

# 15 kV Megohmmeter Test Set Catalog No. 210415 Series

**High-Voltage Equipment**  
**Read the entire manual before operating.**

**Aparato de Alto Voltaje**  
**Antes de operar este producto lea este manual enteramente.**

**Megger** 

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*megger.com*

**15 kV Megohmmeter Test Set  
Catalog No. 210415 Series**

**Megger** <sup>®</sup>

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The information presented in this manual is believed to be adequate for the intended use of the product. If the product or its individual instruments are used for purposes other than those specified herein, confirmation of their validity and suitability must be obtained from Megger. Specifications are subject to change without notice.

**Megger**®

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# 1

## INTRODUCTION

This Instruction Manual is intended as a guide to the operation and maintenance of the portable 15 kV Megohmmeter Test Set, Catalog No. 210415 for use on 120 Volt supply and Catalog No. 210415-47 used when supply is between 200 and 250 Volts. References in this manual to optional functions and equipment may be disregarded when such information does not apply to the Test Set in use. The options included in the set for which this manual is supplied are indicated in nameplate data.

The instructions and suggestions provided in this manual anticipate the normal use of the Megohmmeter Test Set for testing electrical insulation systems on such equipment as motors, generators, bushings, and cables. These tests, which are based on measurement of the applied dc voltage, the equivalent resistance, and the manner in which resistance varies with time, provide data that indicate the condition of the insulation system of the apparatus being tested. When these data are recorded on graph paper such as Megger KiloVolt-Megohm Paper (Catalog No. 220000), the shape of the curve made by connecting the plotted points will aid in evaluating the condition of the insulation system. Information on the interpretation of observed data and guides for testing are given in Section 10.





**Figure 1: 15 kV Megohmmeter Test Set,  
Catalog No. 210415**

# 2

## SAFETY PRECAUTIONS

**SAFETY IS THE RESPONSIBILITY OF THE USER.  
LA SEGURIDAD ES LA RESPONSABILIDAD DEL OPERADOR.**

The Test Set and the equipment to which it is connected are a source of high-voltage electrical energy. All persons performing or assisting in the tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and associated circuits. Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit unless the Test Set is de-energized and all parts of the test circuit are grounded. Persons not directly associated with the work must be kept away from test activities by suitable barriers, barricades or warnings.

The Test Set panel must be connected to a reliable local ground to prevent possible shock danger to the operator. Since the energized test setup may induce a static voltage charge on nearby insulated objects, including people, all insulated objects must be grounded or kept at least two feet (61 cm) from the energized structure.

All apparatus to be tested must be de-energized and should be bonded to ground except during the actual test. *Note that even isolated conductors may develop static voltage with respect to ground due to nearby electric fields, wind friction or passing electrified clouds.* Test connections should be made with the ground bonds in place.

At the completion of a test, after the power source has been shut down and the Test Set kilovoltmeter reads zero, all

energized parts of the test setup must be short-circuited by means of a safety ground (hot stick). Ground bonds should then be reapplied.

If the Test Set is operated in accordance with the safety precautions noted above and in Sections 7 and 8, and if all grounds are correctly made, rubber gloves are not necessary. As a routine safety procedure, however, some users require that rubber gloves be worn, not only when making connections to the high-voltage terminals, but also when manipulating controls. Megger considers this an excellent safety practice.

### ***PACEMAKERS***

High voltage discharges and other sources of strong electric or magnetic fields may interfere with the proper functioning of heart pacemakers. Personnel using heart pacemakers should obtain expert advice on the possible risks before operating this equipment or being close to the equipment during operation.

### ***OTHER PRECAUTIONS***

- Be especially careful when testing apparatus having high capacitance such as cables. These items store a dangerous charge, even at low voltage.
- Identify apparatus terminals and verify apparatus ground, prior to making connections.
- Do not operate in an explosive atmosphere.
- Read and follow the instruction manual.

# 3

## RECEIVING INSTRUCTIONS

When your instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify Megger:

Megger  
Valley Forge Corporate Center  
2621 Van Buren Avenue  
Norristown, PA 19403 U.S.A.

of any shortage of materials.

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

This instrument has been thoroughly tested and inspected to meet rigid inspection specifications before being shipped. It is ready for use when set up as indicated in Section 7.

A qualified person should become familiar with this entire Manual and make a test run. This pre-test serves both to familiarize the user with the Test Set and to check that the set is operating properly.

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# 4

## SPECIFICATIONS

### POWER SUPPLY: Catalog No. 210415

|                             |   |
|-----------------------------|---|
| Voltage (rms):              | 105-130 Volts   |
| Recommended Source:         | NEC 15 Ampere, 120 Volts, single-phase branch circuit (3 wire: line, neutral and ground). |
| Current (rms):              | 1.5 Amps, maximum continuous.   |
| Frequency:                  | 60 Hz, full rating. 50 Hz, reduced rating.  |
| Basis of Rated Performance: | 120 Volt 60 Hz supply with stabilizer out.  |

### OPTIONAL SUPPLY: Catalog No. 210415-47

|                             |  |             |                 |
|-----------------------------|--|-------------|-----------------|
| Voltage (rms):              | Specify nominal voltage on order.                        |             |                 |
|                             | NOMINAL  | RANGE       | MAXIMUM CURRENT |
|                             | 210V   | 208 to 225V | 0.80A           |
|                             | 230V   | 225 to 240V | 0.83A           |
|                             | 250V   | 240 to 265V | 0.85A           |
| Recommended Source:         | 10-Ampere, nominal voltage, single-phase branch circuit. |             |                 |
| Frequency:                  | 60 Hz, full rating; 50 Hz, reduced rating                |             |                 |
| Basis of Rated Performance: | 230 Volt 60 Hz supply with stabilizer out.               |             |                 |

---

**OUTPUT TEST VOLTAGE:** 0-15 kV dc, negative with respect to ground.

**OUTPUT CURRENT:**

With Stabilizer Out at 60 Hz: 2 mA continuous; 5 mA for 12 minutes.

at 50 Hz: 1.67 mA continuous; 4.17 mA for 12 minutes.

With Stabilizer In at 50 or 60 Hz: At 15 kV, 50  $\mu$ A continuous.

Short Circuit: 12 mA maximum, limited by circuit breaker.

**RIPPLE VOLTAGE (rms)** 1% at 3 M $\Omega$  resistive load

**OUTPUT VOLTAGE REGULATION:**

Internal Stabilizer Out: 13% no load to 7.5 M $\Omega$  load  
 $\pm$ % percent change in line voltage

Internal Stabilizer In: 0.1% no load to 300 M $\Omega$  load including  
 $\pm$ 10% line voltage change

**METERING:**

Kilovoltmeter: 4½ inch (11.4 cm) Taut-Band. 3 color-coded scales: 0-7.5 kV (red), 0-15 kV (black) and 0-1.5 reference (green). Accuracy:  $\pm$ 2% full scale.

Megohmmeter: 4½ inch (11.4 cm) Taut-Band. 2 scales: 1-100 Megohms (red), 2-200 Megohms (black). Accuracy:  $\pm$ 2% of full scale length at any marking, better near high resistance end.

Ranges: 8 ranges, 4 per scale, as described in following Table.

| VOLTMETER RANGE SETTING | VOLTAGE kV | MEGOHMMETER SPAN, MEGOHMS |                      |                       |                      |
|-------------------------|------------|---------------------------|----------------------|-----------------------|----------------------|
|                         |            | RANGE SWITCH at x 1       | RANGE SWITCH at x 10 | RANGE SWITCH at x 100 | RANGE SWITCH at x 1K |
| 15                      | 10         | 2-200                     | 20-2000              | 200-20,000            | 2000-200,000         |
| 7.5                     | 5          | 1-100                     | 10-1000              | 100-10,000            | 1000-100,000         |
| EITHER                  | ANY        | up to 300                 | up to 3000           | up to 30,000          | up to 300,000        |

**CONTROLS**

Power OFF-ON switch (Circuit Breaker) with green lamp indicator.

High Voltage OFF-ON switch (Circuit Breaker) with red lamp indicator.

Voltage control with Zero-Start interlock, 0-100 reference dial.

Stabilizer selector switch: IN-OUT.

Voltmeter Range Switch: 7.5-15 kV.

Megohmmeter multiplier switch, 4-position: x1, x10, x100, x1K



---

**CABLES AND CONNECTORS**

- Input Cable: Attached; 5 feet (1.5 meters), 3-wire with plug.
- Output Cable: Attached; shielded with GUARD terminal, high voltage clip and boot; 15 feet (4.6 meters) long.
- Ground Cable: Separate, 10 feet (3.3 meters) with positive action clamp at outboard end.
- Ground Terminal: ¼ inch stud with wing nut.
- External Instrument Jack: Accepts ¼-inch 2-wire phone plug for connecting external recorder or current meter to read current in test item.

**PHYSICAL**

- Case: High-impact structural foam, polycarbonate plastic with metal control panel and removable hinged lid

| Size: | Overall Width | Depth | Height |        |
|-------|---------------|-------|--------|--------|
|       | 20 1/8        | 12    | 13     | inches |
|       | 52            | 20.5  | 33     | cm     |

- Weight:
- Cat. No. 210415: 35 lbs. (15.9 kg)
- Cat. No. 210415-47: 37 lbs. (16.8 kg)
- Instruction Card: Permanently attached inside lid.
- Cable & Manual Storage: Fits in compartment case.

***ENVIRONMENT***

|                      |  |
|----------------------|--|
| Temperature:         | 0°F (-17.7°C) to 122°F (50°C)<br>maximum operating.  |
| Altitude:            | 10,000 feet, (3,048 meters)<br>maximum operating.  |
| Relative Humidity:   | Non-condensing conditions.   |
| Shock and Vibration: | Will withstand normal shock and<br>vibration encountered in field use<br>and transportation. |

***PROTECTIVE FEATURES***

- Dual overload protection for all overload conditions by two separate circuit breakers.
- Metering protected against overload and transient conditions.

***SAFETY FEATURES***

- "Zero start" interlock: Voltage Control must be at zero to enable the output voltage circuit to be energized (started).
- Grounded metal control panel.
- Separate visible panel ground cable.
- Permanently attached shielded output cable.
- Separate switches for control power and high voltage output.

