INSTRUCTION MANUAL 65-100Jb

FOR

IMPULSE GENERATOR/DC PROOF TESTER
BIDDLE CATALOG NO. 651027-1 (120V)
651027-1-47 (240V)

HIGH-VOLTAGE EQUIPMENT

PLEASE READ CAREFULLY BEFORE OPERATING

Safety is the responsibility of the user.

APARATO DE ALTO VOLTAJE

SIRVANSE LEER ESTE LIBRO CON CUIDADO
ANTES DE OPERARLO

La seguridad es la responsabilidad del operador

JAMES G. BIDDLE CO.
Plymouth Meeting, PA 19462

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Figure A: The BIDDLE CAT. No. 651027-1 CABLE FAULT LOCATOR TEST SET.

SECTION A

INTRODUCTION

This instruction manual is intended as a guide to the operation and maintenance of the Impulse Generator/DC Proof Tester[1], Biddle Catalog No. 651027-1. References in this manual to optional functions and equipment may be disregarded when such information does not apply to the test set in use.

The instructions and suggestions given in this manual anticipate normal use of the equipment for testing power cables used in circuits rated up to 22kV and for applying impulses to such cables so that faults can be located.

This Test Set design provides a simple but safe control system, with a minimum of controls and instruments that require attention during operation.

The Impulse Generator/DC Proof Tester has two modes of operation; one is the Impulse Mode; the second is the Proof Test Mode. The tester is a compact, single unit contained in a fiberglass case with a grounded metal panel. This rugged design provides both convenience in handling and the durability to withstand frequent transportation from site to site.

In the impulse method of fault location, the tester repeatedly applies a high voltage waveform to the defective cable by means of a solenoid-driven switch. This waveform travels along the cable until it reaches the fault. At the fault, the voltage causes significant current to pass into the return path. This current or its results can be detected and the fault position along the cable length can be traced by a detector which is carried along the cable path. Suggested detectors are:

BIDDLE CATALOG NO.	DESCRIPTION	GENERAL APPLICATION
651103	Acoustic Detector	Direct buried cable.
651110	Ballistic Impulse Detector	Cable in duct.

[1] Previously named Cable-Fault-Locator/Impulse Generator.

In the Proof Mode the internal dc power supply is used for both Proof Test and for Burn. The output voltage of the power supply and the leakage current is measured on the same meter by means of a simple switching arrangement to permit evaluation of the cable under test.

If the observed output voltage is substantially lower than expected from the voltage control setting, the cable under test is passing significant current and assumed defective. When the current passing through the cable under test is confined by the defect to a localized region, it will tend to heat the path. If this situation is allowed to persist a Burn condition exists. The generation of localized heat reduces the resistance of the path and a high resistance fault is altered to a low resistance fault that can be located by the impulse method.

SECTION B

SAFETY PRECAUTIONS

SAFETY IS THE RESPONSIBILITY OF THE USER.

LA SEGURIDAD ES LA RESPONABILIDAD DEL OPERADOR

CAUTION

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

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

Since the energized test setup may induce a static voltage charge on nearby insulated objects, including people, all such objects must be grounded or kept at least three feet from the energized structure.

High voltage impulse waveforms and resultant current pulses create special safety problems as a large rapidly changing current,even across small values of impedance, can generate dangerous voltage levels. The Tester design, therefore, provides two separate and distinct ground systems: the apparatus case ground, and the surge ground. The apparatus case ground, which must be connected to a good local ground, is designed to protect the operator by preventing a difference of potential between the panel and the ground in the immediate vicinity. The surge ground is designed to return the impulse current back to the capacitor. This ground lead should not be extended.

On termination of a test, even after power has been removed from the Tester, energy can still be stored in the capacitor bank and cable. For this reason, a safety grounding resistor and a manual ground are included in this equipment. The resistor will gradually reduce such stored energy to a safe low level. The Voltmeter on the Tester indicates when this safe level has been reached. Then the manual ground must be closed to place a direct short circuit across the capacitor bank and the cable under test. It is recommendd that, before removal of the Tester a ground bond be placed across the cable under test and that this bond remain in place until access to the cable is again required.

NOTE:

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

The James G. Biddle Co. recommends that the Tester have an operator in attendance during operation, particularly when using the Proof Mode.

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

SECTION C

RECEIVING INSTRUCTIONS

When your Biddle instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify James G. Biddle Co., Plymouth Meeting, PA 19462 of any shortage of materials.

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

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

SECTION D

SPECIFICATIONS

POWER SUPPLY

Cat. No.	Voltage Range (RMS)	Freq. Hz.	Current Amps RMS	Recommended Supply
651027-1	102 to 132	50/60	7	NEC 15 Amp 120V single phase branch
651027-1-47	204 to 264	50/60	3½	NEC 15 Amp 240V single phase branch

OUTPUT IMPULSE MODE

Peak Output Voltage: 25kV maximum (continuous) variable

Polarity: Negative with respect to ground.

Pulse Timing: Fixed rate by motor-driven switch operating a solenoid-driven HV switch.

IMPULSE ENERGY

Cat. No.	Energy Storage Capacity	Stored Energy (Joules) 25kV/4μF	Impulse Timing Sec	Pulse Decay Time *
651027	4μF	1250	6 @ 60 Hz	50μs
651027-1-47	4μF	1250	7.2 @ 50 Hz	50μs

* Time for pulse to decay to 1/2 voltage output short circuited.

OUTPUT PROOF MODE

Voltage: 25kV maximum, variable 0 to 25kV.

Polarity: Negative with respect to ground.

Cat. No.	Continuous Current @ 25kV	Burn Current Continuous	Time To Build Up Voltage	Add.Time for Charg. Capacity	Resistor Discharge Time	Add. Time To Discharge Cable
651027-1	10mA 60Hz	20mA @ 60Hz	20 Sec.	12 Sec/µF	40 Sec.	12 Sec/µF
651027-1-47	8mA 50Hz	16.7mA @ 50Hz	24 Sec.	24 Sec/µF	40 Sec.	12 Sec/µF

METERING

Voltmeter/Ammeter:	3½" taut band ±2% Full Scale: Voltage 0-25kV Current 0-1mA

CONTROLS

ON-OFF Switch	2-pole magnetic circuit breaker tripfree either pole trips both.
Mode Selector Switch 4-position	Manual Ground, Discharge, Proof Test and Impulse
Voltage Control	Manual Adjustment: Scale 0-100%, 5% resolution.
Indicator Lamp	Green; A-C ON
Indicator Lamp	Red; H-V ON
Meter Range Selector	VM, X1, X10, X50mA

PHYSICAL

Height:	30 inches, (76 cm)
Diameter:	18 inches, (46 cm)
Handles:	24½ inches (62 cm) wide x 13 inches (33 cm)
Weight:	
651027-1	125 lbs., (57 kg)
Output Cable:	50 ft. (15.2 meters) permanently attached.
Supply Cable:	25 ft. (7.7 meters) permanently attached.
Ground Cable:	25 ft. (7.7 meters) detachable.

ENVIRONMENT

Operating Temperature:	20 F (-7 C) to 122 F (50 C) continuous.
Altitude:	10,000 ft., (3050 meters) maximum.
Rain:	Not for operation when exposed to direct precipitation.
Relative Humidity:	Operation restricted to non-condensing conditions.
Vibration:	Will withstand normal transport and handling.

PROTECTIVE DEVICES AND SAFETY FEATURES

Fuse:	Control circuit protection.
Thermal Sensor:	Temperature cut-off on high voltage transformer.
Zero Start:	Output not available unless voltage control is initially at zero.
Overvoltage Cut-Off:	Solid State Circuit to prevent overvoltage of test set.
Isolated Surge Ground:	To confine surge voltages to test set interior.
Panel Ground:	To provide safe operation.
Voltmeter Protection :	Solid state meter protection for transients and overload.
Visible Ground Switch:	To provide visual assurance that safe conditions exist.

ACCESSORIES

Handtruck:	Fold away handtruck for ease of transport.

SECTION E

DESCRIPTION

GENERAL

The James G. Biddle Co. recommends that the user become acquainted with this section to obtain the best results from the Tester for fault location and as a guide to maintenance and repair.

Figure 1 on Page E4 shows the schematic of the Tester for use on a 120V or 240V 50/60 Hz power supply depending on the model. (See Specifications of Section D.)

INPUT POWER CONTROL CIRCUIT

Power from an appropriate service outlet is brought into the set by the permanently attached power cord W1. In accordance with electrical code specifications the neutral white and green wires are not interrupted. The black "hot" lead is interrupted by one pole of the circuit breaker K1A that is also the ON-OFF switch. Closing K1 causes the green lamp DS1 to come on. Resistor R3 is the ballast for DS1.

120 & 240 VOLT OPERATION (See Figure 1)

Closure of K1 will cause the green ON light to come on and fan B1 will run. For 240V models the line adjusting transformer T3 will also be energized. In earlier models the drive motor B100 for the impulse switch would also start to run. Fuse F1 provides protection for this circuit. Closing the contacts of K2 by moving the Voltage Control Transformer T1 to zero will mechanically close the contacts of K2 and cause K2 coil to hold the contacts closed only if the thermal overload switch S1 is closed and the Mode Selector Switch S100 is in the Proof or Impulse position, which closes S102, the high voltage interlock switch. This action also causes the red HV ON lamp DS2 to light (through the ballast R2) and applies the line voltage to the primary of the Volage Control Transformer T1.

The Voltage Control can now be advanced to apply a percentage of the line voltage to the primary of the step-up transformer T2 through the circuit breaker pole of K1B (overcurrent protection) and through the limiting resistor R1.

Transformer T2 has a dual primary winding. For 120 volt operation both windings are parallel connected, and T2 is rated for 120V while for 240V operation the primaries of T2 are series connected and T1 is rated for 240V operation.

The output voltage from T1 is sensed by the overvoltage protection network between Pin 3 and Pin 2 of the printed circuit card E100. This voltage is half-wave rectified by CR10 and filtered by Capacitor C10. Resistors R10 and R12 form a voltage divider. The divider output voltage is stored on Capacitor C11 and applied to the DIAC Q10. When the output voltage from T1 exceeds the limit set by R12 the DIAC conducts and supplies current to the gate of the SCR Q11. The gate current is limited by resistor R11. This causes Q11 to conduct and short circuit the output of T1 through R1. The short circuit current then causes K1B to trip and open both poles of K1.

Opening K1 or S1 will cause K2 to open and remove power to T1. Changing position of the Mode Selector Siwtch S100 during operation will open contacts D and cause K2 to open to remove power to T1. Current overload on either pole of K1 will also open K2. In any case power output can only be restored by setting the Voltage Control to zero with K1 closed.

HIGH VOLTAGE CIRCUIT

The voltage applied to the primary of T2 is stepped up then rectified by the half-wave voltage doubler rectifier consisting of capacitor C100, the rectifiers CR100 and CR101 and their protective resistors R100 and R101. The high voltage developed is stored in capacitor C101. Resistor R102 and Meter M101 form a voltmeter multiplier that measures the voltage present on C101. Resistors R104 and R105 standardize and calibrate the voltmeter. Capacitor C102 protects the voltmeter against transients.

The high voltage output from C101 passes through the peak current limiting resistor R102 to one pole of the S101 Impulse switch.

PROOF OPERATION

The Mode Selector switch S100 bypasses S101 which is deenergized in the Proof position so that the output voltage appears on the output cable W100 as a steady state. The return path of the circuit is through the shield of W100, back to capacitor C101.

