



**Instruction Manual  
for the  
DC Dielectric Test Sets**

**Catalog Nos.**

|         |        |                  |
|---------|--------|------------------|
| 220070: | 70kV   | Digital Metering |
| 220072: | 70kV   | Analog Metering  |
| 220123: | 120 kV | Digital Metering |
| 220124: | 120 kV | Analog Metering  |
| 220163: | 160 kV | Digital Metering |
| 220164: | 160 kV | Analog Metering  |

**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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[www.megger.com](http://www.megger.com)



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| 220072: | 70kV   | Analog Metering  |
| 220123: | 120 kV | Digital Metering |
| 220124: | 120 kV | Analog Metering  |
| 220163: | 160 kV | Digital Metering |
| 220164: | 160 kV | Analog Metering  |

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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.

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# 1

## INTRODUCTION

### *Receiving Instructions*

Check the equipment received against the packing list to ensure that all materials are present. Notify Megger of any shortage.  
Telephone (610) 676-8500.

Examine the instrument 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.

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

### *General Information*

Megger dielectric test sets provide the high-voltage dc output needed to check (the quality of electrical insulation on motors, power cables, switch gear, bushing, insulators, transformers, and capacitors. The test sets are designed for making proof, acceptance, and maintenance tests on electrical insulation of equipment used by electrical utilities and industry for generation and distribution as well as for the testing of aerial boom trucks and other high-voltage equipment. A test set comprises a control unit, a high-voltage (HV) unit, four cables and one input power cord. See Figures 1 through 3.

This instruction manual describes the operation and maintenance of Megger DC Dielectric Test Sets with Catalog Numbers 220070, 220072, 220123, 220124, 220163 and 220164. These catalog numbers when combined with a "-47 suffix" denote test sets with 220/240 V input power. Unless otherwise specifically stated, information in this manual applies to all models of the test set.

The tests made by these test sets are based on measurement of the applied dc voltage, the resulting current, and the manner in which current varies with time.

These measurements provide data that indicate the condition of the insulation system of the sample being tested. Information on the interpretation of recorded data and guides for test voltage and time are given in Section 6 of this manual.



**Figure 1: Catalog No. 220070, 70 kV Test Set**



**Figure 2: Catalog No. 220123, 120 kV Test Set**



**Figure 3: Catalog No. 220163, 160 kV Test**

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# 2

## **SAFETY**

### ***General***

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

The surface of the HV unit must be treated as part of the energized circuit during tests. It must also be isolated from personnel by suitable barriers, barricades or warnings. Locate the control unit with an absolute minimum air clearance from the HV unit as indicated in Section 5 of this manual. Position the HV unit on a flat surface at least 3 ft (90 cm) away from the test sample and any other structures to prevent the possibility of an accidental flashover through the insulated cover of the HV unit.

This HV unit as well as the equipment to be tested should be enclosed in an interlocked area. Interlock facilities are provided with the test set.

This test set is designed to be connected to de-energized cable and other high-voltage power apparatus. Treat all terminals of high-voltage, power equipment as a potential electric shock hazard. There is always the possibility of voltages being induced at these terminals because of proximity to energized high-voltage lines or equipment. Always ground the terminals of power equipment, before attempting to connect or disconnect the test set leads. The ground connection must be the first made and the last removed. An interruption of the grounding connection can create an electric shock hazard.

### ***General Safety Precautions for DC Testing***

While energized at high voltage, a test setup may induce a static charge on nearby insulated objects, including people. To avoid such a condition, all insulated objects must be grounded or kept at the minimum air clearances from the energized structure.

Devices which rely on solid or solid/liquid dielectrics for insulation should be grounded and short-circuited with bonding jumpers when not in use.

Good safety practice requires that capacitive objects be short-circuited in the following situations:

- Any capacitive object not in use which might be within the influence of a dc electric field should have its exposed high-voltage terminals grounded. Failure to observe this precaution could result in a voltage being induced in the capacitive object.
- Capacitive objects should be short-circuited after being tested with dc. Failure to observe this precaution could result in a build-up of voltage on the object due to dielectric absorption in the insulation. The short circuit should remain in place until the dielectric absorption has dissipated or until the object has been reconnected to a circuit.

## NOTE

**It is good practice for all capacitive devices to remain short-circuited when not in use.**

- Any open circuited capacitive device should be short-circuited and grounded before being contacted by personnel.

Upon completion of a test, after the high-voltage power source has been shut down, allow sufficient time for the sample to discharge (indicated by a zero reading on the test set kilovoltmeter), then switch the test set MAIN BREAKER off. The terminals of the test sample must be short-circuited with a safety ground (hot stick) to ground all live parts. Ground bonds should then be applied and left in place. Do not approach the HV unit until the ground bonds have been applied.

Discharging a test sample may take a considerable amount of time depending on the type and size of the sample. To hasten the discharge, once the sample has discharged to less than one-fourth the voltage used during the test, a suitably rated high-voltage resistance discharge stick may be applied to the high-voltage terminal. This should be followed by the direct ground with a safety ground (hot stick) and the ground bond.

For further details on safety practices and precautions in high-voltage testing, refer to IEEE Standard 510-1983 "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing."

If the test set is operated properly and all grounds correctly made, test personnel need not wear rubber gloves. 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.

- 
- **Safety is the responsibility of the user.**
  - Never connect the test set to energized equipment or use the test set in an explosive atmosphere.
  - Corrective maintenance must be performed only by a person who is familiar with the construction and operation of the test set and the hazards involved.
  - The word "**DANGER**" on the equipment identifies areas of immediate hazard which could result in personal injury or loss of life.
  - The purpose of the test set is limited to use as described in this manual. Do not use the test set or its cables with any device other than specifically described.

Users of high-voltage equipment should note that high-voltage discharges and other sources of strong electric or magnetic fields may interfere with the proper operation of heart pacemakers. Personnel having heart pacemakers should obtain expert advice on possible risks before using this equipment or being close to the equipment while it is in operation.

This instrument operates from a single-phase power source. It has a three-wire power cord and requires a two-pole, three-terminal, live, neutral, and ground type connector. The voltage to ground from the live pole of the power source must not exceed the maximum rated input operating voltage. The neutral pole must be at ground potential. Before making connection to the power source, determine that the instrument rating matches the voltage of the power source and has a suitable two-pole, three-terminal grounding type connector.

The power input plug must be inserted only into a mating receptacle with a ground contact. Do not bypass the grounding connection. Any interruption of the grounding connection can create an electric shock hazard. Determine that the receptacle is properly wired before inserting the plug.

Test sets energized with 220/240 V input power (designated by catalog numbers with a "-47" suffix) are energized via an autotransformer which is used for voltage reduction. Depending on whether the test set is supplied with a black, white, and green input supply cord or a brown, blue, and green/yellow supply cord, the black or brown cord lead must be connected to the live pole of the line power source and the white or blue cord lead must be connected to the neutral pole of the line power source. The green or green/yellow ground lead of the input supply cord must be connected to the protective ground (earth) contact of the input plug. These test sets must not be energized from a power source where both poles are live.

The following specific warning and caution notices are used throughout this manual where applicable;

## **WARNING**

**Warning, as used in this manual, is defined as a condition or practice which could result in personal injury or loss of life.**

## **CAUTION**

**Caution, as used in this manual, is defined as a condition or practice which could result in damage to or destruction of the equipment or apparatus under test.**

# 3

## SPECIFICATIONS

### *Electrical*

Table 1 delineates the electrical specifications for the test sets.

**Table 1: Specifications of Input and Output**

| <b>Cat. No.</b> | <b>Input Voltage<br/>For nominal line<br/>voltage, single phase</b> | <b>Output Voltage<br/>For nominal dc line<br/>voltage, continuously<br/>variable, negative<br/>polarity with respect<br/>to ground, less than 1<br/>mA output current.</b> | <b>Output Current<br/>Maximum rating<br/>(thermal)</b> |
|-----------------|---|--|--|
| 220070          | 120 V (105-130 V)<br>50/60 Hz 5 A                                   | 0 to70 kV  | 5 mA for 30 min<br>3.5 mA continuous                   |
| 220072          | 120 V (105-130 V)<br>50/60 Hz 5 A                                   | 0 to70 kV  | 5 mA for 30 min<br>3.5 mA continuous                   |
| 220070-47       | 240 V (210-260 V/)<br>50/60 Hz 2.5 A                                | 0 to70 kV  | 5 mA for 30 min<br>3.5 mA continuous                   |
| 220072-47       | 240 V (210-260 V/)<br>50/60 Hz 2.5 A                                | 0 to70 kV  | 5 mA for 30 min<br>3.5 mA continuous                   |
| 220123          | 120 V (105-130 V)<br>50/60 Hz 10 A                                  | 0 to120 kV   | 5 mA for 20 min<br>2.5 mA continuous                   |
| 220124          | 120 V (105-130 V)<br>50/60 Hz 10 A                                  | 0 to120 kV   | 5 mA for 20 min<br>2.5 mA continuous                   |
| 220123-47       | 240 V (210-260 V)<br>50/60 Hz 5 A                                   | 0 to120 kV   | 5 mA for 5 min<br>2 mA continuous                      |

| <b>Cat. No.</b> | <b>Input Voltage</b><br><b>For nominal line</b><br><b>voltage, single phase</b> | <b>Output Voltage</b><br><b>For nominal dc line</b><br><b>voltage, continuously</b><br><b>variable, negative</b><br><b>polarity with respect</b><br><b>to ground, less than 1</b><br><b>mA output current.</b> | <b>Output Current</b><br><b>Maximum rating</b><br><b>(thermal)</b> |
|-----------------|---|--|--|
| 220124-47       | 240 V (210-260 V)<br>50/60 Hz 5 A   | 0 to120 kV   | 5 mA for 5 min<br>2 mA continuous                                  |
| 220163          | 120 V (105-130 V)<br>50/60 Hz 10 A  | 0 to160 kV   | 5 mA for 20 min<br>2 mA continuous                                 |
| 220164          | 120 V (105-130 V)<br>50/60 Hz 10 A  | 0 to160 kV   | 5 mA for 20 min<br>2 mA continuous                                 |
| 220163-47       | 240 V (210-260 V)<br>50/60 Hz 5 A   | 0 to160 kV   | 5 mA for 5 min<br>1.5 mA continuous                                |
| 220164-47       | 240 V (210-260 V)<br>50/60 Hz 5 A   | 0 to160 kV   | 5 mA for 5 min<br>1.5 mA continuous                                |

Ripple is less than 2 percent on capacitive test samples at continuous-rated output values.

Regulation is less than 20 percent from no-load to continuous-rated output current.

Special internal guard circuit eliminates the extra meter connection lead required on most dc test sets. The simplified guard circuit reduces internal leakage current to less than 0.1  $\mu$ A at full-rated output voltage. Guard terminal on HV output cable allows optional connection to test sample.

## **VOLTMETER**

|                |   |
|----------------|---|
| 220070 and -47 | Digital voltmeter: 0 – 70 kV  |
| 220123 and -47 | Resolution: 100 volts   |
| 220163 and -47 | Accuracy: $\pm 2\%$ of reading + 100 volts  |
| 220072 and -47 | 4.5", Analog voltmeter: 0 – 40 kV, 0 – 80 kV<br>Resolution: 1 kV/ 2 kv<br>Accuracy: $\pm 2\%$ of full scale |

---

|                |  |
|----------------|--|
| 220124 and -47 | 4.5", Analog voltmeter: 0 – 60 kV, 0 – 120 kV<br>Resolution: 1 kV/ 2 kV<br>Accuracy: $\pm 2\%$ of full scale |
|----------------|--|

---

|                |  |
|----------------|--|
| 220164 and -47 | 4.5", Analog voltmeter: 0 – 80 kV, 0 – 160 kV<br>Resolution: 2 kV/ 4 kV<br>Accuracy: $\pm 2\%$ of full scale |
|----------------|--|

---

### **AMMETER**

|                |   |
|----------------|---|
| 220070 and -47 | Digital ammeter: 0 – 19.9, 0 – 199 $\mu\text{A}$ , 0 – 1.99, 0 – 5.00mA |
|----------------|---|

|                |  |
|----------------|--|
| 220123 and -47 | Accuracy: $\pm 2\%$ of reading + 1 count |
|----------------|--|

|                |  |
|----------------|--|
| 220163 and -47 |  |
|----------------|--|

---

|                |   |
|----------------|---|
| 220072 and -47 | 4.5", Analog ammeter: 0 – 5 $\mu\text{A}$ |
|----------------|---|

|                |                                 |
|----------------|---------------------------------|
| 220124 and -47 | Multipliers: x1k, x100, x10, x1 |
|----------------|---------------------------------|

|                |  |
|----------------|--|
| 220164 and -47 | Maximum Resolution: 0.1 $\mu\text{A}$<br>Accuracy: $\pm 2\%$ of full scale |
|----------------|--|

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All high-voltage components are encapsulated or sealed in dielectric housing for high reliability and minimum size and weight. There is a surge-limiting resistor in series with the high-voltage output and a bleed-off resistor for the discharging of charge stored in the unit.

## ***Safety Features***

- Input supply line circuit breaker.
- Output current overload relay.
- Zero-start interlock for high-voltage output.
- Push-button controls for high-voltage ON and OFF.
- Indicating lights for high-voltage ON and OFF.
- Connection for external permissive and safety switches.
- Protection against damage by overloads and surges.
- Control unit separated from HV unit by 15 ft (4.6 m) of interconnection cable.

## *Physical Characteristics*

### **CONTROL UNIT**

The control unit is housed in a sturdy, suitcase-style portable case.

| <b>Cat. No.</b>   | <b>Dimensions</b>   | <b>Weight</b>      |
|---|---|--------------------|
| 220070, 220072, 220123,<br>2200124, 220163 and<br>2200164                   | 20 x 12 x 12 ½ in. (L x W x H)<br>(50.8 x 30.5 x 31.8 cm) | 23 lb<br>(10.5 kg) |
| 220070-47, 220072-47,<br>220123-47, 2200124-47,<br>220163-47 and 2200164-47 | 20 x 12 x 12 ½ in. (L x W x H)<br>(50.8 x 30.5 x 31.8 cm) | 25 lb<br>(11.4 kg) |

### **HV UNIT**

The HV unit is housed in a high-impact strength polyethylene housing with an adjustable shoulder carrying strap.

| <b>Cat. No.</b>                  | <b>Dimensions</b>                                      | <b>Weight</b>    |
|----------------------------------|--|------------------|
| 220070 and -47<br>22072 and -47  | 12 x 12 x 20 in. (L x W x H)<br>(30.5 x 30.5 x 51 cm)  | 44 lb<br>(20 kg) |
| 220123 and -47<br>220124 and -47 | 12 x 12 x 29 in. (L x W x H)<br>30.5 x 30.5 x 74 cm)   | 65 lb<br>(30 kg) |
| 220163 and -47<br>220164 and -47 | 12 x 12 x 29 in. (L x W x H)<br>(30.5 x 30.5 x 100 cm) | 73 lb<br>(33 kg) |

### **CABLE CARRYING CASE**

The cable carrying case is a sturdy canvas bag that holds all test cables, instruction manual, and test reports. Bag has convenient carrying handle and an adjustable shoulder strap.

| <b>Cat. No.</b>                  | <b>Dimensions</b>                                | <b>Weight</b>              |
|----------------------------------|--|----------------------------|
| 220070 and -47<br>220072 and -47 | 12 W x 17 H x 4 in. thick<br>(30.5 x 43 x 10 cm) | 7 lb (3 kg)<br>incl Cables |

| <b>Cat. No.</b> | <b>Dimensions</b>         | <b>Weight</b> |
|-----------------|---------------------------|---------------|
| 220123 and -47  | 15 W x 17 H x 4 in. thick | 9 lb (4 kg)   |
| 220124 and -47  | (38 x 43 x 10 cm)         | incl Cables   |
| 220163 and -47  |                           |               |
| 220164 and -47  |                           |               |

## TEST CABLES AND ACCESSORIES

- One 8-ft, 3-wire input supply cord
- Two 15-ft ground cables
- One 15-ft interconnection cable
- One 15-ft shielded HV output test cable, detachable
- Instruction Manual
- Kilovolt/megohm graph paper, 100-sheet pad (Cat. No. 220000).