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# 5

## DESCRIPTION

### ***GENERAL***

The portable Megohmmeter Test Set measures the electrical quantities of applied voltage and resistance of the apparatus to which it is connected. Designed for field or shop use, the complete Test Set (including all leads) is housed in a rugged structural foam, polycarbonate case that includes a sturdy protective lid and carrying strap. For safety in operation, the control panel of the Test Set is of grounded metal.

### ***ELECTRICAL***

The Test Set consists of a variable dc power supply with metering of the output voltage and current passing between the high voltage output terminal and ground.

Figure 2 is the schematic diagram of this Test Set.

The high voltage dc power supply is contained within an internal guard shield. The output of the step-up transformer T101 supplies a full-wave voltage-doubling rectifier consisting of protective resistors R107 and R108, the silicon rectifiers CR101 and CR102 and the output filter capacitors C101 and C102. For safety the power supply is discharged by the bleeder resistors R101 and R102. Resistor R104 limits the output current if the apparatus being tested breaks down. Resistor R103 is the kilovoltmeter multiplier and capacitor C103 protects the voltmeter from transients. The negative terminal

of the power supply is the high voltage output and is connected to the center conductor of output cable W101. The positive terminal of the power supply is used as a guard and is connected to the shield of the output cable with a terminal at the outboard end.

The kilovoltmeter M101, the range selector switch S101 and the two range calibration resistors R105 and R106 are located on the panel and complete the voltmeter circuit.

Current passing from the high voltage output through the apparatus being tested and then to earth is measured by the multi-range current meter M102 and the range selection/protection network assembly U1. The scale of this meter is marked in megohms rather than current. The meter M102 and U1 are located on the panel. The Earth cable W102 completes the path for the megohm measuring circuits. For safety the path from Earth to the metering is paralleled by the green wire of the power cord W1. Within U1 is the megohmmeter transient protection capacitor C1 and voltage limiting Zener diode CR2. The Zener CR1 is connected so that any ac will not cause a false meter indication. In series with M102 is a swamping resistor R2 and a calibration adjustment R1. The ranges are selected by shunting the series combination of M102, R1 and R2 by precision resistors R3 for X1; R4 and R5 for X10; R4, R5, R6 and R7 for X100. No shunt is used for X1K range.

In series with M102 is a two-wire phone jack J1 that is shorted unless a plug is inserted. For use see Section 9.

For the use and significance of the guard see Sections 9 and 10.

The Test Set is energized directly by W1 with the green wire tied directly to the panel to provide a panel ground. The white neutral wire is uninterrupted and is considered the return path for the Test Set supply. The black wire is considered hot and power is fed to the set via the CB1 circuit breaker that also is

---

used as the power-on switch. When power is available and CB1 is closed the green ac ON lamp comes on. The path is interrupted by the contact of K2. Moving the voltage control T1 to zero closes the contacts of the zero start switch. This action applies the line voltage to the coil of K2 and ultimately to T1. The red "HIGH VOLTAGE ON" lamp lights since it parallels the coil of K2. Relay K2 will now remain closed even if the voltage control is advanced off its zero position. The line voltage is fed to T1 through the stabilization selector switch S1, directly when S1 is closed in the OUT position. Raising the voltage control now applies a controlled voltage to the primary of T101 through the trip coil of circuit breaker switch CB2.

When S1 is set to the "IN" position (stabilized) voltage is applied to T1 through resistor R1 and a parallel path exists from the input of T1 to the circuit return through the back-to-back connected Zener diodes CR1 and CR2. These diodes clip the peaks of the voltage across T1 so that any transient changes in the line supply voltage do not change the crest amplitude. This stabilizes the output voltage as long as the load current does not exceed 50  $\mu\text{A}$ . *The 50  $\mu\text{A}$  limit is equivalent to 300 Megohms at 15 kV.*

### **Power Supply Option**

Test sets equipped with the -47 optional input differ from standard sets in that separate step-down transformers T2 and T3 are included between the power source and the Test Set. The nominal line voltage is specified at purchase. Transformers are located in the cover of the Test Set.

Optional output voltages may be selected in accordance with the table on the schematic Figure 2.

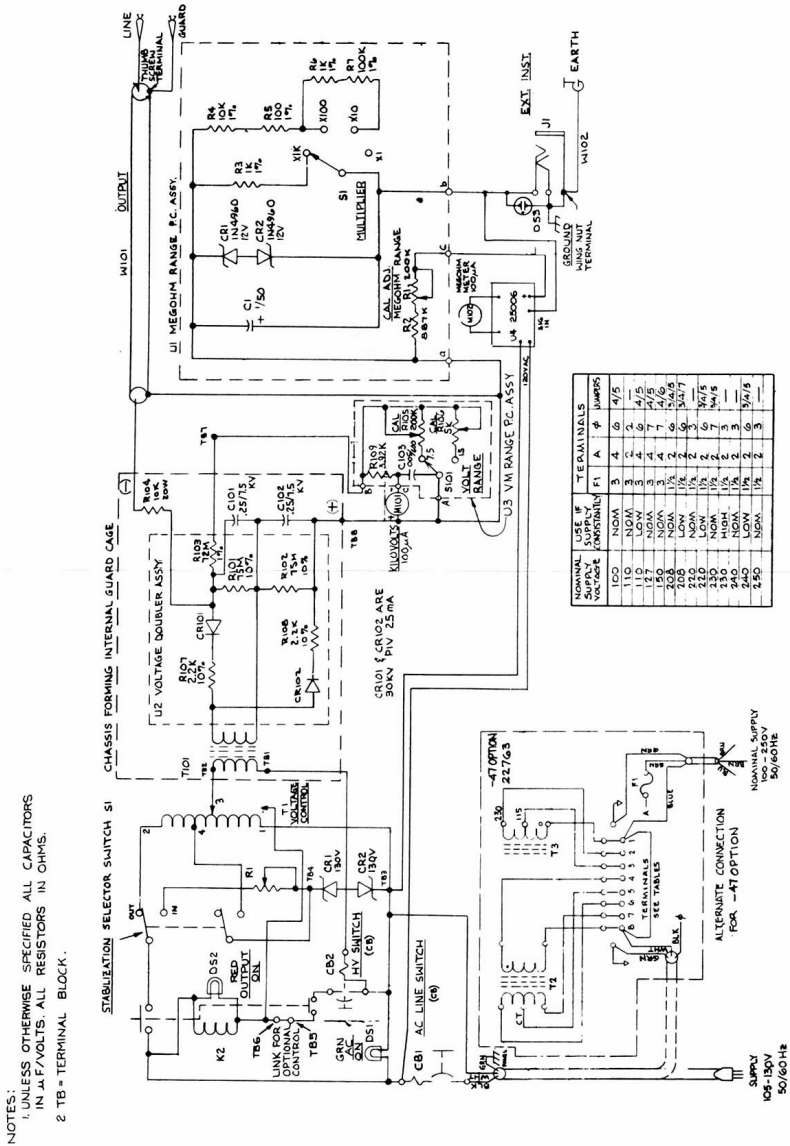
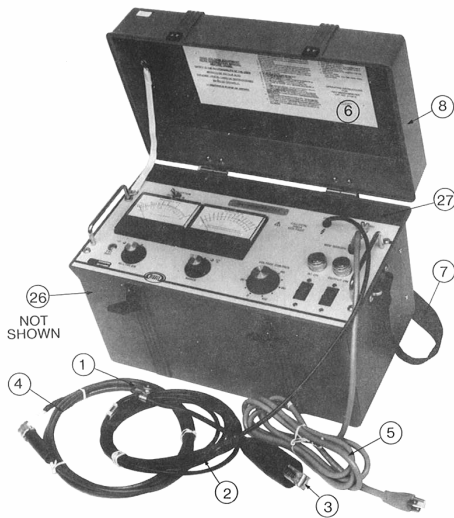


Figure 2: Schematic Diagram of the 15 kV Megohmmeter

# 6

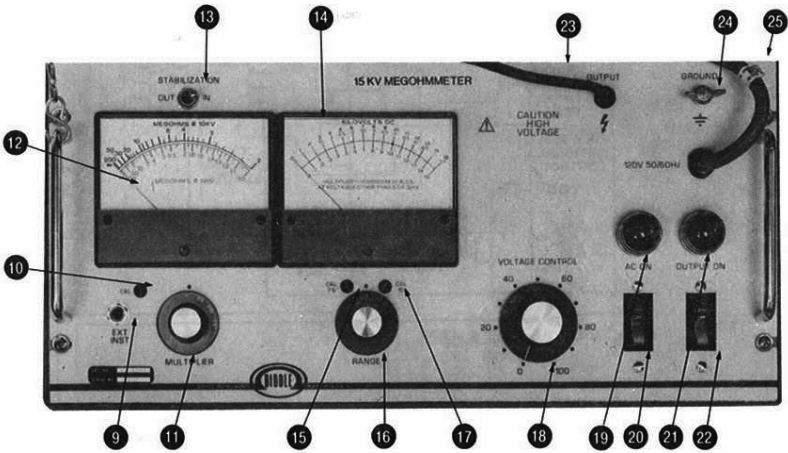
## CONTROL & CONNECTOR IDENTIFICATION



- |          |                       |     |  |
|----------|-----------------------|-----|--|
| 1.       | Guard Terminal        | 7.  | Carrying Strap                               |
| 2. & 23. | Output Cable          | 8.  | Removable Case Cover                         |
| 3.       | High Voltage Terminal | 26. | Location of -47 Option Step-Down Transformer |
| 4.       | Ground Cable          | 27. | Lead Storage                                 |
| 5. & 25. | Power Cord            |     |  |
| 6.       | Instruction Card      |     |  |

**Figure 3A: View of the 15 kV Megohmmeter Test Set**





**Figure 3B: View of the 15 kV Megohmmeter Test Set**

- |                                  |                                |
|----------------------------------|--------------------------------|
| 9. External Instrument Jack      | 17. 15 kV Voltmeter Calibrator |
| 10. Megohmmeter Calibrator       | 18. Voltage Control            |
| 11. Megohm Multiplier Selector   | 19. AC "ON" Green Lamp         |
| 12. Megohmmeter                  | 20. Input Power Switch         |
| 13. Stabilization Selector       | 21. Output "ON" Red Lamp       |
| 14. Kilovoltmeter                | 22. Output "ON" Switch         |
| 15. 7.5 kV Voltmeter Calibrator  | 23. Output Cable               |
| 16. Kilovoltmeter Range Selector | 24. Panel Ground               |
|                                  | 25. Power Cord                 |

# 7

## SETTING UP

Test set controls and terminals are identified in Section 6. Special instructions for test sets having 200 to 250-volt supply are given below. The following steps are listed as a general guide for setting up the Megohmmeter Test Set. Suggested setup arrangements are shown in Figures 4 through 8.