IMPULSE OPERATION

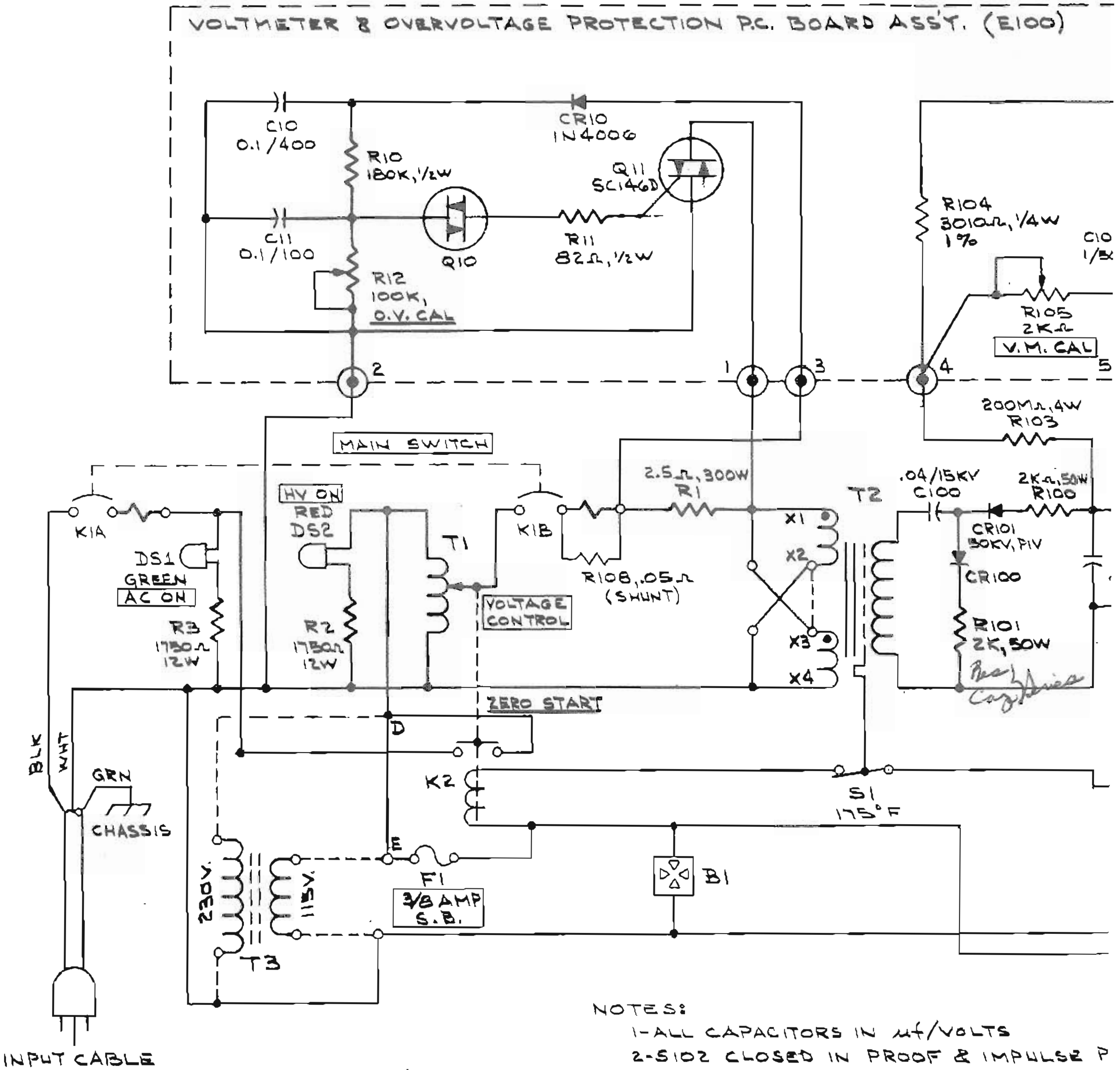
Mode Selector switch S100 does not short circuit S101 so the high voltage output is intermittently connected to the output cable W100.

DISCHARGE

For any mode of operation moving the Mode Selector to the Discharge position will cause control relay K2 to open and remove power to the high voltage circuit. Discharge resistor R106 is now connected across the output cable W100 and across the capacitor C101 by S100 to discharge the entire circuit by drawing limited current. This prevents transient voltage doubling and is considered a safety feature.

GROUND

Moving the Mode Selector to the Ground position short circuits the discharge resistor R106 to place a very low resistance across the entire output circuit. As a safety feature the grounding switch pole is visible in the viewport of the Mode Selector switch.



NOTES:

1- ALL CAPACITORS IN µf/VOLTS

2- S102 CLOSED IN PROOF & IMPULSE P

3- 230 V. MODELS

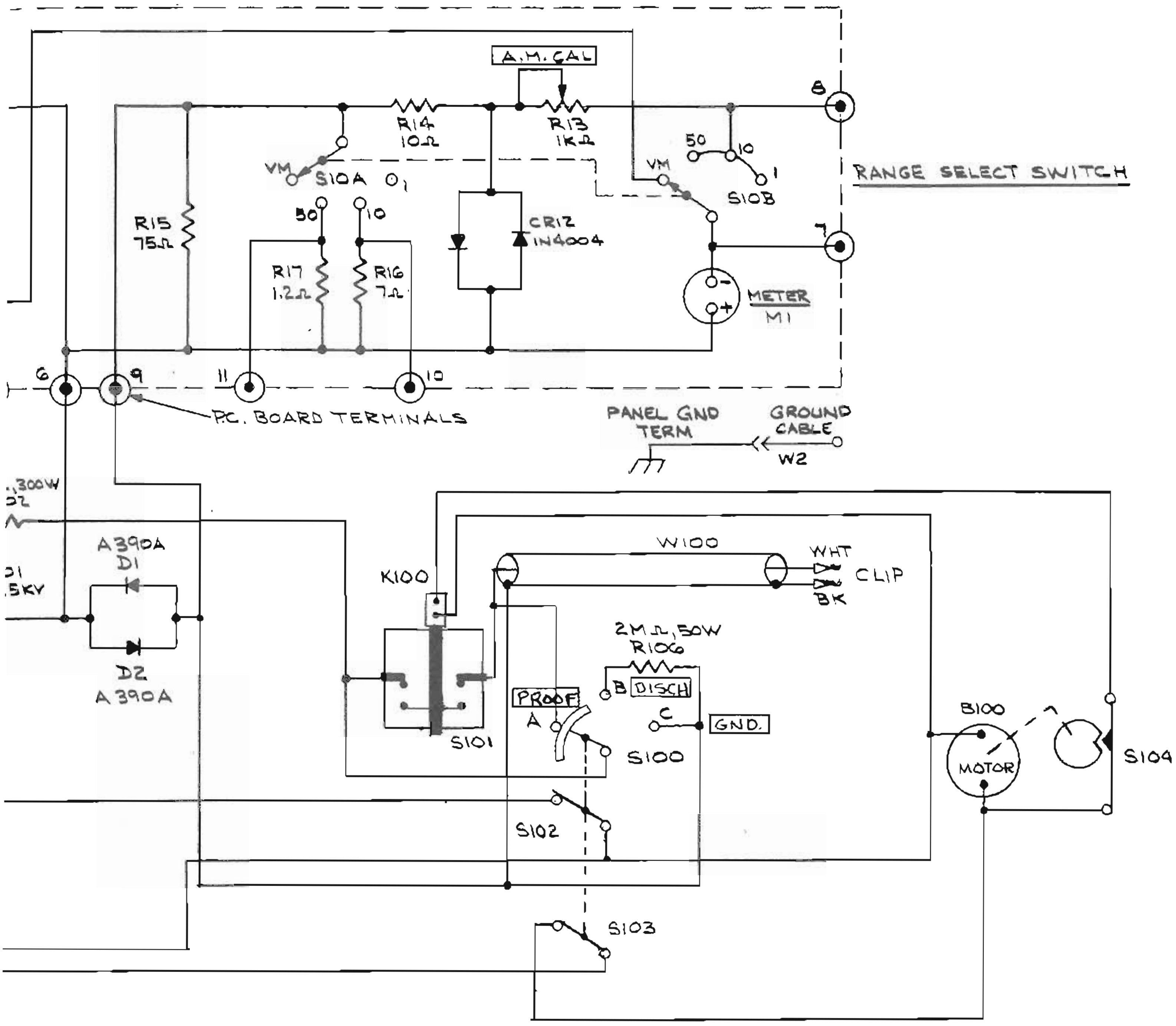
a. ---- LINES.

b. "D" - "E" CONNECTION OMITT

c. T3 INCLUDED.

d. T2, X2 CONNECTED TC

4- S10 & M1 NOT PART OF PC



S100	CONTACT		
	A	B	C
IMPULSE	—	—	—
PROOF	X	—	—
DISCHARGE	X	X	—
GROUND	X	X	X

"—" OPEN
"X" CLOSED

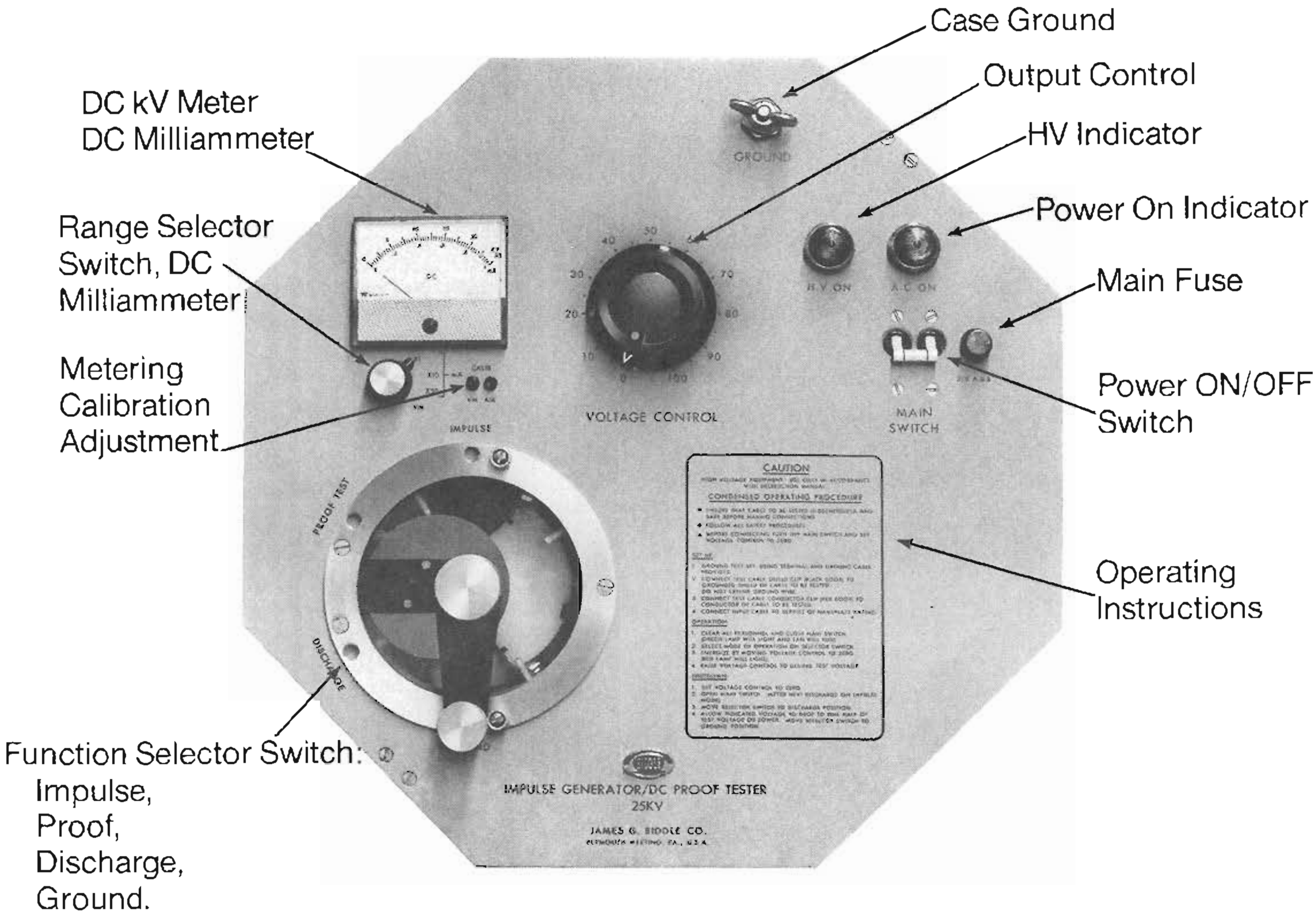
.ITION.

D.

K3 ONLY.

BOARD ASSY.

Figure 1: Cable Fault Locator Schematic Diagram -



Hand Cart, securing straps, and canvas protective cover are supplied with each instrument.

