Circuit Tracer
Model T-240

USER MANUAL

AEMC® INSTRUMENTS

WARNINGS

- Do not attempt to perform any tests with this instrument until you have read and understood the instruction manual.
- The Circuit Tracer should never be used in an explosive environment, including poorly ventilated battery rooms and enclosures.
- Make sure that the internal battery is fresh prior to testing. If the instrument has been left unused for several months, replace the battery.
- If the case needs cleaning, do not use any alcohol or oil based cleaners. Clean with a damp soapy cloth or sponge.

RECEIVING YOUR SHIPMENT

Upon receipt of your instrument, check the contents against the packing list and your purchase order. Notify your distributor of any missing items. If the equipment appears to be damaged, file a claim immediately with the carrier and notify your distributor at once with a detailed description of the damage. Save the damaged packing container to substantiate your claim.

PACKAGING

The Circuit Tracer may be ordered in individual component form or as a complete system.

COMPONENTS

- Catalog #1417.01 — Receiver and instruction manual.
- Catalog #1417.02 — Transmitter Model T-240 and instruction manual.
- Catalog #1417.03 — Transmitter Model T-650 and instruction manual.

SYSTEMS

- Catalog #2110.11 — Receiver, Transmitter Model T-240, carrying case, set of leads (2 leads with alligator clips, one lead with 2 pin AC plug, one AC adaptor plug) and instruction manual.
- Catalog #2110.12 — Receiver, Transmitter Model T-650, carrying case, set of leads (2 leads with alligator clips, one lead with 2 pin AC plug, one AC adaptor plug) and instruction manual.
- Catalog #2110.13 — Receiver, Transmitter Model T-240, and Transmitter Model T-650, carrying case, set of leads (2 leads with alligator clips, one lead with 2 pin AC plug, one AC adaptor plug) and instruction manual.

REPLACEMENT ITEMS

- Catalog #2118.17 — Leads, 2 leads with alligator clips, one lead with 2 pin AC plug, one AC adaptor plug.
- Catalog #2118.19 — Carrying Case.
- Catalog #2975.14 — Fuses: Set of 10, 0.1A, 380 V, 5 x 20 mm, for Transmitters T-240 and T-650.

SPECIFICATIONS

ELECTRICAL, TRANSMITTER

Reference Conditions:
Temperature: 23°C ± 3°C
Humidity: 40 to 60% RH
Transmitter Frequency: 50/60 Hz ± 2.5 Hz
Detector Power Supply: 8 V ± 0.25 V

Voltage*:
Model T-240: 9 to 140 VAC/DC
Model T-650: 180 to 300 VDC, 180 to 440 VAC

* The T-240 and T-650 are rated for phase (hot)-to-ground voltages. Distribution systems are normally rated phase (hot)-to-phase (hot), or as working voltages. The table below shows working voltages for the T-240 and T-650. In three phase systems, the phase-to-phase voltage equals the phase-to-ground voltage multiplied by the square root of 3.

	Max. Working Voltage (Max. Phase-to-Phase)		Maximum Phase-to-Ground Voltage		Frequency Hz
T-240	DC	9 to 140 V	DC	9 to 140 V	
	AC	16 to 242 V	AC	9 to 140 V	50/60 ± 2.5
T-650	DC	180 to 300 V	DC	180 to 300 V	
	AC	311 to 650 V	AC	180 to 440 V	50/60 ± 2.5

Frequency: 50/60 Hz to 1 Hz
LED Frequency: Approximately 3 flashes per second, when energized
Duty Cycle: 3.5 kHz, 10 ms transmission every 320 ms. Crystal controlled digital circuit
Current Consumption: 5 mA average, 250 mA peak for 10 ms during pulse transmission (every 320 ms)
Output: 4 mm recessed banana jacks
Power Supply in Non-Energized Circuits: Five 9 V batteries or higher may be used (within transmitter specified voltage range) to sustain a 250 mA pulse in high resistance circuits (such as through the soil to trace pipes) or if tracing for extended periods of time. Several 9 V batteries may be set in series to accomplish this.

ELECTRICAL, RECEIVER

Power Supply: 9 V battery, (alkaline recommended, NEDA 1604A or equivalent)
Current Consumption: 20 mA typical
Display: 9 segment LED bar graph field strength meter
Buzzer: 3,500 Hz chirping sound with volume proportional to the distance between the circuit carrying the pulse and the detector
Sensitivity: 5 button-selectable levels

MECHANICAL

Operating Temperature: 32 to 122°F (0 to 50°C)
Storage Temperature: -4 to 122°F (-20 to 50°C)
Humidity: 20 to 70% RH
Case Material: Polycarbonate
Dimensions: *Receiver:* 8.46 x 2.17 x 1.77" (215 x 55 x 45 mm)
Transmitters: 0.59 x 2.17 x 0.98" (15 x 55 x 25 mm)
Weight: *Receiver:* 6.5 oz. (184.3 g) with battery
Transmitters: 2.7 oz (76.5 g)

