TM

AMPHENOL

OPERATING
SERVICE
MANUAL

FIELD
EFFECT
TRANSISTOR
VOLTOHMMETER

MODEL 870

MILLIVOLT COMMANDER

WARRANTY

The manufacturer warrants equipment manufactured by it to be free from defective material or factory workmanship and agrees to repair such equipment, which, under normal use and service, disclose the defect to be the fault of the manufacturer. Under this warranty, the manufacturer's obligation is limited to repairing equipment which proves to be defective, when returned transportation prepaid, within 90 days from the date of original purchase, and provided the registration card has been filled in and returned within 10 days of original purchase.

This warranty does not apply to any equipment which has been repaired or altered by unauthorized persons or service stations in any way so as, in our judgment, to injure its stability or reliability, or which has been subject to misuse, negligence, or accident, or which has had the serial number altered, defaced or removed. Neither does this warranty apply to any equipment which has been connected, installed, adjusted otherwise than in accordance with the instructions furnished by the manufacturer. Accessories, including all vacuum tubes and semiconductors not of our manufacture, used with this equipment are not covered by this warranty.

The manufacturer reserves the right to make changes in the design of any product and to make additions or improvements to any product without incurring any obligation to modify any units previously sold.

This warranty is in lieu of all other warranties expressed or implied, and no representative or person is authorized to assume for the manufacturer any other liability in connection with the sale of its equipment.

RETURNING EQUIPMENT FOR REPAIR

When returning any equipment for service, under warranty or otherwise, send equipment prepaid to your nearest Amphenol Service Agency of the Amphenol Distributor Division, 2875 S. 25th Avenue, Broadview, Illinois 60153. For the name of your nearest Amphenol Service Agency, contact your Amphenol Distributor or Amphenol Field Sales Office.

Transportation cost on returned equipment must be prepaid by the owner. The manufacturer will pay transportation cost from the company back to the owner on equipment under warranty only. All correspondence pertaining to repairs should be addressed to the company, as above, and marked attention: Service Department.

REGISTRATION CARD

The above warranty is contingent upon the attached registration card being returned to the factory within 10 days of the date the equipment was purchased.

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Figure 1-1. Model 870

SECTION I

GENERAL INFORMATION

1-1. PURPOSE

The Model 870 Millivolt Commander is an electronic high sensitivity voltmeter designed to measure a wide range of AC and DC voltages, and resistance.

1-2. CHANGES

At the time of publication of this manual, no modifications had been made to the equipment. A supplement or change sheet may be included with this manual to reflect any changes required during the life of the equipment.

1-3. SPECIFICATIONS

POWER SOURCE:

Batteries:

2 "AA" 1.4v Mercury cells
Eveready E9 or equivalent.

8 "AA" 1.35 to 1.5v cells
Eveready 915 or equivalent.

DC VOLTMETER - +DCV, -DCV

Ranges:

0- 0.1, 0.3, 1.0, 3.0, 10., 30., 100., 300., 1000.

Accuracy:

±2% of full scale all DC ranges.

Input Resistance:

10.6 megohms on all ranges.

AC Rejection:

A voltage at 60 Hz 40 dB greater than full scale affects reading less than 1%.

AC VOLTMETER - ACV, dB

Ranges:

0- .01, .03, 0.1, 0.3, 1.0, 3.0, 10., 30., 100., 300.

-40, -30, -20, -10, 0, +10, +20, +30, +40, +50 dB
(-12 to +2 Scale).

Accuracy:

±3% of full scale on all ranges from 50 Hz to 50 KHz.

Input Impedance:

10 mv to 1 v
10 megohm shunted by 31 pf.

3 v to 300 v
10 megohm shunted by 20 pf.

OHMMETER

Resistance Range:

Resistance from 10 ohm center scale to 10 megohms center scale.

Accuracy:

±3 degrees of arc.

Voltage:

1.5v open circuit.

WEIGHT

With batteries - 5 Lbs.
Without batteries - 4.5 Lbs.
Shipping - 8.5 Lbs.

OVERALL SIZE

9-1/4 x 5-3/4 x 6-3/8

1-4. LIST OF EQUIPMENT SUPPLIED

1 ea.	Model 870 Part No.	111530
1 ea.	Instruction book Part No.	111712
1 ea.	Probe assembly Part No.	111575
1 ea.	Warranty card Part No.	101598

SECTION II

OPERATION

2-1. INSTALLATION

The Model 870 is a portable instrument and can be operated in any normal environment. To place the Model 870 in operation, remove the unit from case by removing four retaining screws from instrument rear, and install batteries as described in paragraph 2-2(a).

Check meter mechanical zero adjustment with the unit OFF and the FUNCTION SWITCH to the BATTERY TEST position. To reset zero, turn the adjustment screw located at center of the meter.

2-2. BATTERIES

(a) Installation:

Install batteries, observing polarity, as shown in Figure 2-1.