SECTION F

CONTROLS and CONNECTORS

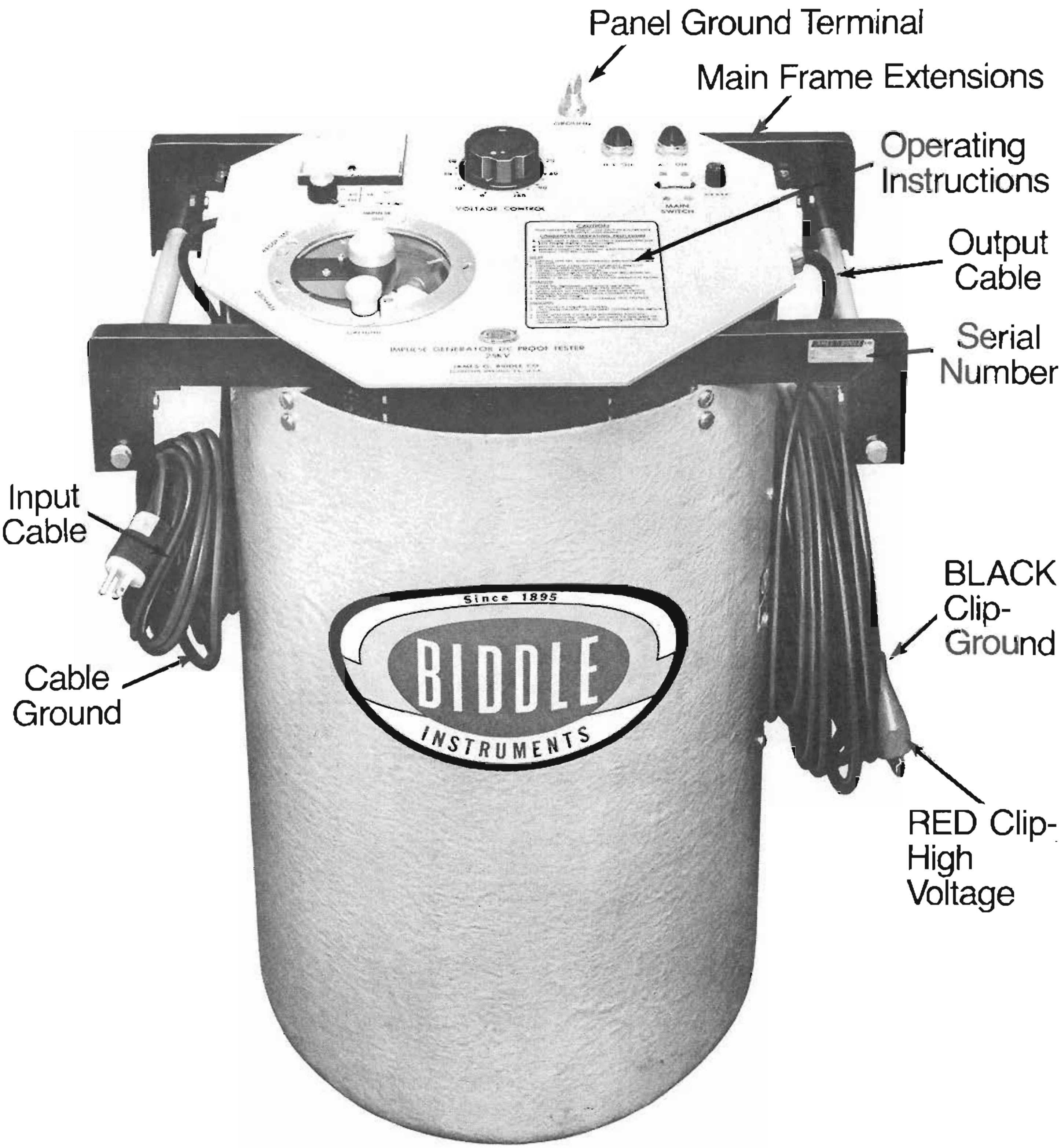


Figure 2: Controls and Connectors.

SECTION G

SETTING UP

The following steps are a general guide for setting up a Cable Fault Locating Test. Figure 3 shows suggested setups. All work must be done in accordance with company safety rules and safety considerations listed in Section B. Refer to Section I and J for operating notes and test theory.

PRELIMINARY:

1. Identify the faulted cable; obtain access to both ends and erect barriers.

2. Choose a location for the Tester that meets the following conditions:

   a. The cable conductor and shield must be accessible. THE CABLE SHIELD MUST BE GROUNDED (IN SOME SPECIAL INSTALLATION THE SHIELD GROUND IS OMITTED. FOR SUCH CASES A TEMPORARY SHIELD GROUND MUST BE PROVIDED.)

   b. An electrical service suitable to operate the Tester must be available within 25 feet of the chosen location.

   c. A reliable station ground must be within reach without adding to the length of the ground cables (i.e., it must be within 25 feet of the tester.)

   d. The Tester must be within 50 feet of the cable end.

   e. The operating area should be as dry as possible.

   f. The operating area must be free of traffic hazard and allow the operator free access to all controls.

CONNECTIONS:

1. Connect the Tester panel Ground to a reliable local ground.

2. IMPORTANT: CONNECT THE H.V. OUTPUT CABLE SHIELD (BLACK CLIP LEAD) TO THE SHIELD OR CONCENTRIC NEUTRAL OF THE CABLE UNDER TEST. DO NOT EXTEND THIS LEAD.

3. THE BIDDLE CO. RECOMMENDS THAT AS A SAFETY PRECAUTION AN OHMMETER CHECK BE MADE BETWEEN THE SHIELD OF THE CABLE UNDER TEST AND THE TESTER PANEL WITH THE TESTER MODE SELECTOR IN THE PROOF POSITION. IF THE RESISTANCE MEASURED EXCEEDS 50 OHMS RECHECK AND CORRECT ALL GROUND CONNECTIONS. IF ACCEPTABLE, RETURN THE MODE SELECTOR TO THE GROUND POSITION.

4. Connect the H.V. output cable center conductor to the faulted conductor of the cable under test making a firm, low-resistance connection. Be sure that the exposed conductor and clamp are sufficiently insulated to withstand the test voltage. Provide a minimum of two inches of direct air path.

5. Connect any other conductors of the cable under test to the cable shield making firm, short connections.

6. Remove any ground bonds; be sure that the power supply is OFF, that the Manual Ground switch is OPEN, and the Voltage Selector switch is set to ZERO.

7. Connect the power supply to the power source.

When these steps have been performed, the test may be conducted in accordance with the procedure given in Section H.

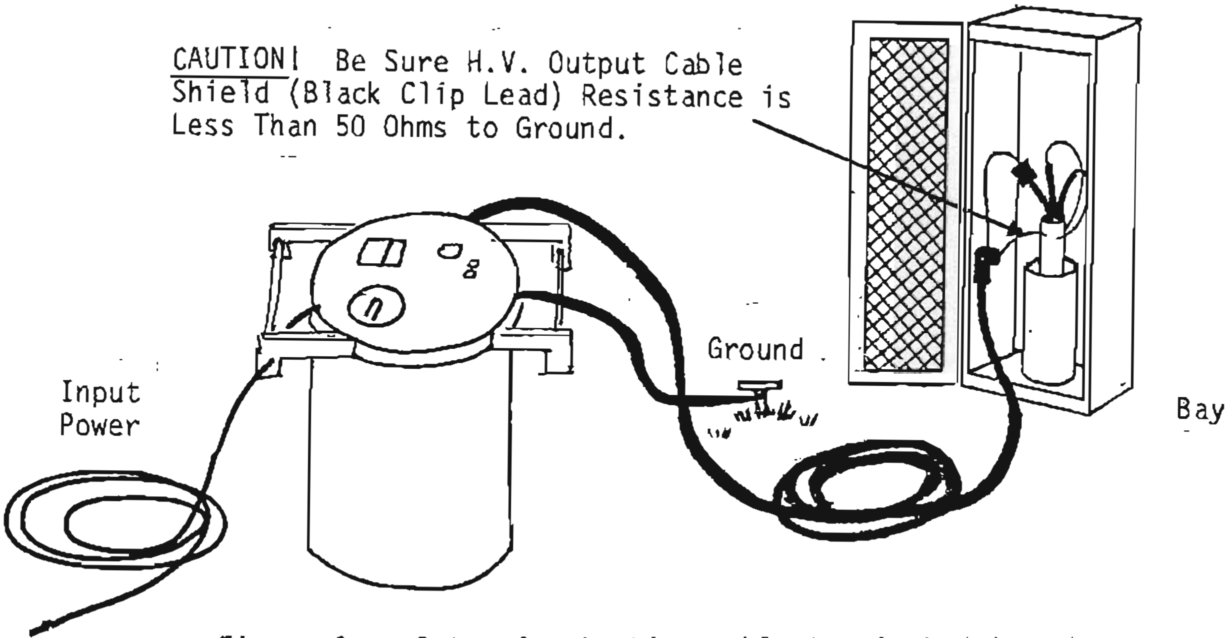


Figure 3a: Setup for testing cable terminated in a bay.

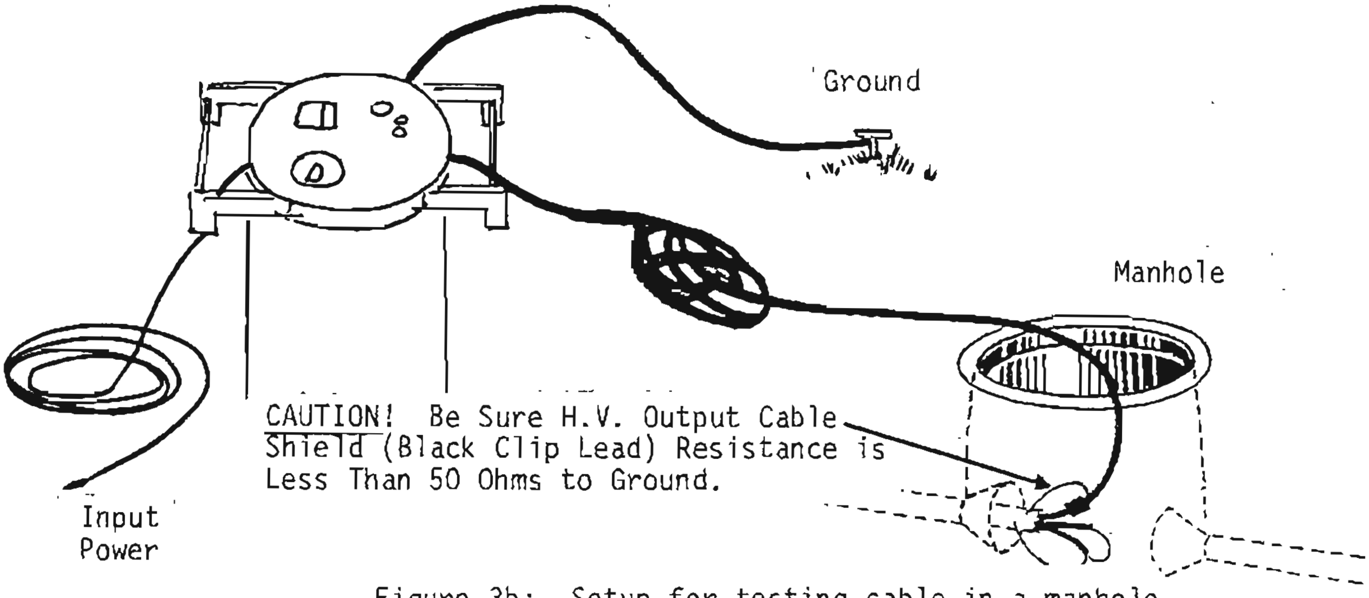


Figure 3b: Setup for testing cable in a manhole.

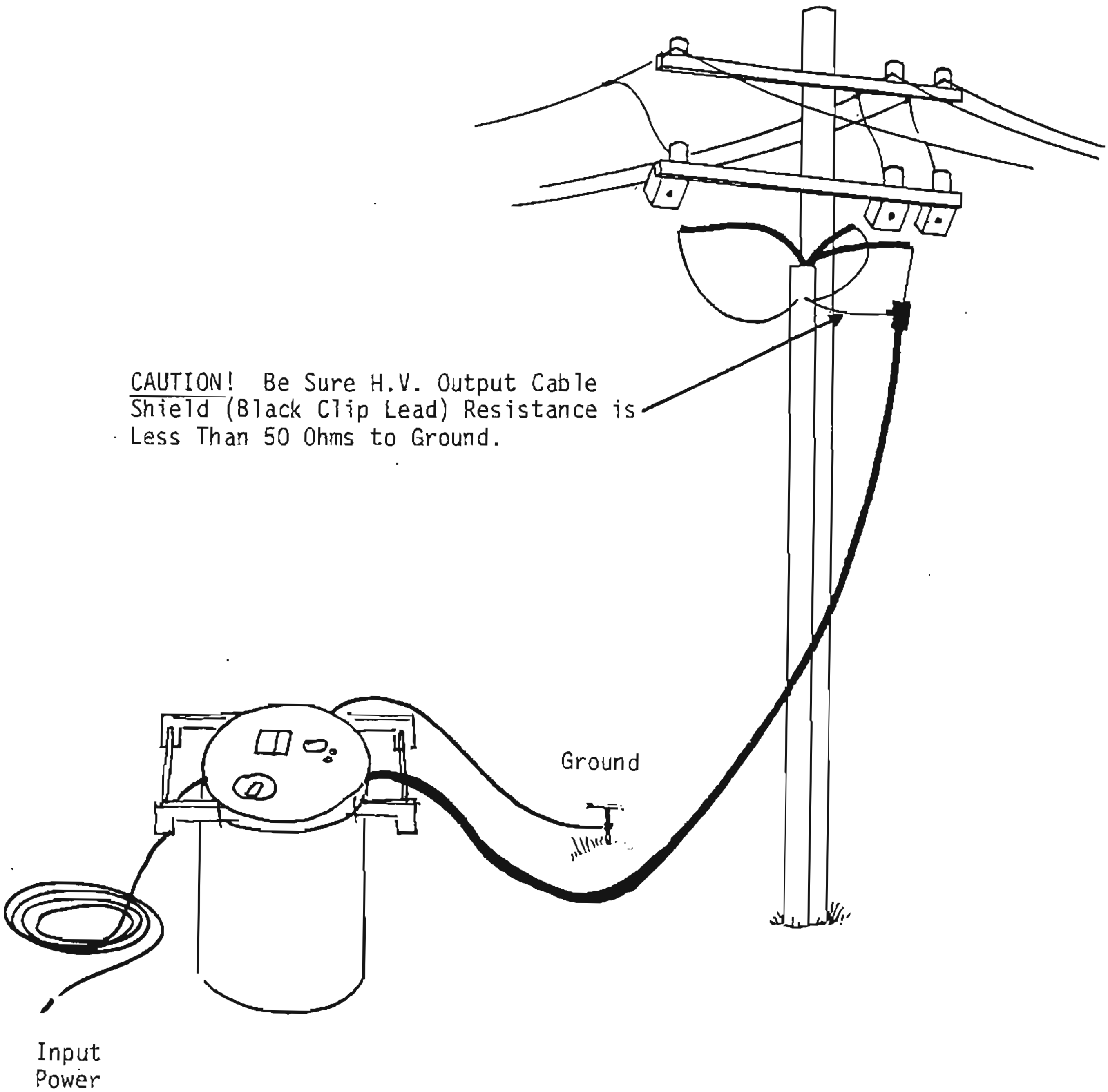


Figure 3c: Setup for testing cable terminated on a pole.