## *Environmental*

**Operating Temperature Range:** -20 to 130°F (-30 to 55°C)

**Storage Temperature Range:** -40 to 150°F (-40 to 65°C)

**Relative Humidity:** 0 to 90% non-condensing (operating)  
0 to 95% non-condensing (storage)

### CAUTION

**Storage for extended periods of time at high temperature and relative humidity may cause degradation of the digital displays.**

## *Additional Accessories & Options Available*

| <b>Cat. No</b> | <b>Item</b>   |
|----------------|---|
| 222070-62      | Manual HV Resistance Discharge Stick, 60 to 70 kV   |
| 222120-62      | Manual HV Resistance Discharge Stick, 120 kV  |
| 222160-62      | Manual HV Resistance Discharge Stick, 160 kV  |
| 220004         | External Line Voltage Regulator   |
| 220003         | Miniature dc Current Recorder with two measuring ranges of 0 to 50 $\mu$ A and 0 to 500 $\mu$ A |
| Option 56      | Longer lengths of shielded HV output test cable. (50 ft maximum)                                |

# 4

## CONTROLS AND CONNECTORS

Table 2 describes the controls, indicators, and connectors of the test set. See Figures 4 and 5 for their location.

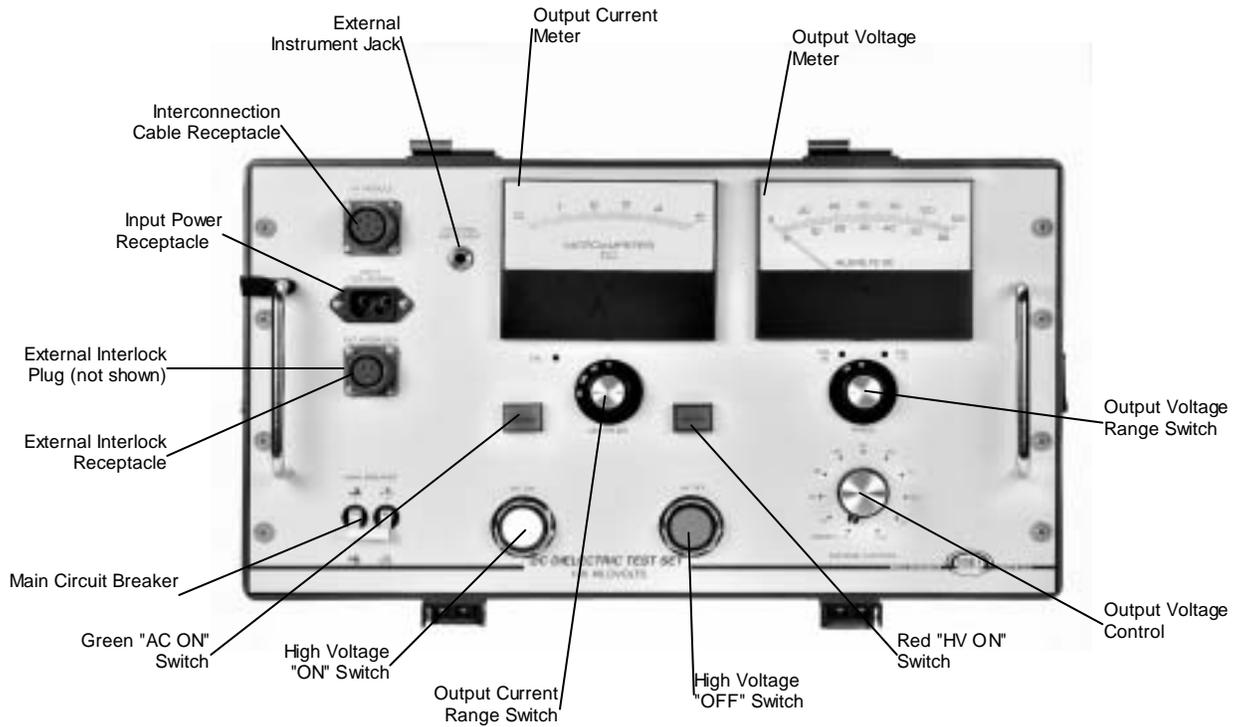
**Table 2: Test Set Control Identification**

| <b>Test Set Control</b> | <b>Description</b>   |
|-------------------------|--|
| MAIN BREAKER            | two-pole magnetic circuit breaker controls all power to the test set and provides short-circuit and overload protection.   |
| AC ON Lamp              | green light indicates circuit breaker ON, test set energized.  |
| HV ON Switch            | push-button switch controls an internal relay, energizing the test set and the HV ON lamp.   |
| HV ON Switch            | red light indicates HV is ON and voltage can be applied.   |
| HV OFF Switch           | push-button switch de-energizes line relay turns off red HV ON lamp.   |
| VOLTAGE CONTROL         | variable-ratio autotransformer adjusts output voltage by controlling primary voltage of HV power transformer, in conjunction with zero-start switch, which requires the control shaft in "0" (RESET) position for operation. |
| OUTPUT VOLTAGE          | Kilovoltmeter measures applied dc test voltage. Analog models provide two position range switch.   |
| OUTPUT CURRENT          | ammeter measures test sample current.  |
| Current RANGE           | 4-position rotary switch selects output current measuring range.   |

| Test Set Control | Description   |
|------------------|---|
| Voltage RANGE    | 2-position rotary switch selects upper or lower scale on analog metering  |
| EXT INTERLOCK    | receptacle allows connection of a normally open external interlock switch (test sets shipped with short-circuited plug, with removable jumper, inserted in receptacle). |



**Figure 4: Test Set and Cable Identification**



**Figure 5: Control Panel and Connector Identification**

**WARNING**

**When the external interlock circuit is open and the HV ON switch is depressed, the complete interlock circuit is energized at 120 V. The interlock circuit wiring must be insulated for 120 V.**

**EXTERNAL INSTRUMENT**

output jack (in series with current meter) allows connection of an auxiliary current-indicating meter or recorder. Standard 1/4- in. phone plug (not supplied) will fit this jack.

**WARNING**

**Never connect or disconnect an external instrument while the rest set is energized.**

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# 5

## OPERATION

### *Safety Precautions*

The output of the test set can be lethal. As with any high-voltage equipment, caution must be used at all times and all safety procedures followed. Refer to Section 2, Safety. Be sure that the test sample is de-energized and grounded before making connections. Make certain that no person can come in contact with the HV unit, the HV output terminal, or any material energized by the output. Use protective barriers if necessary. Locate the control unit in an area which is as dry as possible.

Be sure that adequate clearances are maintained between energized conductors or the HV unit 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 3 indicates minimum personnel clearances that will limit the danger of static induced voltages being developed on nearby insulated objects, including people. The HV unit should be treated as part of the energized circuit.

The clearances shown in Table 3 are absolute minimums. However, as a safety guide, Megger strongly recommends that clearances never be less than 6 ft (180 cm).

**Table 3: Minimum Air Clearances**

| <b>Voltage of Test (kV)</b> | <b>Minimum Personnel Clearances with Grounded Barrier</b> | <b>Minimum Personnel Clearances without Grounded Barrier</b> |
|-----------------------------|---|--|
| 5                           | 2 ft (60 cm)  | 2 ft (60 cm)   |
| 10                          | 2 ft (60 cm)  | 2 ft (60 cm)   |
| 20                          | 2 ft (60 cm)  | 2 ft (60 cm)   |
| 30                          | 2 ft (60 cm)  | 3 ft (90 cm)   |
| 40                          | 2 ft (60 cm)  | 3 ft (90 cm)   |

| <b>Voltage of Test (kV)</b> | <b>Minimum Personnel Clearances with Grounded Barrier</b> | <b>Minimum Personnel Clearances without Grounded Barrier</b> |
|-----------------------------|---|--|
| 50                          | 2.5 ft (60 cm)  | 4 ft (120 cm)  |
| 60                          | 3 ft (90 cm)  | 5 ft (150 cm)  |
| 70                          | 3.5 ft (110 cm)   | 6 ft (180 cm)  |
| 80                          | 4 ft (120 cm)   | 7 ft (210 cm)  |
| 100                         | 5 ft (150 cm)   | 9 ft (280 cm)  |
| 120                         | 6 ft (180 cm)   | 10 ft (310 cm)   |
| 140                         | 7 ft (210 cm)   | 12 ft (370 cm)   |
| 160                         | 8 ft (250 cm)   | 14 ft (430 cm)   |

## *Setting Up the Test Set*

### **WARNING**

**Make sure all safety grounds are in place before making any connections.**

To connect the test set to the cable or apparatus to be tested, perform the following procedure. Figures 6, 7 and 8 show the setup arrangement for testing cable samples.

1. Position the HV unit on a flat surface at least 3 ft (90 cm) away from the cable or apparatus to be tested, as well as any other structure.
2. Connect the wing thumb-nut GROUND terminal of the HV unit to a low-impedance earth ground using one of the 15-ft ground cables supplied with the test set.

### **NOTE**

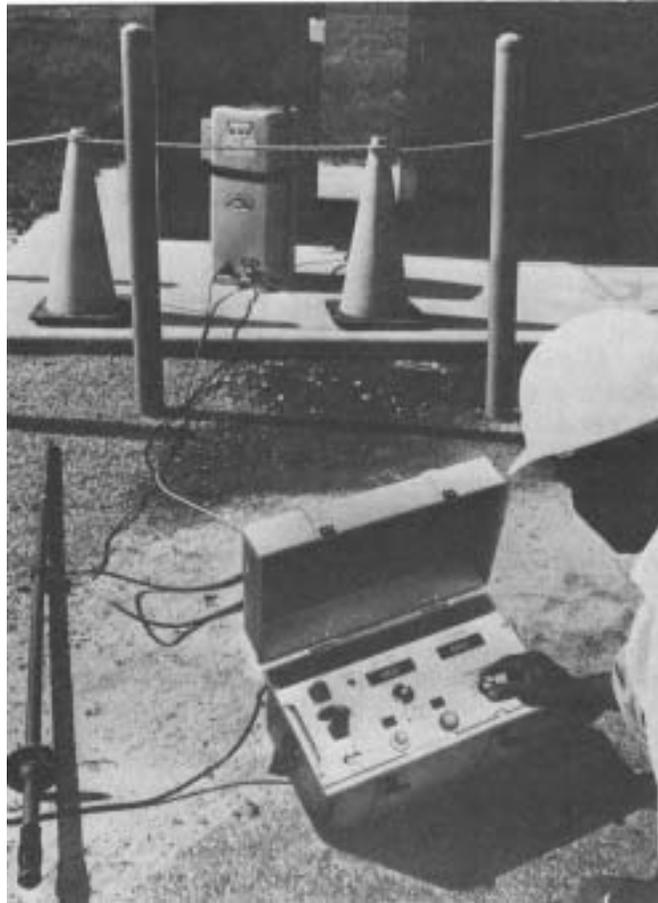
**The safety ground ("hot stick") should also be connected to earth ground.**

3. Connect the wing-thumb nut GROUND terminal of the HV unit to the test sample ground terminal using the second ground cable supplied with the test set.

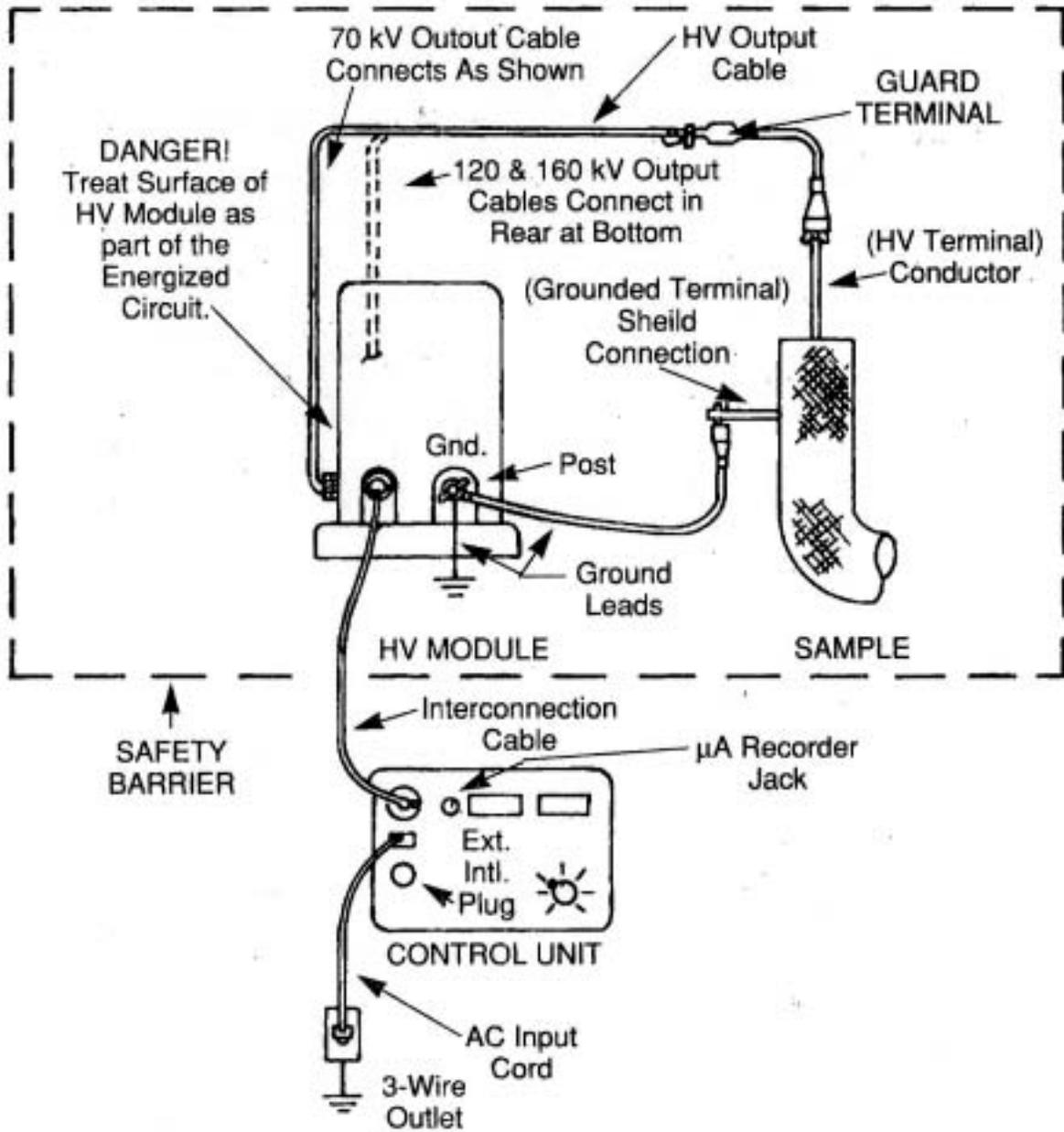
4. Position the control unit at least 6 ft (180 cm) away from the HV unit.
5. Connect the control unit to the HV unit with the interconnection cable. The plug shells should be fully screwed down on the receptacles.
6. Remove the protective cap from the HV terminal on the HV unit. Then connect the HV output cable to this terminal. Screw down the plug shell fully on the receptacle. Connect the alligator clip of the HV cable to the HV terminal of the sample to be tested.

### NOTES

- a. The exposed shield connection on the (outboard end of the HV output cable is at guard potential and must not be grounded. If a guarded test is to be run connect the cable shield to the guard lead of the sample to be tested.
  - b. Keep the core insulation at each end of this cable free from moisture and dirt during installation and operation and also protect this insulation from cuts and abrasions as corona will cause deterioration of the insulation. Clean as required with a clean, dry rag or one moistened sparingly with alcohol.
  - c. Drop the webbed carrying strap which wraps around the HV unit to the ground. This strap absorbs moisture and may increase the leakage current reading.
  - d. If the high-voltage termination of the test setup contains sharp points or corners or is in close proximity to grounded objects, the adjacent air may be ionized by electrical stress when energizing the test sample. This can cause excessive leakage current and since such current can be significant, it may tend to mask the true sample current. To minimize this effect the exposed high-voltage termination should be spaced as far as possible from grounded objects or it should be covered with Kearney Air Seal or similar compounds. Another very effective method of preventing excessive leakage current is to wrap the exposed high-voltage termination with a thin plastic film or bag.
7. Insert the external interlock plug into the receptacle marked EXT INTERLOCK. This plug must be wired to an external interlock switch or short-circuited with a jumper (Pins 1 and 3 of interlock plug). When connection is made to an external interlock switch, it is recommended that two conductor-shielded wires be used and the shield connected to Pin 2 of the interlock plug.
  8. With the MAIN BREAKER switched off, plug input power cord into control panel receptacle and into three-wire grounded power outlet.



