Instruction Manual
AVTM 22-3J

For the

Regulated DC Dielectric Test Set

Catalog Numbers 223015 and 223080

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High-Voltage Equipment
Read the entire manual before operating.

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

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RECEIVING INSTRUCTIONS

Check the equipment received against the packing list to ensure that all materials are present. Notify Biddle Instruments of any shortage. Telephone (215) 646-9200.

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.

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

GENERAL INFORMATION

The Regulated DC Dielectric Test Set provides the high voltage dc output needed to test the quality of electrical insulation on high capacitance test specimens such as power cables, generators, and capacitors. It also has the capability for precise measurement of test specimen current and voltage. The test set consists of the high-voltage (HV) module and the controller, interconnected by a cable. The test set is lightweight and designed for use in the field, shop, or laboratory.

The instructions and suggestions provided in this manual anticipate the normal use of dielectric test sets for testing electrical insulation systems on such equipment as motors, generators, bushings, and cables. The 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 (Cat. No. 220000), the shape of the curve made by connecting the plotted points will aid in evaluating the quality of the insulation system. Information on the interpretation of observed data and guides for test voltage and time interval are referenced in Section 6 of this manual and in Biddle Technical Publication 22T1.

The standard test set has been designed for 115 V 50/60 Hz, single phase line voltages. If 230 V operation is desired, a -47 suffix will be used with the catalog number of the test set. Refer to Section 3 for exact ac line specifications of both models.

Section 2
Safety

Safety is the responsibility of the user. Misuse of this equipment can be extremely dangerous.

The purpose of this equipment is limited to the use as described in this manual. Do not use this equipment or its accessories with any device other than specifically described.

This manual assumes a knowledge of standard high-voltage safety and testing techniques. Refer to IEEE Std 510-1983, "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing," for additional information.

This instrument operates from a single phase power source. It has a two-pole, three-terminal grounding type connector. The voltage to ground from either pole of the power source must not exceed the maximum rated input voltage. 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 connector can cause an electric shock hazard. Determine that the receptacle is properly wired before inserting the plug.

This test set is designed to be connected to de-energized cable and other high-voltage power apparatus terminals. 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.

If the test equipment is operated properly and all grounds are 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 instrument controls. Biddle Instruments considers this to be an excellent safety practice.

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. Persons with heart pacemakers should obtain expert advice on the possible risks before operating the equipment or being close to the equipment during operation.

Any ungrounded object or capacitor which is not in use but may be within the influence of the test set's electromagnetic field should have all accessible surfaces bonded to ground during the high-voltage test.

Capacitive objects should be fully discharged and then short circuited after being subjected to high voltages. Failure to maintain a short circuit on the capacitor after testing may allow the eventual buildup of hazardous voltages due to the effect of dielectric absorption.

The test set has an internal trickle discharge circuit and voltmeter. The internal discharge circuit will only provide rapid discharge of specimens with small capacitances. Refer to Section 3 for specifications on discharge times. In all cases, the internal discharge circuit and voltmeter should be regarded as secondary safety features, and not as substitutes for the standard safety practice of manually discharging and short circuiting capacitive objects prior to handling. Discharging and short circuiting should be performed with a properly rated high-voltage resistive grounding stick.

Do not short circuit capacitors until fully discharged. Discharging a capacitor at a rate greater than specified by the capacitor manufacturer can lead to damage or explosion.

Do not leave the test set unattended while operating. Observe all cautions marked on the equipment.

This test set is a source of hazardous voltage. The test set, connected test specimen and all other connected equipment should be enclosed within an interlocked area that meets with the requirements specified in Section 5. The test set is equipped with an interlock connector. Follow the interlock installation procedures detailed in Section 5.

Do not operate the test set under conditions of precipitation or excessive humidity. Refer to Section 3 for environmental specifications.

The following specific warning notice is used throughout this manual where applicable and should be strictly observed,

WARNING

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

Section 3
Specifications

ELECTRICAL

Control: active control on both voltage and current.

Control range: from 2 to 100 percent of rated output on both voltage and current.

Output polarity: negative with respect to ground.

Supply voltage: 105 to 125 V, 50/60 Hz, single phase, grounded.
210 to 250 V, 50/60 Hz, single phase, grounded.

Maximum supply current: 5 A (normal operation).

Ripple, full load (resistive): 0.2 percent rms.

Rate of rise limit: 25 sec typical to full output voltage or current.

Regulation: better than 0.4 percent for all loads.

Voltmeter: three digit autoranging indicating kilovolts.

Current meter: three digit autoranging indicating milliamperes and microamperes.

Megohm meter: three digit autoranging indicating megohms and gigohms.

Meter accuracy: ± 2 percent of full scale for voltage and current.
± 4 percent of reading for insulation resistance.

Overload protection: magnetic circuit breaker in input line.

Output trip features: overvoltage, overcurrent, thermal, flashover.

Control circuit: universal controller can be used with any HV module in family. Dual function meters read control settings or measure actual HV conditions. Records voltage of load at flashover. Direct readout of apparent insulation resistance.