SECTION H

OPERATING PROCEDURE

- HIGH VOLTAGE EQUIPMENT
- SAFETY IS THE RESPONSIBILITY OF THE OPERATOR.
- EQUIPMENT TO BE TESTED MUST BE DEENERGIZED.
- PERSONNEL MUST BE KEPT CLEAR OF TEST SETUP.
- FOLLOW SET UP PROCEDURE PER SECTION G.

Impulse Operation

The usual objective of this test is to establish an arc-over or high current through the cable fault. The current is a pulse that is regularly repeated and each pulse will be of the same magnitude.

1. Set Function Selector to Impulse.

2. Close Main Switch ~~(circuit breaker)~~: AC ON lamp lights.

   2.1 GREEN ON lamp lights and fan will run.

3. Move Voltage Control firmly to zero.

   3.1 RED HV lamp comes on

4. Increase Voltage Control.

   4.1 The voltmeter will slowly rise to a maximum set by the Voltage Control.
   4.2 If the fault is breaking down the voltmeter will suddenly drop toward zero once every 6 seconds, then the voltmeter rise will be repeated.
   4.3 If the fault does not break down the voltmeter drop will not exist or be very small.
   4.4 The maximum voltmeter reading is the peak voltage in use.

5. To stop the test move the Voltage Control to zero.

6. Immediately after a discharge open the Main switch.

7. Move Selector switch to Discharge position.

8. Allow indicated voltage to drop to one half of test voltage or lower. Move Selector switch to Ground position.

Proof or Burn Operation

The purpose of a Proof test is to determine if the cable under test can support a high voltage.

The purpose of the Burn operation is to reduce the resistance of a fault or to lower the voltage required to arc-over a gap-type fault so the Impulse Mode will be effective.

1. Set the Function Selector to Proof.

2. Close the Main switch.

   2.1 GREEN ON lamp lights and fan will run.

3. Move the Voltage Control firmly to zero. HV ON indicator becomes red.

   3.1 RED HV ON lamp lights.

4. Increase the voltage as required.

5. Sustain the test voltage for the time required.

   a. If the voltage falls to zero the cable has failed.

   b. A sample current reading may be made by rotating the Range Selector switch to either the X50, X10 or X1 position. If the current is very high and voltage very low then a BURN condition may very well exist.

6. To perform a BURN test continue the preceeding tests advancing the Voltage Control to maintain the applied voltage and/or current.

   a. As the localized heating at the fault reduces the resistance the Voltage Control is adjusted to maintain the BURN condition. A maximum of 50mA burn current is allowed at which time the voltage will be essentially zero. The fault at this time should be approaching a short circuit condition and may very well be located now using the IMPULSE method.

7. To stop the test move the Voltage Control to zero.

8. Open the Main Switch.

9. Move Selector switch to Discharge position.

10. Allow indicated voltage to drop to one-half of test voltage or lower. Move selector to Ground position.

When testing has been completed for any mode of operation first disconnect the Tester from the service outlet, remove the test lead from the conductor under test and place a short circuiting jumper between the conductor that was tested and the shield of the cable under test. Remove the test lead shield connection. The short circuit jumper should remain in place across the cable that was tested until further access is required. Finally, remove the Tester case ground connection.

A condensed version of the foregoing procedure appears on the Tester Instruction Card.

To change modes of operation during a test, it is necessary to follow the normal shutdown and start-up procedures again.

SECTION I

OPERATION NOTES

When impulsing into a faulted cable, the operator must be sure that an adequate signal is being generated. The amount of energy being passed into the cable under test is a guide to the available signal. Although the signal is normally proportional to the energy in use, the type of cable being tested, its installation, and the nature of the fault may all influence the proportionality factor.

The energy available from the Tester is related to the Joule energy number for the voltage in use. (See Sections D and J). The cable under test and the nature of the fault limit the energy taken from this available energy. The strongest signal for any given voltage is obtained when all the available energy is passed through the fault.

To estimate the energy transferred from the set to the cable under test use the voltmeter as follows: Just after the discharge, the voltmeter will dip toward zero. The lower the pointer dips toward zero the higher the energy transfer is to the cable under test. The voltmeter indication will be steady for no effective energy transfer. If no fault exists in a cable subjected to test or if the fault does not arc over, the cable becomes charged to the test voltage after several Impulse switch closures. The voltmeter responds by first showing complete energy transfer; then on successive switch closures, less and less energy transfer.

To ensure strong working signals the usual practice is to first determine at what voltage the voltmeter dip is noted, then increase the setting of the voltage vontrol to give a voltmeter dip as low as practical without exceeding the peak voltage rating that applies to the cable under test. The objective is to ensure a maximum energy transfer that is consistent before actually starting the tracing operation.

NOTE: If the actual fault in the cable arcs over, acoustic noise is generated and can be detected audibly or with a Biddle Acoustic Detector. Both arcing and non-arcing faults can be detected electromagnetically using a Biddle Ballistic Detector. For additional details, see the instruction manual of the detector in use.

Operation with a Ballistic Detector

Common cable construction consists of three conductors bundled in a shield and directly buried or installed in a conduit or duct. In such construction, a ground bond is usually applied at every manhole. For cables of this type, the Ballistic Detector is most effective. Because the conductors are not concentric with respect to the shield, an external magnetic field exists around the cable and the Ballistic Detector may respond to this field or to the ground current between bonds. (See the instruction manual of the Ballistic detector for additional details).

When using the Ballistic Detector, it is suggested that the pickup coil be applied to the cable at a point close to the Tester prior to patrolling the cable. The pickup should be applied to sense the current in the shield extension cable or at the first bond. This will confirm an established signal and thereby check the detector prior to the test.

Cable Test Set Voltage Limits

For some installations the available 25kV impulse may be considered too great to apply to a cable. When such a limit exists, the operator must be cautioned not to exceed the selected voltage limit. The tendency is to use the maximum voltage; but impressing excessive energy on a fault (especially in polyethylene cable) may result in clearing the carbon or conducting bridge of the fault so that it will no longer arc over. Experience will dictate the test practice.

Proof Testing (Proof Mode)

Prior to actually locating a fault or after repairs are made, it is common practice to test the cable by applying a voltage as proof that the conductor is faulted or that the conductor will support voltage. To perform such tests operate the Tester in the Proof mode. This permits applying the test potential as indicated by the voltmeter, and at the same time, measurement of the sample current by rotating the range select switch to the appropriate current range.

Burn Operation

This operation is performed when using the Proof Test mode.

For faults having significant leakage resistance apply voltage and allow the resultant leakage current through the fault resistance to produce heat at the fault. The heat will, in most cases, cause the fault resistance to lower and thus further increase the current. This eventually leads to thermal runaway and burns the fault until the resistance is low enough to effectively capacity-discharge fault locate.

To burn the fault it is only necessary to wait after advancing the Voltage Control to either the limit, or to any limit imposed by the cable under test. As the fault resistance decreases the voltmeter reading will decrease (for a fixed Voltage Control setting). When the fault resistance decreases to a low value the voltmeter will read essentially zero.

Discharge of Cable

When a cable becomes charged, either because the fault has failed to arc over or because it has been subjected to a proof test, it must be discharged before being handled.

Turning OFF the Tester will not remove this stored energy. Setting the mode switch to Discharge connects a discharge resistor across the cable and Tester output to reduce the voltage slowly. This is a safety feature designed to protect the cable since a sudden discharge will start a traveling wave. When such a wave reaches an open terminal, the voltage tends to double by reflection, and such overvoltage may damage a good cable or the equipment to which it is connected.

The state of discharge of the cable is indicated by the voltmeter when the indicated voltage is less than 5kV. The Manual Ground switch can safely be closed. As an additional safety feature, the position of the Manual Ground switch is visible through the viewport.

The Cat. No. 658000 Accessory

The combination of the Cat. 651027-1 Tester and the Cat. No. 658000 accessory form an Interturn Test System. The purpose of this system is to make comparison tests on coils that form the windings of motors and generators. The comparison tests are intended to determine if there are short-circuited turns within a coil.

The principle is to impulse a standard coil and observe its ringing frequency and the damping of the wave train. A shorted turn will result in a higher ringing frequency and increased damping. The Cat. No. 651027-1 is used in the Impulse Mode to develop the voltage waveform required to shock-excite the system. The Accessory Cat. No. 658000 provides a controlled voltage rise time and an isolated output voltage divider so the waveform can be either observed on an oscilloscope for frequency and damping or alternatively the voltage divider output can be evaluated by a Cat. No. 651500 Analog Meter that measures the frequency.

For additional data, see the Instruction Manual for the Cat. Nos. 658000 and 651500 instruments.

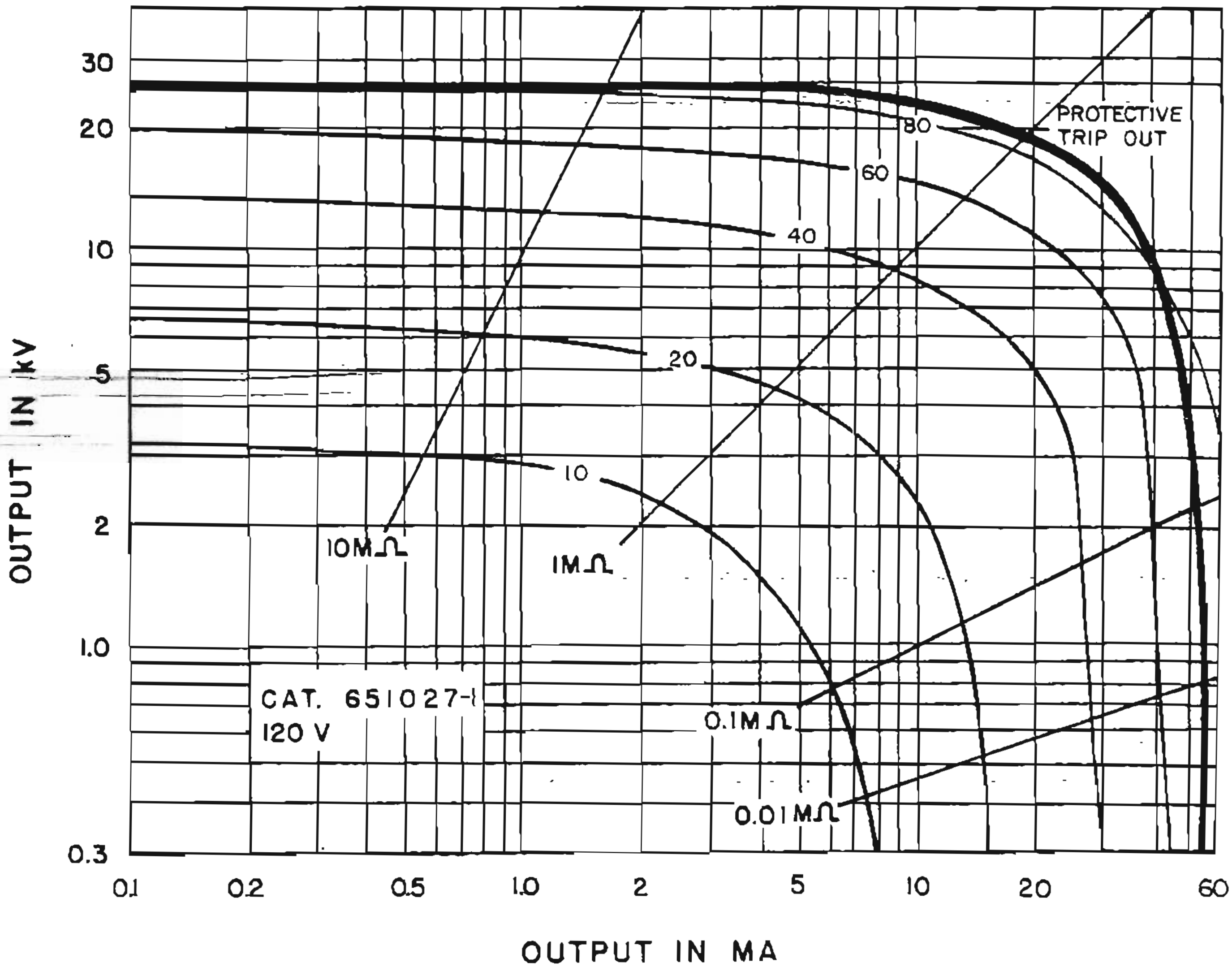


Figure 4: Regulation Curves.

