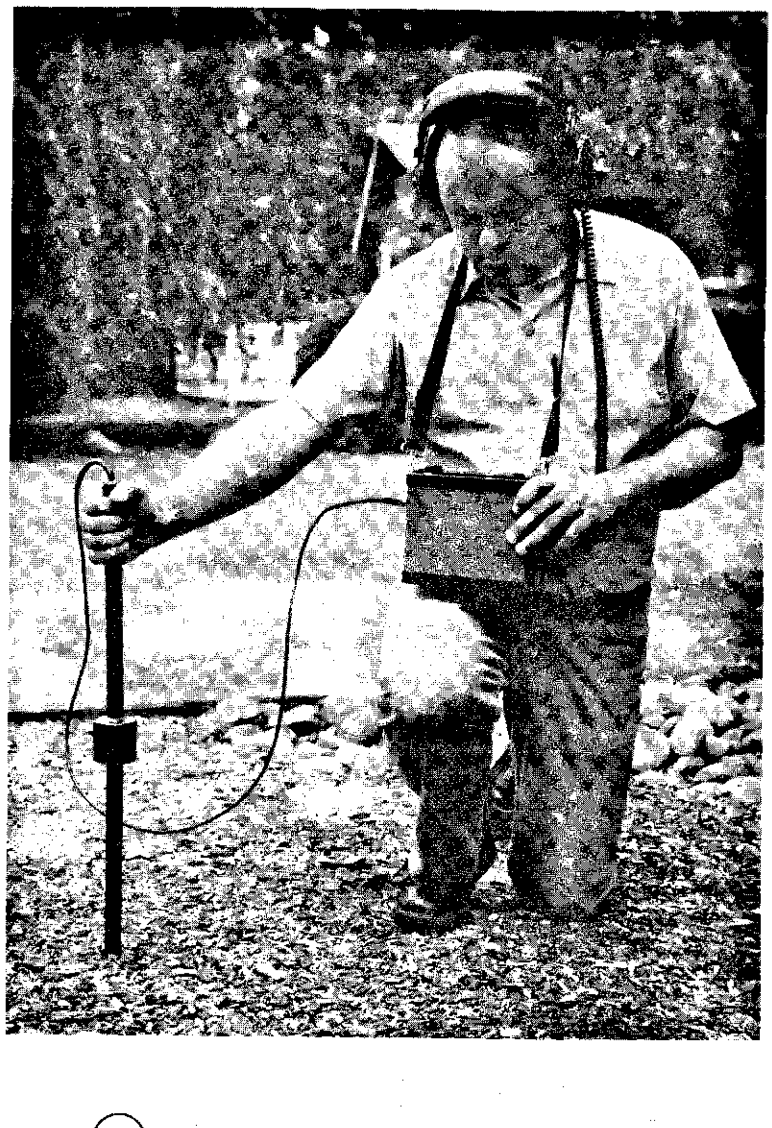
OPERATOR'S MANUAL

AD-100

Acoustic Detector
for Locating Cable Faults with any Thumper.



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AD-100 Acoustical Detector
by Aqua-Tronics, Inc.