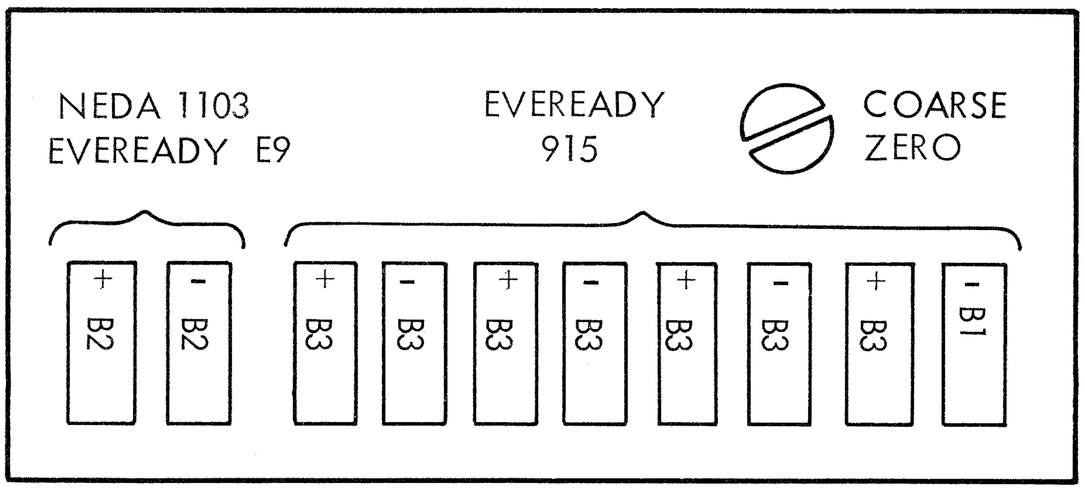


Figure 2-1. Battery Location

Set FUNCTION SWITCH to BATTERY TEST position and turn unit ON. An indication greater than the BATTERY TEST line on the meter indicates usable batteries.

Set FUNCTION SWITCH to +DCV and RANGE SWITCH to 1 KV range. Rotate panel ZERO ADJUST to right stop. Adjust COARSE ZERO CONTROL (battery compartment) for an indication of .6 on the 0-1 scale. Adjust panel ZERO ADJUST for zero indication.

(b) Replacement:

The batteries used are in three different circuits. The type, life expectancy, and quality test for each is described below:

B1 - OHMS BATTERY

Eveready Type 915 or E9 or equivalent. The ohms battery is discharged only when resistance measurements are being made. This battery should be replaced when the ohms adjust control will no longer calibrate the ohm range to full scale.

B2 - ZERO REFERENCE BATTERY

Eveready Type E9 or equivalent. The zero reference battery supplies a bias potential required by the amplifier. To eliminate drift, these cells are constantly loaded by a small current. Life of these cells is limited by chemical deterioration, not electrical discharge. They should be replaced every two years or when zero drift becomes excessive.

Eveready Type 915 or equivalent cells may be used here if a zero drift of approximately one millivolt per day can be tolerated.

B3 - AMPLIFIER SUPPLY BATTERY

Eveready Type 915, E9 or equivalent. The amplifier load is approximately 0.8 mA in the DC mode and 1.2 mA in the AC mode. Battery life is approximately 1000 hrs. Replacement is needed when battery test indication is less than BATTERY OK line.

NOTE

The battery test indicates quality of the cells in B-3 group only.

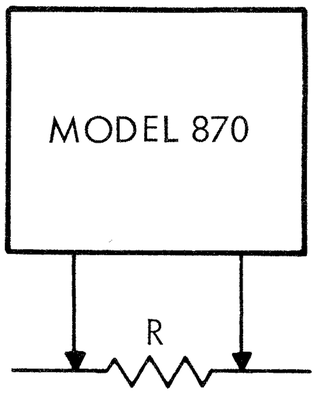
2-3. OPERATION

The high sensitivity of the Model 870 allows measurement not previously possible.

The AC sensitivity of .01V full scale allows measurement of tape head and other magnetic transducer outputs directly.

The DC sensitivity of 0.1V full scale allows measurement of semiconductor bias levels easily. More accurate nulls can be resolved. Also, current measurements can be made with little circuit disturbance.

EXAMPLE:



0.1V RANGE ON DC
.01V RANGE ON AC

To find DC current through resistor

For 1A Full Scale	R = 0.1 Ohm
100 Ma	R = 1 Ohm
10 Ma	R = 10 Ohm
1 Ma	R - 100 Ohm
100 Ma	R = 1 K

To find AC current through resistor

For 100 Ma	R = 0.1 Ohm
10 Ma	R = 1 Ohm
1 Ma	R = 10 Ohm
100 μa	R = 100 Ohm
10 μa	R = 1 K

CAUTION

THE HIGH VOLTAGES WHICH CAN BE MEASURED WITH THIS EQUIPMENT MAY BE DANGEROUS TO LIFE. EXTREME CARE SHOULD BE TAKEN TO AVOID BODILY CONTACT WITH EXPOSED HIGH VOLTAGES.

2-4. DC VOLTAGE MEASUREMENTS

1. Turn the FUNCTION SWITCH TO +DCV.

2. Turn the RANGE SWITCH to the range which will cover the voltage to be measured. If the appropriate range is unknown, choose the highest range.

3. Check the meter for zero setting. To set zero, adjust the ZERO ADJUST CONTROL with the RANGE SWITCH in the 1KV range (zero control is most sensitive on this range).

4. Set the test probe to the DC position.

5. Connect the unknown, using the black ground lead and the test probe.

6. If meter reads down scale, turn the FUNCTION SWITCH to -DCV.

7. Read the numerical value from the scale directly and apply the multiplying factor for the setting of the RANGE SWITCH.

8. NULL MEASUREMENT can be performed by setting the zero to the center scale null line with the ZERO ADJUST CONTROL. Only the 0.1, 1.0, 10, 100, and 1 KV ranges can be used for null measurement.

2-5. AC VOLTAGE MEASUREMENT

1. Turn the FUNCTION SWITCH to ACV.

NOTE

To minimize battery drain, the instrument's AC amplifier operates only in the ACV position. The turn-on transient of the amplifier will momentarily peg the meter. This, however, causes no damage to the meter.

2. Turn the RANGE SWITCH to the range which will best cover the voltage to be measured. If this is unknown, turn to the highest range.

3. Set the test probe to the AC position.

4. Connect the test probe and black ground lead to the voltage to be measured.

5. Read the numerical value from the scale directly and apply the multiplying factor for the setting of the RANGE SWITCH.

NOTE

No zero adjustment is required in the ACV function. However, stray pick-up will cause an indication on the high sensitivity ranges.

2-6. RESISTANCE MEASUREMENTS

CAUTION

BE ASSURED THAT THERE IS NO EXTERNAL POWER TO RESISTOR UNDER TEST. FALSE READINGS OR DAMAGE MAY RESULT.

