Instruction Manual 24-1J

Revision 12.0

for the use of DLRO(R)
DIGITAL LOW RESISTANCE
OHMMETERS

Catalog No. 247000 Series

JULY 1988

BIDDLE INSTRUMENTS
Blue Bell, Pa. 19422

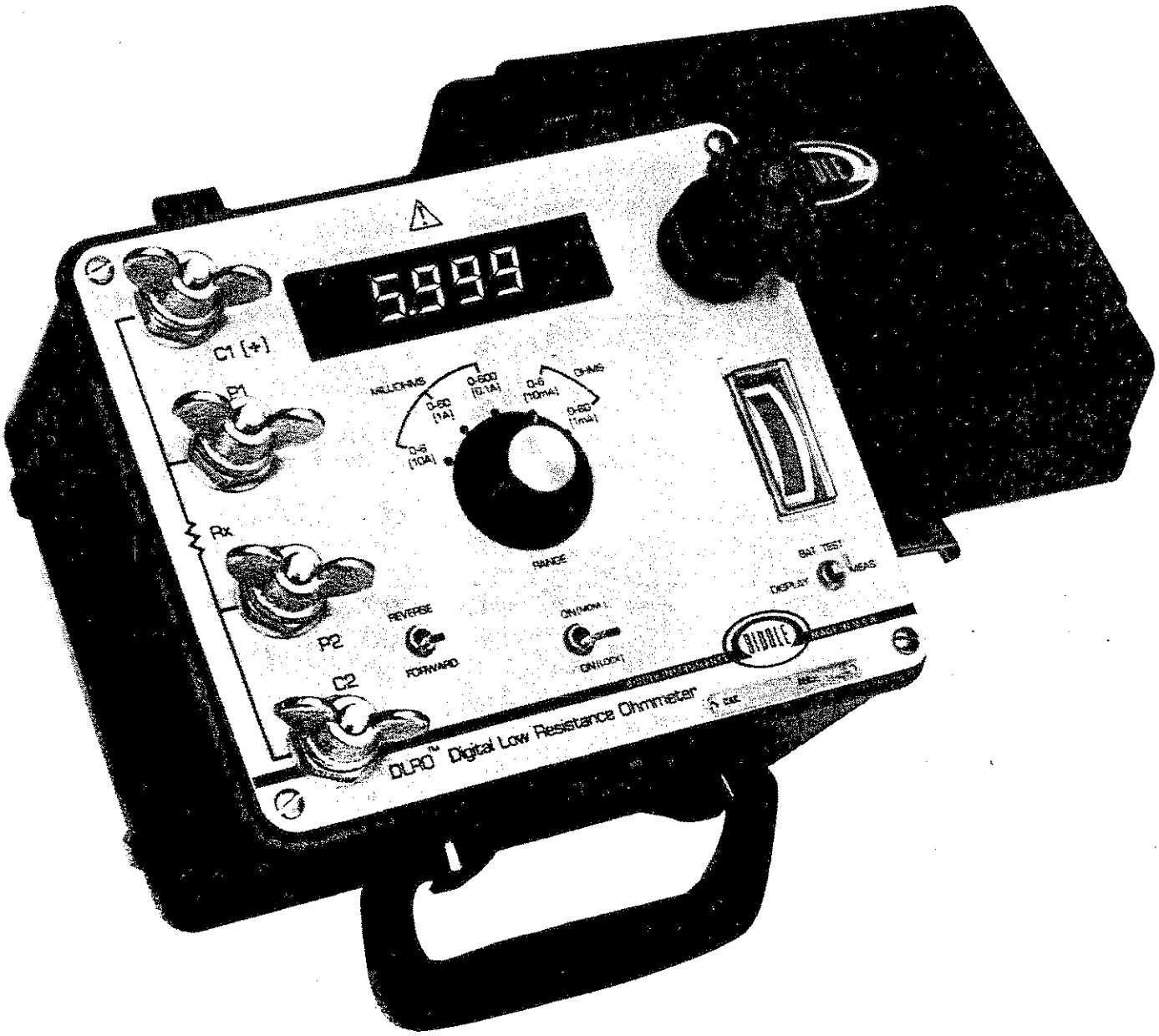

Figure a. The Catalog No. 247000 DLRO instrument without charger.

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Part I: 10 Ampere Systems

Section A

INTRODUCTION

This manual applies to a series of instruments; the principal models are Catalog Numbers 247000, 247001, 247002, 247000-5, 247010-4 and 247100.

The Catalog No. 247000 Digital Low Resistance Ohmmeter is a portable, rugged instrument that provides a direct-reading digital display of resistance in five ranges. It is powered by self-contained rechargeable batteries. A battery charger, operating from 115V 50/60 Hz, is furnished in a separate package.

The Catalog No. 247010-4 instrument is the same except for the power supply which is a line-operated supply.

The Catalog Nos. 247000-5 and 247001 are similar to Cat. No. 247000 except they have built-in, line-operated chargers.

The Catalog No. 247100 is a 100 Ampere Test System composed of a Cat. No. 247000-3 Measuring Module, and a Cat. No. 247120 100-Amp power supply.

The ohmmeter has four terminals for a Kelvin connection to the sample under test, and it is recommended that Biddle test leads shown in Bulletin 24-1 be used with this instrument.

Panel features include a two-position on-off switch that allows continuous or momentary operation, and on the rechargeable battery models a meter to indicate relative state of charge of the internal batteries.

A prop is provided to keep the lid in a partly open position so that it can be used as a sunshade when reading the digital display in bright sunlight.

The Catalog No. 247002 is similar to Catalog No. 247001 except that it has an extra 600 $\mu\Omega$ range.

Section B

SAFETY PRECAUTIONS

- SAFETY IS THE RESPONSIBILITY OF THE USER -

- La seguridad es la responsabilidad del operador -

DO NOT CONNECT THIS INSTRUMENT
TO ENERGIZED CIRCUITS.

The Digital Low Resistance Ohmmeters have been designed and constructed to meet the requirements of ANSI C39.5-1974 "Safety Requirments for Electrical and Electronic Measuring and Controlling Instrumentation". There is no shock hazard from the instrument itself and it may be used freely in wet or outdoor environments. The line-operated battery charger and the A.C. supply, however, should be used and maintained by trained personnel who are familiar with the usual precautions for handling line-operated equipment.

DO NOT USE IN EXPLOSIVE ATMOSPHERE
(This includes poorly ventilated battery rooms and enclosures.)

The Digital Low Resistance Ohmmeters have been designed and constructed to meet the requirements of ANSI C39.5-1974 "Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation." There is no shock hazard from the battery-operated measuring module itself when not under charge. It may be used in wet or outdoor environments. Any unit operating with the line (mains) cord connected, however, should be used and maintained by trained personnel who are familiar with the usual precautions for handling line-operated equipment.