SAFETY, TRANSMITTER

Dielectric Strength: 3,000 V, 50/60 Hz, 1 minute
Transients: IEC 801-4, safety level 3 (2 kV)
Electric Shock: IEC 60-2, safety level 5 kV, 2 joules, between both inputs
Fuses: 0.1 A, 380 V high interrupting capacity, 5 x 20 mm (Set of 10 fuses - Cat. #2975.14)

SAFETY, RECEIVER

Transients: IEC 801-4, safety level 3 (2 kV)
Drop Test: 1 meter, IEC 68-2-32
Environmental: IP-10

INSTRUMENT DESCRIPTION

The AEMC Circuit Tracers (shown in the outline drawing in Figure 1) are light, compact, hand held instruments that do not require special converters or transformers for field use in a wide range of environments. An audible beeping tone and 9 segment LED display clearly indicate the received signal level to guide the user in accurately tracing and pinpointing the desired circuit. The product design is unique: the transmitter and receiver interlock into one convenient package, as shown in Figure 2 (patent pending). The instrument requires only a pair of test leads to operate.

AEMC Circuit Tracers are designed to locate and identify breakers and fuses or to trace energized circuits, legs or branches from any location, even through non-shielded walls and floors or in nonmetallic conduits without shutting down the power or disrupting running equipment. Typically, the user will track an energized phase, a neutral or a ground from an outlet or control box to a distribution panel to locate the breaker. Non-energized wires, pipes and conduits may also be traced or followed by using one of several standard batteries.

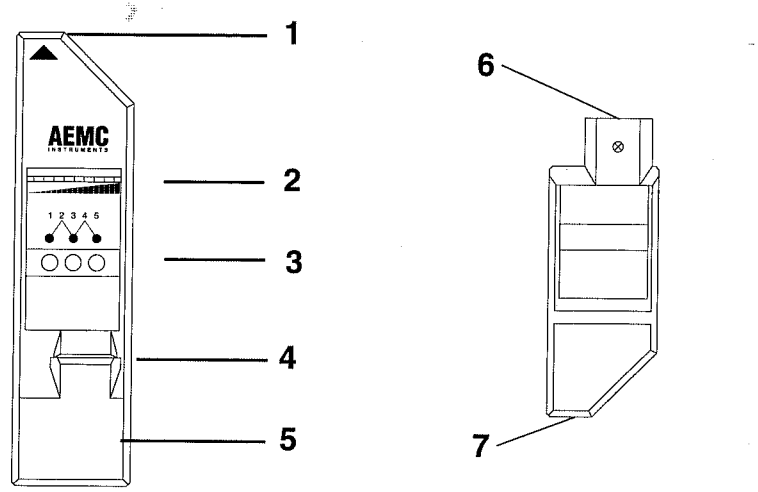
The specific applications are numerous. The two models offered cover phase-to-ground voltages from 9 VDC to 300 VDC and 9 VAC to 440 VAC (see **Specifications** on page 2 for phase-to-phase working voltages).

Applications include:

- Locating low voltage control circuits on walls or shorts-to-ground or following conduit or pipe in systems such as heating and ventilating.
- Tracing coaxial cable or identifying cables in telecommunications and computer networks.
- Locating open breakers, neutrals and grounds, buried cables, short circuits, open fuses or breakers or ground faults in power distribution systems.

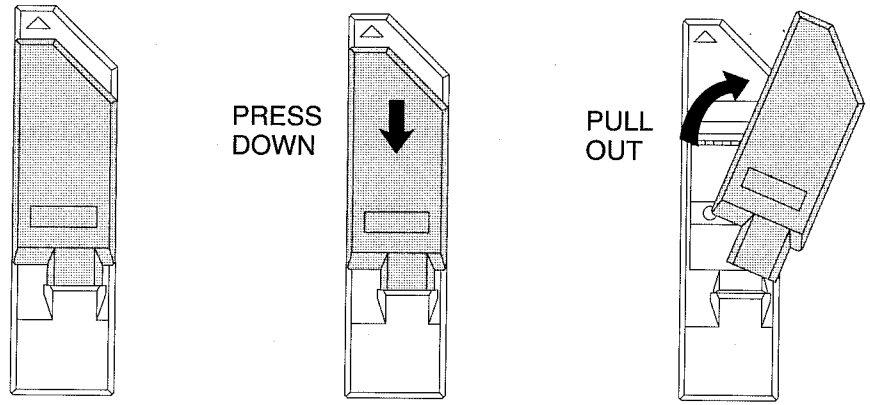
Internal batteries are not used in the Model T-240 or T-650 transmitters. To replace the battery in the receiver, turn the unit over and locate the screw that secures the battery door. Remove this screw with a small

Figure 1 - Instrument Identification



1	Receiver Probe Tip	5	Battery Door (on back)
2	9 Segment LED/Field Strength	6	Line Terminals
3	Sensitivity Selection	7	Power Indication LED
4	Transmitter Receptacle		

Figure 2- Separating the Transmitter and Receiver Units



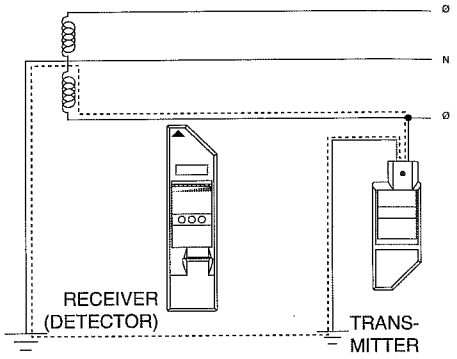
Phillips screwdriver. Lift off the battery door to expose the 9 Volt battery. Lift out the battery and remove the lead clip. Attach the leads to a new battery and place it inside the compartment. Replace the battery door and its screw.