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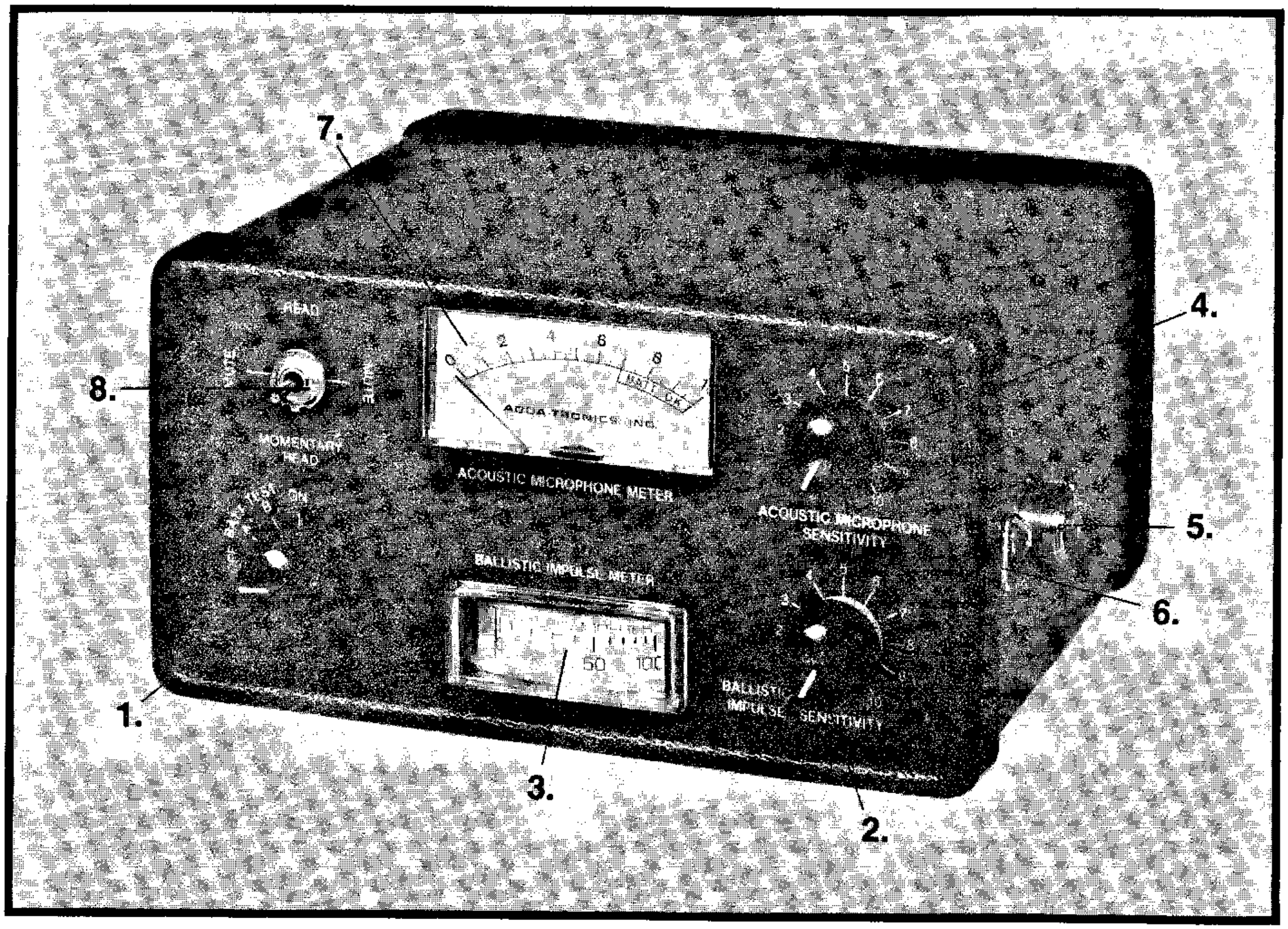
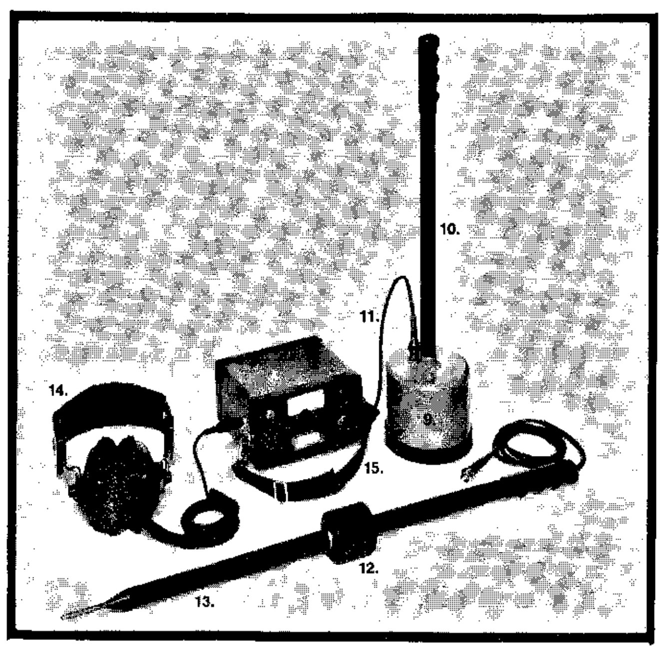


