

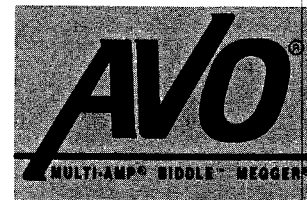
**Instruction Manual  
AVTM 23-30J**

**For the**

# **Tool and Appliance Tester**

**Catalog Number 235303**

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## **Instruction Manual 23-30J**

for

## **Tool and Appliance Tester** **Catalog Number 235303**

**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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The industry leader since 1895, AVO Biddle Instruments offers a comprehensive line of electrical test and measurement products, from portable instruments for use in the field to fully-integrated systems for high voltage systems testings. AVO Biddle Instruments fulfills a range of requirements found in electric utility, large industrial, electrical apparatus manufacturing, military and governmental applications worldwide.

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## **Section 1 Introduction**

### **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.

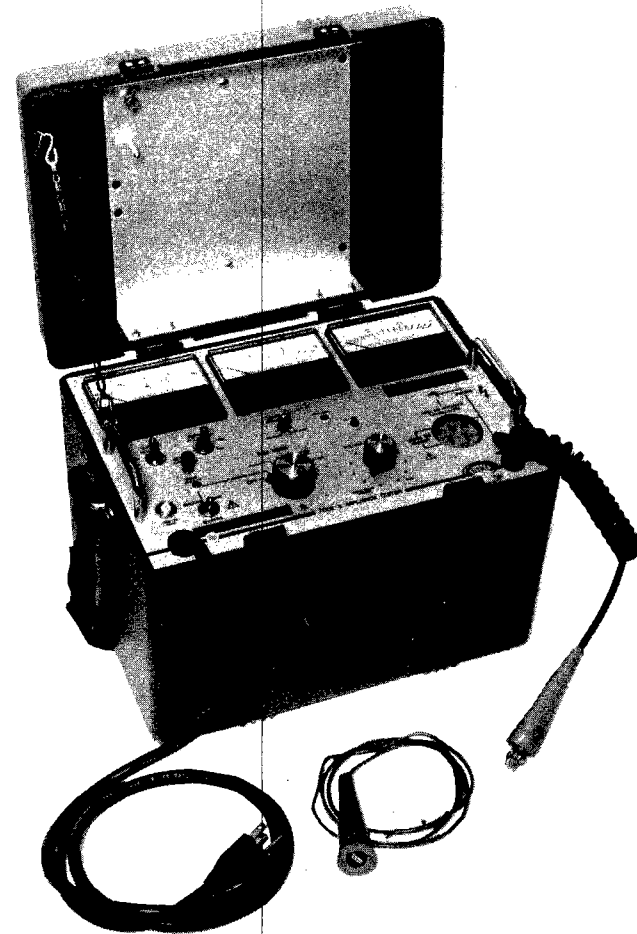
This instrument has been thoroughly tested and inspected to rigid specifications before being shipped. It is ready for use when set up as indicated in this manual.

### **General Information**

The Tool and Appliance Tester shown in Figure 1 tests electrically operated tools and appliances for possible shock hazard to ensure their continued safe operation. The tester tests equipment which operates from 120 V ac, 60 Hz and a maximum of 12 A, including portable hand tools, medical and dental equipment, and three-wire extension cords. Limited testing above 12 A may also be performed using optional adapter plugs. The tester is supplied in a molded plastic case with carrying handle and strap, making it portable, compact, and easy-to-use. It performs ground check, leakage, insulation withstand, and functional tests of equipment in the shop or at the job site. The tester operates from a 120 V ac, 60 Hz 15 A single-phase source.

The item under test is plugged into the three-wire receptacle (NEMA 5-15R) on the tester panel. The lid of the tester can be removed to serve as an insulating holder for the item under test. The lid contains a metal plate to contact the housing of the item and to hold the instruction manual. A separate coiled cord test probe with an alligator clip connects to the contact plate in the lid or directly to the housing of the item under test.

The tester should be used as part of a comprehensive program which includes regular visual inspection and careful maintenance and repair. Electrical standards such as Underwriters Laboratories Standard UL 45 for Portable Electric Tools, UL 73 for Motor-Operated Appliances, and UL 544 for Medical and Dental Equipment detail excellent inspection programs for tools and appliances. Even the best designed and built equipment may eventually, as a result of wear and tear, become a shock hazard. Therefore, it is wise to perform frequent tests and then repair or discard faulty equipment to prevent injury and possibly save a life.



*Figure 1: Tool and Appliance Tester*

## Section 2 Safety

The Tool and Appliance Tester and the recommended operating procedures have been designed with careful attention to safety. Biddle Instruments has made formal safety reviews of the initial design and any subsequent changes. Regardless of these efforts, it is not possible to eliminate all hazards from electrical test equipment or to foresee every possible hazard which may occur. It is therefore essential that the user also carefully consider all safety aspects of the test before proceeding. Safety is the responsibility of the user.

The test set and the specimen to which it is connected are a source of high-voltage electrical energy. Observe all the following safety precautions:

- Do not use the tester or its accessories for any purpose other than that described in this manual.
- Observe all safety warnings marked on the equipment. The words DANGER and CAUTION on the equipment identify areas of immediate hazard which could result in personal injury or loss of life.
- All persons participating in a test must use all practical safety precautions to prevent contact with energized parts of the tester and related circuits.
- Locate the item under test out of the user's normal reach.
- Persons actually engaged in the test must stand clear of all parts of the complete circuit unless the tester is de-energized and parts of the test circuit are grounded.



- ❑ Persons not directly involved with the work must be kept out of the area by suitable barriers, barricades, or warnings.
- ❑ Do not operate any tool or appliance that has failed any of the tests performed by this tester, as dictated by the appropriate standard for that equipment.
- ❑ Refer to IEEE 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 three-wire power cord and 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 operating voltage, 120 V. The power input plug must be inserted only into a mating receptacle with a ground contact. Do not bypass the grounding connection. Any interruption of the grounding connection will create an electric shock hazard. Determine that the receptacle is correctly wired before inserting the plug.

If the test set is operated in accordance with the instructions in this manual and all connections are correctly made, rubber gloves and shoes are not required, but Biddle Instruments considers their use an excellent safety practice when handling the RETURN test probe, the high-voltage test probe, or the item under test.

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

Because the purpose of the tester is to locate electric shock hazard of the item under test, a shock hazard exists for the user if the proce-

dures given are not carefully and consistently followed. Specific warning and caution notices are used throughout this manual where applicable.

### WARNING

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

### CAUTION

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

The tester is a source of high-voltage and potentially lethal electrical energy. Dangerous voltages are present inside the case, and therefore the tester must not be operated with its case removed except for the purpose of performing calibration procedures. Calibration and repair should only be attempted by qualified personnel who are familiar with the hazards involved and the precautions required.

Tools and appliances may have mechanical or physical hazards as well as electrical ones. Persons performing the tests must assume responsibility for preventing injury from rotating shafts or cutting edges of tools and must handle the equipment to prevent injury due to vibration, movement, or heating when the equipment is operating.

To ensure safe use of the tester, do not treat it casually. Read and understand all instructions and follow all safety rules. Safety will be enhanced if test procedures are practiced until they are completely learned before evaluating equipment to be placed in general service. The item under test must be treated as a shock hazard until proven otherwise by the tests performed according to the procedures given in this manual.

## Section 3 Specifications

### Mechanical

Dimensions: 10 H x 13-1/2 W x 10 in. D (254 x 343 x 254 mm)

Weight: 28 lb (12.7 kg)

### Environmental

Operating Temperature Range: 50 to 104°F (10 to 40°C)  
5 to 95 percent relative humidity

Storage Temperature Range: -22 to 131°F (-30 to 55°C)  
5 to 95 percent relative humidity

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

### Electrical

#### Input

Recommended Source: National Electric Code  
(NEC) 15 A, 120 V ac  
single phase with ground

Voltage: 108 to 132 V

Current (maximum rms): 12 A continuous in functional test mode,  
limited to 15 A

Circuit Protection: 15 A, 120 V circuit breaker

Frequency: 60 Hz

**Output (Maximum)**

Ground Check test mode: 3 V ac  
Leakage test mode: 120 V ac  
Insulation Withstand test mode: 3000 V ac  
Functional test mode: 120 V ac

**Ground Check Limit**

0.1  $\Omega$  +10 percent (accurate only when input voltage within the range 115 to 121 V)

**Rating of Items Tested**

120 V, 60 Hz, single phase, up to 12 A  
limited testing above 12 A using optional adapter plugs.

**Tests Performed**

The tester tests the various levels of protection of an appliance as follows:

Type of Shock Protection Used In Appliance	Ground Check	Leakage	Insulation Withstand	Functional
Grounded	YES	YES	YES	YES
Double-Insulated	NO	YES	YES	YES
Neither of above (2-wire cord, single insulation)	NO	YES	YES	YES

**Metering**

The three meters used on the tester are 3-1/2 in., zero left, analog meters with high torque, ruggedized movements. They are average reading and rms calibrated.

**LEAKAGE TEST Meter**

Accuracy: at 0.1, 0.5, 0.75 and 1 mA,  $\pm 5$  percent of reading  
at 0.01 and 10 mA,  $\pm 10$  percent of reading

**INSULATION WSTD TEST Meter**

Range: 0 to 3000 V

Accuracy:  $\pm 5$  percent full scale

**FUNCTIONAL TEST Meter**

Range: 0 to 15 A

Accuracy:  $\pm 3$  percent full scale

**Safety Features**

Tester grounded function is activated as soon as the tester is plugged into line power.

In the Insulation Withstand mode, output can be energized only by setting VOLTAGE CONTROL to ZERO START (RESET). Failure switches off output voltage within 50 ms and starts failure signals.

No further testing can be performed if the apparatus fails the Ground Check limit.

## Options

Cat. No. 235300-1 adapter plug tests 120 V, 60 Hz, 1 phase, 15 A tools which use a NEMA L5-15R twist lock plug.

Cat. No. 235300-2 adapter plug tests 120 V, 60 Hz, 1 phase, 20 A tools which use a NEMA L5-20R twist lock plug.

Cat. No. 235300-3 adapter plug tests 120 V, 60 Hz, 1 phase, 20 A tools which use a NEMA 5-20R standard 120 V, 20 A plug.

Cat. No. 235300-4 adapter plug tests 120 V, 60 Hz, 1 phase, 30 A tools which use a NEMA L5-30R twist lock plug.

## Section 4 Description

### Controls, Indicators, and Connectors

The controls, indicators, and connectors for the tester are arranged on a color-coded panel as shown in Figure 2. The following descriptions are in alphabetical order by schematic reference number.

#### CB1: Circuit Breaker

This single pole circuit breaker controls the power input to the tester. It disconnects power from the tester if more than 15 A is drawn by the tester or by the item under test. A recessed reset button extends indicating that an overload has occurred.