1. Check meter zero on the 1KV range, +DCV function.

2. Turn the FUNCTION SWITCH to OHMS.

3. Turn the RANGE SWITCH to the range which will best cover the resistance to be measured.

4. Check for ∞ with leads open. To reset, adjust the OHMS ADJUST CONTROL.

5. Set the test probe to OHMS.

6. Connect the unknown resistance between the test leads, making sure that it is isolated from any other circuit components which might introduce error.

7. Read the numerical value from the scale directly and apply the multiplying factor for the setting of the RANGE SWITCH.

NOTE

With the test lead shorted in the Rx1 range, the test lead resistance is indicated on the meter. This resistance should be subtracted from the value measured.

2-7. dB MEASUREMENTS

The DECIBEL SCALE can be used to determine power level based on 0 dB = 1 mW in 600 OHMS. The Operation of the Model 870 is the same as in paragraph 2-5. The numerical value is indicated by meter scale and added to the dB value for the position of the RANGE SWITCH.

Refer to Figure 2-2 for decibel correction for impedances other than 600 ohms.

The following formula or Figure 2-3 can be used to convert the dB reading into watts:

$$P_{(watts)} = (1 \times 10^{-3}) \text{ antilog } (dB/10)$$

$$P_{(mw)} = \text{antilog } (dB/10)$$

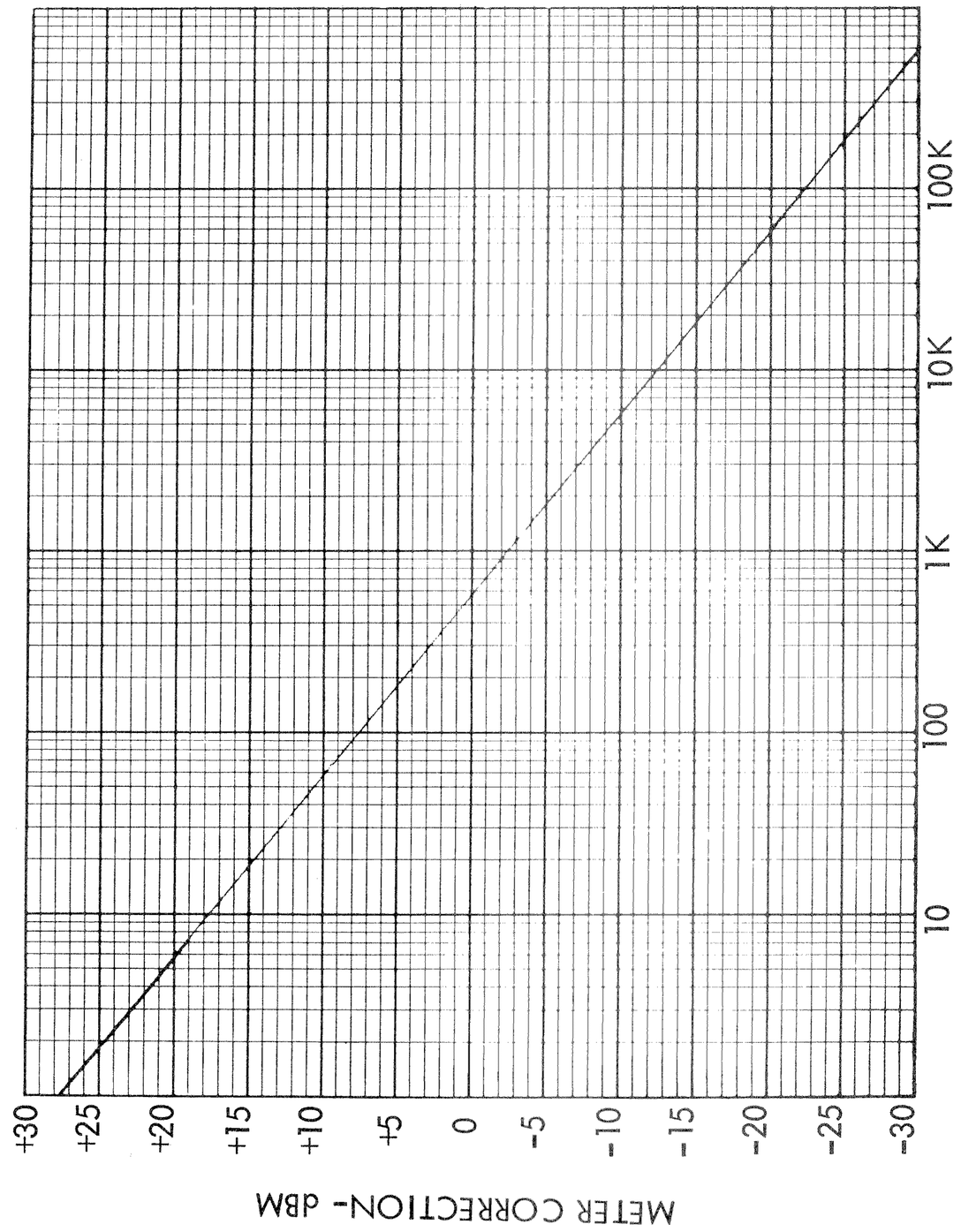


Figure 2-2. dB Correction Chart

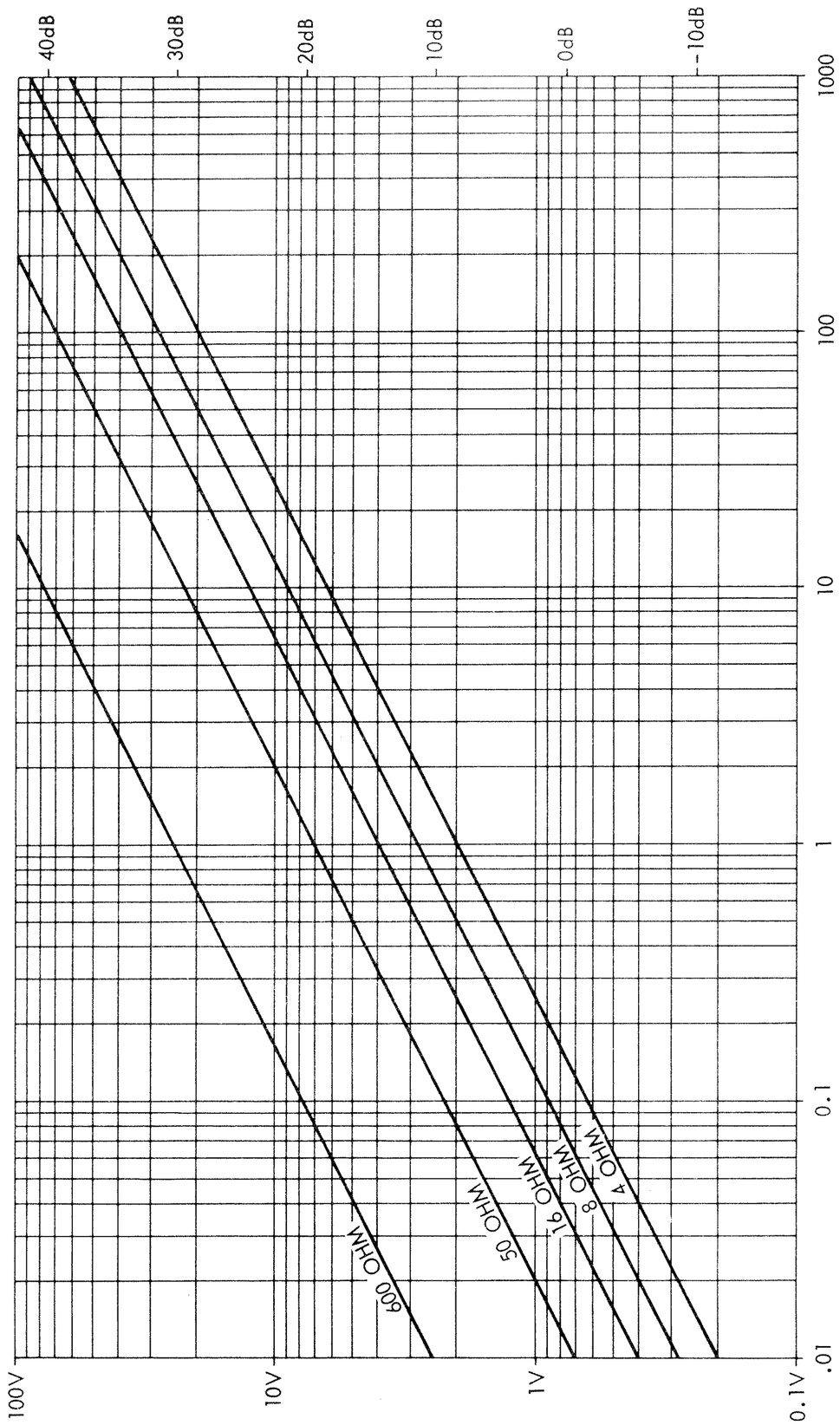


Figure 2-3. Voltage Vs Power

SECTION III

CIRCUIT DESCRIPTION

3-1. GENERAL

In the DC mode of operation, an amplifier using a field effect transistor at the input provides impedance conversion and drives the meter. Precision voltage dividers extend the range from the basic 100 mv sensitivity and permit resistance measurement. In the AC mode, an additional amplifier provides the necessary gain for 10 mv sensitivity.

3-2. DC VOLTMETER

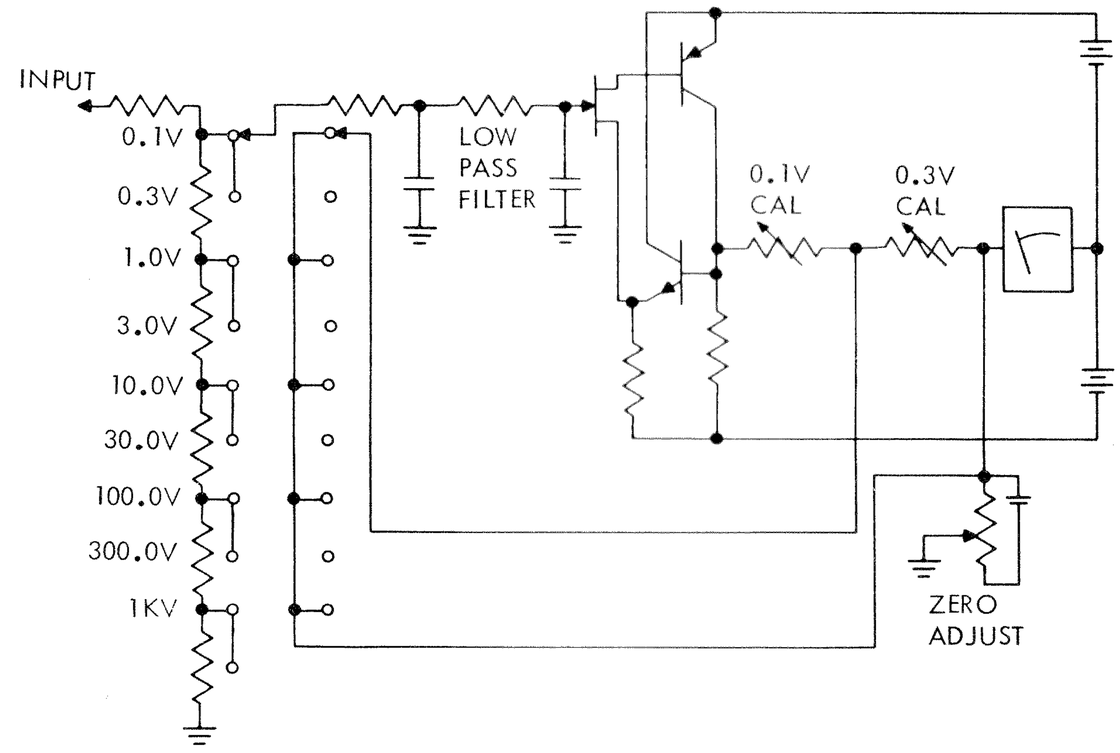


Figure 3-1. Simplified Schematic DC Voltmeter

The DC input voltage at the test probe is applied through a voltage divider to the amplifier. Basic attenuation is in decade steps, with intermediate ranges achieved by reducing amplifier sensitivity.

