HICKOK

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INSTRUCTION MANUAL

for

VACUUM TUBE VOLTMETER

MODEL 209C

THE HICKOK ELECTRICAL INSTRUMENT COMPANY • 10514 DUPONT AVENUE • CLEVELAND 8, OHIO

VACUUM TUBE VOLTMETER

MODEL 209C

10514 DUPONT AVENUE • CLEVELAND, OHIO 44108

PHONE — 541-8060

TWX — CV 662

CABLE — HICKOK, CLEVELAND

WESTERN UNION — KJ

2490-513

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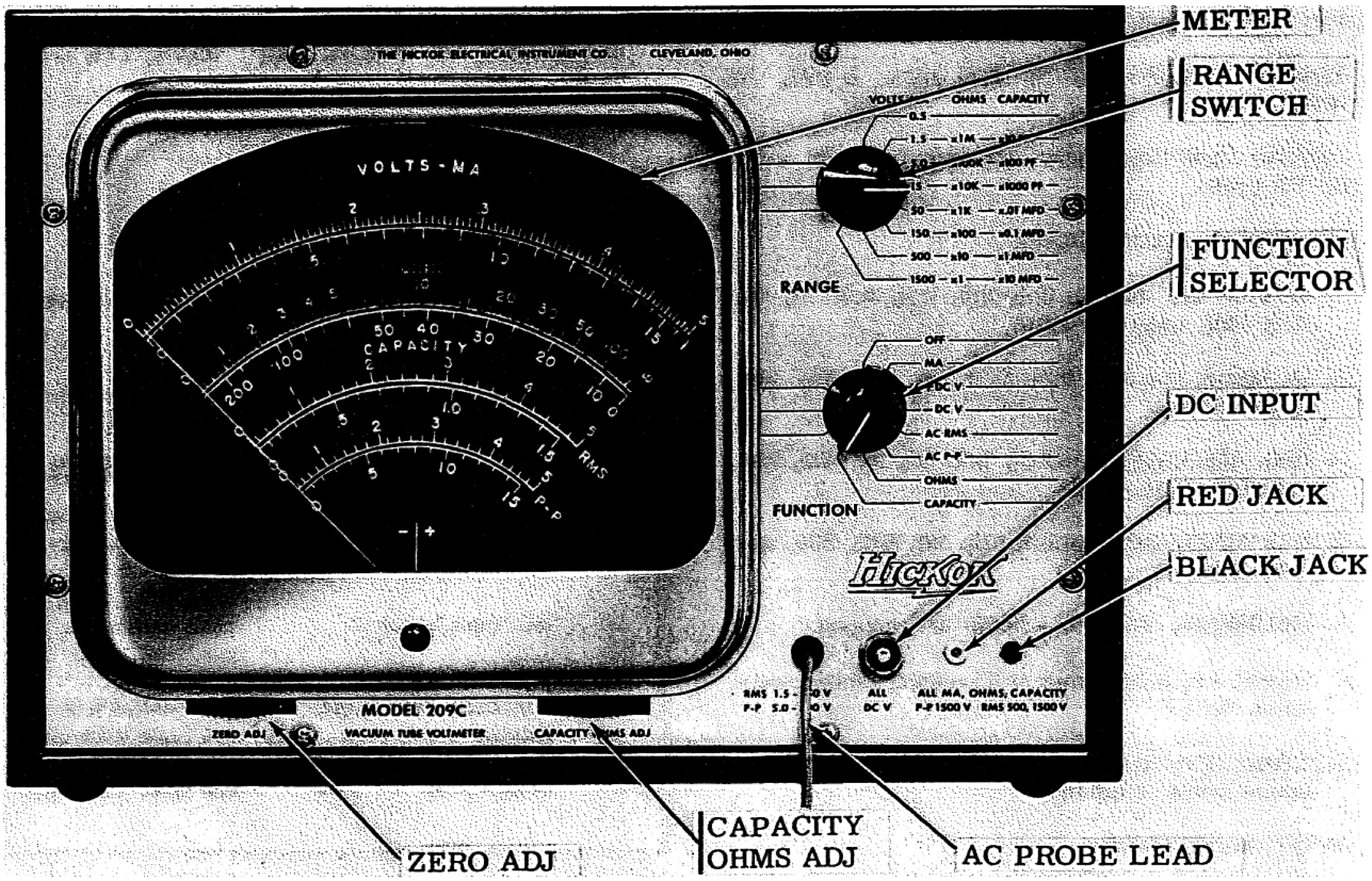

Figure 1. Front Panel Controls

PURPOSE

The Model 209C Vacuum Tube Voltmeter is designed to accurately measure DC currents, AC and DC voltages, resistance, capacitance, and inductance. It supplies the technician with one instrument for all measurements and has the accuracy demanded in industrial and laboratory applications.

QUICK REFERENCE DATA

a. POWER REQUIREMENTS: 115 volts, ± 10%, 50 to 60 cps.

b. POWER CONSUMPTION: approximately 10 watts at 115 volts.

c. FUNCTIONS AND RANGES:

1. + DC or -DC voltage; 0 to 0.5, 1.5, 5.0, 15, 50, 150, 500, and 1500 volts.
2. DC MILS; 0 to 0.5, 1.5, 5.0, 15, 50, 150, 500, and 1500 ma.
3. RMS VOLTAGE; 0 to 1.5, 5.0, 15, 50, 150, 500, and 1500 volts.
4. P-P VOLTAGE; 0 to 5.0, 15, 50, 150, 500, and 1500 volts.
5. DECIBELS; -10 db to + 66 db in 7 ranges.
6. OHMS; Rx1 to Rx1 meg in 7 ranges, center scale value 10.
7. CAPACITY; Cx10 mfd to Cx10 pf in 7 ranges, center scale value 40.

d. INPUT IMPEDANCE:

1. ± DC VOLTS; 11 megohms.
2. DC MILS; 0.5 ma - 1000 Ω, 1.5 ma - 316 Ω, 5 ma - 100 Ω, 15 ma - 31.6 Ω, 50 ma - 10 Ω, 150 ma - 3.16 Ω, 500 ma - 1 Ω, and 1500 ma - 0.316 Ω.
3. AC VOLTS; approximately 10 megohms shunted by 11 picofarads.

e. ACCURACY:

DC VOLTS, AC VOLTS, and MILS; ±3% of full scale.

OHMS and CAPACITY; ±3° of arc.

f. MECHANICAL SPECIFICATIONS:

1. WEIGHT: 15 pounds.
2. OVERALL SIZE: 1" high x 18" wide x 8" deep.

Qty per Equip.	Nomenclature	Description
1	Instruction Manual	8-1/2 x 11 inches
1	AC Test Lead	Permanently attached 4 ft test lead with probe.
1	DC Test Lead	Detachable 4 ft. test lead with probe.
1	Common Test Lead (black)	Detachable 4 ft. test lead with clip.
1	Ohms-Mils-Cap Test Lead (red)	Detachable 4 ft. test lead with clip.

