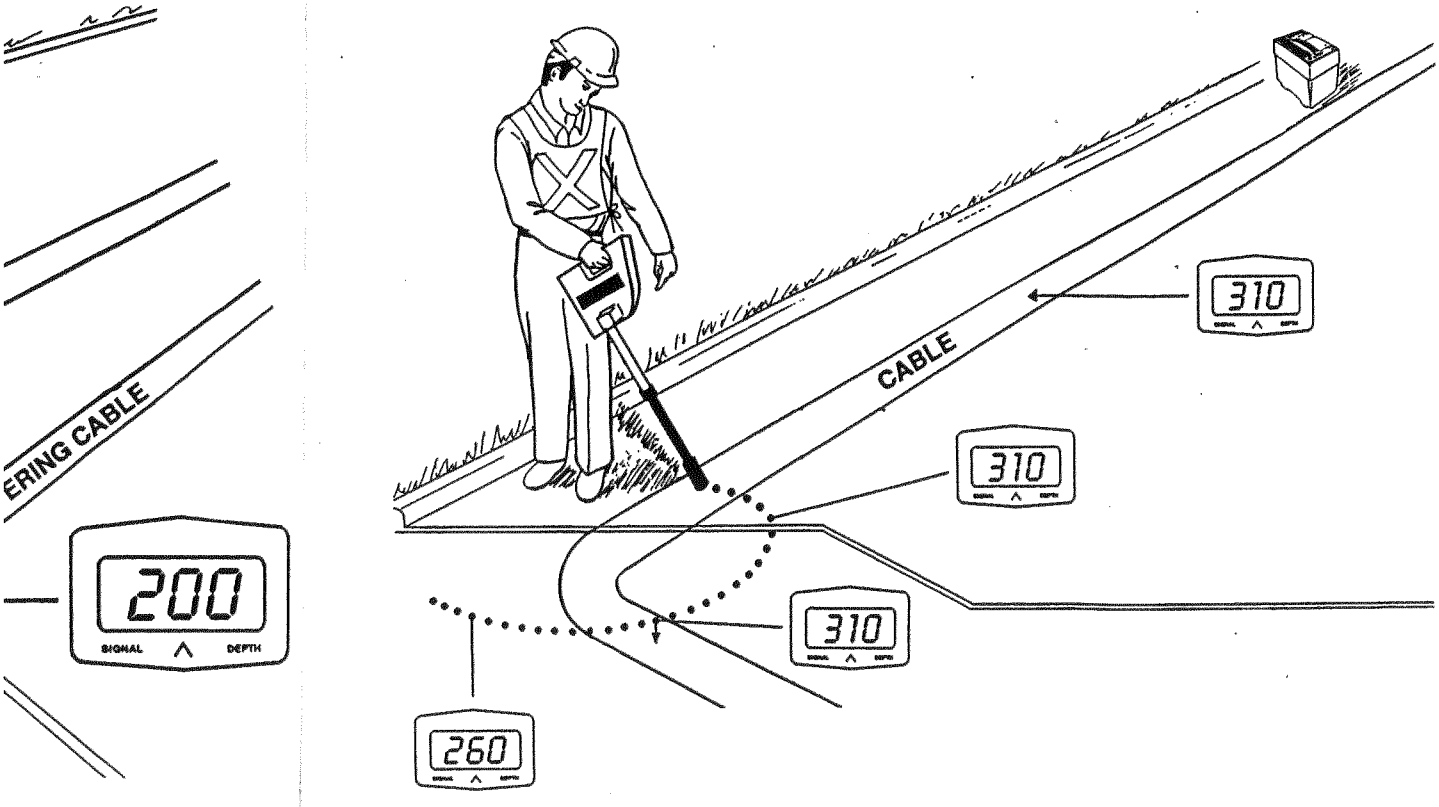

NOTE: SPIs are for example only and will vary due to local conditions.

Figure 10: Locating a Bend

3. Set the four-position switch on the receiver to POWER. The receiver's SPI numbers appear after the unit's self-test is complete to indicate that all systems have passed self-test.