OPERATION THEORY

PRINCIPLE

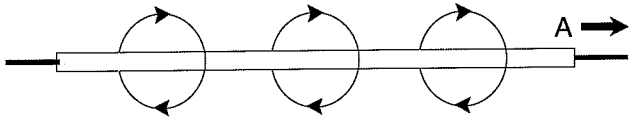
The transmitter connected between the circuit and ground acts as a resistance switched on and off at high frequency (3,500 Hz) and draws very low current. This switching principle creates a pulsating current which follows the circuit towards the voltage source. By switching at high frequency and not over a full cycle, GFCI's or breakers will not trip, and the transmitter will not heat up. This is illustrated in Figure 3.

Figure 3 - Example of Use



The detector responds to the magnetic field created around the circuit (see Figure 4) through an electronic filtering circuit. The visual LED display and audible pulses vary in intensity to the selected sensitivity and proportionally to the distance from the traced circuit. The closer that the detector is to the traced circuit, the louder the intensity of the beeper and the greater the signal level indicated by the LED display. Circuits may thus be traced over their entire length even through walls, conduits, or concrete up to 1.6 ft. (50 cm) thick.

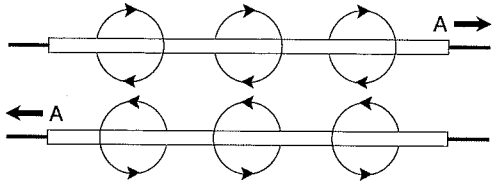
Figure 4- Magnetic Field on a Conductor



SEPARATE GROUND RETURN

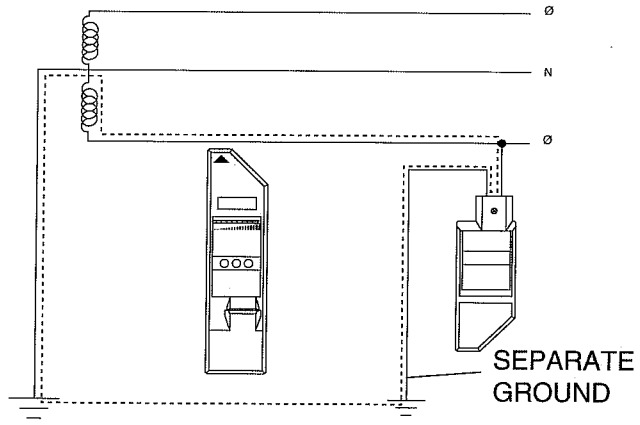
In most power distribution systems, the hot phase(s), neutral and ground are laid adjacent to each other. When using the tracer, the hot leg and the ground have signals flowing in the opposite direction and the magnetic fields tend to cancel each other out when side by side, as shown in Figure 5.

Figure 5 - Magnetic Field Cancellation in Adjacent Conductors



For best results and sensitivity, separate the signal paths to trace them. The most effective way is to use a separate ground away from and not adjacent to the traced circuit (e.g., grounded metal water pipe), as shown in Figure 6.

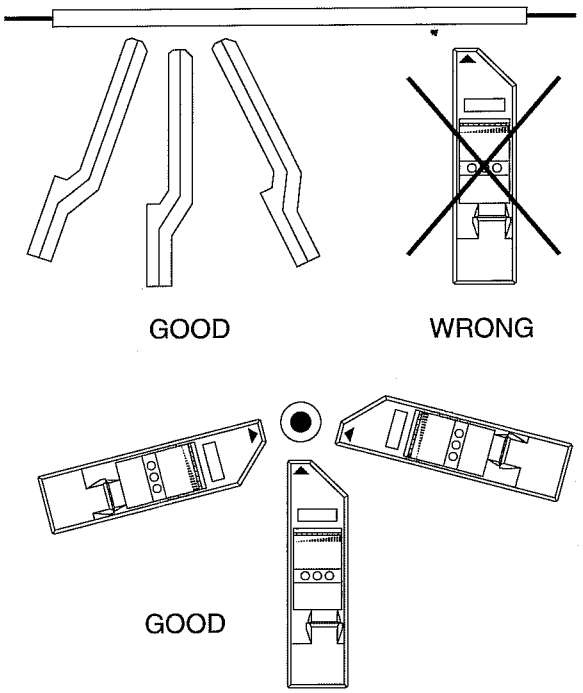
Figure 6 - Using a Separate Ground Return



RECEIVER POSITION AND SENSITIVITY SETTING

The position and angle of the receiver probe is important to ensure the best results and enhance receiver sensitivity. The receiver should be perpendicular to the traced circuit, as shown in Figure 7.

