ohmic instruments co
102 CHEW AVE. ST. MICHAELS, MARYLAND 21663
(301) 822-4844 (301) 745-2277

I. INTRODUCTION

The Model BET-300A was engineered and field-tested by hospital and biomedical engineers for ease of operation, ruggedness, and portability. The unit is capable of performing safety tests on electrically-operated equipment and wiring on grounded as well as isolated power systems. It can simulate probable fault conditions such as loss of equipment ground and reversed power wiring. The BET-300A reads leakage current and voltages above or referenced to ground. Resistance tests are made with respect to ground. The test set's case is internally shielded to limit high frequency interference, and it is grounded in order to reduce shock hazard to the operator. In conformance with the 1977 Association for the Advancement of Medical Instrumentation (AAMI) standard, the BET - 300A has a 1 - kilohm input impedance and a frequency response from D.C. to 1 megahertz. In the V only range, the input impedance is 1 megohm.

II. DESCRIPTION OF CONTROLS

1. TWO-POLE MAGNETIC BREAKER. Applies power to meter and test receptacle.

2. POWER ON LIGHT. Indicates power is applied to unit.

3. GROUNDING & INSULATION NON-ENERGIZED RECEPTACLE. This outlet is used for the grounding and insulation tests (Test 1).

4. LEAKAGE TESTS ENERGIZED RECEPTACLE. Leakage current and isolation, Tests 2 through 6, are conducted with equipment under test (E.U.T.) in this outlet.

5. ECG LEAD TEST PUSHBUTTONS. When depressed, the five pushbuttons connect each lead to the unit during Tests 3, 4, and 5.

Description of Controls. (Continued)

6. PROBES. Connect red and black test leads to the unit for Tests 1, 4 and 6.

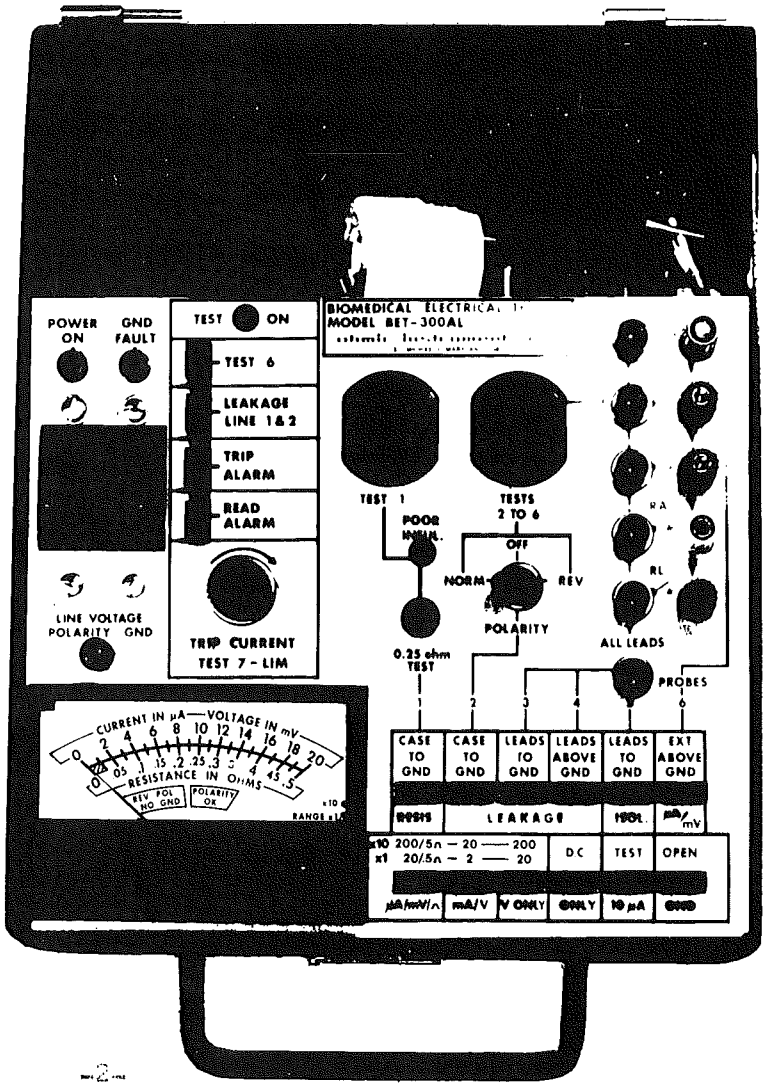
7. 1/16 and 1/4 AMPERE FUSES. Provide overcurrent protection for the unit's resistance circuitry (1/16 ampere) and power supply (1/4 ampere).

8. COLOR CODED LEAD CONNECTORS. Allow the patient leads to be connected to the unit.

9. NORMAL, OFF AND REVERSE POLARITY SWITCH. This toggle switch is used to reverse the HOT and NEUTRAL lines to the E.U.T. The switch has a center OFF position.

10. POOR INSULATION TO GROUND. The poor insulation light comes on if the E.U.T. has a short circuit or resistance path of less than approximately 500 kilohms between the combined HOT and NEUTRAL lines and ground. Test 1.

11. TEST ALL LEADS. When depressed, this pushbutton connects all patient leads to the unit during Tests 3 and 5.



The model shown at right has Test #7 for Isolated Power System. All BET-300A Series have provision, if desired, to install Test #7 at nominal cost.

Description of Controls (Continued)

12. FUNCTION TEST SELECTOR PUSHBUTTON. Selects Resistance, Leakage, Isolation and External Leakage Tests.

13. OPEN GROUND ON E.U.T. Depress this pushbutton to disconnect the ground from the energized receptacle and to simulate loss of equipment ground for Tests 3, 4 and 6.

14. OPEN NEUTRAL TOGGLE SWITCH. Depress this toggle switch to disconnect neutral pin on energized receptacle. Simulates loss of equipment neutral with polarity switch in "Normal" position.

15. TEST 10uA. Depress this button in leakage or isolation position to test the meter's calibration.

16. D.C. ONLY. When this pushbutton is depressed, the meter reads D.C. component only of input signal.

17. TAUT-BAND PRECISION METER. Leakage Scale: 0 to 20 microamperes
Resistance Scale: 0 to 0.5 ohm.

18. THREE POSITION RANGE SWITCH. Selects the following ranges, together with the autoranging circuits:

Range	Autorange	Full Scale	Input Z
uA/mV/Ω	x1	20 uA/mV	1 K AAMI
uA/mV/Ω	x10	200 uA/mV	1 K AAMI
mA/V	x1	2 mA/V	1 K AAMI
mA/V	x10	20 mA/V	1 K AAMI
V ONLY	x1	20 Volts	1 Meg. Flat
V ONLY	x10	200 Volts	1 Meg. Flat

The uA/mV/Ω range is used when measuring resistance and gives full scale ranges of 0.5 ohm (x1) or 5 Ohms (x10).

19. FAULT WARNING: HIGH LEAKAGE LIGHT. A red light comes on whenever the meter is connected to line voltage.

20. LINE VOLTAGE POLARITY/GROUND. Checks the outlet in which the test set is connected for proper polarity and ground.

21. 0.25 OHM TEST. With the red probe plugged into this test jack, the calibration of the resistance test is verified.

III. OPERATION. (SHORT FORM)

USING THE BIOMEDICAL ELECTRICAL TEST SET - MODEL BET-300A - SHORT FORM

Before proceeding with tests, plug the BET-300A into a wall receptacle, turn POWER on and check line voltage, wall polarity and grounding by momentarily depressing the LINE VOLTAGE POLARITY/GND. switch.

Step 1a) GROUNDING. Tested using non-energized receptacle. Plug in E.U.T. Depress CASE TO GND. (Switch 1). Depress uA/mV/Ω range switch. Check calibration by touching red test lead to 0.25 ohm jack. Measure grounding resistance by touching red test lead to E.U.T. case.

Step 1b) POWER SIDE INSULATION. Tested using non-energized receptacle. If grounding is OK, turn on POWER switch of E.U.T. The POOR INSUL. light will come on if the combined HOT and NEUTRAL to Ground resistance is approximately 500 kilohms or less.

Step 2) LEAKAGE FROM CASE TO GROUND. Depress CASE TO GND.(Switch 2). Check calibration with TEST 10uA pushbutton. Next, plug in E.U.T. and take readings in NORMAL and REVERSE polarity. Multiply reading by the multiplier as indicated by one of the two red lights.

Step 3) LEAKAGE FROM LEADS TO GROUND. Connect ECG leads to binding posts. Depress LEADS TO GND.(Switch 3) and hold down ALL LEADS pushbutton to read total leakage-to-ground. Individual leakages may be read by depressing the pushbutton beside each patient lead.

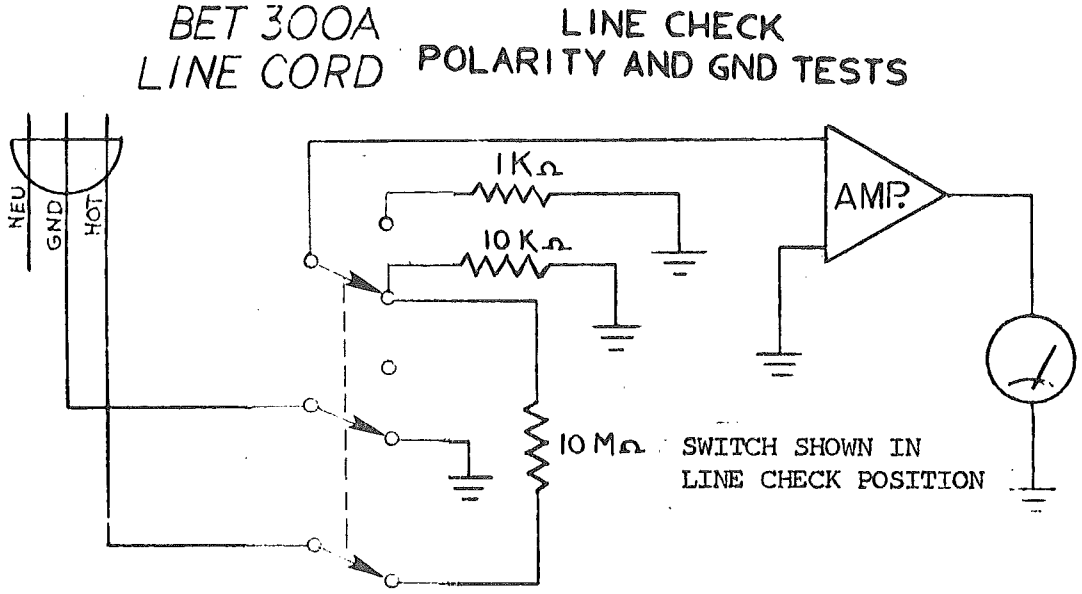
Step 4) LEAKAGE BETWEEN LEADS ABOVE GROUND. Depress LEADS ABOVE GND.(Switch 4). Touch red probe to one patient lead post (Example LL) and depress the pushbuttons beside each other lead in sequence.

Step 5) ISOLATION OF LEADS TO GROUND. Depress LEADS TO GND. (Switch 5). Push each of the five lead pushbuttons and record the highest reading. Isolation Impedance equals 120 volts divided by the leakage reading.

Step 6) EXTERNAL ABOVE GROUND. Depress EXT. ABOVE GND. (Switch 6). Use the black and the red test leads to measure current or voltage between any conductive surfaces. The meter is floating above ground during this test, with an effective isolation over 10 megohms.

IV. OPERATION (DETAILED).

(Use OHMIC Test Form TF-2 for ECG and TF-4 for General Equipment). Before proceeding with the tests, plug the BET-300A test set into a grounded wall receptacle, switch POWER on, and check line voltage, wall receptacle polarity, and grounding by momentarily depressing the LINE VOLTAGE-POLARITY/GND. switch. If the receptacle wiring is correct, the meter will measure line voltage (12 microamperes corresponds to 120 volts). If the grounding is poor, or if the wiring is incorrect, the meter needle will stay in the lower end of the scale, marked REV. POLARITY/OPEN GND. Do not proceed with tests if receptacle is not properly wired.



STEP 1A) GROUNDING. (For all types of line-operated equipment). Use Test Forms TF-2 and TF-4. Plug the equipment under test (E.U.T.) into GROUNDING TEST 1 non-energized receptacle. Depress CASE TO GND. RESISTANCE (Switch 1). The meter needle will peg to the right for open circuit condition, which is normal and will not damage the meter movement. Next, depress uA/mV/Ω RANGE switch, and check calibration by touching the red test probe to the TEST 0.25 ohm standard jack. Touch the red probe to the equipment chassis at a screw head or unpainted surface, and read line cord

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Equipment: _____ Mfgr. _____ Model _____

Serial No. _____ Control No. _____ Location _____

ECG SAFETY TEST With Model BET-300A

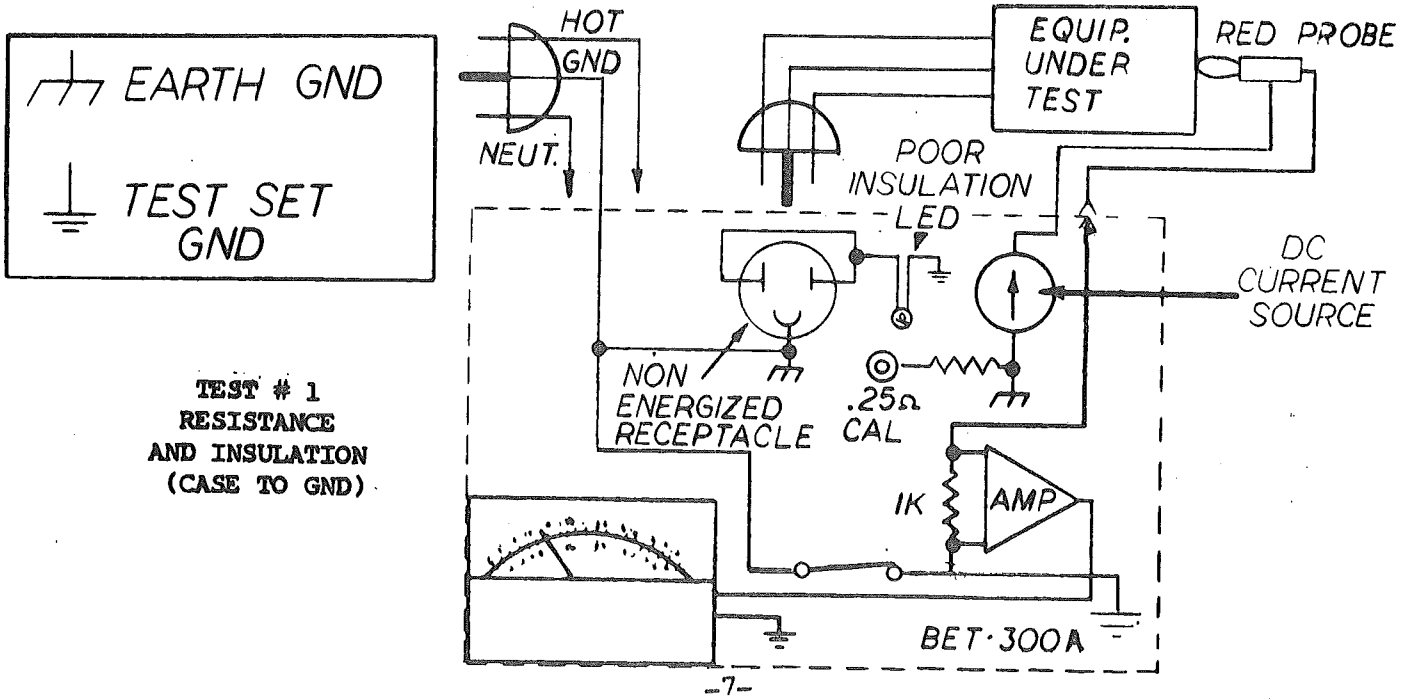
					Limits 60 Hz RMS*						
	Test Date & Initials										
	Physical Inspection										
	Line Check: Voltage, Polarity, and Ground										
	TESTS IN GROUNDING RECEPTACLE (NON-ENERGIZED)										
1.	Resistance From Plug, U-Blade, to Case				.15 ohm						
1.	Insulation of Hot/Neutral To Ground				.5 Meg.						
	LEAKAGE TESTS IN ENERGIZED RECEPTACLE										
2.	CASE TO GROUND	Normal Polarity		Power ON	100 uA						
				Power OFF	100 uA						
		Reverse Polarity		Power OFF	100 uA						
				Power ON	100 uA						
3.	LEADS TO GROUND	Reverse Polarity	Gnd.	All	50 uA						
				Highest	10 uA						
			Ungnd.	All	50 uA						
				Highest	10 uA						
		Normal Polarity	Gnd.	All	50 uA						
				Highest	10 uA						
			Ungnd.	All	50 uA						
				Highest	10 uA						
4.	Leads Above Ground Norm/Rev. Gnd./Ungnd. Highest				10 uA						
5.	Isolation Of Each Patient Lead To Ground (Test Current Limited To 1.2 mA Nominal)				20 uA 6 Meg.						
6.	Leakage Current Or Voltage Differential Between Conductive Surfaces				100 uA 100 mV						

* Maximum allowable readings suggested by NFPA, NEC, and AAMI.

resistance. (Typical 8-foot line cords will read less than 0.2 ohm). Flex the line cord at the plug and the chassis to check for intermittent connections. A fluctuation in the reading could be caused by contact resistance or a corroded connection. Caution: Do not measure resistance when the equipment has a direct electrical connection to the patient's heart. The D.C. test current used to measure resistance is 40 milliamperes.