4. Slowly sweep with the receiver to search for the cable. The signal intensity will be at its peak when the receiver is directly over and lined up with the power cable. Its actual intensity will depend on the amount of current being carried by the cable, the "twist" of the cable, and the depth of the cable. The SPI numbers will range from 0 to 999. As the operator nears the conductor, the numbers will increase; as the operator moves away from the conductor, the numbers will decrease. The numbers are the highest when the operator is directly over the conductor, and the receiver is lined up with it.

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SECTION 7

CABLE FAULT LOCATING APPLICATIONS

USING THE TRANSMITTER FOR FAULT LOCATING

To locate a fault in a cable, it is necessary to know the path of the cable under test. Prior to locating the fault, it is necessary to mark the path of the cable by tracing it using one of the methods described in Section 6. Before proceeding, read, understand, and observe all safety precautions contained in this manual. Refer to Section 2.

WARNING

Testing involves a connection to the phase conductor and there is always the possibility that this conductor could be energized. Furthermore, there may be other exposed conductors that have hazardous voltages on them. Only qualified personnel with the proper training should connect the instrument when exposed live conductors are present. Personnel should follow all applicable company safety policies and procedures.

1. Observing all safety precautions, be sure all equipment and cables are de-energized. Identify the cables to be traced and erect barriers.

2. Discharge cable under test by applying a ground using a safety grounding stick (not supplied). Connect a safety ground jumper (not supplied) from the phase conductor of the cable under test to the neutral conductor (the ground conductor of the cable under test).

WARNING

Failure to apply a safety ground jumper to the cable under test prior to connection of the transmitter can be extremely dangerous.

3. Choose a location that meets the following conditions:

   a. Both the phase conductor and the neutral conductor of the cable to be tested must be accessible at both ends.

   b. A secure low-resistance ground (less than 5 Ω) must be located near the

cable under test. A driven ground is often used; this ground is called the local earth ground.

c. Set up suitable barriers to protect the operator from traffic hazards and to prevent intrusion by unauthorized personnel. Warning lights or beacons are recommended.

4. After a satisfactory location for the transmitter of the SFL 2000 has been selected, connect the ground cable between the SAFETY GROUND (instrument chassis) wing nut on the SFL 2000 transmitter and the local earth ground (refer to step 3b).

WARNING

The transmitter chassis must be earth grounded to prevent an electric shock hazard.

5. Be sure that the POWER PULL ON switch on the transmitter is set to OFF.

6. Connect the test leads into the DIRECT ACCESSORY jack on the side of the transmitter.

WARNING

Before connecting the output test leads, make sure that the transmitter power is turned off.

7. Extend the black cable as far away from the path of the buried cable as its length will allow. The path of the black lead should be in line with the cable under test and behind the transmitter.

8. Install a suitable signal ground, such as the spike or grounding plate provided. Drive the spike firmly into the soil, the ground plate may be pushed vertically into the soil or laid flat on the ground if soil penetration is not possible, such as when working over concrete. If the plate is laid flat on concrete or blacktop, it is advisable to wet such surfaces to obtain a good ground and a weight placed on the plate to maintain good ground contact. This ground is the return path for the fault location signal.

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NOTE

A good signal ground is essential to fault location. It is generally advisable to ground in line with the cable being tested.

9. Connect the black lead of the output test leads to the ground stake or plate.

10. Disconnect the sheath ground bond at each end of the cable under test if one is present.

WARNING

When making connections, it is recommended that insulated rubber gloves be worn to prevent inadvertent contact with hazardous voltages. Make sure that the safety ground jumper is still in place before connecting to the cable.

11. Connect the red test lead to the phase conductor of the faulted cable. A good connection to the phase conductor is essential for a clear, strong signal.

12. Remove the safety ground jumper.

13. Verify that the conductor under test is not energized by observing the voltage reading on the LCD Display of the transmitter. If the cable is energized and it is less than 500 V (ac or dc) a voltage will be displayed. If the voltage is greater than 500 V the word HOT will flash on the display. If any voltage is present, immediately disconnect the test leads, determine the source of the voltage and de-energize the conductor before proceeding with the test.