### ***PREPARATION***

Before setting up the test equipment, read Section 2, SAFETY. Working with due regard to safety, identify the terminals of the apparatus to be tested. Be sure that the low voltage terminal is securely grounded. Provide a ground connection, if necessary, using wire of 18 AWG or larger.

Define the type of test required; references listed in Sections 9 and 10.

Place guard connections on the terminals if a guarded test is required. (See Sections 8 and 9). Set up barriers or use other means to keep unauthorized personnel away from all high voltage terminals of the complete test arrangement.

### ***SELECTION OF LOCATION***

Select a location for the Test Set which meets the following conditions:

1. The operating area must be as dry as possible.

2. The Test Set must be within 10 feet of the high-voltage terminal of the apparatus to be tested.

*NOTE: For operator safety, the output cable should be fully extended to provide maximum distance between the operator and the high-voltage terminal.*

3. A reliable ground connection must be within 12 feet of the Test Set.
4. If an electrical service outlet is not within range of the 5 ft. input cable, a UL-approved extension cord rated for 15 amperes (minimum) and not longer than 50 feet may be used.
5. The operator of the Test Set must be able to conduct the test without being exposed to traffic hazard; he must have free access to all controls and be able to read the meters and panel markings easily without approaching energized high-voltage terminals.

### **CONNECTIONS PROCEDURE**

1. Connect the Test Set ground lead to the panel and to the local ground.

#### **CAUTION**



**For safe operation this separate ground cable must be used. The green wire of the input cable provides a parallel path but cannot be relied on to provide an adequate ground path for the panel.**

2. Connect the output cable clip to the high-voltage terminal of the apparatus to be tested. (See below under Clearances.)
3. If guard is not in use the output cable shield must not be grounded. Grounding this shield will short-circuit the megohmmeter; the set, therefore, will not register a resistance measurement.

4. If a guarded test is to be run, connect the guard lead of the apparatus to be tested to the shield of the output cable. (See Sections 8 and 9.) Insulate the guard circuit from ground.
5. With the Test Set switch OFF, connect the input cable to the service outlet.

## **CLEARANCES**

Be sure adequate clearances are maintained between energized conductors and ground to prevent arc-over. Such accidental arc-over may create a safety hazard or damage the equipment being tested. The position of the exposed conductors with respect to ground can often be maintained by tying the conductors in place with clean, dry nylon rope. Table I lists the minimum air clearances that must be maintained and also suggests the minimum path length along a rope if it is tied directly to a conductor. Finally, the table indicates minimum personnel clearances (based on OSHA specifications) that will limit the danger of static induced voltages being developed on nearby insulated objects, including people.

**TABLE 1: Minimum Air Clearances**

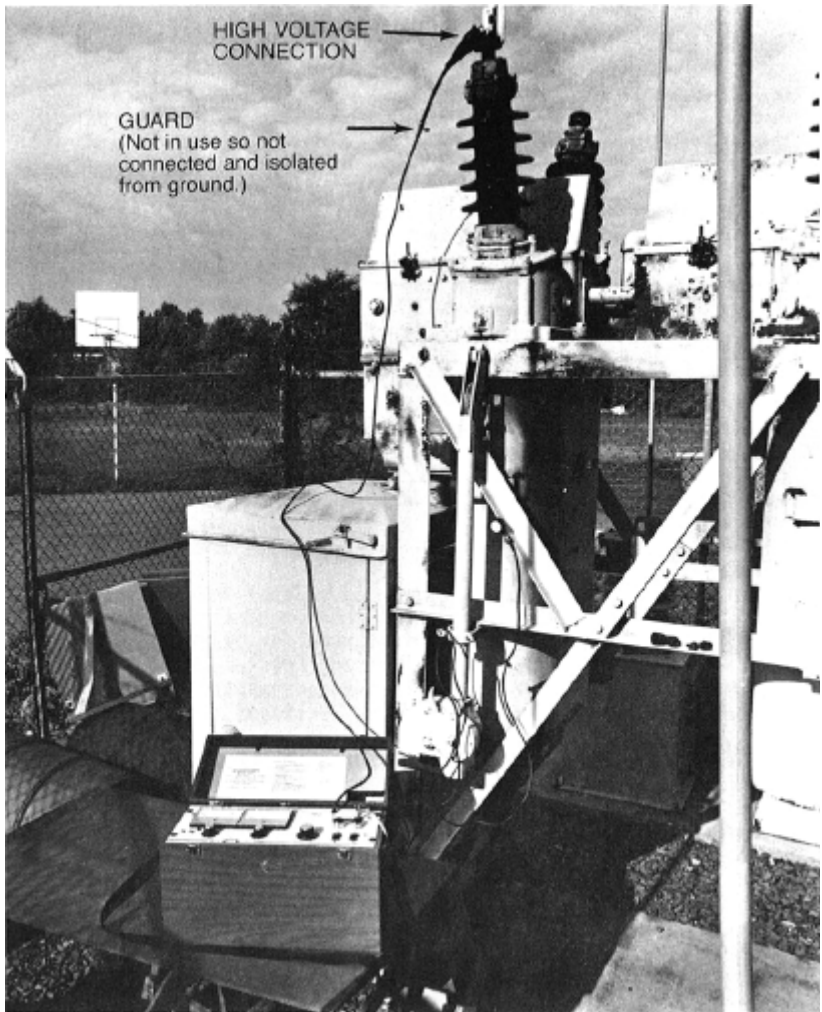
| Voltage of Test | Direct Air Path (inches) | Path Along Dry Nylon Rope (inches) | Minimum Personnel Clearances (feet) |
|-----------------|--------------------------|------------------------------------|-------------------------------------|
| 5 kV            | 0.5                      | 1-1/8                              | 2                                   |
| 10 kV           | 1.0                      | 2-1/4                              | 2                                   |
| 15 kV           | 1.5                      | 4                                  | 2                                   |
| 30 kV           | 4.0                      | 10                                 | 2.4                                 |

After completion, make a careful review of the test setup. Tests can then be conducted per Section 8. For convenience a condensed operating procedure is given on the Instruction Card.

**POWER SUPPLY OPTION, Catalog No. 210415-47**

When this option is supplied, Megger recommends that the service supply be limited by an appropriate line fuse to provide protection in case of a malfunction of the stepdown transformer. **Providing this protection is the responsibility of the user.** A fuse of not less than 1 ¼ amperes or more than 3 amperes is recommended.

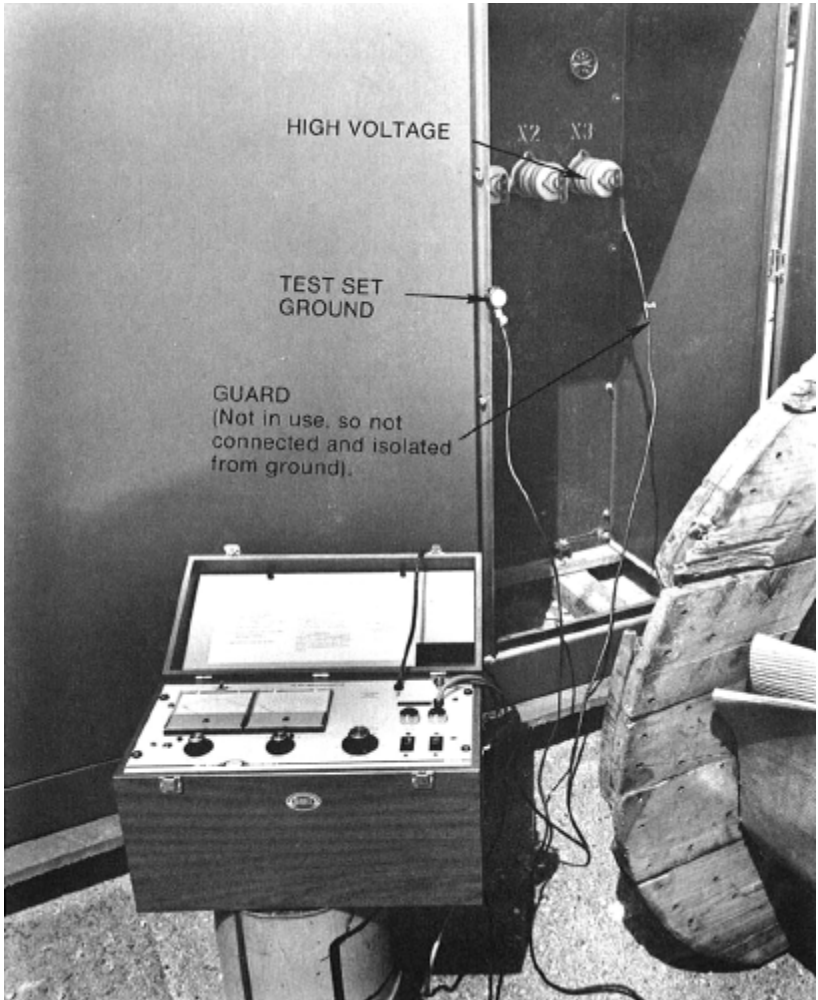
Because of the many different service sockets in general use, the input cable has been provided with a plug for which adaptors are readily available. If use of an adaptor is not desirable, the plug supplied can be cut off and replaced with one best suited to the service conditions. The green lead of the input cable is to be connected to ground, the white lead to the supply neutral, and the black lead to the "hot" portion of the line.