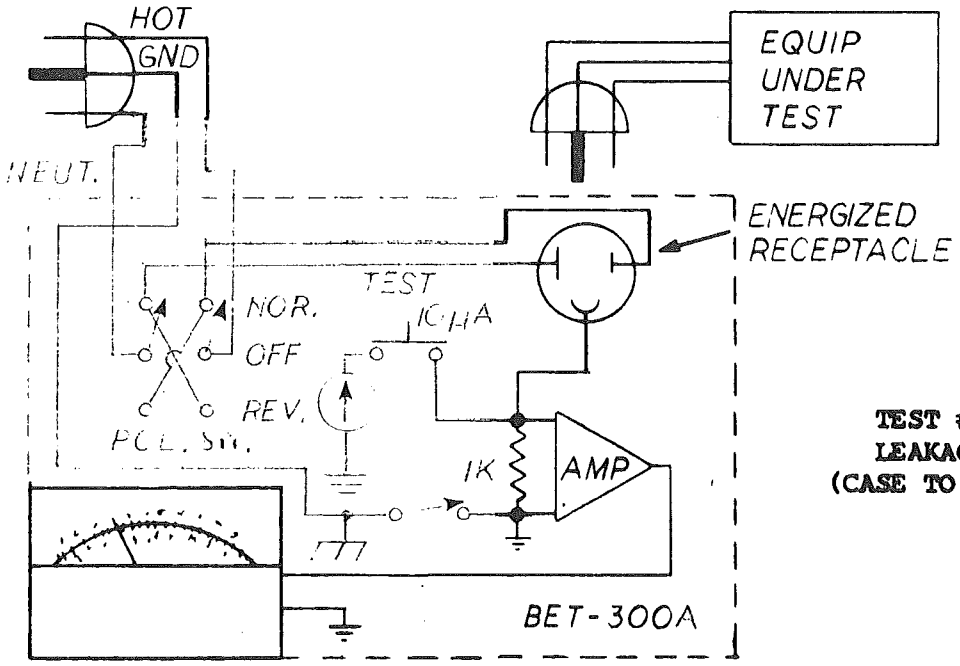
Grounding of Conductive Surfaces. In Test 1, the black lead, or meter reference is connected to the line cord ground, so the black test lead is not needed and should not be used. With the red test lead, touch each metal surface and read resistance.

Step 1B) POWER SIDE INSULATION. (For all types of line-operated equipment.) Use Test Form "TF-2", Part 1, and "TF-4", Part 1. If the grounding resistance is acceptable, turn on the E.U.T. POWER switch. The POOR INSUL. light comes on if the HOT and NEUTRAL TO GROUND resistance is below 500 kilohms. This test will detect gross faults, such as grounded neutral.



TEST # 1 RESISTANCE AND INSULATION (CASE TO GND)

STEP 2) LEAKAGE FROM THE CHASSIS TO GROUND. (For 120 volt A.C. equipment with a grounded line cord). Use Test Forms TF-2 and TF-4, Part 2. Depress CASE TO GND. (Switch 2). Depress uA/mV/Ω range switch. Check the leakage calibration by momentarily pushing the TEST 10uA pushbutton. Next, plug E.U.T. into the TESTS 2 to 6 receptacle. Make sure that the E.U.T. chassis is isolated from earth ground and remove all secondary ground paths. (Test probes are not required in this test). Read the chassis-to-ground leakage as follows: POWER ON WITH NORMAL POLARITY, POWER OFF WITH NORMAL POLARITY, POWER OFF WITH REVERSE POLARITY, and POWER ON WITH REVERSE POLARITY. This sequence is intended to prevent heavy surge currents through the polarity switch. A line cord leakage with the power switch off is typically 8 to 10 microamperes (1 microampere per foot). Important Note: A zero leakage reading is incorrect and may be caused by a bad ground at the wall outlet, a broken ground wire to the E.U.T., or a secondary ground path carrying the chassis leakage away.



TEST #2
LEAKAGE
(CASE TO GND)

Test Form TF-4

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Equipment: Mfgr: Model

Serial No. Control No. Location

MEDICAL EQUIPMENT WITHOUT PATIENT LEADS USING MODEL BET-300A

Initials									
Test Date & Initials			Limits						
Physical Inspection			60 Hz						
Line Check: Voltage, Polarity, and Ground			RMS*						
TESTS IN GROUNDING RECEPTACLE (NON-ENERGIZED)									
1.	Resistance From Plug, U-Blade, to Case		.15 ohm						
	Insulation of Hot/Neutral to Ground		.5 Meg						
LEAKAGE TESTS IN ENERGIZED RECEPTACLE									
2.	FOR EQUIPMENT WITH GROUNDED LINE CORD	Normal Polarity	Power ON	100 uA					
			Power OFF	100 uA					
		Reverse Polarity	Power OFF	100 uA					
			Power ON	100 uA					
3.	FOR UNGROUNDED EQUIPMENT TOUCH TEST LEADS BETWEEN CHASSIS AND GROUND	Normal Polarity	Power ON	10 uA					
			Power OFF	10 uA					
		Reverse Polarity	Power OFF	10 uA					
			Power ON	10 uA					

*Maximum allowable readings suggested by NFPA, NEC, and AAMI.

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VOLTAGE DIFFERENTIAL AND GROUNDING RESISTANCE

Location_____

Tested By_____

Date_____

Instruments Required:

Low Current Tests, OHMIC Model BET-300A Series or HSM200 or OHMIC HSM-200R With Resistance Range, or

High Current Tests, OHMIC Model HPS-180

(Room Sketch)

COLUMN:	1.	2.	3.	4.	5.
	Location		Voltage	Resistance	
No.	Reference Point	To Point	Ground Potential Millivolts	Test Current 40 mA Ohms	Test Current 2 Amps Ohms
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
LIMITS (ICU, CCU, OR):			5 millivolts	0.1 ohm	0.1 ohm
LIMITS (General Areas):			250 mV	0.5 ohm	Not Req'd.

PROCEDURE:
1) Disconnect line-operated equipment from patient during tests
2) Test for voltage differential from reference point to all other points
3) Use direct current (40 milliamperes) to check grounding resistance
4) Use A.C. 2-ampere test between receptacle grounds.

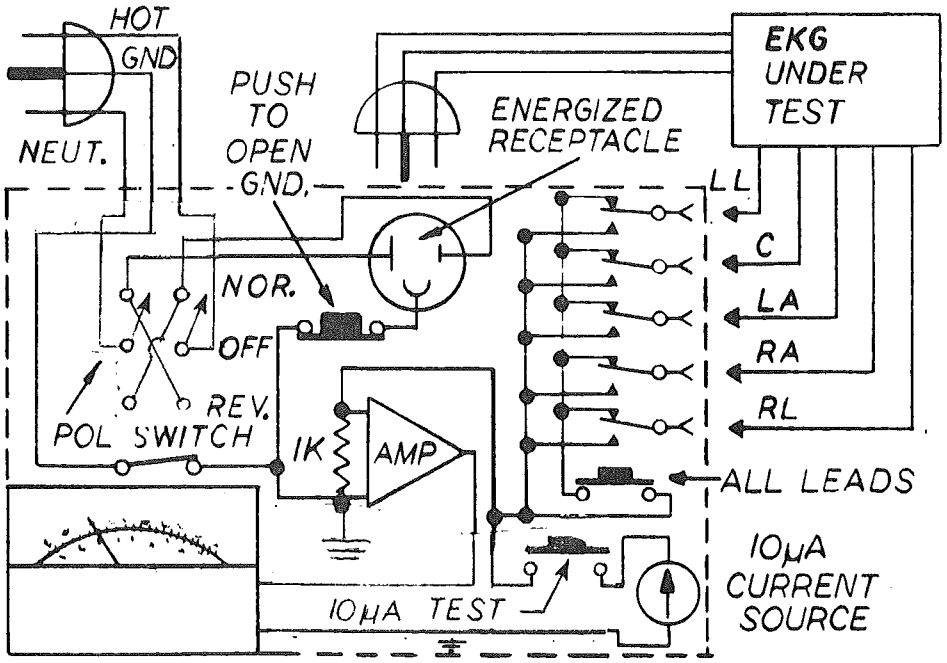
TESTS in O.R., C.C.U., I.C.U., Catheter Lab, and other Critical Patient Areas.

STEP 3) LEAKAGE FROM LEADS TO GROUND. Use Test Form TF-2, Part 3.

A. Checking ECG or Monitor. Connect patient leads to the binding posts of the BET-300A, and set ECG or monitor lead selector to V position. Depress LEADS TO GND. LEAKAGE (Switch 3), and hold down the ALL LEADS button to read the total lead leakage-to-ground. Individual leakages may be read by depressing the pushbutton beside each patient lead. Record the highest reading of the three to five patient leads for each combination listed below. Test with NORMAL or REVERSE polarity and the E.U.T. grounded or ungrounded. (The red and the black test probes are not used because the connections are internal). It is recommended to perform these tests in all ECG lead selector positions. Note: If the D.C. ONLY switch is depressed and a leakage at RL is noted, the D.C. leakage is probably the driven reference signal used in certain ECG machines to reduce noise and interference. (See Page 2). If pushing ALL LEADS and D.C. ONLY pushbuttons gives a zero reading, it indicates a proper operation of the Right Leg drive.

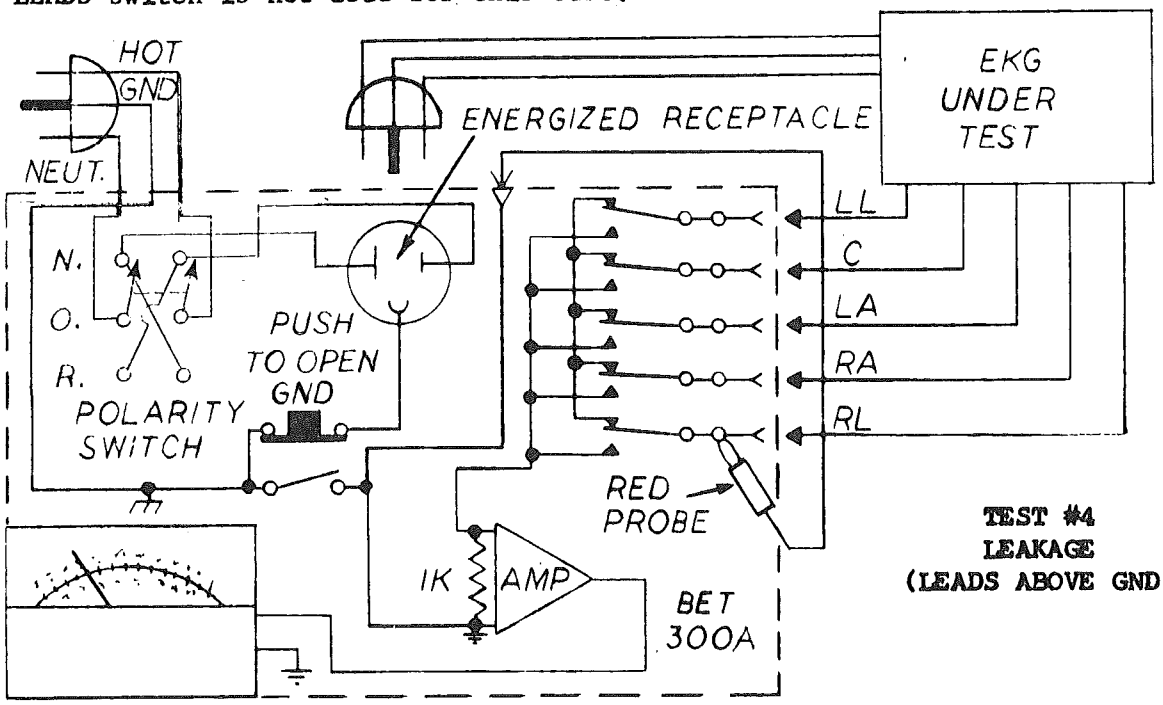
B. To Check Other Devices With Patient Connections. For example, pacemaker, defibrillator, EEG, muscle stimulator, temperature probe, pressure transducer, use the procedure described in Step 6.

TEST #3
LEAKAGE
(LEADS TO GND)



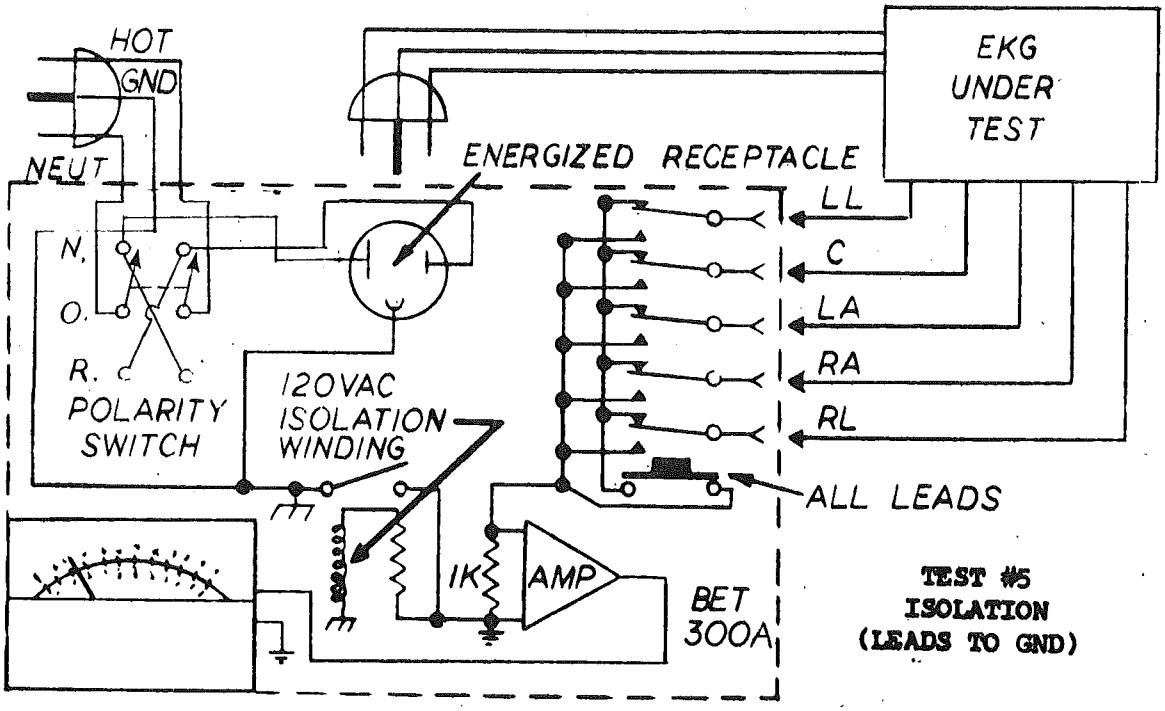
Operation. (Detailed). (Continued)

STEP 4) LEAKAGE BETWEEN LEADS ABOVE GROUND. Use Test Form TF-2, Part 4. To test ECGs and monitors, depress LEADS ABOVE GND. (Switch 4). The probe end of the red test lead is inserted into the LL patient lead post. Depress the pushbutton beside C, LA, RA, and RL in sequence. Repeat with the ECG lead selector switches in all active lead positions, POWER switch ON and OFF, ground OPEN and CLOSED, NORMAL and REVERSE polarity. Record the highest reading from all of the lead combinations and fault conditions. The ALL LEADS switch is not used for this test.



