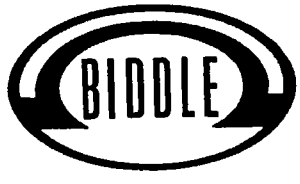
Instruction Manual
25-J-3

Megger(R) Earth Testers
(NULL BALANCE)

Catalog Numbers
63220, and 63241



James G. Biddle Co.
PLYMOUTH MEETING, PA. 19462

5 L 7/77

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES

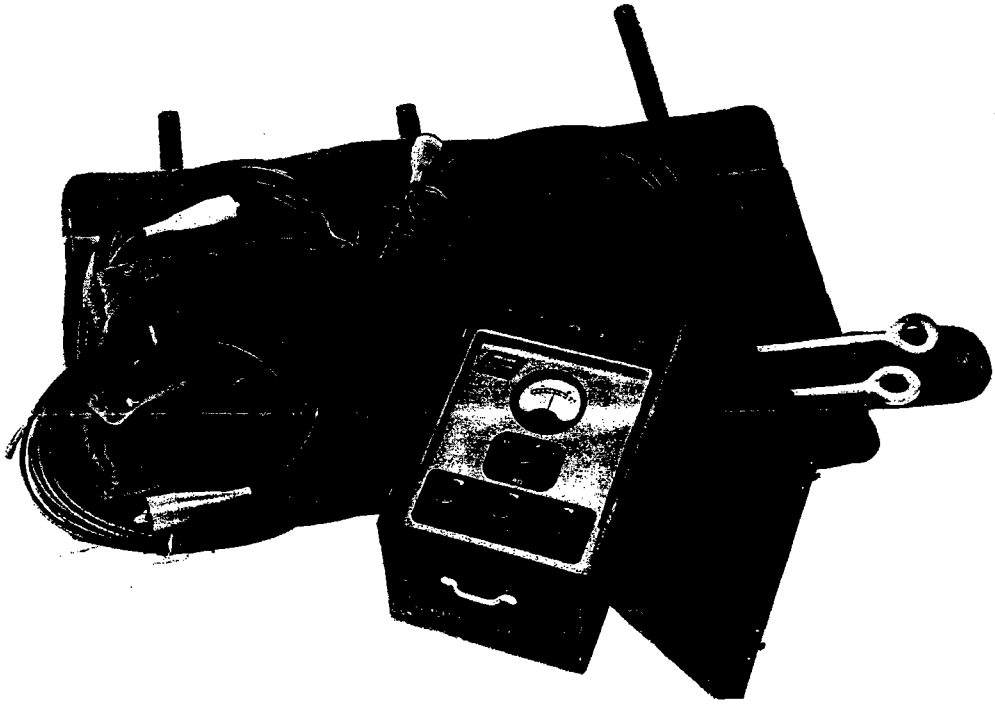


Figure 1-1. Earth Electrode Test Equipment, Consisting of Null Balance Earth Tester, Carrying Case and Accessory Kit.

SECTION 1

GENERAL INFORMATION

1–1. SCOPE.

The purpose of this manual is to supply information which will assist in the installation, operation, and maintenance of two Megger® Null Balance Earth Testers, Catalog Numbers 63241 and 63220. See Figure 1-1 for a typical earth test package with a hand-crank instrument, carrying case, and accessory kit containing rods and leads.

The earth tester contains either a hand-cranked ac generator or a battery-powered oscillator with four resistance ranges adjustable from 0.01 to 9990 ohms. The earth tester measures ground resistance by applying a test current through the earth electrode under test which returns through the soil and a remote current terminal. The potential between the earth electrode and a remote potential terminal is observed and balanced against an equal potential in the earth tester. When a null condition is achieved, a digital readout in ohms is displaced which, under proper test procedures, is the earth electrode resistance.

1–2. GENERAL DESCRIPTION.

The earth tester is portable with a compact, two-piece, metal case having four rubber feet. A multiplier switch, three resistance decades, and a null balance meter are mounted on the top. A vinyl carrying case is available.

a. HAND-CRANKED TESTER. In addition to the above, the hand-cranked earth tester has five binding posts mounted at the top of the instrument. The hand-crank is mounted on the right side with a recess provided to store the handle when not in use.

b. BATTERY-OPERATED EARTH TESTER. In addition to the general features, the battery operated earth tester has four binding

posts mounted at the top of the instrument and an operating pushbutton to the left of the meter. Six 1-1/2 volt (Size C, NEDA Type 14, Eveready 935 or equal) dry cell batteries provide power. Two screw-cap tubular battery compartments permit batteries to be inserted without opening instrument case. There is a battery-check position on the multiplier switch, with a battery condition scale on the meter.

1–3. REFERENCE DATA.

a. HAND-CRANKED EARTH TESTER.

1. Physical Characteristics

(a) Length	9-1/2 inches 240 mm
(b) Width	6-1/2 inches 165 mm
(c) Height	6-3/4 inches 172 mm
(d) Weight	9 lbs. 4 kg.

2.	Type of Operation	Hand-Cranked AC Generator
3.	Operating Temperature Range	20° to 120° F -7° to 49°C
4.	Output	150 to 160 volts (open circuit) at 100 Hz.
5.	Accuracy	±1% of range in use with probe resistances up to 1500 ohms.
6.	Resistance Range	0.01 ohm to 9990 ohms in four overlapping ranges.

b. BATTERY-OPERATED EARTH TESTER.

1. Physical Characteristics

(a) Length	9-1/2 inches 240 mm
(b) Width	6-1/2 inches 165 mm
(c) Height	5 inches 127 mm
(d) Weight	6 lbs. 2.7 Kg.

2.	Type of Operation	Battery-Driven Oscillator
3.	Operating Temperature Range	41° to 113° F 5° to 45° C
4.	Output	140 Volts (open circuit) at 126 Hz.
5.	Accuracy	± 2% of range (with 0.01 multiplier, percent error is larger).
6.	Resistance Range	0.01 ohms to 9990 ohms in four overlapping ranges.
7.	Types of Batteries	Six 1-1/2 volt (Size C, NEDA 14 Type, Eveready 935, or equivalent).
8.	Maximum Battery Drain	400 Milliamps (batteries at lowest possible internal resistance).

TABLE 1-1. EQUIPMENT DATA

NOMENCLATURE			Overall Dimensions English (Metric)			Shipping Weight English (Metric)	
Item	Name	Catalog No.	Height	Width	Depth	Net	Gross
1	Megger Null Balance Hand-Cranked Earth Tester	63220	6-3/4 (172)	6-1/2 (165)	9-1/2 (240)	9 (4)	14 (6.4)
	or						
1-A	Megger Null Balance Battery Operated Earth Tester	63241	5 (127)	6-1/2 (105)	9-1/2 (240)	6 (2.7)	10 (4.5)
2	Case, Vinyl	63850	7 (178)	10-3/4 (273)	7 (178)	3-1/2 (1.6)	5-1/2 (2.5)
3	Set of 3 leads as follows:	63576				8 (3.6)	10 (4.5)
3.1	25' coded Red (7.5M)						
3.2	50' coded Yellow (15M)						
3.3	100' coded Blue (30M)						
4.1	Set of 2 Galvanized Steel Ground Rods	63580	20 (508)	-	-	3 (1.4)	5 (2.3)
4.2		63582	30 (762)	-	-	6 (2.7)	9 (4.0)
5	Heavy Canvas Carry-All (for holding Cat. No. 63576 leads and two pair of rods, Cat. Nos. 63580 or 63582).	63578	-	-	-	3 (1.4)	5 (2.3)

1–4. OPTIONAL ACCESSORIES.

Three leads are available for use with the earth tester: one 25-foot lead coded red at each end; one 50-foot lead coded yellow at each end; and one 100-foot lead coded blue at each end. Two 20-inch or 30-inch galvanized steel ground rods with hardened points at one end and a loop at the other end are also available. These rods and leads may be housed in a heavy canvas carry-all as a kit. (Refer to Table 1-1 for a listing of catalog numbers and shipping weights.)

1–5. EQUIPMENT REQUIRED FOR MAINTENANCE.

The equipment required for checking the earth tester is a four decade resistance box, 0 to 9999Ω.

1–6. SAFETY PRECAUTIONS.

- SAFETY IS THE RESPONSIBILITY OF THE USER

- LA SEGURIDAD ES EL CARGO DEL OPERADOR

The Earth Tester is not considered a hazardous source of high-voltage electrical energy in the usual sense. However, the use of rubber gloves is strongly recommended as protection against accidental voltages that might appear on structures, ground conductors, or ground grids under test, and particularly when handling test leads. The James G. Biddle Co. urges that the best safety practices be carefully observed during testing.

1–7. RECEIVING INSTRUCTIONS.

Your Megger instrument has been thoroughly tested and inspected to rigid inspection specifications before being shipped and is ready for use after it is set-up as indicated in the Installation section. Check the equipment received against the packing list. Notify James G. Biddle Co., Plymouth Meeting, Pa. of any shortage of materials. The Megger instrument should be examined for damage received in transit. If any damage is found, file a claim with the carrier at once and notify James G. Biddle Co. or its nearest representative giving a detailed description of the damages observed.

1–8. WARRANTY.

All products supplied by the James G. Biddle Co. 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.

1–9. REPAIR.

The James G. Biddle Co. 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.