**Figure 4: Testing in a Substation.**

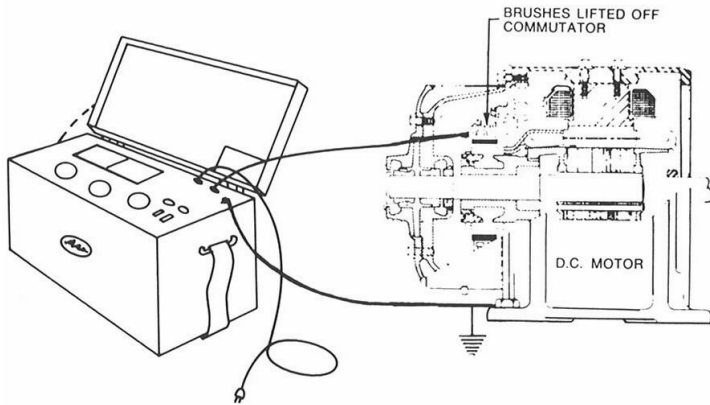


**Figure 5: Testing Parking Lot Lighting; the Test Set Shown is Operating from an Inverter.**

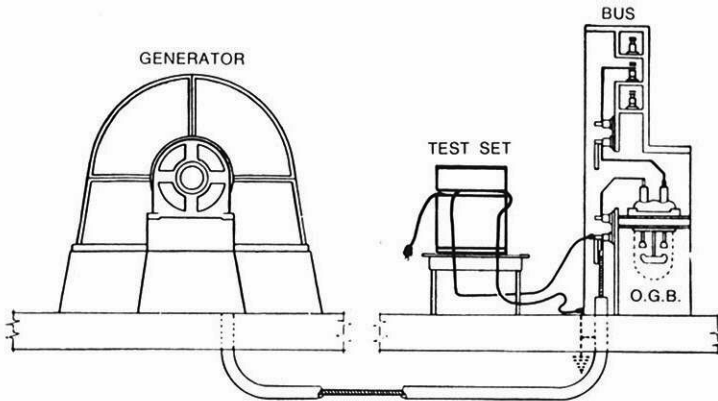


**Figure 6: Testing Transformer Terminals**





**Figure 7: DC Motor Test Setup.**



**Figure 8: Generator Test Setup.**

# 8

## OPERATION

Before conducting a test, consult Section 2 for Safety, Section 7 for Setting Up and Section 10 for Test Theory. When the Test Set and apparatus are set up as indicated in Section 7, the equipment can be energized and the necessary test performed by following the steps listed below.

### ***TEST PROCEDURE***

1. Remove all safety grounds from the Apparatus to be tested.
2. Close the AC "ON" switch; green lamp comes on.\*

\* If the service outlet voltage exceeds the rated limit for the Test Set the Power "ON" indicator will be abnormally bright. This will warn and alert the operator to stop the procedure and correct the problem.

3. Close the OUTPUT "ON" switch.
4. Set the voltmeter range switch to desired range.
5. Set megohm MULTIPLIER switch to X1 range.
6. Set stabilizer to "OUT" position.
7. Firmly move voltage control to zero; red lamp comes on.
8. Turn voltage control clockwise to increase output voltage as required for test being conducted.

9. Note voltage, resistance, and time as required by the test procedure being followed. Make settings and take readings as described in steps below.
10. If indicated resistance fluctuates during the reading the stabilizing switch may be set to the "IN" position (see Section 9).
11. To measure insulation resistance at 10 kV, set the voltmeter range switch to 15 kV and set the voltage to exactly 10 kV. Read the upper black scale. Read the resistance in megohms on the upper black scale of the megohmmeter. Multiply value read by multiplier to which the megohmmeter range switch is set (i.e. by 1, 10, 100 or 1000; see Section 9).
12. To measure insulation resistance at 5 kV, set the voltmeter range switch to 7.5 kV and set the output voltage to exactly 5 kV. Use the lower red meter scale. Read the megohmmeter lower red scale and multiply the value by the megohmmeter RANGE SWITCH setting.
13. To measure insulation resistance at voltages other than 5 or 10 kV:
  - a. Read megohms on the scale corresponding to the voltmeter range, matching red (inner) scales and black (outer) scales.
  - b. Multiply by the megohmmeter range setting.
  - c. Multiply by the reading from the voltmeter lower green scale. (See "Megohm Readings", for explanation).

### ***BREAKDOWN OF TEST ITEM***

In the event of failure of the apparatus being tested, the Test Set circuit breakers will trip out within twenty (20) seconds. When the stabilizer is in use trip-out may not occur but the

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output current is limited to 7.5 mA. When such a trip-out occurs, before approaching the equipment, apply the grounding stick to the high voltage terminal to discharge the test setup as all stored energy may not be dissipated by such a failure.

### ***NORMAL SHUTDOWN PROCEDURE***

When the test has been completed, follow this shutdown procedure:

1. Set the voltage control to zero.
2. Open the AC "ON" switch or the OUTPUT "ON" switch or both.
3. When the voltmeter indicates that voltage has decreased to a value of less than half the voltage used during the test, use an insulated grounding stick to apply a direct short circuit to all ungrounded terminals of the apparatus being tested.
4. Disconnect cables in the following sequence; first, the input cable; second, the output cable (including the guard if in use), finally, the ground cable.
5. Apply ground bonds to the equipment that has been disconnected.

### ***INTERRUPTING A TEST***

At any time, the AC "ON" or HV "ON" switches can be opened manually to interrupt a test, provided that the grounding stick is applied afterward to discharge any stored energy as described in the normal shutdown procedure.

For any circumstances requiring that a test be stopped immediately, the procedure is to apply the grounding stick directly to the high-voltage terminal. This action will remove

the test voltage in the shortest possible time. If the stabilizer is out the AC "ON" or HV "ON" circuit breakers will trip or they can be operated manually. If the stabilizer is "IN" it is necessary to open either the HV "ON" or the AC "ON" switches manually to permanently de-energize the test. This procedure should be followed only when absolutely necessary since there is a risk of damage to both the Test Set and the apparatus being tested.

# 9

## OPERATION NOTES

### ***LINE SUPPLY***

When operation requires a temporary service, the operator should verify the voltage and overcurrent protection at the service outlet for the Test Set prior to plugging in the Test Set.

### ***METER RANGE SETTINGS DURING TRANSIT***

The meters included in this set are of rugged construction; but it is recommended that during transportation of the Test Set the meter range switches be set as follows: the voltmeter to 15 kV and the megohmmeter to the X1 position.

### ***MEGOHM READINGS***

The megohmmeter is a current meter measuring the current passing through the item under test, but calibrated in megohms. The relation between current and megohms (resistance R) is expressed by Ohm's law:

$$R = \frac{V}{I}$$

The meter calibration depends on both the current I, and the test voltage V. Therefore, each megohm scale applies only when the test voltage is set to the correct value. In the Catalog No. 210415 two megohm scales are provided; one black for a test voltage of 10 kV, and one red for a test voltage of 5 kV.

These voltages are used because they are called for in dc testing of commonly encountered services. In addition, tests can be run at any voltage up to 15 kV.

Resistance at any other test voltage within the range of the Catalog No. 210415 can be computed by the following:

$$R_V = R_C \times \frac{V}{V_C}$$

where:  $V$  = actual test voltage

$V_C$  = standard voltage of either 5 or 10 kV as selected by full scale range of 7.5 or 15 kV

$R_C$  = indicated resistance on scale corresponding to selected  $V_C$

$R_V$  = actual resistance being measured at voltage  $V$

The factor  $\frac{V}{V_C}$  can be read directly from the lower (green) scale of the Voltmeter.

When the test voltage is set to one of the standard voltages 5 kV or 10 kV as in the normal usage, the equation reduces to the direct-reading case, namely:

$$R_V = R_C$$

To summarize, the following rules hold for all situations:

1. Read megohms on the scale corresponding to the voltmeter range, matching red (inner) scales and black (outer) scales.
2. Multiply by the megohmmeter range setting.
3. Multiply by the reading from the voltmeter lower green scale.

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## ***CORRECTION FOR INTERNAL LEAKAGE***

If the insulation resistance is high, arbitrarily over 20,000 megohms, a more accurate measurement can be made by correcting for the internal leakage of the Test Set.

To do this first suspend the output terminal well clear of all objects and raise the voltage to the value required by the test. Read the resulting leakage resistance.

Make the required resistance measurement, then use the equation:

$$R_T = \frac{R_L \times R}{R_L - R}$$

where:

$R_L$  = measured leakage resistance (typically above 100,000 megohms)

$R$  = measured resistance of item under test.

$R_T$  = corrected measured resistance of item under test.

## ***STABILIZING SWITCH***

In most cases the motion of the Megohmmeter pointer is slow and steady enough to permit a definite megohm reading.

In certain cases the Megohmmeter pointer will be observed to swing rapidly and widely so that a definite resistance reading cannot be made. This happens when the item under test has significant capacity and resistance values on the order of thousands of megohms. It is the result of line voltage transients that cause small changes in the test voltage.

The readings can be significantly stabilized under these conditions by switching the stabilizer "IN" during the test, and readjusting the test voltage if necessary. The stabilizer is only



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effective if the equivalent current is less than 50  $\mu\text{A}$ . The stabilizer can be "IN" for the complete test but the output voltage will take longer to reach its final value than if the stabilizer is "OUT".

### ***USE OF GUARD (See also Section 10)***

Occasionally when measuring apparatus, the leakage resistance of interest is masked by a parallel path. Such a situation is often encountered when measuring the leakage resistance of a cable. In the practical situation, the value of the resistance along the leakage path from the conductor over the surface of the pothead may be less than that within the major length of the cable. Under such conditions the guard feature of the Test Set is useful in excluding the resistance of the surface path from the measurement (See Figures 10 and 11). This is easily accomplished by forming an intercepting electrode by wrapping a bare wire around the outer surface of the cable pothead insulation close to the cable shield or ground. This wire electrode, which will intercept the surface current, must be connected to the Test Set guard terminal. The unwanted current then bypasses the megohm indicating meter and is not measured; the meter will read only the insulation resistance of the main portion of the cable.

The same guard principle can be used on other apparatus (Figures 12 and 13) where a suitable intercepting electrode can be added on a temporary basis. On some kinds of apparatus, notably bushings, the guard electrode is built-in.

The Guard terminal is only a few volts above ground and does not pose a safety hazard; however, it must not be allowed to contact ground.

