Instruction Manual 25-J4
for MEGGER® Direct Reading
Earth Testers
Catalog Numbers 250260 and 250261,
and Accessories

Megger, Inc.

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Figure 1: At left: Cat. No. 250260 Direct Reading Earth Tester; Cat. No. 250260 Accessory Kit consisting of probes, calibrator and test lead set; and Cat. No. 217719 Carrying case. (style of probes may vary).

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Section A
INTRODUCTION

The Megger® Direct-Reading Earth Tester is a portable special-purpose ohmmeter designed to measure the resistance between a ground electrode and the earth. It is ideally suited for routine testing of relatively small earth electrodes having resistances in the range of a few ohms to a few hundred ohms. Every effort has been made to provide an instrument for making this kind of test reliably, safely and economically, while avoiding unnecessary complexity in operation.

This Tester is available in two models. They differ only in the test signal frequency which is set to reject interference from currents of the local power frequency. The Catalog No. 250260 tester is intended for use where the local service operates at 60 Hz. The Cat. No. 250261 is for 50 Hz areas.

In addition to the tester itself, you will need accessory earth probes and connecting leads. Biddle offers two accessory kits containing these and other items. They are described in Section D, page 6.

Applications for the tester include tests of grounds for utility poles, distribution transformers, service entrances, lightning rods, farm and other private power generators, machinery, secondary distribution substations, telecommunications and data transmission systems, railway electric substations, railway signal systems, and anti-static grounds for petroleum-handling equipment.

For more demanding applications, Biddle offers other models having higher performance, featuring a wider resistance range, higher accuracy, greater rejection of earth current interference or resistivity measurement capability (four terminals).

Further general information on both ground resistance and its testing can be found in the Biddle manual 25T entitled "Getting Down to Earth". One copy is supplied with each tester. Read this manual before attempting to make measurements with the instrument.

Safety

There is an inherent safety problem in earth resistance testing which requires care and planning by the user of the test set.

The possibility exists that a fault in the power system will cause a high current to flow into the ground system while the test is in progress. This may cause unexpected high voltages to appear at the current and voltage probes, also at the terminals of the test set.

This risk must be evaluated by the person responsible for the tests, taking into account the fault current available and expected step-and-touch potentials. This subject is fully covered in IEEE Standard 80 entitled "Safety in Alternating-Current Substation Grounding".

If a significant risk exists, we recommend that the operator wear rubber protective gloves (ANSI/ASTM D120 or equal) while handling the connections, and use a rubber safety mat (ANSI/ASTM D178 or equal) while operating the test set.

Section B

SAFETY PRECAUTIONS

1. The electrical output of the Biddle Earth Tester is limited to a low value for the protection of users and bystanders. This output while not considered dangerous to a healthy adult, can cause perceptible shock to a person with damp hands or feet. Therefore, take care to prevent any person from coming in contact with the X, P or C terminals or the probe spikes while the test set is energized.

2. When setting up for tests, take the following precautions:

    a. Select a safe operating location free of traffic hazards and clear of live equipment. Do not operate in explosive atmospheres.

    b. Before making connection to the ground electrode under test, make certain that it is not energized.

    c. Do not drive spikes into buried pipes or cables! Relocate the spikes if they become difficult to drive.

3. It is recommended that the interconnecting leads be treated as energized conductors since stray fields and earth potentials can place unexpected potentials on these leads.

4. Do not use this instrument or its accessories for any purpose not described in this Instruction Manual.

Section C

RECEIVING INSTRUCTIONS

RECEIVING INSTRUCTIONS

When your Biddle instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify BIDDLE Instruments, Blue Bell, PA of any shortage of materials. Identify specific components by reference to Figure 1 and the Specifications section of this manual.

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

This instrument has been thoroughly tested and inspected to rigid specifications before being shipped and is ready for use. To confirm that the instrument is in good operating condition, make the operational checks given in Section H, page 19.

