

INSTRUCTION MANUAL for  
BIDDLE ELECTROMAGNETIC  
(BALLISTIC)  
IMPULSE DETECTOR  
Cat. No. 651113

Consisting of:

Cat. No. 651110 Amplifier Unit  
651111 Sheath Pickup Coil  
651114 Carrying Case

Optional Items:

651112 Surface Pickup Coil  
651115 Earth Probe Frame

PLEASE READ CAREFULLY BEFORE OPERATING

Safety is the responsibility of the user.

SIRVANSE LEER ESTE LIBRO CON CUIDADO  
ANTES DE OPERARLO

La seguridad es la responsabilidad del operador

BIDDLE INSTRUMENTS  
Blue Bell, PA 19422

INSTRUCTION MANUAL  
BALLISTIC IMPULSE DETECTOR SET

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SECTION A  
INTRODUCTION

The Biddle Ballistic Impulse Detector set responds to direction and magnitude of short duration current pulses from capacitor discharge generators, and is used for locating faults between conductors or between conductor and sheath in underground power cable. With a selection of two magnetic pickups and one conductive pickup, it locates faults in shielded or unshielded cable, direct buried or in duct. The magnetic pickups give a general location of the fault; more accurate spotting on unshielded direct buried cable is possible with the conductive or "earth gradient" pickup (to be used only if safety considerations permit). The Biddle Acoustic Detector (a separate set) permits accurate spotting of faults on shielded buried cable.

The set is also effective for tracing buried cable, giving a precise fix on both location and depth. In addition to impulse detecting, the system can be used for tracing buried cables energized at frequencies of 60 to 1000 Hz.

Finally, the set includes a separate high impedance voltmeter circuit for locating high-resistance earth faults in direct buried cable energized at 60 Hz, using earth gradient probes.

The Detector is carefully designed to give optimum response to the typical current impulse waveform produced in cable by a capacitor discharge. This wave is usually a complex damped radio frequency oscillation. The Biddle Ballistic Detector derives from the magnetic field a signal accurately proportional to the peak value of the magnetic field being sensed, as well as its direction (polarity), regardless of waveform. (Ordinary electronic voltmeter circuits will not reliably do either of these things with a complex pulse wave.) These properties give the Ballistic Detector the ability to not only indicate the presence or absence of a current impulse in the vicinity, but also to indicate its direction and magnitude, information which is essential in fault locating.

The set consists of an amplifier unit and one or more pickups, usually with a carrying case. The catalog numbers of these components are tabulated below.

Amplifier Unit	651110
Sheath Pickup Coil	651111
Surface Pickup Coil	651112
Carrying Case	651114
Earth Gradient Probe Frame	651115

The carrying case holds both magnetic pickups, but not the earth gradient probes.

Figure 1 shows all the components of the set. The set is rugged, yet light in weight, and designed for durability and convenience in field use. It is battery-operated, with a built-in battery check feature.

The 651110 series Ballistic Impulse Detector set is the newest successor to the original patented electromagnetic detector introduced by Biddle in 1948 and long established as the standard of equipment in this field.

The new system retains the unique ability of the original set to sense both magnitude and polarity (or direction) of an impulse current, even though such impulses usually go through several reversals before dying out.

The unit is improved in ways which have been suggested by user requirements:

- Solid state circuitry for greater reliability and portability.
- Greater sensitivity.
- Greater range of gain (sensitivity) control.
- Elimination of zero adjustment.
- Sheath pickup smaller in size for working in confined quarters.
- Surface pickup smaller and collapsible, enabling storage in the carrying case.
- Earth gradient probes insulated for safety; and of more sturdy construction.
- Addition of a-c voltmeter range for 60 Hz earth fault probing.

## SECTION B

### SAFETY PRECAUTIONS

- SAFETY IS THE RESPONSIBILITY OF THE USER -

The Impulse Transmitter used with this Detector and the cables to which it is connected may be a source of high-voltage electrical energy, and all persons making or assisting in the tests must use all practical safety precautions to prevent contact with the energized parts of the test equipments and the cables. When the Detector is used with the Earth Gradient Probes, care must be exercised to avoid contact with any energized equipment or cables, whether on the surface or buried, or whether energized by the Impulse Transmitter or the power line.