#### DS1: TESTER GROUNDED Indicator

This white indicator lamp lights when the tester is connected to a correctly wired power supply. It does not light when there is a ground wire open or when hot and neutral wires are interchanged. It operates on low current (less than 0.5 mA) and therefore is not as bright as other indicators when lit. This indicator must be lit before any tests are performed.

#### DS2: GOOD WHEN LIT Indicator

This green indicator lamp lights when the ground circuit on three-wire devices is continuous and its resistance is found to be less than approximately 0.1  $\Omega$ , when the tester is operating in the Ground Check mode.

#### DS3: HV ON Indicator

This red indicator lamp lights when the tester is operating in the Insulation Withstand mode and the VOLTAGE CONTROL is set to ZERO START (RESET). High voltage is present at the TOOL or APPLIANCE CONNECTIONS receptacle and the high-voltage test probe receptacle.

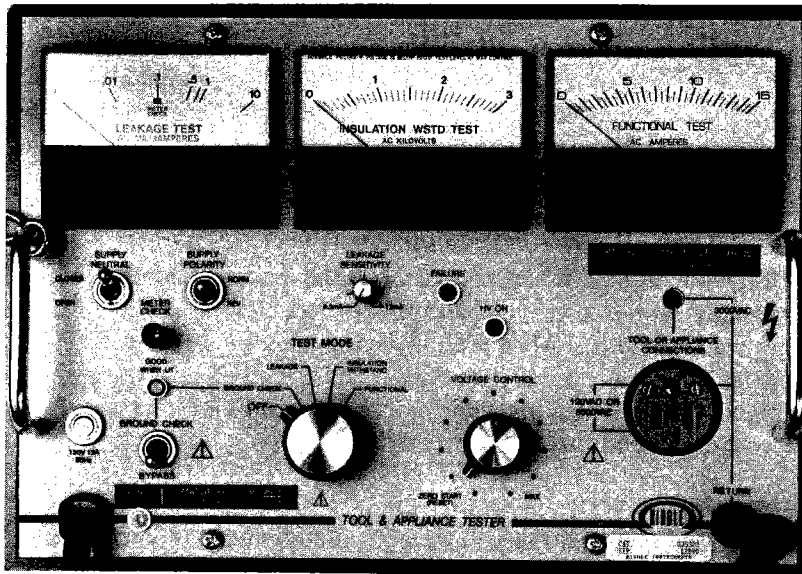


Figure 2: Tester Control Panel

**DS4: FAILURE Indicator**

This amber indicator lamp lights and a buzzer sounds when the tester is operating in the Insulation Withstand test mode and a breakdown occurs in the item under test.

**J1: TOOL or APPLIANCE CONNECTIONS Receptacle**

The input cord of the item to be tested is plugged into this three-wire receptacle on the panel to make Ground Check, Leakage, Insulation Withstand, and Functional tests.

**J2: High-Voltage Test Probe Receptacle**

This receptacle accepts the high-voltage test probe W3 for high-voltage testing when the tester is operating in the Insulation Withstand test mode.

**M1: LEAKAGE TEST Meter**

This meter displays the actual leakage current of the item under test when the tester is operating in the Leakage test mode.

**M2: INSULATION WSTD TEST Meter**

This meter displays the voltage being applied between the item under test hot and neutral wires and ground when the tester is operating in the Insulation Withstand test mode.

**M3: FUNCTIONAL TEST Meter**

This meter displays the current being drawn by the item under test when the tester is operating in the Functional test mode.

**R28: LEAKAGE SENSITIVITY Control**

This control varies the adjustment of the trip level of the breakdown current between 0.3 mA and 12 mA when the tester is operating in the Insulation Withstand test mode. When the capacitance value of the item under test is unknown, this control should be set to 0.3 mA. Hash marks are provided for reference only and do not indicate specific values of leakage current.

**S1: TEST MODE Switch**

This five position selector switch selects between OFF, GROUND CHECK, LEAKAGE, INSULATION WITHSTAND, and FUNCTIONAL settings.

**S2: GROUND CHECK/BYPASS Switch**

This toggle switch allows overriding of the Ground Check test for double-insulated tools or appliances which do not use three-wire grounding type line cords.

**S3: SUPPLY POLARITY Switch**

This momentary action toggle switch, when activated to the NORM position, applies normal line voltage (hot to hot wire, neutral to neutral wire) to the item under test when the tester is operating in the Leakage test mode. When this switch is activated to the REV position, the line voltage is reversed (hot to neutral wire, neutral to hot wire).

**S4: METER CHECK Push Button**

This push button, when pressed, causes a half-scale deflection to the METER CHECK band (0.1 mA) of the LEAKAGE TEST meter when the tester is operating in the Leakage test mode.

**S5: SUPPLY NEUTRAL CLOSED/OPEN Switch**

This toggle switch, when set to CLOSED or OPEN, closes or opens the neutral line when the tester is operating in the Leakage test mode.

**T3: VOLTAGE CONTROL**

When the tester is operating in the Insulation Withstand test mode, this autotransformer serves as voltage control, reset and zero start. When the TEST MODE selector switch is set to INSULATION WITHSTAND or after a failure has occurred, no output voltage will be present at the TOOL or APPLIANCE CONNECTIONS receptacle until the VOLTAGE CONTROL has been set to ZERO START (RESET).

**W1: Input Power Cord**

This three conductor, 14 gauge, 5-ft cord plugs into a standard 120 V 15 A, 60 Hz, two-pole, three-wire grounding type receptacle (NEMA 5-15R).

**W2: RETURN Test Probe**

This coil cord connects to the contact plate in the lid of the tester or directly to the housing of the item under test.

**W3: High-Voltage Test Probe**

This lead plugs into the high-voltage test probe receptacle J2 when high-voltage testing with the test probe is desired.

**Contact Plate (not shown in Figure 2)**

This metal plate in the tester lid contacts the metal housing of the item under test. Four holes in the plate accept hooked fasteners to secure the item.

**Thumbscrew (not shown in Figure 2)**

This thumbscrew is mounted on the contact plate and allows easy connection of the RETURN test probe (W2) to the contact plate.

**Round Pin (not shown in Figure 2)**

This round pin is mounted on the contact plate and is provided to allow testing of three-wire extension cords.

Refer to the Glossary for an explanation of symbols used on the tester.

**Tests Performed****Ground Check**

This test supplies a current of up to 25 A ac at no more than 3 V between the tool or appliance ground conductor and its housing to check the integrity of the ground circuit. The green GOOD WHEN

LIT indicator lights when the ground circuit has a resistance of approximately  $0.1 \Omega$  or less. The ground check test is interlocked with all other tests so that no other test can be performed on three-wire appliances unless the appliance has passed the ground check test. Provision is made to bypass this portion of the test on double-insulated appliances or appliances which do not use the three-wire grounding type line cord. Duty cycle (short circuit) is continuous.

This test can also be used on three-wire extension cords by plugging the cord connector (female) end ground socket (round hole) onto a special round pin on the tester lid contact plate and the cap connector (male) end into the TOOL or APPLIANCE CONNECTIONS receptacle.

### **Leakage Test**

This test conforms to American National Standard C101.1-1986 "Leakage Current for Appliances" which is the basis for safety tests made by government agencies and independent testing laboratories such as UL and ETL.

This test is made in one case with the appliance energized and operating and in the other case with the appliance neutral conductor open. The leakage test measures the current which could flow through a grounded person holding onto the appliance while it is in operation. In other words, it measures the current that leaks through or around the insulation.

On grounded tools, this test measures the current through the green ground wire which a person might receive if the ground wire were accidentally opened and he were in its place. On double-insulated tools, the leakage test is ordinarily applied to exposed metal parts of the appliance. Thus, the tester tests both layers of protective insulation at once. There is no separate check for each layer unless the item is disassembled. On two-wire appliances which may not be double insulated, the test is made in the same way on all accessible metal parts.

Line voltage is applied to a tool or appliance in the normal polarity when a momentary action toggle switch SUPPLY POLARITY is pressed and held to NORM and in the reverse polarity when the toggle switch is pressed and held to REV. A SUPPLY NEUTRAL switch controls whether the test is performed with the supply neutral OPEN (down) or CLOSED (up). The current in the green ground wire, if any, and through the exposed metal parts of the appliance is measured by the LEAKAGE TEST meter. The greatest value is used. A meter calibration check at 0.1 mA can be made at any time by pressing the METER CHECK push button. This check will detect any defects in the internal leakage test circuit. The meter check circuit will function properly even with a  $\pm 10$  percent fluctuation in line voltage.

The LEAKAGE TEST meter reads leakage current ranging from 0 to 10 mA. Refer to the appropriate standards to derive the maximum safe leakage current for each individual type of appliance or tool.

### **Insulation Withstand Test**

In this test, a high-voltage transformer supplies test voltage between the panel receptacle line connections and ground, and between the high-voltage and RETURN test probes. A voltmeter indicates the test voltage. A visible and audible alarm signals when the total leakage current exceeds an adjustable preset value or when arcing occurs. Output voltage is turned off within 50 ms.

### **Functional Test**

This test is made with the item under test energized and operating at rated voltage. The current drawn is displayed on a 15 A ac meter and can be used for nameplate comparison. This test can also be used in conjunction with a load test such as the load test detailed in Section 34 of UL 45, Standard for Portable Electric Tools.

## Section 5 Setup and Operation

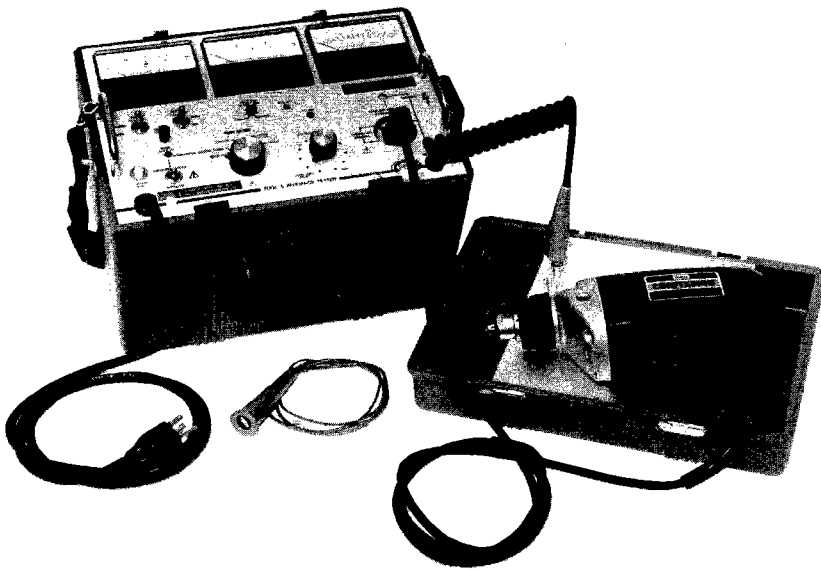
### Setup

1. Follow all safety precautions in Section 2 of this manual.
2. Select a dry test area with the operator and all equipment shielded by suitable barriers from distractions and intruders.
3. Locate the tester within 5 ft of a three-wire grounded outlet and within 5 ft of the item under test.