WARNING

The test leads and the cable will have hazardous voltages on them while in the CABLE FAULT mode.

CAUTION

Turning on the transmitter with any voltage present on the conductor under test may damage the transmitter.

14. Pull the POWER PULL ON switch of the transmitter to the on position. After the transmitter performs a self-test, the CABLE LOCATE LED illuminates, indicating that the unit is now operating in the Cable Locate mode and voltage is present at the output red lead and the phase conductor of the cable under test.

15. Press the MODE SELECT button on the transmitter to place the unit in the FAULT OHMS mode; the FAULT OHMS LED will be illuminated. The word FAULT appears on the digital display and digits shown will read from 0 to 990 K Ohms in 10 K steps (with the K OHMS LED above the digital display automatically lit) or from 1 through 10 M Ohms in 1 M Ohm steps (with the M OHMS LED above the digital display automatically lit. If the resistance value is over 5 M Ohms, the digital display digits covert to — straight bars to indicate overrange condition of the digital ohmmeter. Determine that the conductor under test has a fault by verifying that the fault resistance is 5 M Ohms or less.

WARNING

The test leads and the cable will have hazardous voltages on them while in the FAULT LOCATE mode.

16. Press the MODE SELECT button on the transmitter to place the unit in the FAULT LOCATE mode; the FAULT LOCATE LED will be illuminated. In this mode, a low frequency fault tracing signal is added to the cable tracing signal.

17. Set the POWER OUTPUT switch to HI or LO. The appropriate power level is selected considering the depth of the cable and the length of the trace desired. The transmitter automatically adjusts to provide full power into the load impedance. The SFL-2000 is able to load match both the cable tracing signal and the cable fault signal independently due to the vastly different frequencies used for cable location and cable fault location (7776.4 Hz vs 11.11 Hz).

The bar graph shown on the digital display indicates relative power output. On the HI power setting all eight segments come on, unless the ground return or cable connection is poor, in which case the segments will be less. The optimum bar graph readout for the LO power setting is four bars. This reminds the operator whether the unit is switched to LO or HI.

18. Push the % BATTERY switch to display the percentage of charge remaining in the battery. If the digital display shows LO in place of a number, operation is locked

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19. Refer to the topic "Using the Receiver for Fault Locating" for instructions on tracing the cable.

20. During a temporary or permanent shutdown, push the POWER PULL ON switch of the transmitter to the off position.

21. To disconnect the setup, manually ground the phase conductor with a safety ground stick and then apply safety ground jumpers.

WARNING

Never assume that the output test leads or the cable under test are completely discharged, even after following the above procedures. Always use a safety grounding stick to ground any conductive part of the circuit and then apply safety ground jumpers before touching any connections.

22. Remove the test leads from the phase conductor (or the neutral conductor) and from the signal ground. Remove the safety ground lead from local earth ground.

23. Remove the safety ground jumper.

USING THE RECEIVER FOR FAULT LOCATING

1. Set the four-position switch on the receiver to BATT % to perform a battery test on the receiver to verify that sufficient charge is available for operation. Available power in the batteries is shown in a percentage and BATT is displayed during battery testing.

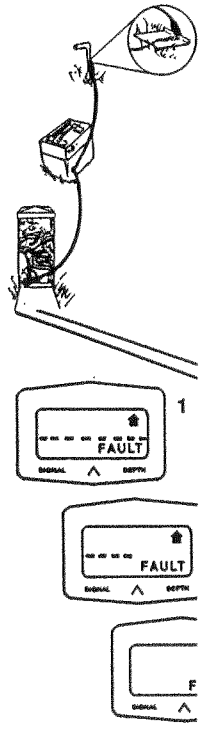
2. Set the four-position switch on the receiver to NORMAL and plug the earth contact ground frame into the FAULT jack on the rear panel of the receiver. The receiver will indicate FAULT on the display for the fault location mode after the unit self-test is complete to indicate that all systems have passed self-test. The unit is ready for fault location. Unplugging the earth contact ground frame automatically returns the unit to the cable tracing and depth location mode.