Rev. 11-90

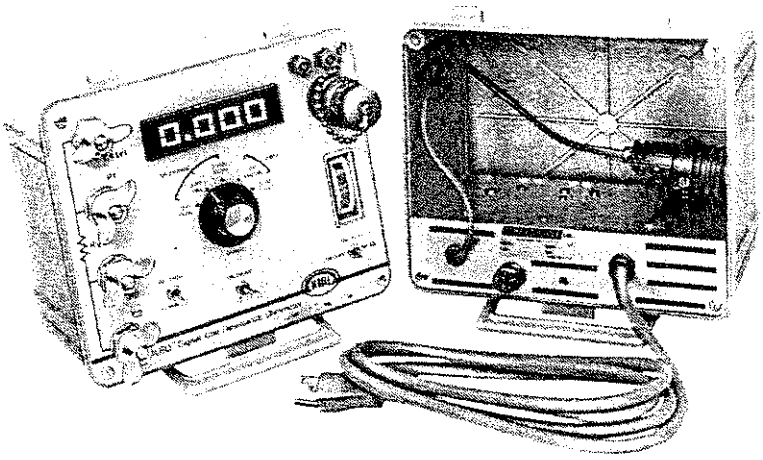
Section C

RECEIVING INSTRUCTIONS

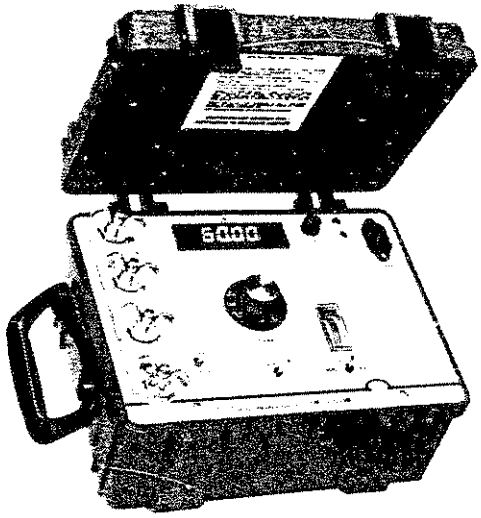
READ COMPLETELY BEFORE OPERATING

Your Digital Low Resistance Ohmmeter has been thoroughly tested and inspected to rigid specifications before being shipped and is ready for use. Check the equipment received against the packing list. Notify BIDDLE Instruments, Blue Bell, Pa. 19422 of any shortage of materials. The instrument should be examined for damage received in transit. 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.

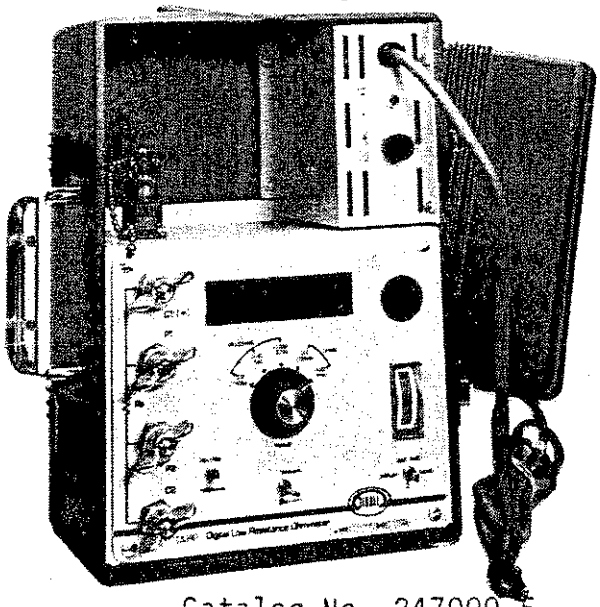
Charge batteries overnight before initial use of instrument. Refer to Section G for charging procedure. Check for correct operation of the instrument by connecting it to a resistor of known value. See Section G, Operating Procedure.



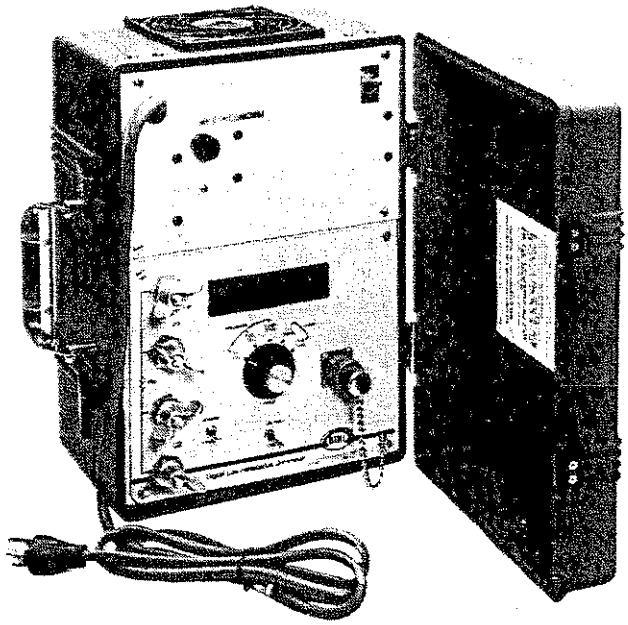
Catalog No. 247000
complete
with Charger.



Catalog No. 247001



Catalog No. 247000-5
with built-in
Battery Charger.



Catalog No. 247010-4
with Line-Operated
Power Supply.

Figure 3a: Various DLRO Unit Combinations

Section D

SPECIFICATIONS

Ranges, Resolution, Accuracy and Test Current

RANGE	TEST CURRENT AMPERES (±20%)	RESOLUTION	LIMIT OF ERROR 1 year, 15-35°C	LIMIT OF ERROR 1 year, 0-50°C
0.000 - 5.999mΩ	10	1μΩ	1/4% Rdg + 1 lsd*	1/2% Rdg + 1lsd*
00.00 - 59.99mΩ	1	10μΩ	"	"
000.0 - 599.9mΩ	0.1	100μΩ	"	"
0.000 - 5.999Ω	0.01	1mΩ	"	"
00.00 - 59.99Ω	0.001	10mΩ	"	"

* (Least Significant Digit)

Zero Offset: Typically 0-1 count over 15-35°C. Full accuracy can be realized by using the Forward-Reverse switch to average the readings. An internal zero adjustment is also provided.

On-Off Control: Toggle switch energizes all circuits. Has momentary and lock positions.

Response Time: (after On-Off switch is closed): 2 seconds to final reading.

Interference Effects: Error in item under test caused by line-frequency current of 0.1X test current: ±1 lsd

Error caused by 5-gauss line-frequency magnetic field: ±2 lsd

Error caused by connection to ground or voltage to ground (assuming battery operation): None

Input Protection: One volt peak may be applied between any two of the Rx terminals.