1. **OFF - ON, and two-position batt. test control.**
2. **BALLISTIC IMPULSE SENSITIVITY control:** Controls instrument's detection of thumper pulse in cable, which is shown on Ballistic Impulse Meter.
3. **BALLISTIC IMPULSE METER:** Shows thumper pulse in cable.
4. **ACOUSTIC MICROPHONE SENSITIVITY control:** Controls amplification of audio signal to head phones.
5. **Headphone input terminal.**
6. **Neck strap connector (one on each side).**
7. **ACOUSTIC MICROPHONE METER:** Shows indication of acousitc signals on meter. Amplification controlled by Acoustic Microphone Sensitivity switch.
8. **MOMENTARY READ:** Toggle switch turns sound off/on to headphones and meter. Activates up to "READ" where it is on permanently, or down to "MOMENTARY READ" where it shuts off upon release.



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9. **Microphone: ground-contact type.**
10. **"Walking Handle" for ground-contact microphone (disconnects).**
11. **Microphone cable, for ground-contact microphone.**
12. **Microphone: earth-probe type.**
13. **Earth-probe rod, for earth-probe microphone.**
14. **Stereo headphone set.**
15. **Neck strap.**

Batteries

Testing

Rotate the OFF-ON control through the two "BATTERY TEST" positions and observe the "DIRECTION TO FAULT" meter. If the indicator needle points to the bottom line of the "Batt. OK" range or below it for either battery, replace both batteries. Both batteries should be operating at or near the same voltage.

Replacement

The two batteries are located inside the back cover of the instrument. To replace batteries, remove the small plastic nut to open the battery compartment door.

Approved Batteries

Two 9-volt Eveready #246 batteries, or the equivalent, are recommended to operate the instrument (NEDA #1602). If the recommended batteries are not available, two 9-volt Eveready #216 batteries, or the equivalent, can be used. However, these batteries will offer a shorter operating life span than the recommended batteries.

Sound

General Characteristics of Sound

Sound Waves

Sound is mechanical energy in the form of pressure waves. You can't see sound waves, but you can form a mental picture of how sound works by comparing it to what happens when a rock is dropped into a quiet lake. Sound waves leaving the sound's source would look like ripples on the lake's surface leaving the spot where the rock was dropped. As the ripples move away in all directions, they get smaller and gradually lose their energy. If any of the ripples strike a solid object in the lake, they reflect off the object and start traveling back in the direction they came from. Sound waves act very much like these ripples in the lake. They radiate out in all directions from the source of the sound; they grow weaker and lose more energy the farther they travel; and they bounce off objects and reflect back in the direction they came from.

Thumpers used to locate cable faults create sound waves which radiate out from the fault. When the high-voltage thumper pulse reaches the fault and arcs across a faulted primary to ground, it creates an "explosion" or rapid ionization of air. If this occurred in the open air, it would sound much like a large caliber rifle discharging. Since the explosion caused by the thumper pulse occurs under ground, the exact type of sound it causes can be very different depending on the nature of the fault, the type of material surrounding the cable, the density of the soil, the amount of moisture in the soil, the voltage level used in the thumper pulse, and other factors. An operator standing near the point of the fault might hear a soft "thump," a very sharp "crack," or some other type of sound.

Most of the time, the sound of the thump is loud enough in the area of the fault that the operator can hear it without using any equipment to amplify the sound. Sometimes, the voltage arc at the fault releases enough energy to actually move the soil at ground level. In these cases, the thump can be felt with the operator's foot or hand.