**Figure 6: Typical Test Setup Arrangement**



**Figure 7: Test Setup for Typical Cable Tests (Without Guarding)**

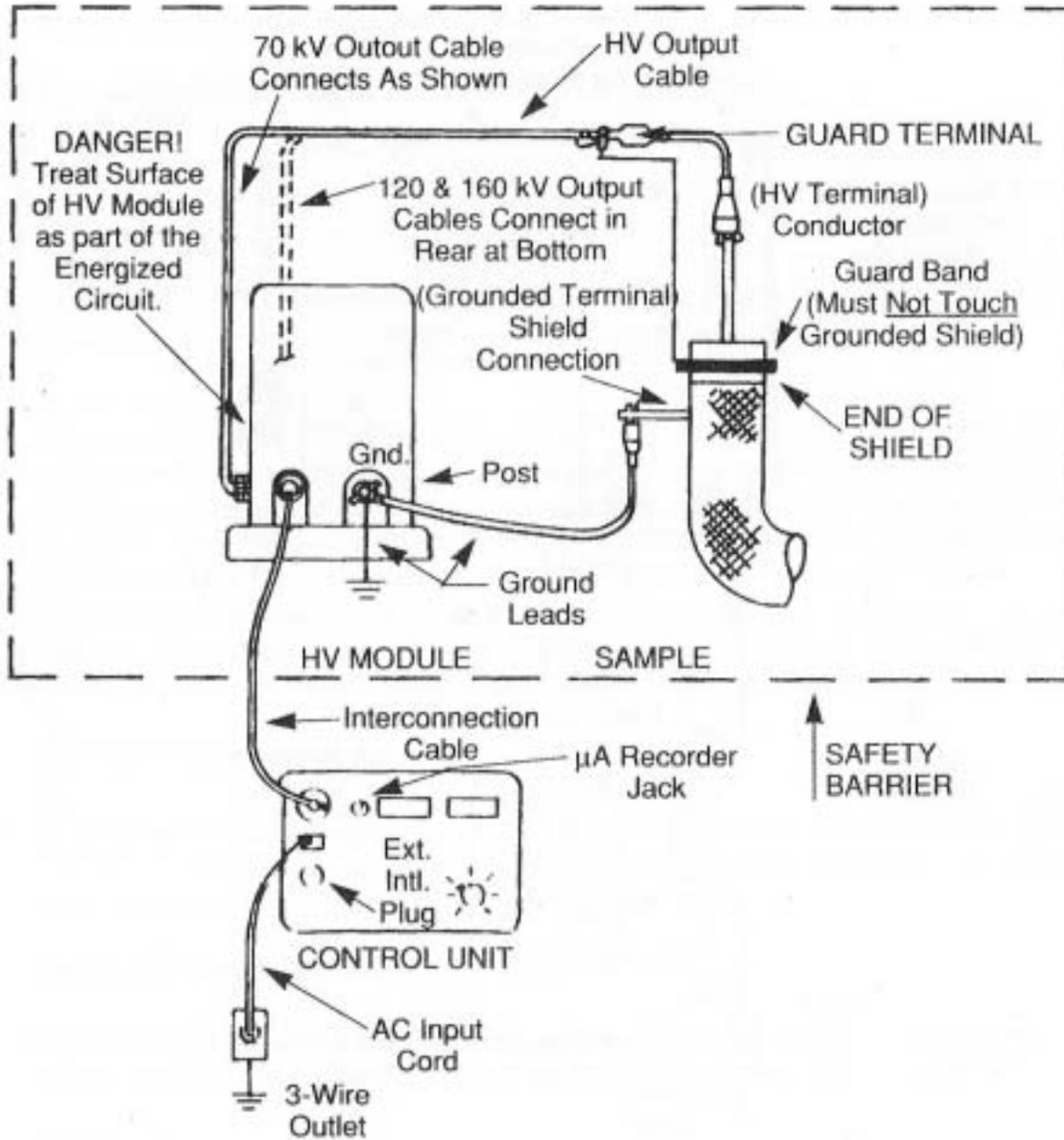


Figure 8: Test Setup for Typical Cable Tests (With Guarding)

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## Operating Procedure

Proceed only after fully understanding Section 2, Safety, and setting up the test set as described. An operator familiar with the contents of this manual, the test setup and the operation of the test set may follow the condensed operating procedure in the lid of the test set. The following is a step-by-step procedure for conducting a test on a sample.

1. Remove all safety grounds from the sample, to be tested.
2. Energize the test set by closing the MAIN BREAKER switch. The green AC ON lamp and the two digital panel meters should light.
3. Initially set the current RANGE switch to the 5 mA range (x1K on analog models).
4. Close the external interlock switch, if used.
  - 4a. On analog sets, select desired voltage RANGE.
5. Set the VOLTAGE CONTROL to "0" (RESET), then depress the HV ON push-button switch. The red HV ON lamp should light.

|                |
|----------------|
| <b>WARNING</b> |
|----------------|

|   |
|---|
| <b>The test set is now capable of producing high voltage at the output.</b> |
|---|

6. Advance the VOLTAGE CONTROL slowly until the desired test voltage is read on the OUTPUT VOLTAGE kilovoltmeter.
7. Maintain the test voltage for the desired period of time. The OUTPUT CURRENT meter indicates the leakage current of the sample under test. Set the current RANGE switch to the desired current range.
8. After maintaining the test voltage for the desired time, turn the VOLTAGE CONTROL slowly in the counterclockwise direction to "0" (RESET).
9. Depress the HV OFF push-button switch or open the external interlock switch.
10. Allow sufficient time for the test sample charge to bleed off, which is indicated when the kilovoltmeter reading returns to zero.

11. Switch the MAIN BREAKER off. The green AC ON lamp and the two digital panel meters should now be out.

## WARNING

**The test sample may retain a lethal electrical charge even when the test set is turned off. Discharge the test sample with a safety ground ("hot stick") to ground all live parts, then solidly ground these parts with a ground bond. Keep the HV terminal of the sample and the test set's HV output cable grounded at all times except when actually performing tests. Do not approach the HV unit until the test set's HV output cable has been grounded.**

## CAUTION

**In case of an emergency, power can be interrupted immediately by either switching the MAIN BREAKER off or opening the external interlock switch. This procedure should be followed only when absolutely necessary, since it risks damage to both the test set and the test sample.**

12. Disconnect the test set cables in the following sequence: Disconnect the HV output cable first from the sample, then from the test set; then disconnect the input power cord; then disconnect the interconnection cable; and finally disconnect the two ground cables.

## Operation Notes

1. In the event of a test sample breakdown or an excessive load current, either the MAIN BREAKER or line relay will trip out. The VOLTAGE CONTROL must be returned to the "0" (RESET) position before high voltage can be applied again.
2. A high-voltage resistance discharge stick may be used initially to ground the test sample high-voltage terminal to hasten the sample discharge after the kilovoltmeter indicates the voltage has diminished to a low, safe level.
3. If excessive leakage current is observed, it may be due to a high corona high-voltage termination. Refer to the setup instructions. It should also be noted that the test set measures the total test sample current including surface leakage, unless guarded.
4. When measuring the leakage current of test samples which have a significant capacitance, small line voltage transients may cause large transient swings of the current meter. This effect will be most noticeable when using the

20  $\mu\text{A}$  (x1) range and will require that the operator judge the indicated current value by visually and mentally averaging the value. The transient swing can be substantially reduced with an external Line Voltage Regulator, Megger Cat. No. 220004.

5. Occasionally when measuring a test sample the leakage current of interest is masked by a parallel path. This is often encountered when measuring the leakage current of a cable. The value of current along the leakage path from the conductor over the insulation surface to ground may be greater than that within the major length of cable. Under such conditions, the guard feature of the test set is useful in excluding the undesired surface leakage current. This is accomplished by forming an intercepting electrode around the outer insulation surface between the conductor and the ground shield. The electrode may be made by tightly wrapping bare wire or a conductive band around the insulation surface close to ground. The electrode should then be connected to the guard terminal of the high-voltage output cable. Figure 8 illustrates this guarding. It should be noted that the guard circuit is only a few volts above ground. The exposed shield connection on the output end of the HV output cable is at guard potential and must not be grounded.

## ***Performance Check***

### **PRELIMINARY CHECKS**

Proceed only after fully understanding Section 2, Safety, and the Setting-Up and Operating Procedures.

Set up the test set as described in "Setting Up the Test Set" except do not connect the outboard end of the HV cable to a test sample. Cover the exposed HV termination with a thin plastic bag and suspend it in free air using dry nylon rope, so that it is clear of all surrounding objects by at least 4 ft (120 cm).

1. Set the MAIN BREAKER to the ON position. The AC ON lamp should light. The digital OUTPUT CURRENT meter should read:

0.0 on 20  $\mu\text{A}$  range

00 on 200  $\mu\text{A}$  range

0.00 on 2 mA range

0.00 on 5 mA range

The analog OUTPUT CURRENT meter should read:

0 at multipliers of 1k, 100, 10 and 1.

The OUTPUT VOLTAGE meter should read 00.0.

2. Remove the EXT INTERLOCK plug from the control panel and set the VOLTAGE CONTROL to 10. Press the HV ON push button. The HV ON lamp should not light. Turn the VOLTAGE CONTROL to "0" (RESET).

Press the HV ON push button. The HV ON lamp should light only while the push button is depressed. Replace the EXT INTERLOCK plug.

Press the HV ON push button. The HV ON lamp should light and remain lighted when the push button is released.

3. Rotate the VOLTAGE CONTROL knob to 10. The HV ON lamp should remain lighted. The OUTPUT VOLTAGE meter should read voltage. The value should be approximately 10 percent of the rated output voltage. The OUTPUT CURRENT meter should read zero on all current ranges.
4. Press the HV OFF push button. The HV ON lamp should go out. The digital displays should remain lighted. The AC ON lamp should remain lighted.
5. Switch the MAIN BREAKER to the OFF position. All lamps and digital displays should go out.
6. If there are no malfunctions, proceed to Voltage Withstand Test.

## ***Voltage Withstand Test***

The test setup is the same as for the preliminary check. Proceed with the test as follows:

1. Set the OUTPUT CURRENT meter to the 20  $\mu\text{A}$  (x1) range.
2. Energize the test set, and then slowly raise the output voltage to the specified voltage control settings. Hold at each setting for the specified time interval.

| <b>Voltage Control Scale Setting</b> | <b>Time Interval</b> |
|--------------------------------------|----------------------|
| 70                                   | 1 min                |
| 80                                   | 1 min                |
| 90 (rated output)                    | 5 min                |

There should be no breakdowns and the output current for a new unit should not exceed 0.1  $\mu\text{A}$ .

3. Return the voltage control to "0" (RESET), then depress the HV OFF push button.

4. Allow sufficient time for the internal charge to bleed-off, which is indicated when the output voltage reading returns to zero.
5. Switch the MAIN BREAKER to the OFF position.
6. Puncture the plastic bag on the outboard end of the HV output cable with a safety ground (hot stick). Then ground the alligator clip of the HV cable with the hot stick and solidly ground the clip with a ground bond.

## CURRENT METER OPERATION AND CURRENT OVERLOAD TRIP

1. Connect the alligator clip of the HV cable to the GROUND terminal on the HV unit.
2. Set the RANGE selector switch to the 2 mA (x100) range.
3. Energize the test set then slowly advance the VOLTAGE CONTROL from "0" (RESET) until the current meter indicates a minimum reading. A normal reading is anywhere between 200  $\mu$ A and 2 mA.
4. Set the RANGE switch to the 200  $\mu$ A (x10) range. The OUTPUT CURRENT meter should indicate an overrange.
5. Set the RANGE switch to the 20  $\mu$ A (x1) range. The OUTPUT CURRENT meter should also indicate an overrange.
6. Set the RANGE switch to the 5 mA (x1K) range. The OUTPUT CURRENT meter should indicate approximately the same value as obtained in step 3.
7. Advance the VOLTAGE CONTROL until either the MAIN BREAKER or line relay trip-outs. This should occur at a current value between 3 and 4 mA.

### NOTE

**Trip-out at the nominal 5.5 mA overload value will only occur when the test set is connected to a normal resistance load.**

8. This completes the performance check. Disconnect the test set cables in the following sequence: disconnect the HV output cable first; then disconnect the input power cord; then disconnect the interconnection cable; and finally disconnect the two ground cables.

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# 6

## APPLICATION NOTES

### *Theory*

Any device that uses electrical energy can ordinarily be considered as consisting of elements that may be classified in two separate categories; 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 measures 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 current, 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 following references contain detailed information on the subject of dc testing:

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.

Guide for Making High Direct Voltage Tests on Power Cables in the Field. IEEE Standard P400.

Standard Handbook for Electrical Engineers. Donald G. Fink and John M. Carroll, McGraw-Hill, 1968.

## *Circuit Description*

The schematic diagrams of Figures 9 and 10 show the electrical operation of the 70-kV test set and the 120 and 160-kV test sets, respectively.

Power is supplied to the test set through the three-conductor input cable. The green wire of this cable conforms to electrical code requirements and provides a separate panel ground connection. For safety purposes two separate ground cables are provided to prevent a shock hazard to the operator or damage to the test set. The ground lead connected to the test sample provides a current return path to the test set while the other ground lead permits connection to a known earth ground.

Input power is brought directly to the main power switch K1, a magnetic circuit breaker of the trip-free type. This switch also serves as the test set on/off switch. A second pole on this circuit breaker provides protection for autotransformer T1 so that under all overload circumstances at least one pole will have a current overload. If either circuit breaker pole is tripped by overload, both poles will open.

Test sets equipped with the 240 V 50/60 Hz option differ from standard sets only in that a separate step-down transformer (T2) is connected in series with the input. It is connected between the input power cord and main power circuit breaker K 1. The 240 V ac input is stepped down to 120 V ac before reaching the circuit breaker. This transformer is wired as an autotransformer to minimize the required kVA rating and thus reduce size and weight. With this option, line fuses F1 and F2 are connected in the two input lines to provide protection to step-down transformer T2 in case of a malfunction. The step-down transformer and fuses are mounted in the bottom of the instrument case.

The power controlled by K1 is brought to relay K2. Autotransformer T2 receives power under control of K2. Output voltage is controlled by the variable autotransformer T1, whose output feeds the primary of the high-voltage transformer T101 via the test set interconnection cable. The shield of the interconnection cable provides a second ground for the test set control panel.

The zero-start safety feature of this test set requires that the voltage control T1 be set at "0" (RESET) in order for the advance of the voltage control to develop an output voltage. This feature is a function of control relay K2, whose contacts remain open after the power source is connected and after circuit breaker K1 is closed. This prevents the application of voltage to the input of high-voltage transformer T101 until the contacts of relay K2 are mechanically closed. The contacts are closed by "0" (RESET) positioning of variable voltage control T1, which closes zero-start switch E1, and by depressing HV ON switch S1. The external-interlock circuit must also be closed before relay K2 can be energized. The test sets are shipped with external interlock plug P2 short-circuited with a

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removable jumper; therefore, when connection is made to a normally open external interlock switch, this switch must also be closed.

The contacts of relay K2 remain closed until power is removed by operation of HV OFF switch S3, opening of an external interlock switch or opening of the main circuit breaker switch K1. To reestablish output, power must again be applied and the voltage control set to zero.

In the 70 kV test set, transformer T101, rectifiers CR101 and CR102, and capacitors C101 and C102 form a Cockcroft-Walton voltage doubling rectifier circuit that provides the required dc output voltage. Resistors R101 and R102 provide current overload protection to the rectifiers. Resistor R107 provides current limiting protection of the output to help prevent damage to a test sample during a breakdown. Resistor R103 is a safety bleeder resistor to discharge high voltage capacitors C101 and C102 when the test set is disconnected.