Figure 7 - Proper Receiver Operating Position and Angle



The receiver probe sensitivity is selected by pressing one or two of the three available push-buttons as shown below:

● ○ ○ Low	○ ● ● Medium-high
● ● ○ Medium-low	○ ○ ● High
○ ● ○ Medium	(● ← pressed)

APPLICATIONS

LOCATING CIRCUIT BREAKERS AND FUSES

Industrial, Office, and Residential (110/220 VAC) with Electrical Outlets

WARNING: Use a voltmeter to measure phase-to-ground voltage to ensure that you have selected the appropriate transmitter for your application:

T-240: 9 - 140 VDC or VAC

T-650: 180 - 300 VDC
180 - 440 VAC

- Use the supplied lead with two safety banana plugs on one end and an electrical plug on the other.
- Connect the safety banana plugs to the transmitter first and then connect the plug to the outlet (Figure 8).
- **Note:** 110 VAC US plug is supplied. Refer to general application for use without the outlet plug.
- Do not connect the transmitter to a separate ground in electrically susceptible areas of health care facilities.

Operation

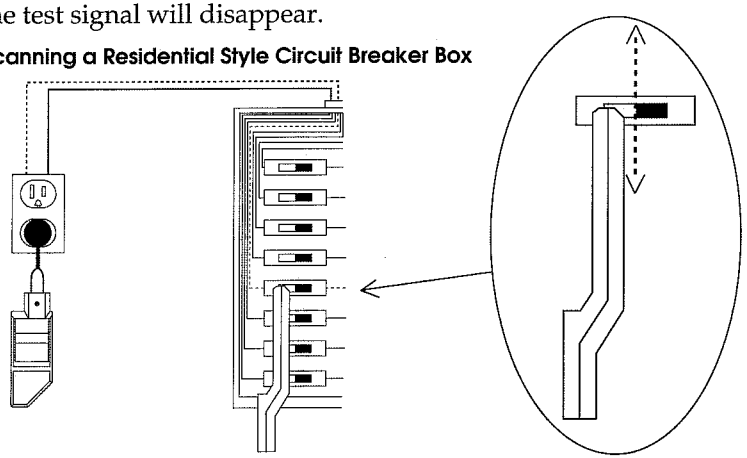
- Confirm that the red LED is flashing on the transmitter, which indicates that a signal is being transmitted. Align your receiver so that it points to one of the leads from the transmitter and select the highest sensitivity level. The receiver should beep and the receiver LEDs should light up. If it does not respond, check its battery.
- Go to the breaker or fuse panel box. If there are several panels, choose the highest sensitivity and wave the receiver outside the closed doors. As the receiver approaches the correct panel, the beeping and the signal strength LED will be stronger. Not all the LEDs need to light up when the correct panel is located.

- Choose the panel with the strongest signal. Open the panel box door.
- Use a receiver sensitivity level which gives a strong signal and beep. Fluorescent lighting or panels with many breakers may require use of the highest sensitivity level. Hearing a distinct beep with a strong LED signal strength indication is important.
- Scan the breakers or fuses methodically up and down as shown in Figure 8. Touch the receiver's tip to each breaker for best results. **Note:** It is important to keep the receiver perpendicular to the breaker (see **Receiver Position and Sensitivity Setting** on page 8).
- If several breakers give the same signal strength, select a lower receiver sensitivity. If this does not help, remove the panel trim.

WARNING: Authorized personnel only. Use appropriate safety precautions prior to trim removal and use the receiver on a lower sensitivity setting. Remember to hold the receiver at the right of the circuit being traced and to listen for the actual beeping.

- The breaker that produces the strongest distinct signal response is the breaker controlling the outlet. **Note:** If the correct breaker is turned off, the test signal will disappear.

Figure 8- Scanning a Residential Style Circuit Breaker Box



Note: For minimum interference from adjacent wires within the breaker panel, scan the side of the breakers closest to the outer edge of the panel.

LOCATING CIRCUIT BREAKS (General Application)

WARNING: Use a voltmeter to measure phase-to-ground voltage to ensure that you have selected the appropriate transmitter for your application:

T-240: 9 - 140 VDC or VAC

T-650: 180 - 300 VDC
180 - 440 VAC

- ➲ Use the supplied leads with two safety banana plugs on one end and insulated clips on the other.
- ➲ Connect the safety banana plugs to the transmitter. Then first connect one alligator clip to the ground and the other to the hot phase, as shown in Figure 9.
- ➲ When finished, disconnect the ground *last.*
- ➲ Do not connect the transmitter to a separate ground in electrically susceptible areas of health care facilities.

Operation

- Confirm that the red LED is flashing on the transmitter, which indicates that a signal is being transmitted. Align your receiver so that it points to one of the leads from the transmitter and select the highest sensitivity level. The receiver should beep and its LEDs should light up. If it does not respond, check its battery.
- Because circuit breaks usually occur at circuit breaker or fuse locations, begin with the breaker or fuse panel box. If there are several panels, choose the highest sensitivity and sweep the receiver over the outside of the closed doors. As the receiver approaches the correct panel, the beeping and the signal strength LED will be stronger. Not all the LEDs need to light up when the correct panel is located.
- Choose the panel with the strongest signal. Open the panel box door.
- Use a receiver sensitivity level which gives a strong signal and beep. Fluorescent lighting or panels with many breakers may require the

highest sensitivity. Hearing a distinct beep with a strong LED signal strength indication is important.