NOTE

To pinpoint a ground fault, trace and accurately mark the cable path prior to fault location.

3. Hold the receiver with one hand, the word FAULT is shown on the digital display indicating that the unit is in the fault detecting mode. With the other hand, hold the earth contact ground frame with the green-banded leg pointing to the front and the red-striped leg pointing to the rear. (Fig. 11)

4. At the signal ground rod, insert the probes firmly into the ground for good earth contact, with the earth contact ground frame in line or parallel to the conductor path, while facing the cable section to be tested.



The digital display arrow will point forward indicating the fault or faults are ahead of the operator in the direction of the green-banded leg of the earth contact ground frame. Simultaneously the bar graph indicator will show the closeness and size of the fault by the number of segments indicated; as the unit moves closer to the fault, fewer segments are indicated.

5. Walk parallel or in line with the cable under test, re-inserting the frame every few steps and watching the direction arrow and segment indicator on the digital display (Fig. 12).

When the arrow indicator reverses direction and points to the rear, the fault has now been passed and is behind the operator. The segments shown on the digital display will be at the highest point at arrow reversal.

6. Back up slowly; the fault is very close to this point. Continue inserting the earth contact ground frame every few inches until the arrow indicating fault direction reverses direction again. Then move forward slowly inserting the earth contact ground frame until both arrows disappear. The fault is located beneath or next to the center of the frame and on the cable path when the direction arrow is between forward and reverse, and the bar graph segments are at maximum.

7. If unsure of the cable path, place the receiver in the cable locate mode by unplugging the earth contact ground frame and trace the cable. By again plugging the earth contact ground frame into the FAULT jack on the receiver, the cable fault locate mode will be restored.

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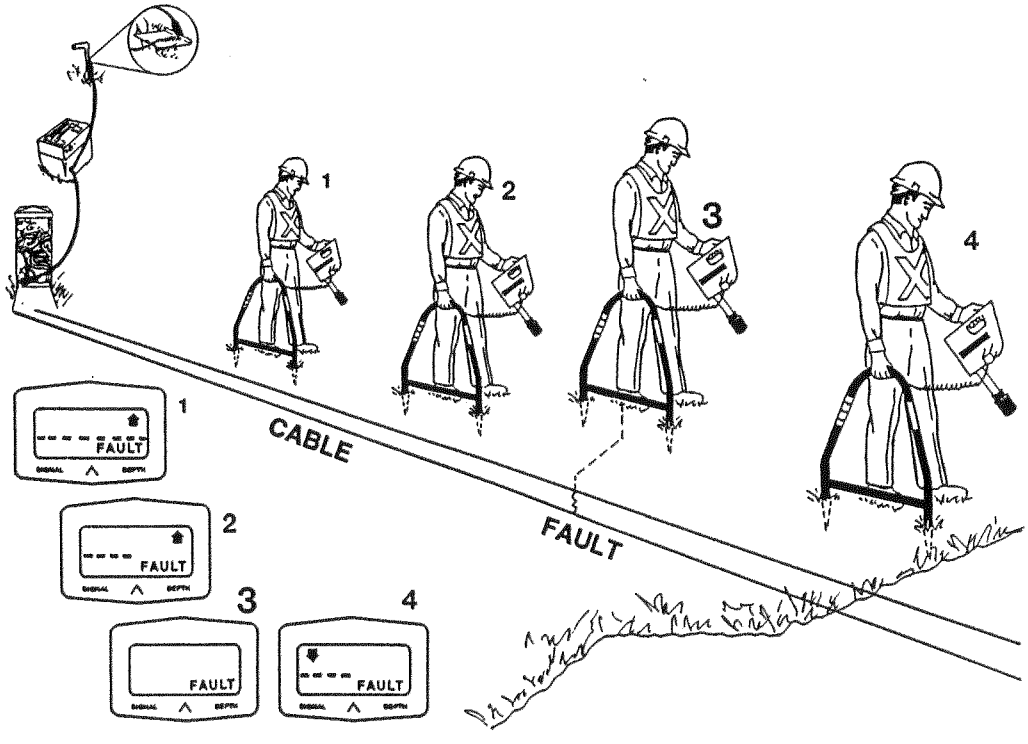