Section D

SPECIFICATIONS

Measurement Range: 0.5 ohm to 500 ohms

Accuracy:

Reading, Ohms	Limit of Error* for 15-35°C	Limit of Error* for 0-50°C
0 to 100	10% rdg + 0.25Ω (2% full scale deflection)	20% rdg + 0.5Ω (4% full scale deflection)
500	20% rdg. (4% full scale deflection)	30% rdg. (6% full scale deflection)

*Includes scale errors and effect of probe resistances, C probe 0 - 5000 ohms, P probe 0-10,000 ohms.

Effect of Earth Current Interference:

No effect in the range 5 to 100 ohms for voltage across P-X terminals up to 2 volts at power frequency; no effect at all for up to 150 volts dc.

Meter: Rugged taut-band movement, single 3 1/4" scale.

Test Signal:

AC square wave, limited to 50 volts open circuit, or 5mA short circuit. Test frequency is:

Catalog No. 250260: 135 Hz ±5%

Catalog No. 250261: 121.6 Hz ±5%

Section D

SPECIFICATIONS (Cont'd.)

Self-Checking Features:

Battery Condition: meter shows good/bad when button is pressed.

Probe Resistance: meter shows good/bad when lever switch is pressed.

Calibration: at 5 ohms and 100 ohms, using optional plug-in standard.

Power Supply:

Four size "C" alkaline dry cells: Eveready E93, Burgess AIL or Ray-O-Vac 814 (NEDA 14A). Provide seven hours of actual test time, (about 2500 tests at 10 seconds each). Ordinary "C" cells can be used with decreased life expectancy.

Safety Features:

Output not hazardous to a healthy adult, (only 5mA short circuit).
Non-conductive case material.

Physical:

Material: Shock-resistant molded polycarbonate case.

Size: Overall dimensions: 7 1/2" x 6 1/2" x 4 3/4" (19 x 16 1/2 x 12 cm)

Weight: 2.8 lbs. (1.3 kg) including batteries.

Section D

SPECIFICATIONS (Cont'd.)

Accessories Included:

1 - Instruction Manual 25-J4.
1 - Technical Manual 25T "Getting Down to Earth".
10 - Test Record Cards.

Optional Accessories Ordered Separately:

Catalog No. 250560 Accessory Kit containing:

2 - 12" x 3/8" diameter spike probes.

1 - 50 ft. blue lead, 18 gage plastic insulation, .140" O.D.

1 - 31 ft. yellow lead, 18 gage plastic insulation, .140" O.D.

1 - 10 ft. red lead, 18 gage plastic insulation, .140" O.D.

1 - 3-way plug-in calibrator (5 ohms, 100 ohms, X-C jumper.)

Cat. No. 217719 Carrying Case for instrument and Cat. No. 250560 Accessory Kit.

Cat. No. 250579 Heavy Duty Accessory Kit - (does not fit in Cat. No. 217719 Case) contains:

2 - 20" x 1/2" diameter spike probes.

3 - Leads, 25, 50 and 100 feet, coded red, black, and blue respectively. Extra-flexible 14 gage Heavy-Duty (type SO) cord, 1/4" O. D., oil resistant jacket.

1 - Canvas carryall for leads and spikes.

Catalog No. 250942 Test Record Cards.

Section E

DESCRIPTION

General:

The tester is housed in a sturdy molded polycarbonate case. Brief hookup and operating instructions are printed on the case.

The following are featues of special value and interest:

a. Readings are on a single quasi-logarithmic scale. This is spread out to give excellent resolution (0.1 ohm plus 2% of reading) over the whole range from 0.5 to 500 ohms. For comparison, a linear scale of 0-100 ohms could resolve only about 10% of reading at ten ohms.

b. The single direct-reading scale means that all readings are made without confusing multiple scales or multiplying factors.

c. There are no calibration or compensation adjustments of any kind, thus no errors caused by incorrect or forgotten adjustments.

d. The tester tolerates high probe resistance, especially in the potential probe circuit. Nevertheless, the very high resistance which sometimes occurs can cause errors. To prevent such errors the tester has a simple pushbutton probe resistance check feature.

   The current probe is checked simply by moving the main test switch to the right and reading the meter. The potential probe can also be checked by interchanging two test leads and repeating the above procedure.