Table 1. List of Equipment Supplied

GENERAL

It is most desirable that the operator be thoroughly familiar with the purpose and function of all phases of the operation of the Model 209C Vacuum Tube Voltmeter. Only in this manner can the full potentials of this versatile instrument be realized. Complete knowledge of the front panel controls and connectors enables the technician to adjust to all test requirements that he may encounter.

FRONT PANEL CONTROLS AND CONNECTORS

The purpose and function of the front panel controls and connectors (see figure 1) are as follows:

a. METER; nine scales measure DC currents, AC and DC voltages, resistance, capacitance, inductance, and decibels.

b. RANGE switch; eight position step switch determines meter range.

c. FUNCTION selector; eight position step switch - determines the electrical function being tested.

d. DC INPUT; microphone type connector, matches DC probe for all DC measurements.

e. RED JACK; pin type, used with red lead for all milliampere, ohms, high voltage (above 500 volts, peak-to-peak), and capacity readings. Used in conjunction with black lead.

f. BLACK JACK; pin type, used with black lead in conjunction with red lead for above readings.

g. AC PROBE LEAD; used to measure up to 500 volts, peak-to-peak.

h. CAPACITY OHMS ADJ; continuously variable control used to zero the meter pointer to the right side of the scale at zero for capacity and infinity for ohms.

i. ZERO ADJ; continuously variable control used to zero the meter pointer to the left side of scale for reading AC and DC voltages, as well as ohms measurements. The ZERO ADJ control is not used for milliampere or capacity measurements.

OPERATING PROCEDURE

Connect the Model 209C VTVM to a 115 volts, ±10%, 50 to 60 cps power source. Allow a five minute warm-up period so that stable operation is assured. If the instrument is to be used intermittently over a period of time, keep it turned on to avoid delay.

To avoid errors in resistance, capacitance, and inductance measurements, the unknown to be measured must be isolated from other circuits. In resistance measurements it is sufficient to free only one terminal of the resistor.

WARNING

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.

AC VOLTAGE MEASUREMENTS

CAUTION

Do not attempt to measure AC potentials over 500 volts (peak-to-peak) with AC PROBE, as you may damage the equipment.

To make AC voltage measurements, proceed as follows:

a. Connect the black unshielded test lead to the BLACK JACK. If voltages are being measured at high frequencies, make a braided ground connection from the diode probe to the unit being tested. Make the lead as short as practical.

b. Turn the FUNCTION SELECTOR to the AC RMS or AC P-P position.

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

d. Check the METER for zero setting. If necessary, adjust to zero with ZERO ADJ control. In setting the METER to zero do not touch the tip of the AC PROBE as stray pick-up may deflect the meter pointer.

e. Connect the AC PROBE and the BLACK TEST LEAD to the voltage to be measured.

f. Read the numerical value directly from the scale and apply the multiplying factor for the setting of the RANGE SWITCH. With the FUNCTION SELECTOR in the AC RMS position, the METER indicates directly the RMS value of a sine wave; in the AC P-P position, the METER indicates directly the peak-to-peak value of the wave form being measured.

g. For high voltage AC measurements (to 1500 volts), the controls are set as above except that connection to voltage to be measured is made with the RED TEST LEAD and the BLACK TEST LEAD.

DC VOLTAGE MEASUREMENTS

To make DC voltage measurements, proceed as follows:

a. Turn the FUNCTION SELECTOR to the + DCV position.

b. Turn the RANGE SWITCH to the range which will cover the voltage to be measured. If an approximate range is not known, choose the highest range.

c. Check the METER for zero setting. If necessary, adjust to zero with ZERO ADJ control.

d. Connect the unknown, using the BLACK TEST LEAD and the red DC probe.

e. If the METER indicates in the wrong direction, turn the FUNCTION SELECTOR to -DC V.

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

g. Note: The Model 209C VTVM may be used as a null detector with no change in accuracy. Turn the RANGE SWITCH to the 0.5 position and adjust the pointer to center scale by means of the ZERO ADJ control.

CURRENT MEASUREMENTS

To make current measurements, proceed as follows:

WARNING

Do not under any condition make measurements in circuits of a potential in excess of 1000 volts with respect to ground. This could be dangerous to personnel, as well as equipment.

a. Turn the FUNCTION SELECTOR to the MA position.

b. Turn the RANGE SWITCH to the range which will cover the current to be measured. If the correct range is not known, turn to the highest range (1500 MA).

c. To avoid error due to an inaccurate initial setting of the METER, check the zero indication of the METER before making any measurements. Mechanically adjust the zero setting by means of the screwdriver adjustment in the front of the METER.

d. Using the BLACK TEST LEAD and the RED TEST LEAD inserted in their respective panel JACKS, connect the METER in series with the circuit to be measured.

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

NOTE

In order to minimize hazards and errors, the preferred point of connection is in the low side of the circuit. See figure 2.