#### NOTE

If it is necessary to use an extension cord between the tester and service outlet, a high quality (three-wire) cord rated for at least 20 A is required. The use of an extension cord should be avoided if possible.

4. Place the item under test out of the operator's normal reach. Arrange the work area so that the operator can reach the controls of the tester without any danger of touching the item under test, the RETURN test probe, the high-voltage test probe, or the contact plate in the tester lid.
5. Provide a secure insulated mounting area for the item under test. The insulation must isolate the item under test from ground and any adjacent conductors. As a convenience, the tester lid can be used but any appliance which is to be operated may require securing to the lid. See Figure 3 for a typical test setup. As an alternative, it is suggested that a rubber electrical grade insulation mat or a suitable piece of acrylic plastic or phenolic be used.



NOTE: The test setup shown is for convenience of photography. In actual tests, the item under test in the lid should be located as far as possible from the tester to be out of reach of the operator.

*Figure 3: Typical Test Setup*



6. If the test set is operated in accordance with the instructions in this manual and all connections are correctly made, rubber gloves and shoes are not required, but Biddle Instruments considers their use an excellent safety practice when handling the RETURN test probe, the high-voltage test probe, or the item under test.

7. It is recommended that a sturdy workbench be used. A simple support may be provided to hold the entire tester at a convenient angle with its case secured to the support. Arrange an area on the workbench so that the item under test can be securely clamped in place and insulated from ground. Barriers are strongly recommended to prevent accidental contact with the item under test.

8. Before testing begins, make a visual inspection of the item under test. In the case of a power tool, the housing should be wiped off and the cooling vents blown clear with compressed air. Carefully inspect the line cord for frayed wires and the plug for a cracked housing or broken pins. Review any damage report, if submitted. Repair visible defects before testing.

### Preliminary Test Procedure

1. Set the TEST MODE switch to OFF and plug in the input power cord.
2. Verify that the TESTER GROUNDED indicator lights.

#### WARNING

Do not proceed if the TESTER GROUNDED indicator is not lit. If this indicator is not lit, unplug the input power cord and refer to Section 8, Troubleshooting and Repair of this manual.

3. When the tester lid contact plate is to be used, remove the lid from the tester and connect the RETURN test probe to the thumbscrew on the contact plate. If the tester lid contact plate is not used, connect the RETURN test probe to any exposed metal on the item under test.
4. Secure the item under test to the lid contact plate (if used) or to a well-insulated stable surface. The item under test must be insulated from ground for the Leakage test to be valid.

5. Make sure that the TEST MODE switch is set to OFF and that the GROUND CHECK/BYPASS switch is set to GROUND CHECK.

6. Plug the item under test into the TOOL or APPLIANCE CONNECTIONS receptacle.

### Shutdown

Testing can be stopped at any time by setting the TEST MODE switch to OFF. Set the TEST MODE switch to OFF whenever connecting or disconnecting the item under test.

### Operation

After completing the Preliminary Test Procedure, perform the following tests in order. If the item under test fails any test, set the TEST MODE switch to OFF and repair the item before proceeding. Repeat all tests after repair.

Types of appliances and special test settings:

Type	Setting
a. "As received" appliances ordinary 120 V ac input without special settings	Close all switches and thermostats.
b. Appliances with speed control	Speed controls on appliances are to be set to produce the maximum leakage current.
c. Motor operated appliances	To be tested under conditions simulating normal operating conditions (normally maximum heat setting of the controls). The cycling of the thermostat must be induced by reducing the setting, if necessary, before completing the test.

**NOTE**

Some heating appliances, such as broilers, are constructed with thermostats that are bypassed at their highest settings and unless some provision is made to induce the cycling condition, the maximum leakage will not be seen. Refer to ANSI Standards C101.1-1986.

**Ground Check Test**

Perform this test only on items having three-wire grounding type line cords. For double-insulated items or items which do not have three-wire grounding type line cords, set the GROUND CHECK/BYPASS switch to BYPASS and proceed to the Leakage test which follows.

**WARNING**

Do not use the Ground Check/Bypass function to override the Ground Check test on items which have a three-wire grounding type line cord. The Ground Check test must be performed on three-wire grounding type items.

1. Set the TEST MODE switch to GROUND CHECK.
2. Verify that the GOOD WHEN LIT indicator lights. If it does not light, set the TEST MODE switch OFF and repair the item before proceeding. If the GOOD WHEN LIT indicator does light, proceed to the Leakage test which follows.

To check other metallic parts of the item to verify their connection to the item's green (ground) wire, first set the TEST MODE switch to OFF. Move the RETURN test probe to the desired location on the item under test, then repeat steps 1 and 2. Repeat this process as often as desired.

The Ground Check test, unless overridden by the use of the GROUND CHECK/BYPASS switch, is interlocked with all other tests (Leakage, Insulation Withstand, Functional), so the GOOD WHEN LIT indicator must light before any other test is performed.

**Leakage Test**

**WARNING**

During the following leakage tests, if the LEAKAGE TEST meter reads 1 mA or above, release the SUPPLY POLARITY switch and set the TEST MODE switch to OFF. Repair the item under test before proceeding.

ANSI C101.1-1986 specifies that the appliance grounding conductor, if any, be open at the receptacle feeding the appliance. This is

not necessary when using the tester since the leakage measuring circuit is already connected internally between the ground of the TOOL or APPLIANCE CONNECTIONS receptacle and the grounded supply conductor.

1. Verify that the RETURN test probe is connected to the thumbscrew on the tester contact plate or to any metallic part of the item under test.
2. Set the TEST MODE switch to LEAKAGE.
3. Momentarily press the METER CHECK push button. The LEAKAGE TEST meter should deflect to midband to the METER CHECK area of the scale (0.1 mA). If the LEAKAGE TEST meter shows little or no deflection, refer to Section 8, Troubleshooting and Repair, before proceeding.

**WARNING**

Before proceeding, verify that all safety precautions have been met. Refer to Section 2. Do not touch the item under test, the tester contact plate, or the RETURN test probe.

4. Set the SUPPLY NEUTRAL switch to OPEN.
  - a. Momentarily hold the SUPPLY POLARITY switch to REV; record the current reading in milliamperes.
  - b. Momentarily hold the SUPPLY POLARITY switch to NORM; record the current reading in milliamperes.
5. Set the SUPPLY NEUTRAL switch to CLOSED.

**WARNING**

Always set the TEST MODE switch to OFF before touching the item under test.

It is important to note that to fully comply with ANSI standard C101.1 1986, Leakage Current for Appliances, the following measurements should be made within 5 s after the SUPPLY NEUTRAL switch is set to CLOSED. When testing an item having more than one speed, obtain measurements at various speeds as quickly as possible. In the case of any thermostat that does not cycle at the maximum heat setting, adjust the thermostat on the item until it does cycle before taking final measurements at the thermal stabilization. Take measurements with the thermostat open and closed at both normal and reverse polarity.

**WARNING**

In the following tests, the item under test will be operational.

- a. Momentarily hold the SUPPLY POLARITY switch to REV; record the current reading in milliamperes.
- b. Momentarily hold the SUPPLY POLARITY switch to NORM; record the current reading in milliamperes.

**NOTE**

If the LEAKAGE TEST meter shows no deflection in steps 4 and 5, release the LEAKAGE TEST POLARITY switch and check all connections. Repeat steps 4 and 5. If there is still no deflection in the LEAKAGE TEST meter after repeating steps 4 and 5, set the TEST MODE switch to OFF and refer to Section 8, Troubleshooting and Repair.

6. Compare the largest of the four recorded measurements with proper UL, ANSI, VDE, CSA, and IEC specifications.

#### **Insulation Withstand Test**

After the Leakage test has been completed, perform the Insulation Withstand test as follows:

1. Set the VOLTAGE CONTROL to ZERO START (RESET).
2. Set the LEAKAGE SENSITIVITY control to the desired sensitivity setting. For details on the setting of this control, refer to Section 6, Application Notes.
3. If using the high-voltage test probe, connect it between the tester high-voltage test probe receptacle and the item under test. Before proceeding, verify that all safety precautions have been met. Refer to Section 2.

#### **WARNING**

Do not plug in the high-voltage test probe when using the TOOL or APPLIANCE CONNECTIONS receptacle for testing. Do not touch the item under test, the high-voltage probe, the tester contact plate, or the RETURN test probe.

4. Set the TEST MODE switch to INSULATION WITHSTAND. If the FAILURE indicator lights and the buzzer sounds, the VOLTAGE CONTROL has not been properly set to ZERO START (RESET). The HV ON indicator will light once the VOLTAGE CONTROL is set to ZERO START (RESET) indicating that the tester is capable of producing high voltage.

5. Slowly turn the VOLTAGE CONTROL clockwise while observing the INSULATION WSTD TEST meter. Set the withstand voltage to the desired value and maintain it for the required time.

6. During the test, be alert to these indications of failure:

Buzzer sounds and FAILURE indicator lights.

Sudden voltage drop; retarded or erratic INSULATION WSTD TEST meter reading.

7. When the withstand voltage has been applied to the item under test for the required period of time or when a failure occurs, set the VOLTAGE CONTROL to ZERO START (RESET).

8. If the item under test has failed the Insulation Withstand test, set the TEST MODE switch to OFF and repair the item under test before proceeding. When the item under test has passed the Insulation Withstand test, remove the high-voltage test probe, if used, from the tester and proceed to the Functional test which follows.

#### **Functional Test**

1. Set the TEST MODE switch to FUNCTIONAL.

2. Observe the FUNCTIONAL TEST meter as the item under test operates. Read the current value from the FUNCTIONAL TEST meter after the item under test stabilizes in its normal operating condition.

3. If the item under test is drawing excessive current or more than the functional metering circuit can handle (15 A), set the TEST MODE switch to OFF and repair the item under test. If the item under test is within normal operating limits and all other tests (Ground Check, Leakage, Insulation Withstand) have been successfully completed, the testing cycle is finished.

4. Set the TEST MODE switch to OFF. Remove the item under test and connect the next item to be tested, if desired.

### Testing Extension Cords (Three-Wire Grounding Type)

Perform the following procedure to test extension cords. Follow all safety precautions.

1. Inspect the extension cord cable for frayed or broken wires and the cord and cap connectors for cracked housings or broken pins. Repair any defects before testing.
2. Set the TEST MODE switch to OFF and plug in the input power cord.
3. Verify that the TESTER GROUNDED indicator lights.

#### WARNING

Do not proceed if the TESTER GROUNDED indicator is not lit. If this indicator is not lit, unplug the input power cord and refer to Section 8, Troubleshooting and Repair.