## ***VOLTAGE CONTROL SCALE***

A reference scale is provided so that the voltage control position can be repeated. This convenience feature is useful when making repetitive tests such as those required on the three-phase wires of a cable. In addition, the voltage control scale is used to predetermine the voltage developed even though the actual voltage buildup may lag behind the motion of the voltage control because of the capacitance charging effect. Using this feature minimizes the possibility of applying excessive voltage to the apparatus being tested.

To predetermine the voltage control setting, refer to the regulation curve given in Figure 9. The accuracy of the voltage setting will normally be on the order of 5 to 10%, depending on the line voltage and the nature of the apparatus being tested.

## ***USE OF REGULATION CURVE***

The regulation curve given in Figure 9 applies when the stabilizer is "OUT" and has been provided for convenience in planning the adaptation of the Test Set to measurement of various apparatus. It is also useful in adapting the Test Set to special use such as production testing. The regulation curve relates the output voltage control setting to the actual output voltage and load resistance. From this curve, peak ripple voltage can be estimated and the equivalent internal resistance of the Test Set can be estimated for a wide variety of circumstances. The curve also indicates the circuit breaker limits of operation.

## ***STEP VOLTAGE TESTING***

This Test Set is well adapted to the commonly used test procedure of increasing the voltage applied to the apparatus being tested in steps (See Section 10 for additional data). The

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regulation curve given in Figure 9 is useful for estimating in advance the voltage control position for each step. Then during the test, the control can be advanced to the next predetermined setting. This procedure gives the sharpest step change in voltage and provides better test results than if the control is inched to the next step.

### ***FAULT LOCATING (BREAKDOWN TESTING)***

In practice, if the apparatus being tested fails, the user may be faced with the problem of locating the failure so that repairs can be made. Often the failure occurs in the form of an arc-over; that is, the apparatus will support some voltage, but above this level a spark forms at the failure, the voltage collapses, and the current soars.

This will usually trip out the Test Set; but if the voltage control is set just beyond the voltage that causes arc-over, it is possible that the arc-over will repeat several times before trip out. During this time, the operator can look for the light and noise generated by the spark and so locate the fault. Arc-over can be induced quite deliberately without damage to the test set; it is even possible to place some resistance in series with the high voltage connection and allow the arc-over to periodically repeat and continue for long periods of time. In some cases, however, this result can be obtained simply by careful adjustment of the voltage control.

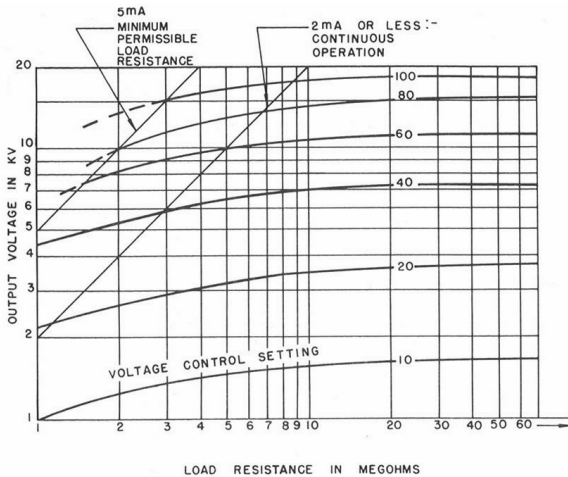
As an alternate the stabilizer can be switched "IN" because it increases the time to charge a cable without the need of an external resistor. Trip-out will be avoided and the voltage control setting is not as critical.

This test set is not recommended for locating faults in long cables but it may be used occasionally for cable fault locating on short cables (on the order of 1000 ft. or less) that arc over at voltages of less than 15 kV.

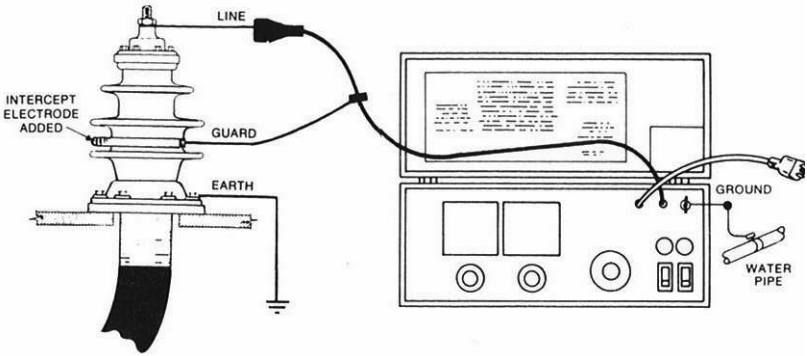
In any case, when used for this purpose the test set can continue, for long periods, to generate arc-overs at a rate not exceeding one discharge every three seconds. Attempts to shorten this time interval may result in trip-out. Trip-out warns that the thermal limit of the components will shortly be reached unless the discharge rate is reduced by lowering the voltage or adding series resistance. When series resistance is added, care must be taken to avoid hazards from the new connection. When using the stabilizer in the "IN" position the voltage control should be set to comply with the discharge rate.

**EXTERNAL CURRENT METER**

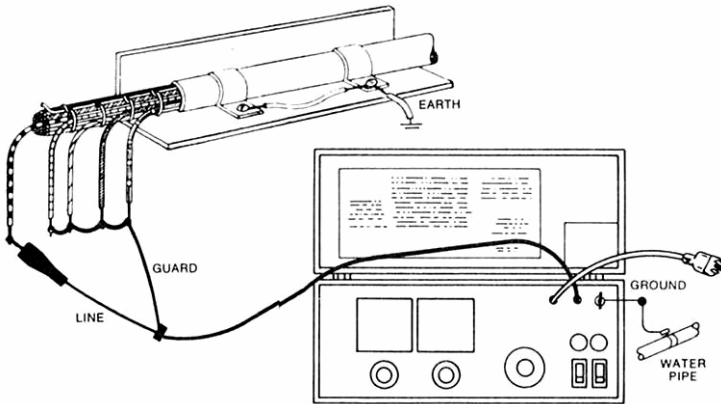
To read or record the test current, connect a suitable instrument to a two-wire phone plug that mates with EXT. INST jack J1. The tip of the plug will be positive, the ring negative. The external meter impedance must not exceed 10,000 ohms. The meter should be protected against overcurrent transients.



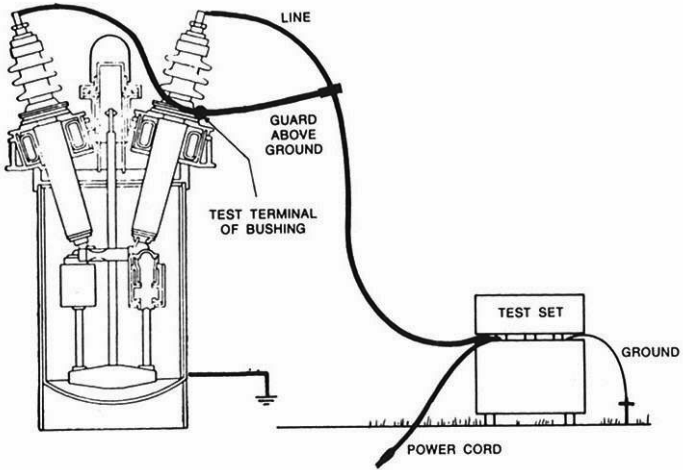
**Figure 9: Regulation Curves with Stabilizer "OUT", 120V Supply.**



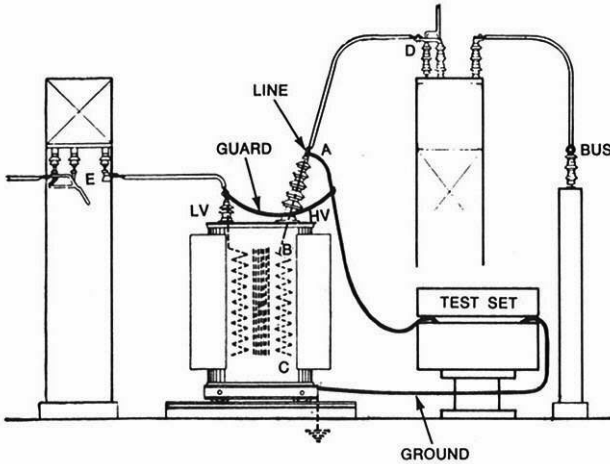
**Figure 10: Typical Guard Connection to Cable Pothead.**



**Figure 11: Guard Connection for a Typical Cable Test.**



**Figure 12: Typical Guard Connection for an Oil Circuit Breaker.**



**Figure 13: Typical Guard Connection for Transformer Test.**

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# 10

## APPLICATION NOTES

### ***THEORY OF INSULATION TESTING***

Any device that uses electrical energy can ordinarily be considered as consisting of elements that may be classified in two separate categories, namely, those parts of the apparatus that conduct the electrical energy and those parts that are not intended to conduct. It follows that any such apparatus includes an insulation system that is not intended to conduct electrical energy but which is under electrical stress. If such insulating parts do become conductive, the apparatus will fail. Electrical insulation can be tested by a variety of methods and measurements may be taken to anticipate such failures. Each method has its own merits, but one technique is to apply a dc voltage to the insulation system and measure such quantities as the applied voltage, the leakage resistance, and the manner in which such quantities vary with time. These dc test techniques have been well developed over many years and considerable literature exists on this subject.

The few references given below are not presented in any special order and no particular preference is implied; they are included merely for the convenience of the user so that you may make full use of this Megohmmeter test set.

The Lowdown on High Voltage DC Testing, Megger Technical Publication AVTM22P-1

Fink, Donald G. and Carroll, John M. Standard Handbook for Electrical Engineers (New York: McGraw-Hill, 1968)



Guide for Testing Insulation Resistance of Rotating Machinery, IEEE Standard 43.

Guide for Insulation Maintenance for Large Alternating Current Rotating Machinery, IEEE Standard 46.

Guide for Making Dielectric Measurements in the Field, IEEE Standard 62.

Guide for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage, IEEE Standard 95.

## **APPLYING THE TEST SET**

The Test Set measures the test voltage and the resistance of the item under test; the operator must introduce the time parameter into the test.