Section E

DESCRIPTION (Cont'd.)

e. The tester tolerates a substantial amount of interference from power frequency earth currents. It also detects such interference and indicates when there is too much for good results. Likewise, it confirms readings that are not being adversely affected. The method gives a direct indication of possible error magnitude in ohms. This is superior to measuring the interference in volts since voltage readings are difficult to interpret as to their effect on the resistance measurement.

f. The tester is powered by size C dry cells which are available everywhere. Typical service life is seven hours of actual testing. These cells are housed in easily accessible battery compartments, completely separate from the instrument circuits and meter .

g. The tester circuitry is fully solid state. It employs no vibrator or other moving parts which may wear out in use.

h. The output is limited to 50 volts open circuit and 5 milliamperes short circuit. This provides a high degree of protection to users. (See Section B, Safety Precautions, before using, however!)

i. A plug-in calibrator accessory is available. This enables readings to be checked at any time. This can establish confidence whenever test results are doubtful.

Figure 2, page 9, shows a close-up view of the tester including all controls, connectors, and the meter face.

Section E

DESCRIPTION (Cont'd.)

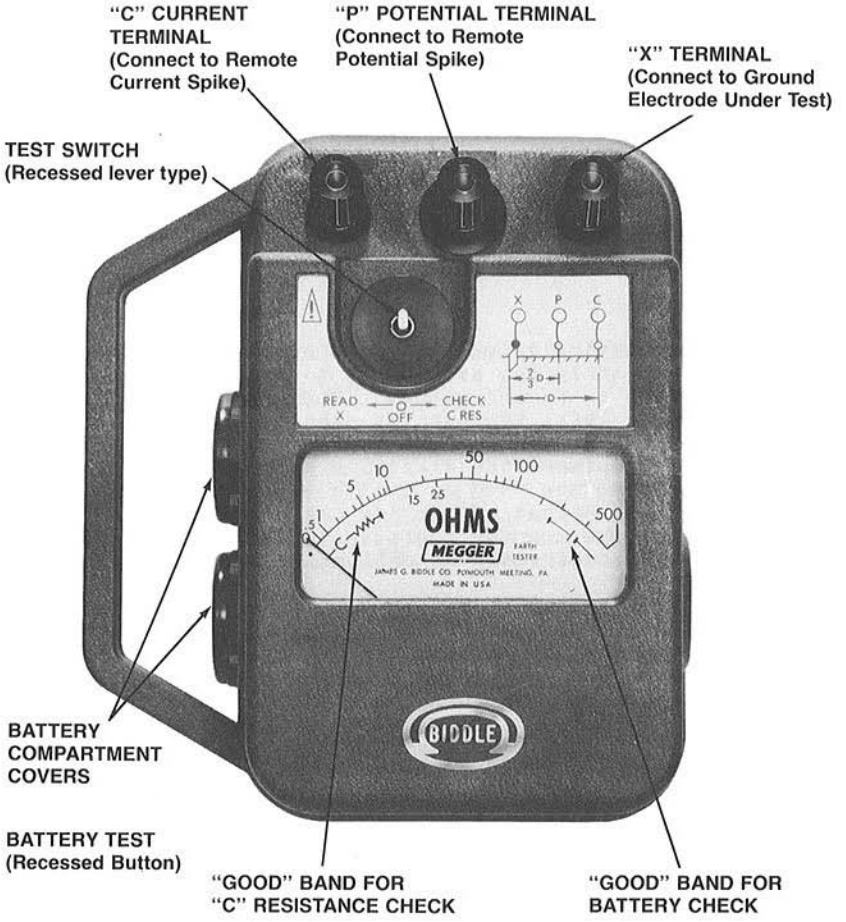


Figure 2: Detail View of Tester.

Section E

DESCRIPTION (Cont'd.)

The necessary earth probe spikes and interconnecting leads are separate . The various components of the Accessory kit are shown in Figure 1, page a. The entire measuring package can be conveniently stored and transported in the carrying case which has compartments for the tester, manuals, and all items of the Accessory kit consisting of leads, spikes and 3-way calibrator. The optional heavy-duty lead and spike kit fits in a separate canvas carryall.