4. Remove the lid from the tester and connect the RETURN test probe to the thumbscrew on the tester lid contact plate.
5. Coil the extension cord in or on the tester lid and plug the female cord connector end ground socket (round hole) onto the round pin on the tester lid contact plate.
6. With the TEST MODE switch set to OFF, plug the cap connector (male) end into the TOOL or APPLIANCE CONNECTIONS receptacle.

#### WARNING

Do not plug in the high-voltage test probe when using the TOOL or APPLIANCE CONNECTIONS receptacle for testing.

7. Follow all steps in the Ground Check, Leakage, and Insulation Withstand Test operating procedures already outlined in this section.

#### NOTE

The Functional test will be inoperative during this test.

The Ground Check test is a test of the green (ground) wire continuity. The Leakage and Insulation Withstand tests are applied between the green (ground) wire and the black or white wires. Note that the Leakage and Insulation Withstand tests are applied only to the insulation between conductors within the cord. Leakage from a supply conductor through the outer cable jacket is not checked unless special arrangements are used.

The following tabulation details various wire gauges, assumed strandings, and the maximum length that each can be tested on a tool tester with 0.1  $\Omega$  acceptance level:

Wire Gauge	Assumed Stranding	Ohms/1000 ft @ 20°C	*Maximum ft for 0.1 $\Omega$ Limit
18	16/30	6.48	15
16	26/30	4.00	25
14	19/27	2.70	37
12	19/25	1.70	58
10	49/27	1.09	91

\* Does not include any contact resistance of connections.

## Section 6 Application Notes

### Properties of Insulation

#### Insulated Tools and Appliances

Tools and appliances (items) are made with one or two levels of protection. Most modern appliances, especially those intended for outdoor, industrial, or military use, are double insulated, i.e., have two layers of electrical insulation and have two-wire line cords and plugs.

Some items have a metal frame enclosing the electrical components, wiring, and insulation. This frame is connected to ground by a third green wire in the line cord. Items having this construction are referred to as grounded; they have three-wire line cords and plugs. The ground is the round pin of the plug.

Older items intended only for use in the home do not have a secondary protection. They rely on the fact that in a dry indoor environment the user seldom has a good connection to earth.

#### Leakage Current

All electrical insulating structures, when subjected to voltage, conduct some current. When alternating voltage is applied, this current consists of two components: one due to conduction through or across the surface of the insulator, (the resistive component) and one due to the capacitance of the structure (the capacitive component). Both components are undesirable and are minimized by design in new equipment. Nevertheless, some current of both types always leaks around or through any insulator; hence the name "leakage current." By some definitions, leakage includes only the resistive component; however, existing practice also includes the capacitive component and therefore that is how leakage is used in this discussion.

Leakage current of both resistive and capacitive types increases with voltage, and generally with the size of equipment; capacitive current especially is high for items having windings (motors, transformers), or long runs of wire (wired control panels, etc). In good new equipment, the resistive component is usually much smaller than the capacitive component.

Do not confuse the leakage which occurs during the Insulation Withstand test (high voltage leakage) with the leakage which exists when an appliance is energized at its normal operating voltage during the Leakage test and for which limits are specified by various safety standards, such as UL. This operating leakage is an important safety consideration, but is only indirectly related to the high-voltage leakage, and it is normally much smaller. For the remainder of this section the definition of the phrase leakage current is high-voltage leakage current.

Figure 4 shows the leakage current paths during an insulation test. The resistive component,  $I_R$ , is usually much less than the capacitive component,  $I_C$ .

#### Insulation Failure

Defective insulation subjected to a high voltage may result in:

- a. Leakage current increasing greatly because part of the insulation has become conductive, or
- b. A spark jumping across an air gap which has become too short to withstand the applied voltage.

Condition (a) may lead to (b), and (b) usually leads to a continuing breakdown discharge which emits light, heat, and a crackling sound, and carries as much current as the tester will deliver. Such a discharge also causes high frequency variations in the current, which is useful in detection.

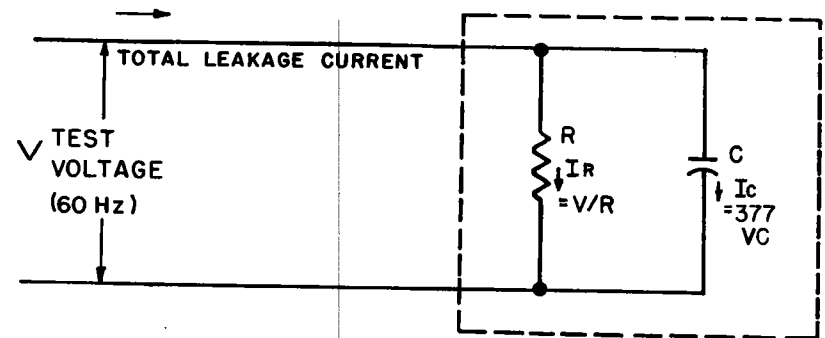


Figure 4: Leakage Current Paths

Some defects which cause failure are:

- a. Dirt on the insulation causes increased resistive current; this may heat the surface and cause a further increase and may lead to a discharge. Moisture always aggravates this condition.
- b. Cracks or pinholes in insulation usually lead to a quick breakdown and discharge.
- c. Shortened air gap due to defective assembly may cause discharge across the gap. An example is a loose strand of wire near the frame.
- d. Insulation saturated with moisture may cause a large increase in either component of leakage current.
- e. A short circuit conducts a large current, but may not produce any immediately visible or audible effects.

### How the Insulation Breakdown Test Works

#### Output

Figure 5, a graph of output voltage versus capacitance, shows the typical output characteristics of the tester. Note that the tester can drive a capacitive load of well over 11 nF to its full rating of 3000 V. Loads having high capacitance, however, cannot be driven to full voltage. For test items having capacitances outside the range of the tester, a larger tester must be used.

#### Automatic Failure Detection

The tester is equipped with a failure detection circuit which detects insulation failure in the form of excessive leakage current or an arcing fault and indicates this failure by activating an audible alarm (buzzer), lighting the FAILURE indicator, and switching off high voltage within 50 ms. The leakage current trip level is adjustable between 0.3 mA and 12 mA by the LEAKAGE SENSITIVITY control.

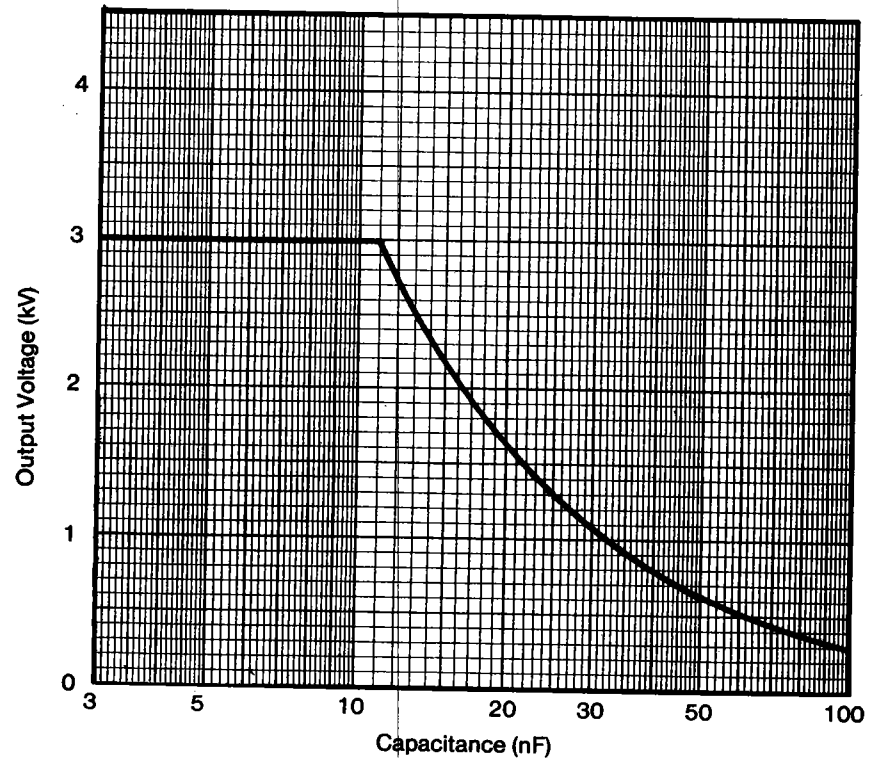


Figure 5: Typical Output Characteristics of the Tool and Appliance Tester



The operator may occasionally detect a visible or audible discharge or erratic voltmeter indication without an accompanying failure signal by the tester. These represent borderline cases in which the discharge energy remains small and does not build up to a full breakdown. If repeated during the test period, these should be taken as signs of failure. If a single snap or pop occurs and is not repeated, it may be due to a stray projection or dirt which has burned off, in which case the item under test may be acceptable. Such weak pops seldom occur at higher test voltages and with high capacitance test items. However, some complex structures such as relays and transformers may emit a more continuous buzz at high voltage; this is a very low energy corona discharge and generally not a sign of insulation failure.

### Instructions for Setting the Leakage Sensitivity Control

Set the LEAKAGE SENSITIVITY control based on the capacitance of the item under test, if known, from the following details:

#### Capacitance of Item Unknown

If the capacitance of the item under test is unknown, set the LEAKAGE SENSITIVITY control at the most sensitive setting, toward the 0.3 mA position (counterclockwise). This ensures the best test and the maximum protection for both the operator and the item under test. If the tester trips at this setting, slowly increase the LEAKAGE SENSITIVITY control setting toward the 12 mA position (clockwise) until testing can be performed. If the tester trips at the 12 mA setting, refer to the instructions for "Excessively High Capacitance Items."

#### Low Capacitance Items

Most items have a capacitance well below 1 nF which implies a leakage current less than 0.3 mA when tested at 1000 to 1200 V. In such cases the tester can be used with the LEAKAGE SENSITIVITY control set to 0.3 mA.

#### Medium to High Capacitance Items

Items having a capacitance greater than 1 nF, and where the capaci-

tance as a function of voltage (C-V) point falls below the maximum output line in Figure 5, can be tested with the LEAKAGE SENSITIVITY control set to some intermediate position between 0.3 mA and 12 mA.

#### Excessively High Capacitance Items

If the capacitance of the item is so large that its C-V point falls beyond the maximum output line in Figure 5, it is too large for the tester to handle. This will be clear when attempting to test since even on a good appliance the voltage will not reach the desired value before a failure indication is signaled.

### Notes on Dielectric Withstand Testing of 120 V Appliances

Most 120 V ac tools and appliances are frequently tested at two times working voltage + 1000 V (1240 V). Some standards call for other values of dielectric withstand voltage. The latest issue of the standard which applies in each particular case should be consulted. Such standards are issued by many different authorities (refer to the following list).