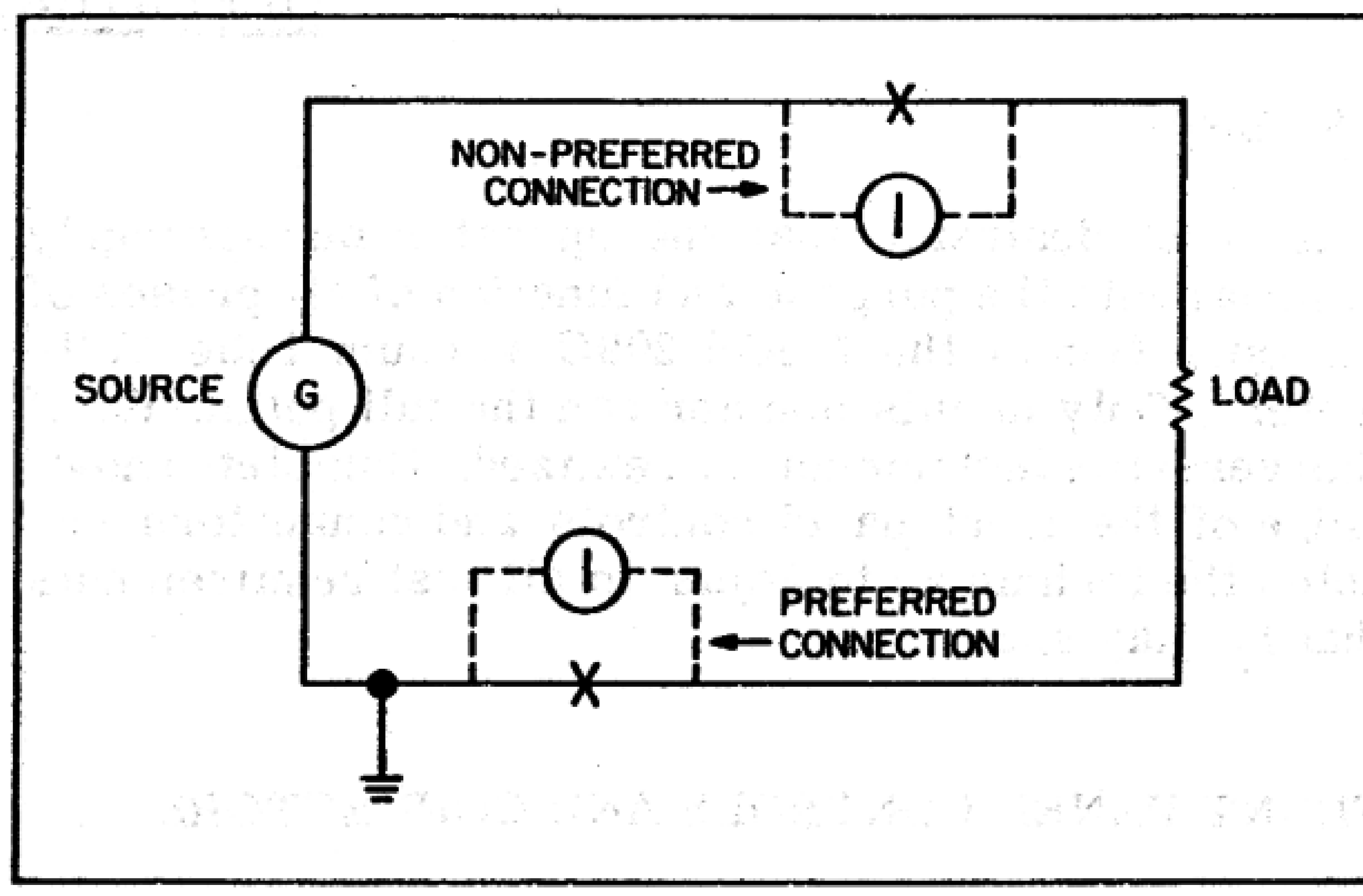

Figure 2. Preferred and Non-Preferred Connections

RESISTANCE MEASUREMENTS

To make resistance measurements, proceed as follows:

a. Turn the FUNCTION SELECTOR to the OHMS position.

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

c. Insert the BLACK TEST LEAD and RED TEST LEAD in their respective panel JACKS. Adjust the METER to zero by means of the ZERO ADJ control, while shorting the leads together. Open the LEADS and adjust the METER to full scale by means of the CAPACITY-OHMS ADJ control.

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

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

CAPACITANCE MEASUREMENTS

To make capacitance measurements, proceed as follows:

a. Turn the FUNCTION SELECTOR to the CAPACITY position.

b. Turn the RANGE SWITCH to the x.01 MFD position.

c. Check for full-scale METER pointer deflection (zero on CAPACITY scale). If necessary, adjust by means of the CAPACITY OHMS ADJ control. This is done with the LEADS open, if they are in their respective JACKS. Since the instrument inherently has some internal capacity, the METER will read this capacity when the RANGE SWITCH is turned to x10 PF and x100 PF. Even though it is planned to use these ranges, do not readjust the CAPACITY OHMS-ADJ control when using these ranges, but note the readings on the METER before the unknown capacitor is connected. Then subtract this reading from the reading with the capacitor connected to obtain the true capacity of the unknown. This subtraction is not necessary on other scales.

d. Turn the RANGE SWITCH to the range which will best cover the capacitance to be measured. Do not readjust the CAPACITY-OHMS ADJ control.

e. Insert the BLACK TEST LEAD and the RED TEST LEAD in their respective panel JACKS, if not previously there.

f. With the exception noted below, connect the VTVM to the capacitor to be measured, using the BLACK and RED TEST LEADS. Remove the capacitor from its associated circuits in making this measurement.

> **NOTE**
>
> Since the capacity measuring circuit is exceedingly sensitive on the two lowest capacity ranges (x100 PF and x10 PF), the TEST LEADS may pick up stray AC voltage fields near the LEADS. This will generally cause the METER to read off-scale to the right, which may result in erratic readings. It is therefore advisable to connect the capacitor under test directly to the BLACK and RED JACKS when using either of these two ranges. In the event of any further instability, reverse the line cord plug.

g. Multiply the numerical value indicated on the scale by the multiplying factor indicated by the position of the RANGE SWITCH. In cases where it is necessary to use the x100 PF or the x10 PF ranges, the true value of the unknown capacitor will be the difference between the METER reading, with and without the capacitor connected.

> **CAUTION**
>
> If the RANGE SWITCH is in the x10 MFD position and the FUNCTION SELECTOR is in the CAPACITY position, do not operate the VTVM for prolonged periods of time with the BLACK and RED TEST LEADS shorted. Damage to resistor (R41) of the VTVM may result.

h. Capacitance measurements when used on other than 60 cycle power supply can be converted by a conversion factor. The formula is:

$$CA = \frac{C_m\, 60}{f}$$

Where:

CA = Actual Capacity
C_m = Measured Capacity
f = line frequency

In the case of 50 cycles, the formula is reduced to

$$CA = 1.2\, C_m$$

INDUCTANCE MEASUREMENTS

To make inductance measurements, proceed as follows:

a. Turn the FUNCTION SELECTOR to the CAPACITY position.

b. Turn the RANGE SWITCH to the x10 MFD position.

c. Insert the BLACK TEST LEAD and the RED TEST LEAD into their respective pin JACKS.

d. Open the LEADS and adjust for full-scale METER pointer deflection (zero on CAPACITY scale) by means of the CAPACITY OHMS ADJ control.

e. Insert the inductance to be measured between the TEST LEADS. If the METER reads zero on the x10 MFD scale, the inductance is too small to read with the Model 209C.

f. Rotate the RANGE SWITCH counterclockwise until a suitable reading can be obtained on the METER. Observe the numerical value of the capacity and apply to the following formula:

$$L = \frac{7.04}{C} \text{ henries}$$

where C is in MFD.

NOTE: This formula is accurate only if the ohmic resistance of the inductance is negligible with respect to the inductive reactance at 60 cycles.