3-3. OHMMETER

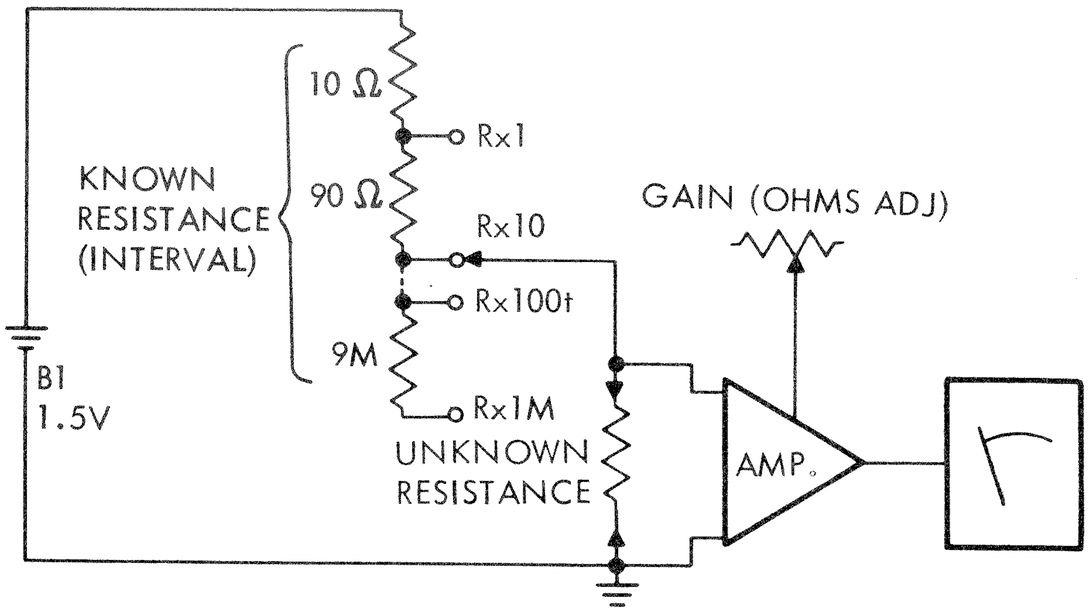


Figure 3-2. Simplified Schematic Ohmmeter

When an unknown resistance is connected across the input, it is placed in series with a portion of the voltage divider network and battery 1. The voltage drop across the known and unknown resistance is proportional to their value since the same current flows through each. The voltage across the unknown is applied to the amplifier. The meter deflection is calibrated in terms of resistance.

3-4. AC VOLTMETER

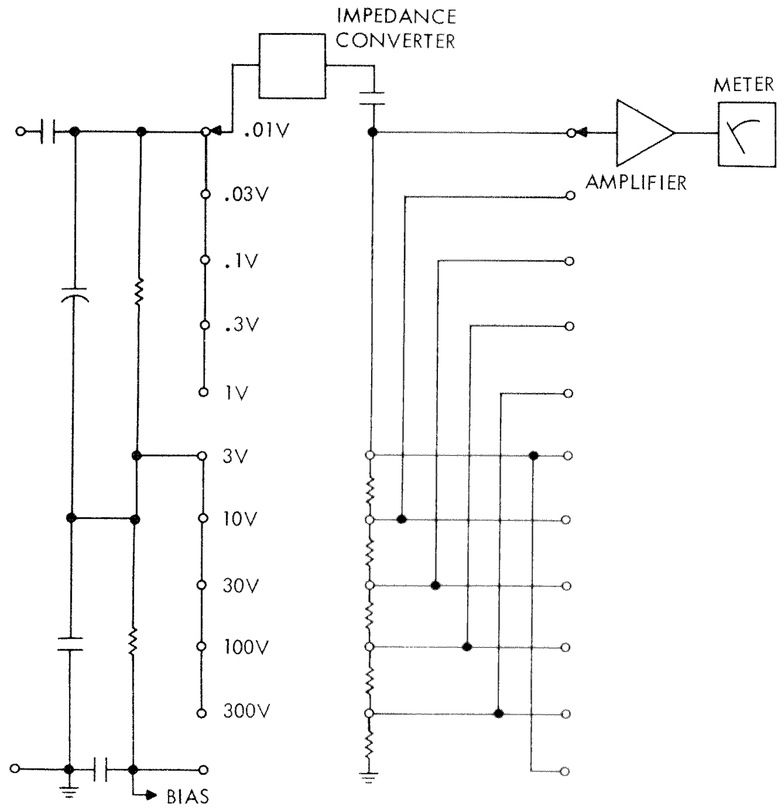


Figure 3-3. Simplified Schematic, AC Voltmeter

AC voltages less than one volt magnitude are fed directly into an impedance converter circuit. The output of this stage is attenuated to give 10 mv input to the amplifier at full scale on any range. Voltages between 1v and 300v are attenuated 50 dB by a compensated attenuator before impedance conversion.

The AC amplifier is conventional with DC feedback from Q4 emitter to Q5 base for bias stability. The output is detected by an average responding detector and applied to the meter. Current feedback from the detector to the emitter of Q5 provides gain stability and linearity.