Sound Traveling in Different Materials

Sound travels at different speeds, and with greater ease or difficulty, in different materials. This can have an effect on the operator's efforts to accurately locate a fault. The operator should keep in mind some basic facts about how sound travels in different materials.

(1) Speed of Sound & Sound "Resistance." Sound waves travel at different speeds in different materials. In open air, sound travels at about 1,100 feet per second (750 mph). In steel, sound travels at about 16,000 feet per second (11,000 mph). In general, sound travels faster in hard or dense materials. Sound waves also travel "easier" in dense or hard materials. For example, sound waves will travel farther in steel than they will in air before losing so much of their energy that they can no longer be heard. For the same reason, sound travels better in water than it does in air, which is why you can hear distant sounds better with your head under water than you can with your head above water. Also, like water running downhill or lightning darting through the sky, sound prefers to take the "path of least resistance." If sound has more than one material to use in moving away from a point, it will travel faster and with less loss in sound level (amplitude) through the material that is more dense. If you tap on the bottom of a boat sitting on a lake, someone on shore would hear the sound faster and louder with their head under water than they would standing on the shore.

(2) Sound Reflection. Sound waves are reflected when they run into an object or surface that is more dense than the material they are traveling in. Like ripples on a lake's surface reflecting off a floating log, sound waves traveling through soil will reflect off building foundations, underground pipes, the bottom surface of streets or sidewalks, and any other object that is more dense than the soil.

(3) Sound in Air. Compared to many other materials, air is a very poor conductor of sound waves, or sound energy. Water, metals, compact or moist soil all conduct sound better than air.

Factors Affecting Sound in Fault-Location Efforts

Soil Types

Some types of soil can muffle the sound created by a thumper pulse arcing to ground. This muffling effect can be so severe that an operator standing near the fault may not be able to hear the thump. Dry, porous soil will muffle a thump to the greatest degree. Sand is a good example of a soil type that will severely muffle a thump. Even though the sand grains are dense and would be good sound conductors if they were packed together very tightly, sand is filled with tiny air pockets that are poor sound conductors. If the sand is wet, water fills the air pockets and improves the overall sound-conducting ability of the sand. Similarly, loose dirt or dry dirt is a relatively poor conductor of sound. Because of this, the soil around a fault may become a poorer sound conductor during a fault locate effort as the energy released by the thumper's voltage arc heats up the soil and dries it out.

Temperature

While frozen soil is hard and may appear to be dense, there may actually be a lot of air pockets frozen into the soil, making it a poor sound conductor. Further, repeated freezing and thawing of soil tends to create more air pockets due to the soil's movement during the freezing and thawing process.

Asphalt & Concrete Surfaces

How well a thumper's sound can be heard above asphalt and concrete surfaces depends a great deal on whether there are air spaces between the soil and the bottom side of these surfaces. Dead air spaces can be created under these surfaces by soil settling or by soil-surface movements caused by freezing and thawing. Even if a thumper's sound travels well through the soil itself, the sound may be lost or greatly distorted if it runs into a dead air space underneath a road or sidewalk. Further, how well any one area of a road or sidewalk surface conducts sound may change with temperature. A hard freeze may cause an asphalt surface to separate from the soil beneath it, but the asphalt may "relax" and make good contact with the soil on a hot day.

Buried Ducts and Pipes

Because sound travels best along the path of least resistance, cables placed in ducts or cables buried near water pipes or other underground metals may create special difficulties in locating cable faults. In general, ducts will be better sound conductors than the surrounding soil, and the thump sound may travel down the duct and emerge at either end. If this happens, the operator will hear a thump which seems to come from a point that is nowhere near the actual fault. If a water pipe happens to cross the cable's path at a point near the fault, a similar thing can happen. The thump sound will travel faster and with less loss in sound level (amplitude) along the pipe than it will through the soil. If the water pipe picks up and transmits enough sound energy to a water meter or hydrant, it may seem to the operator that the thump sound is coming from a distant point.

