Biddle Instruments

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2.5 5/90 IFS

Instruction Manual
22-5Jb

for the

5kV DC Dielectric Test Set

Catalog No. 220005

Biddle Instruments

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Instruction Manual 22-5-Jb

for Biddle Dielectric Test Set

Catalog No. 220005

HIGH-VOLTAGE EQUIPMENT

PLEASE READ CAREFULLY BEFORE OPERATING

Safety is the responsibility of the user

APARATO DE VOLTAJE ALTO

SIRVANSE LEER ESTE LIBRO CONCUIDADO ANTES DE OPERARLO

La seguridad es el cargo del operador

BIDDLE INSTRUMENTS
Blue Bell, Pa. 19422

The BIDDLE Catalog No. 220005
Dielectric Test Set

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Section A

INTRODUCTION

This instruction manual is intended as a guide to the operation and maintenance of the portable Dielectric Test Set, Biddle Catalog No. 220005.* 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 instructions and suggestions provided in this manual anticipate the normal use of the dielectric 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 resulting current and the manner in which current varies with time, provide data that indicate the condition of the insulation system of the unit being tested. When these data are recorded on graph paper, such as Biddle kilovolt-megohm paper (Catalog No. 220000), the shape of the curve made by connecting the plotted points will aid in evaluating the conditions of the insulation system. Information on the interpretation of observed data and guides for test voltage and time are given in Section J of this manual and in Biddle Technical Publication 22T1.[1]

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* This manual is intended for use with sets manufactured after January, 1985.

[1] Available from BIDDLE Instruments, Advertising Department, Blue Bell, Pa., 19422

Section B

SAFETY PRECAUTIONS

SAFETY IS THE RESPONSIBILITY OF THE USER.

LA SEGURIDAD ES EL CARGO DEL OPERADOR.

The test set and the equipment to which it is connected are a source of high-voltage electrical energy, and 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 related circuits. Persons actually engaged in the tests 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 involved with the work must be kept away from test activities by suitable barriers, barricades or warnings.

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 one foot from the energized structure.

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 applied to the equipment that was tested. These bonds should be left in place until access to the equipment is again required.

CAUTION!

NEVER CONNECT THE TEST SET TO ENERGIZED EQUIPMENT
OR USE THE TEST SET IN AN EXPLOSIVE ATMOSPHERE.

If the test set is operated in accordance with the safety precautions noted above and in Section G, 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. BIDDLE considers this an excellent safety practice.

BIDDLE Instruments strongly recommends that you use IEEE Std. 510 "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing" as a guide for all high voltage testing. (Do not, however, use this standard to reduce any of the precautions given in this manual.) It is available from: The Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017, USA.

Section C
RECEIVING INSTRUCTIONS

When your instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify BIDDLE Instruments, Blue Bell, Pa. 19422 of any shortage of materials.

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

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

Section D
SPECIFICATIONS

General

Input:

Recommended Source	NEC 15-Ampere 120-volt single-phase branch circuit
Voltage	105 to 130 volts
Current (maximum rms)	1.1 Amperes, continuous
Frequency	60 Hz, Full Rating 50 Hz, Reduced Rating

Output: (120 Volt Line)

Voltage (maximum)	5 kV dc, negative with respect to ground
Current (maximum)	5 mA, continuous (4.2 mA 50 Hz)
Ripple (rms)	1% of output voltage at 1 megohm load
Regulation	20%, no load to 1 megohm load

Metering:

Kilovoltmeter	4-inch, taut band 2-range: 0-2.5 and 0-5.0 kV: ±2% FS
Current	4-inch, taut band 4-range: 0 - 5/50/500 µA and 5 mA ±2% FS
External Instrument Jack	To measure current
Meter Damping Switch	Selectively provides current meter damping

Dimensions:

Size	13 1/2 x 9 3/8 x 10 inches (34.3 x 24.8 x 25.4 cm)
Weight	20.5 lbs. (9.3 Kg)
Input Cable	Attached, 5 ft. (1.5 meters)
Output Cable	Attached, 15 ft. (4.6 meters)
Ground Cable	Separate, 10 ft. (3.3 meters)

Environment:

Temperature	0°F (-18°C) 122°F, (50°C) (operating)
Altitude (maximum)	10,000 ft. (3048 meters) (operating)
Relative Humidity	Non-condensing conditions
Vibration	Will withstand vibration normally encountered during field use and transportation

Protective Devices:

Circuit Breaker	Protects against any overload condition.
Zero Start	Safety feature; requires output voltage to be zero to start test.
Voltmeter and Current Meter	Protected against overload and transients by special circuits.

Section E

DESCRIPTION

General

This portable dielectric test set measures the electrical quantities of applied voltage and resultant current in the apparatus to which it is connected. Designed for field or shop use, the complete test set (including all leads) is housed in a durable, impact-resistant plastic case, with removable lid and carrying strap. For safety in operation, the control panel of the test set is of grounded metal.

Electrical Operation

The electrical operation of the standard test set is described below and illustrated in the schematic diagram provided in Figure 1.

Transformer T-102, rectifiers CR-103 and CR-104, and capacitors C-101 and C-102 form a full-wave, voltage doubling rectifier circuit that provides the required dc voltage. The rectifier system is provided with safety bleeder resistors (R-101 and R-102) and is protected by the output limiting resistor (R-107). The output cable (W-101) is permanently connected to the negative terminal of the rectifier system. The positive terminal of the rectifier system is considered the guard terminal, it is connected to the shield of the output cable but is isolated from ground.

> NOTE: The output cable shield should not be grounded. Grounding this shield will short-circuit the current meter; the meter, therefore, will not register a current measurement.

Output voltage is measured by the two-range kilovoltmeter consisting of multiplier resistor R-103 and meter M-101. Voltmeter range is selected by means of a front panel switch (S-101) and resistors R-109, R-105, and R-106. The voltmeter circuit is protected from surges by capacitor C-103.

A resultant ground current in the apparatus under test is measured by the four-range current meter (M-102). Current meter ranges are selected by a front panel switch that is part of the printed circuit card E-102. This card contains the range selector resistors (R_1, R_2, R_3, R_4, R_5, R_6, and R_7) and the current meter circuit protection elements (capacitor C1 and Zener diodes CR_1 and CR_2). The current meter has a sensitivity of 100 uA. To obtain the required 5 uA sensitivity, an amplifier is included in the circuit. This is board E104 in a standard set; when an overvoltage or overcurrent trip circuit is included, the amplifier circuit is on the trip circuit board assembly E105. As a convenience, a jack (J-101) is provided so that the current in the apparatus under test can be metered or monitored by an external device such as a recorder.

The current meter pointer motion is normally slow and steady enough to permit a decisive reading; but when the apparatus under test is capacitive in nature and the resultant current is small, small line voltage transients may cause the current meter pointer to swing widely, thus prohibiting a decisive current measurement. A meter damping switch (S-102) and a capacitor (C-104) are provided so that by placing the damping switch in the IN position (closed), the capacitor will increase the meter damping during the current change so as to cause the meter to integrate the current. Integration reduces the speed and transient deflection of the meter. When the meter damping switch is in the OUT position, minimum integration occurs and the motion of the meter pointer is normal.

The guard terminal is used to bypass current around the current meter. (This feature is described in Sections H, I, and J.)

The separate ground lead (W-102) is included to provide a ground for the meter panel and to provide a current return path from the apparatus under test through the current meter.

Output voltage is controlled by the variable autotransformer (T-101), whose output feeds the primary of transformer T-102. Complete circuit protection is provided by the two-pole circuit breaker (K-101), which also serves as the ON/OFF switch. The two-pole circuit breaker arrangement provides diffferential protection to T-101 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.

Power is supplied to the test set through the three-conductor, permanently attached input cable (W-100). The green wire of this cable conforms to electrical code requirements and provides a separate panel ground connection. For safety purposes, the separate ground cable (W-102) that is provided should be used so that the green wire forms a second parallel ground path.

If the test set is connected to an outlet whose voltage exceeds that for which the set is rated, the panel indicator (DS1) will be abnormally bright when the main switch is closed. This will alert the operator to this condition. Under such a condition, an attempt to obtain output will normally trip the circuit breaker.

The "zero-start" safety feature of this test set requires that the voltage control be set to zero in order for the advance of the output control to develop an output voltage. This feature is a function of control relay K-102, whose contacts remain open after the power source is connected and after circuit breaker K-101 is closed. This prevents the application of voltage to the input of T-101 until the contacts of K-102 are closed by the zero positioning of T-101. When the contacts are closed, relay K-102 is sealed, and the contacts remain closed until power is removed by opening K-101 or by removing the line cord from the outlet. In order to re-establish output, power must again be applied and the voltage control set to zero.

Overcurrent and Overvoltage Trips

Schematic diagrams of test sets equipped with optional features are given in Figures 2, 3, and 4. (Figure 2 provides a schematic of a test set which includes the overcurrent option; Figure 3, a set with the overvoltage option; and Figure 4, a test set equipped with both the overcurrent and overvoltage options.) The basic circuitry and general operation of all sets, including those provided with optional features, is as previously described. The overcurrent and overvoltage options consist of modifications of the respective meters; and since these options work on the same principle, the following is applicable to both.