SECTION J

APPLICATION NOTES

THEORY

All faults can be represented electrically by a gap shunted by a resistance, as illustrated below in Figure 5.

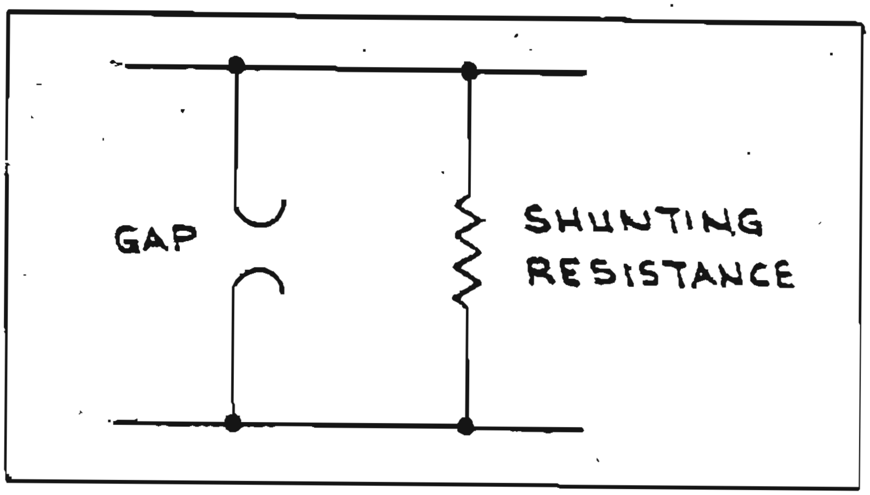


FIGURE 5. A TYPICAL FAULT

The electrical circuit shown in Figure 5 is simple but variations in the conditions of the two paths cover an extremely wide range, the resistance ranging from a dead short to megohms, and the gap breakdown voltage varying from a few to thousands of volts.

When the impulse voltage wave reaches the fault (See Figure 5), it may dissipate itself either through the resistance path or by arcing over the gap. In either event, it liberates its energy to the return path, thereby providing a current that can be detected. If the cable is exposed, faults can usually be located by the sound of the arc discharge or by the flash itself. For more difficult cases where the cable is buried or the sheath intact, either a Ballistic or acoustic detector should be used. (See Page A1) If the energy passes through only the resistance path, no arc will result; therefore, an Ballistic detector <u>must</u> be used. If the resitance of the fault is very high and the voltage of the wave is sufficient, the gap will arc over, in which case either an Ballistic or acoustic detector may be used. Even if the resistance of the fault is infinitely high, the fault can be located by the impulse method provided that the peak value and time duration of the voltage wave are sufficient to cause arc-over. It is for this reason that the impulse method is so generally applicable.

Basically, arc-over is determined by three factors: the nature of the fault (including the characteristic parameters of the cable), the magnitude, and the duration of the voltage wave, the latter determined by the microfarad rating of the Tester.

The breakdown characteristics of faults and the impulse wave of the Tester in use can be plotted in relationship to time and voltage. If these two curves intersect as illustrated in Figures 6 and 7, the fault will arc over.

Tester Rating

Previously, the conditions necessary for fault breakdown were established in terms of capacitance, voltage and time. Mathematically, the relationship is defined by the stored energy as follows:

$$W_c = \frac{E^2C}{2}$$

where W_c is in watt-seconds (joules),

E is the voltage in kV on C at the time of impulse,

C is the capacitance value in μF.

To achieve a given rating the Tester dc power supply joule output must be $W_p = E^2C$ because in either charging or discharging a capacitor the circuit resistance dissipates an amount of energy equal to the stored energy regardless of the value of the resistance. The power supply output W_R in wattseconds is related to the output wattage W_{go} by the following equation:

$$W_{go} = \frac{W_p}{T} = \frac{E^2C}{T}$$

The term T is the required number of seconds to charge C to the Voltage E. Typically T has a minimum value of 3 seconds since for shorter times the required test set wattage increases with little benefit to the fault locating operation. The time T typically has a maximum value of 15 seconds since for longer times fault locating is rather slow and the operator tends to become distracted between impulses.

For a given stored energy the shorter the time T the greater the size and weight and cost of the power supply. Longer values of T trade off the size, weight and cost of the power supply against a longer time to find the fault.

Impulse Ratings

When the Impulse switch closes and connects the charged capacitor across the cable under test all the stored energy is transferred from the capacitor. The circuit resistance must ultimately dissipate the joule energy equal to the stored energy.

If the cable is extremely long or terminated in its surge impedance the major discharge circuit impedance is a pure resistance with typical values between 15 and 50 ohms for power cable. In cables that are of finite length and not terminated, the cable surge impedance is a resistance that limits the initial current. Later in time the voltage wave (or current wave) is reflected by the impedance discontinuity and reaches the Tester. Now the surge impedance becomes a time variant complex impedance.

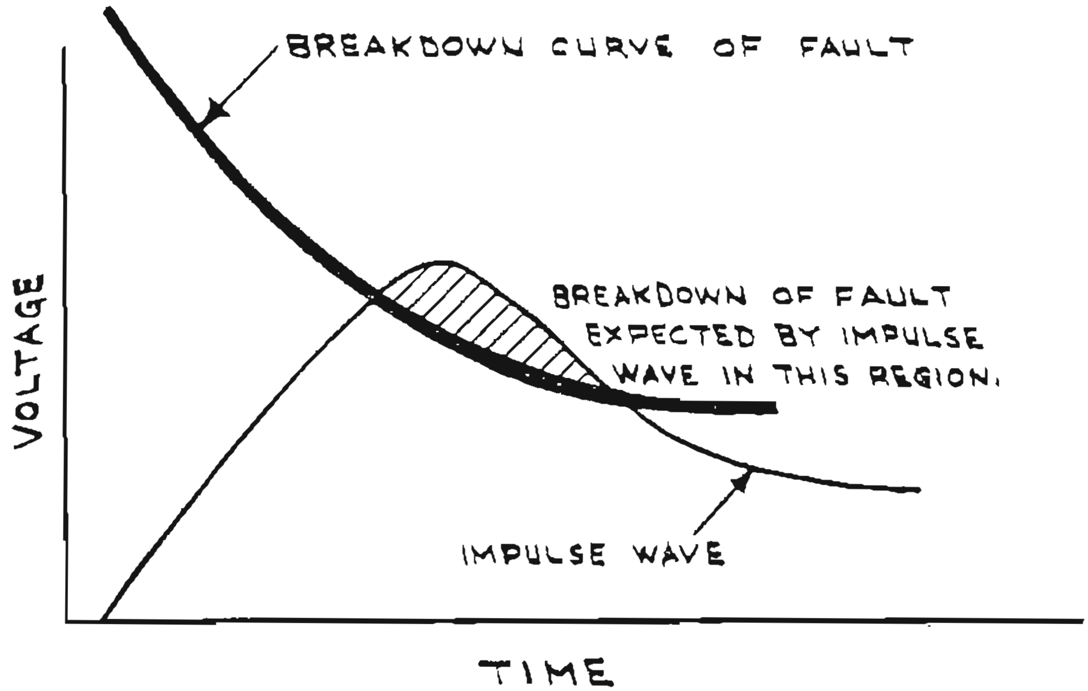


Figure 6: Time-voltage Relationship for Fault Breakdown.

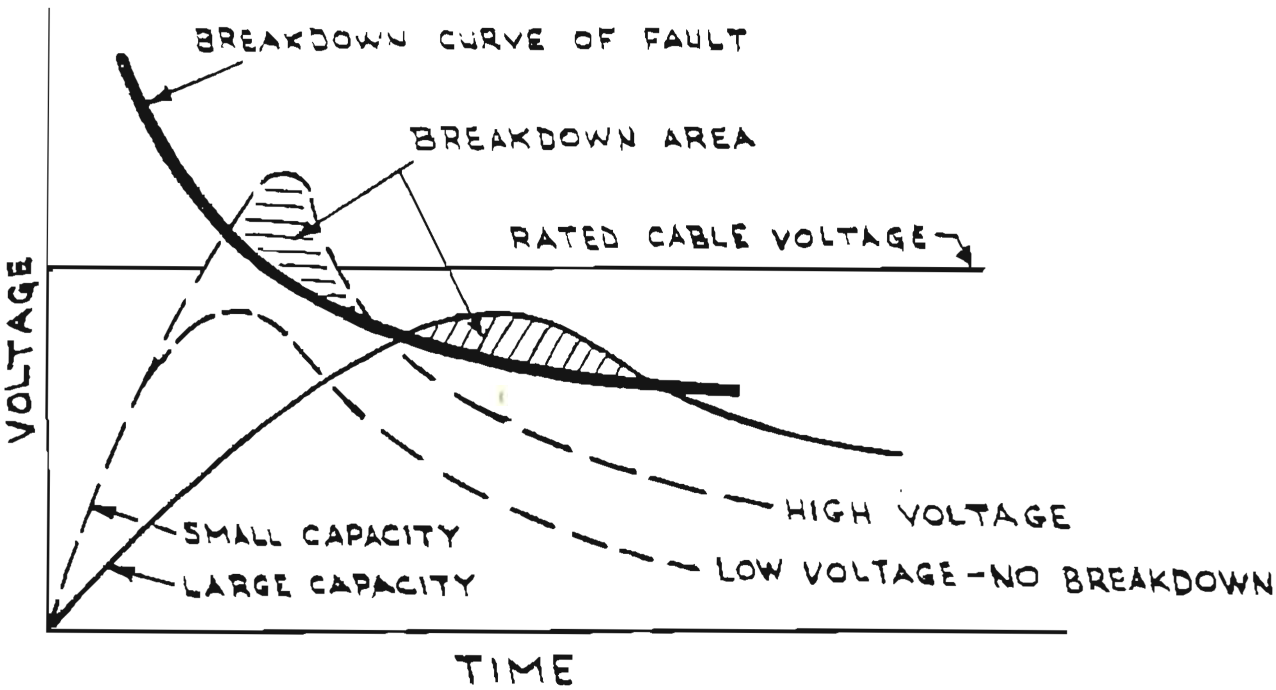


Figure 7: Influence of Capacitance on Fault Breakdown.

All practical capacitors have a peak discharge current limit beyond which the capacitor will be damaged. When reflections are present the time variant impedance at the driving point can become a value very close to zero so the capacitive current can exceed the peak limit. To avoid this situation a series limiting resistor is placed in the discharge circuit. This resistor typically has a value on the order of 1 ohm and so dissipates only a small fraction of the stored energy. For example, a 1-ohm series resistor and a 15-ohm surge impedance cable will result in about 15/16 of the total stored energy being dissipated in the surge impedance and 1/16 of the total stored energy being dissipated in the limiting resistor.

The use of the limiting resistor results in the following benefits:

A. The capacitors will not be damaged by peak current.

B. The voltage distribution will be such that a small and limited portion of the voltage can be developed between the surge ground and the case ground. This is an important safety feature.

C. The rate of voltage rise on the cable under test is limited so that the impulse wave crest is propogated along the cable with less attenuation. This permits breaking down faults at a greater distance from the Tester.

D. The Impulse voltage waveform tail is maintained at a higher voltage for a longer time. This tail stretching also assists in causing breakdown of the fault gap with a lower peak voltage.

Additional Factors during Discharge

The electrodes of the impulse forming switch must be separated sufficiently to permit the capacitor to charge up to voltage. As the switch closes the contacts approach and for voltage above a few hundred volts an arc will form before the contacts actually touch. It is almost impossible to mechanically close the contacts and maintain them in physical contact before the arc transfers most of the energy. The contact arc voltage is relatively constant at a few hundred volts but the arc current can be large, therefore the contact arc has a relatively low resistance and so dissipates a very small fraction of the stored energy.