American National Standards Institute (ANSI)  
1430 Broadway  
New York, NY 10018 USA

Canadian Standards Association (CSA)  
178 Rexdale Boulevard  
Rexdale, Ontario, Canada M9W1R3

International Electrotechnical Commission (IEC)  
1 Rue de Varembe  
Geneva, Switzerland  
(Copies of IEC standards can be obtained from ANSI.)

Underwriters Laboratories, Inc. (UL)  
333 Pfingsten Rd.  
Northbrook, IL 60062 USA

## **Section 7**

### **Maintenance and Calibration**

#### **Routine Maintenance**

Certain routine checks are necessary to ensure the safe and correct operation of the tester. Make all of the following checks after repairs and at regularly scheduled intervals of at least once a year, more often if the tester is heavily used. Maintenance and calibration procedures should only be performed by qualified personnel. Refer to Section 2, Safety.

To perform all of the following maintenance and calibration procedures, it will be necessary to construct certain test fixtures or assemblies. These items are described either in text or schematically, but in no way are these descriptions intended to be complete manufacturing instructions. Construction of these items should only be attempted by personnel who are qualified in this specialized field. Also these items are inherently dangerous and the consequences of their use should be carefully considered each time they are used. Safety is the responsibility of the user.

#### **Mechanical Inspection (Exterior)**

1. Visually inspect the case, checking for cracks and noting if hinges and case locks function properly. Inspect the condition of the carrying strap, handle and case feet.
2. Clean the case, panel, contact plate, RETURN test probe, high-voltage probe, and input power cord.
3. Inspect panel, noting if all knobs are secure on their shafts, all controls operate smoothly without binding, and all mounting screws are tight.

4. Inspect the high-voltage and RETURN probe for any cracks in insulation and confirm that the alligator clips and boots are complete. Confirm that the RETURN test probe is firmly clamped at the panel.

5. Inspect the input power cord for any cracks in insulation and confirm that the cord is firmly clamped on the panel. Inspect the cord plug for a cracked housing or broken pins.

6. Mechanically set meters to zero.

7. Repair any defects found.

### Mechanical Inspection (Interior)

#### WARNING

The tester must be disconnected from the supply and de-energized before removing from case.

1. To remove the panel assembly from the case, remove and set aside the four panel screws. Lift the panel assembly straight up by the panel handles until it is clear of the case and place on a clean dry surface.

2. Clean any accumulated dust from the interior of the case and the panel assembly.

3. Inspect all components and leads for defects. Repair any defects found.

4. Reinstall the panel assembly in its case and reinstall the mounting screws.

### Electrical Inspection

Perform the following electrical inspection only after the mechanical inspections have been completed. Follow all safety precautions

before proceeding with this inspection. Refer to Section 2, Safety.

1. With the TEST MODE switch set to OFF, plug in the input power cord.

2. Verify that the TESTER GROUNDED indicator lights.

#### WARNING

Do not proceed if the TESTER GROUNDED indicator is not lit. If the TESTER GROUNDED indicator is not lit, unplug the input power cord and refer to Section 8, Troubleshooting and Repair.

3. If the TESTER GROUNDED indicator lights, proceed with the following ground check procedure.

#### Ground Check Circuit

Perform the following procedure to check the ground check circuit. A ground check and leakage test plug assembly (see Figure 6) is required.

1. Remove the lid from the tester, connect the RETURN test probe to the thumbscrew on the tester lid contact plate. Safely locate the lid to prevent any accidental contact.

2. Set the GROUND CHECK/BYPASS switch to GROUND CHECK.

3. Set the TEST MODE switch to GROUND CHECK. The GOOD WHEN LIT indicator should not light.

4. Set the TEST MODE switch to OFF.

5. Plug the ground check and leakage test plug assembly into the TOOL or APPLIANCE CONNECTIONS receptacle.

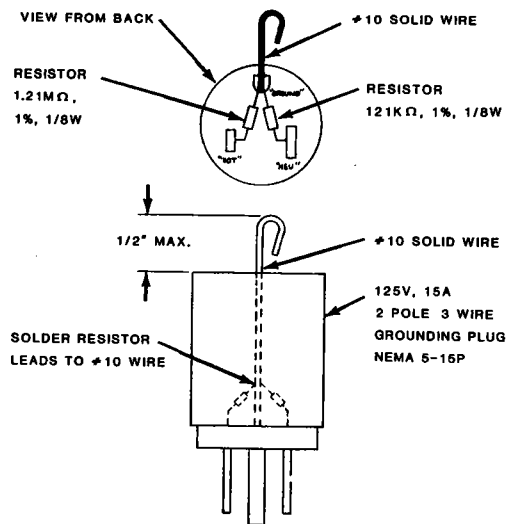


Figure 6: Ground Check and Leakage Test Plug Assembly

6. Connect the RETURN test probe to the wire protruding from the test plug assembly.

7. Set the TEST MODE switch to GROUND CHECK. The GOOD WHEN LIT indicator should light and stay lit.

8. If the ground check circuit does not function properly, set the TEST MODE switch to OFF, unplug the input power cord, and refer to Section 8, Troubleshooting and Repair. If the ground check circuit does function properly, proceed to the following procedure.

### Leakage Circuit

Perform the following procedure to check the leakage circuit. A ground check and leakage test plug assembly as shown in Figure 6 is required.

1. With the ground check and leakage test plug assembly and the RETURN test probe still connected, set the TEST MODE switch to LEAKAGE.

### NOTE

When the TEST MODE switch is set to GROUND CHECK, the GOOD WHEN LIT indicator must light for the leakage circuit to operate.

2. Remove the RETURN test probe from the ground check and leakage test plug assembly.

3. Press the METER CHECK push button. The LEAKAGE TEST meter should deflect to midscale to the METER CHECK area.

4. Set the SUPPLY NEUTRAL switch to CLOSED. Actuate and hold the SUPPLY POLARITY switch to NORM. The LEAKAGE TEST meter should read around the 0.1 mA mark.

5. Actuate and hold the SUPPLY POLARITY switch to REV. The LEAKAGE TEST meter should read around the 1.0 mA mark.

6. Set the TEST MODE switch to OFF. Remove the ground check and leakage test plug assembly from the TOOL or APPLIANCE CONNECTIONS receptacle.

7. If the leakage circuit does not function properly, unplug the input power cord and refer to Section 8, Troubleshooting and Repair. If the leakage circuit does function properly, proceed with the Insulation Withstand procedure which follows.

#### Insulation Withstand Circuit

Perform the following procedure to check the insulation withstand circuit. The following items are required:

- a. One 120 V, 15 A (NEMA Plug 5-15P) line cord with insulated alligator clips on the three wires.
- b. One 1.0 M $\Omega$ , 1 W resistor.
- c. One 50 k $\Omega$ , 7.5 W resistor.

#### CAUTION

Be sure that the ground check and leakage test plug assembly is removed from the TOOL or APPLIANCE CONNECTIONS receptacle before proceeding.

#### Failure Signals, Zero Start (Reset) Test

1. Be sure that the TEST MODE switch is set to OFF.
2. Set the GROUND CHECK/BYPASS switch to BYPASS.
3. Set the VOLTAGE CONTROL to the first mark above ZERO

START (RESET).

4. Set the LEAKAGE SENSITIVITY control to 0.3 mA.

5. Set the TEST MODE switch to INSULATION WITHSTAND and observe the following:

the HV ON indicator ~~lights~~, *does not light*,  
the FAILURE indicator lights and buzzer sounds,

the INSULATION WSTD TEST meter reads zero.

6. Set the VOLTAGE CONTROL to ZERO START (RESET) and observe the following:

the FAILURE indicator goes out and buzzer stops,  
the HV ON indicator ~~remains lit~~, *lights*,  
the INSULATION WSTD TEST meter reads zero.

7. Set the TEST MODE switch to OFF.

#### Leakage Sensitivity Test

1. Be sure that the TEST MODE switch is set to OFF.
2. Plug the high-voltage test probe into its receptacle. Do not plug the 120 V 15 A line cord (item a) into the TOOL or APPLIANCE CONNECTIONS receptacle at this time.
3. Connect the 1.0 M $\Omega$ , 1 W resistor (item b) between the high-voltage test probe and the RETURN test probe.
4. Insulate for at least 3000 V the surface on which the 1.0 M $\Omega$  resistor, high-voltage test probe and RETURN test probe lay from ground and each other; locate the assembly so that it is out of reach to prevent accidental contact with persons.

5. Set the LEAKAGE SENSITIVITY control to 0.3 mA.
6. Set the VOLTAGE CONTROL to ZERO START (RESET).
7. Set the TEST MODE switch to INSULATION WITHSTAND. The HV ON indicator should light.

**WARNING**

Do not touch the test assembly. High voltages now exist.

8. Slowly turn the VOLTAGE CONTROL toward the MAX setting while observing the INSULATION WSTD TEST meter. The FAILURE indicator should light and buzzer sound around 300 V on the INSULATION WSTD TEST meter.
9. Return the VOLTAGE CONTROL to ZERO START (RESET).
10. Set the TEST MODE switch to OFF.
11. Connect the 50 k $\Omega$ ,  $\frac{1}{2}$  W resistor (item c) in place of the 1.0 M $\Omega$ , 1 W resistor.
12. Set the LEAKAGE SENSITIVITY control to 12 mA.
13. Set the VOLTAGE CONTROL to ZERO START (RESET).
14. Set the TEST MODE switch to INSULATION WITHSTAND. The HV ON indicator should light.

**WARNING**

Do not touch the test assembly. High voltages now exist.

15. Slowly turn the VOLTAGE CONTROL toward the MAX setting while observing the INSULATION WSTD TEST meter. The FAILURE indicator should light and buzzer sound around 600 V on the INSULATION WSTD TEST meter.

16. Return the VOLTAGE CONTROL to ZERO START (RESET).
17. Set the TEST MODE switch to OFF.

Breakdown Sensitivity Test

1. Be sure that the TEST MODE switch is set to OFF.
2. Plug the 120 V, 15 A (NEMA plug 5-15P) line cord (item a) into the TOOL or APPLIANCE CONNECTIONS receptacle.
3. Remove the high-voltage test probe from the high-voltage test probe receptacle.

**WARNING**

Do not plug in the high-voltage test probe during the remainder of the insulation withstand circuit check.

4. Insulate the cord leads from ground for at least 3000 V and locate the leads so that they are out of reach to prevent accidental contact with persons. Locate the black (hot) lead and green (ground) lead alligator clips approximately 1/16 in. apart, but not touching. Place the white (neutral) lead away from the other two leads.
5. Set the LEAKAGE SENSITIVITY control to 0.3 mA.
6. Set the VOLTAGE CONTROL to ZERO START (RESET).
7. Set the TEST MODE switch to INSULATION WITHSTAND. The HV ON indicator should light.

## WARNING

Do not touch the line cord assembly. High voltages now exist.