Resistor R105 is the high-voltage portion of a voltage divider circuit used for measuring the actual dc output voltage. Spark gaps El 01 and El 02 are included to prevent a shock hazard to the operator or damage to the test set in the event of a test sample breakdown.

The high-voltage section of the 120 kV and 160 kV test sets is similar in operation to that of the 70 kV test set. The circuit used in these units is a Cockcroft-Walton voltage quadrupler circuit.

The digital voltmeter metering circuit is composed of digital panel meter M2, resistors R9 and R 10, and capacitor C6. Resistor R9 is adjustable to calibrate the voltmeter. The analog voltmeter metering circuit is composed of analog panel meter, resistors R105 and R106 and capacitor C6. Resistors R105 and R106 are adjustable to calibrate the voltmeter in the 40 and 80 kV, 60 and 120 kV, 80 and 160 ranges respectively. Capacitor C6 provides meter damping for line voltage transients. An additional capacitor C9 provides meter protection from high frequency surges, while transient voltage suppressor CR2 provides overvoltage protection.

The resultant ground current in the test sample is measured by the four-range analog meter or the digital panel meter M1. Current meter ranges are selected by the front panel MULTIPLIER or RANGE switch. The digital range selector resistors consist of resistors R1 through R8. Resistors R1, R2, R3 and R4 are adjustable resistors to calibrate the respective 5 mA, 2 mA, 200  $\mu$ A and 20  $\mu$ A ranges. Capacitors C2 through C5 provide meter damping for line voltage transients. An additional capacitor C8 provides meter protection from high frequency surges, while transient voltage suppressor CR1 provides overvoltage protection. The analog multiplier selector resistors consist of resistors R1 through R7. Resistor R1 is adjustable to calibrate the ammeter. The output of the multiplier selector circuit goes to the input of the METER AMPLIFIER U4. The meter amplifier drives the analog meter M1. As a convenience, a jack (J4) is

provided so that the current in the test sample can be monitored by an external device such as a recorder.

The test set also contains a dc current overload relay (K3), which is adjusted by resistor R11, to trip out the high-voltage circuit when the dc current exceeds a nominal value of 5.5 mA. The relay includes a set of normally closed contacts in series with the coil of 120 V ac control relay K2. When an overload current exits the K3 relay contacts open. This opens the coil circuit of K2 and thereby removes high-voltage power from the test set via the K2 relay contacts. After a trip-out occurs, the voltage control must be returned to zero before test set output voltage can be obtained. Capacitor C9 provides relay protection from high-frequency surges, while spark gap DS3 provides overvoltage protection. The "C" switch deck of S4 is used for decimal point selection on digital panel meter M1, while the "B" deck is used for blanking of the least significant digit of M1 when using the 20 mA, 200 mA, and 2 mA current ranges. Power supply PS1 provides the +5 V dc power necessary to energize digital panel meters M1 and M2. Both panel meters are identical and may be interchanged, without disturbing calibration of the voltage or current ranges, when troubleshooting a test set malfunction.

The guard connection on the outboard end of the HV output cable is used to bypass leakage current around the current meter. This connection must not be grounded since this would short-circuit the current meter.

Because of the many different input plugs in general use, the input cable has been provided with a plug for which adaptors are readily available for 220/240 V operation. If use of an adaptor is not desirable, the plug supplied can be cut off and replaced with the plug best suited to the service conditions. The green lead of the input cable is to be connected to ground, the white to line neutral, and the black to the "hot" side of the line.