SECTION 2

INSTALLATION

2–1. UNPACKING AND HANDLING.

Exercise caution in handling and unpacking the equipment to prevent damage. Keep the earth tester clean and dry. It may be stored in the carrying case when not in use.

After unpacking inspect the earth tester for possible damage in shipment before operating.

2–2. INSTALLATION.

The earth tester is a portable unit with no installation requirements.

2–3. PREPARATION FOR USE.

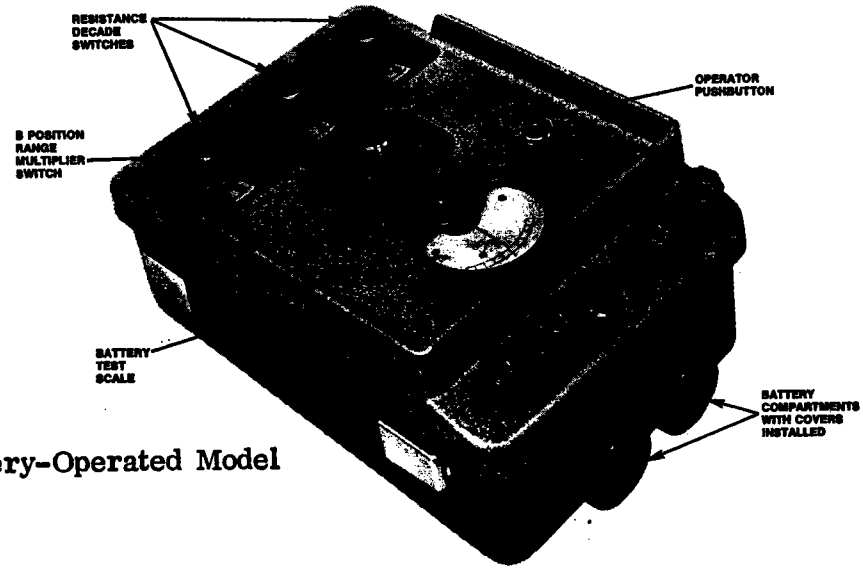
No initial adjustments are necessary. No calibration is required for the earth tester prior to use. Calibration of the instrument is adjusted at the factory prior to shipment.

Use the earth tester on a firm and fairly level base. Avoid large masses of iron and magnetic fields. If the tester is used in rainy weather it must be protected from direct exposure.

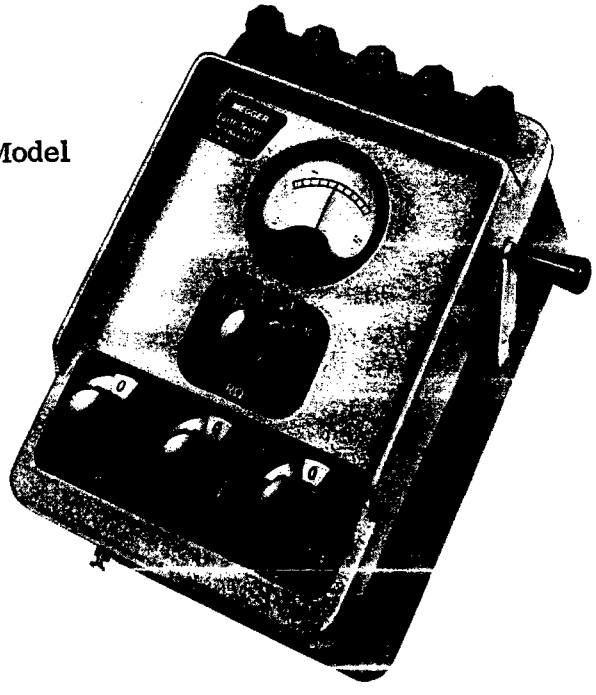
a. HAND-CRANKED EARTH TESTER. No preparations are required for the hand-cranked earth tester.

b. BATTERY-OPERATED EARTH TESTER. Preparation of the battery-operated earth tester consists of installing and testing the batteries as follows:

1. Unscrew the two covers located at the top of the instrument (see Figure 2-1).



Battery-Operated Model



Hand-Cranked Model

Figure 2-1. Megger Null Balance Earth Testers.

2. Insert six 1-1/2 volt type C dry cells (three in each space) making sure that the positive terminal caps on all batteries are facing the covers.

3. Replace the two covers taking care to screw them firmly in place. DO NOT OVERTIGHTEN.

4. Set multiplier switch to B, depress the operating push-button (Figure 2-1) and observe meter. The pointer should read in the white sector of the small scale below the right portion of the main scale (see Figure 2-1).

5. If the pointer does not move beyond the black sector, or reads below the black sector (left), the batteries should be replaced.

2–4. PREPARATION FOR STORAGE OR RESHIPMENT.

Always remove batteries before storage or shipment.

For storage place the earth tester in the carrying case.

For shipment, do not use carrying case. Pack in carton or box with adequate dunnage in accordance with best commercial practice.

SECTION 3

OPERATION

3–1. FUNCTION.

a. USE. The earth tester is designed to measure the resistance of earthing systems in a wide variety of applications. It tests permanent ground connections of electrical equipment and measures the resistance to ground from equipment frames, cases, sheaths, housings, etc., as well as the earth electrodes themselves. The earth tester may also be used in determining soil resistivity which is an aid in locating ore bodies, clay and water bearing gravel, also in geophysical prospecting.

b. CAPABILITY AND LIMITATIONS. The earth tester is a self-contained instrument designed to provide accurate measurements. The earth tester uses an alternating current which is not affected by stray currents present during testing. The earth tester contains either a hand-driven ac generator or a battery-driven oscillator to provide a test current between the earth electrode under test and a current electrode. The potential between the earth electrode and a separate potential electrode is balanced against a voltage which is generated from the ac output via a current transformer across the three resistance decades. The out-of-balance current caused by the difference of potentials is rectified and drives a zero-center meter.

The null balance method means that, at balance, no current flows through the potential electrode, and therefore the resistance of the potential electrode does not affect the reading. Lead resistances are not significant and may be eliminated by following recommended test procedures.

When the meter is balanced, the resistance in ohms is read from the resistance decade switches in combination with the range multiplier switch. Numerical readout of resistance has the advantages of no pointer reading error and the reading remains available until the next test is made.

3–2. OPERATING PROCEDURES.

Since proper operation of the equipment depends on correct use of the controls, the markings and function of these controls must be studied before using the tester.

a. DESCRIPTION OF CONTROLS. All operating controls used on the earth tester are listed in Table 3-1, and Figure 3-1 shows the arrangement of the operating controls on the earth tester.

b. METHOD OF OPERATION. The earth tester contains either a hand-driven ac generator or a battery-driven oscillator which passes current through the resistance under test from terminal C1 to C2 and the consequent potential across terminals P1, and P2 causes a meter to deflect. (See Figure 3-1.)

This potential is balanced by an equal and opposite potential produced across an adjustable resistance in the instrument with the result that, at balance, no current flows in the potential circuit. The measured values are unaffected by ground rod resistances within wide limits. Stray currents in the soil may produce movement of the pointer but will disappear when the generator is turned for the hand-cranked instrument, or the operating pushbutton is depressed for the battery-operated instrument.

With the earth tester connected in accordance with paragraph 3-3 for the test required, operate the earth tester as follows (refer to Figure 3-1 for controls and indicators):

Remember that rubber gloves should be worn during operation of the earth tester as a precaution against accidental high potentials on the structure under test.

1. Set the range multiplier switch to the x 0.01 position and each of the balancing resistor dials to 9 (9, 9, 9 left to right, respectively).

2. Turn the hand-crank clockwise about two revolutions per second for the hand-cranked earth tester, or press operating pushbutton for the battery-operated earth tester, and note the deflection on the meter.

TABLE 3-1. OPERATING CONTROLS

CONTROL	FUNCTION
HAND-CRANK AND BATTERY-OPERATED EARTH TESTERS	
C1 binding post.	Provides ac current to earth electrode under test.
C2 binding post.	Provides return path for ac current.
P1 binding post.	Provides ac voltage connection to earth electrode under test.
P2 binding post.	Provides ac voltage connection to potential electrode grounding rod.
Range multiplier switch.	Provides four ranges: X.01, X.1, X1, X10
Resistance decade switches (3 each).	Digital display from 001 to 999.
Meter	Center reading indicates null balance.
BATTERY-OPERATED EARTH TESTER ONLY	
Operation push-button.	Applies output voltage. Applies output batteries to meter when range multiplier switch is moved to B multiplier.
B position on range multiplier switch.	To display battery output on meter.
Meter battery test scale.	Indicates condition of batteries.
HAND-CRANKED EARTH TESTER ONLY	
G binding post.	Provides a bypass path to a guard rod for leakage current within the instrument.
Hand-crank.	Operates generator to provide test voltage and current.