	Cat. No. 223015	Cat. No. 223080
Maximum output voltage	15.0 kV	80.0 kV
Maximum output current	10.0 mA	2.00 mA
Capacitive load range	0 to 5 µF	0 to 500 nF 500 nF to 5 µF with 1 MΩ external stabilization resistor P/N 25870
Resistive load range	100 kΩ-150 GΩ	1 MΩ-500 GΩ
Internal discharge resistor	85 MΩ	450 MΩ
Time required to discharge fully charged specimen to safe level (60 V dc) using internal discharge circuits	47 s/100 nF	325 s/100 nF

PHYSICAL CHARACTERISTICS

Dimensions of controller:	19-3/4 x 12-1/2 x 11-3/4 in. (50.2 x 31.8 x 29.9 cm)
Weight of controller:	31 lb (14.1 kg)
Dimensions of HV unit:	21 x 10-1/2 x 9 in. (53.4 x 26.7 x 22.9 cm)
Weight of HV unit:	22 lb (9.9 kg)

ENVIRONMENTAL

Operating temperature range: 32 to 104°F (0 to 40°C)

Storage temperature range: -22 to 131°F (-30 to 55°C)

Humidity: 5 to 95 percent relative humidity, noncondensing

Climate: operation prohibited in direct rain or snow for safety reasons.

GROUNDING REQUIREMENTS FOR HV UNIT

Solid metallic rod or counterpoise with a resistance of less than 3 Ω to earth is recommended; 10 Ω or less is required for proper operation. Measure with a ground tester such as Biddle Cat. No 250260 or functional equivalent.

CABLES SUPPLIED

18 ft high-voltage output cable
15 ft ground cable
8 ft three-conductor line power cord
10 ft interconnection cable
The cables are stored in a nylon bag. The weight of the cables and bag is 8.5 lb (3.9 kg).

SAFETY FEATURES

- A connection is supplied for an external safety barrier interlock system which precludes application of high voltage. This connector is shipped from the factory with a shorting plug installed.

- Zero start interlock is provided so that high voltage cannot be activated unless the output VOLTAGE CONTROL is on zero.
- Current limited output with active regulation.
- An internal watchdog timer circuit which causes HV output to be discontinued if the microprocessor fails to refresh every two seconds when HV is being produced.
- Electronic overvoltage and overcurrent protection is provided to switch off the system high voltage output in the event of abnormally low conversion efficiency.

OPTION

- Safety foot switch connects to the interlock receptacle on the controller to give the operator safety control of high voltage (P/N 10229, 10 ft cable or P/N 10229-1, 50 ft cable).

Section 4
Description

GENERAL

Figure 1 shows a block diagram of the system which comprises the controller and the high-voltage module. The controller is universal in nature and can be used with any high-voltage module within the power supply family. The controller is microprocessor based and always adapts the control settings for the high-voltage module used. The voltage and current displays have a dual function via the DISPLAY CONTROL switch located on the front panel. When the DISPLAY CONTROL switch is in the CONTROL SETTINGS position, the readouts will indicate the limits of voltage and current as set by the VOLTAGE CONTROL and CURRENT CONTROL. When the DISPLAY CONTROL is set to MEASURE OUTPUT the displays will indicate the voltage and current being delivered to the test specimen. Additionally, during any discharge cycle caused by a trip condition or by operator command, the VOLTAGE DISPLAY will always show the voltage conditions on the test specimen. During this discharge time all control functions are automatically inhibited until the specimen is discharged to below 40 V. If the discharge cycle was the result of an OVERVOLTAGE trip, OVERCURRENT trip, THERMAL trip, or FLASHOVER condition, the controls will remain locked until the main power is turned off.

The controller will actively regulate both voltage and current. The LIMITING CONDITION LED indicator will show which condition (voltage or current) is presently limiting the output. The limit will be a function of the test specimen impedance. Superior output regulation is achieved by first preregulating and then regulating the total loop.

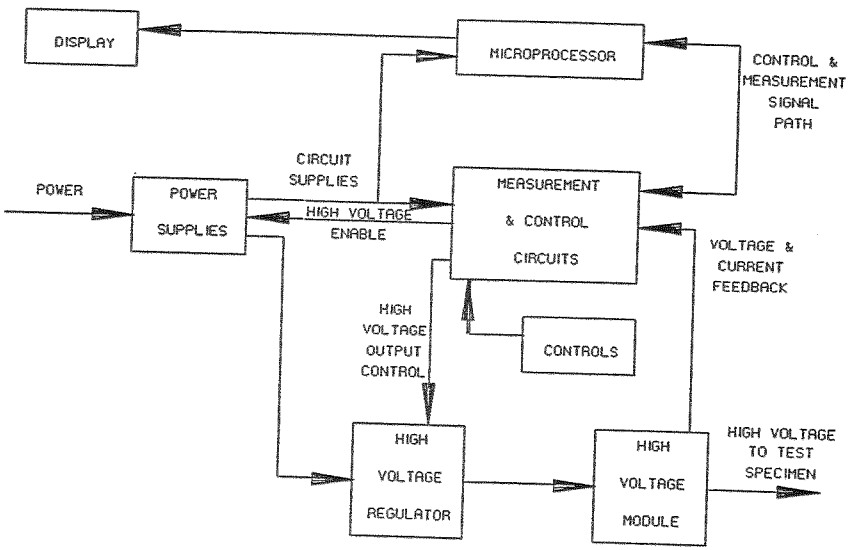

FIGURE 1: SYSTEM BLOCK DIAGRAM

ERROR CODES

The controller performs some self-check tests upon power-up. If an abnormal result is found, an error message will be displayed on the INSULATION RESISTANCE display. If a diagnostic message is displayed, the controls will be locked, preventing further operation of the system until the abnormality is corrected. A description of each error code follows:

ER-1 Controller cannot identify the high-voltage module to which it is attached. Check for proper attachment of high-voltage interconnection cable at both ends. Check for open wire in cable.