- Scan the breakers or fuses methodically up and down as shown in Figure 9. Touch the receiver's tip to each breaker for best results.

  Note: It is important to keep the receiver perpendicular to the breaker (see **Receiver Position and Sensitivity Setting** on page 8).

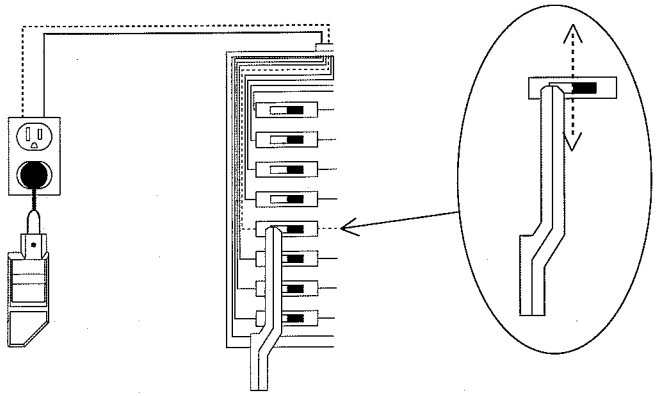
- If several breakers give the same signal strength, select a lower receiver sensitivity. If this does not help, remove the panel trim.

WARNING: Authorized personnel only. Use appropriate safety precautions prior to trim removal and use the receiver on a lower sensitivity setting. Remember to hold the receiver at the correct angle and to listen for the actual beeping.

- The breaker that produces the strongest distinct signal response is the breaker controlling the circuit used.

  Note: If the correct breaker is turned off, the test signal will disappear.

Figure 9 - Tracing Circuits in Walls, Floors, etc.



Note: For minimum interference from adjacent wires within the breaker panel, scan the side of the breakers closest to the outer edge of the panel.

LOCATING AND TRACING NEUTRAL LINES

When using the supplied AC plug to connect the transmitter, the signal returns through the neutral.

The receiver may be used to identify the neutral corresponding to the particular outlet.

Alternately, the transmitter may be connected between phase and neutral with the alligator clip leads, and the neutral may be located (see **Locating Circuit Breaks** on page 11).

TRACING ENERGIZED CIRCUITS (in walls, floors, ceilings, etc.)

WARNING: Use a voltmeter to measure phase-to-ground voltage to ensure that you have selected the appropriate transmitter for your application:

T-240: 9 - 140 VDC or VAC
T-650: 180 - 300 VDC
180 - 440 VAC

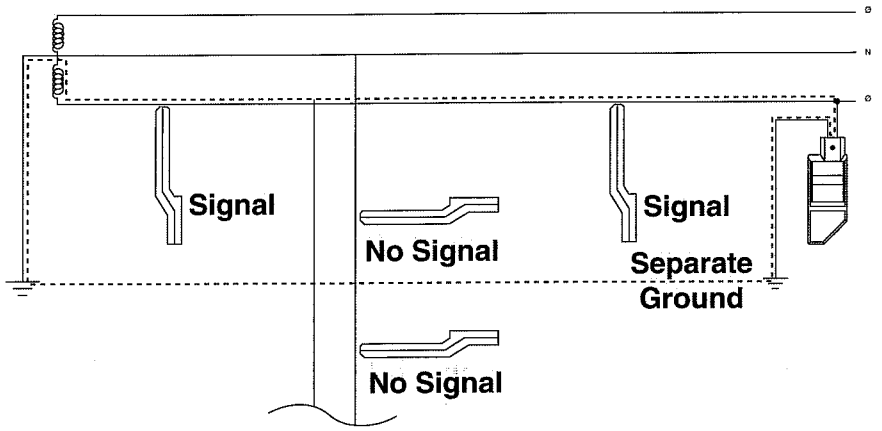
- ➲ Use the supplied leads with two safety banana plugs on one end and insulated clips on the other.
- ➲ Connect the safety banana plugs to the transmitter. Then first connect one alligator clip to the separate ground and the other to the hot phase as shown in Figure 10.
- ➲ When finished, disconnect the ground *last*.
- ➲ Do not connect the transmitter to a separate ground in electrically susceptible areas of health care facilities.

Operation

- Confirm that the red LED is flashing on the transmitter, which indicates that a signal is being transmitted. Align your receiver so that it points to one of the leads from the transmitter and select the highest sensitivity level. The receiver should beep and its LEDs should light up. If it does not respond, check its battery.