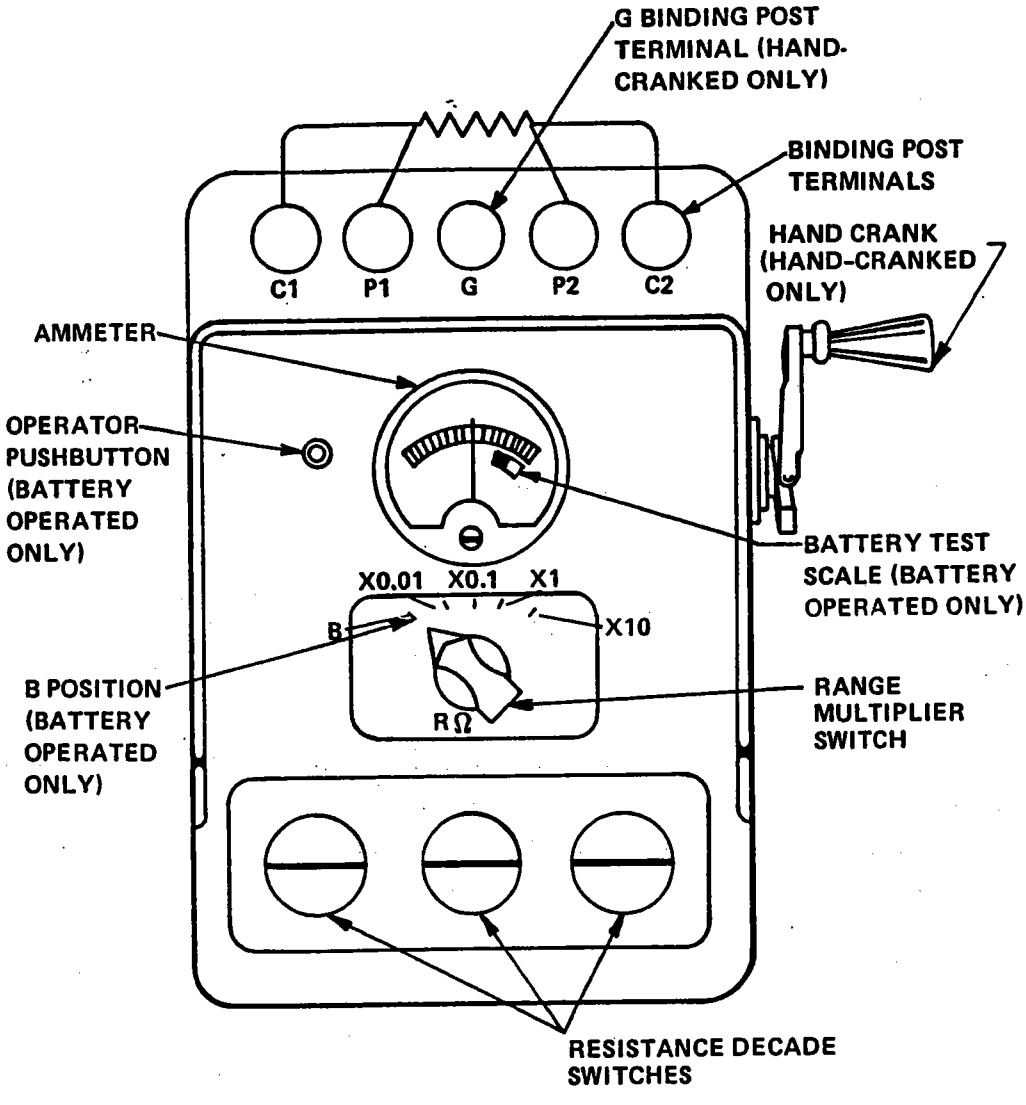


Figure 3-1. Megger Null Balance Earth Tester, Controls and Indicators for Battery-Operated and Hand-Cranked Models.

3. If deflection is to the right (+), increase resistance factor by setting the range multiplier switch to the x 0.1 position. Note the position of the pointer on the meter.

4. If deflection is to the left (-) proceed to the next step. If deflection is still to the right continue to increase the resistance factor with the range multiplier switch until the deflection goes to the left (-).

5. When deflection is to the left (-) decrease the values of the resistance decades, digit by digit, starting with the left dial then the center dial, and finally the right dial until the meter pointer is at the center. Whenever the reading goes to the right (+), the dial has been turned too far.

6. If using the hand-cranked earth tester, increase the cranking speed of the generator to about 160 rpm (about 2-1/2 revolutions of the hand-crank per second) for maximum sensitivity and to avoid the effects of stray currents in the soil.

NOTE

If stray ac is present when using the hand-cranked earth tester, it may be necessary to increase the cranking speed depending upon the frequency of the stray current. Cranking speeds up to 200 rpm (about 3-1/2 revolutions of the hand-crank per second) may be required to accurately balance the meter.

7. Read the resistance directly off the dials (range multiplier times decade dials); this is the resistance of the earthing system under test.

c. Example: If the Earth Tester is connected to an earth electrode in the recommended arrangement and the following settings result at null-balance:

- Range multiplier switch is set at 0.01 position.
- Left resistance decade dial is set at position 3.

- Center resistance decade dial is set at position 7.
- Right resistance decade dial is set at position 6.

Then resistance measured is:

376 x 0.01 = 3.76 ohms.

3–3. OPERATING CONNECTIONS.

a. GENERAL. Before setting up an earth electrode test, spacing requirements and location of test rods must be determined according to the following discussion.

b. TEST ELECTRODE SPACING. Fall-of-potential or 3-point method is commonly used for single rod or small earth grids. This involves positioning current and potential rods C and P as shown in Figure 3-2 and connecting these by suitable cables to the earth tester to complete the current and voltage circuit. The tester is calibrated to read directly the resistance of the electrode E under test. To obtain a valid reading, the current rod must be properly located. Since both possess spheres of influence, the C2 rod must be sufficiently remote to prevent these areas from overlapping. Futhermore, the potential rod must lie between these two areas, preferably along a straight line between them.

In Figure 3-2, the dimensions of the spheres of influence of E and C are frequently unknown and to allow a safe margin the distance chosen for EC may be quite high. It is also necessary to experiment with the location of P.

However, by mathematical analyses and shown by actual test the true resistance of the electrode to be tested is equal to the measured resistance when the distance EP is equal to 62% of the distance EC.

The potential electrode P2 may be inserted at 50% and 75% of the distance EC to verify the measured resistance. In some cases, C2 and P2 may be relocated and the resistance measured again. The average of the measured resistances may be used at the true value.

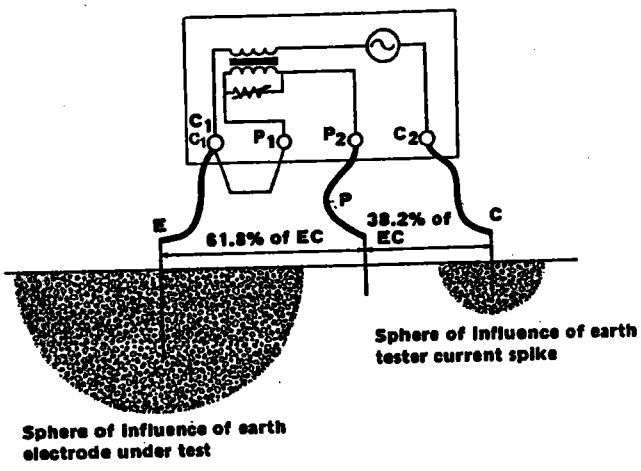


Figure 3-2. Positioning Ground Rods in Relation to the Electrode Under Test.

c. SINGLE RODS AND SMALL GRIDS. For single rods and small grids the current electrode C2 (see Figure 3-3) should be 100 foot from the electrode under test E.

The potential electrode P2 should be inserted at 62% of this distance in a straight line with the other two.

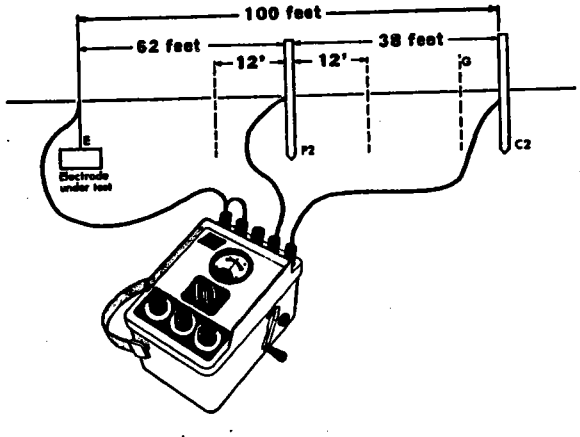


Figure 3-3. Connections for Testing Resistance to Earth of an Earth Electrode.

d. LARGE EARTH ELECTRODE SYSTEMS OR LARGE AREA GROUND GRIDS. In general, the three-point or fall-of-potential method is also applicable to large area earth electrodes. However, the distance to the C2 current rod should be about five times the largest dimension or diagonal of the earth electrode or ground grid area. The P2 potential rod should then be positioned at 62% of the distance from the center of the grid to the C2 rod. See Figure 3-4.

If the P2 rod is driven at several locations, a curve can be drawn for resistance versus distance, typically S-shaped, and the true value of the resistance of the earth electrode will be represented by the point at which the slope of the curve reverses. Usually this point is at the 62% distance previously noted.