ER-2 Controller is overheating. Check for adequate ventilation of controller. Are filters clogged?

ER-3 Overvoltage fault.

ER-4 Overcurrent fault. Controller is experiencing higher than normal usage of power. These conditions can be caused by a variety of circuits which affect system efficiency. If error code will not clear after restarting system, return unit to Biddle Instruments for repair. Both the controller and HV module should be returned.

ER-5 Microprocessor check.

ER-6 Microprocessor check.

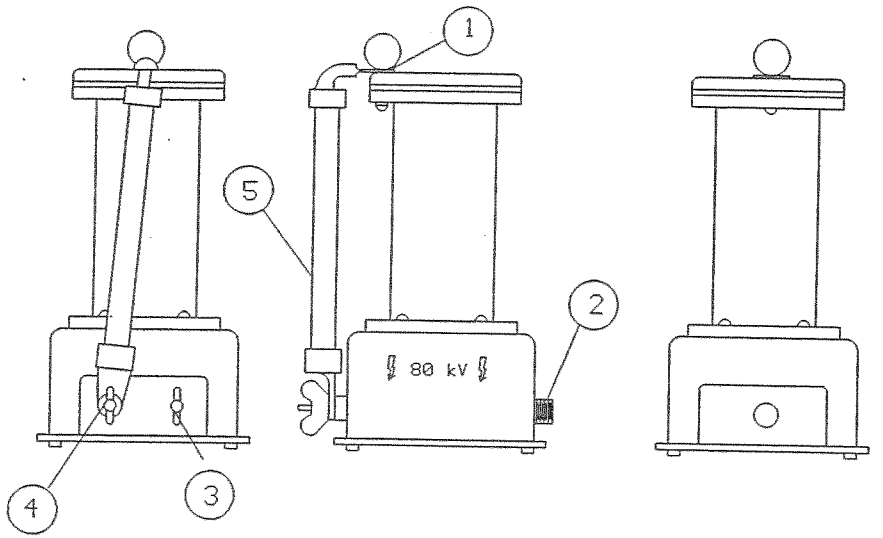

FIGURE 2: HIGH-VOLTAGE MODULE

ER-7 Microprocessor check. System is failing a microprocessor self-check. Return controller to Biddle Instruments for repair.

ER-8 Load flashover. System has sensed that a flashover of the load has occurred. Turn power off and appropriately apply safety grounds. Check clearances at test specimen and high-voltage output cables. Controller will clear fault when power is reapplied.

HIGH-VOLTAGE MODULE PARTS AND CONNECTORS (see Figure 2)

1. High-voltage terminal - Once the carrying handle is removed, this is where the high-voltage output cable is attached.

2. HV interconnection - Mating connector to the female end of the interconnecting cable, this connector carries all of the control and power connections to the high-voltage module.

3. Guard - This is the exposed guard termination and must be connected to the output cable shield to ensure correct operation of the test set.

4. Ground - This is the exposed ground terminal and must be connected to an appropriate earth ground. Refer to the Operation section for connection instructions.

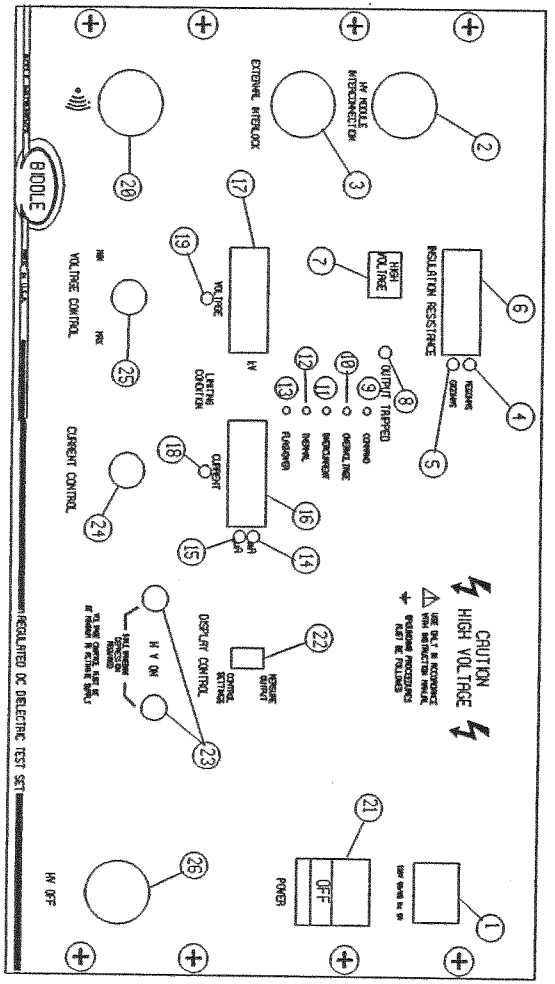

FIGURE 3: CONTROLLER PANEL

5. Carrying handle - This component serves three functions. The first function is as a carrying handle. The second function is to ensure that an electrical short circuit is applied across the high-voltage terminal and ground whenever the module is not in use. As such, the handle has a large braided copper conductor from end to end as a safety discharge measure. The third function is to connect the guard termination to the output cable's guard terminal during testing, as detailed in Section 5.

CONTROLLER CONTROLS, CONNECTORS, AND INDICATORS
(see Figure 3)

1. Input power receptacle - This is the ac input to operate the test set and should be connected to a two-pole, three-terminal, grounding type outlet of the proper rating, via the supplied line power cord.