Submarine Cables

Sound travels well in water with very little amplitude loss, so a thump can be heard at a great distance from the fault if a listening device is placed beneath the water's surface. Problems will be encountered, however, if the listening device is placed above the water's surface. A common property of water is its "surface tension," which creates a thin "skin" on the surface that behaves much like a weak elastic material when it is subjected to pressure. Since sound waves are pressure waves, weak sound waves will be unable to break through the water's surface tension and will be reflected from the surface back down into the water. If a listening device is placed above the water's surface, it will not be able to detect these reflected sound waves.

If an acoustic (sound) microphone is being used to locate a fault in a submarine cable, a metal boat should not be used. If a metal boat is used, sound waves coming from the fault will bounce off the metal hull and produce a loud "ping" that will be picked up by the microphone. This "ping" will confuse the acoustic microphone and will make it difficult to reliably locate the fault. Because wood or fiberglass materials are much less dense than metal, any sound waves that reflect off wood or fiberglass hulls are much weaker and will not cause strong "pings". Wood or fiberglass boats should be used when locating faults in submarine cable.

Surface Reflection

Like water, the top layer of soils has a tougher "skin" that can reflect sound waves back down into the earth. The surface layer of soil can become more dense than the soil beneath it due to rain compaction, sun baking, wind erosion, and the filling of soil voids by dust and other sediments. The harder or more dense the soil surface is, the more reflection of sound waves there will be.

To a sound wave, a change from soil to air, water to air, soil to concrete, soft soil to hard soil, and even hard soil to soft soil "looks" like a "surface." Any such "surface" will cause sound waves to be reflected and sound energy (amplitude) to be lost. This happens because each material has its own unique physical characteristics which determine how fast sound will travel through it, so each material has its own "speed of sound." When a sound wave runs into a material with a different speed of sound than the one through which it has been traveling, the sound wave acts like this is a "surface" and part of the wave is reflected. The more difference there is in the speed of sound between the new material and the old material, the more energy the sound wave is going to lose in getting through this "surface." Because the speed of sound in air is by far the slowest of any single material, sound waves lose more energy when they cross from another material into air.

Microphones

Ground-Contact Microphones

Ground-contact microphones pick up sound waves when they are placed in direct physical contact with the ground or some other solid material. They work well on hard surfaces such as concrete and asphalt because sound waves will make these materials resonate like the skin on a drum or a guitar string. Sound waves traveling through the earth strike the bottom side of these materials and are reflected. When the sound waves bounce off these surfaces they lose energy, and the energy lost is transmitted to the harder material and causes the concrete or asphalt to vibrate, or resonate. The ground-contact microphone detects this vibration and creates a correspnding sound in the headphones. The pickup element in the microphone acts like a phonograph needle on a record; any movement will produce a sound. As long as there is good contact (no air spaces) between the soil and the concrete or asphalt, ground-contact microphones allow good detection of the thump at a long distance from the cable fault. However, since any sound travels fast and without much energy loss through hard materials, it is easy for background noises from cars, machinery, people, dogs, birds and other sources to reach the microphone. Sound waves from these background noise sources can strike the concrete or asphalt at some distance away, and they will travel quickly to the microphone and may cover up the sound of the thump.

Ground-contact microphones do not work well on porous materials containing a lot of air spaces, such as soil, sawdust, bark dust and sand.

Earth-Probe Microphones

To solve the type of problems encountered with ground-contact microphones on surfaces that are not solid, Aqua-Tronics, Inc. developed an earth-probe microphone for use in soils and other "soft" materials. By stabbing the earth-probe microphone through the surface skin, or top layer of soil, sound waves from the thump can be detected before they have a chance to reflect from the soil's surface or disperse into the air (either above ground or in near-surface pockets in porous soil). Earth-probes also eliminate many background noise problems. Sound waves originating at the cable fault travel directly through the soil to the earth-probe microphone. But sound waves from above-ground noise sources have to travel through the air, which has the slowest speed of sound, and through the air-to-soil "surface" before they can reach the earth-probe microphone. Thus, many background noises lose their energy and are filtered out before reaching the microphone.