Effect of Inductive Test Item: None except time constant delay. No damage caused by inductive kick, but see precautions in Section H.

Temperature Range: Operating; 0-50°C (line supply, 0-40°C); Storage: -40°C to + 60°C

Section D

SPECIFICATIONS (Cont'd.)

Display: Red LED, 4 digits 0.5" high, decimal point, and negative (-) sign. Upper right hand segments of digits flash on overrange input.

Calibration Adjustments: Internal zero and span adjustments for all ranges.

Test Lead Resistance Requirements:

Potential Leads (P1, P2): No limitations.
Current Leads (C1, C2): each lead 20 milliohms nominal. Deviations affect test current but do not affect accuracy unless they are large compared to the measuring range.

Power Supply, Rechargeable System:

Battery Complement (internal batteries, nickel cadmium type):

Display circuit, 4 cells size "D" (Eveready CH4 or Gould 4.0 SCB or G.E. #GCW 3.5 SB.)
Measuring circuit, 2 cells, size "F". (Gould 7.0 SCB).

Battery Condition Meter:

Shows state of charge of batteries. Switch selects either battery for test.

Battery Charger:

Separate charger unit plugs into receptacle on measuring unit. Full charge in 14 hours. Charging may be continued while instrument is operating. Fused, with UL listed 3-wire line cord and plug. Power requirements, 0.22 amps at 115 volts, 50/60 Hz; or 0.165 amps at 230 volts, 50/60 Hz. Fuse ratings: 115V-0.2A Slow Blow
230V-0.1A Slow Blow

Section D

SPECIFICATIONS (Cont'd.)

Battery Capacity:

RANGE	CONTINUOUS OPERATING TIME BETWEEN CHARGES		CONTINUOUS OPERATING TIME WHILE ON CHARGE	
	MEASURING CIRCUIT BATTERY	DISPLAY BATTERY	MEASURING CIRCUIT BATTERY	DISPLAY BATTERY
6 mΩ	1 Hour	15 Hours	1 Hour	No Limit
60 mΩ	10 Hours	"	No Limit	"
600 mΩ	100 Hours	"	"	"
6 Ω	1000 Hours	"	"	"
60 Ω	1000 hours	"	"	"

Battery Life:

Approximately 300 full charge-discharge cycles.

Safety:

Meets all applicable requirements of ANSI-C39.5-1974. Highest voltage existing (except in charger primary and line supply primary) is 6 volts.

Case:

The measuring unit and charger have rugged molded case with handles and removable hinged lids. The measuring unit lid can be used as a sun shield. The charger case has similar construction with additional space for storing test leads.

Test Lead Terminals: 5/16" diameter studs with wing nuts for spade or ring lugs.

Section D

SPECIFICATIONS (Cont'd.)

Dimensions and Weights:

Cat. No.	Weight	Dimensions
247000	11 lbs. (5.01 kg)	8 7/8"W x 8 1/8"D x 8 1/8"H (22.4 x 20.6 x 20.6 cm) (Instrument)
247000-47		8 1/8"W x 8 1/8"D x 7 3/8"H (22.4 x 20.6 x 18.8 cm) (Charger)
247000-5	13 1/2 lbs. (6.1 kg)	13 1/2"W x 9 1/2"D x 7 1/2"H (34 x 24 x 19 cm)
247010-4	16 3/4 lbs. (7.6 kg)	"
247120	20 1/2 lbs. (9.3 kg)	"
247001	12.1 lbs. (5.5 kg)	12"W x 9 5/8"D x 6 3/8"H (30 x 24.5 x 16.2 cm)
247002	12.2 lbs. (5.5 kg)	"

Section D

SPECIFICATIONS (Continued)

Catalog Numbers and Unit Combinations for 10-Ampere Systems

CATALOG NUMBER	DESCRIPTION
247000	Instrument with Internal Rechargeable Batteries and separate 115V 50/60 Hz Charger Unit. Range: 0 to 60 Ohms in 5 ranges, 0 to 5.999 Milliohms lowest range (Note 1).
247000-3	Same as Cat. No. 247000 except with 100A adapter plug.
247000-47	Same as Cat. No. 247000 except with 230V-50/60 Hz charger
247000-3-47	Same as Cat. No. 247000-47 except with 100A adapter plug.
247000-5	Same as Cat. No. 247000-3 except with built-in battery charger.
247001	Same as Cat. No. 247000 except in single case.
247002	Same as Cat. No. 247001 except with an extra 600Ω range.
247010-4	Same as Cat. No. 247000-5 except with built-in line-operated power supply.
247120	100 Ampere line-operated power supply;may be used with Cat. Nos. 247000-3, 247000-5 or 247010-4.

NOTES:

Note 1: Leads not included. (See Bulletin 24-1 for recommended test leads.)

See Page 36 for information concerning 100-Ampere systems.

Section E

CIRCUIT DESCRIPTION

Fig. 1 shows a simplified measuring circuit diagram. Complete schematics are shown in Figs. 6 and 6a. B1 and B2 are the measuring circuit batteries that supply the test current. (Two size F nickel-cadmium batteries are used to supply the ampere-hour requirements.)

Ra and RA' set the test current to the values listed in Section D, Specifications; there is a pair of these resistors for each range. On the 6 mΩ 10A range, test current is also affected by the resistance of the test leads connected to the C1 and C2 terminals. The instrument is designed to operate with current leads having a resistance of 0.02Ω each. Using leads that have a resistance other than 0.02Ω will not affect the accuracy of the instrument, but will cause the test current to be different.

RB is a stable resistor used to obtain a voltage proportional to the test current. RC is a calibration adjustment. There are five of these range networks - one for each range.

A digital meter, powered by four size D nickel cadmium cells, displays the ratio:

$$6X \frac{E_{IN}}{E_{REF}}$$

E_{IN} is the voltage across Rx where the potential leads are connected.

(There are no length restrictions on the potential leads). E_{REF}, scaled down by divider RD-RE, is set by the range network and represents the current in Rx.

The calibration network on each range is set to produce, at the specified test current, nominally 60 mV at the E_{REF} input. Consider a test specimen, Rx of 1.5 milliohms and a test current of 10 amperes.

Section E

CIRCUIT DESCRIPTION (Cont'd.)