2. HV MODULE INTERCONNECTION - Mating connector to the male end of the interconnecting cable, this connector carries all control signals and power of the controller.

3. EXTERNAL INTERLOCK - This connector is for the safety interlock used to connect the instrument into an area interlock.

4. MEGOHMS - When lit, this indicates that the number displayed in the INSULATION RESISTANCE display is scaled in megohms.

5. GIGOHMS - When lit, this indicates that the number displayed in the INSULATION RESISTANCE display is scaled in gigohms.

6. INSULATION RESISTANCE - This digital meter displays the specimen resistance as calculated by the test set. This is also where the diagnostic and error codes are displayed.

7. HIGH VOLTAGE flasher - This is a visual warning device that indicates that a voltage of greater than approximately 40 V is present on the test set output or that the high-voltage supply is active and capable of generating a high-voltage output.

8. OUTPUT TRIPPED - When lit, this indicates that the high voltage supply is in the idle state. **This does not imply however that the test specimen and internal capacitors are discharged and are safe to handle.**

9. COMMAND - When lit, this indicates that the test set is ready to accept a user command such as high voltage on.

10. OVERVOLTAGE - When lit, this indicates that a hardware fault has occurred requiring excessive input voltage to generate the required output. It is accompanied by the indication "ER 3" in the INSULATION RESISTANCE display and two beeps on the audible alarm.

11. OVERCURRENT - When lit, this indicates that a hardware fault has occurred requiring excessive input current to generate the required output. It is accompanied by the indication "ER 4" in the INSULATION RESISTANCE display and two beeps on the audible alarm.

12. THERMAL - When lit, this indicates that the temperature inside the case is too high for safe operation of the test set. It is accompanied by the indication "ER 2" in the INSULATION RESISTANCE display and two beeps on the audible alarm.

13. FLASHOVER - When lit, this indicates that the test set has detected a drastic rise in load current, usually caused by a failure in the high-voltage media. This indicator is accompanied by two beeps on the audible alarm immediately following the event. The test set voltmeter will indicate specimen voltage while the test specimen is discharged, either manually with a properly rated resistive discharge stick, or automatically through the test set's internal trickle discharge circuits. Upon completion of discharge, the audible alarm will sound two more beeps, an indication of "ER 8" will appear in the INSULATION RESISTANCE display, and voltage that was present on the test specimen prior to the flashover event will be displayed on the VOLTAGE display.

    Any of the above fault conditions, items 10 through 13, will require that the test set be reset by turning it off for approximately 15 seconds before attempting to resume operation. If the error reoccurs, the test set is faulty and must be serviced.

14. mA (milliamperes) - When lit, this indicates that the number displayed in the CURRENT display is scaled in milliamperes.

15. µA (microamperes) - When lit, this indicates that the number displayed in the CURRENT display is scaled in microamperes.

16. CURRENT - This digital meter displays either the specimen current or the limit value set by the operator when in the CONTROL SETTINGS mode.

17. VOLTAGE - This digital meter displays either the voltage applied to the specimen or the limit value set by the operator when in the CONTROL SETTINGS mode.

18. LIMITING CONDITION CURRENT - When lit, this indicates that the specimen current being supplied is equal to the preset current limit. The operator may select an appropriate value using the CONTROL SETTINGS function.

19. LIMITING CONDITION VOLTAGE - When lit, this indicates that the output voltage is equal to the preset voltage limit. Once the high-voltage supply is active, the operator may select an appropriate limit using the CONTROL SETTINGS function.

20. Audible Alarm - This is a warning device that indicates a condition requiring the operator's attention such as the activation of the high-voltage supply or the existence of an error condition.

21. POWER - This is a combined circuit breaker and on/off switch. The clear rocker lights up green when the switch is turned on.

22. DISPLAY CONTROL - This switch is set to either the MEASURE OUTPUT or CONTROL SETTINGS display mode. In the MEASURE OUTPUT mode, the values displayed are the values present at the specimen. In the CONTROL SETTINGS mode, the values displayed are the preset voltage and current limits, with nothing displayed in the INSULATION RESISTANCE display.

23. HV ON - These two switches are used to activate the high-voltage supply and must be depressed simultaneously.

24. CURRENT CONTROL - This control is used by the operator to set a current limit less than full scale.

25. VOLTAGE CONTROL - This control is used by the operator to set a voltage limit less than full scale. This control must be in its MIN position to activate the supply.