8. Slowly turn the VOLTAGE CONTROL clockwise while observing the INSULATION WSTD TEST meter. The FAILURE indicator should light and buzzer sound when there is an arc between the black (hot) and green (ground) alligator clips.
9. Return the VOLTAGE CONTROL to the ZERO START (RESET).
10. Set the TEST MODE switch to OFF.
11. If no breakdown occurs, check that the spacing of the alligator clips is approximately 1/16 in. and repeat the test.
12. If the insulation withstand circuit does not function properly, unplug the input power cord and refer to Section 8, Troubleshooting and Repair. If the insulation withstand circuit does function properly, proceed with the functional circuit check procedure which follows.

### Functional Circuit

Perform the following procedure to check the functional circuit. The following item is required:

a commercially available 120-V line operated flashlight containing a 100-W bulb.

1. Insert the bulb assembly line cord plug into the TOOL or APPLIANCE CONNECTIONS receptacle. Locate the bulb assembly out of reach to prevent accidental contact with persons.
2. Set the GROUND CHECK/BYPASS switch to BYPASS.

3. Set the TEST MODE switch to FUNCTIONAL. The 100 W light bulb should light and the FUNCTIONAL TEST meter should read approximately 0.8 A.

4. Set the TEST MODE switch to OFF and unplug the input power cord.

5. If the functional circuit does not operate properly, refer to Section 8, Troubleshooting and Repair. If the functional circuit does operate properly and all other circuit tests have been successfully completed. The electrical inspection of the tester is complete.

### Calibration

To perform any of the calibration procedures, the panel assembly must be removed from the tester case. Refer to Mechanical Inspection (Interior) in this section for details on panel assembly removal. An insulated screwdriver is required for all calibration procedures. All calibration adjustment potentiometers are located on the instrumentation assembly printed circuit board A1. Figure 7 shows the location of the calibration potentiometers.

## WARNING

The interior of the tester develops dangerous voltages while in operation. Calibration procedures should only be performed by qualified personnel. Once the tester is energized, do not touch exposed parts.

Set up the tester according to the Electrical Inspection Setup procedure described previously in this section before performing any calibration procedures.

## Ground Check Calibration

The following items are required:

- One 120 V, 15 A (NEMA plug 5-15P) line cord assembly with insulated alligator clips on the three wires.
- One resistor  $0.08 \Omega \pm 1$  percent, 100 W.
- One resistor  $0.20 \Omega \pm 1$  percent, 100 W.
- Adjustable power source held to  $118 V \pm 1 V$ .

Proceed as follows:

- Plug in tester to adjustable power source (item d) and maintain at  $118 V \pm 1 V$  during ground check calibration.

### NOTE

Tester input voltage *must* be maintained at  $118 V \pm 1 V$  for proper calibration.

- With the TEST MODE switch set to OFF, plug in the line cord assembly (item a) and connect the  $0.08 \Omega$  resistor (item b) between the line cord green (ground) wire and the RETURN test probe.
- Insulate the resistor and all leads from ground and each other; arrange to prevent accidental contact with persons. Set the GROUND CHECK/BYPASS switch to GROUND CHECK.
- Set the TEST MODE switch to GROUND CHECK. The GOOD WHEN LIT indicator should light. If it does not light, turn the ground check TRIP CAL potentiometer (R20) using an insulated screwdriver until the GOOD WHEN LIT indicator lights.
- Set the TEST MODE switch to OFF and connect the  $0.20 \Omega$

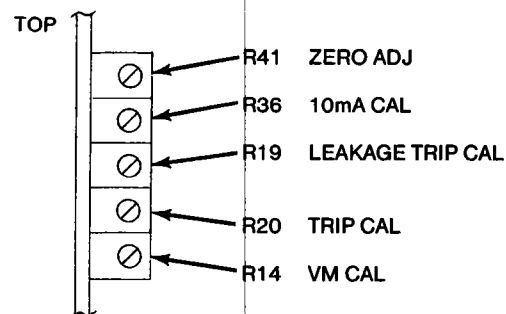


Figure 7: Calibration Potentiometer Location

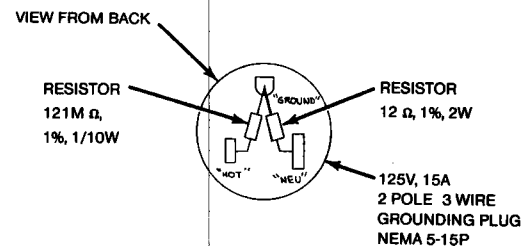


Figure 8: Leakage Test Plug Assembly



resistor (item c) in place of the 0.08  $\Omega$  resistor (item b).

6. Set the TEST MODE switch to GROUND CHECK. The GOOD WHEN LIT indicator should not light. If it does light, adjust the ground check TRIP CAL potentiometer (R20) using an insulated screwdriver until the GOOD WHEN LIT indicator goes out.

7. Repeat steps 2 through 6 until satisfactory results are obtained.

8. Set the TEST MODE switch to OFF and unplug the input power cord. Reinstall the panel assembly in its case and reinstall the mounting screws.

### LEAKAGE TEST Meter Calibration

The following items are required:

- a. Leakage test plug assembly (see Figure 8).
- b. Adjustable power source held to 121 V  $\pm$ 1 V.
- c. Ground check and leakage test plug assembly (see Figure 6).

#### NOTE

There are two different test plugs used during this calibration procedure.

Proceed as follows:

1. Plug in tester to adjustable power source (item b) and maintain at 121 V  $\pm$ 1 V during calibration.

#### NOTE

Tester input voltage *must* be maintained at 121 V  $\pm$ 1 V for proper calibration.

2. With the TEST MODE switch set to OFF, plug in the leakage test plug assembly (item a).

3. Set the GROUND CHECK/BYPASS switch to BYPASS.

4. Set the TEST MODE switch to LEAKAGE.

5. Set the SUPPLY NEUTRAL switch to CLOSED. Actuate and hold the SUPPLY POLARITY switch to NORM. The LEAKAGE TEST meter should read 0 mA.

#### NOTE

The LEAKAGE TEST meter will not display below zero. If the LEAKAGE TEST meter is not indicating 0 mA, slowly turn the leakage test meter ZERO ADJ potentiometer (R41) using an insulated screwdriver until the LEAKAGE TEST meter just reads zero. Turning the leakage test meter ZERO ADJ potentiometer (R41) after 0 mA is reached on the LEAKAGE TEST meter will not change the meter display but will cause the leakage circuit zero to be in error.

6. Actuate and hold the SUPPLY POLARITY switch to REV. The LEAKAGE test meter should read 10 mA. If the LEAKAGE TEST meter is not indicating this value, adjust the LEAKAGE TEST meter 10 mA CAL potentiometer (R36) using an insulated screwdriver until the LEAKAGE TEST meter reads 10 mA.

7. Recheck both the 0 mA and 10 mA points.

8. Once the LEAKAGE TEST meter is calibrated, set the TEST MODE switch to OFF, unplug the leakage test plug assembly (item a), and plug in its place the ground check and leakage test plug assembly (item c).

9. Set the TEST MODE switch to LEAKAGE.

10. Actuate and hold the SUPPLY POLARITY switch to NORM. The LEAKAGE TEST meter should read 0.1 mA. If necessary, adjust the power source from 115 V to 127 V until 0.1 mA is displayed on the LEAKAGE TEST meter. The LEAKAGE TEST meter is within tolerance ( $\pm 5$  percent of reading) as long as the power source limits are not exceeded.

11. Actuate and hold the SUPPLY POLARITY switch to REV. The LEAKAGE TEST meter should read 1.0 mA. If necessary, adjust the power source from 115 V to 127 V until 1.0 mA is displayed on the LEAKAGE TEST meter. The LEAKAGE TEST meter is within tolerance ( $\pm 5$  percent of reading) as long as the power source limits are not exceeded.

12. If either point (0.1 mA or 1.0 mA) of the LEAKAGE TEST meter is out of tolerance, set the TEST MODE switch to OFF.

a. Replace the ground check and leakage test plug assembly (item c) with the leakage test plug assembly (item a).

b. Set the TEST MODE switch to LEAKAGE.

c. Actuate and hold the SUPPLY POLARITY switch to REV. The LEAKAGE TEST meter should read 10 mA. Using an insulated screwdriver, adjust the LEAKAGE TEST meter 10 mA cal potentiometer (R36) for either a slight upscale or downscale change from 10 mA on the LEAKAGE TEST meter depending on the results from steps 10 and 11. Adjust the power source from 109 to 133 until 10 mA is displayed on the LEAKAGE TEST meter. The LEAKAGE TEST meter 10 mA point is within tolerance ( $\pm 10$  percent of reading) as long as the power source limits are not exceeded.

d. Repeat steps 8, 9, 10, and 11 until the LEAKAGE TEST meter is within tolerance.

13. Once the LEAKAGE TEST meter is calibrated and checked, set the TEST MODE switch to OFF. Unplug the leakage test plug assembly (item a) or the ground check and leakage test plug assembly (item c). Unplug the input power cord.

14. Reinstall the panel assembly in its case and reinstall the mounting screws.

#### INSULATION WSTD TEST Meter Calibration

The following items are required:

a. One 120 V, 15 A (NEMA plug 5-15P) line cord assembly with insulated alligator clips on the three wires.

b. A standard voltmeter with a 3000 V rms range and an overall accuracy of 1.0 percent or better.

Proceed as follows:

1. With the TEST MODE switch set to OFF, plug in the line cord assembly (item a) and connect the standard voltmeter (item b) between the green (ground) wire and the black (hot) and white (neutral) wire connected together.

2. Insulate for at least 3000 V the standard voltmeter and all leads from ground and each other; locate the voltmeter so that it can be easily read but is out of reach.

3. Set the GROUND CHECK/BYPASS switch to BYPASS.

4. Set the VOLTAGE CONTROL to ZERO START (RESET).

5. Set the LEAKAGE SENSITIVITY control fully clockwise to 12 mA.

6. Set the TEST MODE switch to INSULATION WITHSTAND. IF

the FAILURE indicator lights and the buzzer sounds, the VOLTAGE CONTROL has not been properly set to ZERO START (RESET). The HV ON indicator will light indicating that the tester is capable of producing high voltage.

**WARNING**

Do not touch energized parts. High voltages now exist.

7. Slowly turn the VOLTAGE CONTROL clockwise while observing the standard voltmeter (item b). Set the insulation withstand voltage to 2 kV on the standard voltmeter. The INSULATION WSTD TEST meter should also read 2 kV  $\pm 5$  percent of full scale ( $\pm 150$  V). If there is a discrepancy, adjust the VM CAL potentiometer (R14) using an insulated screwdriver until the INSULATION WSTD TEST meter reads 2 kV  $\pm 5$  percent of full scale ( $\pm 150$  V).
8. Check several other points along the scale and be sure that they are within tolerance.
9. Repeat steps 1 through 7 using the high-voltage test probe and RETURN test probe instead of the line cord assembly (item a). Connect the standard voltmeter (item b) between the high-voltage test probe and RETURN test probe.