Electrical:

Figure 3 is a simplified schematic of the tester and its connections. Note the similarity to Figure 5 in the "Getting Down to Earth" manual. When the test switch is closed to the left, the current passing through the electrode under test from the testing generator and the voltage drop between the electrode under test and the potential spike are used as inputs to the log ratio computer. The output of the log ratio computer is the logarithm of the unknown resistance. This signal drives the ohmmeter whose scale is calibrated directly in ohms.

When the test switch is closed to the right, the tester will measure the resistance (RC) between the ground electrode under test and the current spike. In this mode a separate range network enables the meter to indicate resistance much higher than the Rx range using the RC sub-scale.

The two detectors operate synchronously with the frequency of the test current. This enables them to reject signals of other frequencies. For example, the 135-Hz test frequency gives good rejection of interference from earth currents of 60 Hz or 120 Hz (second harmonic) or 180 Hz (third harmonic). Very large interference signals can cause errors by saturating the voltage detector. This occurs at about 2 volts across the P-X probes.

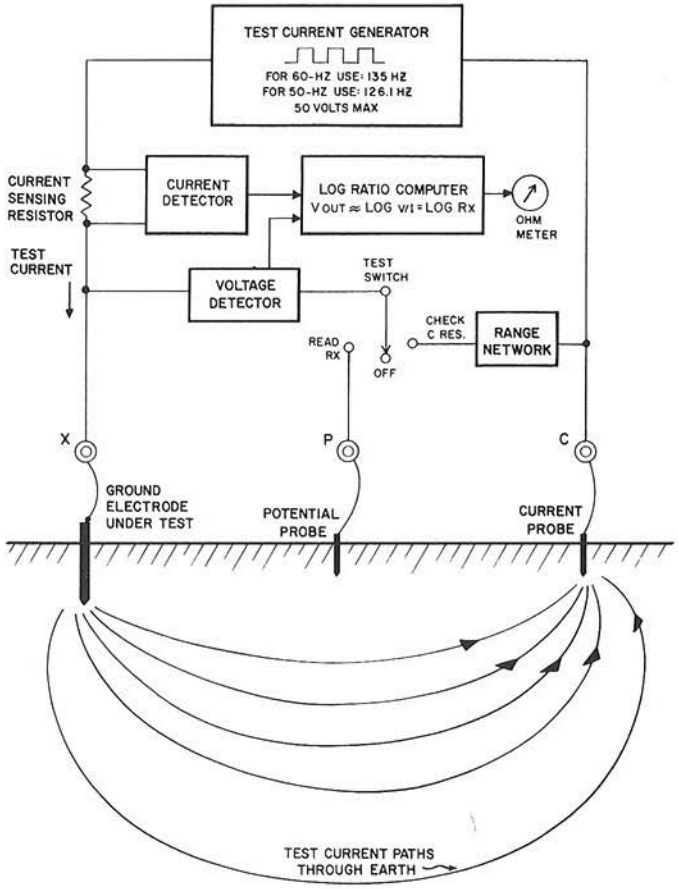


Figure 3: Simplified Schematic Diagram of Earth Resistance Measuring System; Note Similarity to Fig. 5 in the "Getting Down to Earth" manual.

Section F

OPERATION

General

Before making any measurements, read the Manual 25T, entitled "Getting Down to Earth", especially Part I. This gives a general idea of what earth resistance is and how it is measured. Then read through this manual, especially this section and the next one entitled "OPERATION NOTES" which covers special problems.

This section gives a basic step-by-step test procedure which can be followed when using the Accessory Kit, Cat. No. 250560. The next section describes variations in the basic procedure which may be needed under certain conditions.