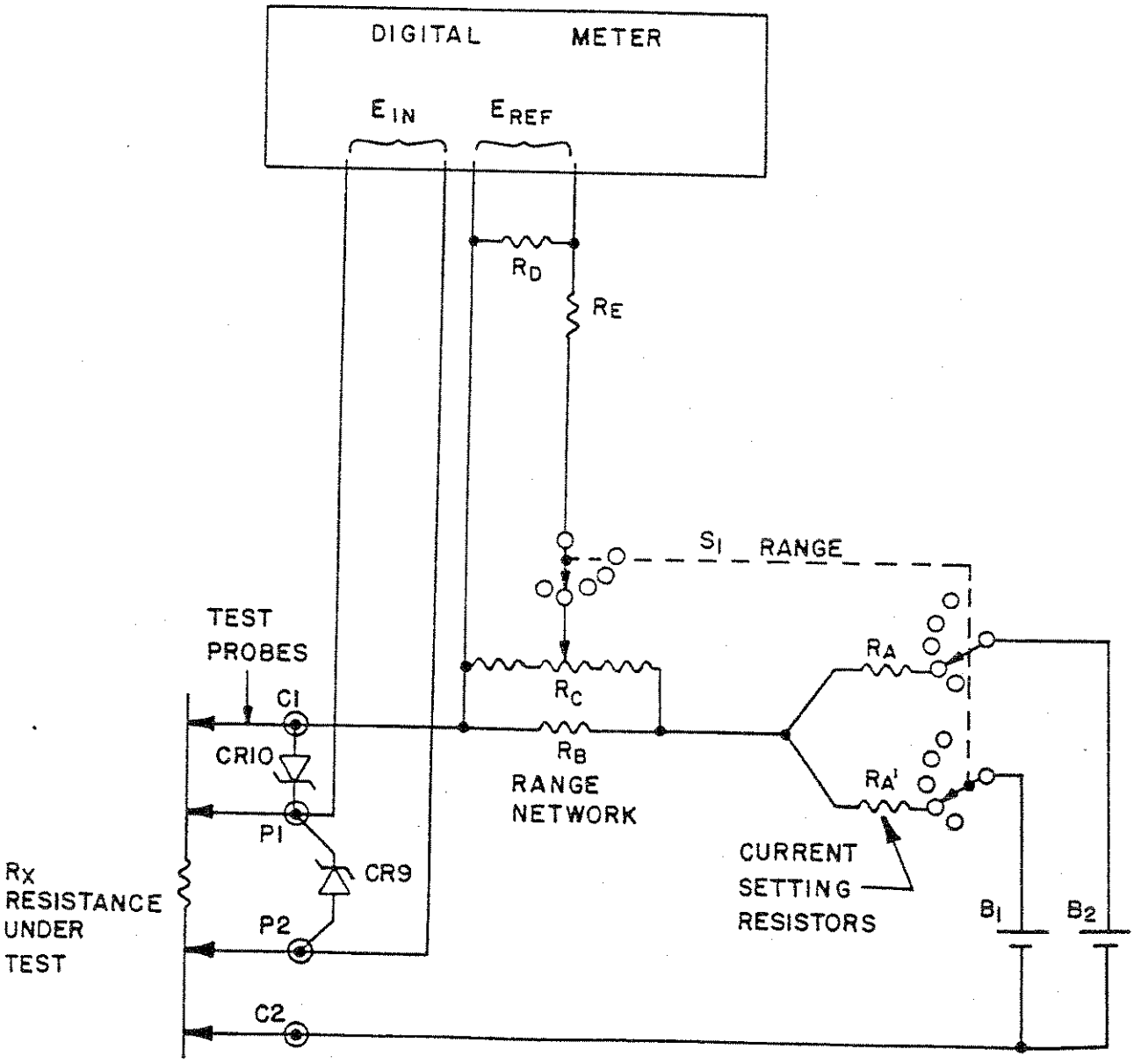


FIGURE 1: Simplified Measuring Circuit Diagram Showing One Range Only.

The display would be:

$$6X \quad \frac{0.0015\Omega \times 10A}{0.060V} = 1.500(m\Omega)$$

If the test current is reduced to 9 amperes:

$$6X \quad \frac{0.0015\Omega \times 9A}{0.054V} = 1.500(m\Omega)$$

Thus the reading is independent of test current variations caused by changes in battery voltage, or by different test lead resistance.

The digital meter has an "auto-zero" circuit that normally holds any zero offset drift to one or two least counts, and a dual-slope integrating converter that is tuned to reject line frequency interference, either 50 Hz or 60 Hz.

The battery charger supplied with models having internal rechargeable batteries is a constant-current type specifically intended for use with nickel-cadmium batteries. There are two charging circuits: one that supplies 0.4A to charge the display battery, and another with two branches that supplies 0.7A to each of the two measuring circuit batteries. These current values are the battery manufacturers' recommended "ten-hour rates" and represent a safe charging level that will not damage the batteries, even if they are allowed to remain on charge indefinitely.

Charging currents are set at the factory and need readjustment only when batteries are replaced.

Zener diodes CR9 and CR10 protect the instrument from damage caused by switching transients that may occur when measuring the resistance of inductive samples, and by 60 Hz pickup that may occur when measuring large equipment in high voltage switchyards.

Section F

CONTROLS AND CONNECTIONS

Fig. 2 shows a front panel view of Catalog No. 247000 with functional parts and operating controls labelled.

S4, M1 - Battery test meter M1 shows the relative state of charge of the internal rechargeable batteries. With S4 in the "Display" position M1 is connected to the battery that powers the digital meter. With S4 in the "measure" position, M1 is connected to the measuring circuit battery. This test is valid only when the instrument is operating and connected to a test specimen or with the C1 and C2 leads shorted. When the pointer indicates in the red zone the batteries should be recharged.

S3 - The ON/OFF switch has two "ON" positions: a "lock" position for continuous operation, and a "momentary" spring-held position that helps conserve battery power when taking a series of readings on the high-current ranges.

S1 - The range switch selects one of five resistance ranges. Panel markings are full-scale values; nominal test currents are shown in parentheses.

M2 - A 3½ digit red LED display shows the resistance of the specimen under test. It is direct reading with decimal points selected by a deck on the range switch.

C1, P1, P2, C2 -Four terminals with wing-nuts are provided for making a Kelvin connection to the specimen under test. Test current is available at the C1 and C2 terminals, and the actual resistance is measured between the points where leads connected to the P1 and P2 terminals are placed.

S2 - The "forward-reverse" switch interchanges the P1 and P2 connections internally. In the "reverse" position, the digital meter sees a voltage of opposite polarity. The purpose is to enable an operator to average the forward and reverse readings if a zero offset error is suspected.

J2 - The external power connector must have its jumper plug (chained to the instrument) in place while the instrument is in normal use. When charging the internal batteries, remove the jumper plug and connect the charger to J2.