For safety reasons one terminal of the Test Set must be connected to ground. One side of the apparatus being tested must be connected to ground. This minimizes exposure of high voltage leads and conforms to the way most apparatus is constructed. This leaves one terminal at high voltage and for dc test sets this high voltage lead is preferably negative with respect to ground.

The Test Set measures the test voltage and the resistance of the item connected across the two output terminals, that is, the high voltage terminal and ground.

For most purposes the two-terminal resistance measurement is all that is required since all paths between High Voltage (Line) and Ground (Earth) are simultaneously measured and a total resistance value is found.

There are certain important practical situations where a two-terminal measurement does not convey the desired information.

In Section 9 the guard was recommended when testing cable. In practical application this arrangement can resolve the problem that the dirty surface path over the pothead may conduct more current to ground than actually passes through the bulk of the cable itself. The practical result is that the cable appears to have a relatively low resistance while in fact the cable itself is acceptable but the pothead is not.

By making an unguarded, then a guarded test it is possible to determine if the cable or the pothead is at fault thus indicating the appropriate action to be taken.

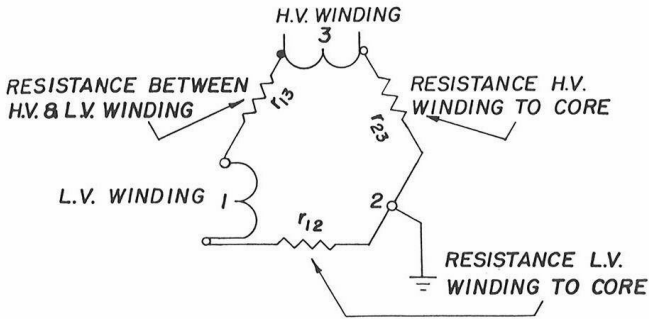
The principle of making more than one measurement with and without guard can be extended to other apparatus in order to separate multiple resistance paths and so better analyze the situation.

In some literature the unguarded measurement is called a two-terminal measurement while the guarded measurement is called a three-terminal measurement.

The principle of combining 2 and 3 terminal measurements is often used when the path of interest does not have the required ground on one terminal in order to make the necessary measurement.

### ***MEASURING AN UNGROUNDED TEST ITEM***

A two winding transformer in a grounded metal case with the core also grounded is a common construction having the typical problem of measurement of an ungrounded resistance path. Frequently it is desirable to measure the insulation resistance between each winding and ground and the insulation resistance between the windings. In Figure 14 this case is shown schematically.



**Figure 14: Two-winding Transformer in Three-Terminal Form.**

The measurements required are a combination of 2 and 3 terminal forms and measurements of resistance are made in accordance with Table 2.

**TABLE 2: Two and Three Terminal Measurement Connection Schedule**

| MEASUREMENT | CONNECTIONS  |        |          |
|-------------|--------------|--------|----------|
|             | HIGH VOLTAGE | GROUND | GUARD    |
| $r_{12}'$   | 1            | 2      | Not Used |
| $r_{12}$    | 1            | 2      | 3        |
| $r_{23}$    | 3            | 2      | 1        |

$$r_{13} = \frac{r_{12}(r_{12}+r_{23})-r_{12}'r_{23}}{r_{12}-r_{12}'}$$

By using the guard, the resistance between each winding and ground are measured directly and with the addition of one extra measurement the resistance between windings is calculated from the above equation.

*NOTE: There are alternate forms possible for the desired equation and measurement table.*

### **GENERALIZED COMBINED 2 and 3 TERMINAL MEASUREMENT**

The schematic of Figure 14 can easily be reduced to the equivalent delta connected resistors with one junction grounded. Many problems can be reduced to this form and then evaluated by the technique given above. The additional effort required to carry out the study to reduce the problem to a grounded delta form and then perform the necessary measurements are often justified for a preventative maintenance program that compares measurements made at long intervals, such as yearly. Another justification is usually related to how important the apparatus is and how reliable it must be.

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# 11

## **ROUTINE MAINTENANCE**

### ***INTRODUCTION***

Field service subjects high-voltage test equipment to a difficult environment, but equipment wear can be minimized by periodic inspection and cleaning. Such inspections and cleaning also will ensure reliable on-the-job operation. The frequency of routine inspection and cleaning will depend on the field conditions encountered. As a guide, for sets operated indoors in a normally dusty atmosphere, this procedure should be performed once every six months; as an extreme, the procedure should be carried out monthly on a set that is used daily outdoors in a heavy dust concentration that is conductive and hygroscopic.

Prior to performing inspection and maintenance, consult any damage reports that may have been completed for the test set.

### ***INSPECTION AND MAINTENANCE PROCEDURE***

Complete inspection and maintenance procedures can be performed in approximately fifteen minutes. The only equipment required consists of a screwdriver, an insulated jumper about one foot long, a clean damp cloth, and a clean dry cloth.

Proceed according to the steps given below.

1. Visually inspect the case, noting that hinges and case locks function properly. Check for breaks in the case or lid. Note the condition of the carrying strap and case feet.
2. Wipe the outside of the case with the damp cloth; then dry with a clean dry cloth.
3. Open the lid; fully extend and visually inspect all cables. If necessary, wipe each cable with the damp cloth; then dry. Wipe out the lead compartment. Wipe the panel and instruction card with a clean dry cloth.
4. Visually inspect the panel, noting that all knobs are secure on their shafts and that all controls operate smoothly without binding.
5. Set meters mechanically to left scale end.
6. **Removal of Test Set from Case**



**CAUTION**

**The test set must be de-energized for at least fifteen minutes before removing from case!**

The Test Set should be removed from its case only by those trained in handling high-voltage equipment since high voltage can be stored in components of the test set interior even after the set has been de-energized.

To remove the test set from the case\* follow the procedure given below:

- a. Set aside the ground cable.
- b. Remove and save the four panel screws.
- c. Raise the panel straight up to clear the case. Handle the set only by the panel. Place the set on a clean surface.

- d. Remove the guard screen, and using the insulated jumper, short circuit both capacitors C101 and C102 (see Fig. 15 for identification).

\*On sets equipped with -47 option, the Test Set chassis must be disconnected from the step-down transformer. This transformer is located in the cover. Before attempting to remove the Test Set from the case, disconnect from the terminal block.

### 7. **Completion of Inspection**

- a. Wipe the circuit card with a clean dry cloth to remove accumulated dust. Wipe the interior of the case. Visually inspect the interior connections and components.
- b. Re-install the guard screens. Make sure that the rear screen fully clears the panel-mounted resistor R1 and that the front screen fully clears the Zener diodes CR1 and CR2.
- c. Re-install the set in the case.
- d. Coil the leads and replace them in the lead compartment.

If defects are discovered during this inspection see Section 12 for repair procedures. If all is in order, the performance may be checked by following the procedure given in Section 13.



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# 12

## TROUBLESHOOTING and REPAIR

### **GENERAL**

Megger maintains a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. The instrument will be cleaned and excessively worn or damaged parts replaced. Following repair, the instrument will perform functionally like a new instrument, but the appearance will be substantially as returned. A new one-year warranty will be extended to those parts repaired.

For those users who prefer to make their own repairs, replacement parts are available from the factory. (Part numbers are given in Section 14). Those items which can be returned separately for repair are indicated in the parts list by an asterisk following the part number. Upon their return to the factory, such items will be repaired or replaced, whichever is less costly, and returned to the user under the same conditions as new replacement parts.

Prior to shipment, all components supplied for field replacement are inspected to the same extent as those used in original equipment; but because of the possibility of related component failure, Megger does not warrant such assemblies. (Shipping damage, of course, is covered by insurance claims.)

If the test set fails to operate properly, the information given in this section will be useful in determining the cause of the malfunction. Table 3 (included at the end of this section) notes possible equipment malfunctions that may be observed during

operation or performance check (see Section 13) and suggests possible causes and means of determining the defective component. The schematic diagram in Section 5 and the interior view of the test set given in Figure 15 will be helpful in locating components. When ordering parts, always include the Test Set serial number. The location of the serial number is shown in Figure 15.

It is important that persons repairing the Test Set fully understand the operation of the circuitry. When an assembly fails, it may damage associated components and this possibility must be evaluated prior to replacing an assembly. The circuitry must also be understood so that measures may be taken to prevent shock hazard to those making repairs.

When making repairs to this test set or replacing components, the procedures outlined in the following paragraphs should be followed.

Remove the Test Set from the case as explained in Section 11.

### ***CASE REPAIRS***

Because of its construction, a damaged lid or lower case will require that both lid and lower case be replaced as a unit. The replacement case is supplied with the instruction card and all hardware so that the test set can simply be placed into it. The case feet, carrying strap, and strap loops are accessible for replacement after the test set has been removed from the case.

### ***REPAIRS TO COMPONENTS OF CHASSIS AND PANEL***

In most cases any work will require separating the panel and chassis. To do this, follow steps below:

1. Remove both guard screens.

2. Locate the shield of the output cable and disconnect it from the chassis.
3. Carefully unsolder the output cable center conductor from the shield eyelet.
4. Mark all leads on the panel terminal strip and disconnect them.
5. Locate the four nuts that secure the chassis to the panel; with the set upright on the chassis remove the nuts, lock washers and flat washers.
6. Withdraw the four mounting stud insulating bushings.
7. Lift the panel off the chassis.
8. Set aside the insulation spacer blocks that are located between chassis and panel.
9. Follow these steps in reverse order for re-assembly.

For Catalog No. 210415-47 Test Sets it is necessary to first disconnect the test set power cord from the step-down transformer that is located in the cover.

### ***CHANGING LINE VOLTAGE TAP (-47 MODELS ONLY)***

To change the nominal supply voltage on the -47 version, disconnect the test set from the line. Remove the 4 screws securing the adaptor to the lid. Re-connect taps per table listed in schematic and on the adaptor (P/N 22763). Install fuse F1 of correct rating. Complete by re-installing adaptor in lid.

### ***REPLACEMENT OF OUTPUT CABLE W101***

It is not necessary to separate panel and chassis for this operation.

1. Remove test set from the case and remove the rear guard screen.
2. Locate the output cable and carefully unsolder the center conductor from the shield eyelet.
3. Remove the screw holding the outer shield to the chassis.
4. With proper tool remove the cable and clamp bushing from the panel. If necessary loosen the circuit card so the cable will come free of the notch.