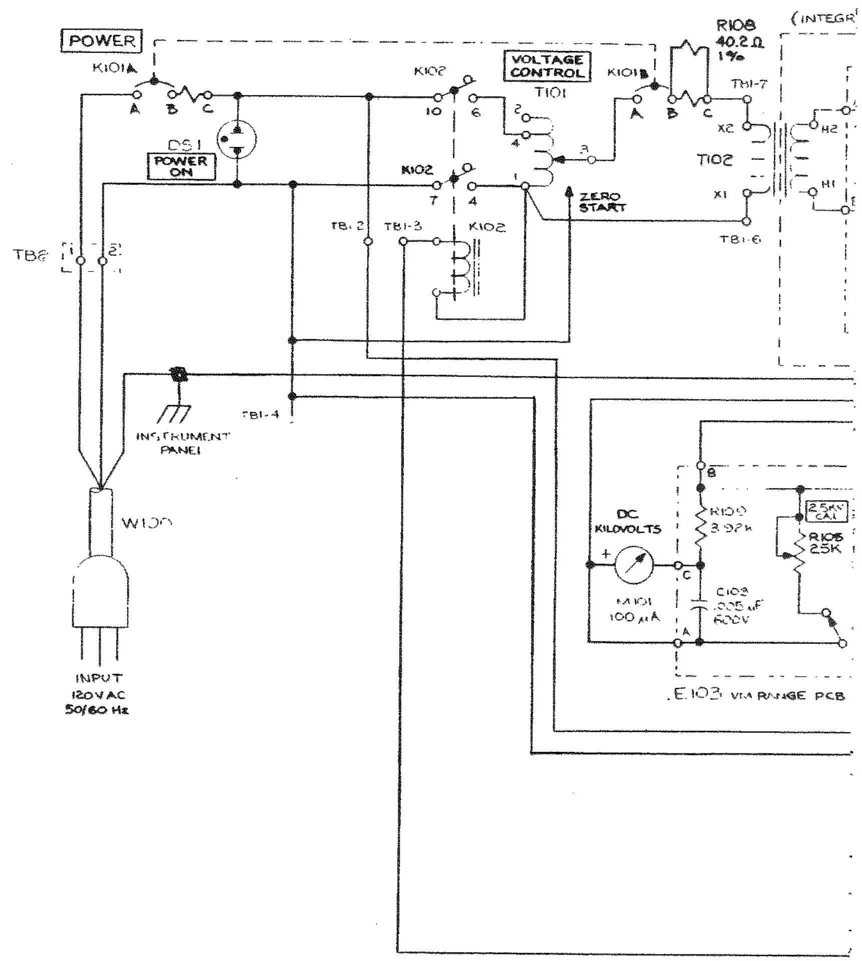
On sets which include either or both of the optional features noted above, the appropriate meter has been modified to include a circuit that senses the input quantity corresponding to the position of the meter pointer. The meter is additionally equipped with a red pointer which may be set to any position on the scale by means of a small manual control knob on the meter. When the position of the meter pointer coincides with that of the red pointer, the circuit responds by tripping a meter relay. This relay includes a set of contacts that are normally closed while the meter pointer rests between zero and the red pointer. However, when the meter pointer reaches the red pointer, the relay contacts open. This opens the coil circuit of K-102 and thereby removes power from the test set. This function results from the placement of the meter relay contacts in series with the return path of relay K-101. For sets equipped with both the overcurrent and overvoltage options, both meter relay contacts are in series so that if either voltage or current limits (as set by the respective red pointers) are exceeded, the test set is de-energized. (For exact limits of operation, see Section H.) After a tripout occurs, the voltage control must be returned to zero before test set output can be obtained.

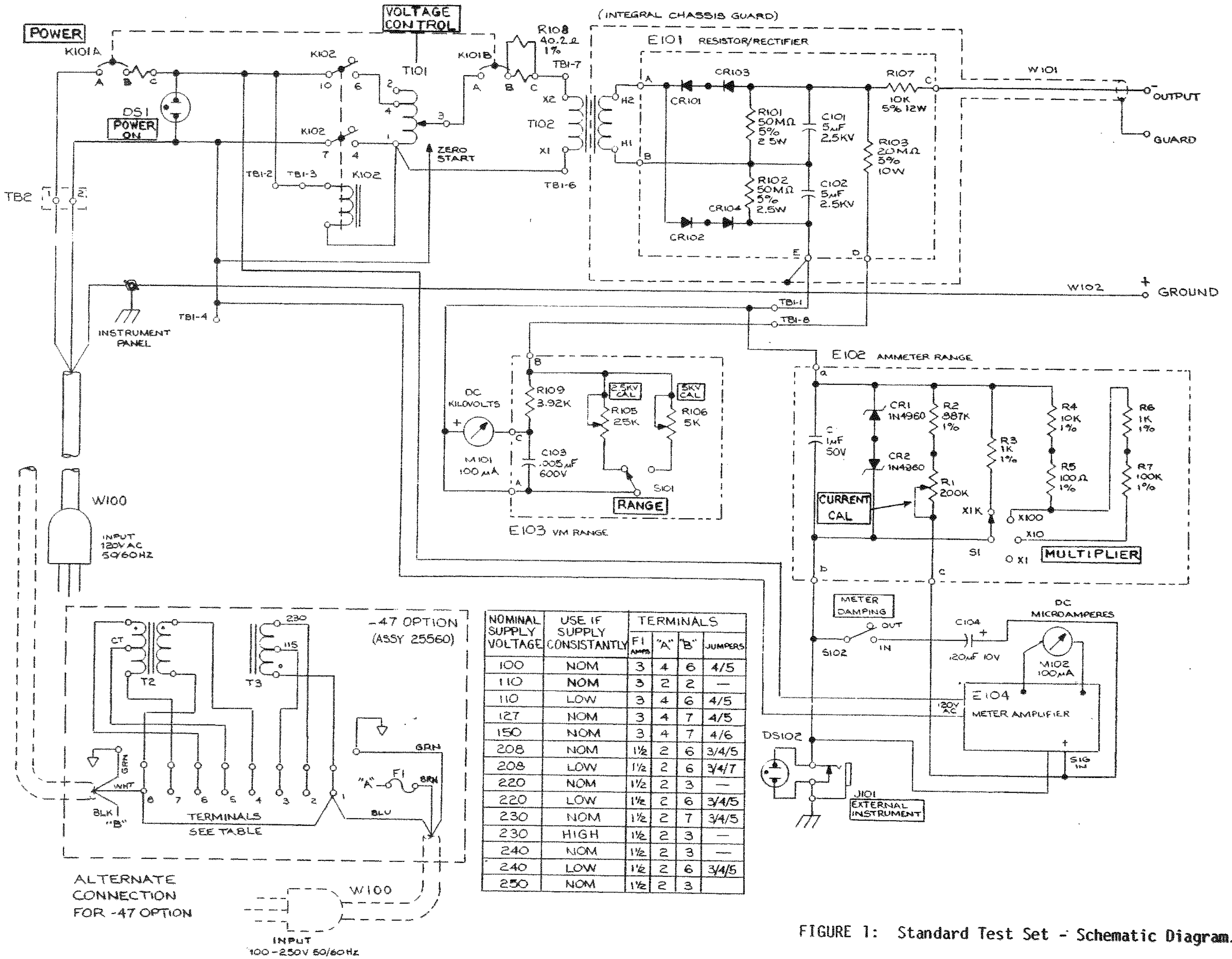
Power Supply Option

Test sets equipped with -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 (See Figure 1). The nominal line voltage is specified at purchase. Transformers are located in the bottom of the test set.

Optional output voltages may be selected in accordance with the table shown in Figure 1. When this option is supplied, Biddle 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 1/4 amperes, nor 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.





NOMINAL SUPPLY VOLTAGE	USE IF SUPPLY CONSISTANTLY	TERMINALS			
		F1 AMPS	"A"	"B"	JUMPERS
100	NOM	3	4	6	4/5
110	NOM	3	2	2	—
110	LOW	3	4	6	4/5
127	NOM	3	4	7	4/5
150	NOM	3	4	7	4/6
208	NOM	1½	2	6	3/4/5
208	LOW	1½	2	6	3/4/7
220	NOM	1½	2	3	—
220	LOW	1½	2	6	3/4/5
230	NOM	1½	2	7	3/4/5
230	HIGH	1½	2	3	—
240	NOM	1½	2	3	—
240	LOW	1½	2	6	3/4/5
250	NOM	1½	2	3	

FIGURE 1: Standard Test Set - Schematic Diagram.