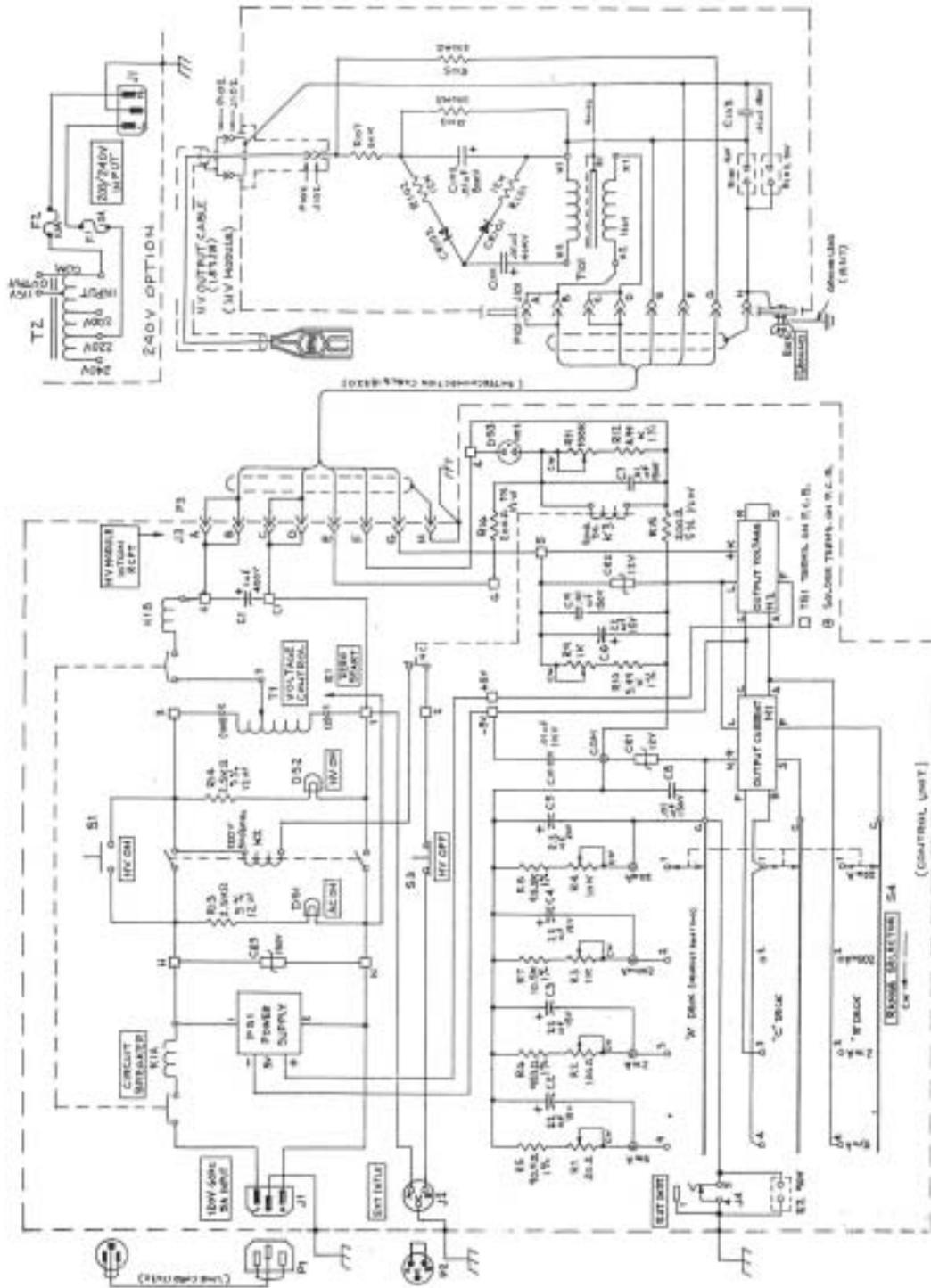


Figure 9: Schematic Diagram, 70 kV Test Set

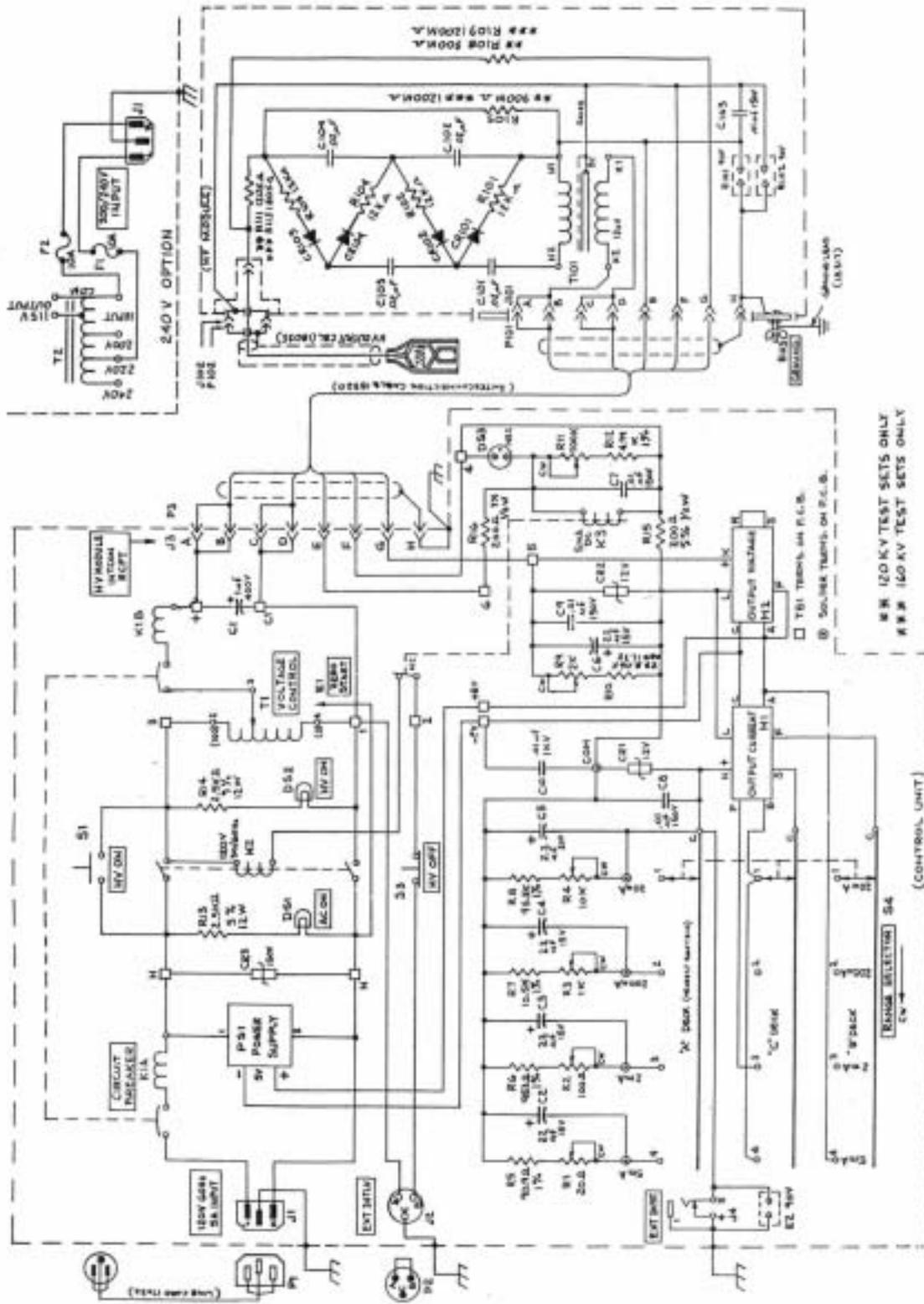


Figure 10: Schematic Diagram, 120 and 160 kV Test Set



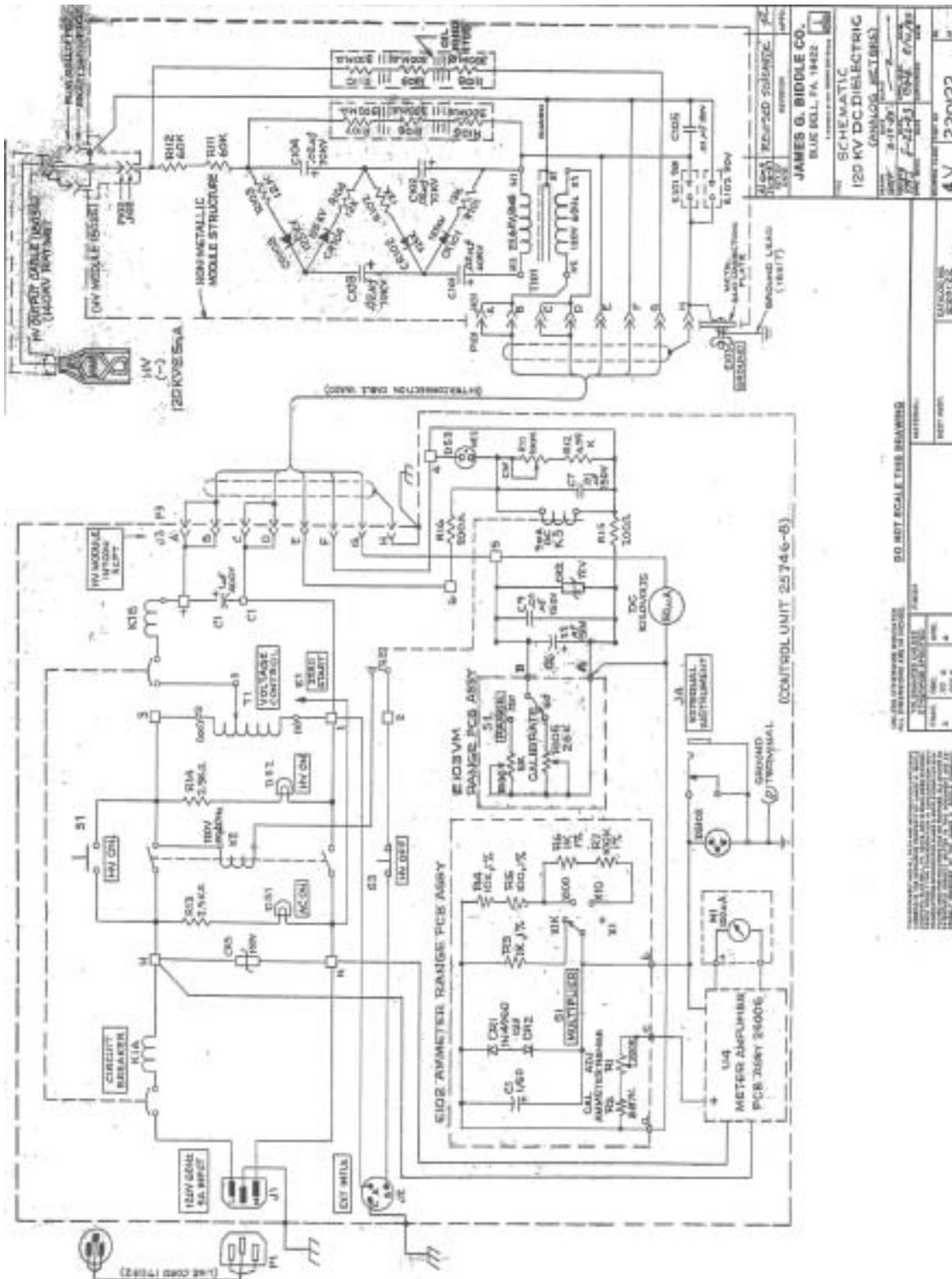


Figure 12: Analog Meter Schematic Diagram Test Set, 120 kV

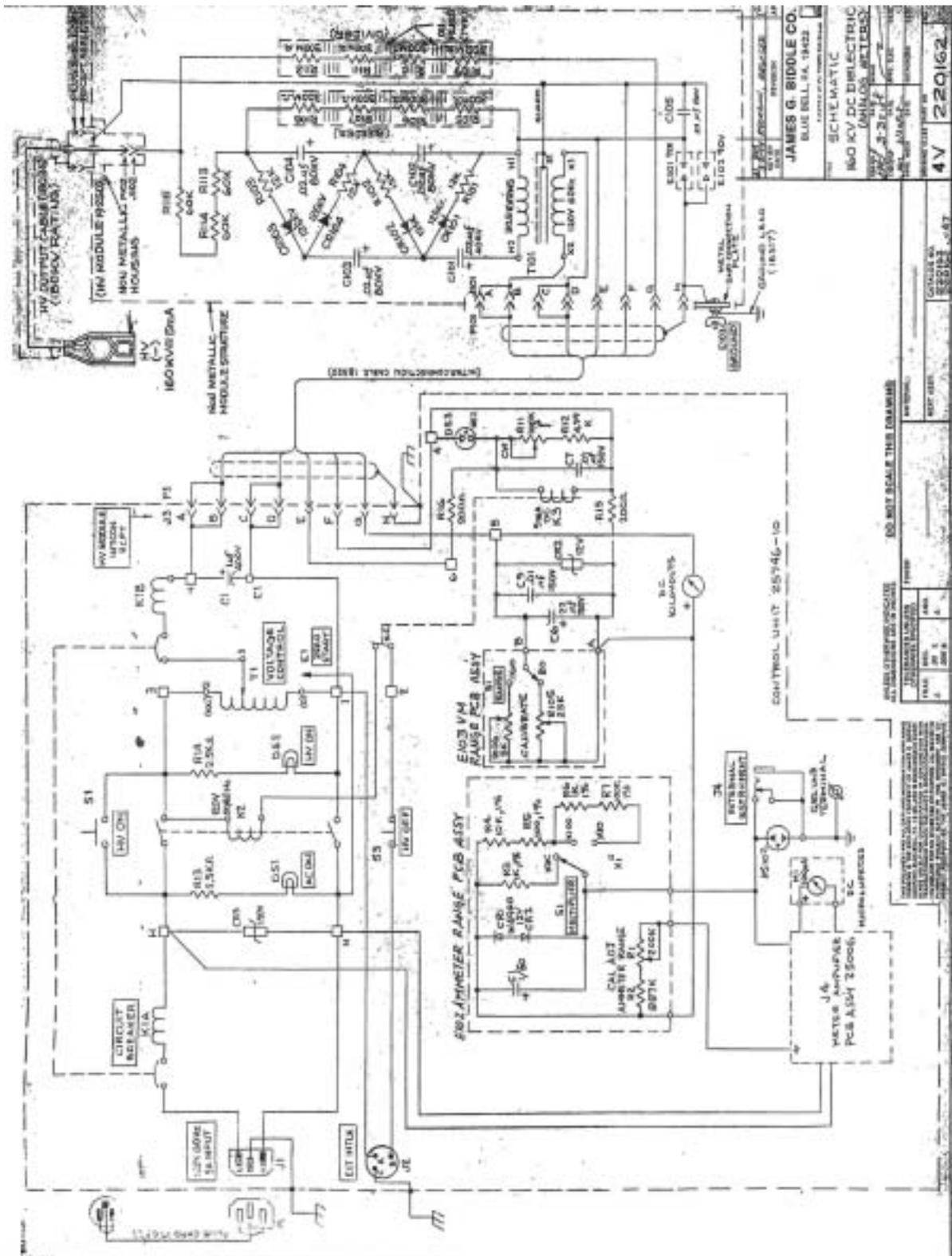


Figure 13: Analog Meter Schematic Diagram Test Set, 160 kV

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# 7

## ROUTINE MAINTENANCE

### *Simple Maintenance*

#### WARNING

**Maintenance and calibration should only be carried out by qualified personnel familiar with high-voltage test equipment and testing techniques. These personnel should be aware of the hazards involved and must take all necessary safety precautions required to prevent injury.**

Routine maintenance is all that is required for these dielectric test sets. The cable should be inspected frequently to be sure all connections are tight and all ground connections intact. The appearance of the test set can be maintained by occasional cleaning of the case and panel of the control unit and the enclosure of the HV unit.

Contamination of some parts of the high-voltage structure will show up as residual current meter readings. Cleaning these sensitive parts will remove the leakage paths which are the cause of the unwanted leakage current.

### COSMETIC CLEANING

#### 1. **Control Unit Carrying Case:**

The outside of the carrying case can be cleaned with detergent and water. Dry with a clean, dry cloth.

#### 2. **Control Unit Panel:**

The panel can be cleaned with a cloth dampened with detergent and water. Water must not be allowed to penetrate panel holes, as it may adversely affect components on the underside. Household furniture spray wax can also be used to clean the panel. Polish with a soft, dry cloth.

#### 3. **HV Unit Enclosure:**

The outside of the enclosure and base can be cleaned with isopropyl alcohol or denatured alcohol. Stubborn dirt may require cleaning with mineral spirits which should then be rinsed with alcohol as above.

## FUNCTIONAL CLEANING

### 1. **HV Cable:**

A portion of the polyethylene or rubber insulation is exposed at each end of the HV cable. Dirt, fingerprints, etc. on the surface of these exposed portions will cause leakage under voltage stress, which will appear as a spurious reading on the instrument current meter. The exposed insulation can be cleaned with isopropyl alcohol or denatured alcohol applied with a clean cloth.

### 2. **HV Outlet Tube:**

The HV outlet tube is located inside the HV unit, at the rear, where the HV cable plugs in. The outlet tube may become a high-voltage leakage path if dirt or dust accumulate on the inside surface. The tube can be cleaned with isopropyl alcohol or denatured alcohol on a small piece of clean cloth. The cloth is inserted using a piece of flexible wire with a small loop formed on the end of hold the cloth. The wire must be approximately 18 in. (46 cm) long to reach the full depth of the tube and still allow a suitable hand hold. Care must be taken that no sharp points on the wire are allowed to score the inside surface of the output tube.

## *Calibration*

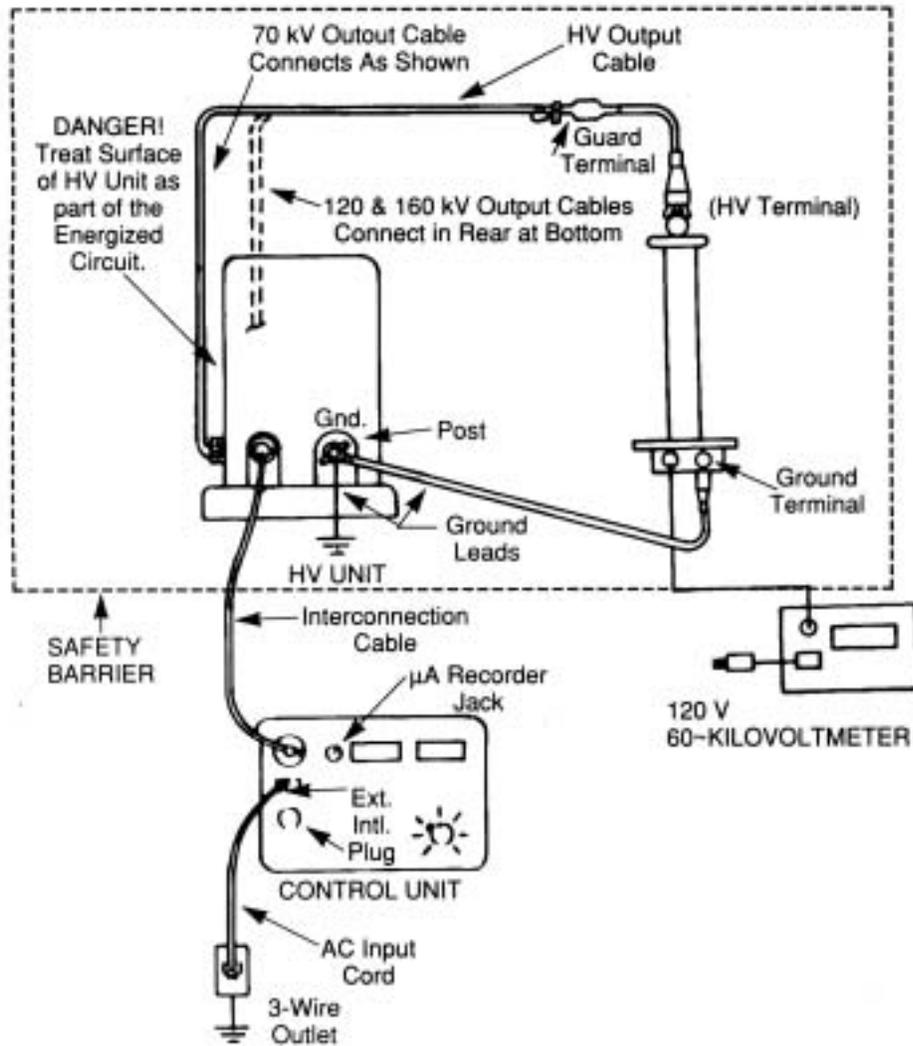
A complete Performance Check, as described in Section 5, should be performed on the test set prior to making any calibration checks. This will ensure that the test set is functioning properly.

## KILOVOLT METER CALIBRATION

Connect the test set to a standard high-voltage kilovoltmeter. The test setup is shown in Figure 11. Observe the setting up procedure described in Section 5.

Proceed as follows:

1. Set the OUTPUT CURRENT meter to the 200  $\mu$ A (x100) range.
2. Energize the test set and then slowly raise the output voltage to the unit's rated operating voltage as indicated on the standard kilovoltmeter. On a digital set, adjust trimmer R9 located on the printed circuit board within the control unit until the OUTPUT VOLTAGE meter matches the standard kilovoltmeter. On an analog set, adjust trimmer R105 or R106 for the low range and high range, respectively.



**Figure 14: Dielectric Test Set Kilovoltmeter Calibration**

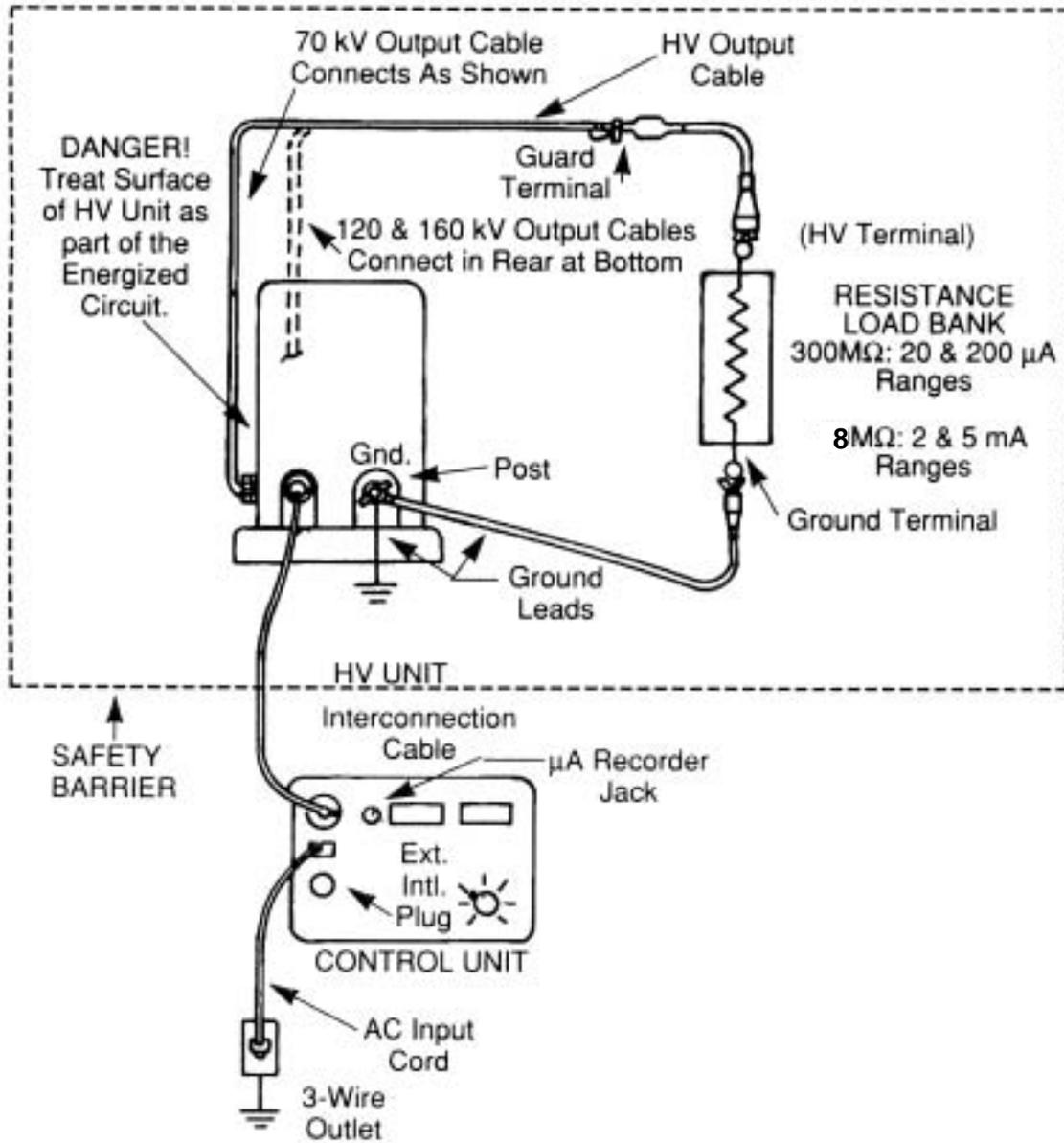
3. Retain the voltage control to "0" (RESET), then de-energize the test set and ground the alligator clip of the HV output cable, following the operating procedures described in Operation Section 5.

## CURRENT METER CALIBRATION

1. Connect a digital multimeter to the test set's EXTERNAL INSTRUMENT jack. A standard 1/4" phone plug will fit this jack. Use shielded cable for this connection and connect the shield to the negative voltage terminal of the multimeter and the plug shell; center conductor to positive terminal and insulated center pin of plug.

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2. Connect the test set to the appropriate value resistive load bank as shown in Figure 12. Observe the setting up procedure described in Section 5.



**Figure 15: Dielectric Test Set Current Meter Calibration**

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## 20 $\mu$ A AND 200 $\mu$ A RANGES (DIGITAL SETS)

1. Connect the test set to a nominal 300 M $\Omega$  resistance load which has a voltage rating of at least 70 kV, and a wattage rating of at least 20 W.
2. Set the test set RANGE selector switch to the 20  $\mu$ A range, and set the digital multimeter to its correct dc current range.
3. Energize the test set and then slowly raise the output voltage until the digital multimeter reads 18  $\mu$ A. If necessary, adjust trimmer R4 located on the printed circuit board within the control unit, until the OUTPUT CURRENT meter matches the digital multimeter to its correct dc current range.
4. Set the test set RANGE selector switch to the 200  $\mu$ A range, and set the digital multimeter to its correct dc current range.
5. Adjust the test set VOLTAGE CONTROL until the digital multimeter reads 150  $\mu$ A. If necessary, adjust trimmer R3 until the OUTPUT CURRENT meter matches the digital multimeter reading.
6. Return the VOLTAGE CONTROL to "0" (RESET), then de-energize the test set and ground the alligator clip of the HV output cable, following the operating procedure described in Section 5.

## 2 mA AND 5 mA RANGES AND CURRENT OVERLOAD TRIP (DIGITAL SETS)

1. Connect the test set to a nominal 8 M $\Omega$  resistance load which has a voltage rating of at least 70 kV and a wattage rating of at least 250 W.
2. Set the RANGE selector switch to the 2 mA range, and set the digital multimeter to its correct dc current range.
3. Energize the test set and then slowly raise the output voltage until the digital multimeter reads 1.9 mA. If necessary, adjust trimmer R2 until the OUTPUT CURRENT meter matches the digital multimeter reading.
4. Set RANGE selector switch to the 5 mA range, and set the digital multimeter to its correct dc current range.
5. Adjust the VOLTAGE CONTROL until the digital multimeter reads 4.5 mA. If necessary, adjust trimmer R1 until the OUTPUT CURRENT meter matches the digital multimeter reading.
6. Advance the VOLTAGE CONTROL slowly and note the reading of the OUTPUT CURRENT meter when trip-out occurs. If necessary, adjust trimmer R11 for trip out at 5.5  $\pm$ 0.2 mA.

7. Return the VOLTAGE CONTROL to "0" (RESET), then de-energize the test set and ground the alligator clip of the HV output cable, following the operating procedures described in Section 5.
8. This completes the calibration procedure. Disconnect the test set cables in **the following sequence:**
  - a. disconnect the HV output cable from the resistance load bank
  - b. disconnect the HV output cable from the test set
  - c. disconnect the input power cord
  - d. disconnect the digital multimeter
  - e. disconnect the interconnection cable
  - f. disconnect the two ground cables

## 5 $\mu$ A RANGE (ANALOG SETS)

1. Connect the test set to a nominal 300 M $\Omega$  resistance load which has a voltage rating of at least 70 kV and a wattage rating of at least 20 W.
2. Set the test set RANGE selector to the x1 multiplier and set the digital multimeter to its correct dc current range
3. Energize the test set and then slowly raise the output voltage until the digital multimeter reads 5  $\mu$ A. If necessary adjust trimmer R3 located on the Meter Amplifier printed circuit board (PCB 25006) until the OUTPUT CURRENT meter matches the digital multimeter.
4. Return the VOLTAGE CONTROL to "0" and de-energize the test set and ground the alligator clip of the HV output cable following the procedure described in Section 5.