FOR ILLUSTRATION ONLY; SAFETY GROUND AND BARRIERS NOT SHOWN

Figure 11: Cable Fault Location

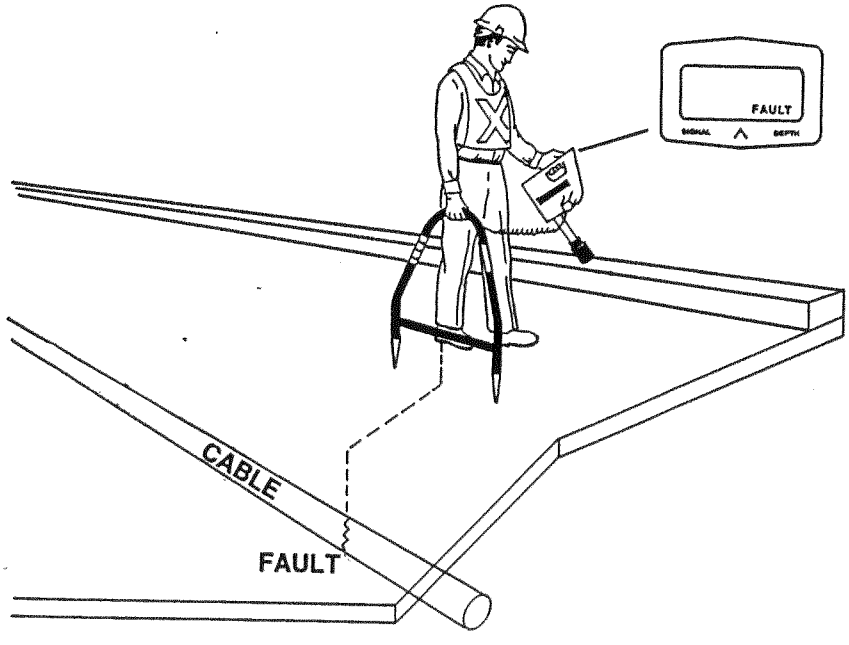

Figure 12: Perpendicular Cable Fault Location

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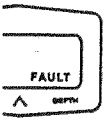
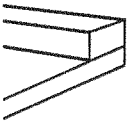
If the cable fault has very high resistance or is very distant, the bar graph display may not appear until the operator is closer to the fault.

8. When the cable path is beneath a paved surface, walk parallel to the cable path; arrow reversal will occur when the earth contact ground frame is directly perpendicular to the ground fault. A triangulation method may be used by moving forward several yards and rotating the earth contact ground frame a few degrees until the arrows disappear. A line marked perpendicular to the frame will intersect the cable path at the fault. Repeat this procedure by backing up several yards and the fault will be at the intersection of the two lines drawn (Fig. 13).



If the cable path is under a large paved area, nails long enough to reach the earth can be driven in to enable the earth contact ground frame to be used. A plunger bar can also be used to punch holes into the pavement.



NOTE

The receiver locates faults by probing parallel to the cable path. This procedure should be used whenever possible for more accurate and faster fault location. The extended earth contact ground frame method may have to be used in extreme cases.