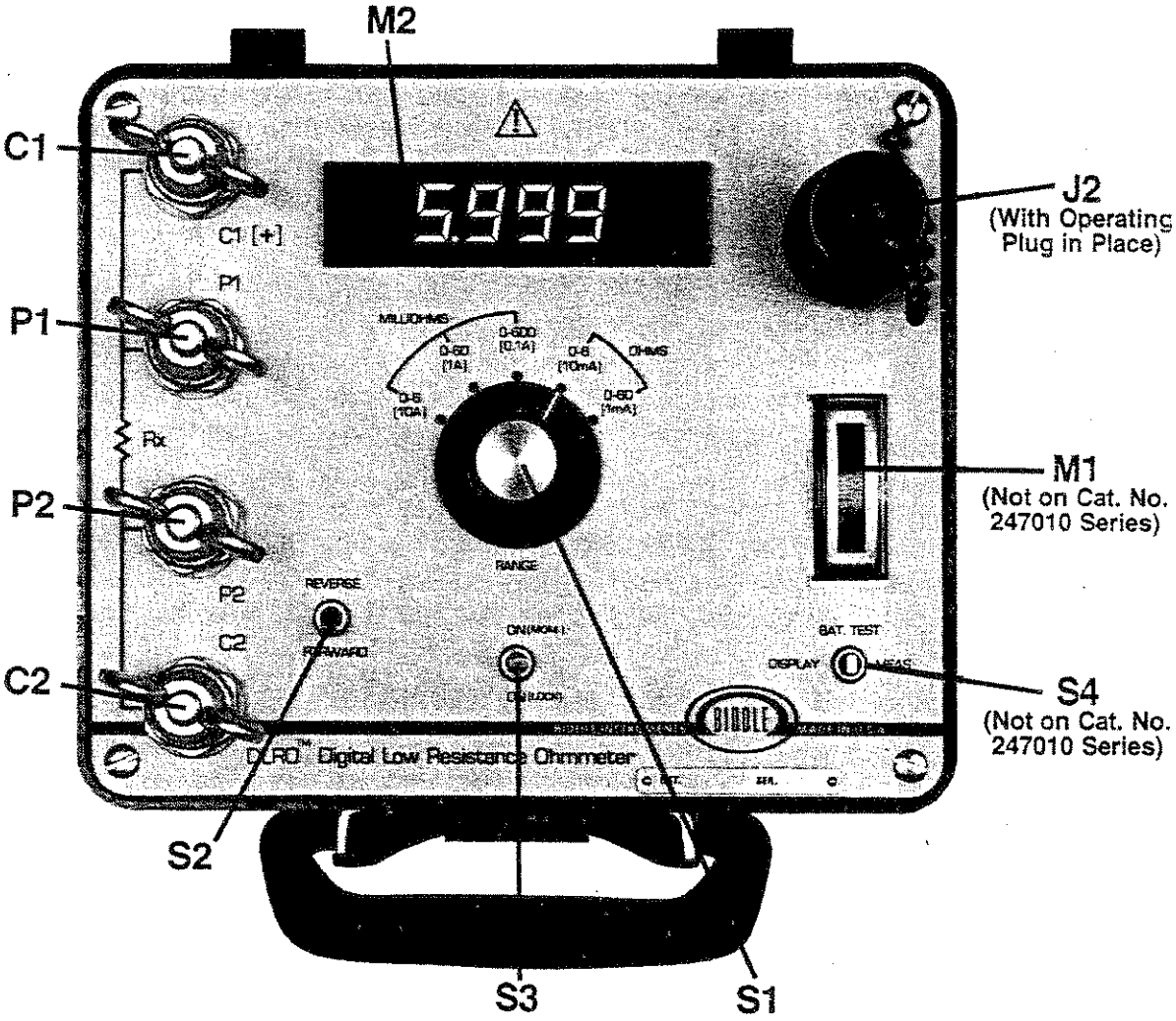


FIGURE 2: CONTROLS AND CONNECTIONS

Section G

OPERATING PROCEDURE

1. RECHARGEABLE BATTERY MODELS

(a) Battery Check

Before using the instrument, check the display and measuring circuit batteries. The battery test meter will indicate their relative state of charge. The battery test is valid only when the instrument is operating on the range that it is intended to be used, connected to a test specimen or with the C1 and C2 leads shorted. If the meter indicates in the red zone, charge the batteries for 14 hours or overnight.

(b) Connections and Reading

Connect the instrument to the test specimen as shown in Fig. 3. Set the ON/OFF switch to the "lock" position and choose the range that gives the highest stable reading. A blinking display indicates an off-scale condition. The digital meter is direct reading, with the range switch indicating the full-scale value and the units for the particular range in use. The "momentary" position of the ON/OFF switch is useful for conserving battery power when using the highest current range. Battery life details are given in Section D, Specifications.

(c) Very Low Resistance

For full accuracy when reading below 0.1 mΩ, use the average of forward and reverse readings. Make the reverse reading by holding the "forward-reverse" switch in the "reverse" position. A minus (-) sign will appear in the display when this switch is in the reverse position; disregard this when calculating the average.

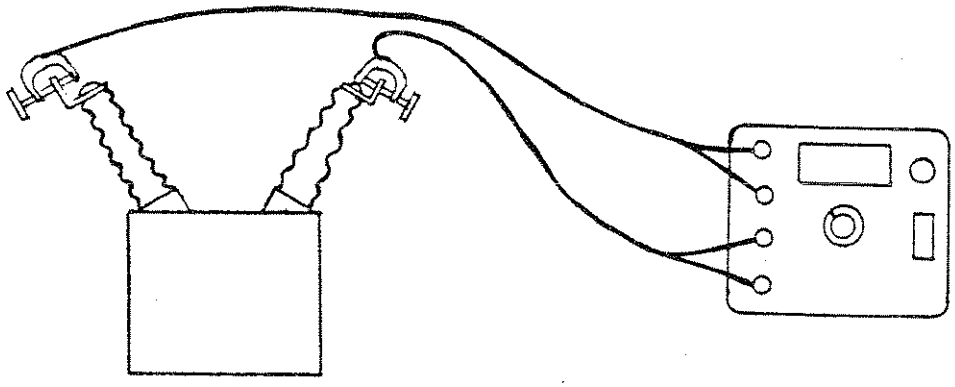
(d) Sunshade

To aid in reading the digital display in bright sunlight, use the prop on the lid to hold it tilted partially open as a sunshade.

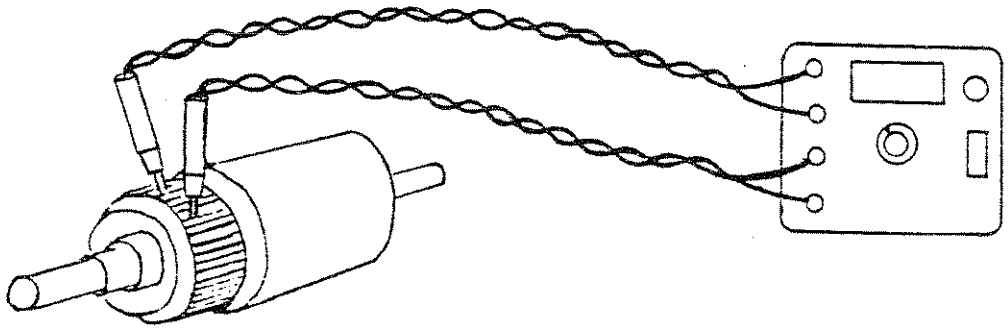
Section G

OPERATING PROCEDURE (Cont'd.)