26. HV OFF - This switch will terminate a test in progress by disabling the high-voltage supply.

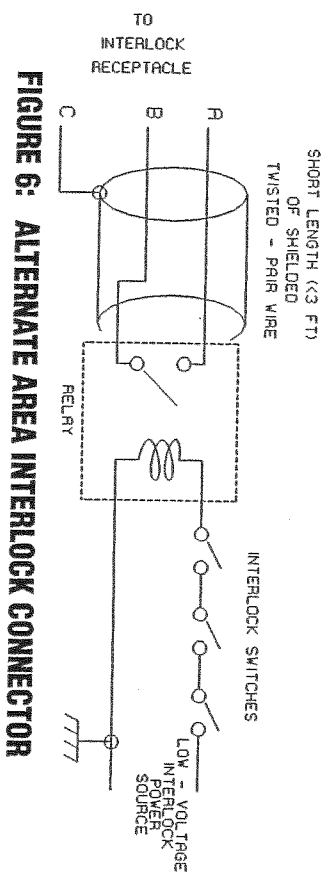

FIGURE 6: ALTERNATE AREA INTERLOCK CONNECTOR

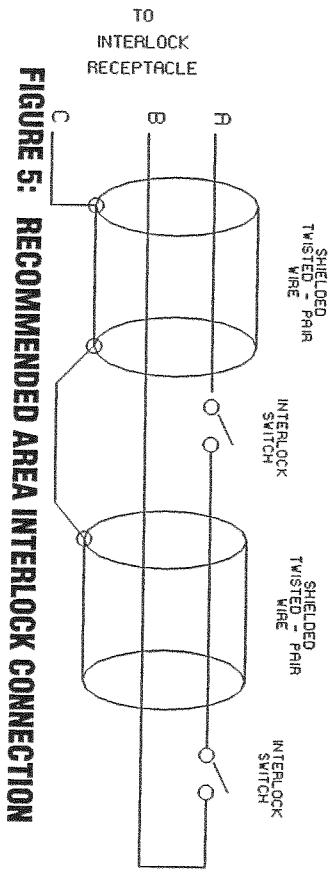

FIGURE 5: RECOMMENDED AREA INTERLOCK CONNECTION

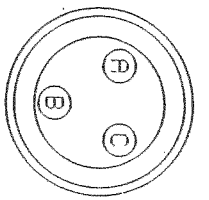

FIGURE 4: INTERLOCK RECEPTACLE AS VIEWED FROM FRONT OF TEST SET

Section 5
Setup and Operation

SETUP

The output of this test set can be lethal. As with any high-voltage equipment, caution must be exercised at all times, and all safety procedures followed. Refer to Section 2, Safety.

The HV module contains insulating oil along with a small air pocket to allow for thermal expansion. For this reason the module should only be operated in an upright level position. If the module has been transported to a new location, after positioning, the module should be rocked a few times to ensure that any trapped air bubbles rise to the top.

Clearances

Be sure that adequate clearances are maintained between energized conductors and other objects to prevent arc-over. Such accidental arc-overs may create a safety hazard or damage the equipment being tested. Biddle Instruments does not know of any accepted industry standard for clearances between high voltage and personnel, but has found the following precautions to be excellent safety practices.

To limit the dangers of static induced voltages which can develop on nearby insulated objects, including personnel: all personnel must maintain a distance from all energized high voltage parts so that the average field strength does not exceed 1 kV/in. in air. This is to be calculated using the crest value of voltage and assuming the field is uniform.

For example, for 80 kV dc, the distance would be 80 kV x 1 in./kV equals approximately 7 ft.

Interlock Connections

To ensure the safety of all personnel, all high-voltage equipment must be located within an area protected by the system interlock. This interlock must preclude the energization of any high-voltage equipment while personnel are within the protected area. This interlock typically comprises a series connection of switches and relay contacts which are activated by door closures, proximity detectors, motion detectors, etc. If any conditions for high-voltage operation are not met, one of the switch or relay contacts will be electrically open, thus breaking the continuity of the series loop and precluding energization of high-voltage equipment.

The external interlock receptacle on the test set is shown in Figure 4. This receptacle is factory-supplied with a mating connector containing a shorting wire. Disassemble the mating connector and unsolder and discard the shorting wire. In its place, connect the area interlock as shown in Figure 5.

In this configuration, the user provides a low-voltage power source to energize the interlock circuit and a low-voltage relay to inform the test set of the interlock status. The advantage of this configuration is that the test set is completely isolated from the interlock loop and thus a long interlock loop will not tend to act as a noise antenna. The contact closures of the relay should have a minimum rating of 0.1 A, 30 V dc. Another less desirable configuration is shown in Figure 6.

Before proceeding, test each component of the interlock to ensure correct operation.

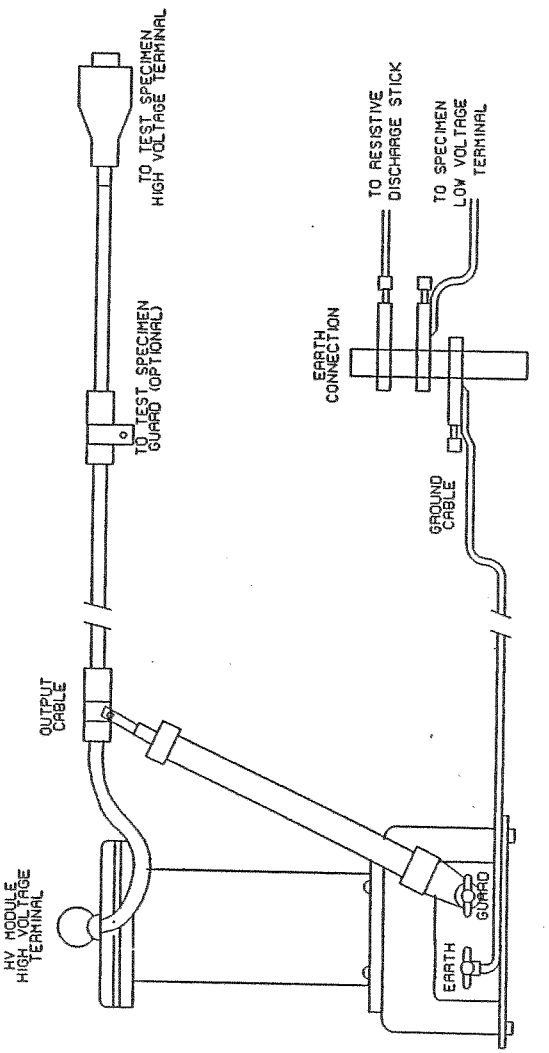

FIGURE 7: CONNECTION DIAGRAM FOR UNGROUNDED TEST SPECIMENS (E.G., SPOOLS OF CABLE).