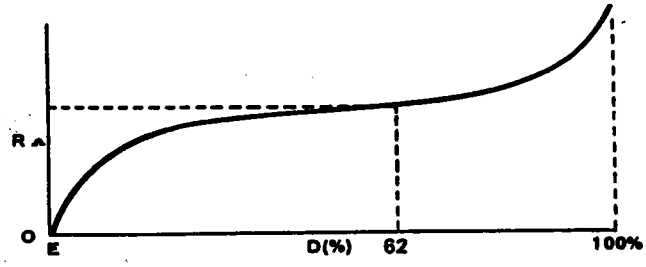


Figure 3-4. Typical Curve for Earth Electrode Resistance Versus Distance from Electrode to C_2 Rod.

e. ALTERNATE METHOD WHEN DEAD EARTH OR REFERENCE GROUND IS AVAILABLE. When it is impossible to find suitable locations for the test rods, an alternative method may be used provided a low resistance earth such as a water main is available. This low resistance earth is commonly refered to as a dead earth or reference ground. To test an earth electrode using the alternate method, proceed as follows:

Connect as shown in Figure 3-5. This test will give the resistance to earth of the electrode under test plus that of the water main,

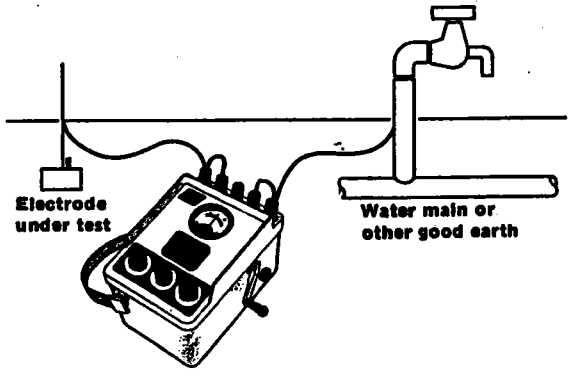


Figure 3-5. Alternative Method of Test When a Dead Earth is Available.

and if the latter is negligible, generally 3 ohms or less according to the National Electrical Code, then the reading may be taken as that of the electrode under test.

NOTE

The resistance of the water main may be measured as shown in Figure 3-3.

The results obtained with this test method will not be accurate if the water main lies too close to the earth under test, and for this reason it is always preferable to use the fall-of-potential method previously described.

3-4. MAKING A MEASUREMENT.

a. To test an earth electrode, connect the earth tester as follows:

1. Jumper terminals C1 and P1 and from them connect a lead to the electrode under test (E, Figure 3-2). Keep this lead short as its resistance will be included in the test. However, separate leads may be used from terminals P1 and C1 to E, as in Figure 3-6, in which case the lead resistance will be excluded.

2. Connect terminals P2 and C2 to two rods driven into the ground, P2 being 62% of the distance between E and C2. (The distances

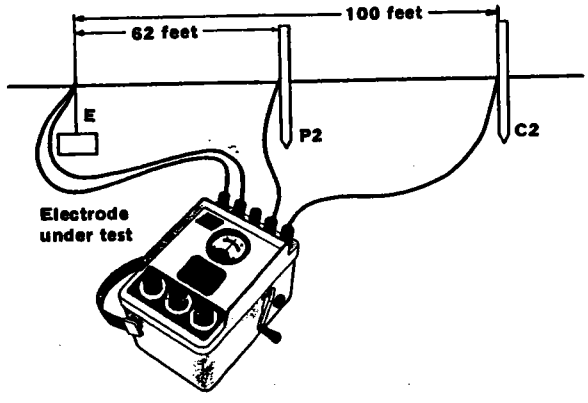


Figure 3-6. Alternative Connections for Testing Resistance to Earth of an Earth Electrode Compensating for Cable Resistance where Long Leads are Required.

shown are normal for simple earth electrodes. Much greater distances will be necessary for complex earthing systems.

3. Turn the hand-crank or depress operating button and observe meter. Adjust range multiplier switch and resistance decades to obtain a null balance. Note and record resistance. Re-position P2 rod at 50% and 75% of EC2 distance, repeat measurement and record results.

Tests may be repeated with C2 at a new location to verify results.

If using the hand-cranked earth tester and the meter reading wavers at certain crank speeds (due to stray ac currents in the soil) increase or decrease the speed of the generator handle to obtain a steady reading.

3–5. SOIL RESISTIVITY MEASUREMENT.

a. Before installing an earth electrode system for a new facility it is often advantageous to make a preliminary survey of the soil resistivity of the surrounding site. This will enable decisions to be made on the best locations for the earth electrode and to decide whether any

advantage is to be gained by driving rods to a greater depth. Such a survey may produce considerable savings in electrode and installation costs.

b. CALCULATION OF RESISTIVITY. Assuming the soil to be homogeneous the resistivity is given by the formula:

$\rho = 2\ \pi aR$, according to Dr. Wenner, NBS,

where R is the resistance measured in ohms, 'a' is the electrode spacing in centimeters and 'ρ' is the resistivity in ohm-cms. An electrode spacing of about 10 feet is quite useful. In fact, if the electrodes are placed 3.18 meters apart, the formula becomes $\rho = 2000$ R.

For non-homogeneous soil this formula will give an apparent resistivity which is approximately the average value to a depth equal to the electrode spacing 'a'.

Although the earth tester measurements are not normally affected by ground rod resistance, under certain conditions leakage currents within instruments of this type will produce a small deviation from zero. These deviations are more noticeable when exceptionally high or unbalanced ground rod resistances are encountered such as in very dry or rocky soils.

These leakage currents are bypassed to earth automatically with the hand-cranked instrument by connecting the guard terminal to a guard rod and the error is eliminated. (See 3.5(d)7.)

c. TYPICAL VARIATIONS IN SOIL RESISTIVITY. The very wide variation in values is due mainly to the concentration of metallic salts and moisture content. The resistivity of any particular kind of soil cannot be forecast accurately and it is very important to test the resistance of any earth electrode when it is first laid down, and at periodic intervals thereafter. Table 3-2 lists some typical specific resistances for various materials.

d. INSERTING TEST ELECTRODES. General procedures for inserting test electrodes are as follows (refer to Figure 3-7):

TABLE 3-2. TYPICAL SPECIFIC RESISTANCES FOR MATERIALS

SOIL	RESISTIVITY, OHM-CM (RANGE)
Surface soils, loam, etc.	100 — 5,000
Clay	200 — 10,000
Sand and gravel	5,000 — 100,000
Surface limestone	10,000 — 1,000,000
Limestones	500 — 400,000
Shales	500 — 10,000
Sandstone	2,000 — 200,000
Granites, basalts, etc.	100,000
Decomposed gneisses	5,000 — 50,000
Slates, etc.	1,000 — 10,000

From: James G. Biddle Co., Manual 25T, Entitled "Getting Down to Earth".

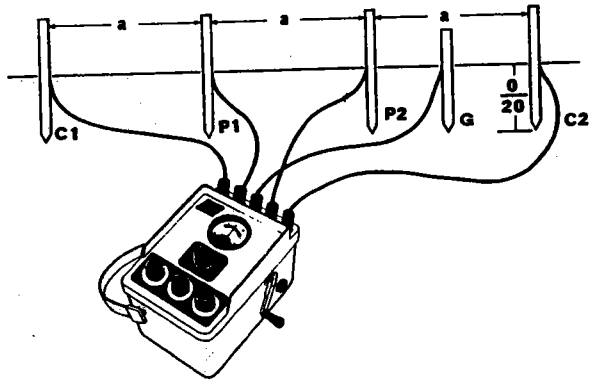


Figure 3-7. Connections for Measuring Earth Resistivity (Guard Terminal is used with Hand-Cranked Earth Tester Only).

1. Four electrodes are driven into the ground in a straight line, at equal distances 'a', and the depth of insertion 'b' should be small compared to spacing

$$b = \frac{1}{20} a.$$

2. The instrument is then connected to the four (or five) rods as in Figure 3-7.

3. The resistance is read in the usual way after establishing a null balance.

4. The resistivity is calculated from $\rho = 2 \pi aR$.

5. The electrodes are repositioned for further tests. If the spacing 'a' is maintained, a directly comparative reading will be obtained each time, and areas of lowest resistivity located (to constant depth 'a'). Results can be posted on a map of the area.

6. The distance 'a' is the depth to which soil resistivity is being measured. Thus a profile of different readings for depths b, c, d, etc. may be obtained by respacing electrodes to distances b, c, d, etc.

7. For the hand-crank instrument, a fifth rod may be required at G, midway between C2 and P2 as in Figure 3-7, and is connected to the Guard Terminal.

3–6. OTHER USES FOR THE EARTH TESTER.

a. TESTING A NEUTRAL-EARTH LOOP. To test a neutral-earth loop, connect the earth tester as illustrated in Figure 3-8.

CAUTION

Use some form of live line detector to make sure that contact is made with the neutral and not the live conductor which would result in damage to the instrument.

b. TESTING THE CONTINUITY OF CONDUIT OR OTHER EARTH CONDUCTORS. To measure metallic resistances of low inductance or capacitance conduit or other earth conductors, connect the earth tester as illustrated in Figure 3-9. Due to the low resistance to be measured, contact resistance between leads and conduit becomes a major consideration and must be as low as possible.

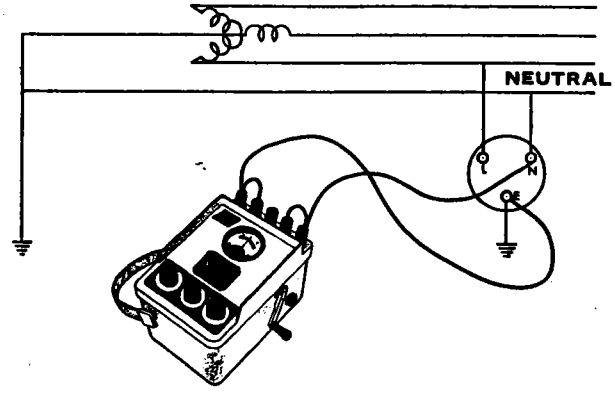


Figure 3-8. Connections for Testing a Neutral-Earth Loop.