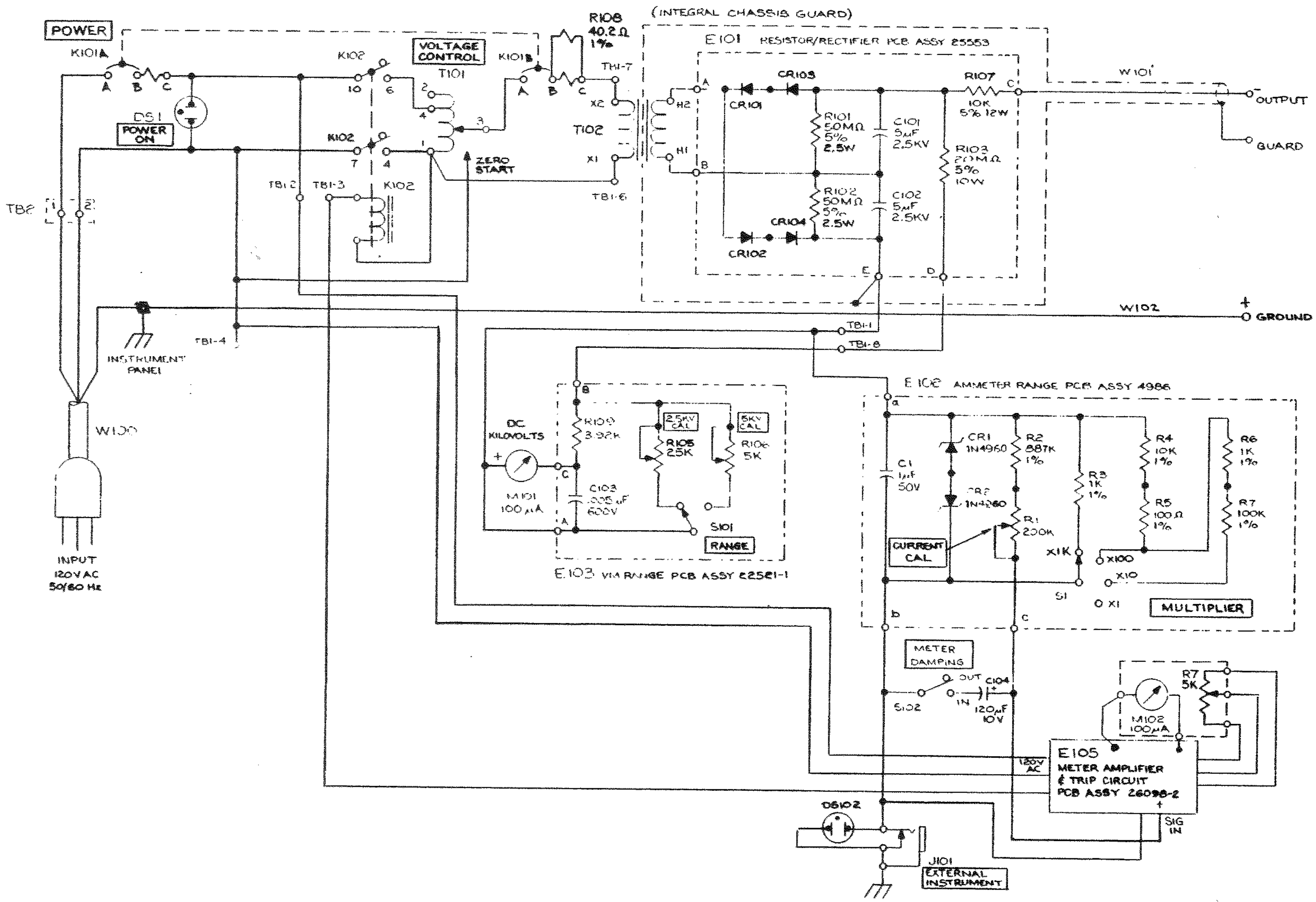


FIGURE 2: Test Set with Overcurrent Option - Schematic Diagram.

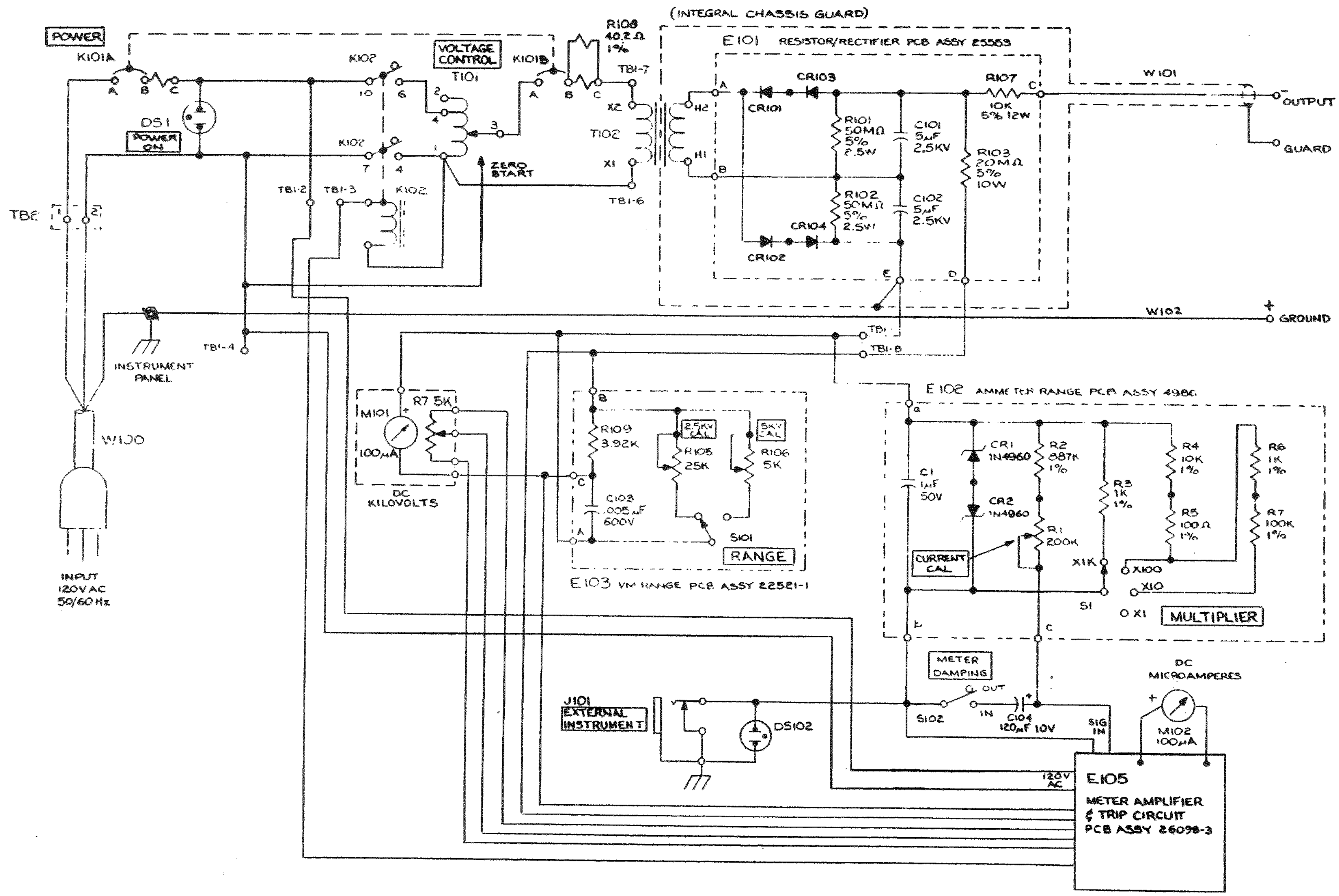


FIGURE 3: Test Set with Overvoltage Option - Schematic Diagram.

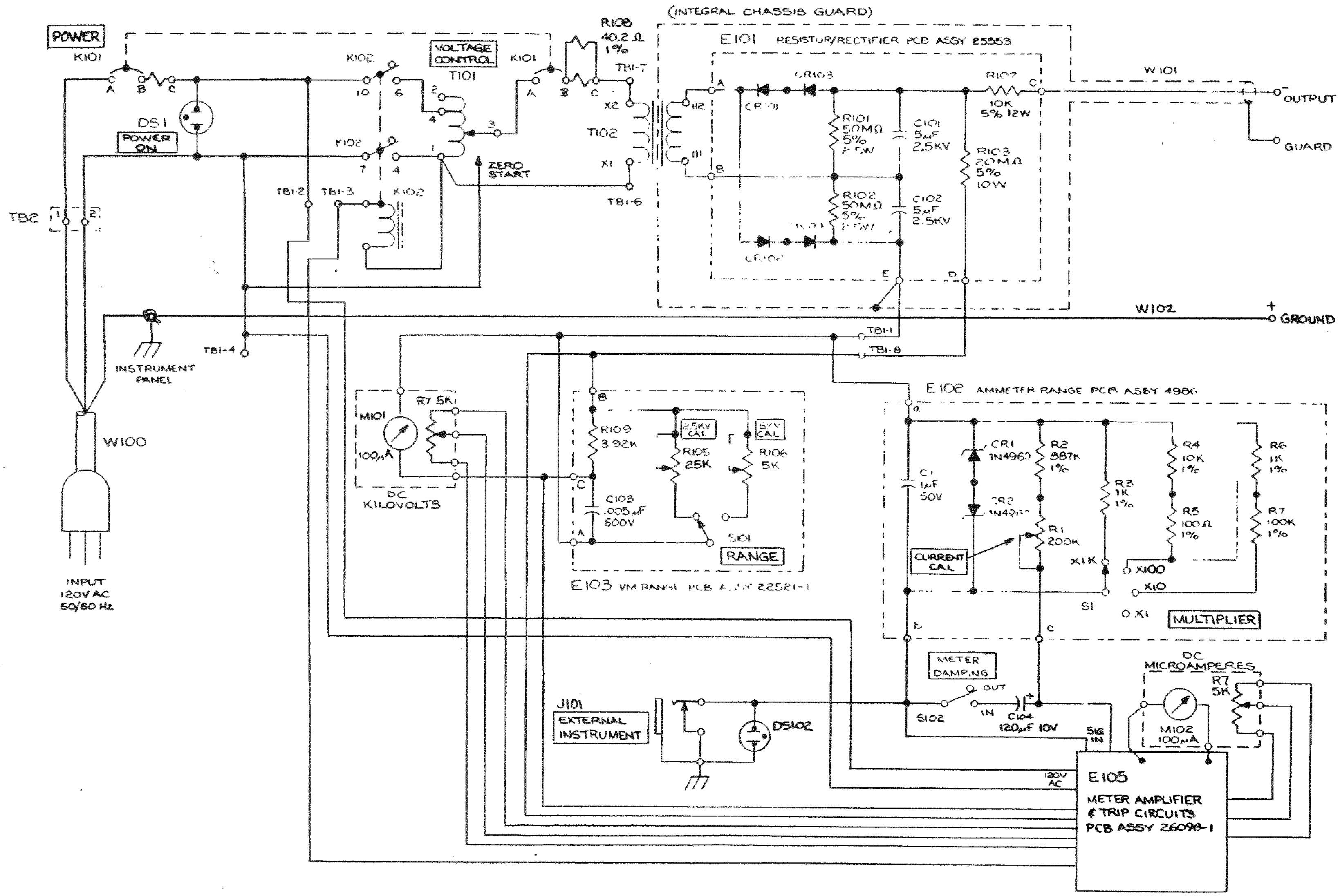


FIGURE 4: Test Set with Overcurrent and Overvoltage Options - Schematic Diagram.