A. Using Duplex Clamp leads on a circuit breaker or transformer.



B. Using Duplex Hand Spikes on a motor commutator.



C. Using Kelvin Clip leads.

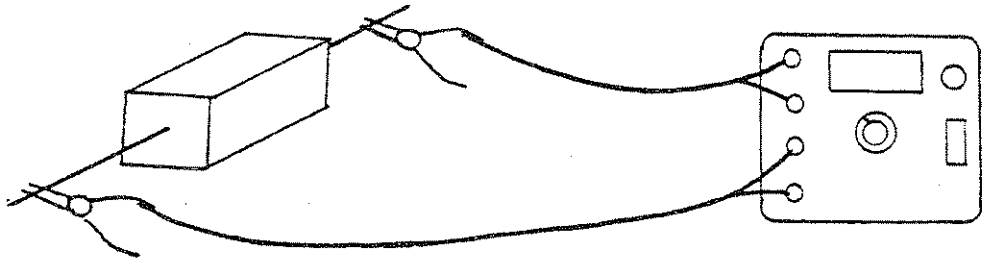


FIGURE 3: Typical Connections to a Test Sample.

Section G

OPERATING PROCEDURE (Cont'd.)

(e) Charging Batteries

To charge the batteries, remove the jumper plug from J2 and connect the output lead of the battery charger to J2. A pilot light on the charger will indicate when it is connected to an energized ac power line. Charging time for fully discharged batteries is 14 hours or overnight. The instrument may be used continuously (except on the 10A range, where battery life limitations apply) while its batteries are charging.

Section H

APPLICATIONS

MEASURING CONTACT RESISTANCE OF CIRCUIT BREAKERS

Biddle Cat. No. 241004-18 Duplex clamp leads are recommended for this application. Connect the leads as shown in Fig. 3A. For safety, one terminal of the sample must be grounded.

MEASURING WINDING RESISTANCE OF TRANSFORMERS, MOTORS, etc.

CAUTION: When the test current through a transformer winding is switched off, the energy stored in the magnetic field must be dissipated. The DLRO instrument provides a path to harmlessly dissipate this energy when the current is interrupted by the On/Off switch.

For personnel safety and to protect the DLRO instrument, proceed as follows:

1. Firmly connect C1 and C2 leads before switching the DLRO on.

2. Switch the DLRO off before disconnecting C1 or C2 connections.

Make connections to the transformer terminals as shown in Fig. 3A. For safety, one terminal of the sample should be grounded. Begin the measurement on the range that will display the expected value. When the power is turned on, the transformer winding resistance will appear high at first (it may indicate off-scale) and will gradually decrease to its correct value. For example, the resistance reading of a 23 kV 37 MVA transformer winding can take as long as fifteen minutes to stabilize. Generally, the larger the transformer, the longer the stabilizing time required. If it is necessary to change the range of the instrument while making a measurement, additional stabilizing time will be required because of the change in test current. For safety, the transformer terminals should be wired together before disconnecting the instrument.

MEASURING WINDING RESISTANCE OF ELECTRIC MOTORS

Fig.3B shows hand spikes being used to make contact with each commutator segment on a large motor.

Section H

APPLICATIONS (Cont'd.)

OTHER APPLICATIONS

Other applications include resistance measurements of bolted bus bar joints, welded connections, rail joints in electric traction systems, etc. The particular application will determine the type of leads and connections needed. (See Biddle Bulletin 24-1 for leads recommended for use with this instrument.)

INTERFERENCE

Alternating current interference in the sample under test can cause several digits fluctuation in a displayed reading. Interference can also be due to pickup in long test leads, especially in the vicinity of strong electric or magnetic fields. In these cases, fluctuation of the reading can sometimes be reduced by twisting the pairs of leads together.

If interference is causing fluctuation in the display, the correct reading is the average of the highest and lowest readings.

A DC voltage in the item under test, however small, will produce an error in the reading. Such a voltage can be caused by ground currents in grounded items such as rails, pipes, etc., or by chemical or thermo-electric EMF in items made of dissimilar materials. If DC voltage interference is reasonably steady, this effect can be eliminated by taking a second reading with leads interchanged (C1 with C2 and P1 with P2) and averaging the first and second readings. Actually, only the C leads need be moved; the P interchange can be made by using the forward-reverse switch on the instrument.

When making a measurement of a totally new kind, interchange the C leads to determine whether there is any DC interference.

Section I

MAINTENANCE

Remove the instrument from its case by removing the screws at each corner of the panel.

RECHARGEABLE BATTERIES

The internal rechargeable batteries may fail to hold a charge after several hundred charge-discharge cycles, resulting in shorter than normal service life. In addition to a low reading on the battery test meter, battery failure evidence is also given by a dim display and/or readings that appear unstable or fluctuate more than normal. If the batteries are suspect, a check should first be made of the contacts in the battery holders to ensure that they are clean. The contact buttons are made of stainless steel and are easily cleaned. To remove the batteries, remove their retainer straps shown in Fig. 4. The cells can then be removed from their holders.

If battery replacement is necessary, use the type of batteries indicated in Section J, Field Replaceable Parts List. Be sure to install them in their holders in the proper polarity, as indicated on the labels in the holders, and replace the retainer straps.

After batteries are replaced, charging currents must be checked and, if necessary, readjusted to acocommodate the characteristics of the new cells.

CHARGING CURRENT ADJUSTMENT (One Transformer)

Charging currents are adjusted as follows:

1. Remove the battery charger from its case.

2. Connect the charger to the instrument. Use a variable auto-transformer to maintain the ac power line at 125 volts. (For Catalog No. 247000-47, set power line to 250 volts if normal line voltage is 240, or to 230 volts if normal line voltage is 220.) The purpose of setting the charging currents with the line voltage approximately 4% high is to prevent over-charging of the cells during periods of higher than normal line voltage.

3. Connect a dc voltmeter across R56 and adjust R55 for a voltmeter reading of .4V.

4. Connect a dc voltmeter across R58 and adjust R57 for a voltmeter reading of .7V.

5. Connect a dc voltmeter across R60 and adjust R59 for a voltmeter reading of .7V.

6. Repeat steps 3, 4 and 5, as there is some interaction in these adjustments.

7. Replace the battery charger chassis in its case.

DIGITAL METER (Biddle)

The digital meter is not serviced in the field, but is replaced as a unit if it fails. To remove it, unplug connector J1 and remove two nuts. The meter is then removed from the rear of the panel. A schematic diagram of the digital meter is shown in Figure 8a. The electrical zero adjustment, described below, must be made after replacing the digital meter.