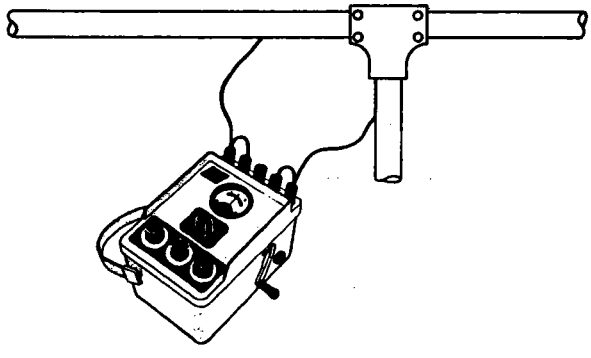


Figure 3-9. Connections for Testing Earth Continuity.

3-7. TESTING SPIKE RESISTANCE.

Although, as previously explained, measurements are theoretically unaffected by probe resistance, under certain conditions leakage currents within an instrument may produce a small deviation of the meter and cause erroneous readings.

To eliminate this possible source of error, a guard terminal has been provided on the hand-crank instrument which by-passes leakage currents to earth through a guard rod. (See Figure 3-4.)

For normal earth electrode testing the guard terminal is not required. If the galvanometer appears insensitive to changes in the resistance decades, the probe resistances should be checked to see that they are not excessive.

To check the resistance of the potential grounding rod, interchange the leads as shown in Figure 3-10 so the potential spike becomes the electrode under test and the earth under test the potential spike.

If the spike resistance is over 3,000 ohms use the guard terminal, connecting it to a guard rod inserted between the potential grounding rod (P2) and the current grounding rod (C2) as indicated in Figure 3-7. The guard terminal is not required on the upper two ranges (x1.0) and (x10).

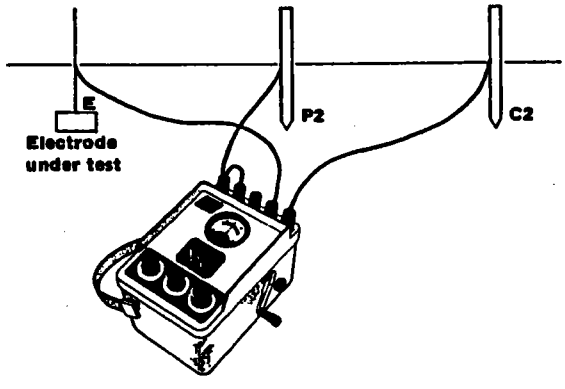


Figure 3-10. Connections for Checking Potential Grounding Rod Resistance.

SECTION 4

THEORY OF OPERATION

4–1. OVERALL FUNCTIONAL DESCRIPTION.

a. HAND-CRANKED EARTH TESTER. The hand-cranked earth tester is an indicating instrument having an alternating current generator with a mechanical rectifier, a gear train and fold-away crank for operating the generator, and a resistance network. (Refer to Figure 4-1 for a schematic diagram of the hand-cranked earth tester.)

1. METER. The indicator is a taut-band microammeter. When current is applied to the indicator the pointer deflects either positive (right), negative (left), or remains at zero (center). The direction and amount of deflection is determined by the relationship of the resistance dialed into the earth tester and the resistance under test. If the resistance under test is greater than the resistance dialed into the earth tester, the indicator will read positive; if the resistance under test is less than the resistance dialed into the earth tester, the indicator will read negative; and if the resistances are equal, the indicator will read zero.

2. GENERATOR. The alternating current generator consists of a single stator coil and a bi-pole permanent magnet rotor. A mechanical rectifier positioned on the end of the shaft converts the returning unbalanced current to dc for the meter. The rotor runs in Oilite bearings which should not require lubrication for the life of the earth tester. The gear train that operates the generator is a simple spur gear drive which has been permanently lubricated at the factory.

3. RESISTANCE NETWORK. Figure 4-1 shows the schematic diagram with the resistance network.

b. BATTERY-OPERATED EARTH TESTER. The battery operated earth tester is an indicating instrument having a battery

operated alternating current inverter, a voltage rectifier, and a resistance network. (Refer to Figure 4-2 for a schematic diagram of the battery-operated earth tester.)

1. METER. The indicator for the battery-operated earth tester is identical to, and functions the same, as the indicator used in the hand-cranked earth tester.

2. AC INVERTER. A four-stage solid state circuit converts the dc battery voltage to ac.

3. RECTIFIER. A two-stage rectifier circuit converts the return unbalanced current to dc for the meter.

4. RESISTANCE NETWORK. - Figure 4-2 shows the schematic diagram with the resistance network.

4-2. THEORY OF OPERATION.

a. HAND-CRANKED EARTH TESTER. (Refer to Figure 4-1.) The test current from a hand-cranked ac generator is passed through the ground under test, the soil, and back through the C2 terminal. This test current also passes through the primary of a current transformer from the secondary of which a current is applied across the adjustable internal resistance, developing a potential in opposition to the external potential developed by the test current between the earth electrode and a potential rod connected to terminal P2. The unbalanced ac current is mechanically rectified to drive the zero-center meter. The adjustable resistance is calibrated in ohms, and when the meter is at balance the earth electrode resistance is read directly from the resistance decade switches and range multiplier switch.

b. BATTERY-OPERATED EARTH TESTER. (Refer to Figure 4-2.) Same as hand-crank earth tester except the current source is a battery-driven inverter with a solid state rectifier supplying current to the meter.

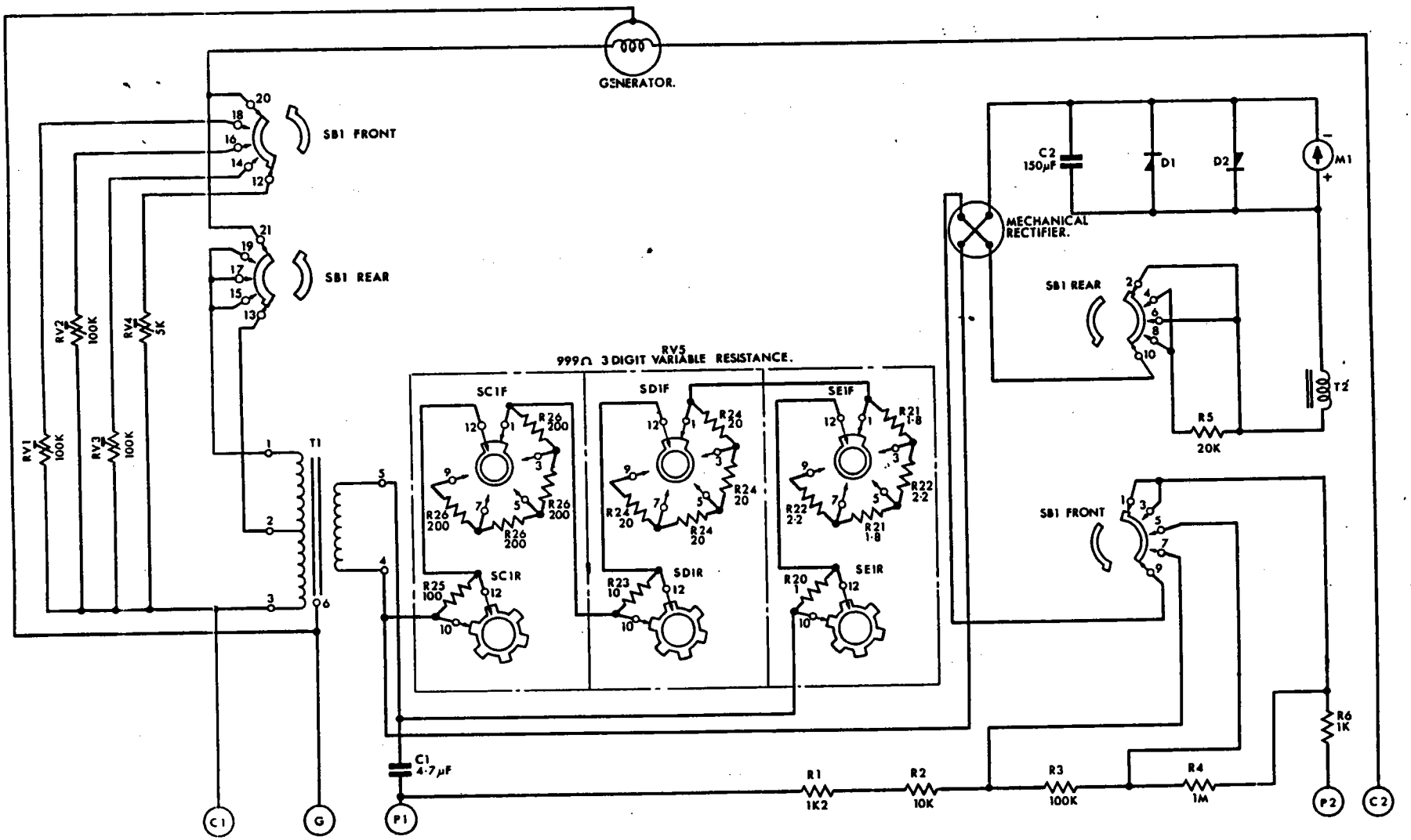


Figure 4-1. Schematic Diagram of Hand-Cranked Earth Tester.