The accuracy of calculation is greater than 1% if the product of the ohmic resistance and the capacity reading in MFD is less than 100 ($RC < 100$).

g. If the ohmic resistance is appreciable, proceed to calculate the inductance as follows:

1. Read the numerical value of the capacity directly from the METER. Find the associated impedance on the graph given in figure 3. This value is Z_L in the formula below.
2. Note the position of the RANGE SWITCH = X10, X100, etc., in the OHMS column. This value is indicated as a small n in the formula.
3. Determine the resistance of the inductance by means of the ohmmeter section. This value is indicated as R_L in the formula.
4. Knowing R_L and the position of the RANGE SWITCH, the inductive reactance, X_L, can be determined from the following formula:

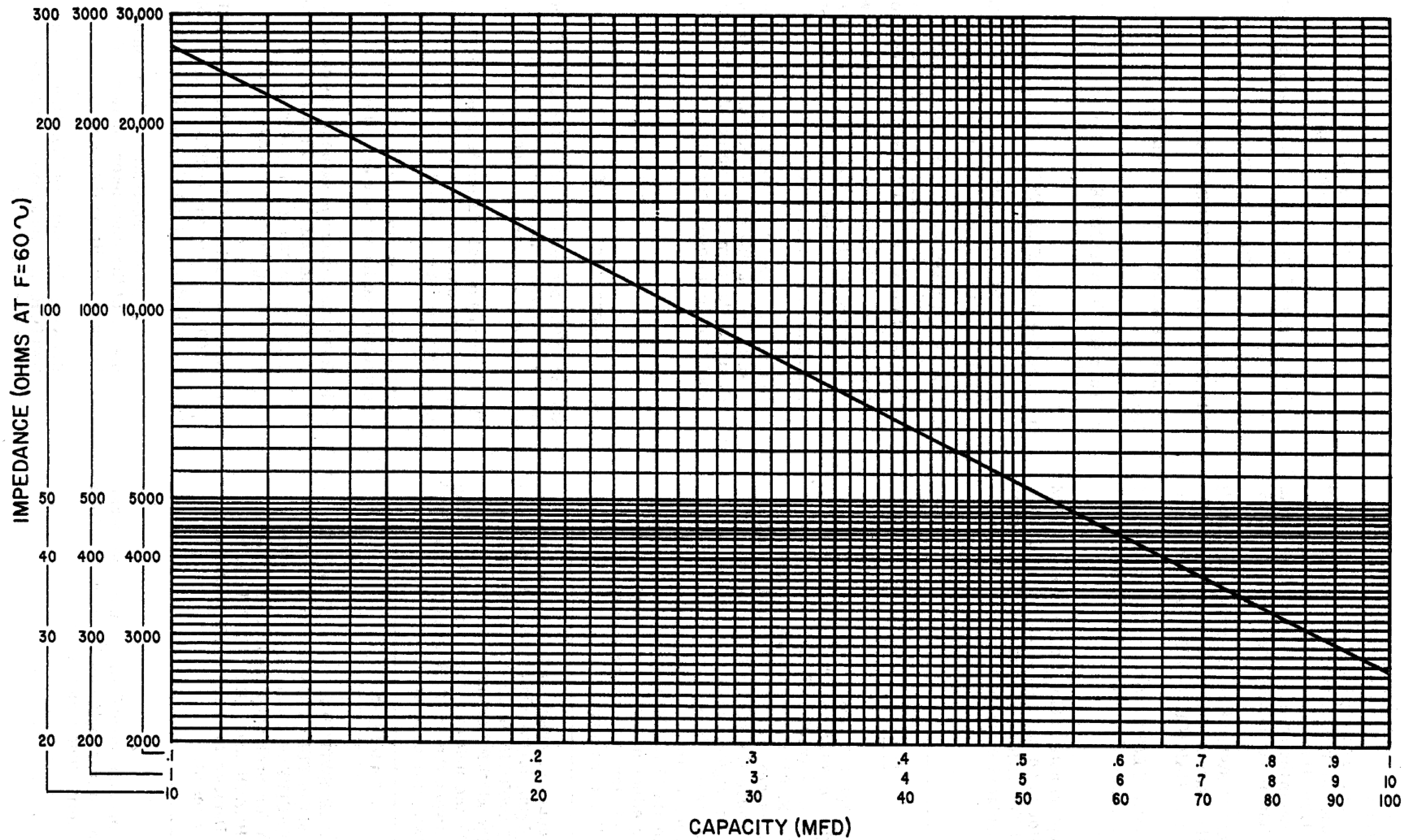

Figure 3. Capacity versus Impedance Graph

$$X_L = Z_L\sqrt{1 - \left(\frac{R_L}{Z_L}\right)^2 + \frac{0.2\,R_L}{n}}$$

where:

X_L = reactance of inductor in ohms.

R_L = resistance of inductor in ohms.

Z_L = impedance in ohms (found by means of impedance graph, figure 3, from associated capacitance indicated on METER)

n = a number numerically equal to the indicated RANGE SWITCH position in the OHMS column.

example:

It is desired to find the inductance of a coil whose resistance, when measured by an ohmmeter is 100 ohms. The "capacity" reading obtained from the Model 209C was 8.8 MFD on the 0.1 MFD range, which was also the X10 ohms range.

R_C = 100 x 8.8 = 880

R_C is greater than 100

Therefore, the error due to resistance is greater than 1%. Referring to the graph in figure 3, it will be found that the impedance for a capacity reading of 8.8 MFD is 300 ohms. Substituting in the formula:

$$X_L = 300\sqrt{1 - \left(\frac{100}{300}\right)^2 + \frac{0.2 \times 100}{100}}$$

$$X_L = 300\sqrt{1 - .111 + .2}$$

$$X_L = 300\sqrt{1.1}$$

$$X_L = 300 \times 1.05$$

$$X_L = 315 \text{ ohms}$$

****

$$L = \frac{X_L}{377} \quad \text{(at 60 cps)}$$

where:

L = inductance in henries.

X_L = inductive reactance from above.

$$L = \frac{315}{377} = .835 \text{ henries}$$

DECIBEL MEASUREMENTS

a. The decibel scale can be used to determine power levels based on 0 DB = 1 MW in 600 ohms. The operation of the Model 209C for decibel measurement is the same as for AC Voltage Measurements. The ranges on the METER used for the various scales are clearly marked on the meter dial with the minus values indicated in red and the plus values in white. Refer to figures 4, 5, and 6 for decibel corrections.

b. The following formula can be used to convert the DB reading to watts, provided the reading is taken across a 600 ohm load.