DIGITAL METER (Newport)

The digital meter is not serviced in the field, but is replaced as a unit if it fails. To remove it, unplug connector J1 (see Figure 4) and detach the mounting band. The meter is then removed through the front panel. A schematic diagram of the digital meter is shown in Figure 8. The electrical zero adjustment, described below, must be made after replacing the digital meter.

ZERO ADJUSTMENT

An electrical zero adjustment for the digital meter is provided to allow for component aging or for initial adjustment of a new meter. The electrical zero is adjusted as follows:

1. Be sure that the batteries are fully charged.

2. Connect a wire between the C1 and C2 terminals on the front panel.

Section I

MAINTENANCE (Cont'd.)

3. Connect another wire between the P1 and P2 terminals on the front panel.

    3a: If operating from a line supply, connect a third wire between C2 and P2 terminals.

4. Set the range switch to 60Ω and turn on power.

5. Adjust R13, located on the adjustment assembly (Newport Meter), or on the meter board (Biddle Meter). (See Fig. 4 or 5) for a reading of 000. The correct point is where the (-) sign blinks on and off.

Section I

MAINTENANCE (Cont'd.)

CALIBRATION

Before calibrating, the meter zero must be adjusted. A set of standard resistors is required with values shown under Rx in the table below. Suitable standards are available individually or as a packaged set from Biddle. Calibration adjustments are located on the range resistor assembly (See Fig. 5) and they should be adjusted to produce the display, on each range, shown in the following table:

RANGE	Rx	ADJUST	DISPLAY
60 Ω	10 Ω	R37	10.00
6 Ω	1 Ω	R38	1.000
600mΩ	0.1 Ω	R39	100.0
60mΩ	.01 Ω	R40	10.0
6mΩ	.001 Ω	R41	1.000

LINEARITY & TURNOVER CHECK

1. Connect the instrument to a precision decade resistance standard accurate to 0.02% or better (such as the Biddle Cat. No. 71-631). Set the range switch to 60 Ω.

   Set the decade box to zero and note the residual reading. Set the decade box to 59.00Ω. The display should be (59.00 + residual) ± no more than 3 counts.

2. Move the forward-reverse switch to the "REVERSE" position and note the reading. The difference between the forward and the reverse readings should be no more than 3 counts.

3. If there is linearity or turnover error, the digital meter must be replaced.

BATTERY TEST METER CALIBRATION

If the battery test meter has been replaced, it will require calibration. Two adjustments, located on the adjustment assembly, (see Fig. 4 or 5) are provided: one for the measuring circuit battery test and one for the display battery test. To calibrate the battery test functions:

Section I

MAINTENANCE (Cont'd.)

1. Remove all batteries.

2. Connect an external dc power supply, set to 4.75V, to the (+) and (-) terminals of the display battery holders, (see Fig. 4).

3. With the front panel of the instrument facing up, hold the batt. test switch in the display position and adjust R17 (see Fig. 4 or 5) so that the batt. test meter points to the dividing line between the red and green areas on the scale. Tap the meter while making this adjustment to remove any friction errors.

4. Connect a jumper between the (+) ends of the measuring circuit battery holders, (see Fig. 4).

5. Connect an external dc power supply, set to 1.05V, to the (+) and (-) terminals of one of the measuring circuit battery holders.

6. With the front panel of the instrument facing up, hold the batt. test switch in the "measure" position and adjust R18, (see Fig. 4 or 5) so that the batt. test meter points to the dividing line between the red and green areas on the scale. Tap the meter while making this adjustment to remove any friction errors.