STEP 5) ISOLATION OF LEADS TO GROUND. Use Test Form TF-2, Part 5. Depress LEADS TO GND. ISOLATION (Switch 5). Push ALL LEADS pushbutton and record reading. Push each of the five lead pushbuttons and record the highest current reading. The isolation test indicates the amount of current that would flow through the patient if he accidentally came into contact with the AC line. For ECG machines this leakage reading should be no more than 20 microamperes per lead. A leakage of 20 microamperes corresponds to 6 megohms, ($\frac{120\ VAC}{20\ uA}$ = 6 megohms). A current reading from 0 to 20 micro-

amperes would indicate good isolation or adequately high impedance to ground. For operator safety, the test current is internally limited to approximately 1.2 milliamperes. Therefore, a reading between 20 uA and 1.2 milliamperes indicates a low impedance path to ground through the patient leads.



STEP 6) EXTERNAL ABOVE GROUND. Use Test Form TF-2, Part 6, and TF-6, Part 3. Depress EXT. ABOVE GND. (Switch 6). Use the black and the red test leads to measure current or voltage. The meter is floating above earth ground during this test. To make tests with respect to ground, connect the black test probe to a ground reference point.

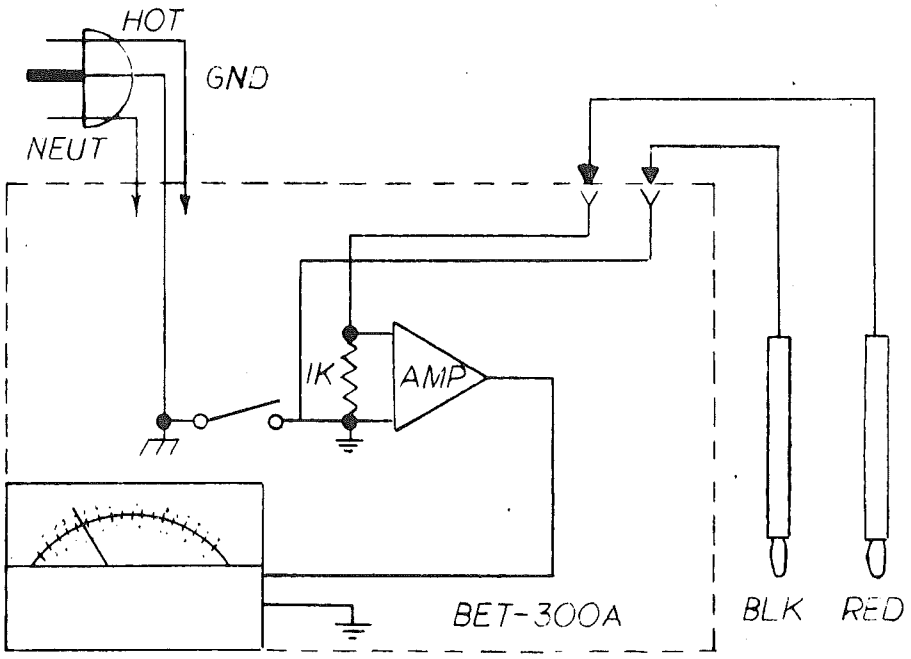
Some Simple Tests:

A. Ungrounded Items. Touch the red test probe to the case of the item to be tested; such as 2-wire ungrounded appliances, battery-operated equipment, grounded equipment having an insulated outer cover. Connect the black test probe to a ground reference at an outlet.

Operation. (Detailed). (Continued)

B. Patient-Connected Devices. Touch the red probe to the conductive surface of the electrodes; for example, electroencephalographs, muscle stimulators, flowmeter probes, diagnostic illuminators, defibrillators, etc.

TEST #6
CURRENT AND VOLTAGE
(EXTERNAL ABOVE GND)



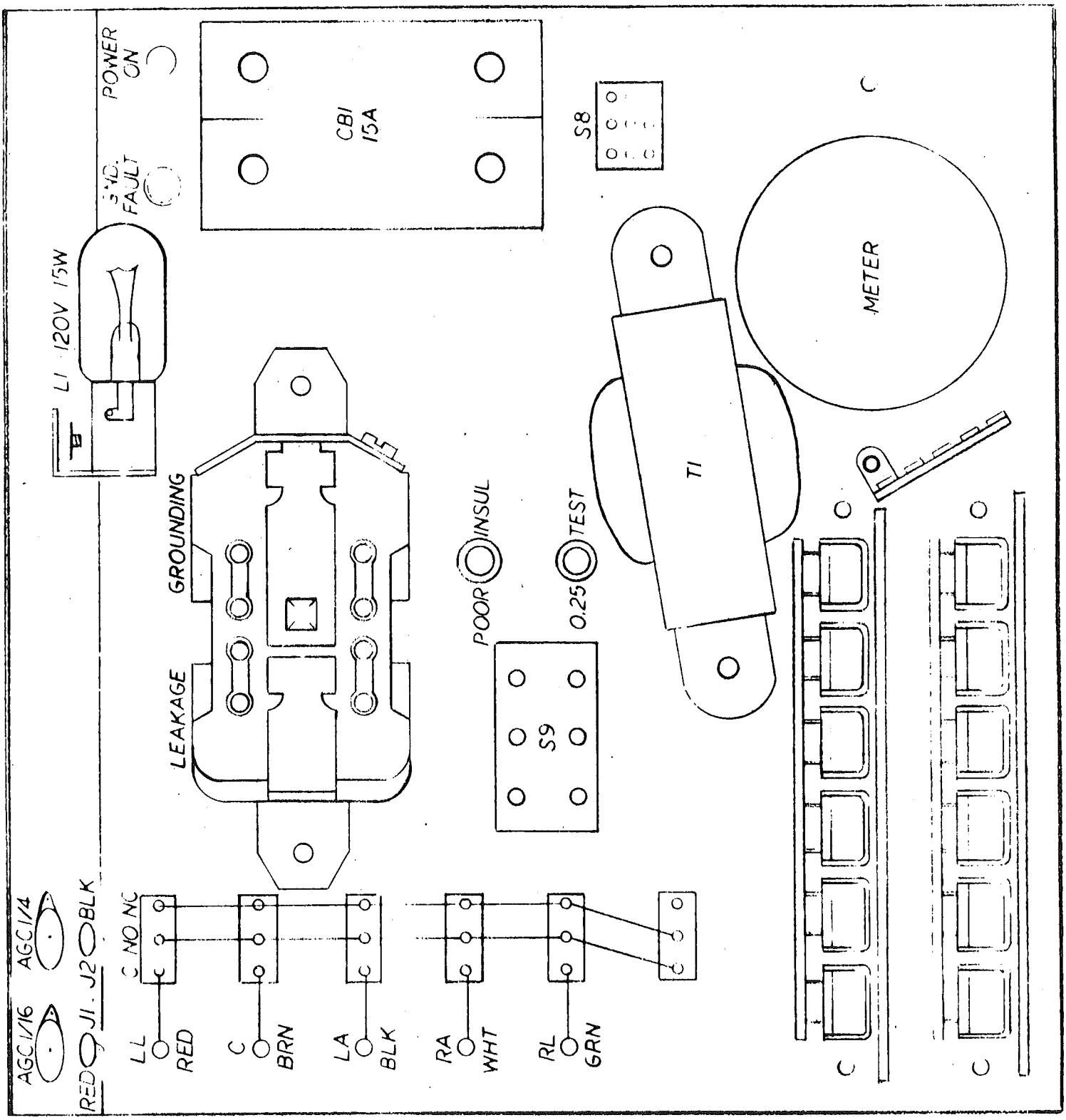
V. MAINTENANCE, TROUBLE-SHOOTING AND CALIBRATION.

If the test set does not operate, first check the items listed below. (For other problems, telephone collect OHMIC Engineering Department, or ship your BET-300A to our factory for repair or calibration.)

Fuses: A) Line Fuse. This fuse is the inside fuse below the probe jacks. Replace with 3AG 1/4 amp, Fast Blow.

B) Resistance Fuse. This fuse is located directly below the probe jacks. It provides protection in case high voltage is encountered during resistance measurements. Replace with 3AG 1/16 amp, Fast Blow.

Magnetic Breaker: The POWER ON switch acts as the overload protector. In case the 15-ampere rating is exceeded by the equipment under test, this breaker will interrupt the power to the test receptacle.



MECHANICAL LAYOUT - Inside View

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DETAILED CALIBRATION PROCEDURES

BET-300A

EQUIPMENT REQUIRED:

1. 0 - 600K decade resistance box.
2. Digital Multimeter. 3-digit with .5% accuracy AC and DC.
3. AC/DC voltage source. Voltage output adjustable between 0 and 10 volts.

CALIBRATION PROCEDURE:

1. Mechanically zero the unit meter by adjusting the screw located on the front of the unit meter for zero.
2. Place the FUNCTION switch in the TEST #6 position and attach a low current ohmmeter to the red and black PROBE jacks located on the back side of the unit. For BET-300 AL unit, verify that the first pushbutton of the isolated power system test marked DEPRESS TEST 2 is depressed.
4. Remove the ohmmeter leads and plug the unit line cord into properly polarized and grounded 120 VAC receptacle.
5. Turn the unit on and insure that the power on light is lit.
6. Place red probe in black jack and depress TEST #6 and uA/mV/Ω switch positions. Adjust the "ZERO ADJUST" potentiometer located on the large circuit board, for minimum indication on the unit meter.
7. Apply a 10 mV rms sinusoidal AC signal at 80Hz to the red and black PROBES.
8. Depress uA/mV/Ω range selector switch.
9. Adjust the "Full Scale Adj." potentiometer located on the large circuit board for a meter indication of 10 mV.
10. Replace the AC voltage source with a DC source of 10 mV.

11. Verify meter indication of 10 mV ±5% for both polarities of DC input.

12. Replace DC source with a source of 100 mV rms sinusoidal AC.

13. Adjust "ATTN" potentiometer, located on edge connector board, to obtain a meter indication of 10 in combination with x10 indicator LED.

14. Adjust "AR Adj." potentiometer to obtain proper shift point for auto-ranging circuit. Meter should change to upper range at 20mV. Clockwise rotation of "AR Adj" potentiometer increases the shift point. This adjustment should be checked by feeding in a 15 mV signal, increasing it slowly, and noting at what signal level the meter shifts to the x10 range. Adjust "AR Adj." potentiometer to obtain shift point of 20 mV.

15. Verify proper input attenuator operation by measuring a 1 Volt RMS AC signal using the mA/V range, and by measuring a 10 Volt RMS AC signal using V only range.

16. Depress uA/mV/Ω range switch.

17. Depress the 10 uA TEST switch, located on the front edge of the unit, and adjust the 10 uA ADJ potentiometer, located on the circuit board, until the unit meter indicates 10 uA. Due to the charging of C7 and C8, the meter will swing initially to the right and then settle toward midscale.

18. Release the switches and depress the LINE VOLTAGE switch.

19. Adjust the LINE potentiometer, located on the circuit board, until the unit meter indicates the line voltage from which the entire unit is operated. (12 uA represents 120 VAC.)

20. Turn the unit off, remove the adapter, plug the unit back into the 120 VAC wall receptacle and place the FUNCTION switch in the TEST #1 position.

21. Connect the red BET-300A probe to the 0.25Ω TEST jack, located above the unit meter.

22. Adjust the OHMS ADJ. potentiometer, located on the circuit board, for an indication of 0.25Ω on the unit meter resistance scale.

23. Remove the probe end from the 0.25 TEST jack and reinsert it into the ground of TEST 1 Receptacle, and insure that the unit meter indicates close to zero.

24. Unplug the red probe.

25. Turn the unit off and place a decade resistance box from the ground slot to the neutral slot on the GROUNDING - TEST 1 receptacle.

26. Turn the unit on, and insure that the POOR INSUL. light come on when the decade box is set to a value between 400 and 600 K ohms.

27. Insert a RIN* into the TEST 2 to 6 receptacle and insure that the receptacle wiring corresponds to the POLARITY switch positions.

28. Turn the unit power off and unplug it from the wall receptacle.

29. Remove the decade box and start patient lead tests.

30. Depress leads to ground TEST 3 switch and connect one of the multimeter leads to the black PROBE jack and the other to the top patient lead jack, then insert 10uA current source in series with the multimeter.

31. Depress the switch to the left of the patient lead jack, into which the ohmmeter lead is connected, and insure that the BET-300A indicates 10uA on each test.

32. Release the switch and depress the ALL LEADS switch and again ensure that the BET-300A indicates 10uA.

33. Repeat steps 31 and 32 until every patient lead jack and switch has been tested.

34. Place the FUNCTION switch in the TEST #4 position.

35. Reconnect the multimeter lead to the red PROBE jack and the other lead to black jack. Insert 10uA current source.

36. Depress the ALL LEADS switch and insure that the BET-300A indicates 10uA.

37. Disconnect the ohmmeter and place the FUNCTION switch in the TEST #5 position.

38. Depress the mA/V range switch. Place a jumper between one of the patient lead jacks and the ground slot of the TEST 2 to 6 receptacle.

39. Depress the switch to the left of the patient lead jack, into which one end of the jumper has been placed, and insure that the unit meter indicates between 900 and 1200 uA.

40. Release switch. Depress the uA/mV/Ω range switch. Insure that the unit meter indicates within the hatch-marked region.

41. Turn the unit off, remove the jumper and unplug the unit from the power receptacle.

*(A neon or L.E.D. receptacle polarity tester)

CIRCUIT DESCRIPTION AND REPAIR PROCEDURES

BIPOLAR POWER SUPPLY

BASIC OPERATION:

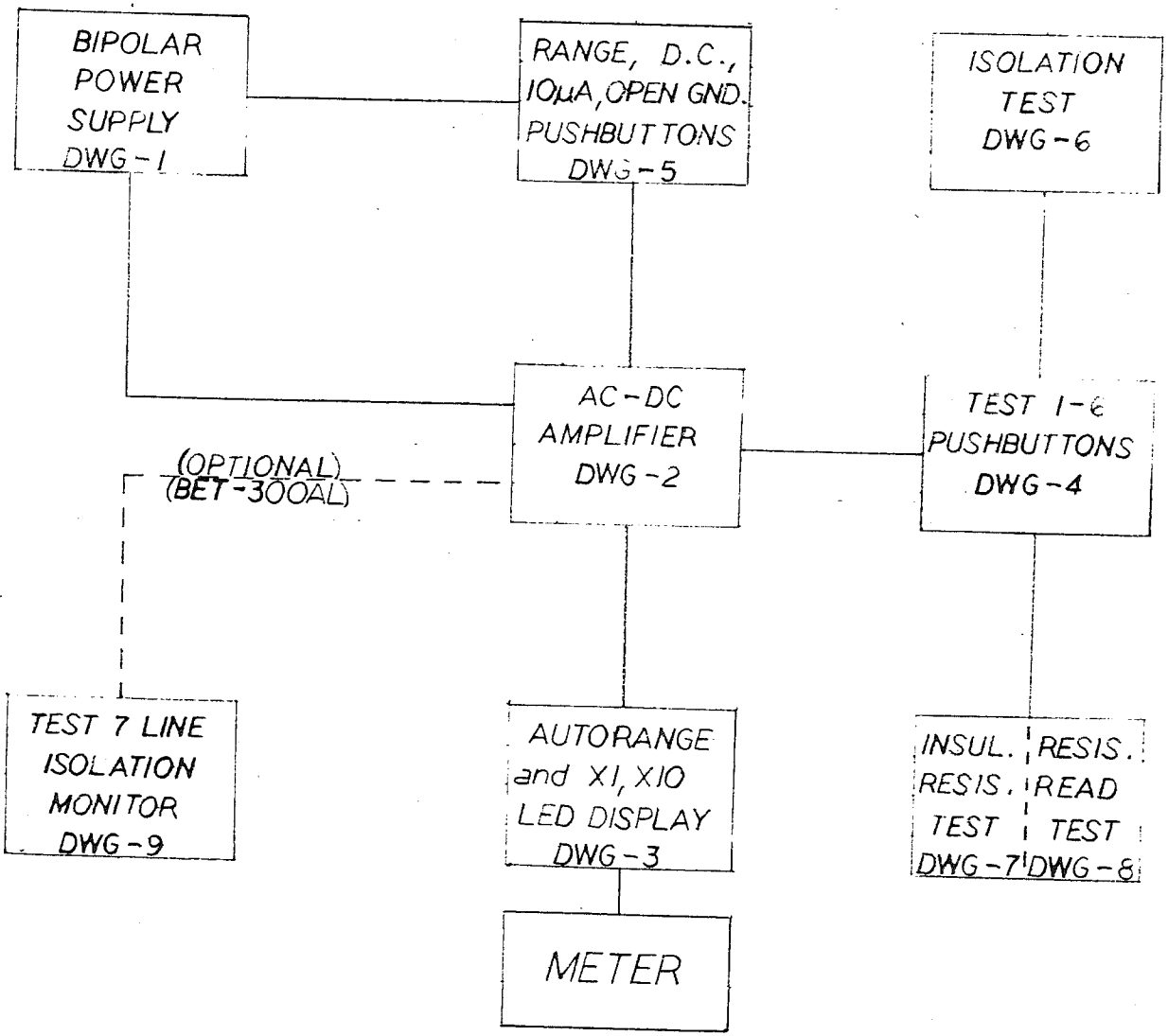
The circuit consists of a center tapped transformer, a full wave bridge rectifier and zener regulated positive and negative voltage regulators. See Block Diagram for functional details and drawing numbers.