## 50 $\mu$ A RANGE (ANALOG SETS)

1. Connect the test set to a nominal 300 M $\Omega$  resistance load which has a voltage rating of at least 70 kV and a wattage rating of at least 20 W.
2. Set the test set RANGE selector to the x10 multiplier and set the digital multimeter to its correct dc current range.
3. Energize the test set and then slowly raise the output voltage until the digital multimeter reads 50  $\mu$ A. If necessary adjust trimmer R1 located on the ammeter range printed circuit board (E102) until the OUTPUT CURRENT meter matches the digital multimeter.
4. Return the VOLTAGE CONTROL to "0" and de-energize the test set and ground the alligator clip of the HV output cable following the procedure described in Section 5.

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### 500 $\mu$ A RANGE (ANALOG SETS)

1. Connect the test set to a nominal 8 M $\Omega$  resistance load which has a voltage rating of at least 70 kV and a wattage rating of at least 250 W.
2. Set the test set RANGE selector to the x100 multiplier and set the digital multi-meter to its correct DC current range.
3. Energize the test set and then slowly raise the output voltage until the OUTPUT CURRENT meter indicates full scale. The digital multi-meter must read between 490 $\mu$ A and 510 $\mu$ A. If the reading is not within specification then the Ammeter Range PCB (E102) is defective and should be replaced.
4. Return the VOLTAGE CONTROL to "0" and de-energize the test set and ground the alligator clip of the HV output cable following the procedure described in Section 5.

### 5MA RANGE AND OVER CURRENT TRIP (ANALOG SETS)

1. Connect the test set to a nominal 8 M $\Omega$  resistance load which has a voltage rating of at least 70 kV and a wattage rating of at least 250 W.
2. Set the test set RANGE selector to the x1K multiplier and set the digital multi-meter to its correct DC current range.
3. Energize the test set and then slowly raise the output voltage until the OUTPUT CURRENT meter indicates full scale. The digital multi-meter must read between 4.90mA and 5.10mA. If the reading is not within specification then the Ammeter Range PCB (E102) is defective and should be replaced.
4. Advance the VOLTAGE CONTROL slowly and note the reading of the digital multi-meter when trip-out occurs. If necessary, adjust trimmer R11 for trip-out at 5.5 +/- 0.2 mA.
5. Return the VOLTAGE CONTROL to "0" and de-energize the test set and ground the alligator clip of the HV output cable following the procedure described in Section 5.

Megger

# 8

## TROUBLESHOOTING AND REPAIR

### *Troubleshooting*

The Troubleshooting Guide, Table 4, is arranged to follow the sequence of the performance check covered in Section 5. The table gives possible equipment malfunctions observed during operation or check-out and suggests the possible cause and the means of determining the defective component. Refer to the schematic diagrams of Figures 9 and 10 and to the internal component illustrations of Figure 13 and 14 for help in locating the components.

#### **WARNING**

**This is high-voltage equipment and contains dangerous voltages; repairs must only be made by those well qualified to deal with such hazards and familiar with routine precautions required to prevent injury.**

Since high voltage can be stored in components of the test set interior even after the set has been de-energized, it is recommended that the test set be de-energized for at least 15 minutes prior to any attempt to gain access to the interior.

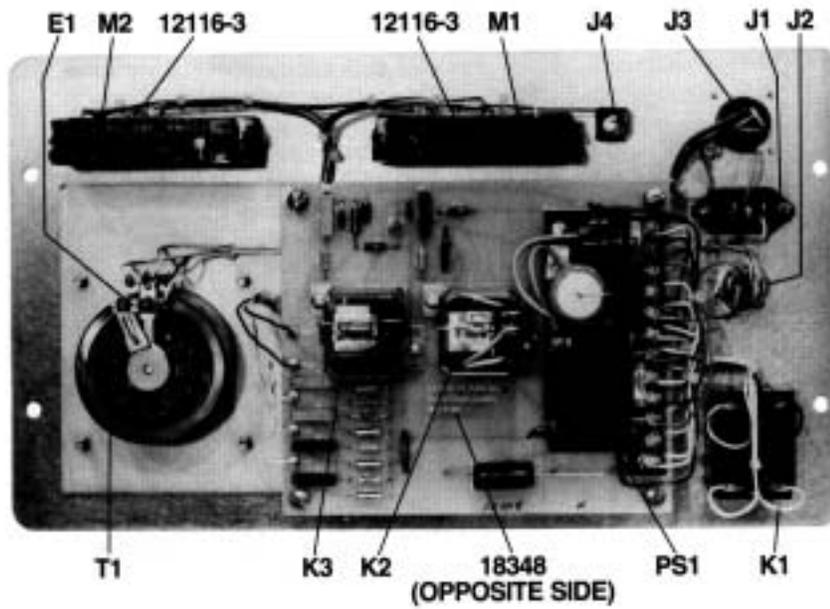
When troubleshooting the control unit, the HV unit should be completely disconnected from the control unit to prevent accidental high-voltage feedback.

**Table 4: Troubleshooting Guide**

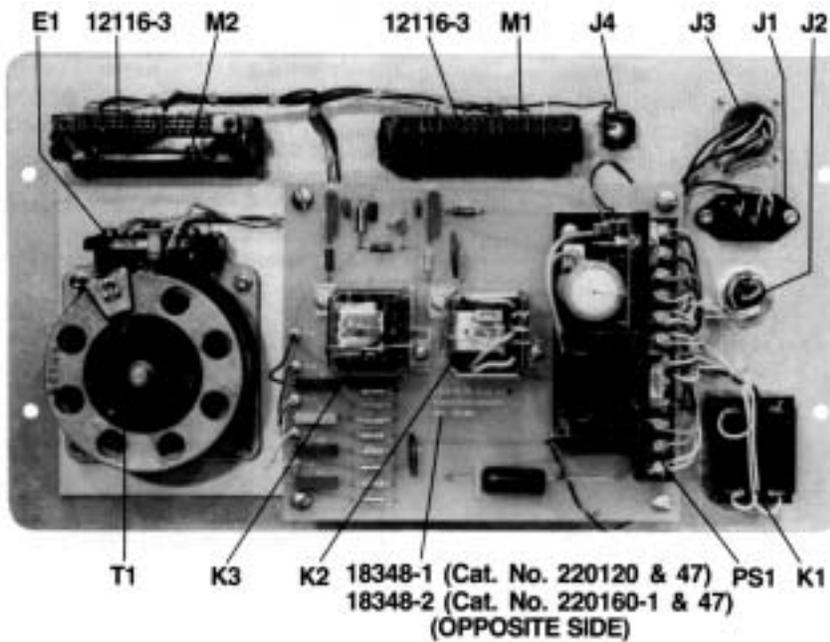
| <b>Malfunction</b>         | <b>Possible Cause</b>   |
|----------------------------|---|
| AC ON lamp does not light. | <ul style="list-style-type: none"><li>▪ No service power.</li><li>▪ Defective line cord.</li><li>▪ Main breaker K1 not closed.</li><li>▪ Defective AC ON lamp DS1.</li><li>▪ Fuse F1 or F2 blown (240 V units only).</li><li>▪ Defective step-down transformer T2 (240 V units only).</li></ul> |

| <b>Malfunction</b>  | <b>Possible Cause</b>  |
|---|--|
| Digital panel meters do not light.  | <ul style="list-style-type: none"> <li>▪ Defective panel meters M1 or M2.</li> <li>▪ Defective connection terminal for M1 and M2.</li> <li>▪ Connection terminal not mated properly to panel meters M1 or M2.</li> <li>▪ Defective power supply PS1.</li> </ul>  |
| Main breaker trips on closure.  | <ul style="list-style-type: none"> <li>▪ Defect in wiring.</li> <li>▪ Defective power supply PS1.</li> <li>▪ Transient suppressor CR3 shorted.</li> </ul>  |
| HV ON lamp does not light.  | <ul style="list-style-type: none"> <li>▪ Voltage control not at "0" (RESET).</li> <li>▪ External interlock open.</li> <li>▪ Defective zero start switch E1.</li> <li>▪ Defective relays K2 or K3.</li> <li>▪ Defective HV ON switch S1.</li> <li>▪ Defective HV OFF switch S2.</li> <li>▪ Defective HV ON lamp DS2.</li> </ul>   |
| Main breaker closes initially but trips when HV ON push button depressed. | <ul style="list-style-type: none"> <li>▪ Defective voltage control transformer T1.</li> <li>▪ Defective relay K2.</li> <li>▪ Defect in wiring.</li> </ul>  |
| Main breaker or line relay trip out when output voltage is increased      | <ul style="list-style-type: none"> <li>▪ Test set output shorted.</li> <li>▪ Defective interconnection cable.</li> <li>▪ Defective HV output cable.</li> <li>▪ Defective rectifier assemblies:<br/>CR101 and 102, 70 kV HV unit<br/>CR101 to 104, 120 and 160 kV HV unit.</li> <li>▪ Defective filter capacitors:<br/>C101 and 102, 70 kV HV unit.<br/>C101 to 104, 120 and 160 kV HV unit.</li> <li>▪ Defective current limiting resistors for rectifiers:<br/>R101 and R102, 70 RV HV unit.<br/>R101 to 104, 120 and 160 RV HV unit.</li> <li>▪ Defective HV transformer T101.</li> <li>▪ Defective voltage control transformer T1.</li> <li>▪ Defective high-voltage insulation</li> <li>▪ Defect in wiring.</li> </ul> |

| <b>Malfunction</b>  | <b>Possible Cause</b>  |
|---|--|
| No output voltage or inability to reach rated output voltage. | <ul style="list-style-type: none"> <li>▪ Defective interconnection cable/connection.</li> <li>▪ Defective HV output cable.</li> <li>▪ Defective rectifier assemblies.</li> <li>▪ Defective filter capacitors.</li> <li>▪ Defective current limiting resistors for rectifiers.</li> <li>▪ Defective HV transformer T101.</li> <li>▪ Defective voltage control transformer T1.</li> <li>▪ Defective HV voltage divider resistor:<br/>R105, 70 kV HV unit.<br/>R108, 120 kV HV unit.<br/>R109, 160 kV HV unit.</li> <li>▪ Defective safety bleeder resistors:<br/>R103, 70 kV HV unit.<br/>R105, 120 kV HV unit.<br/>R105, 160 kV HV unit.</li> <li>▪ Defective output current limiting resistor:<br/>R107, 70 kV HV unit.<br/>R111, 120 kV HV unit.<br/>R113, 160 kV HV unit.</li> <li>▪ Defective output voltage meter M2.</li> <li>▪ Defective voltmeter resistor/capacitor protective circuit.</li> <li>▪ Defective high-voltage insulation. Defect in wiring.</li> </ul> |



**Figure 16: 70 kV Control Unit Component Identification, Internal View**



**Figure 17: 120 and 160 kV Control Unit Component Identification**

| Malfunction             | Possible Cause  |
|-------------------------|---|
| No output current.      | <ul style="list-style-type: none"> <li>▪ Defective or poor grounding.</li> <li>▪ Defective interconnection cable/connection.</li> <li>▪ Guard circuit grounded.</li> <li>▪ Current RANGE switch set too high.</li> <li>▪ Transient voltage protectors E101 or E102 shorted.</li> <li>▪ Capacitor C105 shorted.</li> <li>▪ Defective output current meter M1.</li> <li>▪ Defective RANGE selector switch.</li> <li>▪ Defective current meter resistor/capacitor protective circuit.</li> <li>▪ Defective external instrument jack J4.</li> <li>▪ Defect in wiring.</li> </ul>  |
| Output voltage erratic. | <ul style="list-style-type: none"> <li>▪ Test sample failing.</li> <li>▪ Defective output cable (open circuit or poor connection).</li> <li>▪ Defective interconnection cable/connection.</li> <li>▪ Defective rectifier assemblies.</li> <li>▪ Defective filter capacitors.</li> <li>▪ Defective current limiting resistors for rectifiers.</li> <li>▪ Defective HV transformer T101.</li> <li>▪ Defective voltage control transformer T1.</li> <li>▪ Defective HV voltage divider resistors.</li> <li>▪ Defective output current limiting resistors.</li> <li>▪ Defective output voltage meter M2.</li> <li>▪ Defective voltmeter resistor/capacitor protective circuit.</li> <li>▪ Defective high-voltage insulation.</li> </ul> |

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| <b>Malfunction</b>     | <b>Possible Cause</b>   |
|------------------------|---|
| Output current erratic | <ul style="list-style-type: none"><li>▪ Line voltage transients (most noticeable excessive leakage current observed on 20 <math>\mu</math>A range).</li><li>▪ HV terminal of output cable spaced too close to nearby objects.</li><li>▪ HV terminal of cable or test sample burred, has sharp edges or is dirty.</li><li>▪ High surface leakage at test sample termination, unless guarded.</li><li>▪ Dirty HV output cable.</li><li>▪ Dirty HV unit enclosure.</li><li>▪ Defective output current meter M1.<br/>Defective current meter resistors/capacitors protective circuit.</li><li>▪ Defective or dirty insulation within HV unit.</li></ul> |

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## ***Repair***

Megger maintains a complete instrument repair service and recommends that its customers take advantage of this service in the event of any equipment malfunction. Please indicate all pertinent information, including problem symptoms and attempted repairs. The catalog number and serial number of the test set should also be specified. 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 Repair Department.

For those users who prefer to make their own repairs, replacement parts are available from the factory. Refer to Section 9 when ordering replacement parts.

When replacement of internal parts is required in the HV unit, it is important that all parts be installed in their originally located positions. It is also important that the high-voltage terminations be made in the same manner as originally made. Failure to observe these precautions may result in an internal flashover within the HV unit at a voltage below rated output voltage. Figures 18 to 20 show the component locations and Figures 21 to 23 show the methods of making the high-voltage terminations.