Basic Procedure Using Cat.No. 250560 Accessory Kit:

1. Conditions of Measurement:

   Examine the ground system to be measured to be certain that it is physically small enough to permit accurate measurement of its resistance, using leads provided in Accessory Kit Catalog No. 250560. In particular, be aware of the following:

   a. The largest dimension of the ground system must not exceed 12 feet. For a single rod (electrode), this means that it must not be driven into the earth deeper than 12 feet. For a group of rods, the greatest distance between the most distant ones must not exceed 12 feet. For ground systems larger than this, longer test leads are required, as further described in Manual 25T, Section 1, which discusses test probe placement vs. ground system size.

   b. Test probes must be located 31 and 50 feet away on an accessible straight path from EUT.

   c. EUT and test probes must be located well clear of buried pipes, rails, or other conducting structures.

Note that in Step 2 below the probe locations are established by using the yellow and blue leads as measuring tapes. This is convenient at times, but the lead lengths should be checked before using them in this way. These are approximately 50 feet for C, and 62% of the C distance for P (nominally 31 feet).

2. Making and Checking Setup:

FOLLOW THE SAFETY PRECAUTIONS LISTED IN SECTION B!

(a) Preliminary check: Make the operation check described in Section H.

(b) Probe location: Place the lug ends of the two longer leads (50 ft. and 31 ft.) at the center of the EUT and string them out along a straight line. Choose a path clear of conductors such as rails, buried cables, pipes, or metal fences. Drive a spike at the end of each lead leaving at least one inch exposed. Clip the leads to the spikes.

NOTE: Inspect the insulation on the leads; a bare spot touching the ground may spoil the reading.

(c) EUT connection: With due regard for safety, connect the 10 ft. red lead clip to the EUT, making a clean firm connection. Connect the lug end to the "X" terminal of the tester.

(d) Current (C) probe resistance check: Connect the leads as follows:

Yellow (Potential) to terminal P.
Blue (Current) to terminal C.

Move lever switch to the right. A reading above the "C" band indicates an excessive resistance in the current probe path. Check connections; if necessary, improve the earth contact of the "C" spike by driving it deeper, relocating it, wetting the earth, or using a longer spike for a deeper drive.

(e) Potential (P) probe resistance check: (May be omitted; used to insure good connections. Also suggested when C Resistance test shows a high value.)

Interchange the leads at the P and C terminals as follows:

Yellow (Potential) to terminal C.
Blue (Current) to terminal P.

Move lever switch to the right. A meter reading between zero and 8 ohms indicates that the resistance of the P probe circuit is low enough.

Reconnect the leads as in Step (d).

3. Making the Measurement: Leads connected as in Step (d).

Move lever switch to the left and read meter. This reading is the resistance of the EUT in ohms.

The meter pointer may first make a jump and then take a few seconds to settle. This is normal. However, if it continues to wander or oscillate, see Interference in Section G, page 17.

4. Packing Up after Testing:

Retrieve test leads. Wipe clean and coil for storage.

Retrieve spikes and wipe clean. The spikes can be loosened by tapping the head and pulling with a claw hammer.

Section F

OPERATION (Cont'd.)

Changes in Procedure to Meet Other Conditions

If the EUT is larger than 12 feet, longer leads will be needed. Section I of the "Getting Down to Earth" manual tells how to select the probe spacing. See especially the pages entitled "Effects of Different Reference Probe Locations". Measure probe spacing from the center of the EUT.

For distances up to 100 feet, Biddle Cat. No. 250579 Accessory Kit is recommended. This kit also has the advantages of heavier insulation on the leads and larger spikes which give lower probe resistance.

For longer distances, a reel carrier might be used such as those shown in several of the illustrations in the "Getting Down to Earth" manual. Select wire of 18-gage or larger, heavy enough to stand up in the expected service.

If the two probes cannot be located along a straight line from the EUT, reasonable results can be obtained by moving the "P" probe off at an angle of 45^{o} or even 90^{o}.

If there is no location for the probes clear of other grounded metal objects, then the direct or two-wire method may be the only solution. (See Section G.)

If the earth is too hard to permit driving spikes for probes, try wetting the surface and making contact with a coil of bare wire or a chain pressed down on this surface by a weight such as a pile of stones.

Section G

OPERATION NOTES

General

This section gives further information on dealing with certain problems which may arise in using the Direct-Reading Earth Tester.