FORMULA:

$$P_{WATTS} = (1 \times 10^{-3}) \text{ antilog}\left(\frac{DB}{10}\right)$$

or

$$P_{MW} = \text{antilog}\left(\frac{DB}{10}\right)$$

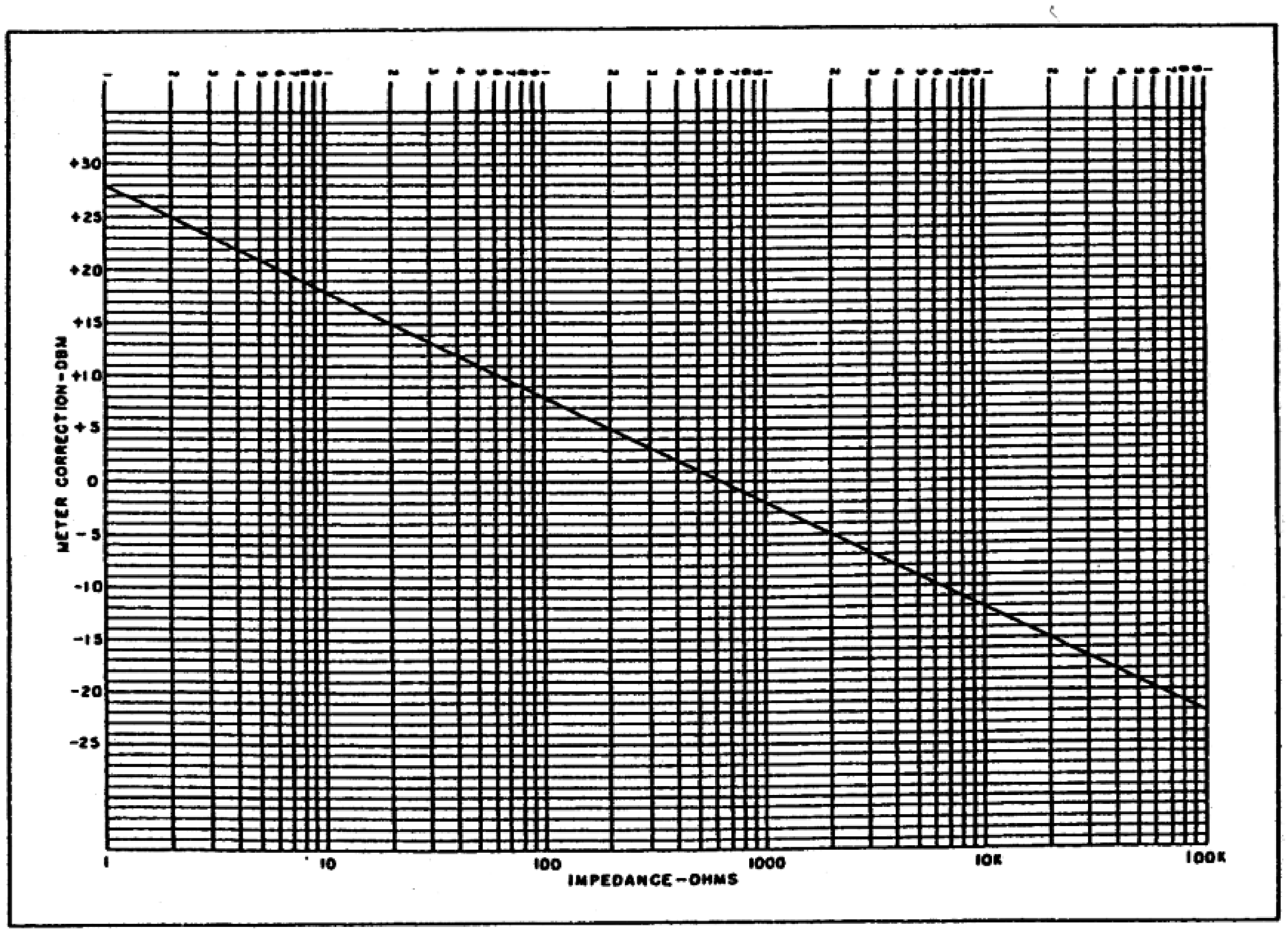

Figure 4. DB and Impedance Chart

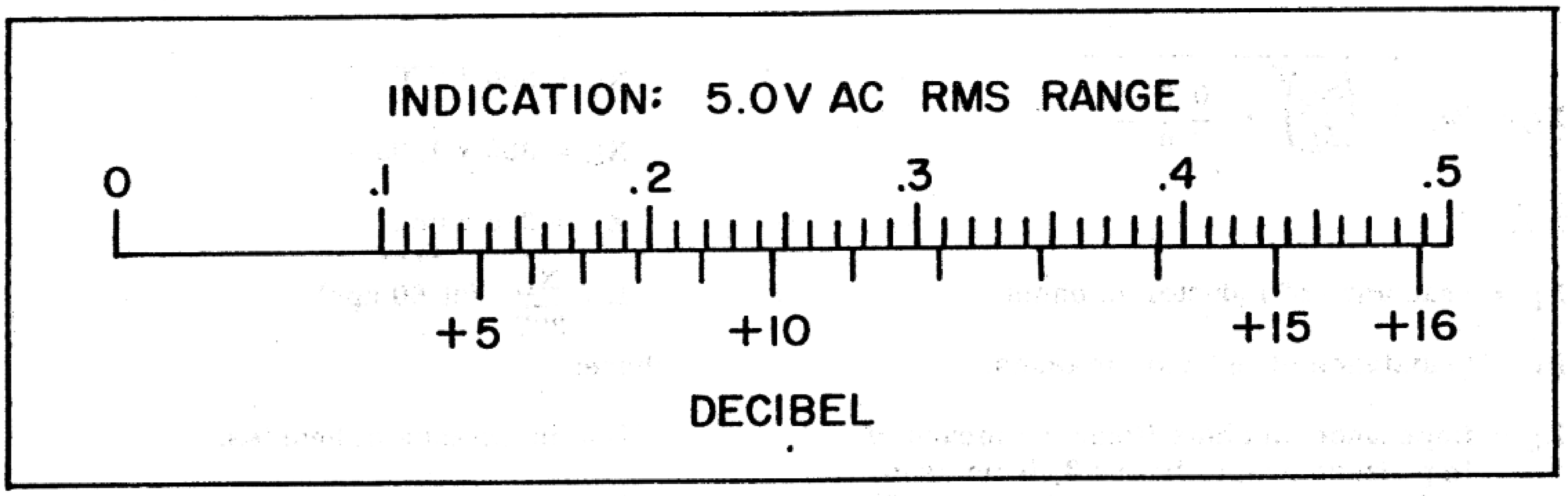

Figure 5. DB Correction Chart (5.0 Volt Range)