CONNECTIONS

1. Temporarily remove the carrying handle from the HV module.

2. Connect the ground wing nut of the HV module to a secure, low-resistance ground, using the cable supplied with the test set. The ground should comprise a solid metallic rod or counterpoise with a resistance to ground of less than 10Ω, with a resistance of less than 3Ω preferred. Measure this resistance with a ground tester such as Biddle Catalog No. 250260 or functional equivalent.

3. Connect the ground terminal of a properly rated resistive grounding stick to the low resistance ground connection. This will facilitate discharging of capacitive specimens and will enhance operator safety. The grounding stick should also provide a shorting circuit so that it may be used as a high-voltage shorting bar when the test set is set up for operation but not in use. The grounding stick must be rated for the maximum voltage used, and its resistance should be such that it provides the proper rate of discharge for capacitive specimens being tested.

4. If the test specimen is ungrounded, connect the low-voltage terminal of the test specimen to the ground connection as shown in Figure 7. The interconnection diagram for grounded specimens is shown in Figure 8.

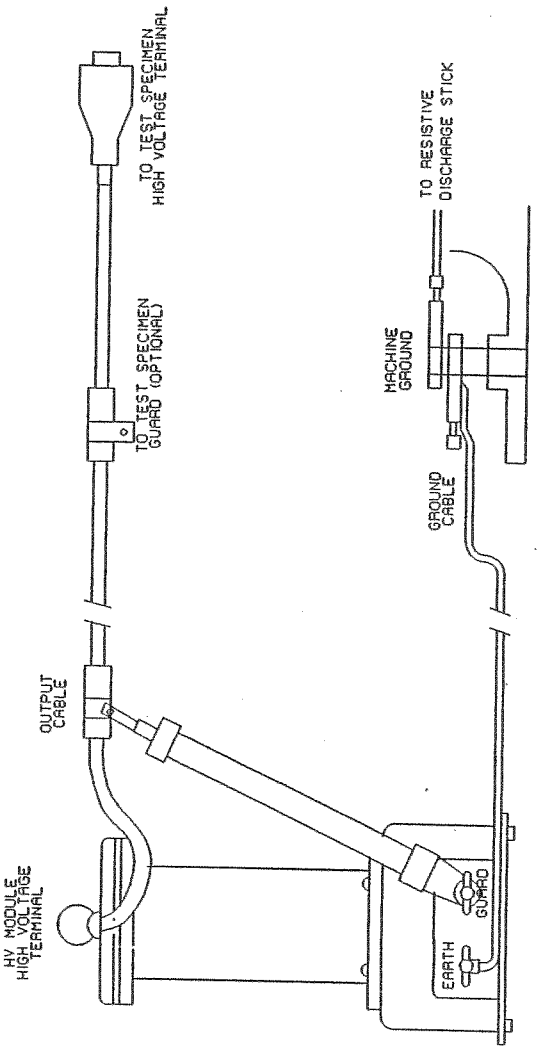

FIGURE: 8: CONNECTION DIAGRAM FOR GROUNDED SPECIMENS (E.G., TRANSFORMERS AND LARGE MACHINERY).

5. Connect the HV module interconnection cable between the HV module and the controller.

6. Connect the high-voltage terminal of the HV module to the high-voltage terminal of the test specimen, using the supplied output cable.

7. Connect one side of the carrying handle to the HV module guard terminal. Connect the other end to the guard of the high-voltage output cable, as shown in Figures 7 and 8. This connection is essential because it provides proper positioning of the high-voltage output cable and prevents excessive leakage.

8. A low-voltage ("cold") guard is used in the test set. If the test specimen has provision for a low-voltage ("cold") guard, connect a short wire from the test specimen guard terminal to the knurled nut on the test set output cable. This connection is optional. The purpose of a guard is to minimize the effects of surface leakage upon current and resistance measurements.

9. Connect the controller ac line cord between the controller and a suitable service. The grounding contact of the power receptacle must be connected to a low-resistance earth ground.

OPERATION

Proceed only after fully understanding Section 2, Safety, and observing the setup and connection procedures previously detailed.

NOTE

When using the Biddle Catalog No. 223080 (80 kV) test set to test specimens with capacitances exceeding 200 nF, the use of an external series limiting resistor will greatly enhance system stability. A 1-MΩ resistor (Biddle P/N 25870) is available for this purpose. Remember to subtract the limiting resistor value from the indicated insulation resistance in this case to determine the test specimen insulation resistance. This resistor is unnecessary with test sets other than the 223080.

High-Voltage Testing

1. Remove all safety grounds and bonding jumpers from the specimen to be tested.

2. Activate the controller power rocker switch. It should light immediately. The system will perform a rapid self-test and then attempt to identify the rating of the HV module to which it is attached. If any problem arises the audible alarm will sound and an error code message will be displayed on the INSULATION RESISTANCE display. Refer to Section 4 for a definition of error codes. If the specimen to be tested has a voltage appearing across its terminals of greater than 40 V dc, then the VOLTAGE indicator will indicate this voltage and the HIGH VOLTAGE flasher will flash. The controls will be electronically locked until this situation is corrected, because there should be no voltage on the test object at this time. When everything is normal both the VOLTAGE and CURRENT displays will be enabled.