*If the replacement cable is P/N 10586 the above procedure is reversed to install the replacement. If not, the replacement cable should be prepared to duplicate the original cable before installation.*

### **REPLACEMENT OF POWER CORD W1**

1. Separate chassis and panel.
2. Turn panel face down on a clean soft cloth.
3. Locate the black and white leads and carefully disconnect and mark the point of attachment.
4. Locate the green lead and free by removal of the panel ground terminal.
5. With the proper tool remove the cable and clamp bushing from the panel.
6. Installation is the reverse of the procedure above.

On -47 sets the power cord is part of the transformer assembly T2 which is connected to the test set with a shortened W1 input cable.

***REPLACEMENT OF METERS OR METER AMPLIFIER BOARD***

1. Place the panel on a clean cloth with the meters face down.
2. Remove the leads and note the terminals to which they should be reconnected.
3. Remove amplifier board if necessary.
4. Remove the four nuts and washers on the meter studs.
5. Slide the meter from the panel.
6. Replace the meter and reverse the above steps to complete the repair.

***REPLACEMENT OF MEGOHMMETER RANGE CIRCUIT***

1. Remove the range switch knob, switch shaft locknut and washer.
2. Unsolder the three leads attached to the U1 circuit card, noting the proper reconnection terminals for each lead.
3. Install the new U1 assembly.
4. Tighten the switch shaft nut.
5. Replace the knob so that the numbers line up with the panel index lines. Be sure that all steps are aligned.
6. Resolder the leads to the printed circuit card.

### ***REPLACEMENT OF VOLTMETER RANGE CIRCUIT***

1. Remove the voltmeter knob and the switch bushing nut.
2. Unsolder the three leads, noting where each one terminates.
3. Replace the switch assembly and tighten the switch bushing nut.
4. Replace the knob, align it with the panel index, then tighten the knob on the shaft.
5. Re-solder the leads to the printed circuit card.

### ***REPLACEMENT OF STABILIZING SWITCH S1***

1. Separate panel and chassis.
2. Mark and remove the leads from the switch.
3. Carefully note the location of the notch in the switch shank.
4. Remove the defective switch.
5. Reverse the procedure to complete replacement.

### ***REPLACEMENT OF CIRCUIT BREAKERS***

1. Separate panel and chassis.
2. Locate defective unit.
3. Carefully mark and disconnect all leads from the defective unit.
4. Remove the two front panel screws and remove the circuit breaker.

5. Be sure that the correct current rating is used for replacement.
6. Install with breaker closing when handle is pushed toward the rear of the set.
7. Reverse the procedure to complete replacement.

### ***REPLACEMENT OF VOLTAGE CONTROL AUTOTRANSFORMER T1***

1. Disconnect all leads, noting the appropriate reconnection terminal for each.
2. Remove the voltage control knob.
3. Remove the bushing nut.
4. Pull the transformer free of the assembly.
5. Replace the transformer through the panel.
6. Tighten the panel nut.
7. Reconnect the wires.
8. Install the knob and check its alignment at zero and full scale, then tighten.

### ***REPLACEMENT OF THE K2 ASSEMBLY***

1. Disconnect relay K2, noting the appropriate reconnection terminals for each wire.
2. Remove K2 from the panel bracket.
3. Replace K2.
4. Reconnect relay K2.



## **REPLACEMENT OF CHASSIS-MOUNTED ASSEMBLIES**

To replace chassis mounted assemblies, remove the panel following the procedure given above and short-circuit the two capacitors, then follow the appropriate steps on the next page.

## **REPLACEMENT OF CIRCUIT CARD U2**

1. Remove panel from chassis.
2. Remove 4 corner screws that secure the card to the chassis.
3. Lift card for access to wiring.
4. Cut or slide back the splice insulation to transformer lead.
5. Carefully unsolder the connection to free the transformer lead.
6. Mark and remove the leads connected to the capacitors.
7. Remove the screws holding the Zener diode heat sink assembly to the card.
8. Cut any tie-wrap and free card.
9. Re-assembly is the reverse of this procedure.

## **CALIBRATION OF VOLTMETER**

This procedure requires a dc meter that is capable of reading both 7.5 kV and 15 kV with an accuracy of  $\pm 1\%$  or better. On either range this standard instrument should draw less than 0.5 mA. *Any AC/DC Kilovoltmeter, 0-19.99 kV, is recommended.*

1. Connect the test set as shown in Figure 16.

2. Remove the cover screws from both the 7.5 kV CAL and the 15 kV CAL adjustments.
3. Operate the test set (Refer Section 8). Set its voltmeter range to 7.5 kV.
4. Adjust the output voltage until the standard voltmeter reads 5.0 kV.
5. Using a fine blade screwdriver, adjust the 7.5 kV potentiometer through the 7.5 kV CAL hole until it agrees with the standard.
6. Check at 7.5 kV full scale, then repeat for the 15 kV range using the 15 kV CAL adjustment and an output of 10 kV. Check at 15 kV full scale.
7. Replace both CAL cover screws.

***CALIBRATION OF MEGOHMMETER***

Calibration accuracy is a function of the voltmeter accuracy. Always calibrate the voltmeter as well as the megohmmeter. The megohmmeter calibration requires a standard dc current meter capable of measuring 5  $\mu$ A to 5 mA to an accuracy of  $\pm 1\%$  or better. Also required are the following testing resistors.

| Desired Resistance & Tolerance | Voltage | Watts | Part No.                |
|--------------------------------|---------|-------|-------------------------|
| 100 Megohms $\pm 1\%$          | 500     | <1    | 4694-12                 |
| 10 Megohms $\pm 1\%$           | 5000    | 2.5   | (2) 4694-7, in parallel |
| 2 Megohms $\pm 5\%$            | 7000    | 25    | (2) 4694-8, in parallel |

Check the X1K range first. This checks the unshunted meter movement. There is no adjustment. Proceed as follows:

1. Make connections as shown in Figure 17 using 5  $\mu\text{A}$  range on standard meter and 100-megohm resistor.
2. Operate the test set (Reference Section 8).
3. Set voltmeter range to 7.5 kV and megohm range to X1K.
4. Increase the output voltage until standard current meter indicates 5  $\mu\text{A}$  (at almost 500 volts).
5. The Test Set megohmmeter must read 1.0 megohms  $\pm 1/16$  inch.

If the required accuracy is not met, the meter or its protective network may require repair. This must be done prior to calibration of the X1, X10 and X100 ranges.

Next, adjust the X10 range using the MOCAL adjustment. (This adjustment applies also to the X1 and X100 ranges). Proceed as follows, using the 10-megohm load resistor:

1. Set multiplier to X10; standard meter for 500  $\mu\text{A}$ .
2. Increase output for a current of 500  $\mu\text{A}$  (at about 5 kV).
3. Adjust the test set calibrator (MOCAL) so that the megohmmeter reads 1 on the lower scale. To make this adjustment, remove the MOCAL cover screw, and use a fine blade screwdriver to adjust the calibration control.
4. To check for tracking, reduce the voltage until the standard current meter reads 0.25 mA. The megohmmeter should then read 2.0 on the lower scale. Re-adjust MOCAL for the best compromise.
5. To test the X100 range:
  - a. Connect the 10-megohm resistor and set the current to 50  $\mu\text{A}$  (at about 500 Volts).
  - b. The test set megohmmeter should read 1.0 megohms.

6. To check the X1 range:
  - a. Connect the 2 M $\Omega$  resistor and set the controls for a current of 2.5 mA (about 5000 Volts).
  - b. The test set meter should read 2.0 M $\Omega$ .

For critical applications requiring certification or a more complete checkout of this test set, a special resistance box is available. If this checkout box is required, contact the factory for information about price and delivery.

### **ADJUSTMENT OF R1 IN STABILIZATION NETWORK**

The objective of this adjustment is to dissipate no more than 48 watts in the stabilizing Zener diodes CR1 and CR2 at maximum line voltage and minimum burden (output current) on the test set.

#### ***Catalog No. 210415***

Remove the test set from the case. Locate R1 on the rear of the panel (see interior view Fig. 15) and remove the rear guard screen. The power cord must be removed from the service outlet while adjusting the slider tap of R1.

To make this adjustment requires a sinusoidal source with an rms voltage of 130 V  $\pm$ 1% and capable of supplying 1.5 amperes. An ac current meter, preferably of the clamp-on type, is required to measure 1.5 amperes  $\pm$ 2% (if other than a clamp-on meter is used the meter voltage drop must not exceed 100 mV).

To adjust R1, proceed as follows:

- a. Arrange the output terminal so that it is isolated.
- b. Set the stabilizer switch to the "OUT" position.

- c. With power cord disconnected, set R1 to about mid-point or leave it as found for first try.
- d. Set the supply to 120 Volts.
- e. Close the "AC ON" switch.
- f. Close the "OUTPUT ON" switch.
- g. Move the voltage control to zero and hold it there.
- h. Read and record the line current.
- i. Set the stabilizer switch to the "IN" position.
- j. Increase the supply voltage to 130 volts  $\pm 2\%$ .
- k. The current should be 1.09 times the reading of Step h plus 0.3 amperes.
- l. If the value observed is greater than calculated in Step k, shut down and move the R1 tap so as to increase the included resistance. (*Facing the resistor, moving the tap to the right increases resistance*). If the observed value is less than calculated in Step k decrease the resistance of R1 (to the left).
- m. Repeat Steps i through k, and continue until the condition of Step k is satisfied.

Care must be exercised to avoid overheating CR1 and CR2.

**Catalog No. 210415-47**

The procedure for adjustment of R1 is the same as for Catalog No. 210415 except the supply voltage for Step d must be the nominal voltage selected by the tap on T2 (see tabulation, or schematic). The supply voltage must be able to be set for the maximum value for the selector nominal voltage range, as tabulated on page 7. The voltage (Steps d and j) must be measured across the input (high-voltage side) of T2 while the current (Steps h and k) must be measured at the output (low-voltage side) of T2.