DETAILED OPERATION:

Primary AC voltage is supplied to the power supply through a 120 VAC step down transformer (T1) with a 16 VAC center tapped secondary winding. Rectifier diodes CR1-CR4, in conjunction with the center tapped secondary of T1, form a positive polarity full wave bridge and a negative polarity full wave bridge. Filter capacitors C1 and C2 reduce the AC ripple from the positive and negative full wave bridges. Resistor, zener diode combinations R2, CR5, and R3, CR6 form positive and negative voltage regulators respectively. Transistors Q1 and Q2 are pass transistors for the positive and negative voltage regulators respectively. Capacitors C3 and C4 further filter the regulated DC voltages and reduce the internal AC impedance of the power supply outputs.

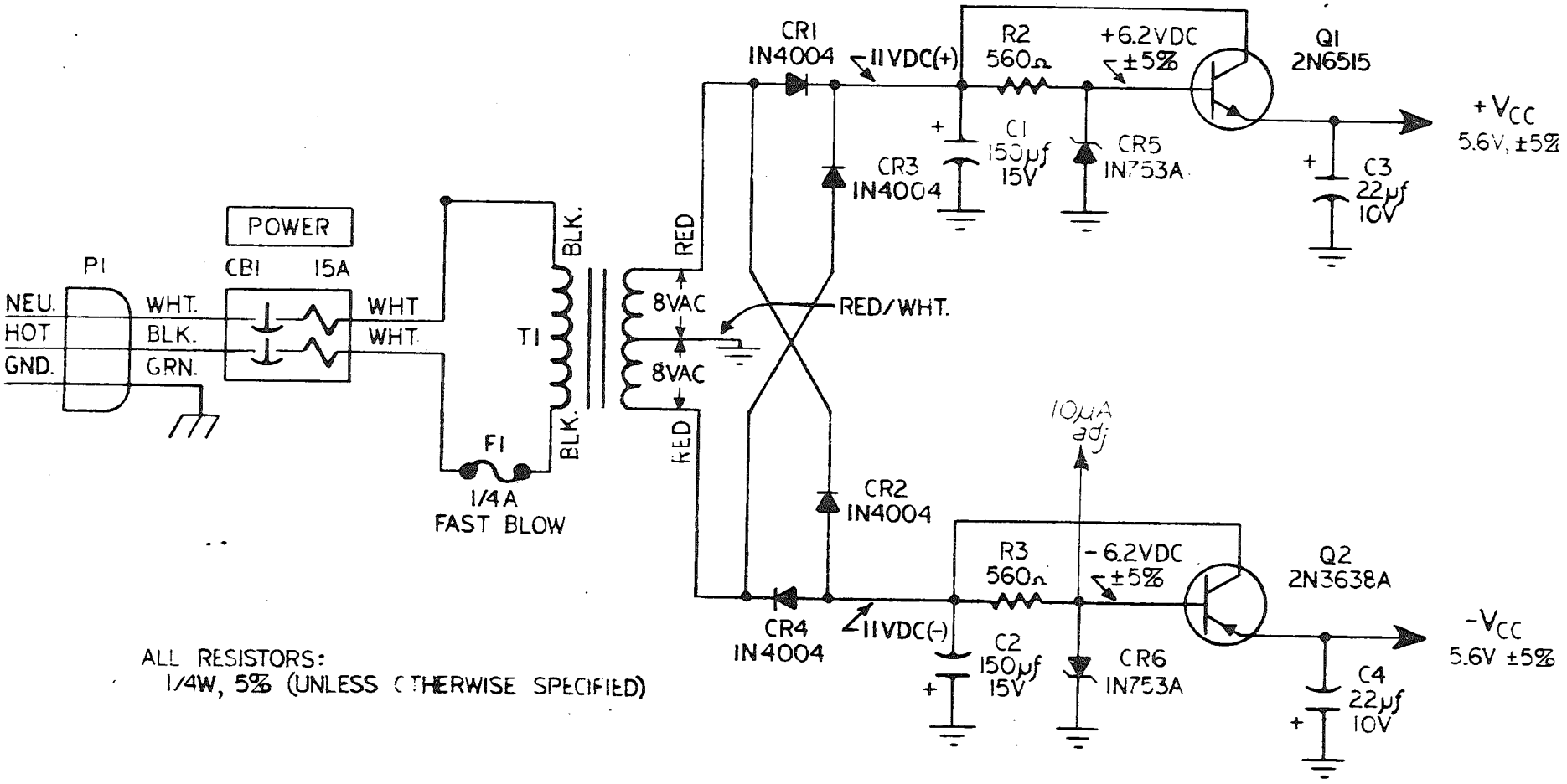
RELATED CALIBRATION PROCEDURE STEPS: NONE

BLOCK DIAGRAM



BIPOLAR POWER SUPPLY

DWG-1



ALL RESISTORS:
1/4W, 5% (UNLESS OTHERWISE SPECIFIED)

BIPOLAR POWER SUPPLY

TROUBLE SHOOTING:

POSSIBLE CAUSES based on the assumption that all related wiring has been checked, and all switches placed in the proper operating positions.

PROBLEM	POSSIBLE CAUSE
1. No 8 VAC from T1	F1 blown. T1 winding open.
2. F1 blows	T1 winding shorted. CR1, 2, 3, or 4 shorted. C1, 2 shorted.
3. Large AC ripple at ± 11 VDC point	C1, 2 open. Shorted ± Vcc output.
4. ± 6.2 V not present	CR5, 6 shorted.
5. ± 6.2 V reads ± 11V	CR5, 6 open.
6. Improper ± Vcc	Q1, 2 bad. C3, 4 shorted.

AC-DC AMPLIFIER-RECTIFIER

BASIC OPERATION:

The input portion of the amplifier consists of an input protection circuit in series with a switchable input attenuator. The meter circuit consists of an operational amplifier non-inverting gain and full-wave rectifier stage, the output of which is fed to the autorange circuit. A switch is provided at the input to shunt all AC signals to ground via a field effect transistor to allow measurement of DC inputs only.

DETAILED OPERATION:

The input protection circuit of the amplifier consists of L1 and current shunting zener diodes CR11, and CR12. Upon application of 120 VAC line voltage to the input of the amplifier, the zener diodes clip the positive and negative peaks to a safe 30V level while the light bulb dissipates the input energy. Within the normal input range of the BET-300A, the light bulb acts as a linear resistance, but when the input level is greatly exceeded the bulb resistance rapidly increases to prevent heavy current damage to the zener diodes.

The amplifier input resistance, which is composed of the series circuit L1, PR4, R20, R21, and R22 is set to 1 K Ω by adjusting PR4.

Input signals are attenuated by the range switches.

R25, C7, and C8 form a low pass filter which is switched into the amplifier input by transistor Q7. Q7 is biased ON or OFF using push button switch S9.

The break frequency of this filter is approximately 1.2 Hz which serves as a complete 60 Hz shunt when it is desired to measure a DC signal in the presence of 60 Hz AC. Hence, switch S9 is designated as DC only.

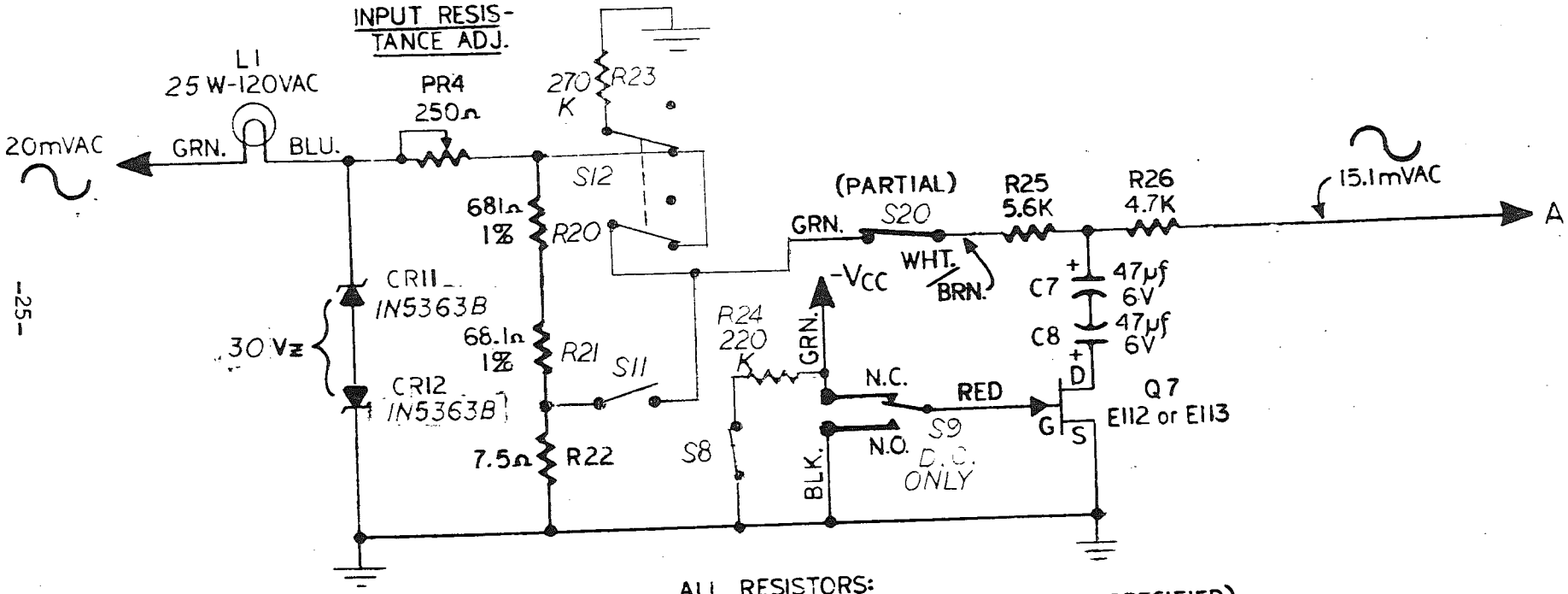
The input offset voltage of op amp IC1 is reduced to zero volts by adjusting PR6 before gain adjustment of the amplifier is attempted.

The 2.7K resistor R-35 and related bridge rectifier diodes CR17-20 are located in the negative feedback path of IC1. In this configuration, IC1 acts as a voltage to current converter with the value of current through R-35 being independent of the resistance and forward voltage drops of the diodes, directly proportional to the voltage level at pin 3 of IC1 and inversely proportional to the parallel resistance value of R29 and PR5. The gain of the amplifier is controlled by adjusting PR5. Series circuit C11, C12 and R30 is connected in parallel with the gain resistors R29 and PR5 to increase the AC gain of the amplifier slightly, as the meter movement would indicate a lesser value for AC signals than DC signals otherwise.

RELATED CALIBRATION PROCEEDURE STEPS: 1 → 17

AC-DC AMPLIFIER

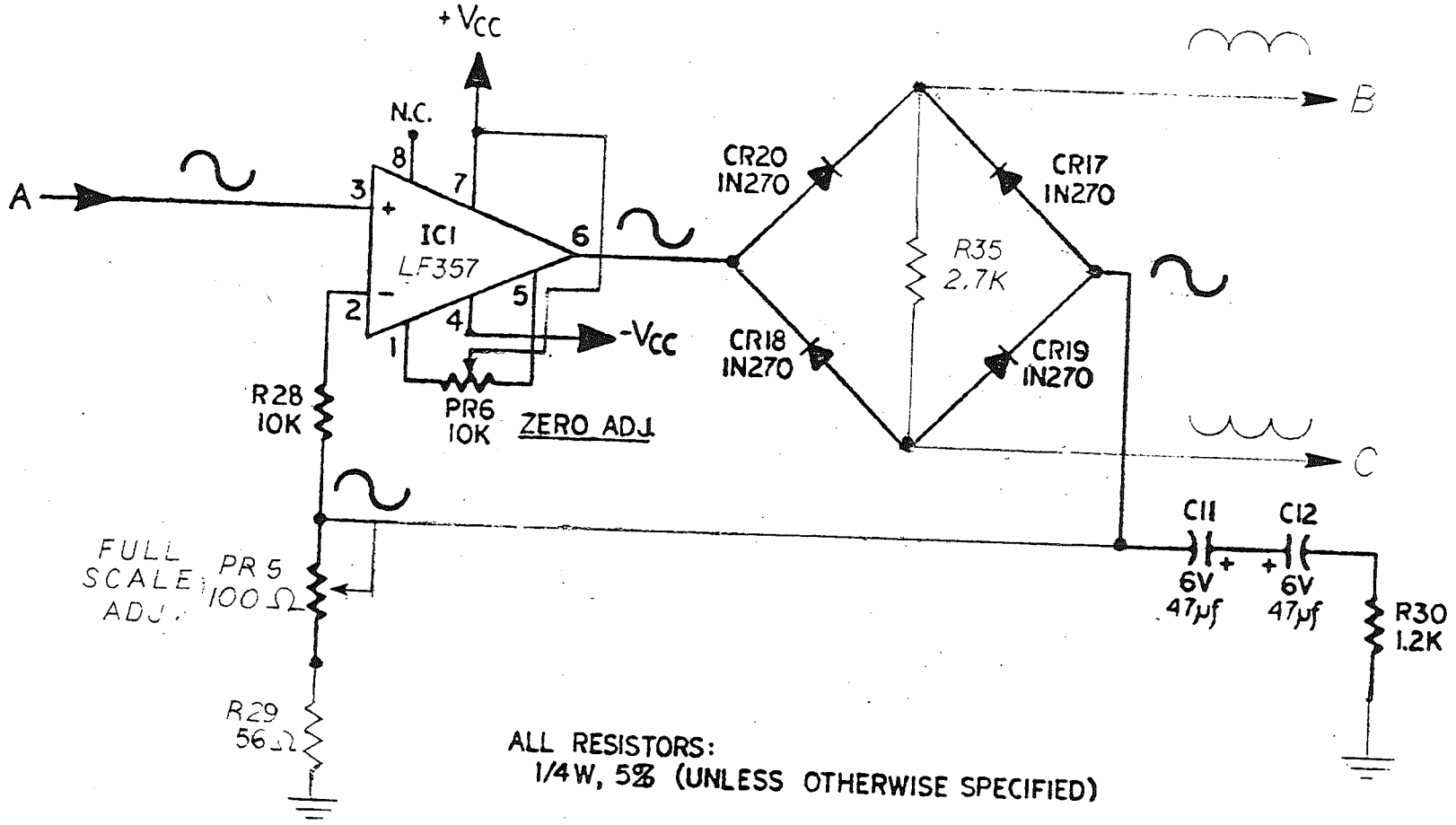
PART I



ALL RESISTORS:
1/4 W, 5% (UNLESS OTHERWISE SPECIFIED)

AC-DC AMPLIFIER

PART II



ALL RESISTORS:
1/4W, 5% (UNLESS OTHERWISE SPECIFIED)

AUTORANGING CIRCUIT

BASIC OPERATION:

The Autoranging Circuit employed in the BET-300A is basically an automatic attenuator that reduces the meter current by a factor of ten when a preset signal level is exceeded. Two LEDs are used to indicate which range has been selected.