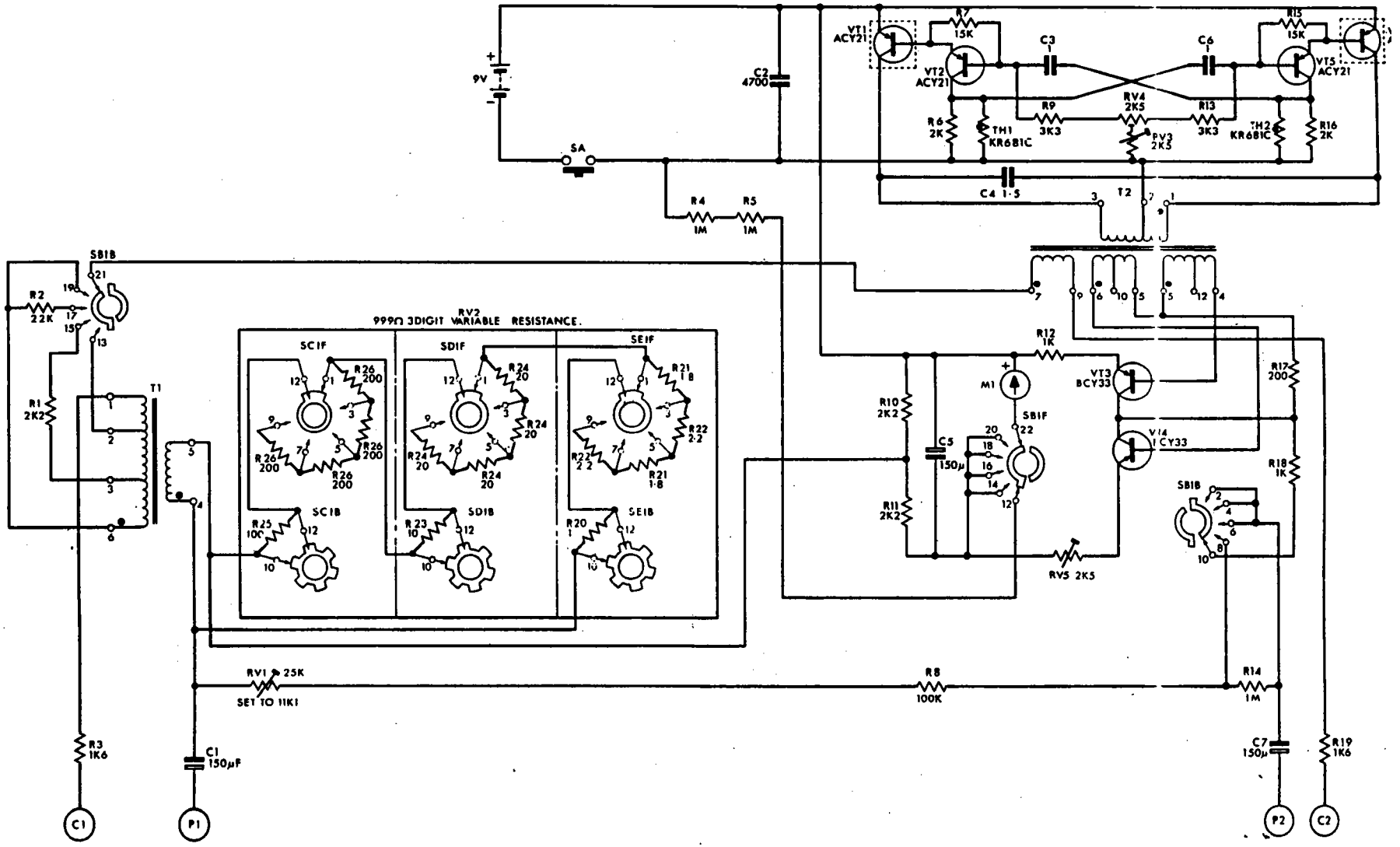


Figure 4-2. Schematic Diagram of Battery-Operated Earth Tester.

SECTION 5

TROUBLESHOOTING AND REPAIR

5–1. PREVENTIVE MAINTENANCE.

a. GENERAL.

1. INSPECTION. Check the earth tester for use in accordance with paragraph 2–3. Visually inspect the earth tester for a cracked or defective case and defective or broken binding posts.

2. PREVENTIVE MAINTENANCE. Keep the earth tester in a clean dry place. Handle with reasonable care. Do not attempt further preventive maintenance.

b. TEST EQUIPMENT. Test equipment is required only for calibration tests. (See paragraph 5–2.)

c. SPECIAL TOOLS. No special tools are required.

5–2. CALIBRATION TESTS.

Do not attempt calibration of the earth tester. Calibration is performed at the factory before shipment. If the following test proves calibration is required, return the earth tester to the James G. Biddle Co. for servicing.

a. TEST EQUIPMENT. The only test equipment required for calibration is a standard four-decade resistance box.

b. TEST PROCEDURE. To test the calibration of the earth tester proceed as follows:

1. Join together terminals P1 and C1 on the earth tester and connect to one terminal of the resistance box.

2. Join together terminals P2 and C2.

NOTE

The guard terminal is not connected for this test.

3. Set up a resistance value of 9,990 ohms on the resistance box.

4. Set the range multiplier switch (Figure 3-1) to the x10 scale and each resistance decade resistor dial switch to 9. Observe indicator. The pointer will point to the center position of the scale.

5. Repeat steps 3 and 4 for each scale of the range multiplier switch, setting the resistance box at 999,99 and 9 ohms. Set multiplier and resistance decades at corresponding positions. The indicator pointer will point to the center position of the scale for each setting.

NOTE

When testing very low resistances on the x0.01 scale, a small error may be observed (positive or negative deflection off center of scale). This error is due to contact and lead resistances which become significant only when measuring very low values of resistance.

5-3. TROUBLESHOOTING.

Table 5-1 lists typical troubles that may be encountered in the earth tester. The first column indicates the nature of the trouble, the second column indicates the probable cause, and the third column indicates the recommended remedy.

5-4. REMOVAL AND DISASSEMBLY OF PARTS AND SUBASSEMBLIES.

Refer to Figures 5-1 and 5-2 for the hand-cranked model, and Figure 5-3 for the battery-operated model.

TABLE 5-1. TROUBLESHOOTING CHART

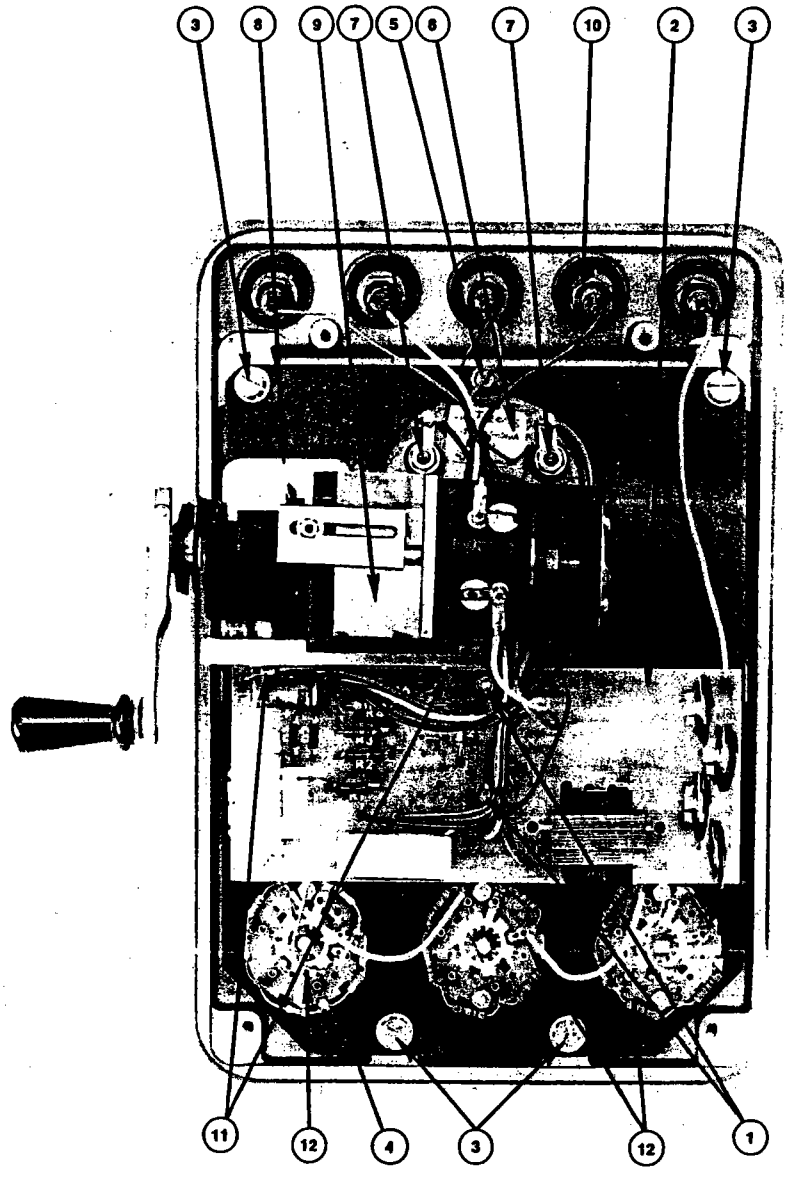
TROUBLE	PROBABLE CAUSE	REMEDY
ALL		
Pointer does not move.	Defective meter.	Replace meter.
Erratic reading.	Defective range multiplier switch.	Replace switch.
	Defective decade switch.	Replace switch.
HAND-CRANKED MODEL:		
No output current at C1, C2 Terminals.	Defective generator.	Replace generator.
BATTERY-OPERATED MODEL:		
No ouput current at C1, C2 Terminals.	Defective batteries.	Replace batteries.
	Poor battery connection.	Check battery housing, terminals.
	Broken battery housing.	Replace.
	Defective push button.	Replace.