Dimensions of Ground Electrode Under Test Not Known:

If the dimensions of the EUT are not known, the simple method mentioned in Section F is not reliable. However, good results are still possible. They will generally require taking several readings and doing some computation.

The idea is to try one distance for the C probe and take a reading with the P probe at 62% of this distance. Then take one or two readings with the P probe at distances a few percent above and below 62%. Measure carefully, and take the center of the EUT as the starting point. Plot the results as shown in Figures 5, 8 and 9 of the "Getting Down to Earth" manual. If there is a definite tendency to flatness of the curve around the 62% point (as in Figure 5 and Curve B of Figure 9), the reading at 62% is reliable. If it is steep as in curve A of Figure 9 the reading might not be the true earth resistance. Better reliability will be obtained by moving "C" out further and trying again. Repeat until a definite flat around 62% is obtained. Then use the 62% reading. (This method is similar to the "Simplified Fall of Potential Test" described in the "Getting Down to Earth" manual, but gives somewhat better results in return for some additional effort.)

If it is not practical to test at a distance which gives a flat in the curve, the best method is to use the 62% reading made at the largest distance that can be reached. The reading will tend to be lower than the actual resistance but the error will usually not be very large.

Section G

OPERATION NOTES (Cont'd.)

Interference from Earth Currents:

Electric currents are flowing everywhere in the earth. They may interfere with earth resistance measurements. Large currents may cause errors or even make the readings unusable. Such large currents may be found around electric power installations or heavy industrial plants.

As long as the meter reading is steady, don't worry about earth currents. However, if the needle vibrates or jumps back and forth or wanders across the scale, earth current interference is probably the cause. Proceed as follows, depending on how large the needle swing is:

a. Up to 1/16": Take the reading at the center of the swing. There should be no error. (This can be confirmed by the tare method; see (b) below).

b. Between 1/16" and 1/8". Read at the center of the swing. There may be an error of a few tenths of an ohm. This can be detected and corrected by taking a tare reading of interference alone, as follows:

   Hookup: Leaving the X and P leads connected, disconnect the C lead from test set. Connect terminal C to terminal X. (Use either the calibrator plug in the "JUMPER" position or a wire.)

   Tare Reading: Move lever switch to left. Ground current interference will make the meter deflect from its rest position, usually to the left. Estimate this deflection in ohms, using about 0.1 ohm per 1/32 inch (extrapolating the scale). NOTE: If the deflection reaches the dot located about 1/16 inch below zero, the tare reading may be larger than it seems as this dot indicates the mechanical stop of the pointer travel.

   Correction: Correct the reading just as on a weighing scale. That is, if the tare is to the left, increase Rx by the tare, and vice versa.

c. Needle swing greater than 1/8 inch. This usually indicates interference too large for the tester to handle. Try a different route for the test leads and probes. If this doesn't work, wait and watch to see if the needle becomes quiet. This often happens because the earth currents are constantly changing. If necessary, try to find a quieter time of day or even a quieter day of the week.

Direct (Two-Wire) Measurement

For two-terminal measurement as described in the "Getting Down to Earth" manual, connect as follows:

Terminal X: Connect to EUT.

Terminals C and P: jumper with a wire, or link supplied,* and connect to the reference ground (water-pipe, etc.).

Checking Accuracy in the Field

You may want to confirm the accuracy of the tester in the field. This is especially helpful in very cold or very hot conditions, or any time your test produces an unexpected result. Use the plug-in calibrator as described in Section H. Note the larger of the errors at 5 ohms and 100 ohms in terms of fractions of an inch on the scale. As a rough guide, the error anywhere between 2 ohms and 200 ohms will be no greater than this.

* Note: From Serial No. 4650 and above, a shorting link is supplied with each instrument.

Section H

ROUTINE MAINTENANCE

General:

Routine maintenance consists of the following steps:

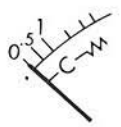
1. Mechanical inspection.
2. Operation and calibration checks.
3. Lead check.
4. Battery replacement.