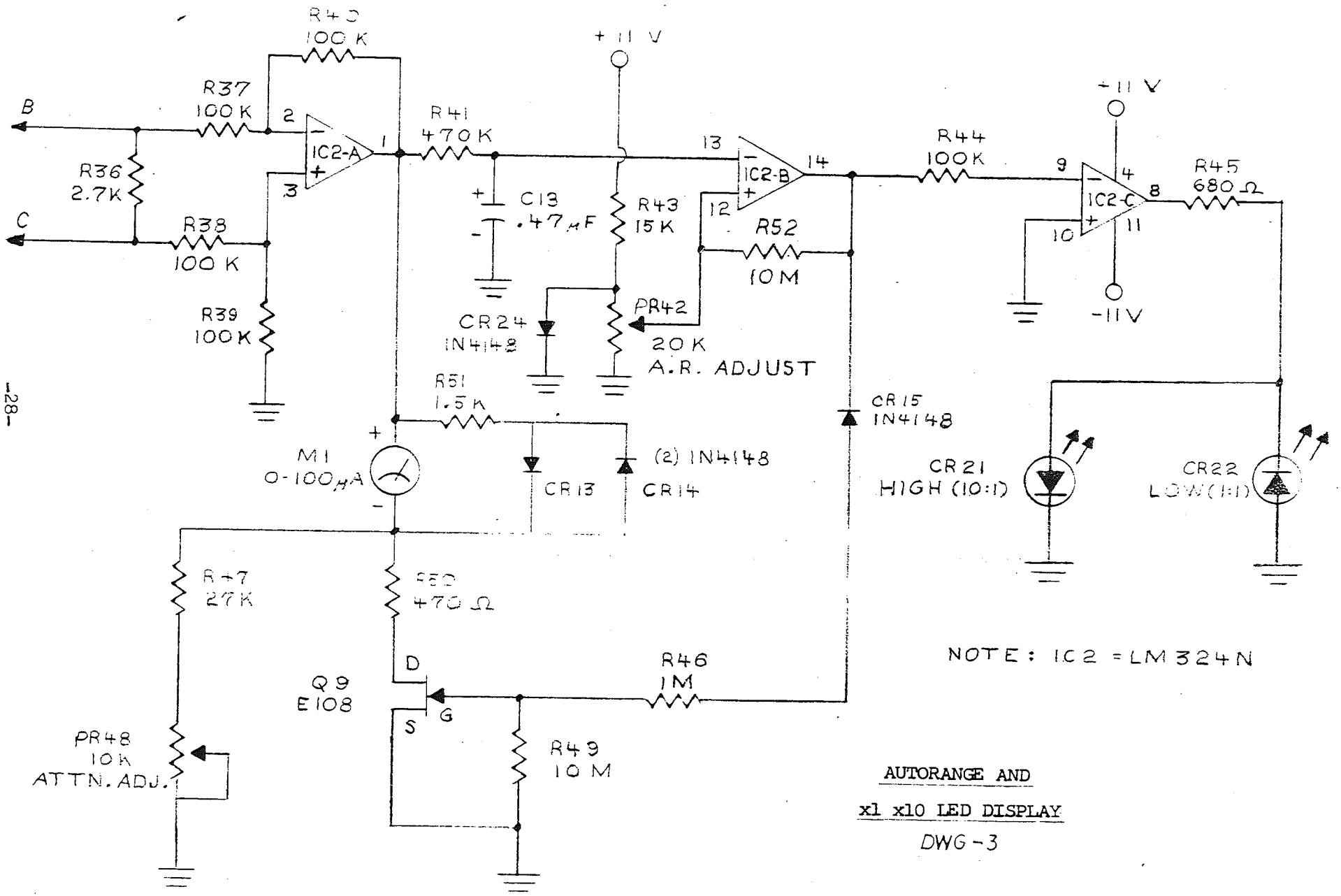
DETAILED OPERATION:

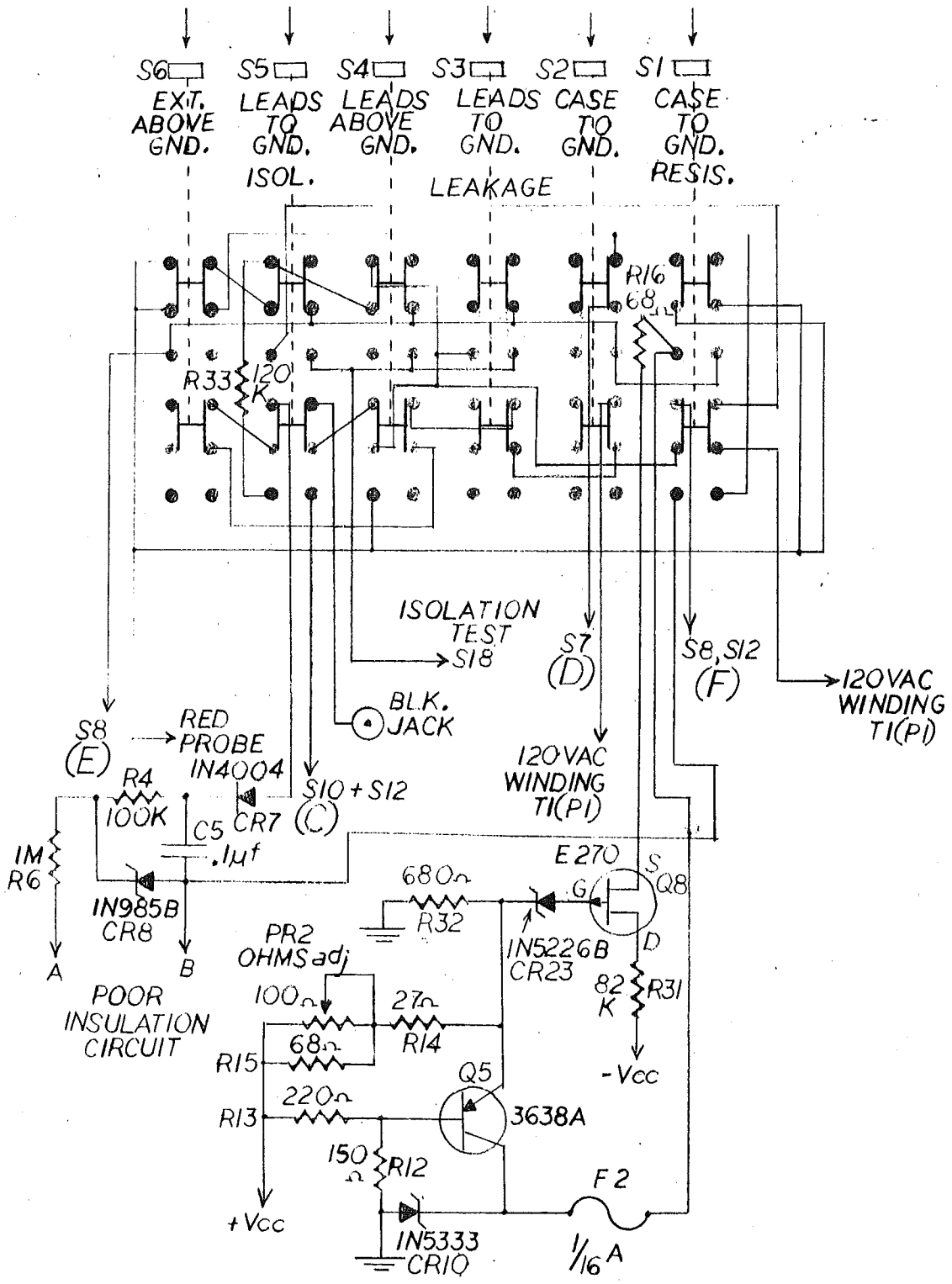
The differential, rectified output of IC-1 and the corresponding bridge circuit is ground referenced by unity gain differential amplifier IC-2A. The output of this stage drives a low pass filter and a threshold detector and is also used to drive the meter.

In the Low (or x1) range, the DC level at pin 13 of IC2-B is less than that at pin 12. The output of this op amp is approximately +10 volts. This causes CR-15 to be reverse biased and Q-9 to be in a low resistance state. Current through meter M is determined by the voltage at pin 1 of IC2-A and the series combination of R-50 and Q-9.

When the input signal causes the DC level at small L pin 13 of OC2-B to exceed the level at pin 12, this op amp switches Low, to approximately -4 volts. This forward biases CR-15 and pinches off Q-9 through R-46. Current through the meter is now determined by the voltage at pin 1 of IC2-A, and the series combination of R-47 and R-48. Trimpot R-48 allows adjustment of series resistance in high range to achieve exactly 10:1 attenuation. Trimpot R-42 sets autoranging threshold to correspond to full scale meter deflection in the Low range.

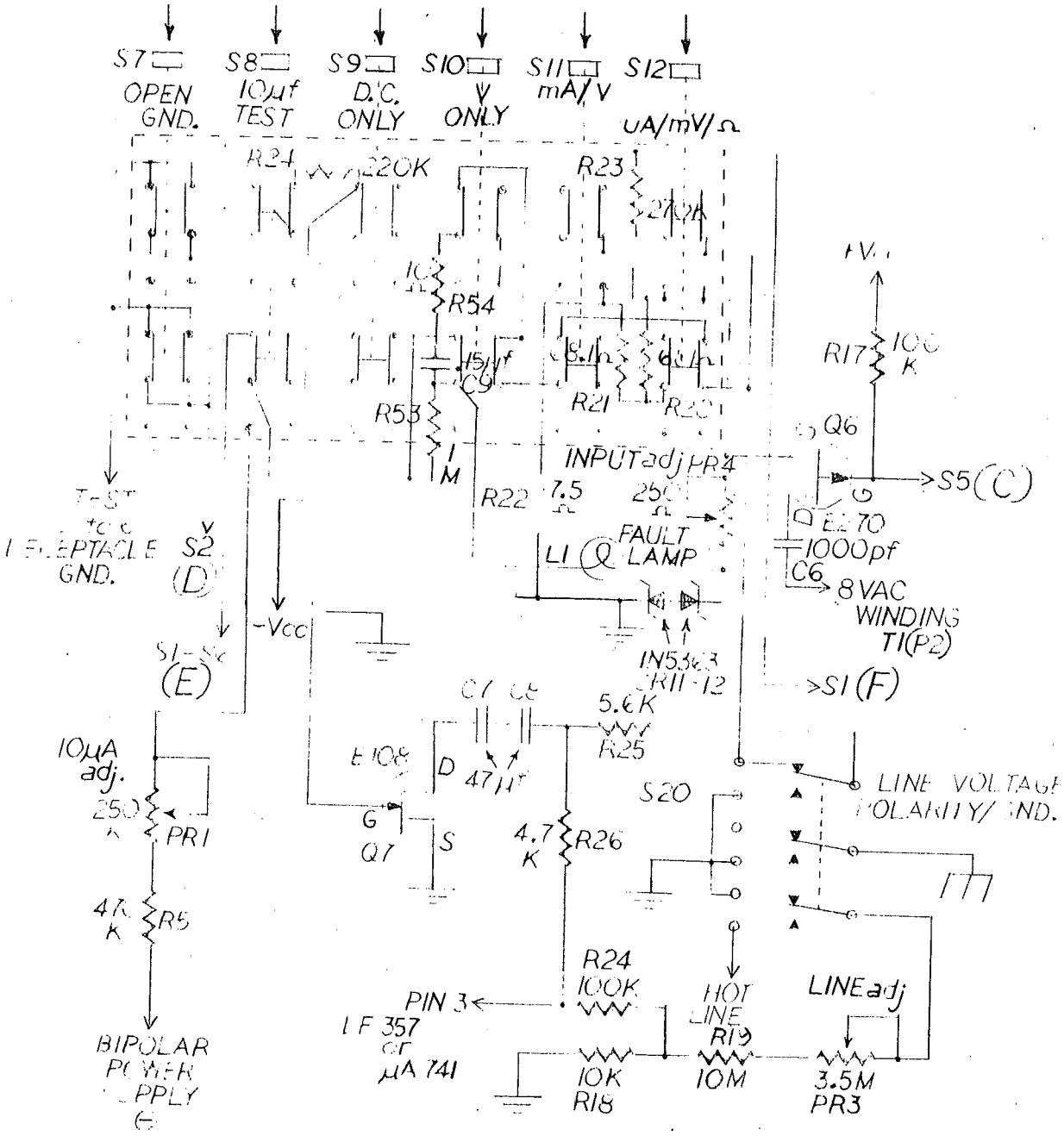
Op amp IC2-C is used as a comparator to drive the x1 and x10 indicator LEDs.


R40
100 K
+11 V
R37
100 K
B
2
IC2-A
1
R41
470 K
13
IC2-B
14
R44
100 K
+11 V
9
4
IC2-C
8
R45
680 Ω
R36
2.7K
3
C13
.47μF
R43
15 K
12
R52
10 M
C
R38
100 K
10
11
-11V
R39
100 K
CR24
IN4148
PR42
20 K
A.R. ADJUST
R51
1.5 K
CR15
IN4148
M1
0-100μA
CR13
(2) IN4148
CR14
CR21
HIGH (10:1)
CR22
LOW (1:1)
R47
27K
R50
470 Ω
D
R46
1M
Q9
E108
S
G
PR48
10K
ATTN. ADJ.
R49
10 M
NOTE: IC2 = LM324N
AUTORANGE AND
x1 x10 LED DISPLAY
DWG-3



TEST 1-6 PUSHBUTTONS

DWG-4



RANGE, D.C. ONLY, 10µA TEST, OPEN GND. PUSH-BUTTONS

DWG-5

LINE CHECK

BASIC OPERATION:

The circuit, in conjunction with the AC-DC amplifier, indicates whether or not the power receptacle is grounded and if the hot and neutral of the receptacle have been reversed. If the receptacle is properly wired, the unit meter will indicate the AC line voltage.

DETAILED OPERATION:

The circuit consists of a variable voltage divider using PR3, R18, and R19. The AC voltage developed across R18 is then applied, through R24, to the AC-DC amplifier. Adjustment for correct line voltage indication is made by adjusting potentiometer PR3.

RELATED CALIBRATION PROCEDURE STEPS: 18 to 22

RESISTANCE MEASUREMENT

BASIC OPERATION:

The resistance measurement circuit consists of a fused 40 mA DC constant current source which is applied to the unknown resistance, the generated voltage across the resistance being measured by the AC-DC amplifier. Four terminal measurement techniques are employed with the use of a special circuit to compensate for switch contact resistances.

DETAILED OPERATION:

A 40 mA DC current is provided at the collector of Q5, which is connected as a constant current source. The voltage at the emitter of Q5 is determined by the voltage divider R12, R13. The value of current is determined using the emitter voltage and the resistance network R14, R15 and PR2. Adjustment of the collector current to 40 mA is made by adjusting PR2.

F2 and CR10 provide line voltage protection to Q5.

Compensation for switch contact resistance is accomplished by applying negative DC current to the input of the AC-DC amplifier through Q8 and R31 in conjunction with -Vcc. This offsets the positive voltage produced across the switch resistance.