CAUTION

After opening the earth tester, observe how parts are removed, what they are, and in what order they are removed. Watch for metallic particles or slivers which may fall onto exposed parts of the instrument. Do not attempt to repair any part of the earth tester; replace the defective component.

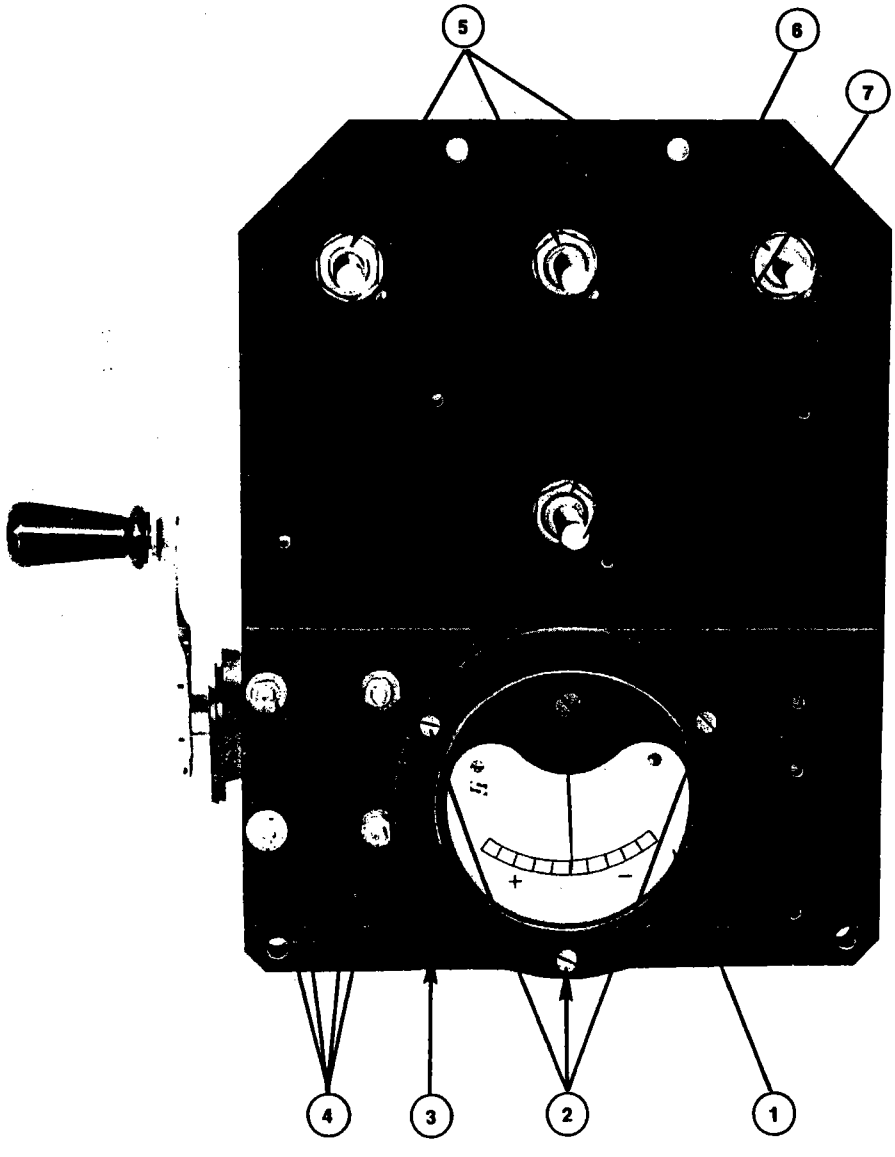
a. REMOVE KNOBS.

1. Earth tester is positioned right side up.



1. PRINTED CIRCUIT BOARD ATTACHING NUTS (2)
2. PRINTED CIRCUIT BOARD
3. MOUNTING BOARD ATTACHING SCREWS (4)
4. MOUNTING BOARD
5. INDICATOR ASSEMBLY ATTACHING NUTS (3)
6. INDICATOR ASSEMBLY
7. INDICATOR ASSEMBLY WIRE TERMINALS (2)
8. GENERATOR ASSEMBLY MOUNTING BRACKET ATTACHING SCREWS (4)
9. GENERATOR ASSEMBLY AND MOUNTING BRACKET
10. TERMINAL BINDING POSTS (5)
11. GENERATOR ASSEMBLY TO MOUNTING BRACKET ATTACHING NUTS (2) AND SCREW (1)
12. RESISTANCE DECADE SWITCHES (3)

Figure 5-1. Hand-Cranked Earth Tester Positioned Face Down with Case Housing Removed.



1. INDICATOR ASSEMBLY
2. INDICATOR ASSEMBLY ATTACHING SCREWS (3)
3. MOUNTING BOARD
4. GENERATOR ASSEMBLY MOUNTING BRACKET ATTACHING NUTS (4)
5. RESISTANCE DECADE SWITCHES ATTACHING NUTS (3)
6. RANGE MULTIPLIER SWITCH ATTACHING NUT
7. RANGE MULTIPLIER SWITCH

CKET

KET

Figure 5-2. Hand-Cranked Earth Tester Positioned Face Down with Case Housing Removed and Component Mounting Board Unattached and In Vertical Position.

2. Set each of the resistance decade switches (Figure 3-1) to 9, and set the range multiplier switch (Figure 3-1) to x.01 position.

3. Remove the four knobs from the switches by removing cap and loosening collet nut; lift off.

4. Position the top of the earth tester so that it is face down.

b. REMOVAL OF CASE COVER. Remove four lead seals from the bottom of the case housing. Unscrew the four exposed screws attaching case housing to top. Lift off case housing exposing internals attached to top which is positioned face down. The case housing in the hand-crank earth tester contains only the four feet. However, in the battery-operated unit, the battery holders are mounted in the case housing. If battery holder is broken, replace by removing two wires, observe color coding, remove threaded collar and slide battery holder out of mounting hole. Insert new holder, tighten threaded collar and resolder two wires.

CAUTION

Do not place exposed internal parts directly onto a surface. Protect and/or provide supports underneath.

c. REMOVAL OF MOUNTING BOARD. Removal of the remaining components requires removal of the mounting board first. To remove the mounting board, proceed as follows:

1. Unscrew four attaching screws and lockwashers (3, Figure 5-1).

2. Lift end of mounting board (4, Figure 5-1) with three resistance decade switches pointed upward until the mounting board is in the vertical position (Figure 5-2).

d. REMOVAL OF INDICATOR ASSEMBLY.

1. Unscrew three indicator assembly attaching screws (2, Figure 5-2) from indicator assembly attaching nuts (5, Figure 5-1).

2. Remove nuts and washers from wire terminals (7, Figure 5-1) and lift off wires from terminals.

3. Remove indicator (1, Figure 5-2) from underside of mounting board (3, Figure 5-2).

4. Remove and store gasket that fits between indicator and underside of top.

d. REMOVAL OF GENERATOR ASSEMBLY.

1. Unscrew four generator assembly mounting bracket attaching screws (8, Figure 5-1) from four attaching nuts (4, Figure 5-2).

NOTE

Remove generator assembly mounting bracket with generator assembly attached to bracket.

2. Remove generator assembly from mounting board to a position that permits removing wires.

3. Unscrew four wire connectors from end of generator assembly and remove the wires making note of the color coding.

4. Unsolder two wires from the terminal binding posts (10, Figure 5-1) and one wire from the printed circuit board (2, Figure 5-1). Remove wires noting color coding.

5. Remove two attaching nuts and one screw from generator assembly mounting bracket (11, Figure 5-1).

6. Remove mounting bracket from generator assembly.

e. REMOVAL OF SWITCHES.

1. Remove retaining clips and unscrew three resistance decade switches attaching nuts (5, Figure 5-2), and one range multiplier switch attaching nut (6, Figure 5-2).

2. Remove three resistance decade switches (12, Figure 5-1) and one range multiplier switch (7, Figure 5-2), with printed circuit board attached to switch, from the mounting board (4, Figure 5-1).

3. Unsolder wire leads from these three resistance decade switches and unsolder printed circuit board from range multiplier switch. Note color coding of all wire and solder connections.