A hazardous voltage may occur at any of the following locations:

1. At or near connections to impulse generator, including earth or earthed conductors in the vicinity.
2. At any other terminal of the cable or connected equipment.
3. At or near the fault, where earth voltage gradients may exist. Location is unknown!.

Any persons not directly associated with the work must be kept away from the danger area by suitable barriers, barricades or warnings.

When finishing a test, after the Transmitter has been shut down, the kilovoltage will gradually return to zero, indicating the cable and the Transmitter are approaching a discharged condition. At this time the Transmitter and cable must be short circuited by means of the shorting switch provided on the Transmitter and a separate safety ground on the cable. See Transmitter instructions for complete safety requirements.

If the set is properly operated and all grounds are correctly made, no rubber gloves are necessary. As a routine safety procedure, however, some users require the use of rubber gloves, not only in making connections to the high-voltage terminals, but in manipulating the controls. The James G. Biddle Co. considers them to be an excellent safety practice.

SECTION C

RECEIVING INSTRUCTIONS

Your BIDDLE Electromagnetic (Ballistic) Impulse Detector has been thoroughly tested and inspected to rigid inspection specifications before being shipped and is ready for use as received.

However, the set should be inspected and tested immediately upon receipt, as follows:

1. Examine the shipping carton, and if it is damaged, save it as evidence in case any claim against the carrier becomes necessary.
2. Check the contents against the packing list and your purchase order, using Figure 1 and the list in Section A to identify the components. Notify BIDDLE Instruments, Blue Bell, PA of any shortage.
3. Examine the set for physical damage. If any damage is found, file a claim with the carrier at once and notify BIDDLE Instruments or its nearest representative giving a detailed description of the damages observed.
4. Read through the Description and Operation sections of the manual, then check out the system using the procedure of Section H. Before using the set on actual fault problems, it will be helpful to become familiar with it on a practice cable if one is available.

SECTION D

DESCRIPTION, LOCATION OF CONTROLS, AND SPECIFICATIONS

AMPLIFIER UNIT

This unit is 8 1/4" long x 3 1/4" wide x 4 3/4" high, and weights 2 1/2 lbs. It contains the electronics, the battery, the output meter, and the controls in an aluminum and black leather-grained plastic housing. An adjustable black neck strap, 55" long x 1" wide is permanently attached. A 3-pin audio type locking jack for the pickup plug is located in the left end of the frame. The unit is gasketed to permit operation in the rain.

The operating controls and indicators are as follows:

- On-Off Switch. This is built in to the input jack. The set is turned on whenever any pickup is plugged in.
- Output Meter. A taut band zero center meter with green battery check "good" zone. Scale is marked 0-100 (10 divisions) in each direction from zero "+" to the right and "-" to the left.  
This meter is used as the output indicator for all operating modes.
- Battery Test Switch. Pushbutton switch, enclosed in silicone rubber sealing boot.
- Mode Selector Switch. Three-position rotary selector switch. The positions are:  
"Impulse and Trace", used for most applications of the unit.  
"Earth Voltage, High" used for detecting 60 Hz ac earth voltage gradient.  
"Earth Voltage, Low" same except in a lower voltage range.
- Gain Control. A single turn control located on the right end of the frame. This control has a graduated scale with a range of 1 to 100,000.

The performance specifications are as follows:

Impulse and Trace Mode:

- Input Impedance: 500 ohms, maximum: depends on gain setting.
- Sensitivity: Cannot be readily specified, as performance depends on generator, cable, fault, and pickup, and the paths of the earth current.