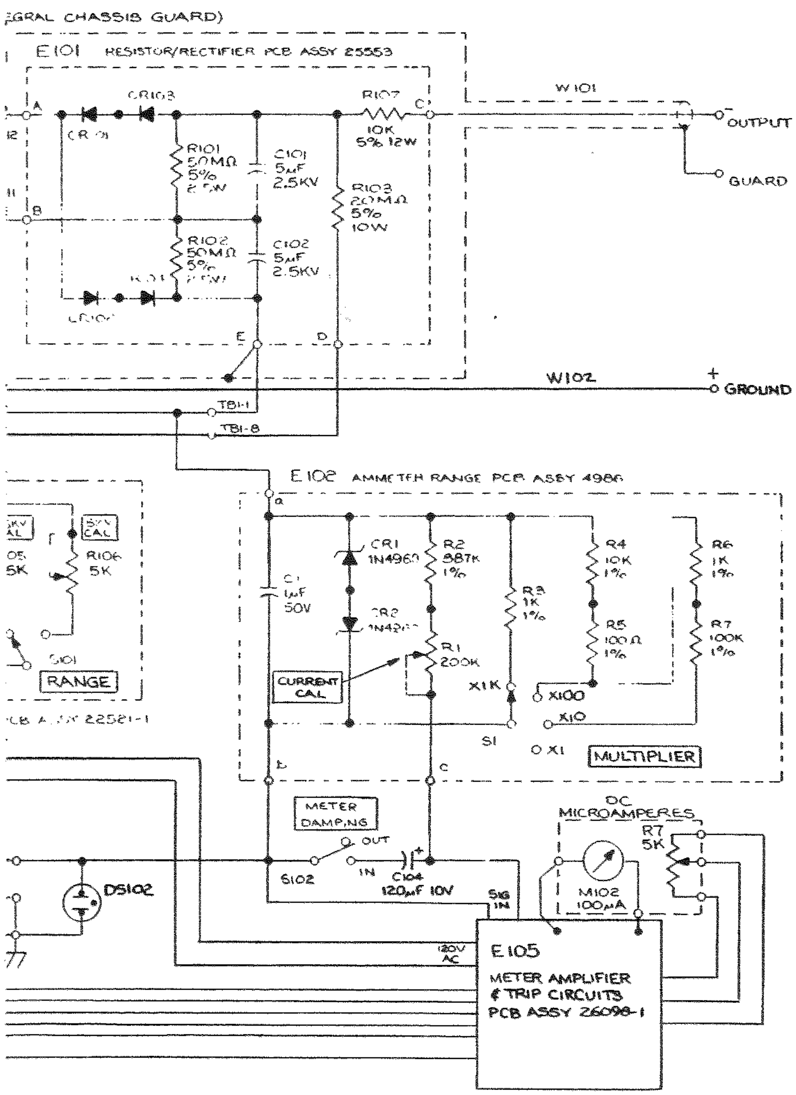
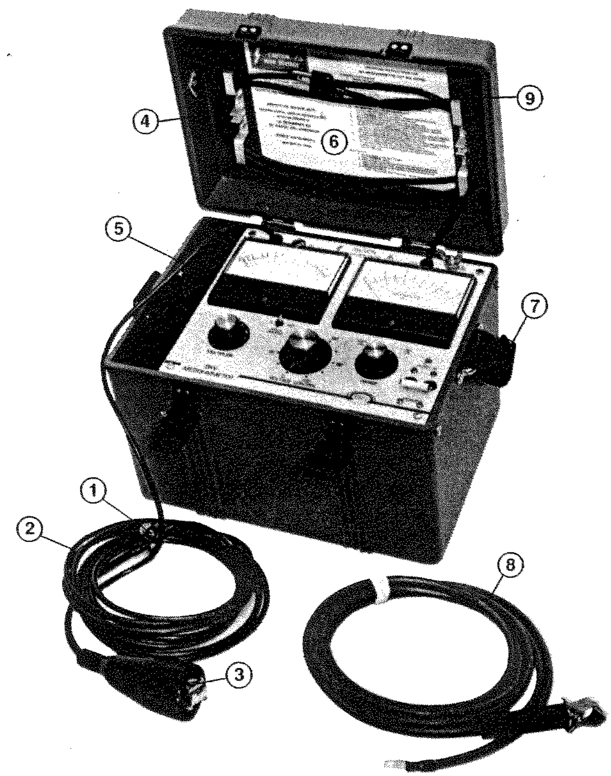


FIGURE 4: Test Set with Overcurrent and Overvoltage Options - Schematic Diagram.

Section F

CONTROL AND CONNECTOR IDENTIFICATION

Figure 5 below illustrates the various controls and connectors.



1. Guard Terminal
2. Output Cable
3. High Voltage Terminal
4. Removable Case Cover
5. Serial Number
6. Instruction Card
7. Carrying Strap
8. Ground Cable
9. Input Cable

Instruction Manual Not Shown

FIGURE 5: Test Set Showing Standard Equipment Supplied.

Section G

SETTING UP

The following steps are listed as a general guide for setting up the dielectric test set. Suggested setup arrangements are shown in Figure 6. Test set controls and terminals are identified in Section F.

<u>Preliminary Procedure</u>

Working with due regard to safety, identify the terminals of the apparatus to be tested. Set up barriers or use other means to keep unauthorized personnel away from all high-voltage terminals of the complete test arrangement.

<u>Selection of Location</u>

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 15 feet of the high-voltage terminal of the apparatus to be tested.

   NOTE: As an added safety measure, 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. An electrical service outlet must be within 5 feet of the test set.

5. The operator of the test set must be able to conduct the test without being exposed to traffic hazard; and 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.

<u>Connections</u>

To connect the test set to the apparatus to be tested, follow the procedure listed below.

1. Connect the test set ground lead to the panel and to the local ground.

2. Connect the output cable clip to the high-voltage terminal of the apparatus to be tested.

3. With the test set switch OFF, connect the input cable to the service outlet.

4. Ensure that the low-voltage terminal of the apparatus to be tested is grounded.

5. 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 H and I.)

Clearances

Be sure that 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 I. 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

Test Sets with Optional Features

Test sets equipped with either the overcurrent or overvoltage options, or both, are set up as previously described; however, before conducting a test, the desired limits of voltage and/or current should be set in accordance with the instructions given in Section H.

When the equipment has been set up according to the above procedure, tests can be conducted in accordance with the instructions given in Section H. An operator familiar with these tests and with the test set in use can follow the operating procedures given in abbreviated form on the lid of the test set.

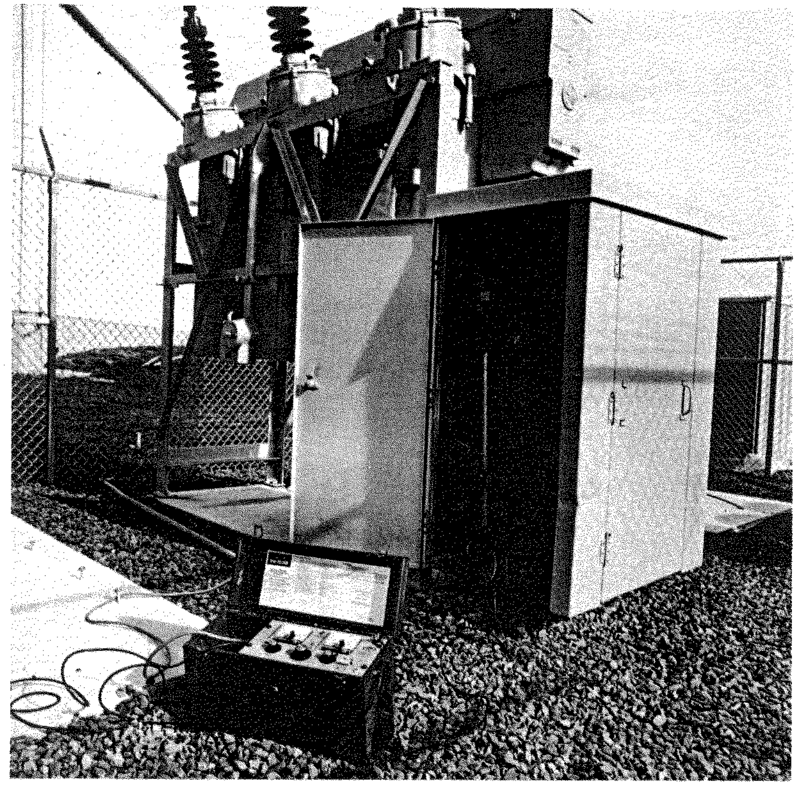


FIGURE 6: Setup Arrangements (View A).

FIGURE 6: Setup Arrangements (View B).

FIGURE 6: Setup Arrangements (View C).