4. Unscrew and remove two printed circuit board attaching nuts and washers (1, Figure 5-1).

5. Remove printed circuit board (2, Figure 5-1) from range multiplier switch (7, Figure 5-2).

f. REMOVAL OF PRINTED CIRCUIT BOARD. Unsolder wires from printed circuit board noting color coding and connection points.

g. REMOVAL OF TERMINAL BINDING POSTS.

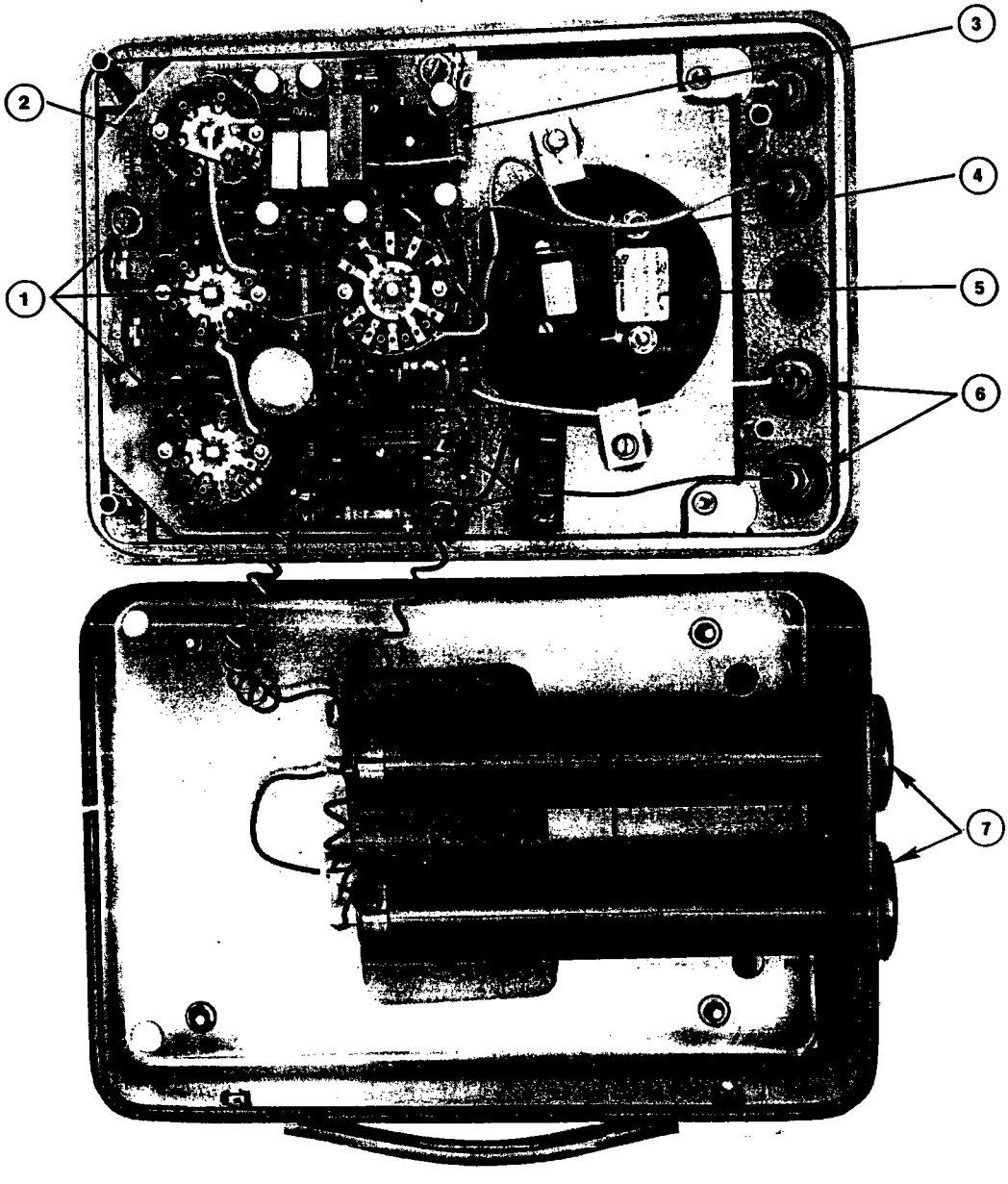
1. Unsolder wire leads from binding posts (10, Figure 5-1) noting color coding and connections.

2. Unscrew one attaching nut each from binding post.

3. Remove binding posts from case.

h. SIMILARITIES AND DIFFERENCES BETWEEN EARTH TESTERS. The internal construction, controls, and wiring of the hand-cranked and battery-operated earth testers are very similar. For removal and reassembly procedures of internal components, the two earth tester models are considered identical except for the generator assembly.

In the battery-operated earth tester, Figure 5-3, the generator assembly is replaced with batteries and an ac inverter. The ac inverter is mounted in the battery-operated earth tester on the printed circuit board.



1. RESISTANCE DECADE SWITCHES
2. PRINTED CIRCUIT BOARD
3. AC INVERTER
4. RANGE MULTIPLIER SWITCH
5. INDICATOR ASSEMBLY
6. BINDING POST TERMINALS
7. BATTERY COMPARTMENTS

Figure 5-3. Battery-Operated Earth Tester Positioned Face Down with Case Housing Removed.

5–5. REASSEMBLY OF PARTS AND SUBASSEMBLIES.

a. REASSEMBLY OF TERMINAL BINDING POSTS.

1. Replace binding posts in case (10, Figure 5-1).

2. Replace attaching nut on each binding post.

3. Solder wire leads to binding posts.

b. REASSEMBLY OF PRINTED CIRCUIT BOARD. Solder wires to the connection points on the printed circuit board.

c. REASSEMBLY OF SWITCHES.

1. Replace printed circuit board (2, Figure 5-1) onto range multiplier switch post (7, Figure 5-2).

2. Replace two attaching nuts and washers (1, Figure 5-1).

3. Solder wire leads to three resistance decade switches (12, Figure 5-1) and solder printed circuit board connections to range multiplier switch (7, Figure 5-2).

4. Replace three resistance decade switches and one range multiplier switch with printed circuit board attached to the mounting board (4, Figure 5-1).

5. Replace attaching nuts and retaining clips to four switches (5 and 6, Figure 5-2).

d. REASSEMBLY OF GENERATOR ASSEMBLY.

1. Attach mounting bracket to generator assembly (9, Figure 5-1).

2. Replace two attaching nuts and one screw to generator assembly and mounting bracket (11, Figure 5-1).

3. Solder two wires to the terminal binding posts (10, Figure 5-1) and one wire to the printed circuit board (2, Figure 5-1).

4. Replace four wires to the end of the generator assembly with attaching screws.

5. Replace mounting bracket with generator assembly attached to mounting board (4, Figure 5-1) using four attaching screws and nuts (8, Figure 5-1).

e. REASSEMBLY OF INDICATOR ASSEMBLY.

1. Replace gasket to underside of top between top and indicator.

2. Replace indicator through underside of mounting board (3, Figure 5-2).

3. Replace wires with connectors to wire terminals (7, Figure 5-1).

4. Replace three attaching screws (2, Figure 5-2) and nuts (5, Figure 5-1).

f. REASSEMBLY OF MOUNTING BOARD.

1. Replace mounting board (3, Figure 5-2) to its horizontal position (4, Figure 5-1).

2. Replace four attaching screws and lockwashers (3, Figure 5-1).

g. REASSEMBLY OF CASE COVER.

1. Replace case housing to the top.

2. Replace four screws through the bottom of the case attaching the case to the top.

3. Turn the earth tester over so that it is positioned right side up. At this point the instrument must be resting on the top panel.

4. Replace knobs onto the four switches. Position knobs so that the three resistance decade switches (Figure 3-1) read 9, and the range multiplier switch (Figure 3-1) reads x0.1.

CAUTION

Knob skirt must clear panel by .040" to .060" (1.0 to 1.5 mm).

SECTION 6

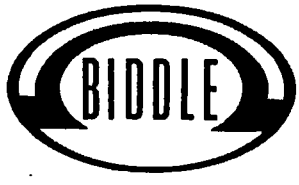
PARTS LIST

6–1. INTRODUCTION.

Table 6-1 lists the earth tester assemblies and component parts. The table includes the description of the part and the part number.

TABLE 6-1. MEGGER NULL BALANCE EARTH TESTER PARTS LIST

DESCRIPTION	PART NUMBER	
	CATALOG NO. 63220	CATALOG NO. 63241
Case Assembly	10383-1	10383-2
Foot	10383-3	10383-3
Carrying Handle	10383-4	10383-5
Battery Holder	-	10383-6
Cover Assembly	10383-7	10383-8
Terminal	10383-9	10383-9
Terminal Disc P1	10383-10	10383-10
P2	10383-11	10383-11
C1	10383-12	10383-12
C2	10383-13	10383-13
G	10383-14	-
Meter	10383-15	10383-16
Push Button	-	10383-17
Knob Assembly Range	10383-18	10383-18
Knob Assembly Decade	10383-19	10383-19
Switch Assembly Range (SB)	10383-20	10383-21
Switch Assembly Decade (SC)	10383-22	10383-22
Switch Assembly Decade (SD)	10383-23	10383-23
Switch Assembly Decade (SE)	10383-24	10383-24
PC Board Assembly	10383-25	10383-26
Generator	10383-27	-



James G. Biddle Co.

PLYMOUTH MEETING, PA. 19462

Printed in U.S.A.

5 L 7/77