When there are reflections in the cable during discharge the arc current in the contacts can be forced to zero so the arc extinguishes. The switch contacts must now close further in order for the arc to form again. In effect the stored energy is transfered by a series of pulses, each pulse being only a fraction of the initial stored energy. Thus the presence of multiple reflections tends to result in an oscillatory wave that transfers the stored energy by a series of small pulses. This reduces the crest voltage and reduces the time the voltage exceeds the fault breakdown level and so decreases the ability to locate the fault. The series limiting resistor dampens circuit oscillations and in part counteracts the loss due to circuit oscillation.

The foregoing brief discussion is a basic introduction to the capacitor discharge impulse method of cable fault locating. For the convenience of the user the following references are included so that maximum benefit can be made of this equipment:

"Power-Cable Fault Locating by High-Voltage Pulse-Tracing Method"
Biddle Technical Publication 65-T-5

"Safety Aspects of High Voltage Power Line Fault Locating Technique"
Biddle Technical Publication 65-T-4

"A New Digital Cable Fault Location Technique"
Biddle Technical Publication 65-T-3

Biddle Technical School Course entitled "CABLE FAULT LOCATION"

"Rome Cable UD Technical Manual" Third Edition, Page 112

The capacitor cable fault locating method has been in use for at least 25 years and there is a significant amount of literature available. The cited references are a random sampling of this literature and are not in any special order. Many contain bibliographies for additional reference.

SECTION K

ROUTINE MAINTENANCE

The Tester components are constructed to withstand use normally encountered in field testing for public utilities and industrial plants. To maintain this equipment in proper condition, a planned program of routine maintenance for all major components should be carried out every six months.

WARNING

> This is a high-voltage system which can produce and contain dangerous voltages. Any service or repair of this equipment should be performed only by qualified persons who are aware of high-voltage hazards and the necessary precautions that must be taken to prevent injury.

Before any inspection, service, or repair of the Tester, it must be completely disconnected from the power supply and from any cables under test. The Manual Ground must be closed and must remain closed for at least fifteen minutes before access is gained to the interior of the Tester (See Section L.) As a safety precaution, once access to the interior is gained and before any other action is taken, a ground bond should be placed across the capacitor bank and across the ac coupling capacitor.

If company policy requires that a defect report be provided to those performing maintenance, this report should be consulted prior to examining the Tester and the items noted on the report should be investigated at the appropriate point in the maintenance procedure.

The inspection and maintenance of the Tester should be carried out in accordance with the steps listed below.

Maintenance Procedure

1. Examine all cables to locate any loose or damaged terminals.
2. Inspect and clean the outer jacket of the output cable; check for breaks in this jacket.

   NOTE: As a temporary repair, apply at least four layers of vinyl tape over any such damage.
3. Check the action of all controls to be sure they operate freely.
4. Check the entire case for damage and wipe it clean.
5. Remove the set from the case. (Apply a bond across the capacitor bank).

6. Check to see that all screws and nuts are tight.

7. Examine all electrical connections; check for evidence of corrosion or fracture.

8. Check the operation of the Manual Ground position of the Mode Selector to be sure that it short-circuits the output.

9. Check the discharge position of the Mode Selector to be sure that it connects the discharge resistor across the output.

10. Clean all bushings and electrical insulating supports with a clean soft cloth. Do not use solvents. Clean, low-pressure air may be used.

11. As the cleaning proceeds, inspect all resistor banks for burned sections or loose end bonds. Check the capacitors for oil leaks or evidence of case swelling.

12. Examine the exterior of the Impulse Switch for loose screws, nuts, roll pins, etc. and tighten as necessary.

    NOTE: Do not oil the motor or any of the shaft bearings.

13. If damage or wear to any of the components of the switch seems to warrant further repair, see Sections Land M prior to proceeding.

14. Remove bond from capacitor bank. Reinstall the set in the case; coil the output cable around the cleats; open the Manual Ground; and place the output cable shield clamp so that it is well insulated from ground.

15. Measure the path between the output cable shield clamp and the chassis ground terminal with an ohmmeter (not over 500V). This path should measure in excess of five megohms. If it does not, see Section L.

16. When work on the Tester has been completed, run the Tester in accordance with the procedure given in Section M.

SECTION L

TROUBLESHOOTING AND REPAIR

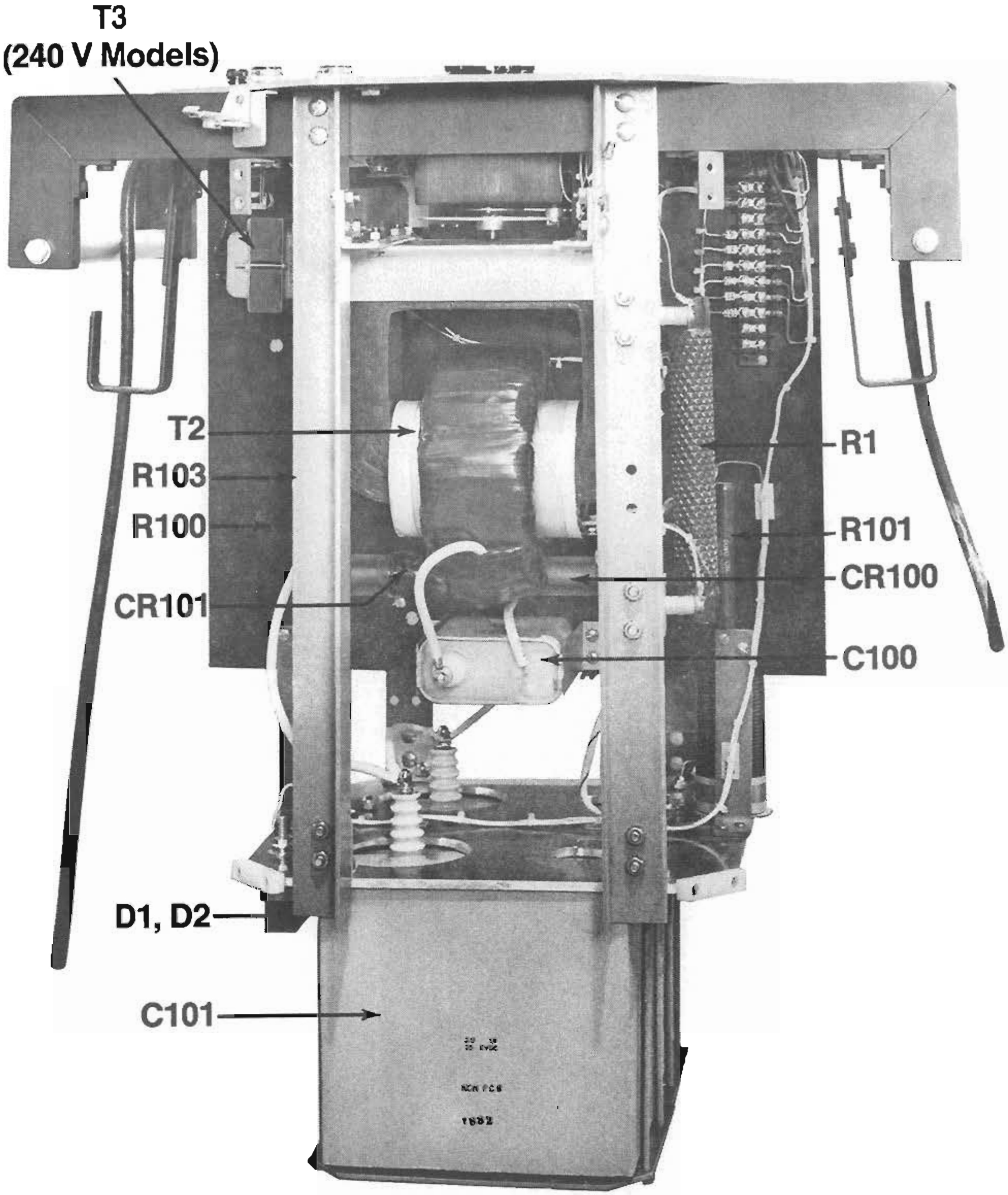
The James G. Biddle Co. maintains a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. The instrument will be cleaned and excessively worn or damaged parts replaced. Following repair, the instrument will perform functionally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

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

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

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

If the Tester fails to operate properly, the information given in this section will be useful in determining the cause of the malfunction. Table III included at the end of this section notes possible equipment malfunctions that may be observed during operation or checkout and suggests possible causes and means of determining the defective component. The James G. Biddle Co. recommends that field repairs by made by replacing assemblies. The schematic diagram in Section E and the interior views of the Tester given in Figure 8 will be helpful in locating components. When ordering parts, always include the Tester serial number. The location of the serial number is shown on Figure 2 (see Section F).


T3
(240 V Models)
T2
R103
R100
CR101
R1
R101
CR100
C100
D1, D2
C101

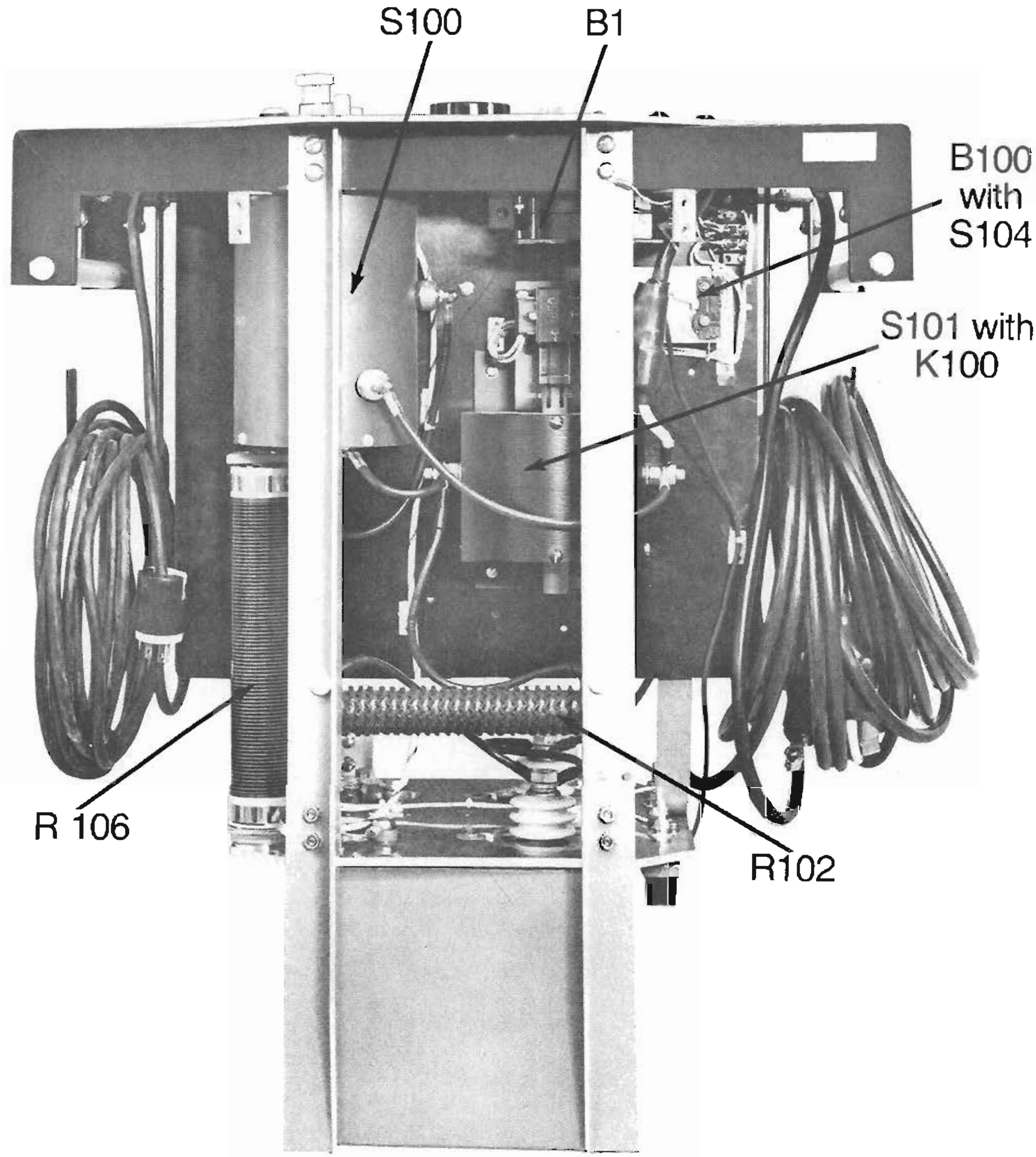


Figure 8: Interior Views of the Test Set.

CAUTION!