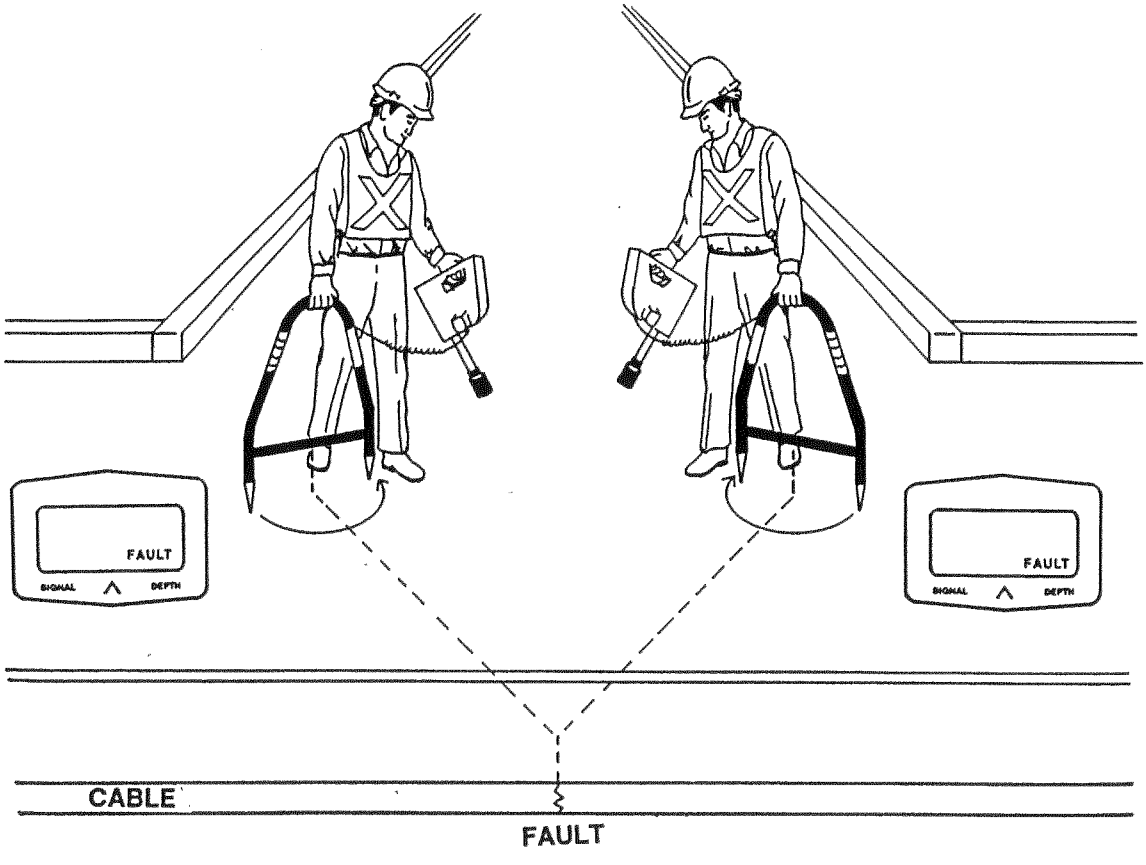


Figure 13: Cable Fault Location by Triangulation

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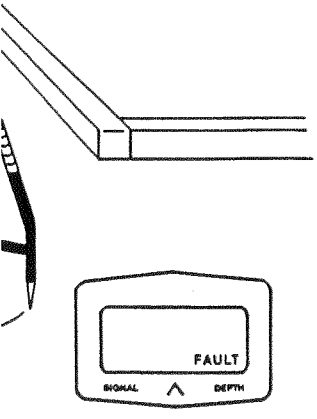
SECTION 8

MAINTENANCE

BATTERY CHARGING AND REPLACEMENT

Transmitter Battery Charging

The SFL-2000 transmitter is equipped with a rechargeable, 6 V maintenance-free, fully sealed, lead-acid battery. A 120 V ac wall mount charger can fully recharge the transmitter overnight with no danger of overcharging if left on continuously.



1. Turn the transmitter off.

2. Plug the charger into the BATTERY CHARGER jack on the transmitter.

3. Plug the wall-mount charger into a 110 to 130 V receptacle.

WARNING

The charger is meant for indoor use only.

4. When charging is complete, unplug the charger from the BATTERY CHARGER jack on the transmitter.

5. Perform a battery test.

NOTE

Leaving the charger jack plugged into the transmitter while the wall-mount charger is not plugged into a 110 V receptacle will deplete the battery.