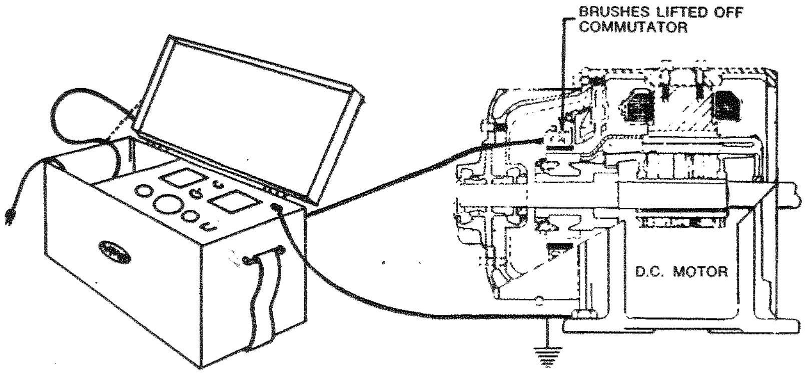


FIGURE 6: Setup Arrangements for DC Motors and Generators (View D).

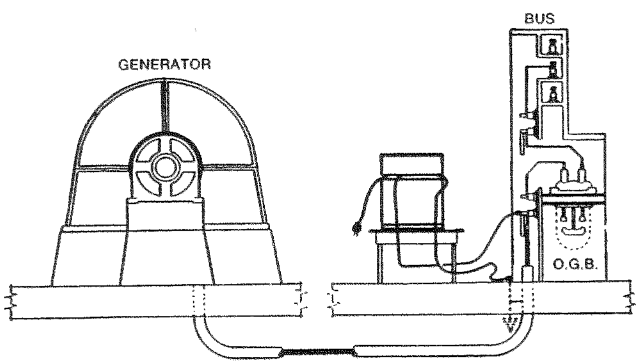


FIGURE 6: Setup Arrangements for AC Generators (View E).

Section H

OPERATION

When the test set and apparatus to be tested are set up as indicated in Section G, the equipment can be energized and the required tests run by following the steps given below.

NOTE: Before operating the dielectric test set, read Section B of this manual and ensure that all appropriate safety precautions are observed.

Before conducting a test, consult Section I for details that may pertain to the test being conducted. For information on test theory, see Section J. For a performance check, see Section M.

Test Procedure

1. Remove all safety grounds from the apparatus to be tested.

2. Close the main switch of the test set.

3. Firmly set the voltage control to zero.

4. Turn the voltage control clockwise to increase the output voltage as required for the test being conducted.

5. Note voltage, current, and time, as required by the test procedure being followed. Set the voltmeter and current range switches as necessary.

6. If the current meter fluctuates during the reading, the meter damping switch may be set to the IN position. (Normally the meter damping switch is in the OUT position.)

7. Follow the same operating procedure for test sets equipped with overvoltage and/or overcurrent options; but prior to energizing the test, set the red pointer on the appropriate meter to the desired limit. (See Section I.)

8. Follow the same operating procedure for test sets equipped with the 230-V 50/60-Hz option. Operation of sets with this option is identical except for the supply line voltage.

Completion of Test

When the test has been completed, follow the shutdown procedure given below.

1. Set the voltage control to zero.
2. Open the main circuit breaker (main switch).
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 the high-voltage terminal of the apparatus being tested.
4. Disconnect cables in the following sequence: first, the input cable; then the test cable; and finally, the ground cable.
5. Apply ground bonds to the equipment that has been disconnected.

These operating instructions appear in an abbreviated form on the instruction card located on the lid of the test set.

In the event of failure of the apparatus being tested, the test set circuit breakers will trip out within twenty (20) seconds. 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.

Emergency Shutdown Procedure

For any circumstances requiring that a test be stopped immediately, the shortest procedure is to apply the grounding stick directly to the high-voltage terminal. This emergency action will remove the test voltage in the shortest possible time and will in time trip out the circuit breaker.

At any time, the main switch (circuit breaker) can be opened manually to interrupt a test, provided that the grounding stick is applied afterward to discharge any stored energy.

Emergency procedures should be followed only when absolutely necessary, since they risk damage to both the test set and the apparatus being tested.

Section I
OPERATION NOTES

Line Voltage

In field service, it is frequently necessary to use a temporary power service. Recognizing that such a service may accidentally be connected cross-phase or may be of improper voltage, the test set has been equipped with a POWER ON lamp placed on the electrical circuitry after the input circuit breaker. When the glow of the POWER ON lamp is abnormally bright, the operator is quickly warned (before he attempts to obtain high-voltage output) that the line voltage is incorrect and may correct the problem before any damage is done to the test set.

Biddle recommends that when using the Cat. No. 220005-47, the service supplying the test set be protected by a fuse of not less than 1 1/4 ampere or more than 3 amperes.

The Cat. No. 220005-47 has been supplied with a line cord connector for which adapters are readily available to fit the many different service outlets in use. The connector may be cut off and replaced with the fitting used in the service area if desired. The green lead must connect to service ground, the white lead to the supply neutral and the black lead to the "hot" lead of the supply.

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 to the highest range (the voltmeter to 5 kV, the current meter to 5 mA) and the meter damping switch placed in the IN position.

Meter Damping Switch

This switch acts on the current meter circuit only. During the measurement of leakage current on apparatus having significant capacitance, small line voltage transients can result in large transient swings of the current meter. This effect will be most noticeable when using the 5 uA range and will require that the operator judge the indicated current value by visually and mentally averaging the value. To assist in this, the meter damping feature and/or a line voltage conditioner ahead of the test set may be used. Placing the meter damping switch to the IN position will cause the meter to integrate and so average the current over a period of time. This helps the operator to judge the value by reducing the number of pointer swings and slowing down the pointer motion. With the damping switch set to OUT, the meter follows current variations most accurately to a limit set by the ballistic meter response. This feature is most useful for tests in which current is measured in relation to time, especially when times are on the order of minutes.

Use of Guard

Occasionally when measuring apparatus, the leakage current of interest is masked by a parallel path. Such a situation is often encountered when measuring the leakage current of a cable. In the practical situation, the value of the current along the leakage path from the conductor over the surface of the pothead may be greater than that within the major length of the cable. Under such conditions, the guard feature of the test set is useful in excluding the current in the surface path from the measured current. (See Figure 7.) This is easily accomplished by forming an intercepting electrode by wrapping a wire around the outer surface cable pothead close to the shield or ground. This electrode, which will intercept the surface current, should be connected to the test set guard terminal. The unwanted current then bypasses the meter and is not measured; the meter will read only the current passing through the main portion of the cable.

This same guard principle can be used on other apparatus 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. (See Figure 8.) The guard terminal is only a few volts above ground and does not pose a safety hazard under normal conditions.

Voltage Control Scale

A reference scale is provided on this set 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 also 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 excess 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 ten to fifteen

percent, depending on line voltage and the nature of the apparatus being tested. For an estimate of the lag time between the voltage control position and the achievement of a steady voltage, see later paragraphs of this section.

External Instrument Jack

A standard jack taking a P/N 6468-1 plug has been provided with this test set for the convenience of users who prefer to use an external current meter. When using this jack, the negative terminal of the external instrument should be connected to the plug shell, and the positive terminal to the insulated center pin of the plug. This connection places the external instrument in series with the test set current meter. When an external current meter or recorder is used, it will measure the same current as that measured by the test set current meter. The external instrument must have its own current range selection and must be separately protected against failure of the apparatus being tested.

It is recommended that the internal impedance of any external meter not exceed 10,000 ohms. Care must be taken when using potentiometer-type recorders as external current meters. In such cases, a standard current-sampling resistor must be connected across the plug, and the recording potentiometer must be connected across the sampling resistor or a portion of it.

Use of Regulation Curve

The regulation curve shown in Figure 9 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. From this curve, peak ripple voltage can be estimated as well as the equivalent internal resistance of the test set for a wide variety of circumstances. The curve also indicates the circuit breaker limits of operation

Overcurrent Option

This option is provided for those users who require that the test set be shut down in the event that output current exceeds a preset value. (Operation of the overcurrent circuit was described in Section E.) To set the trip current, it is first necessary to select the current meter range so that the red pointer can be set to the actual desired value.

This selection and setting normally are made before the test is energized; and while a setting may be selected while a test is in progress, care must be taken that the red pointer does not reach the position of the meter pointer or a false trip out will occur.

In any case, once a trip out has occurred, the voltage control must be returned to zero before output is again available. Tripping by meter relay does not open the main breaker. The time required to trip out once the meter pointer reaches the red pointer is on the order of 60 milliseconds. After trip out, power is removed from the test set but energy may still be stored in the apparatus under test. This will usually be indicated by the test set voltmeter which will still indicate some voltage.

Overvoltage Option

This option functions in the same manner as the overcurrent option, and the same information applies except that the test set voltmeter is the tripping device. This option is used when it is desirable to prevent the application of excessive voltage to the apparatus under test and will function to do so even in the event that the operator makes a mistake in setting the voltage control.

Overcurrent and Overvoltage Options

Both overvoltage and overcurrent limits are included with these options, and each limit can be separate. A trip out caused by either voltage or current will remove power from the test set and will require that the voltage control be returned to zero before output is again available.

Operation Without Limits

When using a test set that includes the overvoltage and/or overcurrent options for a test on which limits are not required, the trip function can be removed by setting the red pointer(s) as far beyond full scale as the knob permits. The test set then operates just as if the option(s) were not included.

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 J for additional data.) The regulation curve shown 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; 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 test; it is even possible to place some resistance in series with the high-voltage connection and allow the arc-over to continue for long periods of time. In some cases, however, this result can be obtained simply by careful adjustment of the voltage control.

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 that arc-over at voltages of less than 3.0 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 hazard from the new connection.