**WARNING**

The line cord assembly (item a) must be disconnected from the TOOL or APPLIANCE CONNECTIONS receptacle when the high-voltage test probe is in use.

10. Once the INSULATION WSTD TEST meter is calibrated and checked, set the TEST MODE switch to OFF, and unplug the input power cord. Reinstall the panel assembly in its case and reinstall the mounting screws.

### Insulation Withstand Leakage Sensitivity Calibration

The following items are required:

- a. One 1.0 M $\Omega$ , 1 W resistor.
- b. One 50 k $\Omega$ , 7.5 W resistor.
- c. A standard milliammeter with ranges of 15 mA and 0.5 mA and an overall accuracy of 1.0 percent or better.

Proceed as follows:

1. With the TEST MODE switch set to OFF, plug in the high-voltage test probe and connect the 50 k $\Omega$  resistor (item b) and the standard ammeter (item c) set on the 15 mA range in series between the high-voltage test probe and the RETURN test probe.
2. Insulate the surface on which the standard ammeter, 50 k $\Omega$  resistor and all leads lay for at least 3000 V from ground and each other; locate the standard ammeter so that it can be easily read but is out of reach.
3. Set the GROUND CHECK/BYPASS switch to BYPASS.
4. Set the VOLTAGE CONTROL to ZERO START (RESET).
5. Set the LEAKAGE SENSITIVITY control fully clockwise to 12 mA.
6. Set the TEST MODE switch to INSULATION WITHSTAND. If the FAILURE indicator lights and the buzzer sounds, the VOLTAGE CONTROL has not been properly set to ZERO START (RESET). Once the ZERO START condition has been met, the HV ON indicator will light indicating that the tester is capable of producing high voltage.

**WARNING**

Do not touch energized parts. High voltages now exist.

7. Slowly turn the VOLTAGE CONTROL clockwise while observing the standard ammeter (item c).

**CAUTION**

Do not exceed 700 V on the INSULATION WSTD TEST meter.

A current reading on the standard ammeter (item c) between 11.4 and 12.6 mA should cause the FAILURE indicator to light and the buzzer to sound. If the current reading is less than 11.4 mA or more than 12.6 mA when the failure indicators activate, adjust the insulation withstand leakage TRIP CAL potentiometer (R19) using an insulated screwdriver until the failure signals indicate within the accepted range. Setting the VOLTAGE CONTROL to the ZERO START (RESET) resets the failure indicators.

8. Set the TEST MODE switch to OFF and connect the 1.0 M $\Omega$  resistor (item a) in place of the 50 k $\Omega$  resistor (item b). Change the standard ammeter (item c) range to the 0.5 mA range.

9. Set the LEAKAGE SENSITIVITY control fully counterclockwise to 0.3 mA.

10. Set the TEST MODE switch to INSULATION WITHSTAND. If the FAILURE indicator lights and the buzzer sounds, the VOLTAGE CONTROL has not been properly set to ZERO START (RESET). Once the ZERO START condition has been met, the HV ON indicator will light indicating that the tester is capable of producing high voltage.

11. Slowly turn the VOLTAGE CONTROL clockwise while observing the standard ammeter (item c).

**CAUTION**

Do not exceed 400 V on the INSULATION WSTD TEST meter.

A current reading on the standard ammeter (item c) between 0 mA and 0.32 mA should cause the FAILURE indicator to light and the buzzer to sound.

12. If the current reading exceeds 0.32 mA without causing the FAILURE indicator to light or buzzer to sound, repeat steps 1 to 11 and adjust the insulation withstand leakage TRIP CAL potentiometer (R19) using an insulated screwdriver to change the trip point setting in the direction required.

13. Once the LEAKAGE SENSITIVITY circuit is calibrated and checked, set the TEST MODE switch to OFF and unplug the input power cord. Reinstall the panel assembly in its case and reinstall the mounting screws.

**FUNCTIONAL TEST Meter Calibration Check**

The FUNCTIONAL TEST meter cannot be calibrated. The meter accuracy is  $\pm 3$  percent of full scale and can be checked for proper operation and accuracy.

The following items are required:

- a. One 120 V, 15 A (NEMA plug 5-15P) line cord assembly with insulated alligator clips on the three wires.
- b. A 120 V ac, 12 A load.
- c. A 120 V ac, 6 A load.

d. A standard ammeter with a 15 A ac range and an overall accuracy of 0.75 percent or better.

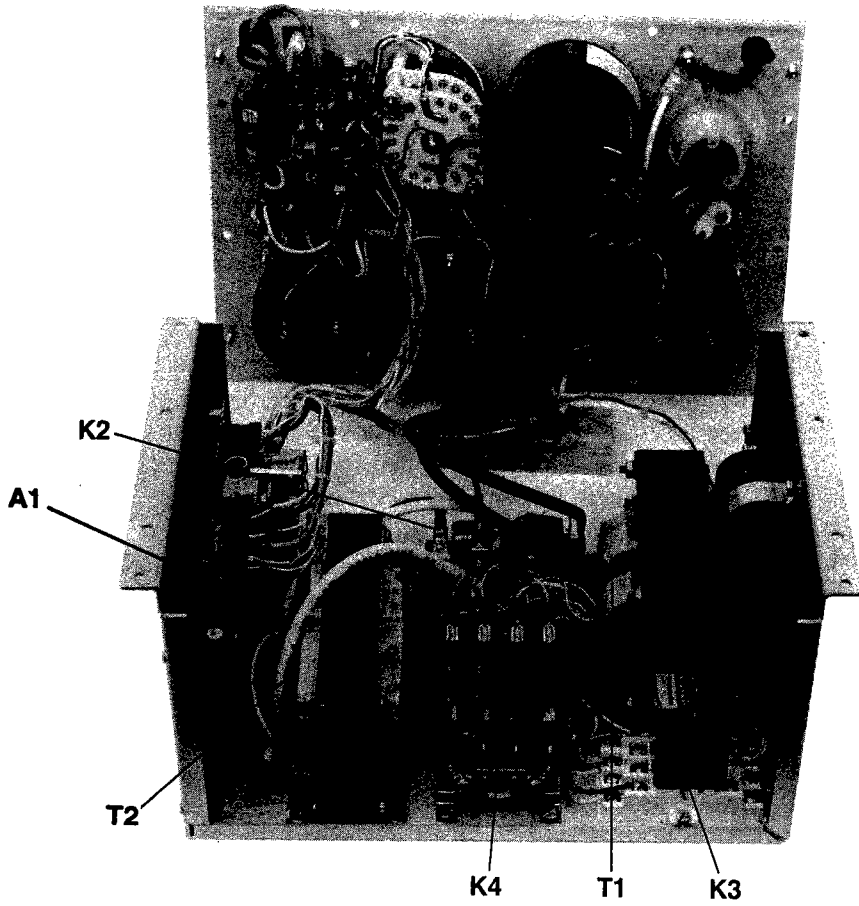
Proceed as follows:

1. With the TEST MODE switch set to OFF, plug in the line cord assembly (item a). Connect the standard ammeter (item d) and the 120 V, 6 A load (item b) in series between the black (hot) wire and the white (neutral) wire. Locate the green wire away from the other two wires (black and white) to avoid contact.
2. Arrange the line cord load assembly to prevent accidental contact with persons.
3. Set the GROUND CHECK/BYPASS switch to BYPASS.
4. Set the TEST MODE switch to FUNCTIONAL.
5. Observe that the FUNCTIONAL TEST meter reading agrees with the standard ammeter (item d) reading within the accuracy of the FUNCTIONAL TEST meter.
6. Set the TEST MODE switch to OFF.
7. Connect the 120 V ac, 12 A load (item b) in place of the 120 V ac, 6 A load (item c) and repeat steps 2 through 6.
8. Once the FUNCTIONAL TEST meter calibration is checked, be sure that the TEST MODE switch is set to OFF, and unplug the input power cord. If the FUNCTIONAL TEST meter is out of tolerance, it will require replacement.
9. Reinstall the panel assembly in its case and reinstall the mounting screws.

## Section 8 Troubleshooting and Repair

### Troubleshooting

The tester should be completely checked for proper operation as described in Section 7 before troubleshooting is attempted. The tester develops dangerous interior voltages and employs printed circuit board construction, therefore, repairs must be made only by qualified personnel. Section 9, Parts List, identifies all components used in the tester and gives the Biddle part number. An internal view of the tester is shown in Figure 9. It is strongly recommended that for the sake of safety, only Biddle replacement parts be used when making repairs. Figure 10 shows the schematic diagram of the tester. If major problems are encountered or additional assistance is required, contact the factory. After making repairs, always perform a complete inspection of the tester as detailed in Section 7, Maintenance. A brief troubleshooting guide follows.



*Figure 9: Tool and Appliance Tester, Internal View*



## Troubleshooting Guide

Problem	Probable Cause
TESTER GROUNDED indicator not lit.	No voltage at service outlet for the tester.  Ground wire open or ground contact of service outlet not grounded.  Hot and neutral wires on service outlet interchanged.  Defective input power cord.  Defective TESTER GROUNDED indicator.
GROUND CHECK MODE	
GOOD WHEN LIT indicator not lit with resistance of less than 0.08 $\Omega$ connected.	GROUND CHECK/BYPASS switch set to BYPASS.  Defective GOOD WHEN LIT indicator.  Defective TEST MODE switch.  GROUND CHECK circuit out of calibration or not functioning.



LEAKAGE TEST MODE

Little or no deflection of the LEAKAGE TEST meter with the METER CHECK push button pressed.

Defective METER CHECK push button.

Capacitor C1 shorted.

Defective diodes CR3, CR4.

Defective op amps U2,U3, U4, U5 or U6.

Defective LEAKAGE TEST meter.

Defective interlock relay K4 or GROUND CHECK/ BYPASS switch.

Defective TEST MODE switch.

No deflection of LEAKAGE TEST meter. Appliance connected and operational when the SUPPLY POLARITY switch is set to either NORM or REV, and SUPPLY NEUTRAL switch set to CLOSED.

Defective LEAKAGE TEST meter.

Defective op amps U2, U3, U4, U5, or U6.

Capacitor C1 shorted.

Defective METER CHECK push button.

No deflection of LEAKAGE TEST meter. Appliance connected but not operational when the SUPPLY POLARITY switch is set either NORM or REV and the SUPPLY NEUTRAL switch is set to CLOSED.

Defective SUPPLY POLARITY switch or SUPPLY NEUTRAL switch.

Defective TEST MODE switch.

INSULATION WITHSTAND TEST MODE

Failure indicators actuate and continue when the VOLTAGE CONTROL is set to ZERO START (RESET).

ZERO START switch not making proper contact.

Failure indicators actuate when the VOLTAGE CONTROL is turned from ZERO START (RESET) with nothing plugged into the TOOL or APPLIANCE CONNECTIONS receptacle.