- Select the highest sensitivity level. Hold the receiver tip close to the wall, floor or ceiling and sweep the probe across the area where you suspect the conductor to be.
- Adjust the receiver sensitivity level as well as the probe position and angle to narrow down the exact location of the hidden circuit. It is important to correctly position the receiver probe for best sensitivity (see **Receiver Position and Sensitivity Setting** on page 8). Also be sure you are tracing the hot wire and not the ground or neutral wire.
- If you lose the signal, select a higher receiver sensitivity setting and sweep the area again. The traced wire may have deviated or changed direction.
- The wire may be traced back to the transformer. If going through step down transformers, the sensitivity will diminish as the signal passes through the transformer. **Note:** UPS (Uninterruptible Power Supplies) or isolation transformers may filter out the signal and reduce its strength.

Figure 10 - Tracing Energized Circuits



TRACING A CONDUIT

WARNING: Use a voltmeter to measure phase-to-ground voltage to ensure that you have selected the appropriate transmitter for your application:

T-240: 9 - 140 VDC or VAC

T-650: 180 - 300 VDC
180 - 440 VAC

- ➲ Use the supplied leads with two safety banana plugs on one end and insulated clips on the other.
- ➲ Connect the safety banana plugs to the transmitter. Then first connect one alligator clip to the separate ground and the other to the hot phase as shown in Figure 11.
- ➲ When finished, disconnect the ground *last.*
- ➲ Do not connect the transmitter to a separate ground in electrically susceptible areas of health care facilities.
- ➲ Make sure that the "hot" wire runs inside the conduit you want to trace, and that the separate ground is not adjacent to the conduit you want to trace (a metallic water pipe may be used as a separate ground). Do not use the conduit as the ground return.

Operation

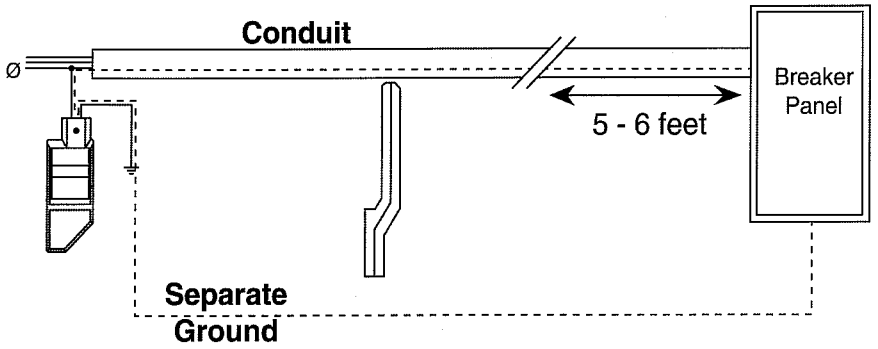
- Confirm that the red LED is flashing on the transmitter, which indicates that a signal is transmitted. Align your receiver so that it points to one of the leads from the transmitter and select the highest sensitivity level. The receiver should beep and its LEDs light up. If it does not respond, check its battery.
- Select the highest sensitivity level. Hold the receiver tip close to the wall, floor or ceiling and sweep the probe across the area where you suspect the conduit to be.
- Adjust the receiver sensitivity level as well as the probe position and angle to narrow down the exact location of the hidden circuit. It is

important to correctly position the receiver probe for best sensitivity (see **Receiver Position and Sensitivity Setting** on page 8). Also, be sure that you are tracing the hot wire in the conduit and not the return ground or neutral wire.

- As you approach the breaker panel, the signal in the conduit may be disrupted by the magnetic field generated by the panel. Hold the receiver probe 5 to 6 feet or more from the breaker panel so that the weaker magnetic field in the conduit will not mask the transmitter signal. Maintain proper receiver position at all times.

Note: Sensitivity is greatly reduced in conduits of magnetic material.

Figure 11 - Tracing Conduits



TRACING DE-ENERGIZED CIRCUITS OR CABLES

WARNING: Use a voltmeter to ensure that the circuit is not live.
Select a transmitter for your DC battery:

T-240: 9 - 140 VDC or VAC

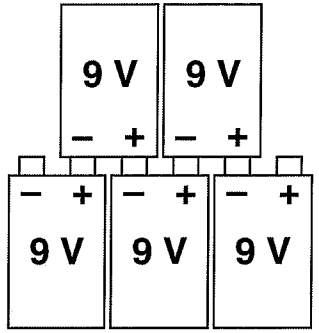
T-650: 180 - 300 VDC
180 - 440 VAC

- ➲ If testing coaxial cable or other cables, verify that they are not in use.
- ➲ Use the supplied leads with two safety banana plugs on one end and insulated clips on the other.
- ➲ Determine the type of battery needed. In a short, low resistance circuit, a single battery or set of series connected batteries may do. In longer or high resistance circuits, such as those using an earth ground return, a larger capacity battery may be needed. Figure 12 shows how five 9 Volt batteries can be connected to make a 45 VDC equivalent battery.
- ➲ Connect the battery terminal (–) to ground and connect the transmitter between the other battery terminal (+) and the coaxial shield, as shown in Figure 13.
- ➲ Make sure the traced circuit is grounded at the other end.