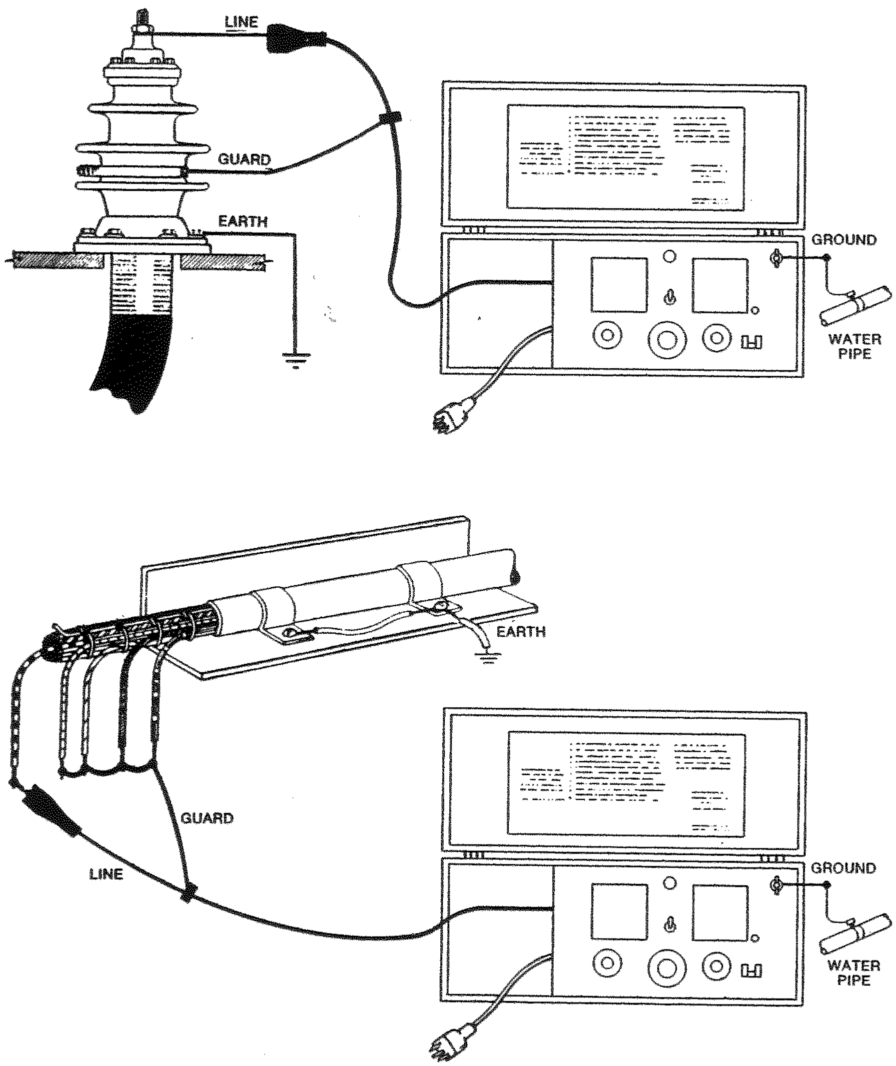


FIGURE 7: Guard Connections for Typical Cable Tests.

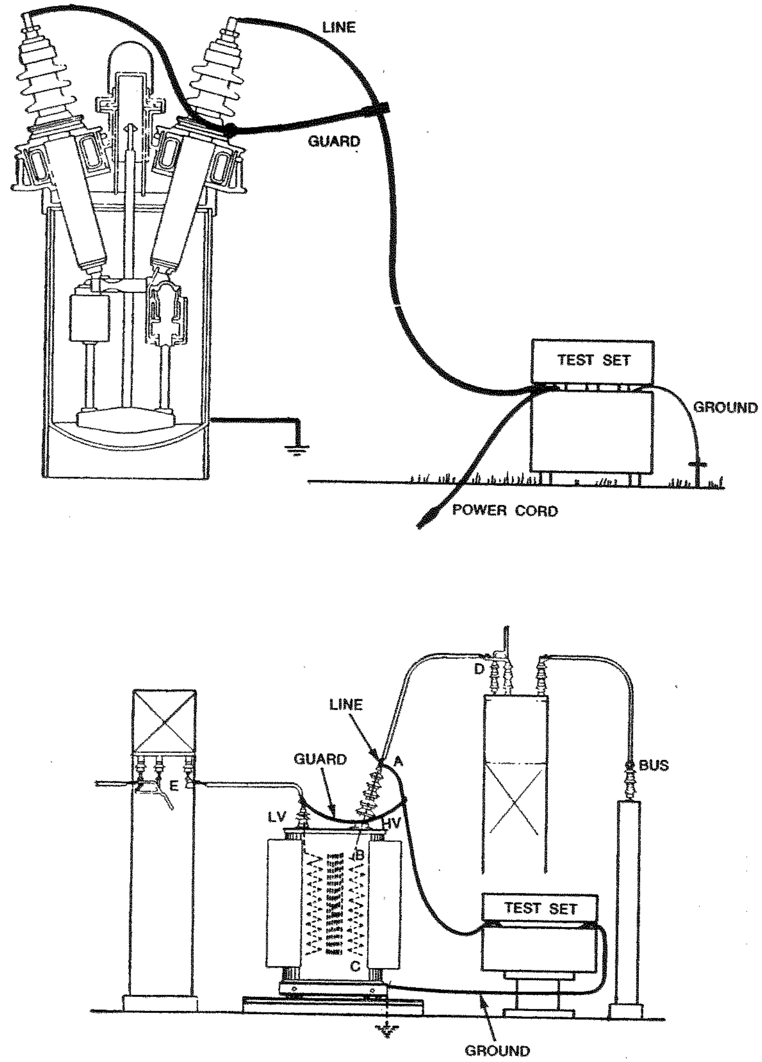


FIGURE 8: Guard Connections for Typical Apparatus Tests.

CURVES: VOLTAGE CONTROL SETTINGS BASED ON 120V LINE VOLTAGE

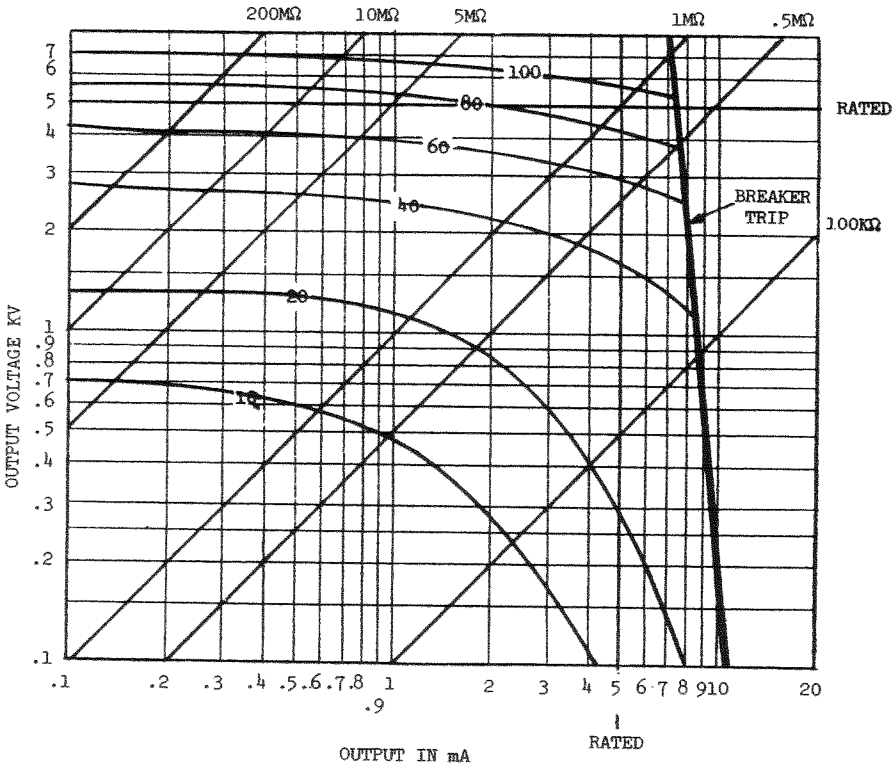


FIGURE 9: Regulation Curve.

Section J

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, 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 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. Detailed information on dc testing is also available in a course entitled "DC Testing of Power Apparatus Insulation" offered by the Biddle Technical School.

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 he may make full use of this dielectric test set.

Insulation Testing by DC Methods. Biddle Technical Publication 22T1, 1971.

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.

Section K

ROUTINE MAINTENANCE

Field service use 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.

Inspection and Maintenance Procedure

The complete inspection and maintenance procedure detailed below can be performed in approximately fifteen minutes. The only equipment required consists of a screw driver, an insulated jumper about one foot long, a clean damp cloth, and a clean dry cloth.

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

> NOTE: As a safety precaution, ensure that the set has not been energized for at least fifteen minutes prior to beginning this work.

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 zero.

6. Remove Test Set from Case.

CAUTION!
THE TEST SET MUST BE DEENERGIZED 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 in the test set interior even after the set has been deenergized.

To remove the test set from the case, follow this procedure:

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. Using an insulated jumper, short-circuit capacitor C-101, then capacitor C-102 to remove any stored charge.

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. Remove the capacitor jumpers and reinstall the set in the case.

C. Coil the leads and replace them in the lead compartment.

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

Section L

TROUBLESHOOTING AND REPAIR

BIDDLE maintains a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. Repairs will be made in accordance with our normal Class 2 repairs. 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 N. 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; because of the possibility of related component failure, BIDDLE 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 II (included at the end of this section) notes possible equipment malfunctions that may be observed during operation or checkout and suggests possible causes and means of determining the defective component. Table II has been arranged to refer to the replacement part assemblies, as BIDDLE recommends that field repairs be made by replacing assemblies. The schematic diagrams give in Section E and the interior view of the test set given in Figure 10 will be helpful in locating components. When ordering parts, particularly for those sets equipped with options, it is desirable to include the test set serial number. The location of the serial number is shown in Figure 5 (see Section F).