Switch the DISPLAY CONTROL switch to CONTROL SETTINGS. The VOLTAGE and CURRENT displays will now show the values as set by the VOLTAGE CONTROL and CURRENT CONTROL. Set the CURRENT CONTROL to the desired current limit, if any. If no specific limit is required, set the control to maximum. Next set the VOLTAGE CONTROL to its minimum position. The high voltage can now be activated.

3. Simultaneous depression of the HV ON buttons will enable the high voltage. The audible alarm will sound and the HIGH VOLTAGE flasher will be activated. The system will now follow control knob settings.

4. Adjust the VOLTAGE CONTROL to the desired voltage. The HV module will attempt to conform to the CONTROL SETTINGS, however, the rate-of-rise limiter circuit will limit the slew rate of current and voltage, if the associated control is operated too quickly or in an erratic manner. The LIMITING CONDITION LED will show whether the system is at the specified voltage or current limit. If both lights are extinguished, the rate-of-rise limiter circuit is controlling the slew rate. This situation will clear as soon as either the voltage or current setting is reached.

5. Once the VOLTAGE CONTROL is set, change the DISPLAY CONTROL to the MEASURE OUTPUT position. The displays will now indicate the actual conditions present at the HV module. The INSULATION RESISTANCE display will indicate dashes if the reading is out of range.

NOTE

The HV module will continue to follow the VOLTAGE CONTROL and CURRENT CONTROL settings. However, since the display is indicating actual conditions there may be a lag between control manipulation and response. As a result the operator may inadvertently command more voltage than he intends. It is strongly suggested that the control settings be manipulated very slowly when displaying actual module conditions. Alternately, the operator should change the DISPLAY CONTROL to the CONTROL SETTINGS position, adjust the value(s) and then change the DISPLAY CONTROL back to the MEASURE OUTPUT position. This will minimize the chance that the desired limits will be exceeded.

6. Under normal operating conditions, the HV module will maintain its set operating condition indefinitely; however, the output may be tripped by:

COMMAND - this occurs when the HV OFF button is depressed by the operator or the interlock is opened.

OVERVOLTAGE - internal unanticipated drop in converter efficiency (rise in required voltage).

OVERCURRENT - internal unanticipated drop in converter efficiency (rise in required current).

THERMAL - inadequate ventilation of the controller.

FLASHOVER - rapid loss of voltage by the HV module accompanied by a high current.

7. When the system experiences a trip condition, the controller will indicate the trip condition on the panel along with the reason, stop further output of high voltage, automatically configure the load VOLTAGE display to show the voltage present and inhibit supply activation until the load has been safely discharged. If the output trip was by COMMAND (operator or interlock intervention) the controls will be unlocked as soon as the load is fully discharged. Full discharge is observed by the HIGH VOLTAGE flasher being extinguished and the displays returning to the condition set by the DISPLAY CONTROL setting. If the trip was caused by an abnormal condition the system will not allow itself to be reactivated and an error message will be displayed. The system should be shut off and the situation remedied. The system will clear the error code when power is turned off. If the trip condition was due to a load flashover, the error code ER 8 will be displayed. At this time the VOLTAGE DISPLAY will show the voltage of the HV module when the flashover occurred.

WARNING

The test specimen may retain a lethal electrical charge even after switching off the test supply. Discharge the test specimen with a safety ground stick to ground all live parts, then, while the safety ground stick is still in place, solidly ground and bond these parts. Keep the HV module and specimen shorted with bonding jumpers at all times except when actually performing tests.

Section 6
Application Notes

Any device that uses electrical energy ordinarily can be considered to consist 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 measurements may be taken to predict such failures. One such method 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 methods have been 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.

Insulation Testing by DC Methods, Biddle Technical Publication 22T1, 1975.

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

Section 7
Maintenance and Repair

ROUTINE MAINTENANCE

The test set has been designed to be virtually maintenance free. However, it will be necessary to keep the HV module and output cable clean. Clean as often as required using a lint-free cloth and isopropyl alcohol. Always keep the HV module shorted with carrying handle while cleaning the tank. Allow the alcohol to evaporate before energizing the test set.

CALIBRATION

Calibration should only be performed by qualified personnel familiar with high voltage test techniques. Observe all necessary safety precautions.

The instrument is fully calibrated when shipped and should never require additional calibration. However, for completeness, the following describes procedures and circuit adjustments which may be used to recalibrate the test set.

1. Remove the controller from its enclosure and set it on a flat insulated surface. All calibration trimmers are located on the large circuit board located directly behind the front panel. Each is identified with a letter E followed by a number. Only trimmers E4, E5, and E7 may be adjusted in this procedure. The settings of all other trimmers must not be altered. See Figure 9 for help in locating trimmers.