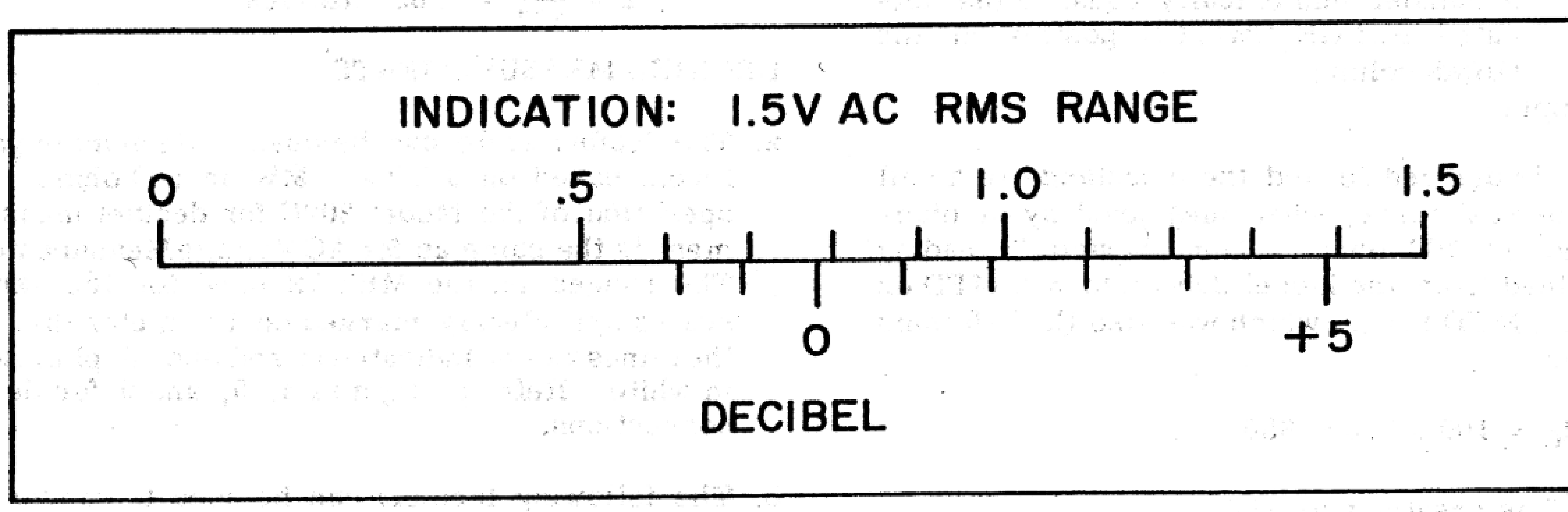

Figure 6. DB Correction Chart (1.5 Volt Range)

GENERAL

The Model 209C Vacuum Tube Voltmeter is capable of making all measurements common to instruments of its type. The following measurements or calibrations give more specialized applications.

DC VOLTMETER

a. High Impedance Circuits

The input impedance in the Model 209C is constant at approximately 11 megohms. As a result of this high input impedance it can, in general, be used to measure dc voltages in any electrical circuit without appreciable loading of the dc circuit. Consequently, the voltage as indicated will be essentially the voltage which would be found under normal operating conditions. In the conventional low impedance type of voltmeter the loading caused by the meter is often sufficiently great to cause extreme error when measurements are made in high impedance circuits.

b. RF and IF Circuits

As a result of incorporating an isolation resistor of 1 megohm in the dc probe, this VTVM can also be used to measure voltages in oscillating or RF circuits without loading these circuits from a capacitive or resistive standpoint. This feature makes it possible to measure avc voltages at such places as the control grids of RF and IF stages without disturbing the normal operation of those circuits.

c. Oscillation Check

Determination of the condition of oscillation or non-oscillation of the oscillator sections in receivers is another application of the VTVM. An immediate check is obtained on the oscillator section by connecting the VTVM so as to measure the voltage at the grid of the oscillator tube and tuning from one end of the band to the other. Note the grid voltage throughout the entire range. In typical receiver circuits a negative voltage of from 5 to 30 volts will be found at the grid of the oscillator tube when the oscillator section is operating properly. Dead spots on one or more of the tuning ranges may be located by this test.

d. Discriminator or Ratio Detector Circuit Alignment

Service instructions for the alignment of FM receivers often call for the insertion of a zero center microammeter in the detector circuit. Misalignment is indicated by any reading, either positive or negative, on the METER and alignment is indicated by a zero reading. The dc zero center range of the Model 209C may be conveniently used to make such alignments. To do so, connect it across the detector load resistance. Make the necessary alignment which will bring the METER pointer back to the zero center position. Thus a satisfactory alignment can be made without the necessity of breaking the circuit to insert the microammeter.

AC VOLTMETER

a. High Frequency Measurements

The ac section of the VTVM has a constant resistive component of approximately 10 megohms shunted by a capacitive component of approximately 11 pfd. The low shunting capacitance is obtained by the use of the diode probe. Useful measurements of voltages at frequencies over 200 mc are possible by using a braided connection from the ground of the probe to the chassis of the unit under test. This lead must be as short as possible to minimize the inductive effect of the lead. At high frequencies the shunt capacitance, although it is only 11 pf, will have a low reactance and may introduce some error in the reading obtained. This error is dependent upon the impedance across which the voltage is measured, and increases as the impedance increases. Also at these frequencies the loading imposed by the capacitance input may detune a radio frequency circuit. The AC PROBE is limited to 500 volts peak-to-peak maximum input. Voltages greater than 500 volts peak-to-peak (500 or 1500 volts RMS, or 1500 volts p-p) are measured with an internal detector with a frequency response limited to power line frequencies.

b. DC Isolation

The ac input circuit includes a blocking condenser between the test probe and the diode circuit, so that any dc components present in the circuit under test are ineffective and only the ac components are measured.

c. Line Frequency Measurements

When the ac VTVM is used to measure voltages of supply line frequency, for example the common 60 cycle supply, small discrepancies in the readings may occur if the polarity of the test leads is reversed. That is, if the grounded test lead changes in position with respect to the ac voltage being measured. The actual voltage in such cases should be taken as the average of the two readings. The BLACK TEST LEAD is connected to the ground lead of the power cable.

OHMMETER

Measurement of Semi-Conductor Devices

The ohmmeter section of the Model 209C uses only 0.5 volt dc for all resistance measurements. This low voltage will not damage germanium transistors or diodes. Semi-conductor devices have a higher resistance at 0.5 volt than at the higher voltages commonly used in ohmmeters. This fact should be considered when comparing measurements with other ohmmeters.