Receiver Battery Replacement

The SFL-2000 receiver uses four alkaline 9 V transistor batteries.

1. Loosen the screw and remove the battery access door (located below the speaker panel) from the receiver.

2. Remove the four exhausted batteries.

3. Install the four new batteries.

4. Replace the battery access door.

5. Perform a battery test.

TRANSMITTER FUSE REPLACEMENT

The transmitter contains a 3 A/250 V fast-blow fuse.

WARNING

This instrument can produce and contain dangerous voltages. Service or repair of this equipment should be performed only by qualified persons who are aware of electrical hazards and the necessary precautions routinely taken to prevent injury.

1. Locate the two screws on each end of the transmitter that hold the transmitter bottom in place.

2. Loosen each screw five turns.

3. Remove transmitter bottom.

4. Completely remove the two screws.

5. Lift off the panel (top) of the transmitter.

6. Locate and replace fuse with a 3 A/250 V fast-blow fuse.

7. Replace transmitter panel (top), and tighten the two screws half-way.

8. Replace transmitter bottom; tighten the two screws.

9. Test transmitter for power output.

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ROUTINE MAINTENANCE

The SFL-2000 is a rugged, durable instrument built to withstand the rigors of day-to-day field use. It is, however, an electronic instrument and should be treated as such.

1. When the SFL-2000 is not being used it should be kept in its carrying case and stored in a safe, dry area. If left in a vehicle, it should be stored in an area where it will not be exposed to extremes in weather conditions. Avoid storing in direct sunlight which may cause excessive overheating.

2. Should the unit become dirty, wipe it down with a damp cloth. Cleaning compounds should not be used on the transmitter or the receiver. Harsh, gritty cleansers can mar or damage the lettering on these units.

3. Periodically inspect the direct connection attachments to make sure that there are no frayed or broken cables. Inspect the clamps to ensure good contact is being made.

WARNING

Frayed, broken, or exposed conductors on the direct connection attachments may present an electrical shock hazard.

CAUTION

When removing the direct connect cables from the transmitter, grab the plug itself, do not remove by pulling on the cables; this may damage the cables.

4. Keep the telescoping probe assembly clean and free of dirt and grit.

REPAIR

AVO Biddle Instruments offers a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. Please indicate all pertinent information including problem symptoms and attempted repairs. Equipment returned for repair must be shipped prepaid and insured and marked for the attention of the Repair Department Manager.

The following suggestions will expedite the repair of your instrument:

1. Package carefully, using the instrument case, original shipping carton, if available, and return all components.

2. Specify your complete shipping and billing addresses.

3. Specify the instrument model number, serial number, and a brief description of the problem you are experiencing.

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GLOSSARY

	Read manual before using.
CLC	Indication on receiver display for calculation.
LCD	Liquid crystal display
LED	Light emitting diode
Local earth ground	Driven earth ground made before each test.
Safety ground	A temporary ground, this connection is made before each test between the phase conductor and ground.
Safety grounding stick	An insulated stick (sometimes called a hot stick) with a hook type electrode connected to ground via an insulated cable. In some designs, frequently known as high-voltage discharge sticks, a resistor is connected between the electrode and the ground cable. Both are used to discharge capacitive specimens by providing a low impedance path to ground. They must be suitably rated for the voltage and capacitance of the specimen to be discharged.
Safety ground jumper	Temporary connection (not supplied) made between the high-voltage conductor of the cable under test to ground.
SPI	Signal power indicator. Numbers ranging from 0 to 999 displayed on the readout panel of the receiver that indicate relative signal strength received.

WARRANTY

Products supplied by AVO Biddle Instruments are warranted against defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair must be shipped prepaid and insured. This warranty does not include batteries, lamps or similar items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.

AVTM651060

AVO INTERNATIONAL
510 Township Line Road
Blue Bell, PA 19422 USA
215/646-9200
FAX: 215/643-2670
TELEX: 685-1045-JGBCO
1-800-366-5543

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