Operation

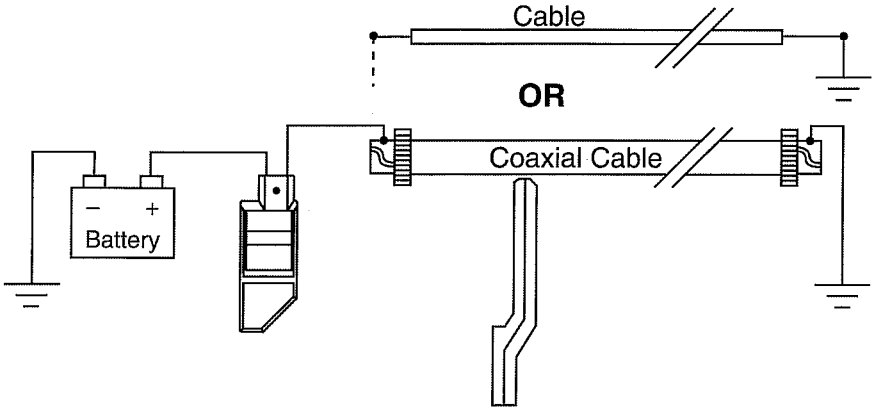
- Confirm that the red LED is flashing on the transmitter, which indicates that a signal is transmitted. Align your receiver so that it points to one of the leads from the transmitter and select the highest sensitivity level. The receiver should beep and its LEDs should light up. If it does not respond, check its battery.
- Select a receiver sensitivity level that gives a clear steady signal and trace the coaxial cable (refer to **Tracing Energized Circuits** on page 13 for tracing details).

Figure 12 - Stacking 9 Volt Batteries for Higher Voltage



This figure shows an equivalent of approximately 45 Volts DC by using five 9 Volt batteries.

Figure 13 - Tracing a De-energized Circuit With a Battery



TRACING A SHORT-TO-GROUND

WARNING: Use a voltmeter to measure phase-to-ground voltage to ensure that you have selected the appropriate transmitter for your application:

T-240: 9 - 140 VDC or VAC

T-650: 180 - 300 VDC
180 - 440 VAC

- Use the supplied leads with two safety banana plugs on one end and insulated clips on the other.
- Check that the grounded phase is not live and that the breaker is OFF.
- Connect the safety banana plugs to the transmitter. Then first connect one alligator clip to the shorted leg, and the other to the hot phase as shown in Figure 14.
- When finished, disconnect the transmitter before turning the breaker back on.
- **WARNING:** Do not connect the transmitter to a separate ground in electrically susceptible areas of health care facilities.

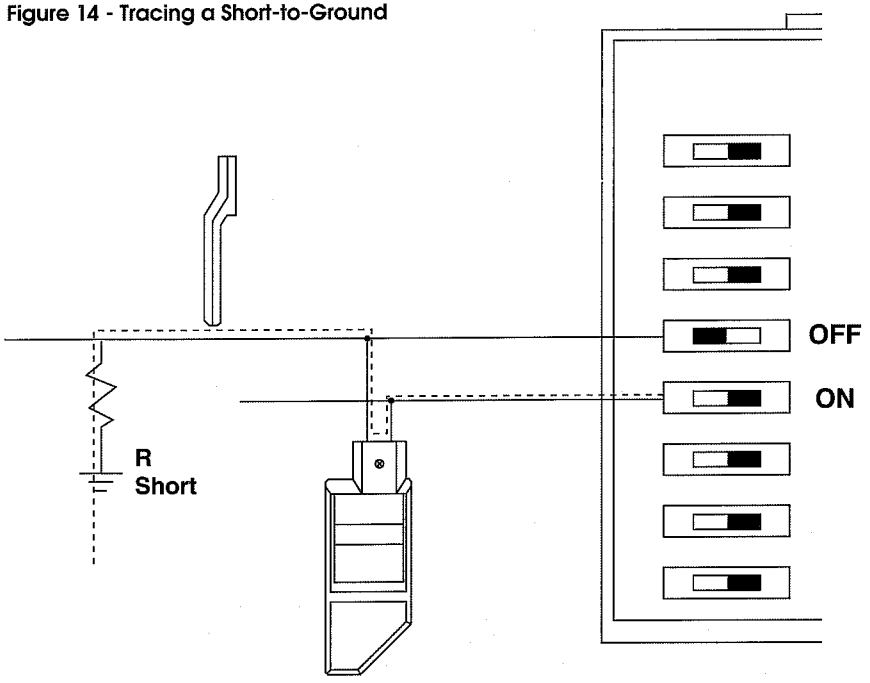
Operation

- Confirm that the red LED is flashing on the transmitter, which indicates that a signal is being transmitted. Align your receiver so that it points to one of the leads from the transmitter and select the highest range. The receiver should beep and its LEDs light up. If it does not respond, check its battery.
- Select the highest receiver sensitivity level. Hold the receiver tip close to the wall, floor or ceiling and sweep the probe across the area where you suspect the conductor to be.
- Adjust the receiver sensitivity level as well as the probe position and angle to narrow down the exact location of the hidden circuit. It is important to correctly position the receiver probe for best sensitivity (see **Receiver Position and Sensitivity Setting** on page 8).

Be sure you are tracing the hot wire and not the return ground or neutral wire.