7. Replace the batteries in the proper polarity, and replace their retainer straps.

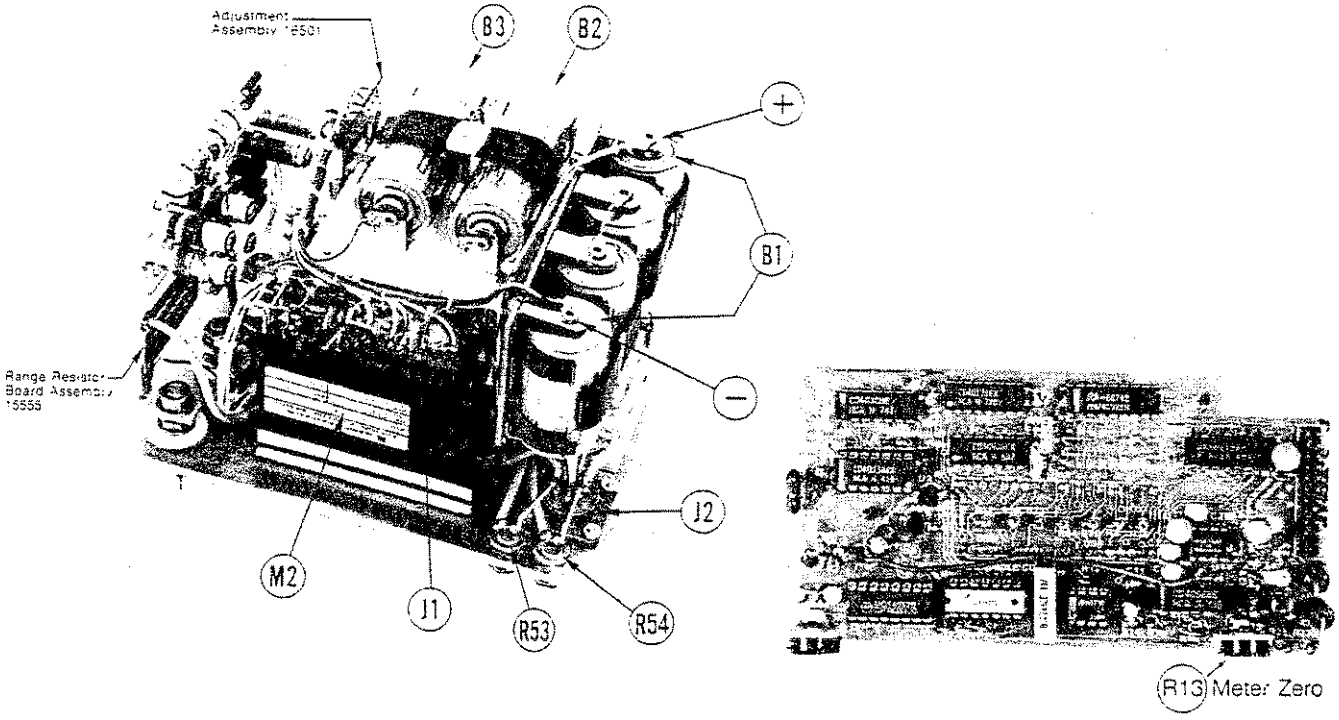


FIGURE 4: Inside View of Sub-Assemblies and Components, Cat. No. 247000

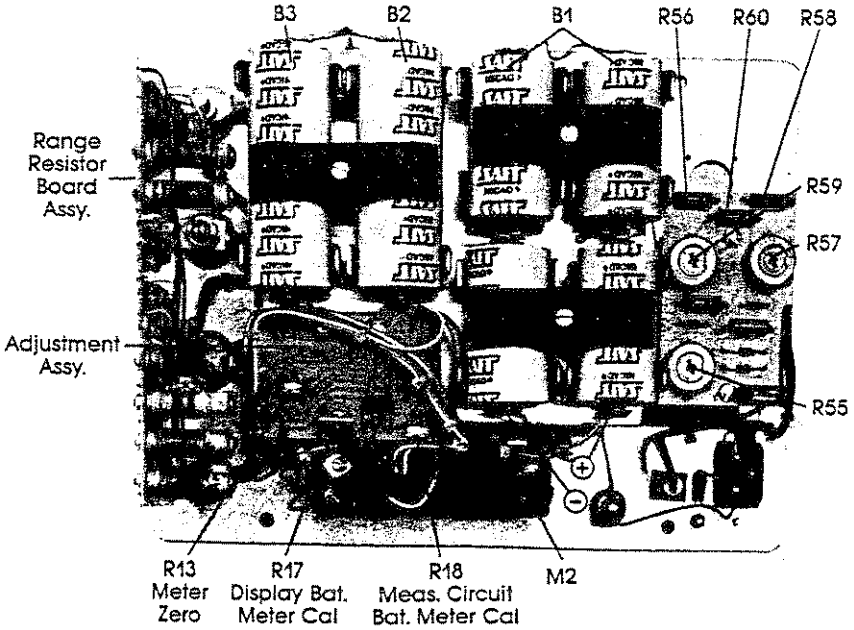


FIGURE 4: Inside View of Sub-Assemblies and Components, Cat. No. 247001

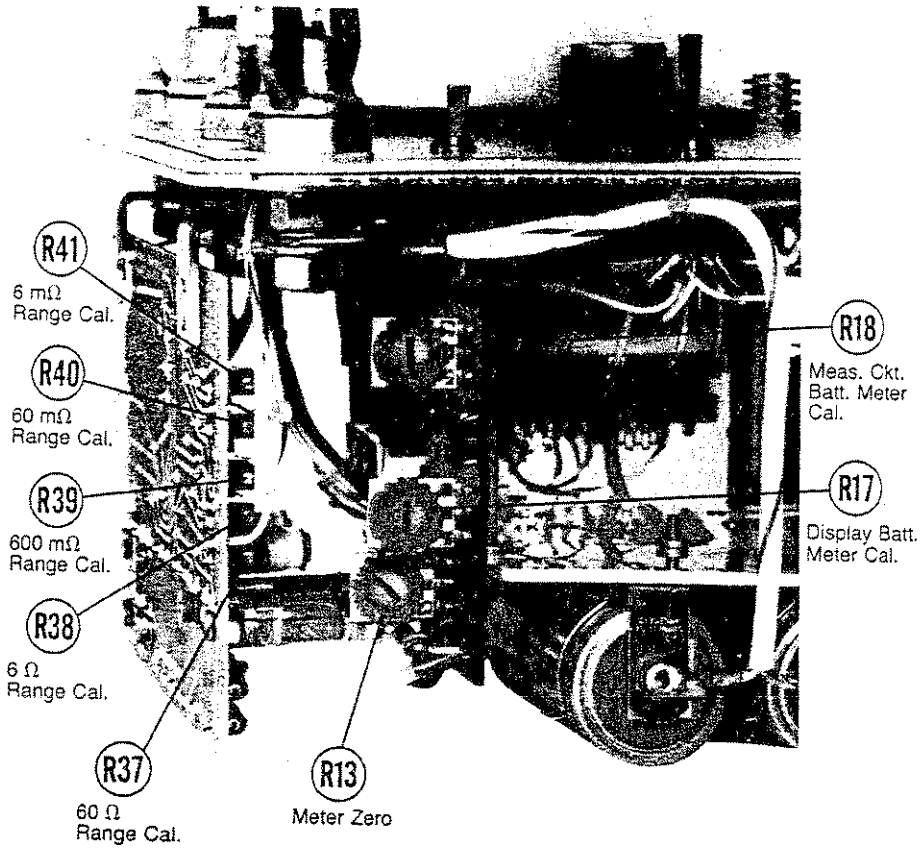


FIGURE 5: Location of Calibration Adjustments, Cat. No. 247000.

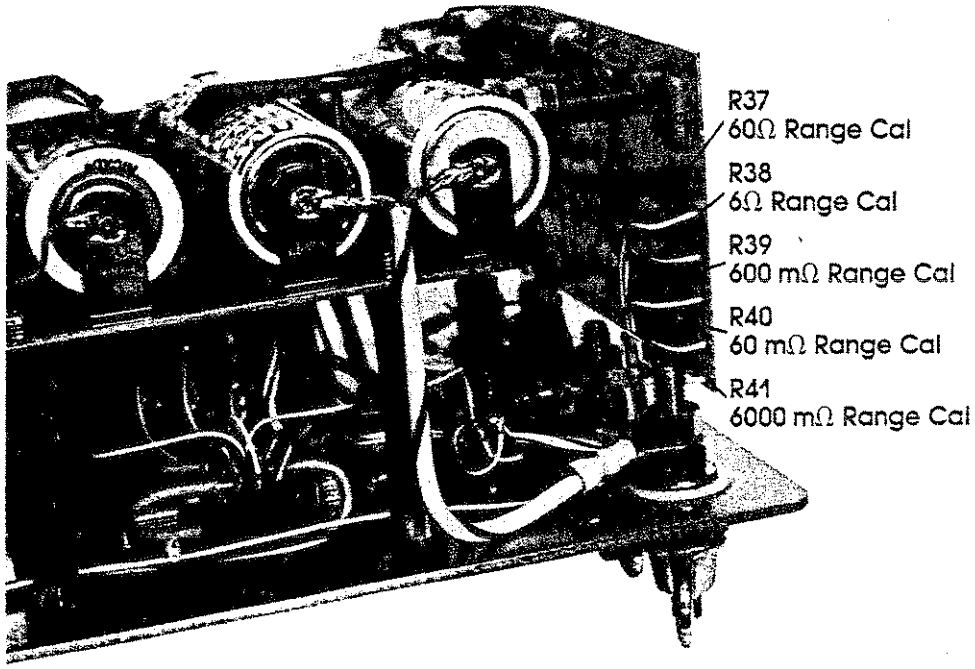


FIGURE 5: Location of Calibration Adjustments, Cat. No. 247001.