It is important that persons repairing the test set fully understand the operation of the circuitry. When an assembly fails, it may damage related 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. See Figure 10 for location of major internal parts.

Remove the test set from the case as explained in Section K.

Case Repairs

Because of their 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 (see parts list) after the test set has been removed from the case.

Replacement of Input Cable W-100 and Integral Plug P-101

1. Remove the test set from the case as indicated above.
2. Locate the input cable and disconnect each of its three wires, noting the terminal from which each lead is disconnected.
3. Squeeze the cable clamp and withdraw the cable and clamp from the chassis. Save the cable clamp.
4. Place the cable clamp on the new cable in the same position as on the original cable.
5. Reinstall the cable in the chassis, dress the leads, and terminate on the original points.
6. Reinstall the test set in the case.
7. On -47 sets the input cord is part of the transformer assembly (T102) which is then connected to the test set with a shortened cord. The input cord to the transformer may be replaced as above.

Replacement of Output Cable W-101

1. Remove the test set from the case.
2. Locate the output cable and disconnect it from the circuit, carefully noting lead dress and terminals.

3. Squeeze the cable clamp, and withdraw the cable and clamp from the chassis.
4. Duplicate the original test set end terminations on the new cable, and place the cable clamp in the same positions as on the original cable.
5. Reinstall cable and clamp in the case, dress the cable into position, and terminate at the original points.
6. Reinstall the test set in its case

Replacement of Ground Cable W-102

When replacement of the ground cable is required, order the cable as a complete assembly ready for use. The replacement cable will be the same as the original detachable ground cable.

Replacement of Panel Mounted Assemblies

A. Disconnect the panel harness from the chassis terminal block. Note the location of each lead so that it may be reconnected to the same point.

B. Remove the panel and follow the steps below.

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 Current Meter Range Circuit

1. Remove the range switch knob, switch shaft, locknut and washer.

2. Unsolder the three leads attached to the E-102 circuit card, noting the proper reconnection terminals for each lead.

3. Install the new E-102 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. Resolder the leads to the printed circuit card.

Replacement of Meter Damping Switch S-102

1. Unsolder the two leads from the back of the switch, noting the terminals to which each wire was connected.

2. Remove the switch nut from the front of the panel.

3. Replace and align the switch, and lock it in place.

4. Resolder the two leads.

Replacement of External Instrument Jack J-101

1. Unsolder the two leads from the center terminal.

2. Remove the nut and washer from the front.

3. Before replacing the jack, jumper the ring and adjacent terminal.

4. Install the new jack in the panel, align and tighten it.

5. Reconnect and resolder the two leads.

Replacement of Damping Capacitor C-104

1. Unsolder the two leads to this capacitor, noting the terminals to which each wire was attached.

2. Cut the tie-wrap holding the capacitor (note polarity).

3. Install the replacement capacitor on the bracket, using a tie-wrap to secure the capacitor in the same position and with the original polarity.

4. Reconnect and resolder the leads to the capacitor terminals.

Replacement of Lamp DS-101

1. Unsolder the two leads from the lamp, noting carefully the terminals to which each lead was connected.

2. Using a knife blade and needle-nose pliers, remove the holding clip.

3. Install the replacement lamp, pressing the clip into place to hold the lamp securely.

4. Reconnect and resolder the leads.

Replacement of Main Breakers

1. Remove the "C" rings holding the cross member between handles, and remove the cross member.

2. Disconnect all terminals, carefully noting the terminal to which each lead must be reconnected.

NOTE: In some sets, a resistor will be found across two of the circuit breaker terminals. This can be discarded. Certain circuit breakers will have the trip value trimmed by such a resistor. If it is not present on the replacement, it is not required.

3. Remove and save the four front panel screws.

4. Install the replacement breaker; and secure it to the panel, making sure that it closes when the handle is moved toward the lid.

5. Reinstall the cross member between the handles.

6. Reconnect all leads to the appropriate terminals.

Replacement of Voltage Control Autotransformer T-101

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 Lightly 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 K-102 Assembly

1. Disconnect relay K-102, noting the appropriate reconnection terminals for each wire.

2. Remove K-102 from the panel bracket.

3. Replace K-102.

4. Reconnect relay K-102.

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 steps listed on the next page.

Replacement of Card E-101

1. Remove the three leads from the terminal strip, noting the proper reconnection terminal for each lead.

2. Remove the four nuts from capacitors C-101 and C-102.

3. Remove the output cable terminal by removing the screw which connects it to resistor R-107.

4. Raise the card, folding it out so that the transformer lead can be unsoldered.

5. Unsolder the lead, noting the appropriate reconnection points.

6. Replace the card and resolder the transformer lead to the replacement card.

7. Reverse the disassembly procedure to complete the installation.

Replacement of Transformer T-102

1. Follow the procedure for removing Card E-101.

2. Disconnect the transformer leads from the terminal strip and chassis.

3. Remove the transformer.

4. Reverse this procedure to install the replacement.

Replacement of Capacitors C-101 and C-102

1. Follow the instructions for removing card E-101.

2. Loosen the capacitor brackets and open the securing band.

3. Remove the capacitor(s).

4. Replace with new unit(s) and resecure band and bracket.

5. Set the terminal nuts so that card E-101 is parallel to the chassis.

6. Reinstall the E-101 card and proceed as for replacement of E-101.

Replacement of Amplifier Ammeter Trip Circuit Board

1. Follow the procedure for removing card E-101.
2. Unsolder leads to board, noting locations.
3. Remove board from chassis.
4. Replace the board, making sure that it faces in the original direction.
5. Reconnect leads to board.
6. Reverse the disassembly procedure to complete.

Recalibration of Current Meter

This operation will require a current meter to measure dc. The meter must be capable of reading 0.5 mA with an accuracy of ±1% or better. A resistor of 2 megohms ±20% that is able to withstand 1000 volts also will be required.

1. Connect the test set as shown in Figure 11.
2. Mechanically zero the current meter, then follow the checkout procedure given in Section M, using the above described resistor as a load.
3. Set the current meter to the 500 uA scale.
4. Increase the voltage until the standard meter reads 0.5 mA.
5. Adjust the curent meter until it agrees with the standard current meter reading. To do this, first remove the cover screw on AMCAL; then use a fine blade screwdriver to make the adjustment.
6. After calibration, check at half-scale; if within 240 to 260 uA, replace the cover screw.
7. If mid-scale error exceeds 250 uA ±10 uA, readjust for best compromise between full-scale and mid-scale.

The above procedure also is applicable to sets equipped with the overcurrent option; but on such sets, it may be necessary to work at 0.45 mA to avoid trip out during the calibration.

Recalibration of Voltmeter

This procedure requires a dc meter that is capable of reading both 2.5 kV and 5 kV with an accuracy of ±1% or better. On either range, this standard instrument should draw less than 0.5 mA.

1. Connect the test set as shown in Figure 12.
2. Mechanically zero the test set voltmeter.
3. Arrange the test following the procedure given in Section M, but use the standard voltmeter as a load on the test set.
4. Remove the cover screws from both the 2.5 kV CAL and the 5 kV CAL adjustments.
5. Adjust the output voltage until the standard voltmeter reads 2.5 kV with the test set voltmeter range switch set for 2.5 kV.
6. Using a fine blade screw driver, adjust the 2.5 kV potentiometer through the 2.5 kV CAL hole until it agrees with the standard.
7. Check at half-scale, then repeat on the 5 kV range.
8. Replace the cover screws.

This procedure also is applicable to test sets equipped with the overvoltage option; but on those sets, the calibration may have to be carried out at 2.0 kV and 4.5 kV, respectively, to avoid trip out during adjustment.

TABLE II. TROUBLESHOOTING GUIDE

Malfunction	Possible Cause
POWER ON lamp does not light.	De-energized service outlet. Defective service outlet. Defective line cord. Defective lamp.
POWER ON lamp abnormally bright.	Incorrect supply voltage.
Main Breaker trips on closure.	Cross link between poles broken. Defective zero start circuit. Defective voltage control autotransformer. Defective overvoltage and/or overcurrent amplifier. Defect in wiring.
Main breaker trips when output voltage is increased.	Test set output shorted. Defective output cable. Defective rectifier assembly. Defective filter capacitors. Defective high-voltage transformer. Defective voltage control autotransformer. Defective high-voltage insulation.
No output voltage.	Defective zero start circuit. Defective rectifier assembly. Defective high-voltage transformer. Defective voltage control transformer. Defective voltmeter movement. Defective voltmeter range selector/protective circuit. Defective voltmeter multiplier. Defective wiring. Defective overvoltage and/or overcurrent relays.

TABLE II. TROUBLESHOOTING GUIDE (continued)

Malfunction	Possible Cause
No output current.	Current range switch set too high. Guard circuit grounded. Defective current meter movement. Defective range selector/protective circuit. Defective damping capacitor (only when in use). Defective wiring. Defective amplifier on overcurrent-equipped options.
Output voltage erratic.	Equipment under test failing. Defective output cable (open circuit or poor connection). Defective voltage control autotransformer.
Output voltage setting does not agree with regulation curve.	Improper line supply voltage. Defective resistive load bank. Voltage control knob not in proper position on autotransformer shaft. (See "No output voltage" malfunction.) Defective output resistor.
Output voltage greater than 500 volts at voltage control zero.	Defective setting of zero start. Defective output voltage control autotransformer.
Current leakage greater than 0.3 µA at 5 kV no load.	Output terminal of output cable not properly spaced from nearby objects. Output terminal dirty. Output terminal burred or damaged. Internal dirt or damage. (See "No output voltage" malfunction.)