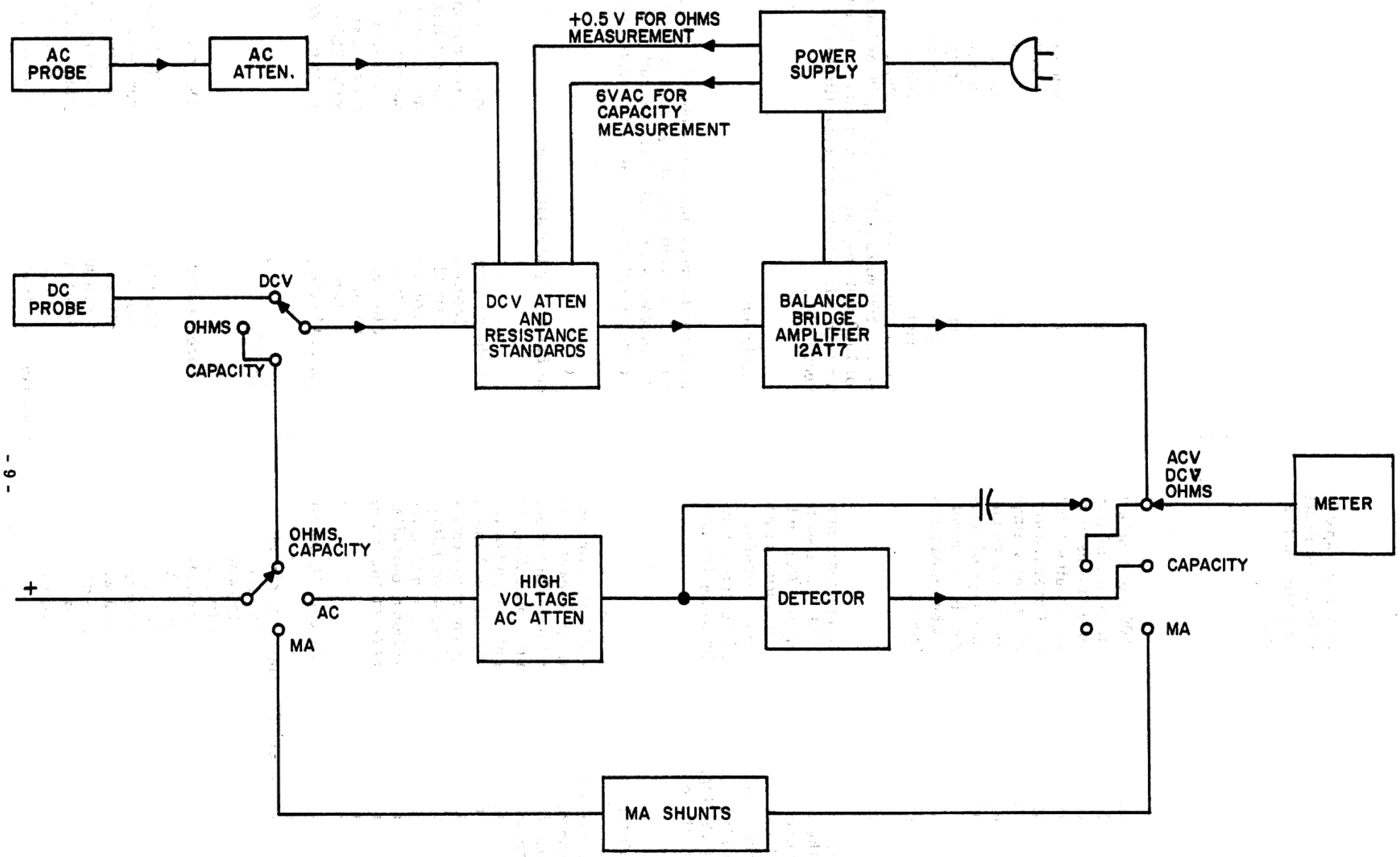

Figure 7. Functional Block Diagram

CAUTION

On the lower ranges the internal shunt resistance between the test leads used in resistance measurements is relatively low. Therefore, never connect the test leads across a voltage which could possibly damage or destroy these resistors. To avoid this, be sure that the resistor being measured is not connected to an active circuit when measurements are being made.

CAPACITANCE MEASUREMENTS

General

In conventional capacitance measuring devices it is necessary to use very high voltages for measuring capacitors of low capacity with a resultant hazard to the operator. This hazard has been completely eliminated in the Model 209C. Capacitance test leads may be handled without fear of electrical shock, as the electronic circuit utilized permits capacitance measurements throughout the wide range of approximately 100 pf to 1000 uf with the use of only 6 volts, ac.

CIRCUIT DESCRIPTION

GENERAL

In the interest of simplicity the circuit description is divided into functional units which are described and discussed separately. The block diagram (figure 7) and the schematic wiring diagram (in the back of this manual) are both referred to for identification.

AC VOLTMETER

In figure 8 the ac voltage to be measured is rectified by the 6AL5 twin diode, and the resultant dc voltage is applied to the divider network. Part of this voltage, as determined by the position of the RANGE SWITCH, is fed to the input grid of one of the triodes of the bridge tube causing the bridge circuit to function. With the FUNCTION SELECTOR in the AC RMS position the instrument is calibrated to read in terms of RMS voltages of a sine wave. In the AC P-P position the instrument is calibrated in terms of peak-to-peak value of the waveform measured.

Negative contact potential is developed across the rectifier tube before any input voltage is applied, due to the normal emission of electrons by the cathode.