Earth Voltage Mode:

	FULL SCALE VOLTAGE	60 Hz INPUT IMPEDANCE	MAX. INPUT VOLTAGE ALLOWED
RANGE	60Hz rms		
High	10	500,000 $\Omega$	120
Low	1	15,000 $\Omega$	120

Battery:

- Type: Burgess 2N6 (NEDA 1602), 9 volts. One required.
- Life: Typically 350 hours. (Will be preserved by storing in a cool place.)

The operating temperature and humidity range are as follows:

- Humidity: 0-95%
- Temperature: 0-120°F (Based on standard carbon-zinc battery limitations).

### SHEATH PICKUP

This unit is a "C" shaped iron core and coil molded into a solid rubber assembly. It is designed for optimum pickup of the small high frequency magnetic field surrounding a cable and sheath, and ability to accurately pick out the one of three conductors inside the sheath which is carrying the test impulse current.

Size: 2" x 2" x 1 1/2", plus cable and strain relief.

Cable: Rubber covered, self coiling; 1 foot long, extends to six feet.

Connector Plug: Self-latching metal-housed type.

### SURFACE PICKUP

This is a ferrite rod antenna enclosed in a protective tube. It is held in a T-bracket at the end of a telescoping aluminum rod with rubber handle grip. This pickup is designed specifically for detecting the magnitude and direction of impulse current magnetic fields. The T-joint is hinged and detented for positioning at 0°, 45°, and 90°, to permit easy location of maximum or minimum signal, and thus location of the cable.

Length: Extended 34", closed 18"

Weight: 1 1/4 lbs.

Cord: Rubber covered, self-coiling; 15" long, extends to 8 feet.

Connector Plug: Self-latching metal-housed type.

### EARTH GRADIENT PICKUP

This is a rigid tubular frame supporting two stainless steel probes at a fixed separation of 20 inches which provides a means of detecting voltage drop along the surface of the earth. Each probe is wired through a connecting cord to a plug. The frame is insulated for operator safety.

The frame provides a convenient sturdy means of inserting the probes into the earth to obtain good contact while maintaining a fixed probe separation. There are no controls or adjustments on this unit.

Size: 2" x 21" x 35"

Weight: 5 lbs.

Cord: Rubber-covered, self-coiling; 1 foot long, extends to 6 feet.

Connector Plug: Self-latching, metal housed type.

### CARRYING CASE:

Material: Molded fiberglass with fitted foam cushions to accept the amplifier unit, sheath pickup coil, surface pickup coil, and instruction manual.

Size: 8 1/2" x 12 7/8" x 17 5/8".

Weight: Empty 8 1/2 lbs.

With complete set, 15 lbs.

## SECTION E

### OPERATION

The operating procedure depends on the kind of pickup being used, as described in the following sections. In all cases, the unit is turned on by the insertion of pickup plug into the socket. Before operating, check the battery as follows: Plug in any pickup and press "BAT TEST" button. If meter deflection is below the green zone, replace battery.

#### 1. Sheath Pickup Coil

Use this probe for locating faults in sheathed single-conductor or 3-conductor cable in conduit, when manholes or other access openings permit the probe to be placed directly on the cable. This method will find the pair of ground bonds between which the fault lies.

Connect the Impulse Transmitter to the suspected cable, and start it in operation. Consult the applicable instruction manual for the operation of the transmitter. Adjust the transmitter voltage to a level which will cause the fault to break down on each impulse.

Set the Mode Selector switch on the Amplifier Unit to "Impulse and Trace".

Start by placing the coil on the cable sheath at a point near the transmitter which is known to be between the transmitter and the fault with the arrow pointing toward the Transmitter. Set the Gain to give about 50% meter deflection. If the cable is multi-conductor, find maximum and minimum readings by placing the pickup at positions all around the circumference of the cable or along a length over which a maximum and minimum can be observed, and record the maximum and minimum (or average). It is well to take the time to observe several pulses and obtain average readings. Do not make any other Gain adjustment during the remainder of the test.

With the Detector thus calibrated, the signal will remain about the same up to the fault. When the fault is passed the readings around the cable will become constant. Normally, also the magnitude will be reduced. When the next bond is passed, the current pulse indication will be much reduced. Thus, the location of the fault can be determined to be within a short length of cable.