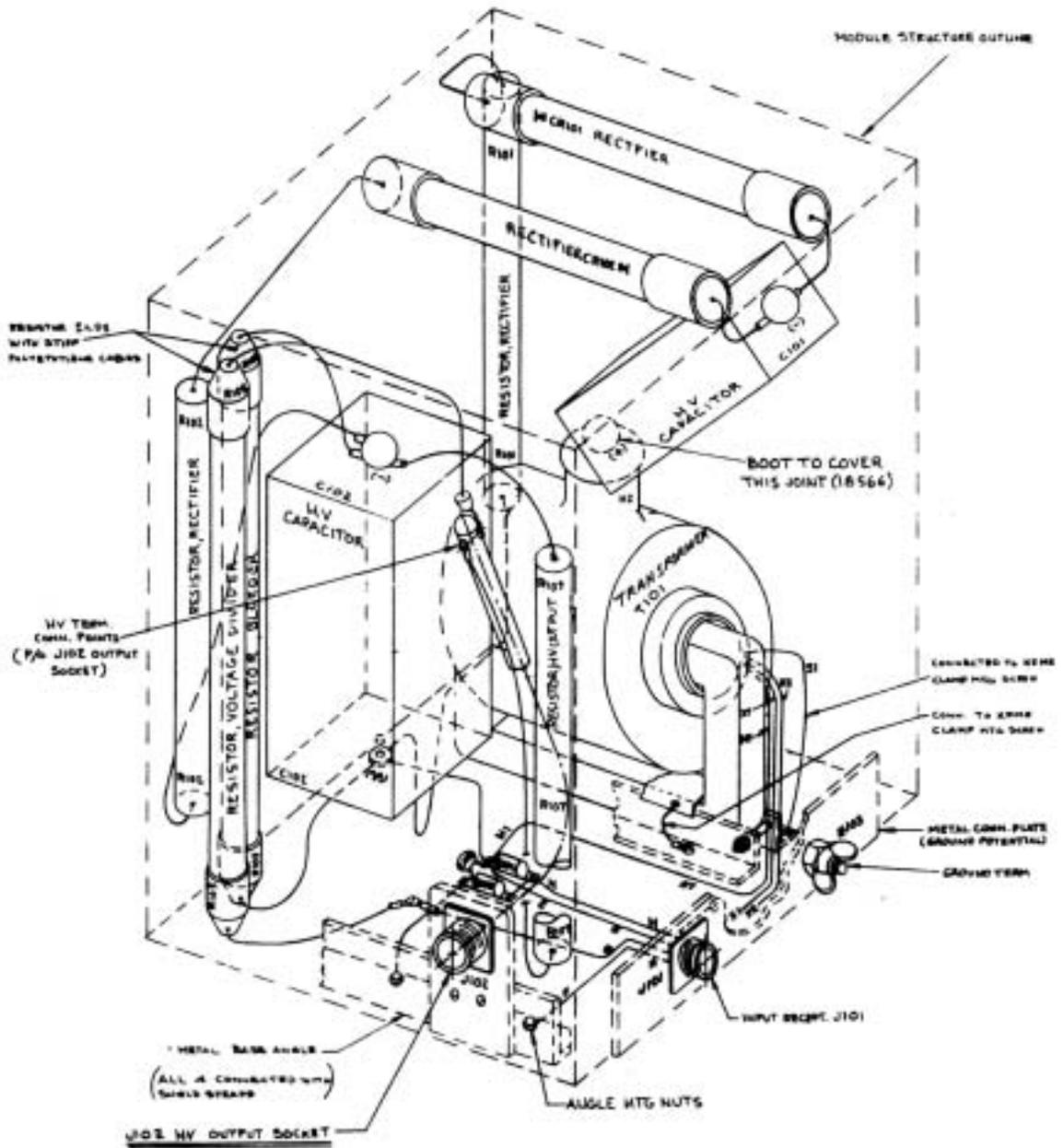


Figure 18: 70 kV HV Unit - Component Identification and Wiring

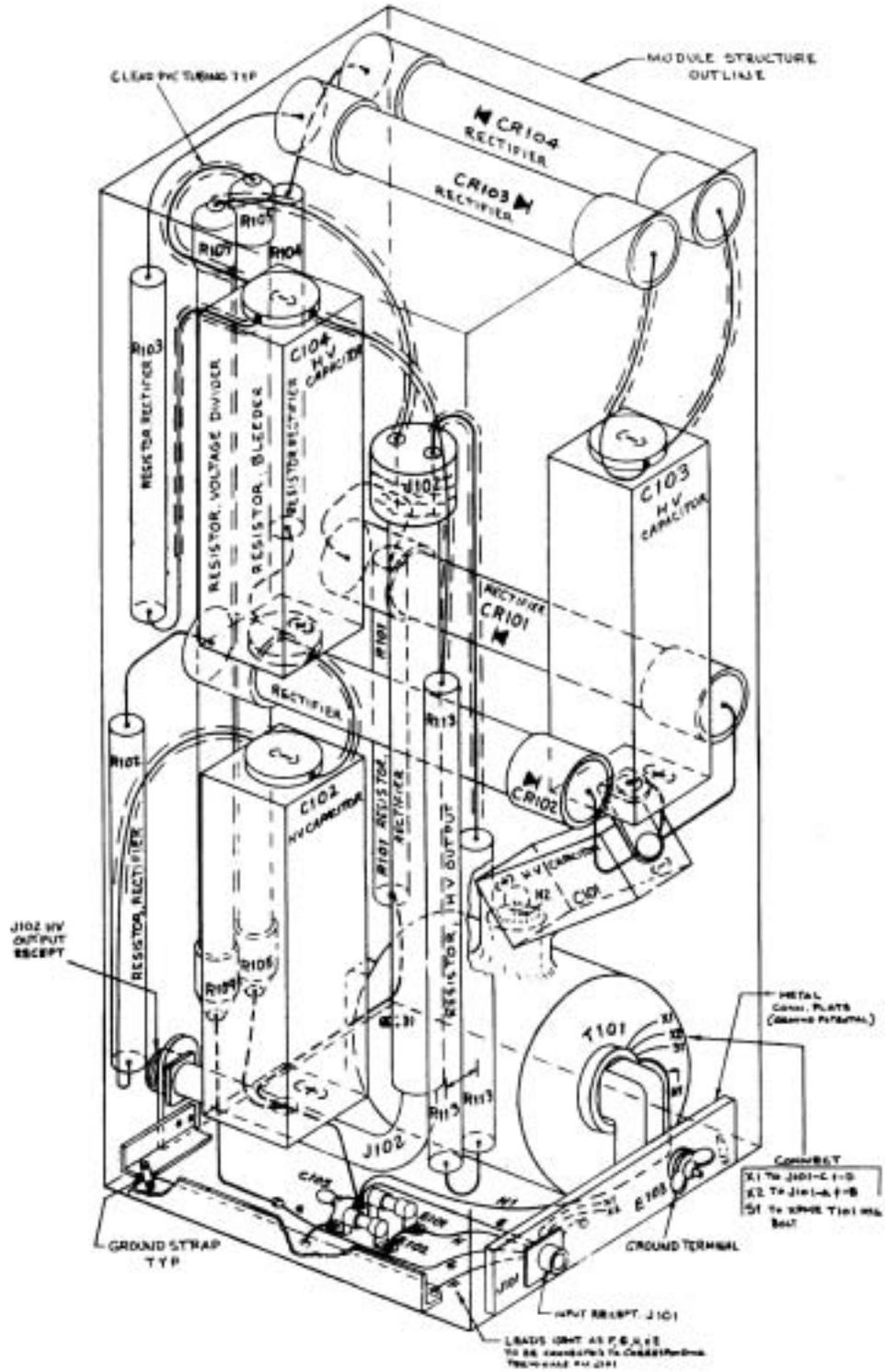


Figure 19: 160 kV HV Unit - Component Identification and Wiring

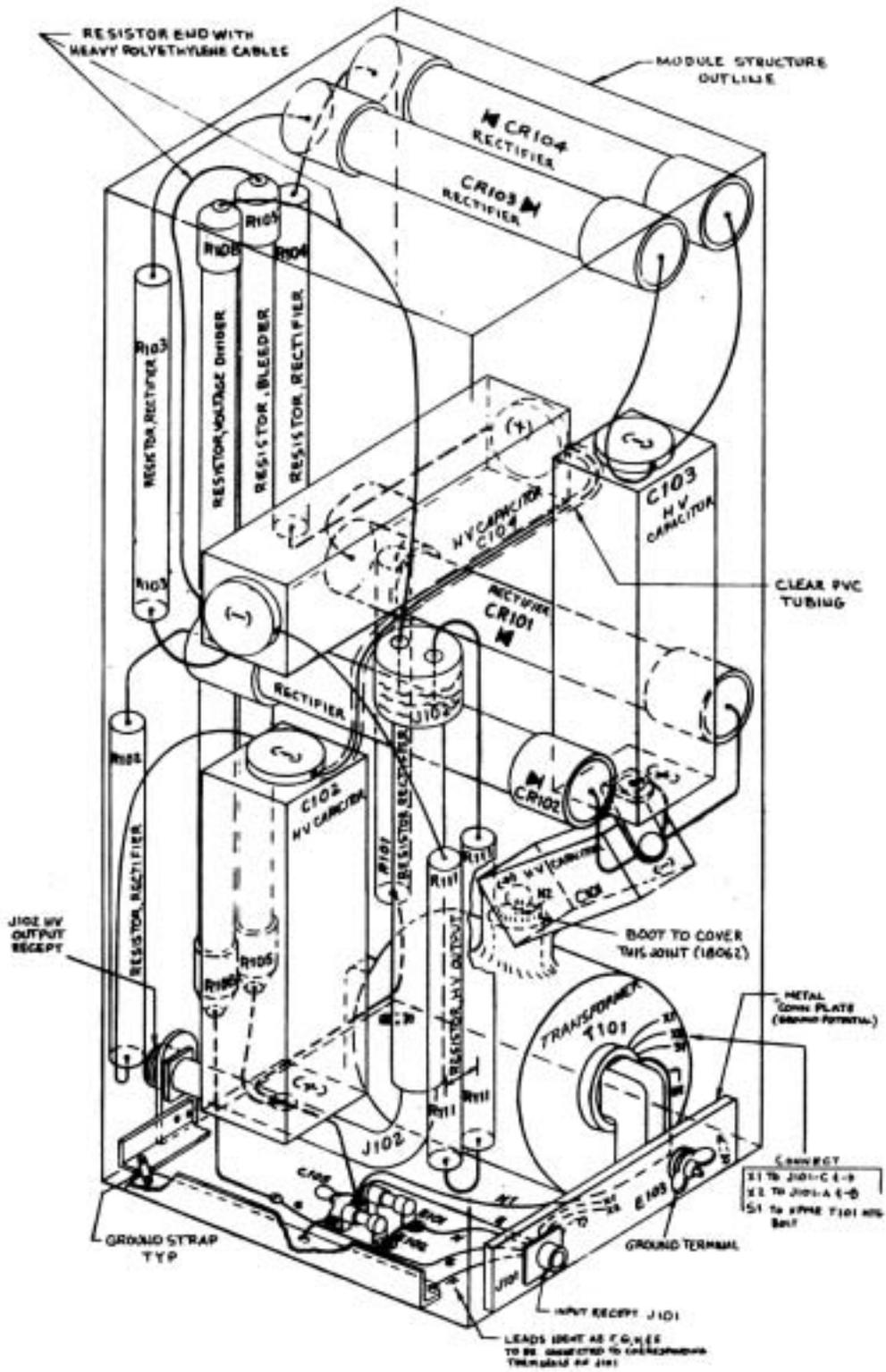
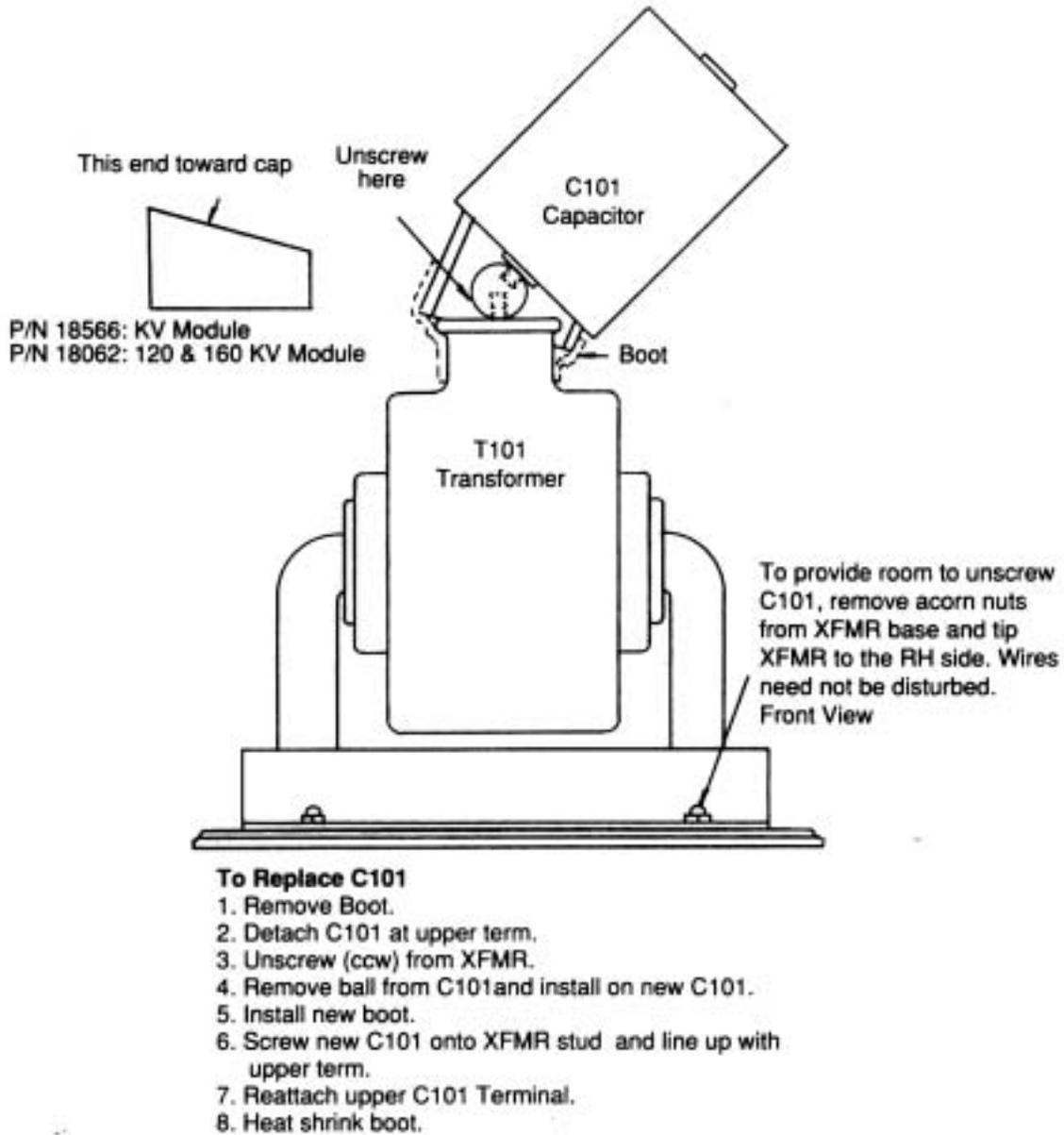
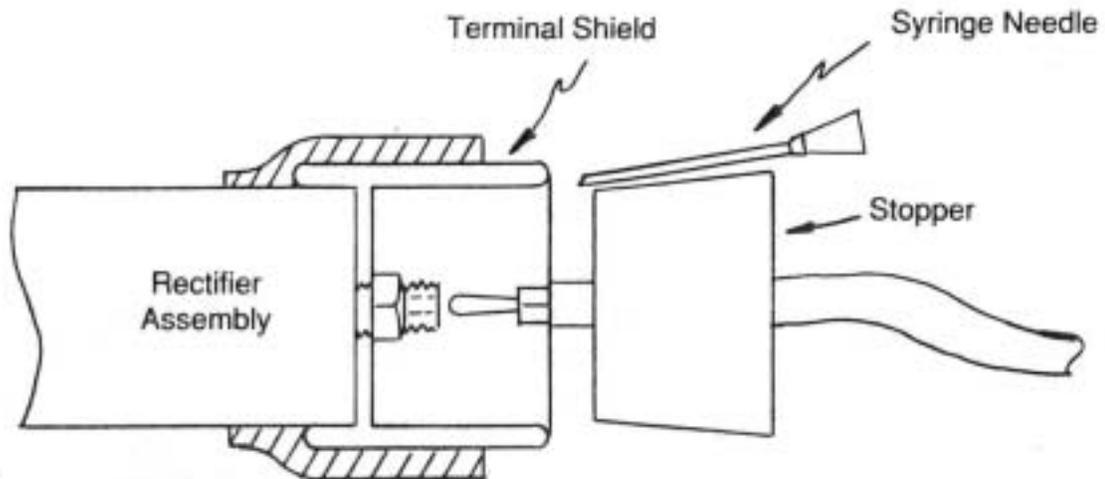