R32 and CR23 provide bias to Q8 using the voltage produced at the emitter of Q5. Q8 is used to switch the negative offset current out of the circuit whenever fuse F2 opens. When F2 opens, the voltage at the emitter of Q5 increases to 3.4V to breakdown the 3.3V zener diode CR23 and bias off Q8. This prevents negative current from flowing to the AC-DC amplifier and causing the meter to indicate as if F2 were still intact.

RELATED CALIBRATION PROCEDURE STEPS: 23 → 29

RESISTANCE MEASUREMENT

TROUBLE SHOOTING:

POSSIBLE CAUSES based on the assumption that all related wiring has been checked, and all switches placed in the proper operating positions.

PROBLEM	POSSIBLE CAUSE
1. F2 blows	Q5 shorted.
2. Meter won't indicate zero ohm (0 Ω)	Q8 not conducting. Bad probe connections.
3. Meter operates normally with F2 removed	CR10, 23 open. Q8 shorted.
4. No meter indication adjustment	PR2 bad.
5. Improper meter indications	F2 blown. +Vcc missing.
6. No meter indication	Q5 open.

INSULATION RESISTANCE TEST

BASIC OPERATION:

The test circuit consists of a regulated 100VDC supply, a series dropping resistor and a voltage threshold detection circuit across the unknown insulation resistance. Whenever the insulation resistance is less than 500 KΩ the detection circuit lights a LED. which indicates POOR INSULATION.

DETAILED OPERATION:

The 100VDC regulated supply consists of the 120VAC from the secondary isolation winding of T1, the half wave rectifier and filter CR7, C5, current limiting resistor R4, and 100 volt zener diode regulator CR8.

Voltage is applied to the GROUNDING TEST 1 receptacle through the series dropping resistors R6 and R8 to form a voltage divider with the insulation resistance of the equipment being plugged into the receptacle. The voltage dropped across the receptacle is proportional to the value of insulation resistance of the equipment under test.

In parallel with the receptacle connections, is the 24V threshold detection circuit. The circuit is a modified Schmitt trigger with a threshold level of 3.6V in series with a 20V zener diode (CR9) to raise the effective input threshold level to approximately 24 volts. Threshold circuitry is composed of input transistor Q3, threshold determining voltage divider R10, R9, output transistor Q4, negative feedback resistor R10, and output indicator light emitting diode CR16.

RELATED CALIBRATION PROCEDURE STEPS: 30 → 31

INSULATION RESISTANCE

TEST TROUBLE SHOOTING:

POSSIBLE CAUSES based on the assumption that all related wiring has been checked, and all switches placed in the proper operating positions.

PROBLEM	POSSIBLE CAUSE
1. F1 blows	T1 120 VAC winding shorted. C5 shorted.
2. Poor insul. light remains on	100 VDC missing. CR9 open. Q3, 4 bad.
3. 100 VDC missing	T1 120 VAC winding open. CR7 open. CR8 shorted.
4. Poor insul. lights only at values less than 100K Ω	CR9 shorted. CR8 open. Q3 bad.
5. Poor insul. won't light, rest of circuit ok	CR16 bad. No + Vcc. Q4 bad.

ISOLATION TEST

BASIC OPERATION:

In this circuit, a low leakage 120VAC isolation transformer winding in series with the 1 K Ω AC-DC amplifier input, is connected between ground and the patient leads of the equipment under test to measure induced AC leakage currents from various leads to ground.

DETAILED OPERATION:

The circuit is the series path consisting of the 120VAC secondary isolation winding of T1, the 1K Ω input resistance of the AC-DC amplifier, the 120 K Ω current limiting resistor, and the unknown lead to ground impedance of the equipment under test.

The secondary isolation winding of T1 exhibits it's own capacitive leakage current of approximately 4uA. In order for the unit meter to read zero leakage current with an infinite value of lead to ground impedance, the offset voltage produced by the offset current must be reduced to zero at the amplifier input by applying a current value of 4uA with a phase angle 180^{o} out from that of the T1 leakage current.

This counteracting current is provided at the input to the AC-DC amplifier by placing a reactive component (C6) between the input and a source of AC voltage which has a phase angle of 180^{o} to that which is causing the T1 offset current. The counteracting circuit is composed of the capacitor C6, the 16VAC center tapped secondary winding of T1, and circuit switch Q6, which is controlled by S5.

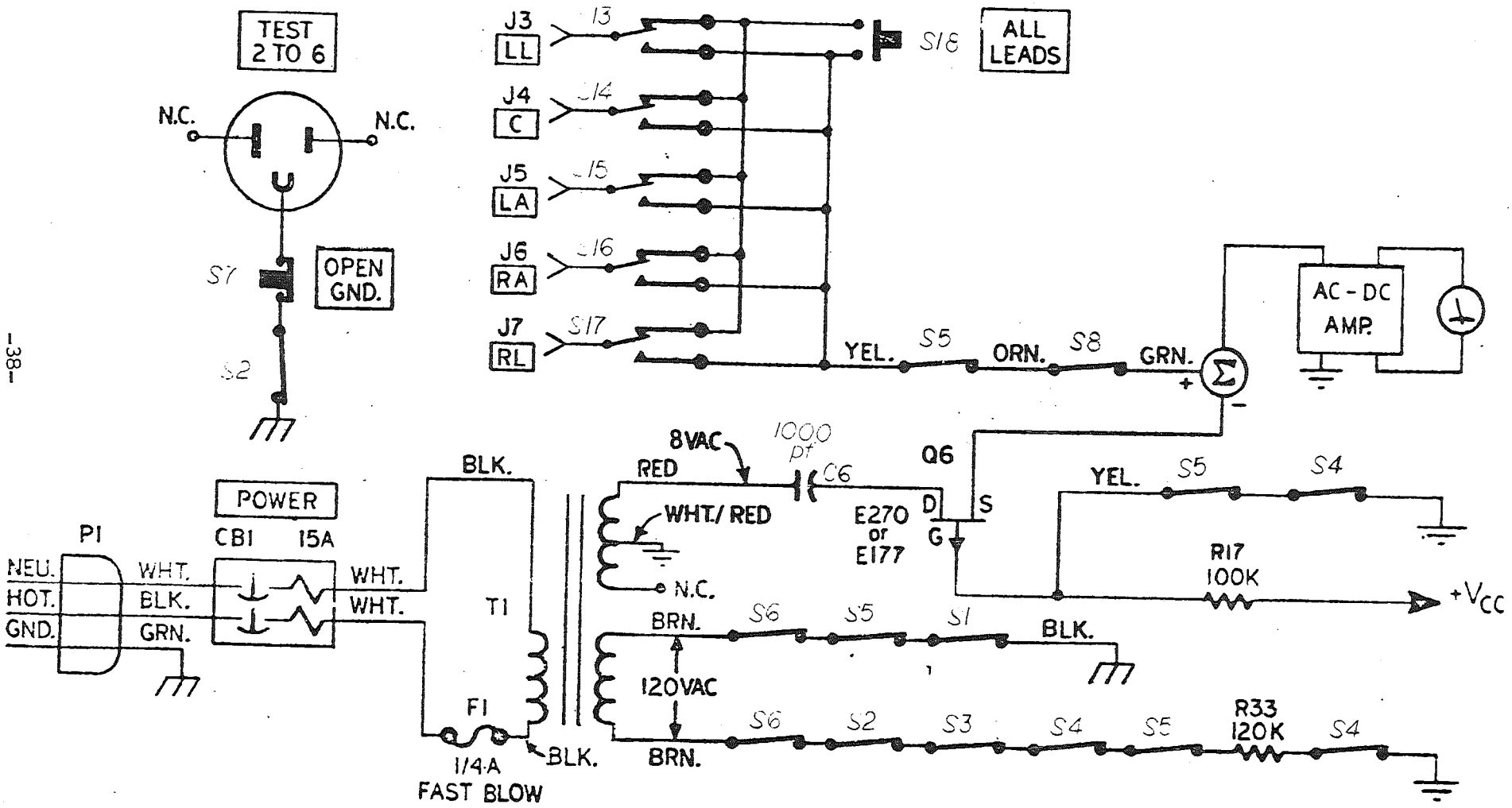
Detailed operation - continued

The appropriate phase angle is determined experimentally by transposing the red leads of the secondary winding of T1 until the unit meter reads zero leakage current.

RELATED CALIBRATION PROCEDURE STEPS: 36 → 50

ISOLATION TEST

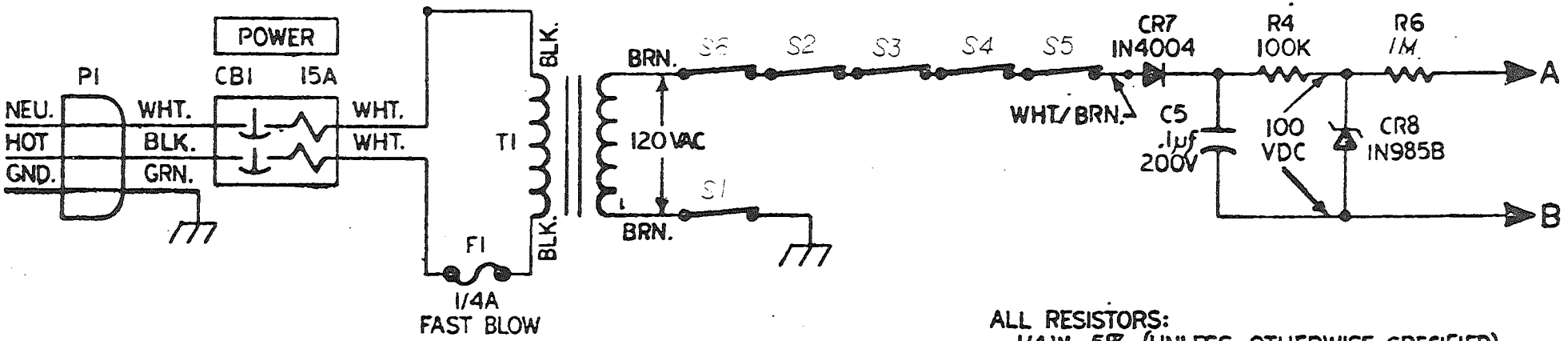
D.U.T.



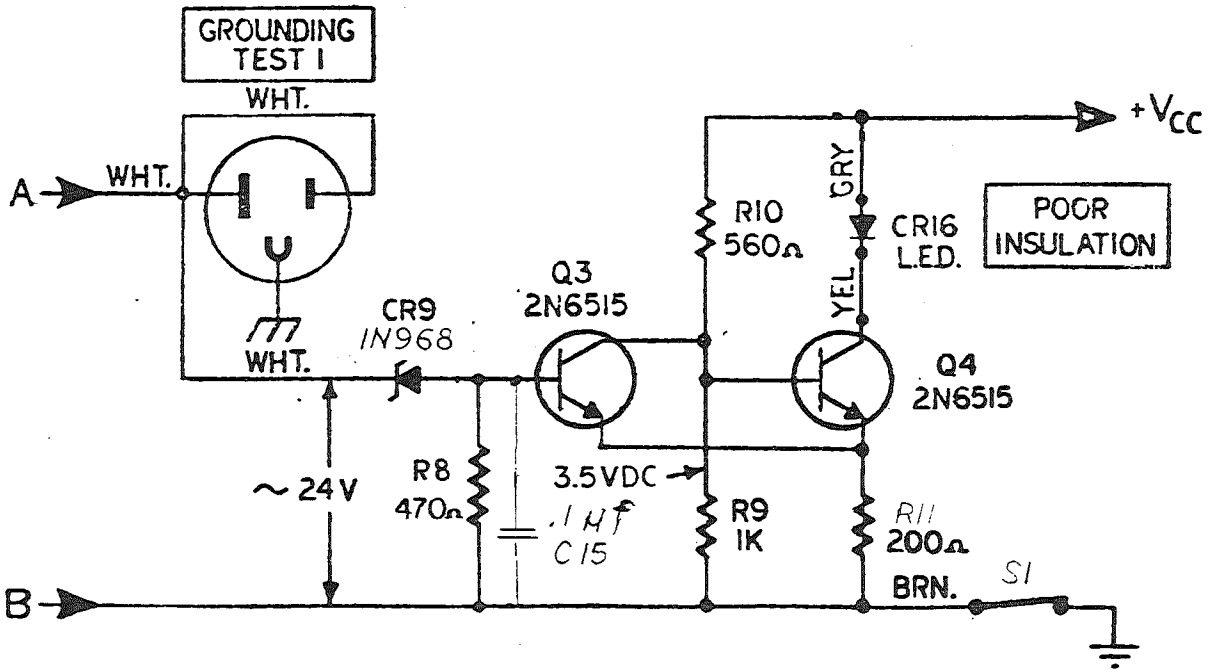
ALL RESISTORS:
1/4 W, 5% (UNLESS OTHERWISE SPECIFIED)

INSULATION RESISTANCE TEST

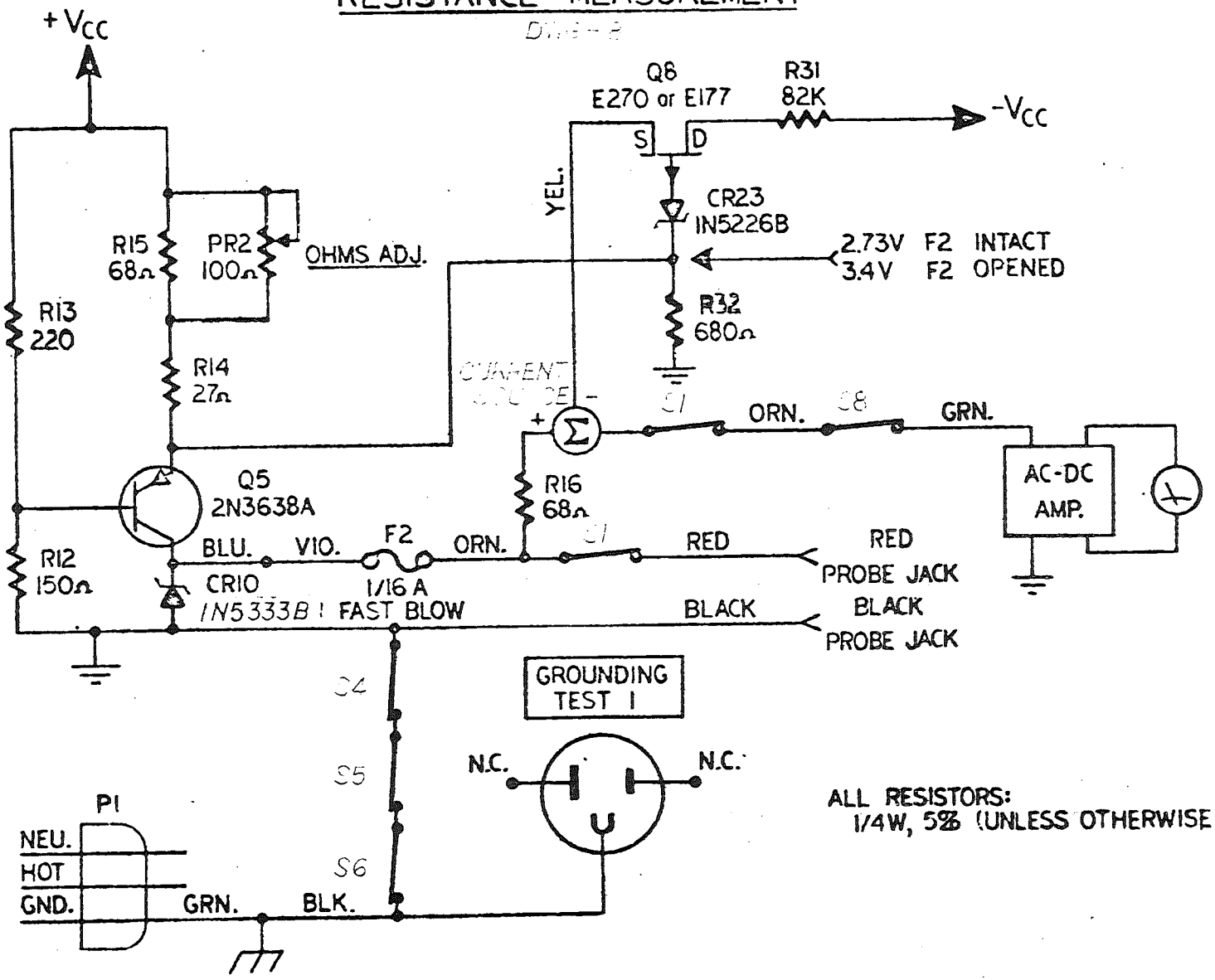
DW -1



ALL RESISTORS:
1/4 W, 5% (UNLESS OTHERWISE SPECIFIED)



RESISTANCE MEASUREMENT



ALL RESISTORS:
1/4W, 5% (UNLESS OTHERWISE SPECIFIED)

OPERATING NOTES - BIOMEDICAL ELECTRICAL TEST SET - MODEL BET-300AL

Before proceeding with tests, turn POWER on. Depress LINE VOLTAGE POLARITY/GND. switch. Read line voltage in upper meter scale and Polarity OK. Next, check TEST 10uA with uA/mV/Ω selector depressed. While making TESTS 1 to 6, the TEST 2 pushbutton of the isolated power system switch of TEST 7 LIM is to be depressed.