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

This section contains testing and service information. Periodic routine maintenance required by the Model 870 is replacement of batteries.

Amphenol Distributor Division maintains complete facilities and trained personel to assist you with problems you may have with this instrument. Correspondence related to maintenance of this instrument should be addressed:

Amphenol Distributor Division
2875 South 25th Avenue
Broadview, Illinois 60153

ATTN: Service Dept.

4-2. REQUIRED TEST EQUIPMENT

1. A DC Voltage source to supply voltages from 0.1 V to 1 KV accurate within 0.5%. A Hewlett-Packard – Model 738 BR is recommended for item 1 and 2.

2. An AC Voltage source to supply voltages from .01 V to 300 V accurate within 0.5%.

3. An AC Voltage transfer standard, to produce accurate voltages over the frequency range of 10 HZ to 100 KHZ such as a Hewlett-Packard – Model 739 AR.

4. Accurate Resistors as listed:

10 OHM	±0.1%,	10K	±0.1%
100 OHM	±0.1%,	100K	±0.1%
1000 OHM	±0.1%,	1 Meg	±0.1%
		10 Meg	±0.1%

4-3. PERFORMANCE CHECK

DCV

Set controls to the 0.1 V + DCV mode. Set probe switch to DC. Check zero.

Apply rated full scale voltage to each range of the + DCV function.

The indication error shall be no greater than 2%.

Repeat above on the – DCV function.

ACV

Set controls to the .01 V ACV mode. Set probe switch to AC.

Apply rated full scale voltage to each range of the ACV function.

The indication error shall be no greater than 3%.

Set controls to the .01 V ACV mode. Probe switch remains on AC.

Using a transfer standard check frequency response from 50 Hz to 50 KHz.

The indication error shall be no greater than 3%.

OHMS

Set probe switch to OHMS.

Set controls to the 1 KV + DCV mode. Check zero.

Set controls to the Rx1 OHMS mode. Adjust OHMS ADJUST CONTROL for full scale indication.

Connect the center scale value of resistance to each range of the ohms function.

The indication error shall be less than 3 degrees of arc.

4-4. CALIBRATION

Case Removal

1. Remove four retaining screws from instrument rear.

2. Slide instrument forward out of cabinet.

3. For internal access remove the four screws from the panel extrusion.

Mechanical Zero Adjustment

1. Turn instrument off, and turn function switch to BATT TEST.

2. Rotate meter adjustment screw, located below meter face until pointer indicates zero exactly.

Electrical Zero Adjustment

1. Set the RANGE SWITCH to the 1 KV range. Adjust the COARSE ZERO ADJUST (R-20 located on housing) to yield proper front panel zero adjustment range — approximately 70% upscale on the +DCV function to 20% upscale on the — DCV function.

2. With controls set to 1 KV range and +DCV function, adjust the front panel ZERO ADJUST for zero indication exactly.

NOTE

The ZERO ADJUST CONTROL is most sensitive in the 0.1, 1, 10, 100, 1 KVDC ranges. Therefore, the most accurate zero setting can be obtained in these positions.

An incorrect mechanical zero adjustment is most often the cause of shift in zero indication between ranges or functions.

CALIBRATION

Set controls to the 0.1V + DCV mode. Set probe switch to DC.

Apply + 0.1 VDC from a calibrator and adjust R4 for exactly 1.0 indication.

Set RANGE SWITCH to the 0.3 V range.

Apply + 0.3 VDC from a calibrator and adjust R6 for an indication of 3.0 exactly.

NOTE

R4 must be adjusted before R6 for correct calibration.

Set controls to the .01 V AC mode. Set probe switch to AC.

Apply .01 VDC from a calibrator and adjust R9 for exactly 1.0 indication.

Set the range switch to the 3v range.

Using a transfer standard obtain a reference indication near full scale at a frequency of 400 Hz. Apply the exact same magnitude of signal at 20 KHz and adjust C-8 until indication is exactly as the reference reading.