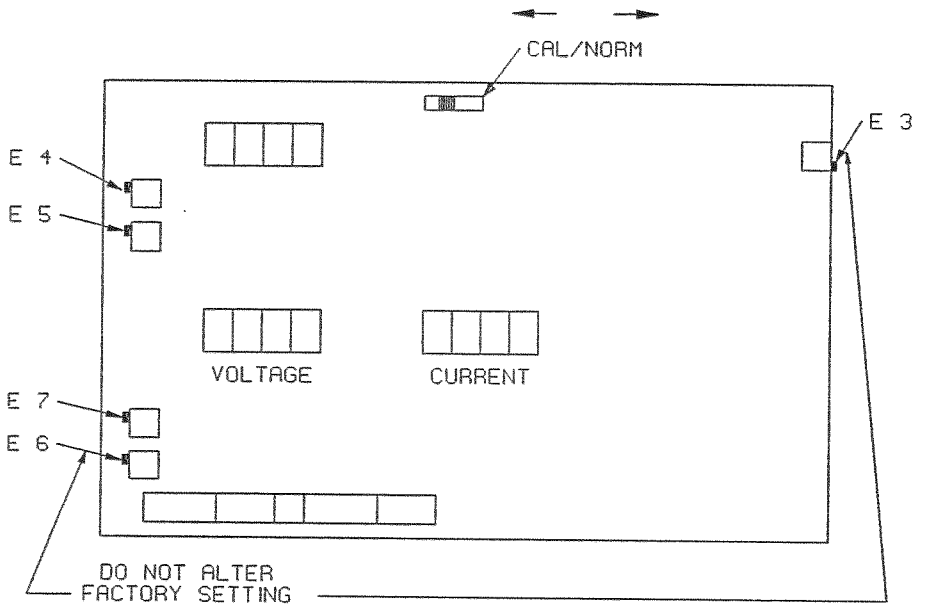

FIGURE 9: CALIBRATION POINTS

2. Although high voltage will not be applied until step 7, configure the system as if a high voltage test were to be conducted. A resistive load with a precisely known resistance is required. The resistance should be close to the geometric mean of the test set's resistive load range, as specified in Section 3. The temperature and voltage coefficients, as well as the leakage characteristics of the resistor must be known.
3. Place the CAL/NORM switch in the CAL position, as shown in Figure 9.
4. Turn the POWER circuit breaker on. The VOLTAGE and CURRENT displays are used to assist in the proper calibration of E4 and E5, respectively. The left-most digit of each display indicates the number of the associated trimmer. The following digit is blanked. The third and fourth digits will display one of the following messages: "--," "HI," or "LO." A "LO" message indicates that the corresponding trimmer should be turned clockwise; a "HI" message indicates the need to turn counterclockwise. The "--" message indicates that the associated trimmer is adjusted correctly.
5. Allow the test set to sit for a minimum of 5 minutes so that it may thermally stabilize. **Do not energize the high-voltage circuits at this time.** Adjust trimmer E5 until the associated display indicates correct calibration. Adjust trimmer E4 in the same manner. There may be some interaction between the two adjustments, so the process may have to be repeated several times to ensure proper calibration.
6. Place the CAL/NORM switch back to the NORM position, as shown in Figure 9.

WARNING

In the remaining portion of the calibration procedure, it is necessary to activate the high-voltage circuits. Before proceeding, take all precautions outlined in Section 2, Safety. Ensure that the test set, test specimen, and associated equipment are configured properly, and that an area safety interlock is used. Refer to Section 5 for this information.

7. Place the system in an operating high-voltage condition. Adjust the voltage across the test specimen until the current drawn reaches 10 percent of the test set's rated output current. Do not overstress the test specimen. Adjust trimmer E7 until the known value of the test specimen is displayed on the INSULATION RESISTANCE meter, taking into account the test specimen's leakage characteristics as well as temperature and voltage coefficients.
8. Vary the voltage across the test specimen to ensure that the indication is not voltage dependent.
9. De-energize the high-voltage output and discharge the test specimen.
10. Repeat steps 7 through 9 using different values of resistance, however, do not readjust trimmer E7. Confirm that the INSULATION RESISTANCE meter indications are within the meter accuracy specifications of Section 3.
11. Calibration is complete. Discharge and short circuit the test specimen. Reassemble the controller and restore all equipment to its original state. If proper calibration is not achievable, or if the test set doesn't work properly after calibration, consult Biddle Instruments.

REPAIR

Biddle Instruments maintains a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. Before returning this equipment for repair, contact your local sales representative to determine if the problem can be identified and corrected on-site.

Should it be necessary to return this equipment to the factory for repair, contact Biddle Instruments for preparation and shipping instructions. Equipment returned for repair should be shipped prepaid and insured and marked for the attention of the Repair Department.

Due to the nature of the circuitry and the complexity of the software, repairs should be carried out by Biddle Instruments. Attempts at circuit repair in the field could cause additional circuit damage or pose a danger to the technician who may come in contact with a high-voltage circuit. A list of replaceable assemblies and components is given in Section 8.

Section 8
Replaceable Parts List

P/N 25860	CONTROLLER
25246	Fan
25275	Fan guard
25432	Linear power supply board assembly
25541	Controller circuit board assembly (main)
25700-1	Switching power supply assembly
25837	Low voltage power supply board assembly
25889	Power transformer
25925	Circuit breaker assembly (120 V)
25925-47	Circuit breaker assembly (240 V)
26044-1	Knob
26046	Lower chassis with three circuit board assemblies
26047	HV indicator assembly
26048	Case

MISCELLANEOUS

10226	Interlock plug assembly
18313	Canvas bag
25705	HV module interconnection cable assembly

P/N 25862 — 15 kV HV MODULE

25681-2	Printed circuit board assembly
25846	High-voltage transformer
25899	Guard/carrying handle assembly
26025-1	Complete base assembly (except oil filled section)
26036-1	HV stack assembly (oil filled section)
19265-1	Ground cable assembly
25737	Output cable assembly

P/N 25861 — 80 kV HV MODULE

25681-1	Printed circuit board assembly
25846	High-voltage transformer
25899	Guard/carrying handle assembly
26025	Complete base assembly (except oil filled section)
26036	HV stack assembly (oil filled section)
19265-1	Ground cable assembly
25737	Output cable assembly

WARRANTY

Products supplied by Biddle Instruments 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. This 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 (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.