STEP 1a) GROUNDING. Tested in non-energized receptacle. Plug in E. U. T. Depress CASE TO GND. (Switch 1) and the uA/mV/Ω selector. Check calibration by touching the red probe to 0.25-ohm jack. Measure grounding resistance by touching the red probe to E. U. T. case. Read 0.5 ohm or 5 ohms, Autorange, F. S.

STEP 1b) POWER SIDE INSULATION. Tested in non-energized receptacle. If grounding is OK, turn on the power switch of E. U. T. The POOR INSUL. light will come on if the combined hot and neutral to ground resistance is approximately 500 kilohms or less. U-blade ground reference is used, therefore, black probe is not required in STEP 1.

STEP 2) LEAKAGE FROM CASE TO GROUND. Plug E. U. T. into energized receptacle STEPS 2 to 6. Depress CASE TO GND. (Switch 2). Depress uA/mV/Ω selector switch to read 20uA and 200uA, Autorange, F. S.; if meter overranges, depress mA/V selector switch to read 2mA and 20mA, Autorange, F. S. Check calibration with the TEST 10uA pushbutton.

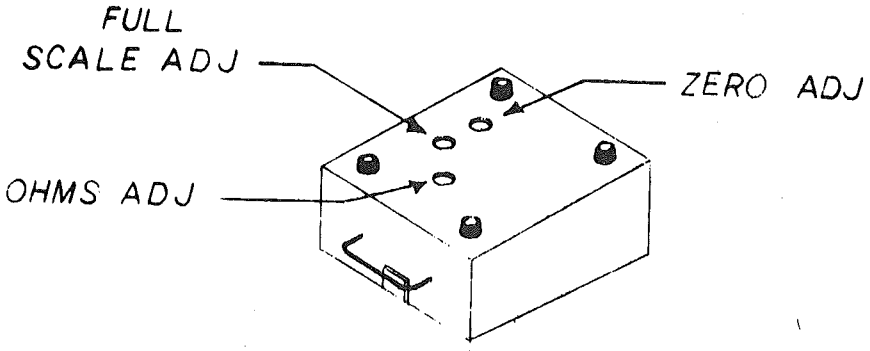
STEP 3) LEAKAGE FROM LEADS TO GROUND. Connect ECG leads to binding posts. Depress LEADS TO GND. (Switch 3). Place selector switch in uA/mV/Ω position. Depress the ALL LEADS pushbutton to read total lead leakage-to-ground. Individual leakages may be read by depressing the pushbutton beside each patient lead.

STEP 4) LEAKAGE BETWEEN LEADS ABOVE GROUND. Depress LEADS ABOVE GND. (Switch 4). Place selector switch in uA/mV/Ω position. Touch the red probe to one patient lead post (for example, LL) and depress the pushbuttons beside each other lead in sequence.

STEP 5) ISOLATION OF LEADS TO GROUND. Depress LEADS TO GND. (Switch 5). Place selector switch in uA/mV/Ω position. Push each of the five lead pushbuttons and record the highest reading. Isolation impedance equals 120 volts, divided by the leakage reading.

STEP 6) EXTERNAL ABOVE GROUND. Depress EXT. ABOVE GND. (Switch 6). Use the black and red probes to measure current or voltage between any conductive surfaces. The meter is floating above ground during this test, with an effective isolation over 10 megohms. To measure voltage (20V/200V), depress the V ONLY selector switch. The input impedance is 1 megohm in the V ONLY position.

STEP 7) ISOLATED POWER SYSTEM TEST. Depress CASE TO GND. LEAKAGE (TEST 2) pushbutton and LEAKAGE LINE 1 & 2 switch in TEST 7-LIM. Next, depress the mA/V selector switch. Autorange is 2 to 20 milliamperes, F. S. Read leakage-to-ground with the polarity switch in Normal (Line 1) and Reverse (Line 2) positions. Depress the TRIP ALARM pushbutton and turn TRIP CURRENT knob slowly clockwise until LIM alarm sounds, then depress the READ ALARM pushbutton. Take readings with the polarity switch in Normal and Reverse positions.

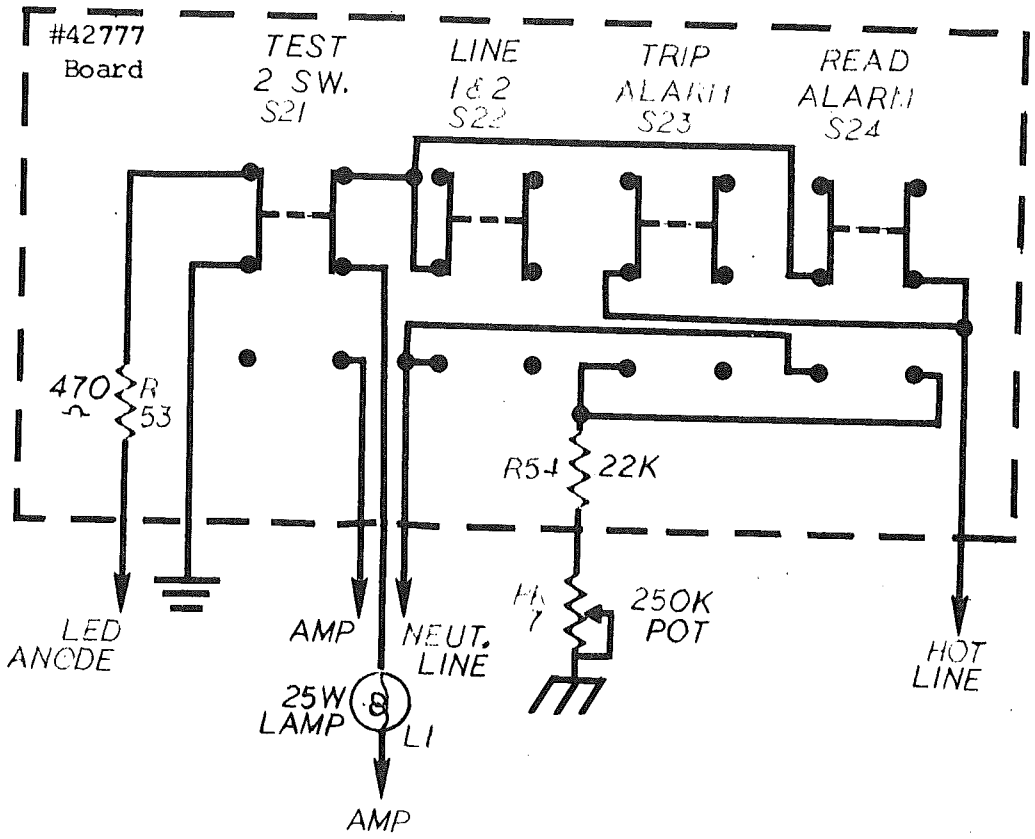


BOTTOM VIEW OF MODELS BET-300A AND BET-300AL

CALIBRATION

DWG-9
SCHEMATIC OF

TEST 7 LINE ISOLATION MONITOR



Isolated Power System. Test Form F-64L. In some C.C.U. and I.C.U. areas, and in most operating rooms, isolation transformers are used to reduce explosion and shock hazards caused by sparking, ground faults, and leakage currents. In an isolated power system, neither of the two power-carrying wires is connected to ground, as opposed to a grounded system which has one side of the line (neutral) connected to ground at the service entrance. On an isolated system, we refer to the power-carrying wires as Line 1 and Line 2. NFPA requires continuous monitoring of the isolation of the transformers, to determine the total amount of current flowing to ground due to leakage currents. This monitoring device originally called a "ground fault detector" is now called a "line isolation monitor" (LIM). This monitor measures and displays the total hazard current to ground, that is, the leakages produced by the transformer, wiring, connected load, as well as the leakage of the detector itself. The total hazard current to ground is also referred to as "total hazard index." A practical alarm point value is established by Code, beyond which, the isolation of the system is no longer considered to be safe. In earlier Codes, it was 2 to 5 milliamperes. Now it is between 0.7 and 1 milliampere plus the current used by the LIM which can be up to 1 milliampere therefore allowing between 1.7 and 2.0 milliamperes before alarm.

II. PRELIMINARY TEST PROCEDURE

Before proceeding, disconnect patient from equipment that is plugged into the isolated power system.

Since portable equipment adds leakage, disconnect all equipment from the power system. This allows the operator to record leakage values which will reflect the actual condition of the isolation transformer, LIM, and associated power wiring.

III. USE TEST FORM F-64L

1. Audible Alarm: Depress the LIM testbutton. When audible alarm activates, push the silence button to mute the alarm. Check the appropriate sections of the F-64L test form.

2. Visible Indicators:

   A.) Green is normally illuminated when leakage is under specified alarm point.

   B.) Red: Illuminates during alarm condition in conjunction with the audible alarm.

   C.) Yellow: When depressed, indicates that the audible alarm is disabled during a first fault or test conditions. The red lamp should remain illuminated until the fault condition is cleared.

3. Line Isolation Monitor Reading (LIM). Always record the meter reading under the same load conditions. This reading indicates the degree of hazard which may exist if someone would accidentally contact either one of the power lines and the ground at the same time. The meter reading may vary depending upon various conditions, such as, humidity, insulation, and the leakages caused by load on the line. Record the Alarm Point specified by the manufacturer of the Line Isolation Monitor (typically 1.7 to 2 milliamperes) and the LIM reading on Test Form F-64L.

4. Isolated power system leakage to ground. Leakage Line 1 and 2. The purpose of this test is to check the current from each side of the line to ground with a meter that simulates the patient. This is a suggested test in all cases either to check the calibration of the LIM meter or to verify acceptable leakage levels in power systems with no display meter.

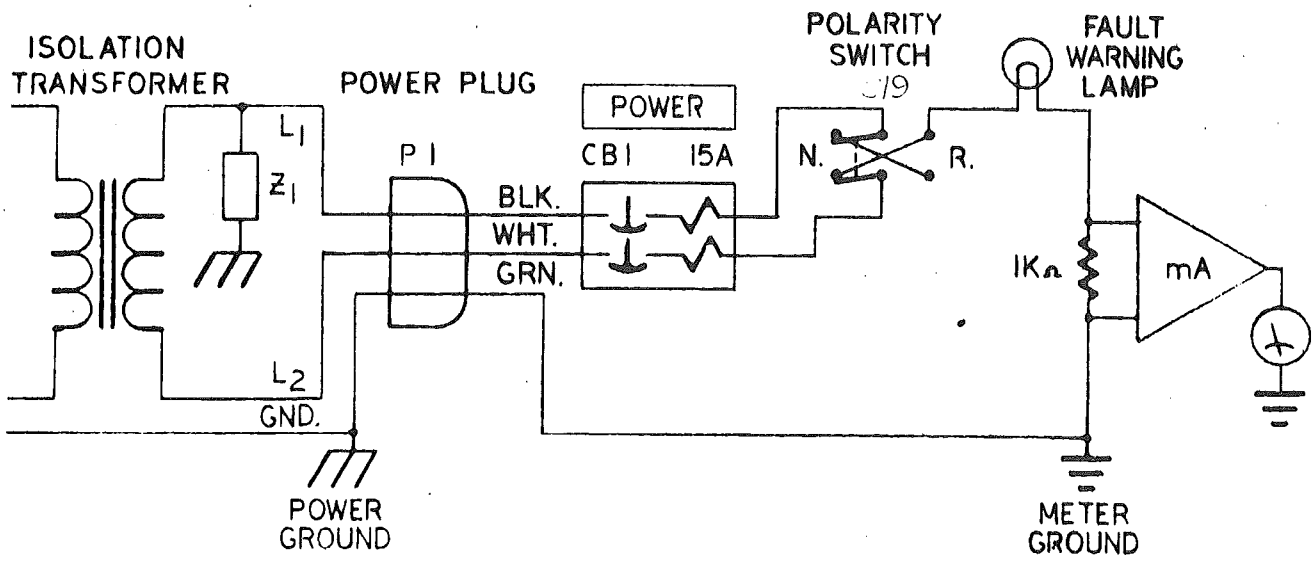
Procedure: Insert BET-300A power plug into the isolated power system to be tested, place polarity switch (S19) in the center off position. Turn on power breaker (CB-1).

A.) LINE ONE LEAKAGE

1. Depress pushbutton six, external above ground.

2. Depress isolated power test selector to Leakage Lines 1 & 2.

3. Place polarity switch (S19) to the normal polarity position (line one). This inserts the meter between line two and ground. The leakage of line one completes the circuit. Silence the audible alarm and record the current reading on form F-64L. (4) To protect the BET-300A circuitry and alert the operator, the fault warning lamp above the test set meter will illuminate if a power line to ground hazard exists. However, this condition should activate the line isolation monitor as noted in previous tests.



LINE ONE: LEAKAGE

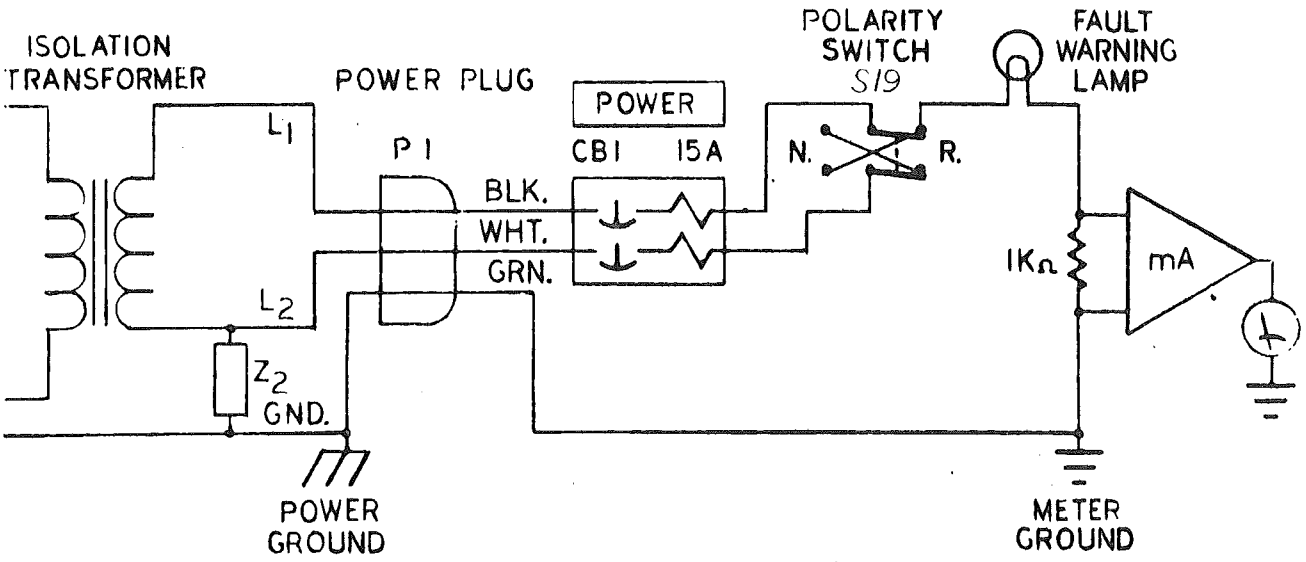
B.) LINE TWO LEAKAGE

1. Place polarity switch (S19) to the reverse position (L-2). With the meter between line one and ground, the circuit is completed by the leakages from line two to ground.