#### 2. Surface Pickup Coil

Use the Surface Pickup Coil for locating and tracing direct buried cable, and approximate fault location.

Connect the Impulse Transmitter to the cable, and start it in operation. Consult the applicable instruction manual for the operation of the transmitter. Adjust the transmitter voltage to a level which will cause the fault to break down on each impulse.

Set the Mode Selector Switch on the Amplifier Unit to "Impulse and Trace".

Find a place near the Transmitter end of the cable where the location of cables is known. Hold the crossbar of the "T" at the end of the wand near to and parallel to the ground over the cable, and explore to find the position of maximum meter deflection. Set the Gain to give an average meter deflection of 50%. Do not readjust Gain during the remainder of the test. Keep the arrow at the end of the wand pointed to the Transmitter in order to maintain constant meter polarity. When the fault is passed there will be a reduction in the impulse signal. Although the fault may not be located exactly, the location may now be pinpointed using the Acoustic Detector Cat. No. 651103.

The depth of the cable can be determined by the "null" method which is based on the fact that when the probe is pointed at the cable a minimum signal is received. First, set the crossbar parallel to the handle and holding the handle vertical locate the position on the surface of the ground where a minimum signal exists. Mark this point, which is directly above the cable. Now turn the crossbar to a 45° angle. Again holding the wand handle vertically, search to the side of the cable run with the crossbar pointing at the cable run. A minimum signal will be observed when the crossbar points directly at the cable again. Mark the location of this minimum. The distance between the two marks is approximately the depth of the cable.

### 3. Earth Gradient Probes, Impulse Signal

CAUTION: For Operator safety, use only the earth probe frame provided.

Use the Earth Probe Frame with impulse generator for locating faults in buried cable by tracing the flow of earth currents to their source at the fault. This method is effective on shielded cable whenever the sheath is in reasonably good contact with the earth. It is effective, but requires more care in prevention of shock hazard, on unshielded cable where all current is forced to return through the earth. In this case, it is known that standard size impulse generators can deliver a painful jolt to a person simply standing in the area.

NOTE: The James G. Biddle Co. expressly urges that impulse testers not be used on unshielded buried cable unless full and adequate precautions are taken under supervision of a responsible engineer. This method can be rendered relatively safe by use of a greatly reduced impulse energy.

Connect the Impulse Transmitter to the suspected cable, and start it in operation. Consult the applicable instruction manual for the operation of the transmitter. Adjust the transmitter voltage to a level which will cause the fault to break down on each impulse.

Set the Mode Selector switch on the Amplifier Unit to "Impulse and Trace".

Start at a location near the generator and probe the earth above the cable, inserting each probe above the cable with the arrow on the frame pointing toward the transmitter. On each impulse a negative meter reading will be observed. Take readings at different positions as the frame is rotated. There should be a negative maximum near the first position, and a reversal to a positive maximum with 180° rotation.

Set the gain control to give a reading of about 25% at the maximum position.

Now move along the cable path and take readings. Under ideal conditions, the signal rapidly grows weaker, then increases as the fault is approached. As the fault is passed, the signal becomes positive and decreases very rapidly.

Variation of contact resistance or buried conductors such as pipes may cause shifts and weakness in the readings, so this method may not be reliable for tracing cable. However, there is a very definite indication of fault location:

Directly over the fault if the leading probe is used as a pivot and the other one rotated to several positions over a full circle. The meter reading does not change polarity.

In hard dry earth, the probe contact may be poor and the resulting signal weak. A wet cloth or sponge under the probe will greatly improve contact.

#### 4. Earth Gradient Probes, 60 Hz Earth Voltage

##### CAUTION

Use this technique with extreme care! Do not attempt at voltages greater than 120 volts. Use only the Biddle earth probe frame which has the following safety features:

1. Entire upper hand contact part is made of insulating material, to protect operator.
  2. Probes are short and dull, to avoid penetrating into a live wire.
  3. Probes are at a fixed distance apart, to minimize voltage which they can see.
- Read all the following instructions.