Defective zero start relay.

Resistor R18 open.

Capacitor C3 shorted.

High-voltage circuits internally shorted.

INSULATION WSTD TEST meter reads zero when the VOLTAGE CONTROL is turned toward MAX. No output voltage. HV ON indicator lights. Failure indications may occur.

High-voltage circuits internally shorted.

HV ON indicator not lit.  
INSULATION WSTD TEST meter  
reads zero when the VOLTAGE  
CONTROL is turned towards MAX.  
No output voltage.

Defective interlock relay  
K4 or GROUND CHECK/  
BYPASS switch.

INSULATION WSTD TEST meter  
reads zero when the VOLTAGE  
CONTROL is turned clockwise.  
HV ON indicator lights.  
Output voltage present.

Defective diode bridge CR6.

No failure indications when  
VOLTAGE CONTROL is turned  
clockwise while the output is  
shorted with the LEAKAGE  
SENSITIVITY control set to  
0.3 mA.

Defective opto-isolator U1.

Pot. R19 or R28 open.

Resistors R16 and/or R17  
open.

Capacitor C4 shorted.

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#### FUNCTIONAL TEST MODE

FUNCTIONAL TEST meter reads  
zero with load connected;  
load inoperative.

Defective transfer relay K3.

Defective interlock relay K4.

Defective TEST MODE  
switch.

FUNCTIONAL TEST meter reads  
zero with load connected;  
load operational.

Defective FUNCTIONAL  
TEST meter.

#### Repair

Biddle Instruments maintains a complete instrument repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. Please indicate all pertinent information including problem symptoms and attempted repairs. When returning equipment for repair, either in or out of warranty, it must be shipped prepaid and insured, and marked for the attention of the Repair Department.

## Section 9 Parts List

Symbol	Description	Part No.
*C1	Capacitor, 0.15 $\mu$ F, 600 V	4559-40
*C2	Capacitor, 10 $\mu$ F, 25 V	17132-2
*C3	Capacitor, 1.0 $\mu$ F, 600 V	4559-26
*C4	Capacitor, 0.002 $\mu$ F, 1000 V	7950-5
*C5	Capacitor, 100 $\mu$ F, 10 V	17132-6
*C6	Capacitor, 100 $\mu$ F, 10 V	17132-6
*C7	Capacitor, 1000 pF, 20 V	17127-1
*C8	Capacitor, 30 $\mu$ F, 250 V	12075-12
*C10	Capacitor, 0.1 $\mu$ F, 50 V	17127-5
*C11	Capacitor, 4000 pF, 100 V	7950-6
*C12	Capacitor, 0.1 $\mu$ F, 100 V	17127-9
*C13	Capacitor, 1000 $\mu$ F, 25 V	25056-2
*C14	Capacitor, 1000 $\mu$ F, 25 V	25056-2
*C15	Capacitor, 0.01 $\mu$ F, 1000 V	9865-25
*C16	Capacitor, 0.01 $\mu$ F, 1000 V	9865-25
CB1	Circuit Protector, 1 pole, 15 A	10666-15
*CR1	Diode 1N4004	11637-34
*CR2	Diode 1N4004	11637-34
*CR3	Diode 1N4148	11637-40
*CR4	Diode 1N4148	11637-40
*CR5	Diode 1N4148	11637-40
*CR6	Diode Bridge, VM48	22921
*CR7	Diode Bridge, VM48	22921
*CR8	Diode 1N4004	11637-34
*CR9	Diode 1N4148	11637-40
*CR10	Diode 1N4148	11637-40
*CR11	Diode 1N4006	11637-36
*CR12	Diode 1N4006	11637-36
*CR13	Diode FDH333	11637-32
*CR14	Diode FDH333	11637-32
DS1	Neon Lamp (white) 125 V, 1/3 W	4499-7
DS2	Neon Lamp (green) 125 V, 1/3 W	4499-5

Symbol	Description	Part No.
DS3	Neon Lamp (red) 125 V, 1/3 W	4499-6
DS4	Neon Lamp (amber) 125 V, 1/3 W	4499-3
E1	Insulated Standoff	23063
E2	Insulated Standoff	23063
J12	2-Pole, 3 Wire Grounding 15 A, 125 V Flanged Outlet (Tested for 5 kV withstand)	23062
J2	High-Voltage Test Probe Receptacle Rated 15 kV dc	25505-1
*K1	Relay 2PDT, 2 A Coil 4.1 mA, 5000 $\Omega$	16082-1
—	Socket for K1	16523-1
K2	Relay 2PDT, 30 A Coil 120 V ac specially modified	19507
K3	Relay 2PDT, 15 A Coil 120 V ac	23059-1
—	Socket for K3	17832
K4	Relay 4PDT, 25 A Coil 125 V dc, 35 mA	6806-1
*L1	Choke, 25 mH	14871
*LS1	Buzzer, 120 V ac	14860
M1	Leakage Test Meter 0-100 $\mu$ A dc	19937-10
M2	Insulation Withstand Test Meter 0-100 $\mu$ A dc	19937-5
M3	Functional Test Meter 0-15 A ac	19937-4
*Q1	SCR 2N6240	11638-69
*Q2	Transistor, MAT02FH	11638-70
*R1	Resistor, 16 $\Omega$ , 5 1/4 W, 5% Wire Wound	4500-33
*R2	Resistor, 27 k $\Omega$ , 2 W, 5% Carbon Composition	4501-460

Symbol	Description	Part No.
*R3	Resistor, 100 k $\Omega$ , 1/4 W, 5% Carbon Composition	4501-91
*R4	Resistor, 499 $\Omega$ , 1%, RN65	11445-59
*R5	Resistor, 1 k $\Omega$ , 1%, RN65	11445-4
*R6	Resistor 47 k $\Omega$ , 1/2 W, 5%	4501-169
*R7	Resistor, 1 k $\Omega$ , 1/4 W, 5%	4501-51
*R8	Resistor, 20 k $\Omega$ , 1%, RN55D	12398-1
*R10	Resistor, 20 k $\Omega$ 1%, RN55D	12398-1
*R11	Resistor, 16 k $\Omega$ , 1/4 W, 5%	4501-61
*R12	Resistor, 3 M $\Omega$ , 1%, 5 W, 10 kV	10646-12
*R13	Resistor, 37.4 k $\Omega$ , 1% RN55D	12398-19
*R14	Potentiometer, 2 k $\Omega$	12340-8
*R15	Resistor, 4.02 k $\Omega$ , 1%, RN55D	12398-131
*R16	Resistor, 3.9 k $\Omega$ , 1/4 W, 5% Carbon Composition	4501-507
*R17	Resistor, 2.74 k $\Omega$ , 1%, RN70	7524-52
*R18	Resistor, 27 k $\Omega$ , 2 W, 5%	4501-460
*R19	Potentiometer, 5 k $\Omega$	12340-9
*R20	Potentiometer, 2 k $\Omega$	12340-8
*R21	Resistor, 100 $\Omega$ , 1/4 W, 5% Carbon Composition	4501-86
*R22,R23	Resistor, 820 $\Omega$ , 1/4 W, 5% Carbon Composition	4501-69
*R24	Resistor, 47 $\Omega$ , 1/4 W, 5% Carbon Composition	4501-96
*R25	Resistor, 330 $\Omega$ , 1/4 W, 5% Carbon Composition	4501-89
*R26	Resistor, 7.5 k $\Omega$ , 5-1/4 W, 5%	4500-27
*R27	Resistor, 100 $\Omega$ , 1/4 W, 5% Carbon Composition	4501-86
R28	Potentiometer, 250 k $\Omega$	17135-8
*R29	Resistor, 20 k $\Omega$ , 1%, RN55	12398-1
*R30	Resistor, 10 k $\Omega$ , 1%, RN55	12398-17
*R31	Resistor, 22.1 k $\Omega$ , 1%, RN55	12398-134
*R32	Resistor, 6.8 k $\Omega$ , 1/4W, 5%	4501-567
*R33	Resistor, 100 $\Omega$ , 1%, RN55	12398-53
*R34	Resistor, 10 k $\Omega$ , 1%, RN55	12398-17
*R35	Resistor, 39.2 k $\Omega$ , 1%, RN55	12398-217
*R36	Resistor, Pot, 2 k $\Omega$	12340-8
*R37	Resistor, 15.4 k $\Omega$ , 1%, RN55	12398-167

Symbol	Description	Part No.
*R38	Resistor, 1 k $\Omega$	23423
*R39	Resistor, 2 k $\Omega$ , 1%, RN55	12398-3
*R40	Resistor, 25 M $\Omega$ , 1%	26856-1
*R41	Resistor, Pot., 10 k $\Omega$	12340-10
*R42	Resistor, 3.6 k $\Omega$ , 1/4 W, 5%	4501-58
*R43	Resistor, 1.21 M $\Omega$ , 1%, RN70	7524-13
S1	Rotary Switch 2 Section, 4 Pole, Shorting	23048-1
S2 & S5	Toggle Switch DPDT ON-NONE-ON	8406-1
S3	Toggle Switch DPDT momentary on-off-momentary on with reversing jumpers	8406-4
S4	Push Button Switch SPDT Momentary on-off	17516-1
T1	Transformer (Ground Check)	23073
T2	Transformer (Insulation WSTD)	25140-1
T3	Autotransformer (Voltage Control)	6408-2
*T4	Transformer DPC10-90	17148-5
—	Zero Start Contact for T3	23202
*U1	Opto-isolator	14865-1
*U2	IC, LF 411 ACN	25053
*U3	IC, LF 411 ACN	25053
*U4	IC, LF 411 ACN	25053
*U5	IC, OP-07EN	25692-1
*U6	IC, LF 411 ACN	25053
*VR1	IC, LM385BZ2.5	23066-1
W1	15 A Input Power Cord	4127-3
W2	Return Test Probe	23060
W3	High-Voltage Test Probe	25507

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\* Part of PC Board Assembly A1 Biddle P/N 26136

## GLOSSARY



Use only in accordance with Instruction Manual.



High-voltage warning

appliance

current conducting, energy consuming equipment, fixed or portable, for example, heating, cooling, and small motorized equipment.

C-V

capacitance as a function of voltage

dielectric  
withstand  
test

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

double  
insulation

an insulation system comprised of functional and protective insulation with the two physically separated and arranged so that they are not simultaneously subjected to the same deteriorating influences.

ETL

Electrotechnical Laboratory (Japan)

leakage

the current that flows through or across the surface of insulation that defines the insulation resistance.

NEC

National Electrical Code

NEMA

National Electrical Manufacturers Association

rms

root mean square

tool

portable electric tools, medical and dental equipment, and other devices which operate from 120 V ac.

## 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 other expendable items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of abuse (failure to follow recommended operating procedures) or failure by the customer to perform specified maintenance as indicated in this manual.