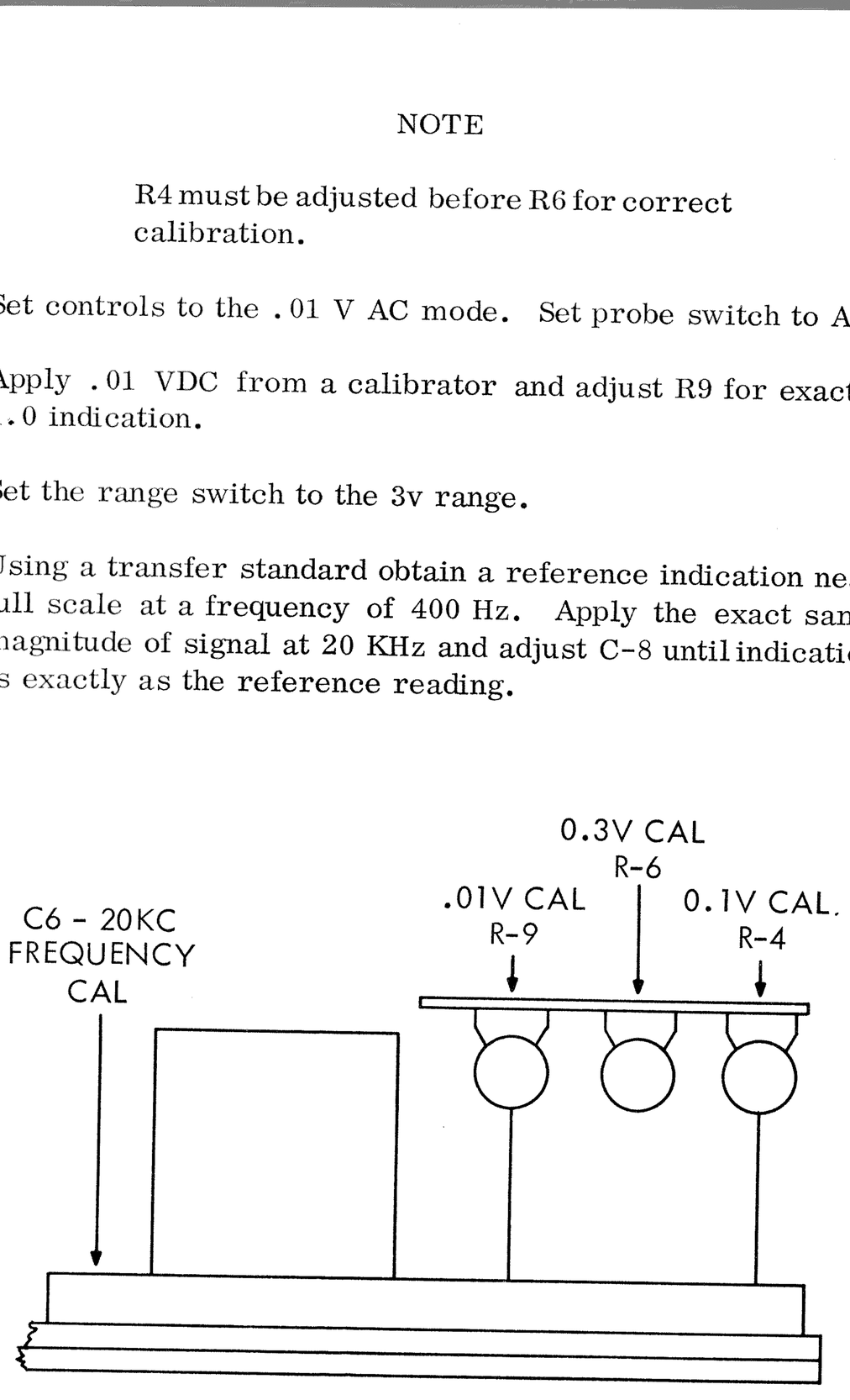


Figure 4-1. Location of Calibration Controls

4.5 TROUBLESHOOTING CHART

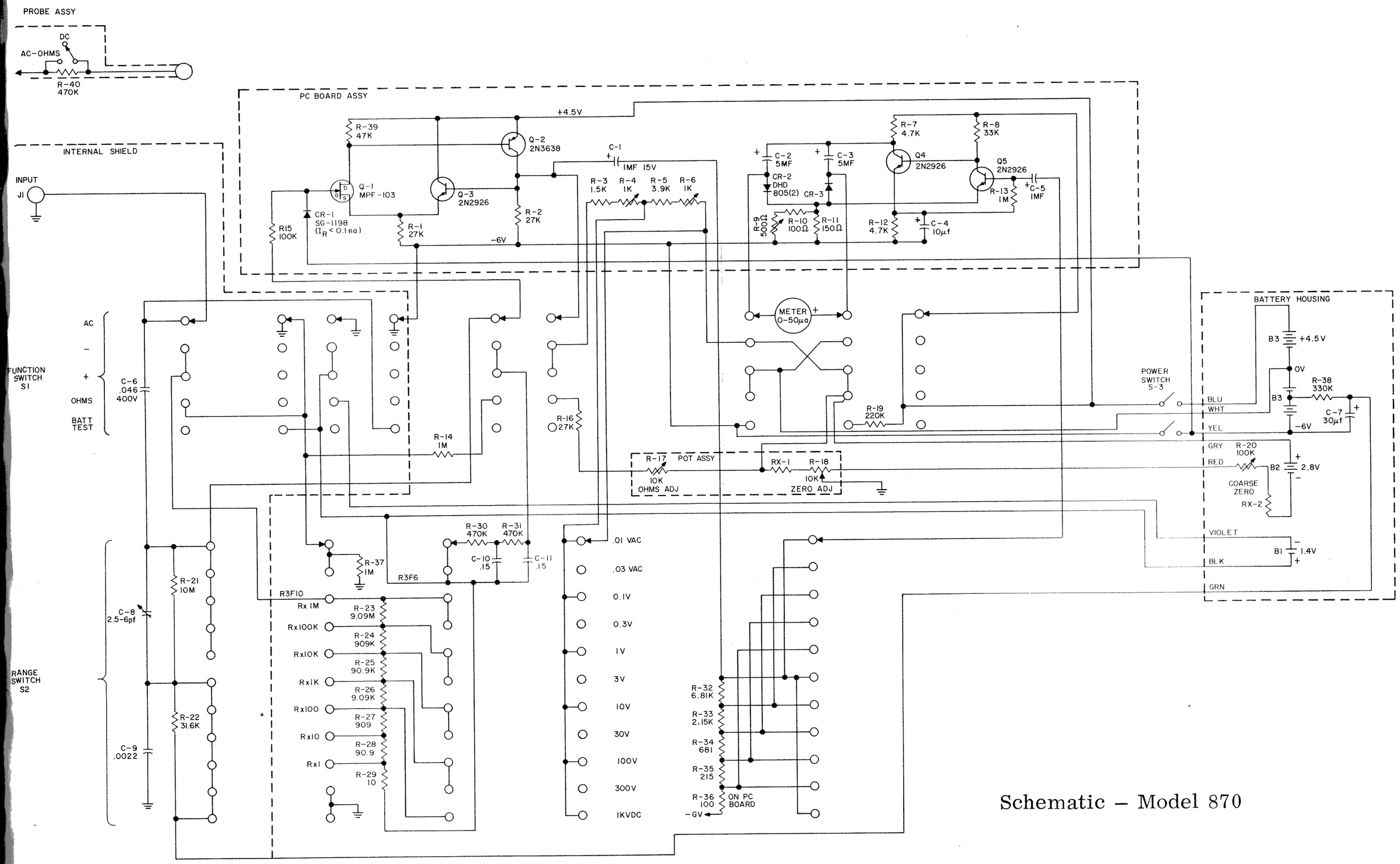
SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
Instrument inoperative or will not zero.	Incorrect coarse – zero setting.	Readjust R – 20.
	Faulty Batteries.	Check Voltage Wht – Yel 5.6 to 6V Blu – Wht 4.2 to 4.5V Blk – Violet 1.5V Each cell of B2 group 1.4V
	Faulty P. C. Board.	Check for presence of input signal at Q1 gate.
Instrument inoperative on ACV only.	Open input attenuator.	Check R – 21, R – 22 (voltage at gate of Q-1 should be approximately 4.5V).
	Faulty attenuator.	Check R – 32 thru R – 36
	Faulty AC Amplifier section.	Check: Ic Q4 = .8 ma approx. Ic Q5 = .2 ma approx.
Instrument inoperative on DCV and ohms.	Faulty attenuator.	Check R – 23 thru R – 31
	Faulty bias network.	Check RX – 1, RX – 2, R – 18 B2.
DCV zero drifts excessively.	Faulty B2 batteries.	Replace B2 batteries
		Check for leakage to ground
Zero Adjustment changes when switched from +DCV to -DCV.	Mechanical zero adjustment of meter incorrectly set.	Correct mechanical zero setting.
	Defective Q1 or CR – 1	Check or replace
±DCV sensitivity incorrect.	R4, R6 incorrectly set	Calibrate
	Defective amplifier	Check Q1, Q2, Q3
ACV sensitivity incorrect.	R9 incorrectly set	Calibrate
	Defective amplifier	Check Q4, Q5