THIS IS HIGH VOLTAGE EQUIPMENT AND MAY CONTAIN DANGEROUS VOLTAGES. REPAIRS MUST ONLY BE MADE OR PERFORMED BY PERSONS AWARE OF SUCH HAZARDS AND FAMILIAR WITH ROUTINE PRECAUTIONS REQUIRED TO PREVENT INJURY.

Prior to gaining access, the set must be completely disconnected and the Manual Ground must be in the Ground position for at least 15 minutes. Any trouble reports submitted should be reviewed prior to work done under this section. The table does not list wiring or hardware defects since these are always possible defects and must be considered in every case.

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

The following items are located on the panel and can be replaced without tools or disassembly:

A. Fuse F1
B. Green Lamp DS1
C. Red Lamp DS2
D. Ground Cable W2
E. Voltage Control Knob

All other components require access to the interior.

1. Removal of the Tester from case.

It is possible to lift the set vertically out of the case but an alternative procedure is described. Provide two blocks such as two 15" long 2 x 4's. Set these up to span the main frame extensions on a firm bench or floor.

1.1 Invert the Tester so that it rests face down with the panel between the blocks; each block spanning a main frame extension.

1.2 Locate, remove and save the eight screws attaching the case to the set.

1.3 Lift the case off the Tester. Note the orientation of case slots with respect to cables, etc.

1.4 Invert the Tester so that it rests on the capacitors:

1.5 Reinstallation is the reverse of the above procedure.

2. Servicing the Rotary Impulse Switch S101

2.1 Removal

2.1.1 Disconnect all leads from switch, then remove the four mounting screws located on the backplate of the switch. The switch will now slide out the side of the unit.

2.2 Inspection

2.2.1 To inspect the inside of the switch, it is only necessary to remove the four screws holding the bottom plate which simply drops out of the cylinder.

2.3 Component Replacement

2.3.1 To replace the shaft or the moveable arm, it is necessary to remove the groove pin that holds the shaft to the armature of the solenoid. Use care when removing the pin so as not to tear the shaft body. The contact assembly can now be removed and the defective shaft or moveable arm be replaced. Reassemble.

2.3.2 To replace the stationary contacts (which should be replaced in pairs), simply loosen the outside nuts and tap lightly on stud to loosen the contact body. Remove and replace.

2.3.3 To replace the solenoid the groove pin holding the shaft to the armature of the solenoid must be removed. Remove the four screws holding the solenoid body; reverse this procedure for reassembly.

2.4 Adjustment

2.4.1 Readjustment of the switch is usually necessary when any component is replaced or if the tester fails to impulse at low voltage. This is done by loosening the four screws holding the solenoid just enough to allow it to slide up and down. Connect an ohmmeter across the stationary contacts and insert a 3/32" shim between the solenoid body and armature. Slide up the solenoid, shim and armature combination until the meter indicates. Tighten the four screws and recheck for meter indication. Remove shim, reinstall switch.

Replacement of the following items requires only the use of hand tools and ordinary mechanical aptitude:

1. C101. Tighten clamps until they feel secure.
2. C100
3. R100, R101
4. CR100, CR101. Carefully observe polarity.
5. R1
6. R102
7. R103
8. R107
9. R106

Replacement of Output Cable W100

Locate the cable and disconnect it from the circuit, carefully noting the points of attachment and lead dress. Locate the gland on the panel that secures the output cable to the Test Set. Loosen the clinch nut securing the gland to the slotted bracket. Run the nut of the gland threads so it is free on the cable, pull the cable and gland free of the bracket until the cable can slide through the bracket slot. Replacement is the reverse of the disassembly procedure.

Replacement of Input Cable W1

Locate W1 and remove the three wires from the terminal block; note the location of connections for later replacement. Locate the bracket fastening the cable gland to the top panel. Remove the clinch nut securing the gland to the bracket and withdraw the gland and cable from the Tester. Loosen the gland cable nut and after noting the position of the gland with respect to the cable end remove the gland and clamp nut from the cable. Note the sequence of assembly. Install the gland on the new cable in the same position it had occupied on the original and tighten the gland to the cable. Install the gland in the panel bracket. Install and tighten the nut and reconnect the leads to the terminal strip.

To replace any components not previously cited requires that the top panel be removed from the Tester.

Removal of Top Panel

a. Locate the output cable and remove the gland from the panel bracket as described under replacement of output cable.

b. Locate the terminal block and disconnect all the terminals on the outer side. Carefully note the location of each lead as removed for later replacement.

c. Remove all the leads from the Function Selector switch S100. The heavy white/green lead is best removed by disconnecting it from the bottom plate that supports the capacitor bank.

d. Remove the gland bracket of the output cable from the panel.

e. Locate and remove the four screws that secure the vertical panel to the top panel.

f. Locate and remove the eight screws that secure the four vertical numbers to the cross numbers that form the handles.

g. Gently lift the top panels from the Tester using the Tester handles as the lifting point.

The steps on the previous page disconnect the top panel from the Tester so it can be set apart for replacement of panel mounted parts or for access to the following main chassis parts:

1. High Voltage Transformer T2.

2. Fan B1.

3. B100; drive motor for S101.

Reversal of the procedure A through G are used to reassembly the Tester.

Replacement of B100

a. Disconnect all leads from B100, making a mental note or rough sketch where they belong, then remove the three screws holding it to the partition board.

b. If S104 (part of B100 assembly) is found to be defective, then only the switch needs to be replaced. This is done by simply removing the two nuts, replacing the switch and reinstalling B100.

Replacement of B1

Disconnect the two leads from the terminals of B1.

Locate the four screws that secure B1 to the bracket and remove the fan from the assembly.

When installing the new fan note that the axial arrow on the terminal block points down, then reverse the above steps for reassembly.

Replacement of High Voltage Transformer T2

First locate S1 and remove the two screws that secure it to the bracket.

Now locate the high voltage output lead and remove from C100.

Locate the remaining lead of the high voltage coil and cut the harness ties (careful not to cut other wires) and disconnect from R101.

Now open the harness for the two groups of primary leads and disconnect them from the circuit.

Facing the transformer, remove the right hand vertical frame member.

Locate the four screws that secure T2 flanges to the cross members. Remove these and withdraw T2 from the Tester.
Replacement is the reversal of the above procedure.

Replacement of Components of Top Panel (See Figure 10)

It is recommended that the printed circuit board P/N 15449 be replaced as a unit. To replace the printed circuit board first remove the nuts securing the board to the back of the meter, then mark and disconnect all leads to the board. Replacement is the reverse of this procedure.

Replacement of Meter M101

To replace the voltmeter first remove the nuts securing the printed circuit board to the meter and move the printed circuit board out of the way. Then remove the four nuts securing the meter to the panel. Replacement is the reverse of the above procedure.

Replacement of Main Switch K1 (L1A & K1B)

First remove the cross piece between the handles by pressing out the cross pin, then remove the panel screws. Remove the leads from the terminals (identify so that they can be replaced). Assembly is the reverse of the foregoing.

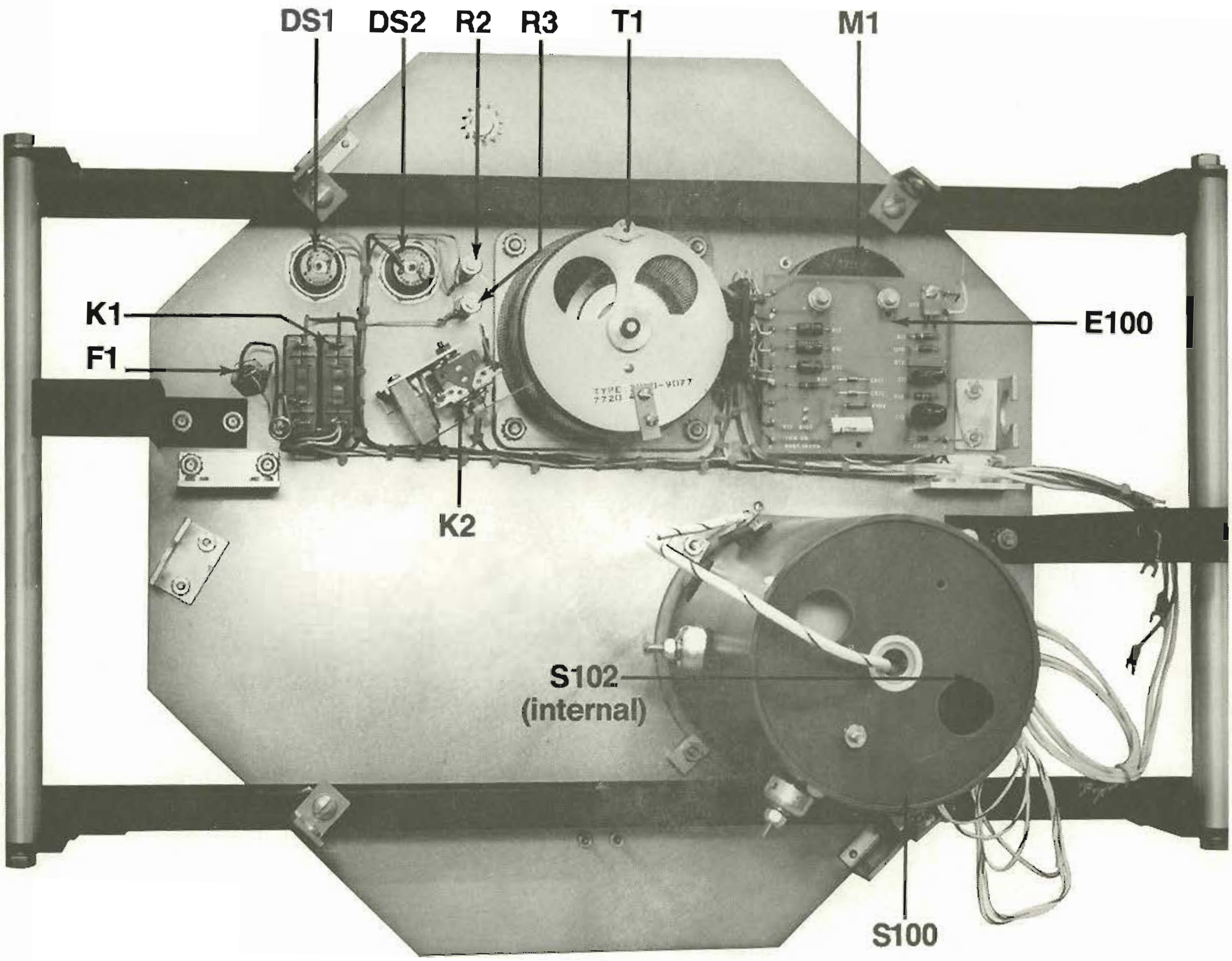


Figure 9: View of top panel.

Replacement of Voltage Control T1

The only precautions are to insure that the mechanical linkage between the arm of T1 and relay controls of K2 are reset so that K2 contacts close when T1 arm is at zero. The remaining precaution is to align the knob so that it registers with the panel scale.

Replacement of K2

The only precautions are to identify leads for replacement and to align the contact linkage with T1 arm.

Replacement of S100

It is recommended that this switch be replaced as a unit. For those who prefer to do the repair themselves the following procedure can be followed for replacing contacts D of the switch or for replacing the Ground contactor viewport.

Locate the four wires that come from S100 near the panel and trace them to the terminal strip.
After marking wires and terminal strip, remove the wires from the terminal strip.
Note the position of the arm with respect to the shaft.
Remove the arm of the function selector switch by loosening the set screws.
Remove the ring from the panel. (Three flat head screws).

There are four clips that retain S100 to the panel.
Loosen these so the switch body is free of the panel.
Pull the wires previously cleared from the terminal strip through so the entire switch is free but restrained to the Tester by the flexible high voltage leads.

Remove resistor R106.
Drop the switch down so that the window can be worked on. If necessary, remove the strut.
Alternatively the main vertical partition can be loosened and sufficient clearance obtained to gain access to S100.
The window of S100 contains a well. Within the well are two microswitches supported by a metal strip and a cam attached to the operating shaft S100 by set screws. Carefully mark the cam position with respect to the shaft and remove the cam and microswitches.
Remove the remaining screws that secure the window to the body of the switch. Remove the window.
Replace the defective window (P/N 15270) and secure with four screws P/N 8623-5.

Reassemble the microswitches and cams into the new window well. Reassemble the S100 switch to the panel with all four clamps.
Replace the microswitch support arm, the shroud, detent ring and the operating arm.

Check the operation of S100 to conform to the contact closure actions shown on the schematic of the instruction manual.

Calibration of Voltmeter

Assumes a Standard kilovoltmeter is available having a proven accuracy of ±1/2% at 25kV dc. This standard must draw no more than 1/4mA.