- If you lose the signal, select a higher sensitivity level and sweep again. The traced wire may have deviated or changed direction.
- The wire may be traced back to the transformer. If going through step down transformers, the sensitivity will diminish as the signal passes through the transformer.
- Select a receiver sensitivity level that gives a clear steady signal and trace the shorted leg (refer to **Tracing Energized Circuits** on page 13 for tracing details).
- When you reach the short, the signal will drop off as you pass the location of the fault.

Figure 14 - Tracing a Short-to-Ground



TRACING PLUMBING

WARNING: Use a voltmeter to measure phase-to-ground voltage to ensure that you have selected the appropriate transmitter for your application:

T-240: 9 - 140 VDC or VAC

T-650: 180 - 300 VDC
180 - 440 VAC

- ➲ Use the supplied leads with two safety banana plugs on one end and insulated clips on the other.
- ➲ Connect the safety banana plugs to the transmitter. Then first connect one alligator clip to the pipe and the other to the hot phase as shown in Figure 15. If a battery is being used, connect the transmitter as shown in Figure 16.
- ➲ When finished, disconnect the ground *last.*
- ➲ **WARNING:** Do not connect the transmitter to a separate ground in electrically susceptible areas of health care facilities.

Operation

- Confirm that the red LED is flashing on the transmitter, which indicates that a signal is being transmitted. Align your receiver so that it points to one of the leads from the transmitter and select the highest range. The receiver should beep and its LEDs light up. If it does not respond, check its battery.
- Select the highest sensitivity level. Hold the receiver tip close to the wall, floor or ceiling and sweep the probe across the area where you suspect the pipe to be.
- Adjust the receiver sensitivity level as well as the probe position and angle to narrow down the exact location. It is important to correctly position the receiver probe for best sensitivity (see **Receiver Position and Sensitivity Setting** on page 8).
- Select a sensitivity level that gives a clear steady signal and trace the pipe (refer to **Tracing Energized Circuits** on page 13 for tracing details).

Figure 15 - Tracing a Metal Water Pipe (AC Power Source)

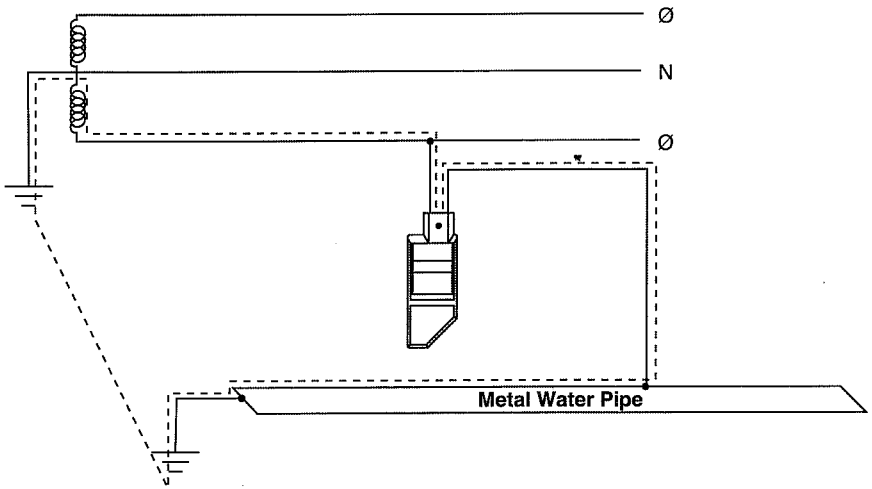
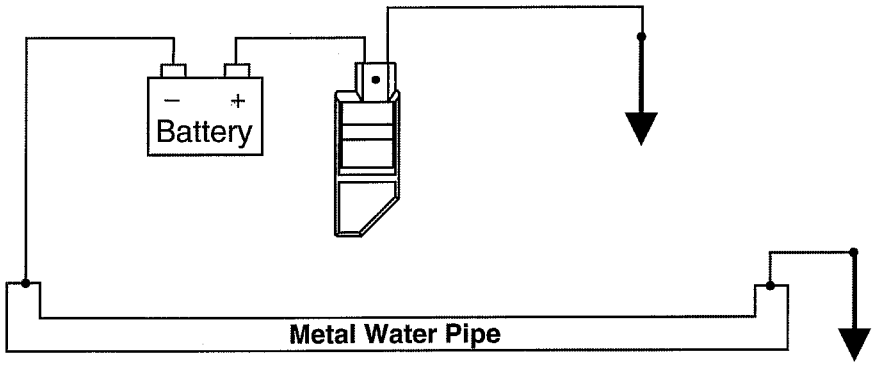


Figure 16 - Tracing a Metal Water Pipe (DC Power Source)



REPAIRS

For instrument repair, contact your authorized distributor or our factory service center:

Instrumentation Corporation
15 Faraday Drive
Dover, New Hampshire 03820 USA
Tel: (603) 749-6434
Fax: (603) 742-2346

Estimates for repairs are available upon request. Overseas customers must receive authorization by fax or letter before returning any instrument.

TECHNICAL ASSISTANCE

If you are experiencing any technical problems or require assistance with the proper application of this instrument, in the USA please call our toll-free hotline.

TOLL-FREE HOTLINE: 1-800-343-1391