PARTS LIST

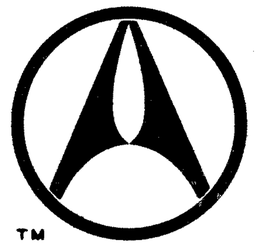
DESIGNATION	PART NUMBER	DESCRIPTION	
	RESISTORS		
R1	1001 - 273	27K, 10%, 1/4W	
R2	1001 - 273	27K, 10%, 1/4W	
R3	1000 - 152	1.5K, 5%, 1/4W	
R4	110271	Pot 1K	
R5	1000 - 392	3.9K, 5%, 1/4W	
R6	110271	Pot 1K	
R7	1001 - 472	4.7K, 10%, 1/4W	
R8	1001 - 333	33K, 10%, 1/4W	
R9	111322	Pot 500 Ohm	
R10	1001 - 101	100 Ohm, 10%, 1/4W	
R11	1001 - 151	150 Ohm, 10%, 1/4W	
R12	1001 - 472	4.7K, 10%, 1/4W	
R13	1001 - 105	1M, 10%, 1/4W	
R14	1003 - 105	1M, 10%, 1/2W	
R15	1001 - 104	100K, 10%, 1/4W	
R16	1001 - 273	27K, 10%, 1/4W	
R17	111395	Pot 10K	
R18	111395	Pot 10K	
R19	1000 - 224	220K, 5%, 1/4W	
R20	111533	Pot 100K	
R21	1012 - 1005	10M, 1%, 1W	
R22	1011 - 3162	31.6K, 1%, 1/2W	
R23	1012 - 9094	9.09M, 1%, 1W	
R24	1011 - 9093	909K, 1%, 1/2W	
R25	1011 - 9092	90.9K, 1%, 1/2W	
R26	1011 - 9091	9.09K, 1%, 1/2W	
R27	1011 - 9090	909 Ohm, 1%, 1/2W	
R28	1011 - 90R9	90.9 Ohm, 1%, 1/2W	
R29	1011 - 10R0	10 Ohm, 1%, 1/2W	
R30	1001 - 474	470K, 10%, 1/4W	
R31	1001 - 474	470K, 10%, 1/4W	
R32	1011 - 6811	6.81K, 1%, 1/2W	
R33	1011 - 2151	2.15K, 1%, 1/2W	
R34	1011 - 6810	681 Ohm, 1%, 1/2W	
R35	1011 - 2150	215 Ohm, 1%, 1/2W	
R36	1011 - 1000	100 Ohm, 1%, 1/2W	
R37	1003 - 105	1M, 10%, 1/2W	
R38	1001 - 334	330K, 10%, 1/4W	
R39	1001 - 473	47K, 10%, 1/4W	
R40	1001 - 474	470K, 10%, 1/4W	
RX1	1003 - XXX	0 - 220K, 10%, 1/2W	VALUE DE-TERMINED IN CALIBRATION
RX2	1003 - XXX	0 - 220K, 10%, 1/2W	

PARTS LIST (Cont)

DESIGNATION	PART NUMBER	DESCRIPTION	
	CAPACITORS		
C1	110485	1 MF Electrolytic	
C2	101431	5 MF Electrolytic	
C3	101431	5 MF Electrolytic	
C4	110490	10 MF Electrolytic	
C5	110485	1 MF Electrolytic	
C6	111393	.047 MF Mylar Film	
C7	105292	30 M - 15V Electrolytic	
C8	111396	2.5 PF - 6 PF Variable	
C9	105221	.0022 Ceramic Disc	
C10	110259	.15 - 75 V Mylar Film	
C11	110259	.15 - 75 V Mylar Film	
	DIODES		
CR1	111708	SG 1198 (Selected)	
CR2	111214	G E DHD 805	
CR3	111214	G E DHD 805	
	TRANSISTORS		
Q1	111394	MPF 103	
Q2	110558	2N3638	
Q3	111219	2N2926	
Q4	111219	2N2926	ORN, YEL, GRN. ONLY
Q5	111219	2N2926	
	MISCELLANEOUS		
-	111384	Meter 50 UA	
JI	111389	Jack	
SW 1	111375	Function Switch	
SW 2	111376	Range Switch	
SW 3	111388	PWR. Switch	
	111575	Probe Assembly	



Schematic – Model 870



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