This test is used when the secondary 115-volt buried cable has a fault to earth, and the line is left energized. Much larger (and more dangerous) signals will usually occur with unshielded than with shielded or concentric neutral cable.

Set the mode switch to "Earth Voltage, Low". In this mode, the gain control has no effect, and the meter reads only positive polarity.

Probe along the cable route, and look for an increasing reading. If necessary, switch to the High range. If the reading is greater than full scale on the High range (about 10 volts RMS) there is a hazardous condition possible, and the operator should back away into a safer region.

If the fault is approached from several direction, the readings will normally increase toward the fault in each case, with a deep minimum occurring when the frame is directly over the fault. By thus approaching the fault from several direction, a fix can be made without actually necessitating moving into the high hazard area close to the fault.

See also the comments on contact resistance and metallic conductors in the preceding paragraph on impulse testing.

## SECTION G

### ROUTINE MAINTENANCE

The only routine maintenance required is a battery replacement. The battery must be replaced after about 250 hours of use or after 1 year if usage is light, or at any time when the battery check gives a reading below the green zone. A Burgess #2N6 battery or equivalent (NEDA 1602) is specified. If this battery is not available, a standard 9-volt transistor radio battery may be used, with a reduced service life. A Burgess 2MN6 or equivalent (NEDA 1604D) is recommended. If such a smaller battery is used, use tape or other means as needed to securely fasten it in place.

The battery replacement procedure is as follows:

1. Perform in a protected location where the unit can be handled on a bench or similar convenient working surface.
2. Remove the (8) screws holding the black cover to the chassis assembly, and carefully remove the cover and the two metal shield panels which are held by the same screws. The battery is located inside the chassis, at the bottom.
3. Lift the battery out of the clamp.
4. Remove the plastic bag, disconnect, and discard the old battery.
5. Install the new battery by a reverse process, making sure it is enclosed in the protective plastic bag to protect the instrument from possible corrosion due to leakage products from the battery. Make sure the battery is tightly held by the clamp before closing the case.

SECTION H

PERFORMANCE CHECK

The amplifier unit can be tested with each of the pickups as described below. First check the battery, as described in Section E.

Impulse and Trace Mode, Sheath Pickup Coil

1. Plug in the Sheath Pickup Coil and set the Mode Selector to "Impulse and Trace". Turn the Gain Control to 100,000.
2. Connect a D size flashlight battery with a loop of wire so that the wire lies between the pole tips of the pickup. Momentarily connect and disconnect the battery. The meter should deflect approximately full scale with one polarity on connection, and full scale of the opposite polarity on disconnection.

Impulse and Trace Mode, Surface Pickup Coil

Test as with the Sheath Pickup Coil, except wrap one turn of the test wire around the circumference of the Surface Pickup Coil.

Earth Voltage Mode, Earth Gradient Probes

1. Plug in the Earth Gradient Probes and turn Mode Selector to "Earth Voltage".
2. Connect an adjustable 60 Hz voltage source to the Probes through an isolation transformer. Check for the following meter readings:

<u>SWITCH SETTING</u> <u>(RANGE)</u>	<u>60 Hz</u> <u>VOLTAGE</u>	<u>CORRECT METER</u> <u>READING</u>
Low	1 volt	+100
High	10 volts	+100

If the device does not perform as described above, it is recommended that the unit be returned to the factory for repair. See Section L.

SECTION L

WARRANTY STATEMENT AND REPAIR POLICY

WARRANTY

All products supplied by BIDDLE Instruments are warranted against all 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 will be shipped Prepaid and Insured. The warranty does not include batteries, lamps or tubes, where the original manufacturer's warranty shall apply. WE MAKE NO OTHER WARRANTY.

The warranty is void in the event of abuse or failure by the customer to perform specified maintenance as indicated in the manual.

REPAIRS

BIDDLE Instruments maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.