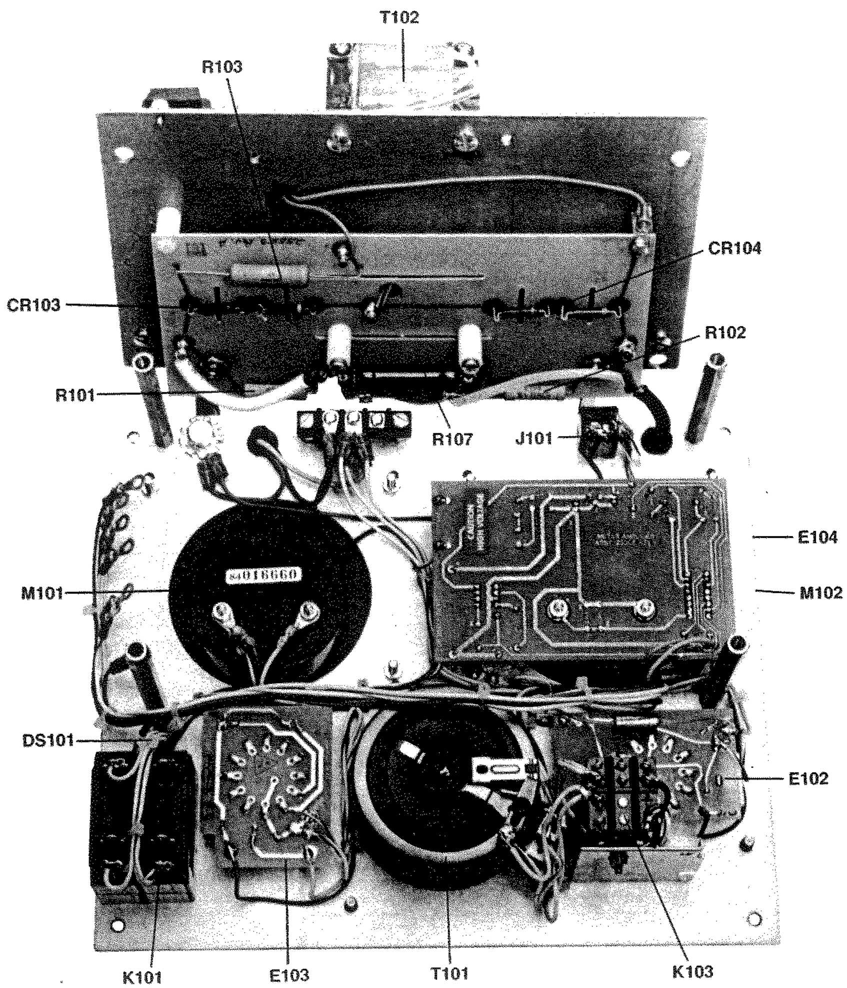


Figure 10: Test Set Interior.

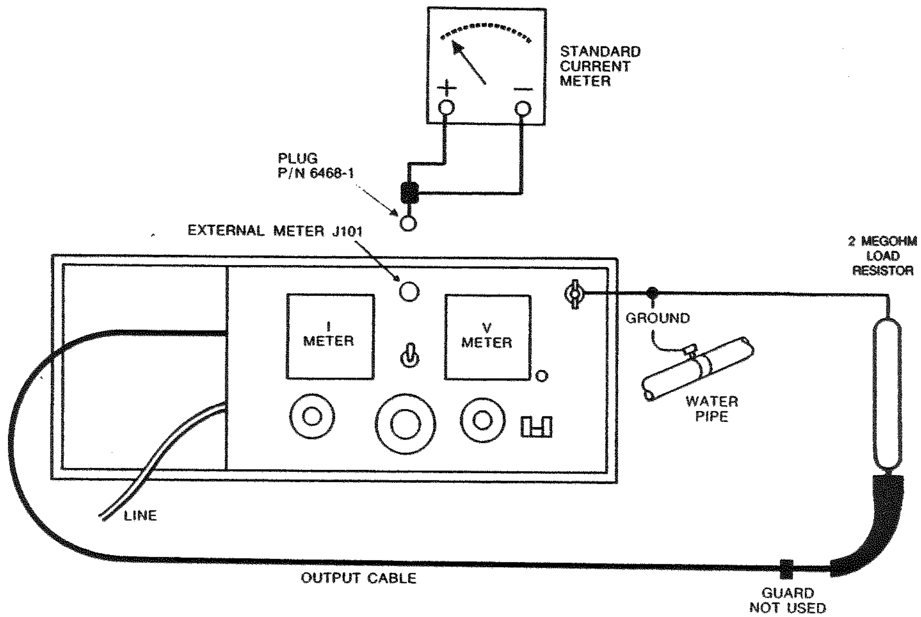


FIGURE 11: Connection for Calibration of Current Meter.

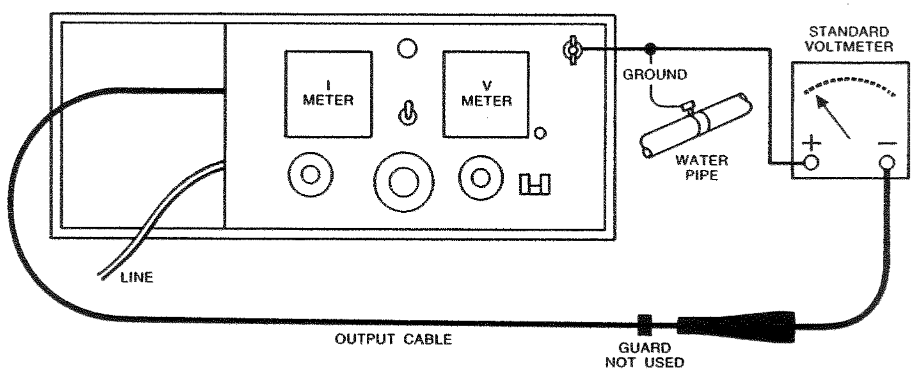


FIGURE 12: Connection for Calibration of Voltmeter.

Section M

PERFORMANCE CHECK

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

> NOTE: 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.

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

Follow the procedure given below.

1. Set up the equipment as indicated in Section G. Suspend the output lead so that the high-voltage clip is clear of all objects by at least two (2) inches.

2. Set the voltmeter range to 5 kV and the current meter to 5 μA.

3. On sets with overcurrent and/or overvoltage options, set the red pointer(s) to the fully clockwise position(s).

4. Operate the set according to the procedure given in Section H, raising the voltage to 5 kV. Note that the current meter does not indicate more than 0.25 μA leakage current. (See Step 11 for overvoltage option.)

5. Follow the shutdown procedure given in Section H.

6. Connect the high-voltage output to ground.

7. Set the voltmeter range to 2.5 kV and the current meter to 5 mA.

8. Operate the set and very carefully turn up the voltage control. Note that the current meter moves to full scale. (See Step 12 for overcurrent option.)

9. After reaching full scale on the 5 mA range, advance the voltage control to 10 and note that the main circuit breakers trip out in 20 seconds or less.

10. For sets equipped with overvoltage and/or overcurrent options, trip out may occur because the red pointer position is reached while performing Step 8 or 9. This is considered acceptable if trip out occurs within one division of full scale.

11. For sets equipped with the overvoltage option, this optional function can be tested by setting the voltage near mid-scale and then moving the red pointer toward the meter pointer until trip out occurs. Trip out should occur when the red pointer is within one division of the meter pointer.

12. The overcurrent option can be functionally tested on any current range, but it is easiest to do so using the 5 mA range. To perform this test, first ground the high-voltage output then set the voltage control so that the current meter reads less than full scale but more than half scale. Move the red pointer toward the meter pointer and note that the set trips out when the red pointer is within one division of the meter pointer.

Section N

PARTS LIST

Symbol	Description	JGB Part No.	
None	Complete Case and Lid	25523	
None	Case Feet	5599-1	
None	Carrying Strap and Bails	6580-2	
W100	Input Cable	4127-2	
W101	Output Cable	6437	
W102	Ground Cable	4702	
None	External Inst. Plug (optional)	6468-1	
Panel Mounted Assemblies			
C104	Capacitor	12019-10	
DS101	Power ON Light	4499-1	
E102	Current Range Selector P.C.	4986	*
Knob	Current Meter Range	9998-81	
J101	External Instrument Jack	4733-2	
K101	Main Breaker	6807-6	
K102	Control Relay	9270	
M101	Voltmeter	25297	
M101	Overvoltage Voltmeter	25566	
M102	Current Meter	25296	
M102	Overcurrent Meter	25565	
T101	Voltage Control Autotransformer	25849	
Knob	Voltage Control	4690-1	
E103	Voltmeter Range Switch Assy.	22521-1	
Knob	V. M. Range	9998-8	
S102	Meter Damping Switch	12119-3	
E104	Meter Amplifier Board	25006	*
Chassis Mounted Asemblies			
E101	Rectifier/Resistor Assembly	25553	*
T102	High Voltage Transformer	6407	
C101	Filter Capacitor	6406	
C102	Filter Capacitor	6406	
For Use on Sets with -42, -43 or 101 Options			
E105	Amplifier, Overvoltage-Overcurrent Board	26098-1	*
	Amplifier Overcurrent Board	26098-2	*
	Amplifier Overvoltage Board	26098-3	*
For Use on Sets with -47 Option			
T2	Transformer	22758-1	
T3	Autotransformer	22754-1	

* can be returned as separate assembly for repair.

Section P

WARRANTY AND REPAIRS

WARRANTY

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

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

REPAIRS

Biddle maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend that it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.