Because they pick up much less background noise, earth-probe microphones should be used whenever possible. If a cable route lies under a sidewalk, for instance, using an earth-probe microphone in the soil to one side of the sidewalk will allow the operator to hear the thump more clearly. With less background noise entering the microphone, a higher sensitivity setting can be used on the acoustic detector, which will allow the operator to hear the thump at a greater distance.

If field conditions allow the operator to use either an earth-probe or ground-contact microphone, the earth-probe microphone will produce better results.

Fault-location - Procedures & Operation

Pre-Location - Before You Begin

Trace the Cable Route

Before you can begin locating the exact position of the fault, you must locate the cable route and trace it.

While you are tracing the cable route, watch for any signs of construction or digging near the route, since these might be an indication of where the cable fault is located.

General Equipment Setup

Use the following steps in initially setting up the equipment for the fault-location process:

1. Connect the thumper to the cable and start it.
2. Check the batteries in the AD-100 by rotating the OFF-ON switch through both "BATTERY TEST" positions and observe the ACOUSTIC MICROPHONE METER for a "BATT. OK" indication.

   Note: If one battery needs to be replaced, replace both batteries. It is important to have both batteries operating at or near the same voltage.
3. Use the procedure described in the following sections to set the BALLISTIC IMPULSE SENSITIVITY and ACOUSTIC MICROPHONE SENSITIVITY controls for your fault-location search.

Finding the General Area of the Fault

Two methods can be used to quickly find the general area of the cable fault. You can use the BALLISTIC IMPULSE METER only, or you can use an ACOUSTIC MICROPHONE with the Ballistic Impulse.

Ballistic Impulse - How It Works

The BALLISTIC IMPULSE METER allows the operator to "see" the output pulse from the thumper as it travels down the cable route from thumper to fault. This meter provides a "reference signal" so you know when each thumper pulse occurs, even when you are some distance from the thumper. It also provides a reference signal that indicates the rate at which the thumper is pulsing the cable.

The AD-100 ballistic impulse circuitry detects the thumper's pulse without a microphone being connected to the instrument. This makes it possible to search for the general area of the fault without using an acoustic microphone, as explained below.

Setting the BALLISTIC IMPULSE SENSITIVITY

At full gain, the Ballistic Impulse Meter can pick-up the thumper pulse at considerable distance from the route of the cable. The lowest sensitivity setting that will provide a small meter reading should always be used. This will help you quickly find the general vicinity of where the fault is located.

To set the ballistic impulse sensitivity control, move 10 to 20 feet away from the thumper and 5 to 10 feet off to one side of the cable path. Set the Ballistic Sensitivity for a small pulse when the thumper fires. About 1 1/2 to 3 on the meter dial. Walk the cable route keeping the same approximate distance from the cable path as used in setting the sensitivity control. THIS SAME METHOD OF PRE-LOCATION CAN BE MADE FROM INSIDE THE PICK UP AND DRIVING THE ROUTE OF THE CABLE. SET THE ELECTRONICS ON THE FRONT SEAT AND ADJUST FOR THE SAME 1 1/2 TO 3 ON THE METER WHEN THE THUMPER FIRES. (The above adjustment can be made 20 to 30 feet off to one side of the cable path providing this same distance can be maintained during the search for magnetic wave fall off.

Quick Search with BALLISTIC IMPULSE Only

With the correct low setting on the BALLISTIC IMPULSE METER, you may be able to quickly locate the general vicinity of the fault without using a microphone. As each thumper impulse travels down the cable, most of the thumper's energy is lost at the fault as the voltage breaks through to ground. However, some of the thumper's energy will be forced past the fault to continue down the cable route. With the BALLISTIC IMPULSE METER set at a high sensitivity, the meter will still detect the part of the thump that gets past the fault, so you will continue to see a meter reading even after you drive or walk past the fault. This is why you should try to use the lowest possible setting for the BALLISTIC IMPULSE SENSITIVITY control. With this control set at the lowest sensitivity that still shows a clear reading before you get to the fault, the meter will stop showing a reading within a very short distance after you have passed the fault. In other words, if you set the control to give you enough sensitivity to show a small meter reading as you start traveling the cable route, the meter will stop showing a reading soon after you pass the area of the fault. By doing this, you can quickly find the general area along the cable route where the fault is located.