**TROUBLE LOCATION**

**TABLE 3: Trouble Location Chart**

| MALFUNCTION   | POSSIBLE CAUSE  |
|---|---|
| AC "ON" lamp does not light.  | De-energized service outlet.<br>Defective service outlet.<br>Defective power cord.<br>Defective lamp.<br>Defective CB1. |
| AC "ON" lamp abnormally bright.   | Supply voltage too high.  |
| AC "ON" switch trips on closure.  | Internal wiring short circuit.<br>Defective socket DS1.<br>Defective K2.<br>Defective CR1 or CR2, (Stabilizer "IN").    |
| No red lamp when "OUTPUT ON" switch is closed and voltage control is at zero. | Defective lamp DS2.<br>Defective K2.<br>Defect in mechanical linkage to T1.<br>Defective CB2.                           |
| Red lamp goes out when voltage control is advanced.                           | Defective K2.   |
| "OUTPUT ON" switch trips on closure.  | Defect in zero-start.   |
| "OUTPUT ON" switch trips when voltage control is advanced.                    | High Voltage output shorted to ground.<br>Defective T101.<br>Defective U2.  |

| <b>MALFUNCTION</b>                                  | <b>POSSIBLE CAUSE</b>   |
|---|---|
| No output voltage when voltage control is advanced. | Defective CB2.<br>Defective S1.<br>Defective R1.<br>Defective T1.<br>Defective T101.<br>Defective U2.<br>Defective R104.<br>Defective M101.<br>Defective W101.                                    |
| No megohmmeter reading.                             | Guard connected to ground.<br>Range switch set too low.<br>Defective M102.<br>Defective U1.<br>Defective J1.<br>W101 not connected to apparatus under test.<br>No ground on apparatus under test. |
| Megohm reading erratic.                             | Supply voltage unstable.<br>Apparatus under test failing.<br>Intermittent guard to ground short.<br>Defective W101.<br>Defective U1.<br>Defect in control circuit or in U2.                       |

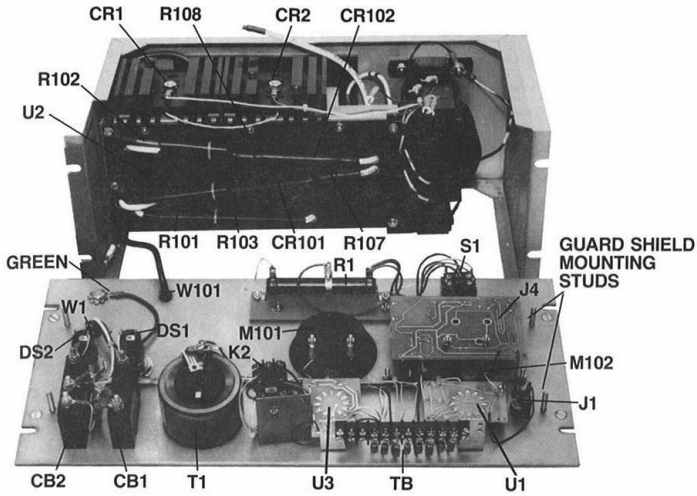
## TROUBLESHOOTING & REPAIR

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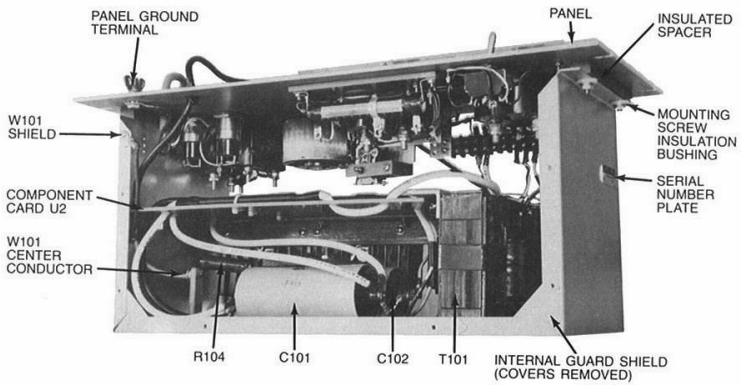
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| <b>MALFUNCTION</b>   | <b>POSSIBLE CAUSE</b>  |
|--|--|
| Output voltage setting does not agree with regulation curve.   | Incorrect supply voltage.<br>Voltage control knob not in proper position on shaft.<br>Defect in R104.<br>Defect in U2. |
| Output voltage greater than 0.25 kV with voltage control at 0. | Improper adjustment of K2 mechanical closure.  |
| Megohmmeter reads less than 300,000 megohms at 15 kV.          | Excessive leakage from HV output terminal to ground.<br>Internal leakage.  |

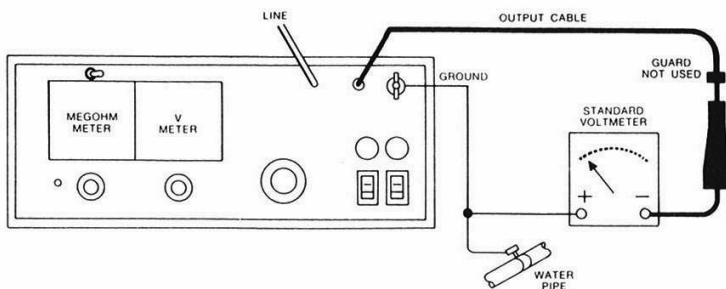




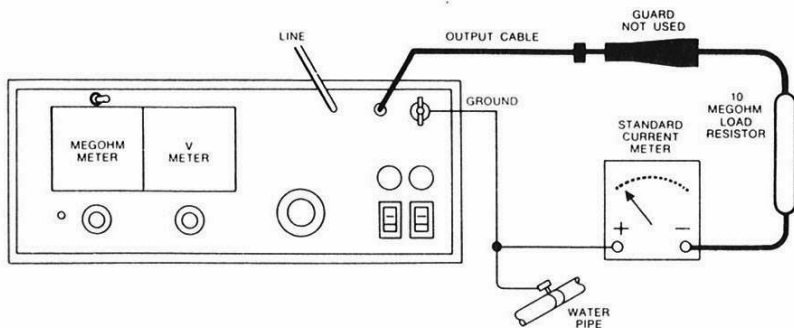
**Figure 15A: Interior View**



**Figure 15B: Interior View**



**Figure 16: Connections for Calibration of Voltmeter.**



**Figure 17: Connections for Calibration of the Megohmmeter.**

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# 13

## PERFORMANCE CHECK

The procedure given below can be used to check equipment performance in the shop after routine maintenance as described in Section 11, or after making repairs as indicated in Section 12. The procedure may be used in the field prior to conducting tests to confirm that the equipment is operating properly and thereby ensure valid test results.

After the equipment is set up, the performance check can be completed in about five minutes.

**CAUTION:** Since high voltage will be developed during this test, persons conducting the test must be familiar with the safety precautions normally followed when operating high voltage equipment and must take all necessary measures to avoid shock hazard.

Follow the procedure given below:

1. Set up the equipment as indicated in Section 7. Suspend the output lead so that the high voltage clip is clear of all objects by at least 18 inches (45 cm).
2. Set the voltmeter range to 15 kV and the megohmmeter multiplier to X1K, stabilizer "OUT".
3. Operate the set according to the procedure given in Section 8, raising the voltage to 15 kV. The megohmmeter should indicate more than 200 megohms. That is, the actual resistance should be above 300,000 megohms, with internal leakage making the difference.

4. With voltage control set for 15 kV output, set stabilizer to "IN". Voltage should drop to about 13.5 kV.
5. Follow the shutdown procedure given in Section 8.
6. Connect the high voltage output to ground.
7. Set the voltmeter range to 7.5 kV and the megohmmeter range to X1, stabilizer "OUT".
8. Operate the set and very carefully turn up the voltage control. *Note that the megohmmeter moves to full deflection.*
9. After reaching full scale on the X1 megohm range, advance the voltage control to 25: either or both circuit breakers must trip in 20 seconds or less with a supply voltage of 117 volts or more. If the supply voltage is between 105 and 117 the time for tripping may be as long as 40 seconds.
10. Shut down as described in Section 8.

# 14

## PARTS LIST

| SYMBOL  | DESCRIPTION                | PART NO. |
|---------|----------------------------|----------|
| -       | Complete case and lid      | 25743-1  |
| -       | Case feet                  | 5599-1   |
| -       | Carrying strap and bails   | 6580-2   |
| W1      | Input cable (power cord)   | 17032    |
| W101    | Output cable               | 10586    |
| W102    | Ground cable               | 4702     |
| CB1     | AC "ON" switch             | 4709     |
| CB2     | HV "ON" switch             | 4710     |
| DS1/DS2 | Lamps only 6S6-125         | 1723     |
| T1      | Voltage control            | 6408-2   |
| R1      | Stabilizer resistor        | 4736     |
| S1      | Stabilizer selector switch | 8406-1   |
| CR1/CR2 | Stabilizer diodes          | 1934-3   |
| K2      | Control relay              | 9270     |
| *(1) T2 | Line selector transformer  | 12147    |

| SYMBOL    | DESCRIPTION                              | PART NO. |
|-----------|--|----------|
| T101      | High voltage transformer                 | 14540    |
| (1) T3    | Autotransformer                          | 22759-2  |
| * U2      | High voltage rectifier assembly          | 10582    |
| C101/C102 | High voltage filter capacitors           | 4706-1   |
| C103      | Voltmeter protective capacitor           | 7950     |
| M101      | Voltmeter                                | 25295    |
| S101      | Voltmeter range selector PC              | 22521    |
| R104      | Output current limit resistor            | 4500-101 |
| * U1      | Megohmmeter protective-range selector PC | 4986     |
| M102      | Megohmmeter                              | 25294    |
| J1        | External instrument jack                 | 4733-2   |
| -         | Voltage control knob                     | 4690-1   |
| -         | Megohmmeter range knob                   | 9998-22  |
| -         | Voltmeter range knob                     | 9998-5   |
| * J4      | Meter amplifier board                    | 25006    |

(1) Used only on -47 model.

\* Can be returned as separate assembly for repair.

# 15

## **WARRANTY and REPAIRS**

### ***WARRANTY***

All products supplied by Megger are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped prepaid and insured. The warranty does not include batteries, lamps, or tubes, where the original manufacturer's warranty shall apply, WE MAKE NO OTHER WARRANTY.

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

### ***REPAIRS***

Megger maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend that it be returned to the factory for repairs 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.



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