2. Silence audible alarm.

3. Record current reading on form F-64L.

4. Return polarity switch (S-9) to the center off position.



LINE TWO: LEAKAGE

5. Trip Alarm Current: During this test either power line can be faulted to ground through a resistive network consisting of a 250 kilohm potentiometer, PR-7, and a 22 kilohm resistor R-54 to provide an approximate injection current from 0.5 to 5.0 milliamperes.

In the Trip Alarm position the fault is placed between ground and the line selected by the polarity switch (S19).

When the trip current control potentiometer PR-7 is rotated clockwise, the fault current is increased. If provided, observe the panel mounted line isolation monitor meter until the alarm point is reached and both the audible and visible alarms are activated. Silence the audible alarm.

Depress the isolation test selector knob to the Read Alarm position. This places the meter input between the line opposite of the resistive fault and ground.

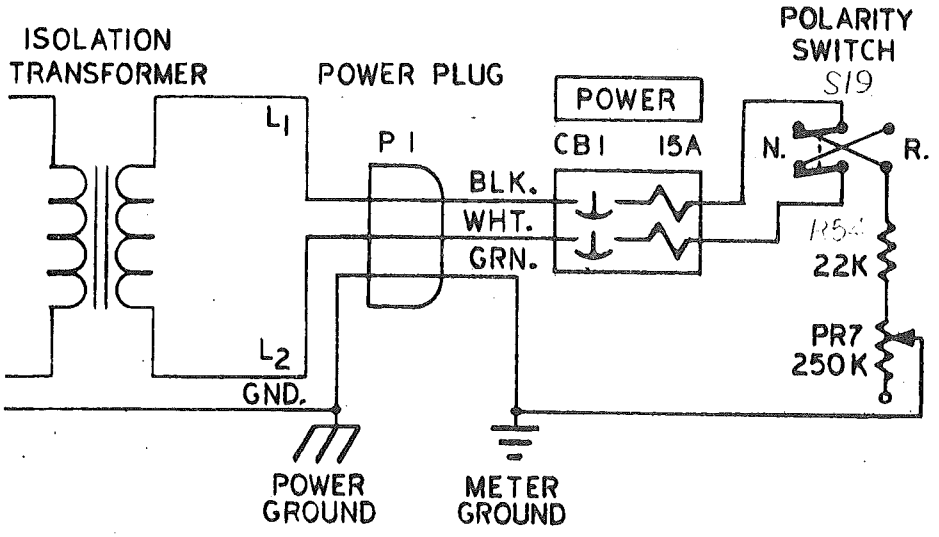
LINE ISOLATION ALARM TRIP POINT.

A. LINE ONE

1. Depress the isolation test knob to the trip alarm position.

2. Select normal (Line One) with the polarity switch (S19).

3. Rotate the trip current potentiometer PR-7 clockwise until the line isolation monitor alarm activates.

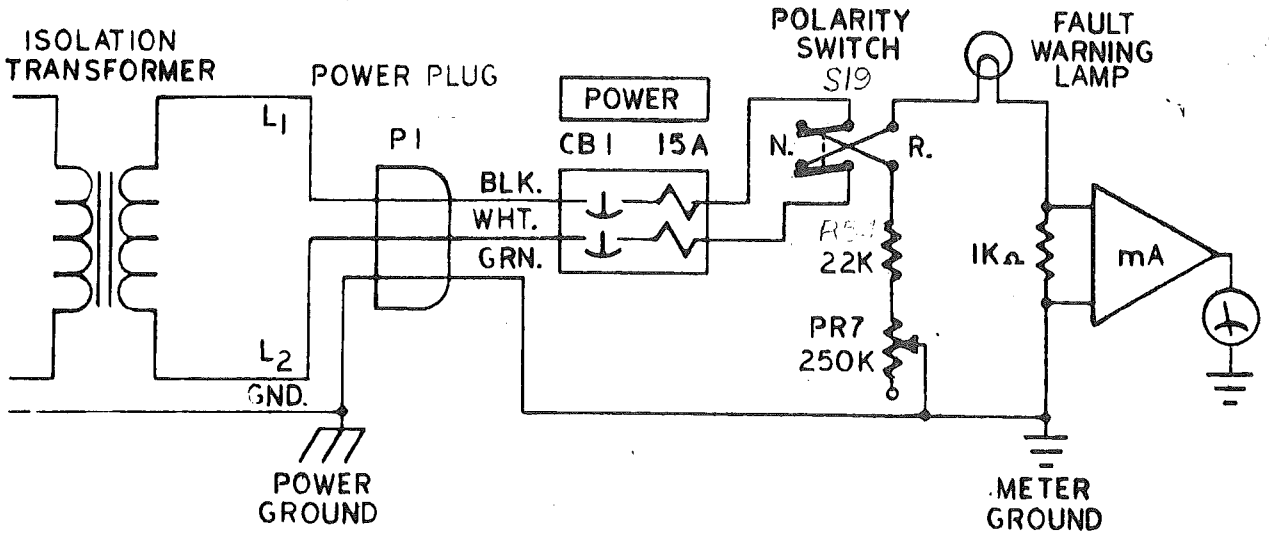


LINE ONE: TRIP ALARM

4. Depress the isolation test knob (S24) to the Read Alarm position.

5. Record the line isolation monitor trip current on the Form-64L.

6. Return the polarity switch (S19) to the center off position.



LINE ONE: READ CURRENT

7. Depress the isolation test selector knob (S23) to the trip alarm position.

8. Rotate the trip current potentiometer fully counterclockwise.

B. LINE TWO

1. Select reverse (Line Two) with the polarity switch (S19).

2. Repeat steps A-3 to A-6.

6. Panel Breakers. Check for proper functioning and identification of circuit breakers in each branch circuit. Record on Test Form F-64L.

7. Emergency Isolated Power. Power transfer to the emergency power should occur in less than 10 seconds. Record the information as shown on Test Form F-64L.

IV - ADDITIONAL OPERATIONAL CHECKS FOR BET-300AL

1. Unplug safety meter.
2. Remove 1/4 amp. fuse from rear of unit.
3. Place ON-OFF switch in "ON" position.
4. Select "CASE TO GND LEAKAGE" function.
5. Depress "LINE 1 & 2" pushbutton.
6. Connect a low-current ohmmeter bewteen the hon and gnd. blades of the unit's AC plug.
7. With the polarity switch in "NORMAL" position, the meter should indicate infinite resistance.
8. With the polarity switch in "REVERSE" position, meter should read 1K ±5%.
9. Now connect the ohmmeter between the neutral and ground blades.
10. With polarity switch in "NORMAL" position, meter should read 1K ±5%.
11. With polarity switch in "REVERSE" position, the meter should indicate infinite resistance.
12. Depress trip alarm.
13. Set the polarity switch to "REVERSE".
14. Place ohmmeter between neutral and gnd. blades of unit's AC plug.
15. With "TRIP CURRENT" control fully counterclockwise, the ohmmeter should read 270 kilohms.
16. With the "TRIP CURRENT" control fully clockwise, the ohmmeter should read 22 kilohms.
17. Connect the ohmmeter between the hot and gnd. blades.
18. Place the polarity switch in the "NORMAL" position.
19. Repeat steps 15 and 16.

TEST FORM F-64L
LOCATION_____

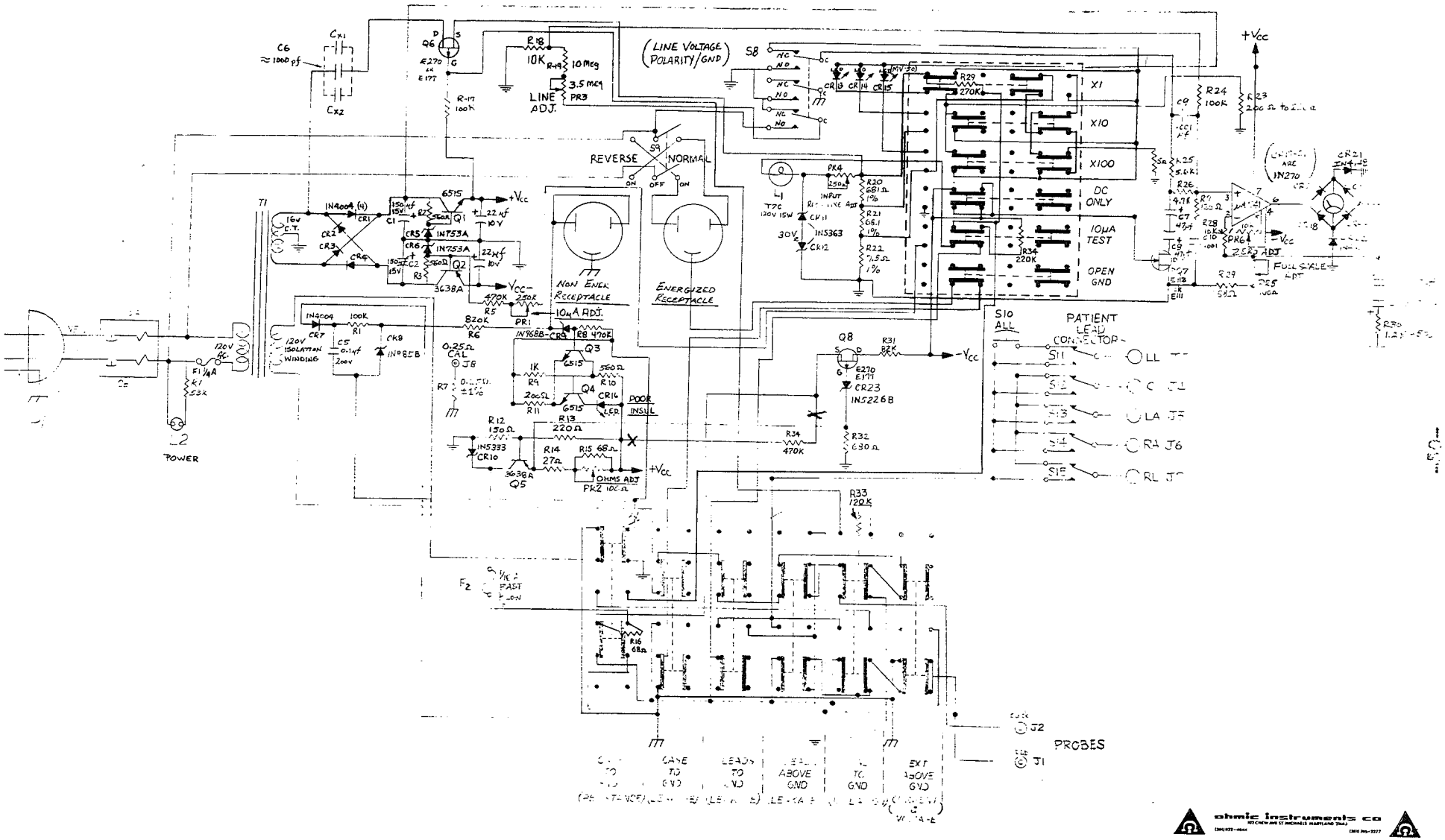
ISOLATED POWER SYSTEM

INSTRUMENTS REQUIRED:
Model BET-300AL, Model IPS-10 or equivalents.

CAUTION: THESE TESTS ARE NOT TO BE CONDUCTED WHILE PATIENTS ARE CONNECTED TO ANY EQUIPMENT PLUGGED INTO THE ISOLATED POWER SYSTEM.

TEST DATE						
INITIALS						
1.	AUDIBLE AND VISIBLE INDICATORS	SELF TEST				
		SILENCE/MUTE				
2.	*Check provided box if indicator is operational	RED (HAZARD)				
		GREEN (SAFE)				
		YELLOW (SILENCE)				
3.	LINE ISOLATION MONITOR	MANUFACTURER'S SPECIFIED ALARM POINT (mA)				
		METER READING (mA)				
4.	ISOLATED POWER SYSTEM LINE LEAKAGE TO GROUND NOTE: Disconnect all portable equipment from system during test	LINE ONE (mA)				
		LINE TWO (mA)				
5.	ALARM POINT	LINE ONE (mA)				
		LINE TWO (mA)				
6.	ARE ALL BREAKERS OPERATIONAL AND CIRCUITS LABELED?					
7.	EMERGENCY POWER	Turn on time (sec)				
		Areas supplied				
		Emergency lighting				
		Total capacity (kw)				

NOTES_____



BET 300 New diagram to follow

ohmic instruments co

USING THE BIOMEDICAL ELECTRICAL TEST SET, MODEL BET-300A
SHORT OPERATING NOTES

Before proceeding with tests, plug the BET-300A into a wall receptacle, turn POWER on and check the line voltage, wall polarity, and grounding by momentarily depressing the LINE VOLTAGE POLARITY/GND. switch.

STEP 1a) GROUNDING. Tested in non-energized receptacle. Plug in E. U. T. Depress CASE TO GND. (Switch 1) and the uA/mV/Ω Selector. Check calibration by touching the red probe to 0.25-ohm jack. Measure grounding resistance by touching the red probe to E. U. T. case. Read 0.5 ohm or 5 ohms, Autorange, F. S.

STEP 1b) POWER SIDE INSULATION. Tested in non-energized receptacle. If grounding is OK, turn on the POWER switch of E. U. T. The POOR INSUL. light will come on if the combined hot and neutral-to-ground resistance is approximately 500 kilohms or less.

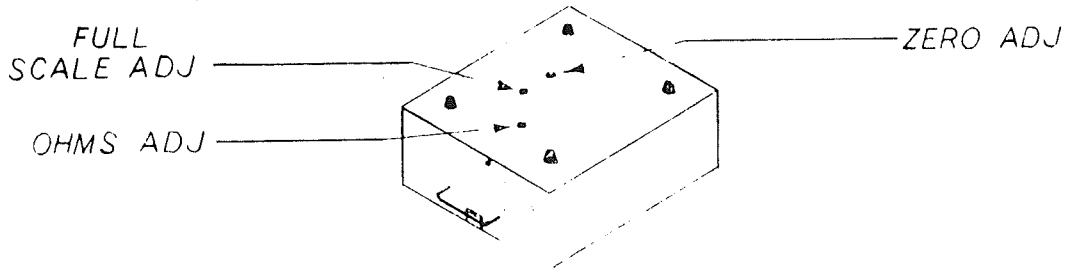
STEP 2) LEAKAGE FROM CASE TO GROUND. Depress CASE TO GND. (Switch 2). Depress uA/mV/Ω selector switch to read 20uA and 200uA, Autorange, F. S; if meter overranges, depress mA/V selector switch to read 2mA and 20mA, Autorange, F. S. Check calibration with the TEST 10uA pushbutton.

STEP 3) LEAKAGE FROM LEADS TO GROUND. Connect ECG leads to binding posts. Depress LEADS TO GND. (Switch 3). Place selector switch in uA/mV/Ω position. Depress the ALL LEADS pushbutton to read total lead leakage-to-ground. Individual leakages may be read by depressing the pushbutton beside each patient lead.

STEP 4) LEAKAGE BETWEEN LEADS ABOVE GROUND. Depress LEADS ABOVE GND. (Switch 4). Place selector switch in uA/mV/Ω position. Touch the red probe to one patient lead post (for example, LL) and depress the pushbuttons beside each other lead in sequence.

STEP 5) ISOLATION OF LEADS TO GROUND. Depress LEADS TO GND. (Switch 5). Place selector switch in uA/mV/Ω position. Push each of the five lead pushbuttons and record the highest reading. Isolation impedance equals 120 volts, divided by the leakage reading.

STEP 6) EXTERNAL ABOVE GROUND. Depress EXT. ABOVE GND. (Switch 6). Use the black leads and the red probe to measure current or voltage between any conductive surfaces. The meter is floating above ground during this test, with an effective isolation over 10 megohms. To measure voltage (20V/200V) , depress the V ONLY selector switch.



CALIBRATION -- BOTTOM VIEW OF BET-300