Connecting and Using Acoustic Microphone

Once you have located the fault's general area by using the Ballistic Impulse Meter, or if you cannot detect the fault area using that method, connect the type of microphone needeed for your working conditions and follow these procedures: (Ground Contact Microphone for a hard surface — Earth Probe Microphone for soft surface).

1. Connect the microphone to the AD-100 and activate the toggle switch.

   The toggle switch can be locked on by pushing it up to "READ", or it can be pushed down for a "MOMENTARY READ". In Momentary Read, the toggle switch will return to "MUTE" when it is released.
2. Connect the headphone set to the AD-100. (The headphone supplied indicates it is a stereo headphone, but it is not. The headphone has been modified so the sound of the thump can be heard on both sides at all times.)

"Zeroing In" on the Fault

The Acoustic Microphone Sensitivity control allows the operator to hear the "THUMP" in the headphones and see the "THUMP" on the Acoustic Microphone Meter.

With the Acoustic Microphone in use over the cable route, the Acoustic Microphone Sensitivity should be adjusted to the highest setting possible. This setting is found as follows:

Activate the toggle switch. Increase the acoustic microphone sensitivity control to the point where "background noise" is not producing an Acoustic Microphone Meter reading. By experimenting with this control, your experience level will soon tell you where this control should be set for the different conditions you must work in.

This control can be set much higher when the Earth-Probe Microphone is being used. The Ground-Contact Microphone is subject to more background noise so the meter will start responding to the background noise at a much lower setting.

Deactivating the toggle switch when the microphone is to be moved will eliminate the microphone input to the electronics. This will remove the noise from the headphone that will be present if the toggle switch is not at the "MUTE" position.

As the sound of the "THUMP" gets louder, the Acoustic Microphone Sensitivity can be reduced. When the Acoustic Microphone Meter is producing an off-scale reading (above 10 on the meter), the meter cannot indicate the exact location of the "THUMP". By reducing the Acoustic Microphone Sensitivity control so the Acoustic Meter is always producing a reading somewhere below its full scale reading of 10, the peak sound level can be found.

When the Acoustic Meter is reading its highest reading and the loudest sound of the "THUMP" is being heard in the headphone, the microphone being used is directly over the fault. (NOTE: If the Ballistic Impulse Meter is not activating at the same time as the Acoustic Microphone Meter and Headphones, check to see if the noise being generated is from another source, as the three should be in sync.

With the microphone setting where you think the loudest noise is being produced (as indicated by the Acoustic Meter and Headphones), turn down the Acoustic Microphone Sensitivity control to a point where the meter will just barely produce a small indication of the thump. With the AD-100 turned down to where the sound of the thump can just barely be found, the noise should not be detected if the microphone is moved in either direction from that point.

Service and Warranty Information

Service

If you have trouble with the AD-100 instrument or require assistance for any reason, contact the nearest Aqua-Tronics sales outlet. You may also call or write directly to the Aqua-Tronics, Inc., to explain your problem or the type of assistance you need.

Warranty

All Aqua-Tronics, Inc. products are warranted against defective materials and workmanship.

The AD-100 is covered by a one-year warranty.

Aqua-Tronics, Inc. will repair or replace all products which prove defective during the warranty period. All repairs will be performed at our manufacturing plant or at one of our field service centers. Aqua-Tronics, Inc. retains sole and exclusive right to determine where repairs are to be made and to determine if defects are covered by warranty or are the result of misuse and/or abuse of the instrument and, thus, not subject to warranty repair or replacement.

All instruments shipped to the factory must be sent prepaid; no collect or C.O.D. shipments will be accepted.

ANY ATTEMPTS BY UNAUTHORIZED PERSONNEL TO REPAIR ANY AQUA-TRONICS, INC., INSTRUMENT WILL AUTOMATICALLY VOID THE WARRANTY COVERING THAT INSTRUMENT.