These steps are described in the following paragraphs. They may be performed either at the work site or on a regular schedule in a calibration laboratory, or both. Biddle recommends both job-site informal checks and scheduled maintenance at least once a year. The program should be adapted to suit the user's needs.

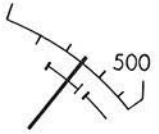
Mechanical Inspection:

Visually inspect case, meter and terminals. Check mechanical operation of switches. Count and inspect accessories. (Figure 1 may be helpful.) If necessary, remove dirt with a dry rag; take care not to break the meter window.

Operation and Calibration Check:



a. Mechanical Zero. Meter pointer should read at the "0" line ±1/32 inch when switches are at rest. (If the offset is excessive, readings can be corrected by the amount of this error, in inches.).



b. Battery Check: Press BAT button. If the meter reads to the left of the band containing the battery symbol, new batteries should be installed.

Section H

ROUTINE MAINTENANCE (Cont'd.)

c. Calibration Check: This can be done very easily even at the job site using the accessory plug-in calibrator. Other resistors of any desired value may also be used. They should have a tolerance of ±1% and a rating of 1/4 watt.

To use the plug-in calibrator, plug it into the 3 terminals of the tester and take a reading in the usual way by pushing the lever left. The reading should be approximately the same as printed on the calibrator and facing the operator. In one position the calibrator is 5 ohms; by turning it end-to-end it becomes 100 ohms. The normal tolerance on the reading is given in the table below.

To use a separate resistor, connect it between the X and P terminals, and connect a jumper between P and C. All connections must be tight, especially when checking low resistance values.

CALIBRATION TABLE

STANDARD USED	Expected Tolerance (New) At 23± 10°C (59 to 95°F)
5 ohms, calibrator	±0.85 ohms
100 ohms, calibrator	±11 ohms

Section H

ROUTINE MAINTENANCE (Cont'd.)

Lead Check:

Examine insulation for cracks, holes or abrasion. Repair or replace as needed to prevent accidental earth contact.

Check continuity with an ohmmeter or other suitable tester. The tester itself can be used if desired. Connect the lead to be checked between terminals X and P, and connect a jumper between C and P. (Another one of the leads, or two adjacent prongs of the calibrator or a resistor of up to 1000 ohms may be used as the jumper.)

Battery Replacement:

Remove both battery compartment caps (See Figure 2). Tilt the set until the cells slide out. Install two new C-size cells in each compartment with the button ends out. Secure caps and test the new batteries.

Section I

WARRANTY & REPAIRS

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 of failure by the customer to perform specified maintenance as indicated in this manual.

REPAIRS

BIDDLE Instruments maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend that 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.

Field usage will sometimes inflict damage that can be repaired without the specialized equipment needed to correct defects on the printed circuit card. The most common damage is done to the case and possibly the mechanical zero of the meter.

To open the case, turn the test set face down and remove the four corner screws. Gently lift the top from the lower case until clear; then fold it across the terminals. This gives access to the window and the meter movement, and the mechanical zero adjustment. The case should only be opened by persons skilled in meter repair.

Section J

REPLACEMENT PARTS

DESCRIPTION	BIDDLE P/N
Battery Alkaline, size C (NEDA 14A) (4 required)	19111
Window	10432
Window Gasket	10433
Battery Holder with cap	3274-1
Terminal	11166-2
Test Switch	12119-20
Bat Test Switch	1422-1
Printed Circuit Card Assembly (including meter)	19109
Carrying Case	Cat. No. 217719

Accessory Kit: Cat. No.250560:

12 inch Spike Probe, pair	P/N 10239
Lead Set, 50 feet. 31 feet and 10 feet	P/N 10241
Calibrator (5- ohm, 100-ohm, X-C Jumper)	P/N 10245

Heavy Duty Accessory Kit: Cat. No.250579

Canvas Carryall	Cat. No. 250578
Set of 3 leads, 25, 50 & 100 ft.	Cat. No. 250576
20 inch Spikes, pair	Cat. No 250586

Test Record Cards (100 cards) ..... Cat. No. 250942