Figure 20: 120 kV HV Unit - Component Identification and Wiring



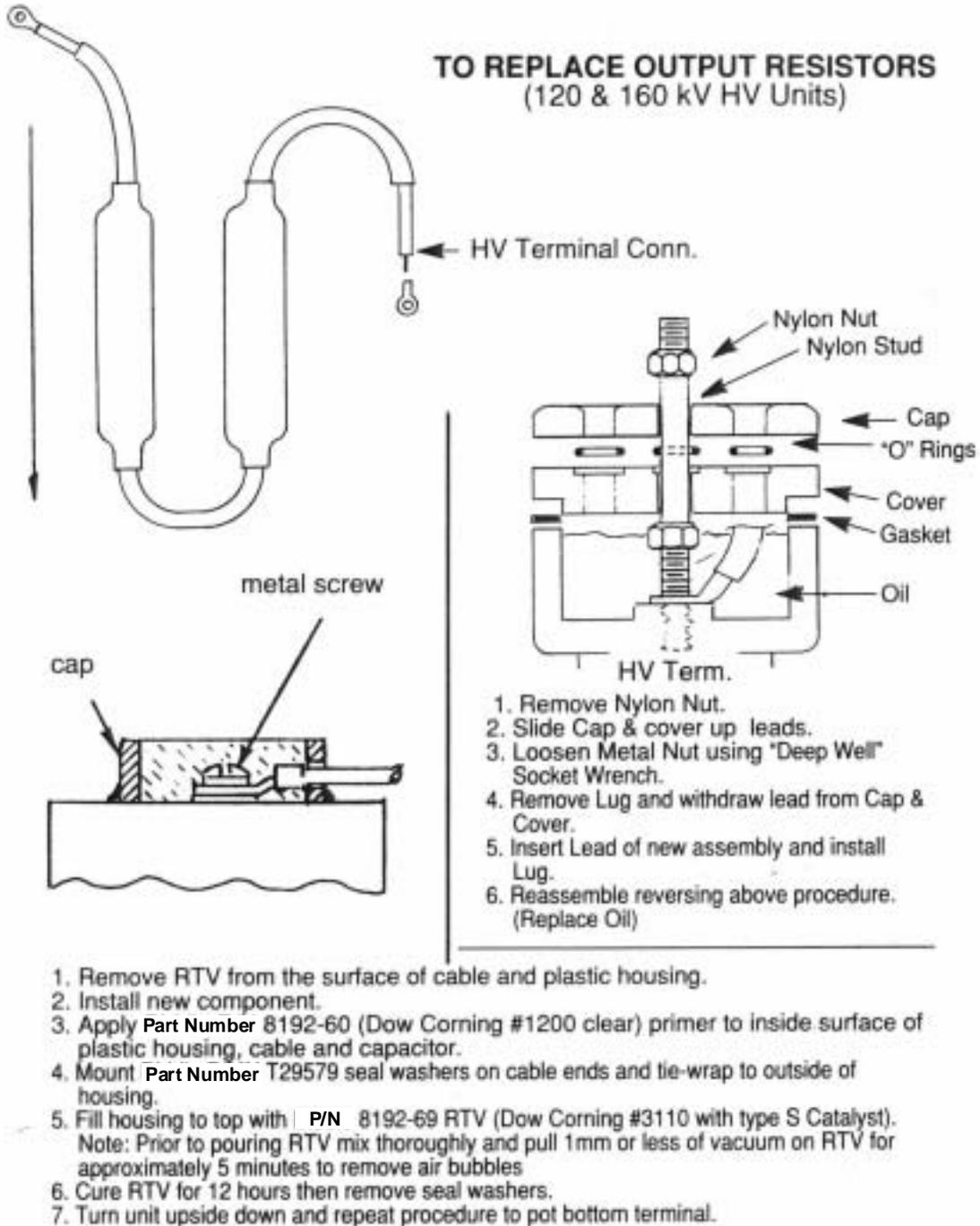
**Figure 21: HV Unit Capacitor/Transformer Replacement**



### To Replace Rectifier Assembly

1. Remove old assembly by pulling end stoppers and cutting Ty-wraps.
2. Install stoppers into new assembly using a syringe needle between stopper and terminal shield to allow displaced air to escape. Remove needle.
3. Fasten rectifier assembly with new Ty-wraps (P/N 18537-2)

**Figure 22: HV Unit Rectifier Replacement**



**Figure 23: HV Unit Output Resistor Replacement**

# 9

## PARTS LIST

| Symbol                                   | Description and Vendor   | Vendor Part No   | Megger Part No. |
|--|--|------------------|-----------------|
| <b>CONTROL UNIT ASSEMBLY (ALL UNITS)</b> |  |                  |                 |
| -  | 70kV Control Unit, Digital   | —                | 25746-1         |
| -  | 70kV Control Unit, Analog  | —                | 25746-9         |
| -  | 120kV Control Unit, Digital  | —                | 25746-2         |
| -  | 120kV Control Unit, Analog   | —                | 25746-8         |
| -  | 160kV Control Unit, Digital  | —                | 25746-3         |
| -  | 160kV Control Unit, Analog   | —                | 25746-10        |
|  | Case and Lid   | —                | 25743-1         |
| M1, M2                                   | Meter, Digital, Voltage & Current<br>(Newport Electronics)           | 215-3            | 18310           |
| M1                                       | Meter, Analog, Current (All Models)                                  | —                | 25292           |
| *M2                                      | Meter, Analog, Kilovolts   | —                | 25384           |
| **M2                                     | Meter, Analog, Kilovolts   | —                | 26975           |
| ***M2                                    | Meter, Analog, Kilovolts   | —                | 25383           |
| *K1                                      | Circuit Breaker, 250 V, 50/60 Hz 2-pole,5A<br>(Potter & Brumfield)   | W68X2Q1<br>-0-5  | 18315           |
| ** ***K1                                 | Circuit Breaker, 250 V, 50/60 Hz 2-pole,<br>10A (Potter & Brumfield) | W68X2Q1<br>-0-10 | 18315-1         |
| F1, F2                                   | Fuses, Line Corrector (BUSS)   | MDA-10           | 2567-14         |
| *T1                                      | Voltage Control Transformer<br>(Superior Electric)                   | 10-C             | 6408-2          |

| Symbol   | Description and Vendor                                | Vendor Part No | Megger Part No. |
|----------|---|----------------|-----------------|
| ** ***T1 | Voltage Control Transformer<br>(Superior Electric)    | 21             | 16820           |
| T2       | Line Corrector Transformer (Signal)                   | 130-0F         | 29900-1         |
| *E1      | Zero Start Contact Spring<br>(Use with Adapter 10765) | 23202          |                 |
| ** ***E1 | Zero Start Contact Spring                             | 14869          |                 |
| E2       | Voltage Protector, 90V (Siemens)                      | B1-C90/20      | 4446-3          |
| S1       | Switch, IDEC Systems & Controls<br>HV ON:             |                |                 |
|          | Contact Operator                                      | ABD-100        | 25481-1         |
|          | Contact Block, N.O.                                   | BST-010        | 25482-1         |
|          | Dummy Contact   | BST-D          | 25482-4         |
|          | Pushbutton, White, Flush                              | ABD1BN-W       | 25483-3         |
| S3       | Switch, IDEC Systems & Controls<br>HV OFF:            |                |                 |
|          | Contact Operator                                      | ABD-100        | 25481-1         |
|          | Contact Block, N.C.                                   | BST-001        | 25482-2         |
|          | Dummy Contact   | BST-D          | 25482-4         |
|          | Pushbutton, Red, Extended                             | ABD2BN-R       | 25483-4         |
| S4       | Switch, Current Range, Digital Meters<br>(Centralab)  | SA-2006        | 1524-3          |
| -        | Knob, Current Range, Digital Meters                   | —              | 23327-1         |
| E102     | Ammeter Switch Assy, Analog Meters                    | —              | 4986            |
| -        | Knob, Current Range, Analog Meters                    | —              | 9998-81         |

| <b>Symbol</b>                             | <b>Description and Vendor</b>               | <b>Vendor Part No</b> | <b>Megger Part No.</b> |
|---|---|-----------------------|------------------------|
| E103                                      | VM Range Switch, Analog Meters (CTS-Keene)  | 212-U212-1            | 22345                  |
| -   | Knob, VM Range, 220072                      | —                     | 9998-84                |
| -   | Knob, VM Range, 220124                      | —                     | 9998-91                |
| -   | Knob, VM Range, 220164                      | —                     | 9998-95                |
| DS1, DS2                                  | Lamp Holder Assembly (EAO Switch)           | 31-040.005            | 25301-3                |
| DS1, DS2                                  | Lamp Bulb, Type "T-1 3/4" (GE)              | 334                   | 5297                   |
| DS1                                       | Lens for Lamp "AC ON"                       | —                     | 25302-36               |
| DS2                                       | Lens for Lamp "HV ON"                       | —                     | 25302-19               |
| R13, R14                                  | Resistor, W.W., 2.5 kΩ, 5%, 12W             |                       | 4500-76                |
| J1  | Receptacle, 120/240 Input (Belden)          | 17252                 | 18305                  |
| J2  | Receptacle, Ext Interlock (Amphenol)        | MS3102A<br>-16-10S    | 10225                  |
| J3  | Receptacle, HV Interconnect (Amphenol)      | MS3102A<br>-18-8-S    | 9018-31                |
| J4  | Receptacle, Ext Instrument (Switchcraft)    | 112A                  | 4733-2                 |
| <b>HIGH VOLTAGE UNIT (70 kV Test Set)</b> |   | —                     | <b>18350</b>           |
| C101                                      | Capacitor, High Voltage                     | —                     | 18307-1                |
| C102                                      | Capacitor, High Voltage                     | —                     | 18307-2                |
| C103                                      | Capacitor, ceramic, 0.01 uF, 150 V, +60-40% | —                     | 9865-1                 |
| CR101, CR102                              | Rectifier Assembly                          | —                     | 18572                  |
| E101, E102                                | Voltage Protector 90 V (Siemens)            | S8-C90                | 16026-2                |
| R101                                      | Resistor Assembly, Rectifier                | —                     | 18541-1                |

# Megger.

| Symbol                                     | Description and Vendor                    | Vendor Part No | Megger Part No. |
|--|---|----------------|-----------------|
| R102                                       | Resistor Assembly, Rectifier              | —              | 18541-2         |
| R103                                       | Resistor Assembly, Bleeder                | —              | 18540-2         |
| R105                                       | Resistor Assembly, Voltage Divider        | —              | 18540-1         |
| R107                                       | Resistor Assembly, HV Output              | —              | 18542           |
| T101                                       | Transformer Assembly                      | —              | 18352           |
| -  | Boot, C101 to T101 joint                  | —              | 18566           |
| J101                                       | Receptacle, Interconnection Amphenol      | MS3102A-18-8-S | 9018-31         |
| J102                                       | Receptacle, HV Output (ITT Cannon)        | MS3105-20      | 18574           |
| E103                                       | Wing Nut, Ground                          | —              | 5026            |
| -  | Module Cover                              | —              | 18345           |
| -  | Carrying Strap                            | —              | 19021           |
| CD-150                                     | Cap Plug, HV Output (Protective Closures) | —              | 18353           |
| CD-130                                     | Cap Plug, Intcon (Protective Closures)    | —              | 18353-1         |
| <b>HIGH VOLTAGE UNIT (120 kV Test Set)</b> |   | —              | <b>29598</b>    |
| C101                                       | Capacitor, High Voltage                   | —              | 18063           |
| C102                                       | Capacitor, High Voltage                   | —              | 29579-1         |
| C103                                       | Capacitor, High Voltage                   | —              | 29579-2         |
| C104                                       | Capacitor, High Voltage                   | —              | 29579-3         |

| <b>Symbol</b>    | <b>Description and Vendor</b>                 | <b>Vendor Part No</b> | <b>Megger Part No.</b> |
|------------------|---|-----------------------|------------------------|
| C105             | Capacitor, Ceramic 0.01 $\mu$ F, 150V +60-40% | —                     | 9865-1                 |
| CR101 -CR104     | Rectifier Assembly                            | —                     | 18572                  |
| E101, E102       | Voltage Protector 90 V (Siemens)              | S8-C90                | 16026-2                |
| R101, R103, R104 | Resistor Assembly, Rectifier                  | —                     | 29594-1                |
| R102             | Resistor Assembly, Rectifier                  | —                     | 29594-3                |
| R105             | Resistor Assembly, Bleeder                    | —                     | 29593-4                |
| R108             | Resistor Assembly, Voltage Divider            | —                     | 29593-3                |
| R111             | Resistor Assembly, HV Output                  | —                     | 29595-1                |
| T101             | Transformer Assembly                          | —                     | 18352-1                |
|                  | Boot, C101 to T101 joint                      | —                     | 18062                  |
| J101             | Receptacle, Interconnection (Amphenol)        | MS3102A-18-8-S        | 9018-31                |
| J102             | Receptacle, HV Output (ITT Cannon)            | MS3105-20             | 29514-1                |
| E103             | Wing Nut, Ground                              | —                     | 5026                   |
| -                | Module Cover                                  | —                     | 18345-1                |
| -                | Carrying Strap                                | —                     | 19021                  |
| CD-150           | Car Plug, HV Output (Protective Closures)     | —                     | 29514-2                |
| CD-130           | Car Plug, Intercon (Protective Closures)      | —                     | 18353-1                |

| Symbol        | Description and Vendor                           | Vendor Part No | Megger Part No. |
|---------------|--|----------------|-----------------|
| <b>CABLES</b> | Ground Lead (2 per test set)                     | —              | 4702-5          |
|               | Interconnection Cable                            | —              | 18320           |
| *             | Output Cable Assembly                            | —              | 18328           |
| ** ***        | Output Cable Assembly                            | —              | 29590           |
|               | Line Cord, 120V Input                            | —              | 17032           |
|               | Line Cord, 240 V Input                           | —              | 17032-2         |
|               | Cable Carrying Bag                               | —              | 18313           |
|               | <b>HIGH VOLTAGE UNIT (160 kV Test Set)</b>       | —              | <b>29599</b>    |
| C101          | Capacitor, High Voltage                          | —              | 18063           |
| C102          | Capacitor, High Voltage                          | —              | 29579-4         |
| C103          | Capacitor, High Voltage                          | —              | 29579-5         |
| C104          | Capacitor, High Voltage                          | —              | 29579-6         |
| C105          | Capacitor, Ceramic, 0.01 $\mu$ F, 150 V, +60-40% | —              | 9865-1          |
| CR101-CR104   | Rectifier Assembly                               | —              | 18572           |
| E101,E102     | Voltage Protector, 90 V (Siemens)                | S8-C90         | 16026-2         |
| R101          | Resistor Assembly, Rectifier                     | —              | 29594-1         |
| R102, R103    | Resistor Assembly, Rectifier                     | —              | 29594-3         |
| R104          | Resistor Assembly, Rectifier                     | —              | 29594-2         |

| <b>Symbol</b> | <b>Description and Vendor</b>             | <b>Vendor Part No</b> | <b>Megger Part No.</b> |
|---------------|---|-----------------------|------------------------|
| R105          | Resistor Assembly, Bleeder                | —                     | 29593-2                |
| T101          | Transformer Assembly                      | —                     | 18352-2                |
| -             | Boot, C101 to T101 joint                  | —                     | 18062                  |
| J101          | Receptacle, Interconnection (Amphenol)    | MS3102A-18-8-S        | 9018-31                |
| J102          | Receptacle, HV Output (ITT Cannon)        | MS3105-20             | 29514-1                |
| E103          | Wing Nut, Ground                          | —                     | 5026                   |
| -             | Module Cover                              | —                     | 18345-2                |
| -             | Carrying Strap                            | —                     | 19021                  |
| CD-150        | Cap Plug, HV Output (Protective Closures) | —                     | 29514-2                |
| CD-130        | Cap Plug, Intercon (Protective Closures)  | —                     | 18353-1                |

240 V 50/60 Hz Test Sets only

\* 70 kV Test Sets only

\*\* 120 kV Test Sets only

\*\*\* 160 kV Test Sets only

**Megger.**

## GLOSSARY



Use only in accordance with Instruction Manual.



High-voltage warning

**arc-over**

a disruptive discharge in the form of an arc or spark between two electrical conductors or between a conductor and earth (also called sparkover or flashover).

**bleeder**

a resistor connected across the high-voltage capacitors to drain off the charge remaining in capacitors when the power is turned off.

**Cockcroft-Walton**

a high-voltage direct current accelerator consisting of cascaded rectifier circuits and capacitors to which a low-voltage alternating current is applied

**guard terminal**

a conductor situated between a source of high voltage and ground in such a way that surface leakage currents are conducted to a return terminal (guard) without entering the signal path.

**rms**

root mean square

**RTV**

room temperature vulcanizing (silicone rubber)

**withstand test**

test made to determine the ability of insulating materials and spacings to withstand specified overvoltages for a specified time to assure their strength

Megger.

## **WARRANTY**

Products supplied by Megger are warranted against 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 must be shipped prepaid and insured. The warranty does not include batteries, lamps or other expendable items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of abuse (failure to follow recommended operating procedures) or failure by the customer to perform specified maintenance as indicated in this manual.

Megger<sup>®</sup>