To check or recalibrate the output meter:

1. Set up the Tester per Section M, Proof, Program B.
2. Connect the conductor of the test cable to the high voltage negative terminal of the standard Voltmeter.
3. Connect the shield of the output cable to ground and ground the positive terminal of the Standard Voltmeter.
4. Raise the Tester output voltage until the Standard meter reads 25kV and compare the readings.
5. If the Tester meter is in error by more than ±15% the problem should be investigated.
6. If the Tester meter is in error by more than ±2% locate the Voltmeter calibration adjustment (R102) on the front panel. Remove the cover screw and make the necessary adjustment.
7. Cross check at 10kV and if the Tester is within 9.5 to 10.5kV (±2% F.S.) calibration is acceptable and the cover screw can be replaced.

Alternative Voltmeter Calibration Method

For this method a standard resistor whose ohms value is accurately known is required and also required is a standard current meter. The resistance value must be at least 100 meghoms and the current meter must measure 250μA with an accuracv of ±1/2% or better.

The resistance value must be known within ±1/2% or better at 25kV. To use this method follow method A but replace the standard voltmeter with the resistor and current meter connected in series to form a standard voltmeter.

Calibration of Overvoltage Protection Circuit R12

This procedure checks both the circuit breaker trip function and the setting of R12.

First remove the Tester from the case per previous instructions in this section.

With the Tester removed from the case, rest it up on an insulating plate such as dry plywood in the normal operating position.
Locate R12.
Connect the Tester per Section M Impulse Function Program A. Rotate R12 fully counterclockwise and operate in the Impulse Mode. The circuit breaker protection should trip out the Tester before 25kV is reached.

With due regard to safety move R12 clockwise about 2 turns and again note the trip-out voltage. Continue in this fashion until trip out occurs at 25kV. Then advance R12 until trip out occurs when the voltage control is 5 divisions higher than required for 25kV. On a nominal 120V 50 Hz line this should be a voltage control setting of 85 to 90.

Perform the test procedure of Section M.
If acceptable seal the R12 adjustment and return the set to the case.

Ammeter Calibration (R13)

A milliammeter capable of ±5% accuracy is required.

To check or calibrate the meter:

1. Connect the meter across the output cable with the negative terminal connected to the center conductor.

2. Operate the Tester in the PROOF mode and check the individual ranges using the appropriate range settings of the standard meter.

3. If recalibration is necessary, remove the AM. cover screw and with the standard meter reading 10mA F.S. and the Tester range selector on X10 reset the meter for full scale by adjusting R13. Recheck other scales.

TABLE I: TROUBLESHOOTING GUIDE

MALFUNCTION	POSSIBLE CAUSE
Green lamp does not light when main switch is closed.	W1 not plugged in. Service outlet inoperative. Lamp DS1 defective. K1A defective. Defective R3
Green lamp on but fan not running.	Fuse F1 open. Defective fan B1.
Red lamp DS2 does not light Assume main switch closed and green lamp on.	Voltage control not at zero. Voltage control linkage to K2 defective. Defective R2. Defective lamp.
Red lamp will not stay on.	S100 in ground position. Fuse F1 open. Thermal overload; S1 open K2 defective Mechanical linage between T1 & K2 defective.
No output voltage in either Proof or Impulse mode.	Defective K1B of main switch. Voltage control T1 defective. R1 open. High Voltage Transformer T2 defective. Defective components C100, C101A, C101B, R100, R101, CR100, CR101. Defective voltmeter M101. Defective R103, R104, R105, C102, R107 or C103.
Output voltage abnormally low or circuit trips out as voltage is raised.	Operating in Proof Mode with short circuited output. See no output voltage Defect in components of PC Card, R10, R11, R12, C10, C11, CR10, Q10 & Q11. Defect in S101 Defective output cable W100. Defective CR100, CR101.
Voltmeter indicates output voltage but no output voltage at output of W100	Defective R102. Defective S101. Defective S100. Defective output cable W100.

TABLE I: TROUBLESHOOTING GUIDE (Cont'd.)

MALFUNCTION	POSSIBLE CAUSE
Output intermittent in Proof mode.	Defective S100.
Output steady in Impulse mode.	Defective S101 or S100. Defective Output Cable W100.
Discharge mode does not bleed voltage down.	Defective S100. Defective R106. Defective R102.
Voltmeter indicates output voltage in ground position.	Defective S100. Defective R102.

TABLE I: TROUBLESHOOTING GUIDE

MALFUNCTION	POSSIBLE CAUSE
Green lamp does not light when main switch is closed.	W1 not plugged in. Service outlet inoperative. Lamp DS1 defective. K1A defective. Defective R3
Green lamp on but fan not running.	Fuse F1 open. Defective fan B1.
Red lamp DS2 does not light Assume main switch closed and green lamp on.	Voltage control not at zero. Voltage control linkage to K2 defective. Defective R2. Defective lamp.
Red lamp will not stay on.	S100 in ground position. Fuse F1 open. Thermal overload; S1 open K2 defective Mechanical linage between T1 & K2 defective.
No output voltage in either Proof or Impulse mode.	Defective K1B of main switch. Voltage control T1 defective. R1 open. High Voltage Transformer T2 defective. Defective components C100, C101A, C101B, R100, R101, CR100, CR101. Defective voltmeter M101. Defective R103, R104, R105, C102, R107 or C103.
Output voltage abnormally low or circuit trips out as voltage is raised.	Operating in Proof Mode with short circuited output. See no output voltage Defect in components of PC Card, R10, R11, R12, C10, C11, CR10, Q10 & Q11. Defect in S101 Defective output cable W100. Defective CR100, CR101.
Voltmeter indicates output voltage but no output voltage at output of W100	Defective R102. Defective S101. Defective S100. Defective output cable W100.

TABLE I: TROUBLESHOOTING GUIDE (Cont'd.)

MALFUNCTION	POSSIBLE CAUSE
Output intermittent in Proof mode.	Defective S100.
Output steady in Impulse mode.	Defective S101 or S100. Defective Output Cable W100.
Discharge mode does not bleed voltage down.	Defective S100. Defective R106. Defective R102.
Voltmeter indicates output voltage in ground position.	Defective S100. Defective R102.

SECTION M

PERFORMANCE CHECK

The checkout procedures given below can be followed either in the shop after performing routine maintenance or in the field prior to conducting a fault locating operation. If the results obtained in both Program A and Program B conform to those described in Section H, the Tester is operational and proper performance is assured.

Impulse Function Test, Program A

To implement this program refer to Section G and set up the equipment. Connect the shield of the output cable to a different ground than used for the case. Connect the conductor of the output cable to the same ground as the output shield. Set the controls as follows:

Main Switch	OFF
Manual Ground	GROUND
Voltage Control	ZERO
Function Selector	IMPULSE

Connect the input cable to a service outlet of nameplate rating.

Perform the test in accordance with the procedure given in Section H under Impulse Operation, noting carefully that all indicators produce the described responses. When proper indicator responses are not obtained, the cause of the problem must be isolated. For recommended procedures, see Section L.

This basic checkout procedure can be performed at any time to verify the Tester operation under normal impulse generation. As noted in Section J, fault characteristics can vary widely and in some cases can even temporarily clear themselves. For such unusual conditions, the Tester check-out procedure can verify the proper performance of the Tester so that the problem of fault characteristics can be clearly isolated.

To check the circuit protection, note the voltage control setting for 25kV, multiply this setting by 1.1. Advance the voltage control to the new setting. Trip-out must occur above 25kV but may not occur until 15 discharges have taken place at the new setting. If trip out does not occur, stop the test and consult Section L, Calibration of Overvoltage Protection Circuit.

Proof, Program B

To implement this program refer to Section G. Connect the shield of the output cable to a different ground than used for the case. Connect the conductor of the output cable to the same ground as the output cable shield. Set the controls as follows:

Main Switch	OFF
Manual Ground	GROUND
Voltage Control	ZERO
Function Selector	PROOF

Operate the Tester and slowly raise the voltage control to a setting of 70. The Main switch should open after 1 minute or less. This test checks the overcurrent protection circuit.

The following test is to prove the ability of the Tester to develop output voltage and to provide a rough test of voltmeter calibrations. The output cable center conductor must be removed from ground and suspended clear of ground.

As a guide in setting up the test, the minimum air clearances given in Table III must be maintained between the exposed energized conductor and any adjacent grounds in order to prevent arc-over. Such accidental arc-over may create a safety hazard. The clearance values shown in the table apply to the direct air path at the point of closest proximity to ground.

TABLE II AIR CLEARANCES

TEST VOLTAGE	DIRECT AIR PATH	PATH ALONG NYLON ROPE
5kV	1-1/4 inches	1-1/4 inches
10kV	1-9/16 inches	2-1/4 inches
15kV	1-7/8 inches	3-1/2 inches
20kV	2-1/4 inches	5 inches
30kV	2-7/8 inches	7-1/2 inches

After completing the test arrangement operate the Tester in the Proof Mode. Advance the Voltage Control to 15kV, 20kV and 25kV; at each step compare the voltage control setting to the regulation curve. If agreement is within ±15 percent the set is acceptable. Disagreement by more than 15% may indicate trouble so consult Section L.

After completion of the Proof test while at 25kV, move the Mode Selector switch slowly to the Discharge position. For an acceptable result the red lamp must go out and the voltmeter will indicate a slow reduction of the output voltage. Allow the voltage to decrease to under 5kV then move the Mode switch to Ground and note if the voltmeter then sharply drops to zero and remains at zero.

The final check is for overvoltage protection, to perform this test proceed as for Proof test check-out then increase the setting of the voltage control toward 90. Trip out must occur above 25kV but not to exceed the above limiting setting.

SECTION N

PARTS LIST

SYMBOL	DESCRIPTION	PART NUMBER
B1	Fan	9741
B100	Motor	7241-2
C10	Capacitor, 0.1μF, X400V	12829-2
C11	Capacitor, 0.1μF, X100V	12829-1
C100	Capacitor, 0.04 X15kV	15323
C101 (2 pcs)	Capacitor, 2μF X25kV	12870-2
C102	Capacitor, 1μF X50V	12024-1
CR10	Rectifier 1N4006	11637-36
CR11, CR12	Rectifier 1N4004	11637-34
CR100, CR101	Rectifier 50kV PIV	15161-2
D1, D2	Diode, A390A	16855
E1	Fuse Holder	7911
E100	PC Board Assembly	16859
E101 (2)	Contacts, Stationary	12934
E102	Contacts, Moving Arm	12935
F1	Fuse, 3/8A SB	2567-23
K1	Circuit Breaker, 115V	6807-8
K1	Circuit Breaker, 230V	6807-4
K2	Control Relay	14265
K100	Solenoid, Impulse Switch	15165
M101	Volt-Ammeter	6576-3
Q10	Diac REA45411	15348
Q11	Triac GE146D	15924
R1	Resistor, Input Limiting 2.5Ω 300W	1935-3
R2, R3	Resistor, Ballast 1750Ω, 115V	4500-88
	Resistor, Ballast 3500Ω, 230V	4500-111
R10	Resistor, 180K, 5%, 1/2W	4501-159
R11	Resistor, 82Ω, 5%, 1/2W	4501-244
R12	Potentiometer, 0.1 MΩ	13183-13
R13	Potentiometer, Ammeter Cal.	4418-7
R14	Resistor, 10Ω, 1/2W, 5%	4501-106
R15	Resistor, 75Ω, 1/2W, .25%	10027-78
R16	Resistor, 7Ω, 1/2W, .25%	10027-5
R17	Resistor, 1.2Ω, 1/2W, .25%	10027-79
R100, R101	Resistor, 2K, 50W	8199-7
R102	Resistor, 1Ω, 300W	1935-6
R103	Resistor, VM Divider, 200 MΩ, 5%	4694-3
R104	Resistor, 3010Ω, 1%	12026-71
R105	Potentiometer, 2KΩ, VM CALIB.	4418-4
R106	Resistor, Bleeder, 2M, 50W, 50kV	15338-1

PARTS LIST (cont'd)

SYMBOL	DESCRIPTION	PART NUMBER
S1	Switch, Thermal	14163
S10 A & B	Switch, Range Selector	1524-1
S100	Switch, Mode Selector	15251
S101	Switch, Impulse	12933
S102	Switch, Interlock	9235
S103	Switch, Interlock	9235
S104	Switch, Timing	Part of B100
T1	Voltage Control, 115V	15332
	Voltage Control, 230V	15332-1
T2	Transformer, HV	14634
T3	Transformer, Control, 230V	4364
W1	Cable, Input	15339
W2	Cable, Ground	7914
W100	Cable, HV Output	12766-2 → 12766-1

Toggle Switch

12-19-13

651027 - HV Contact Switch # 12933

651027-1 # 12766-1

HV Output Cable - This is shielded

10/12/94

B. Vandermade

SECTION P

WARRANTY AND REPAIR

WARRANTY

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

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

REPAIRS

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