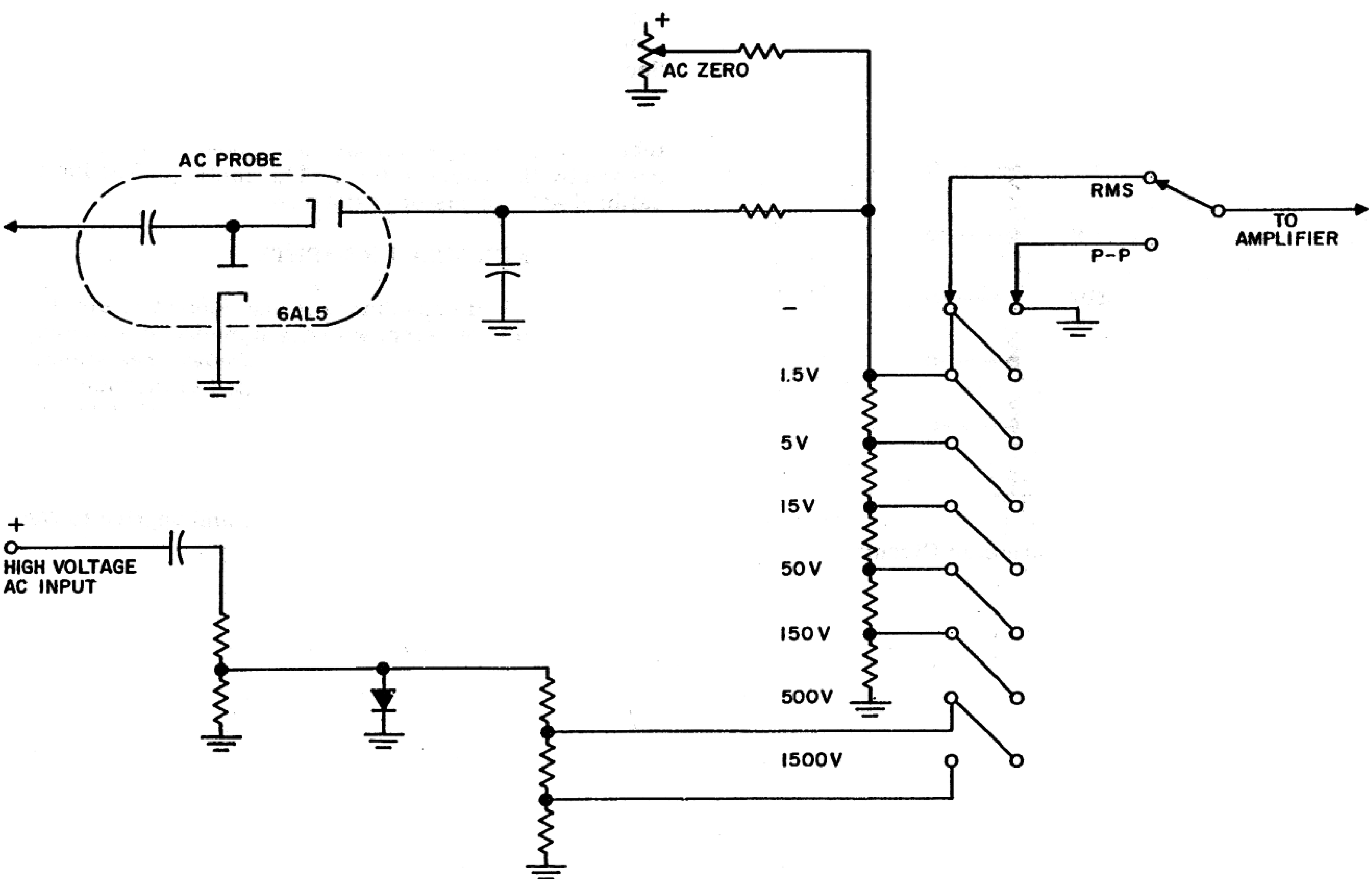

Figure 8. AC Voltmeter Circuit

This negative potential is applied across the input voltage divider network and causes the meter to deflect. To compensate for this a positive voltage from the B+ supply equal to the contact potential is fed to the voltage divider network through a 100 megohm resistor.

DC VOLTMETER

A DC input voltage (see figure 9) applied to the DC INPUT connection of the instrument, is applied through the one-megohm resistor in the probe directly to the voltage divider network. The desired degree of attenuation is selected by the RANGE SWITCH. The signal is applied to the bridge circuit. Deflection of the meter pointer in the wrong direction indicates that the polarity of the voltage being measured is reversed with respect to the polarity of the meter and bridge circuit. A switching arrangement has been incorporated in the instrument, however, which switches the meter to permit measurements of either polarity.

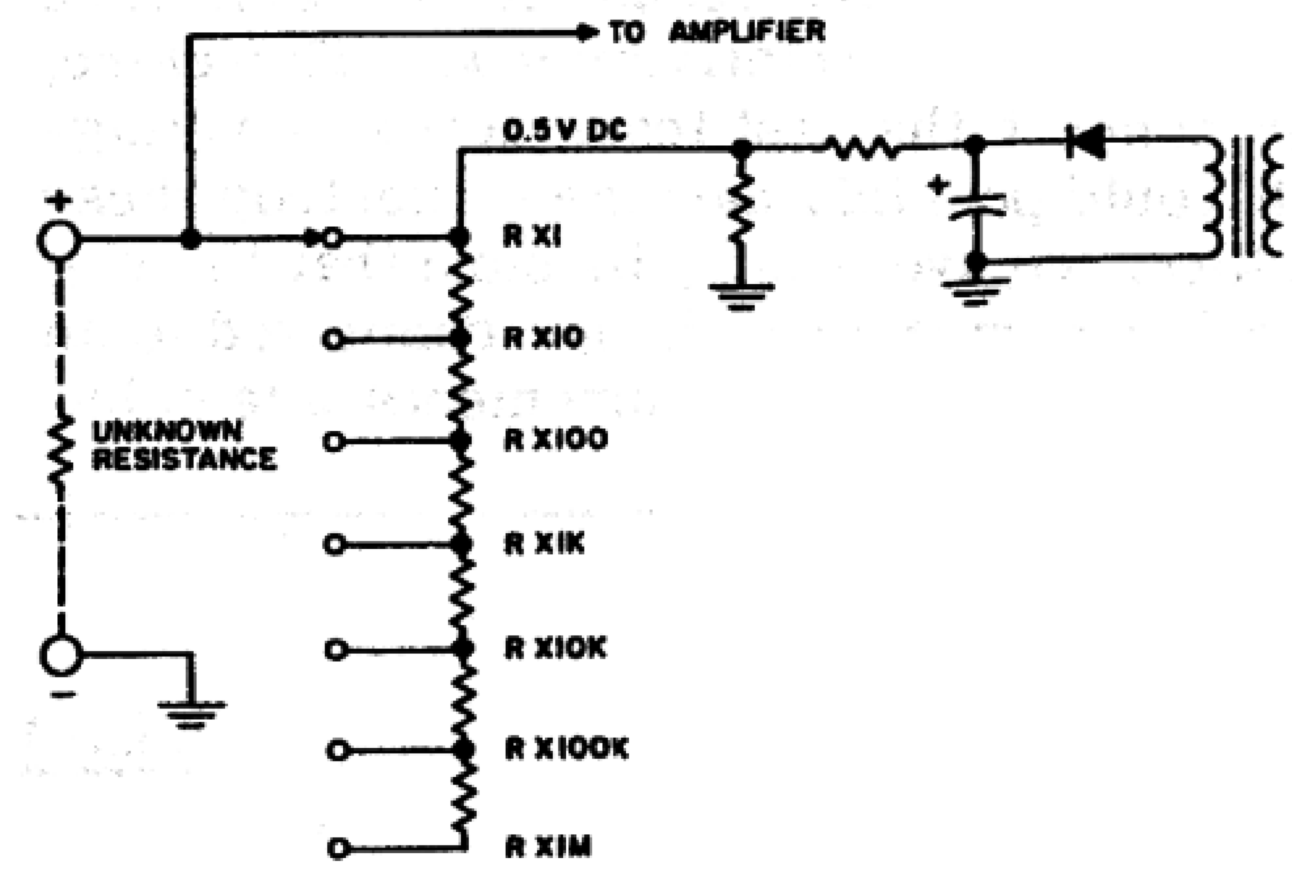

Figure 10. Ohmmeter Circuit

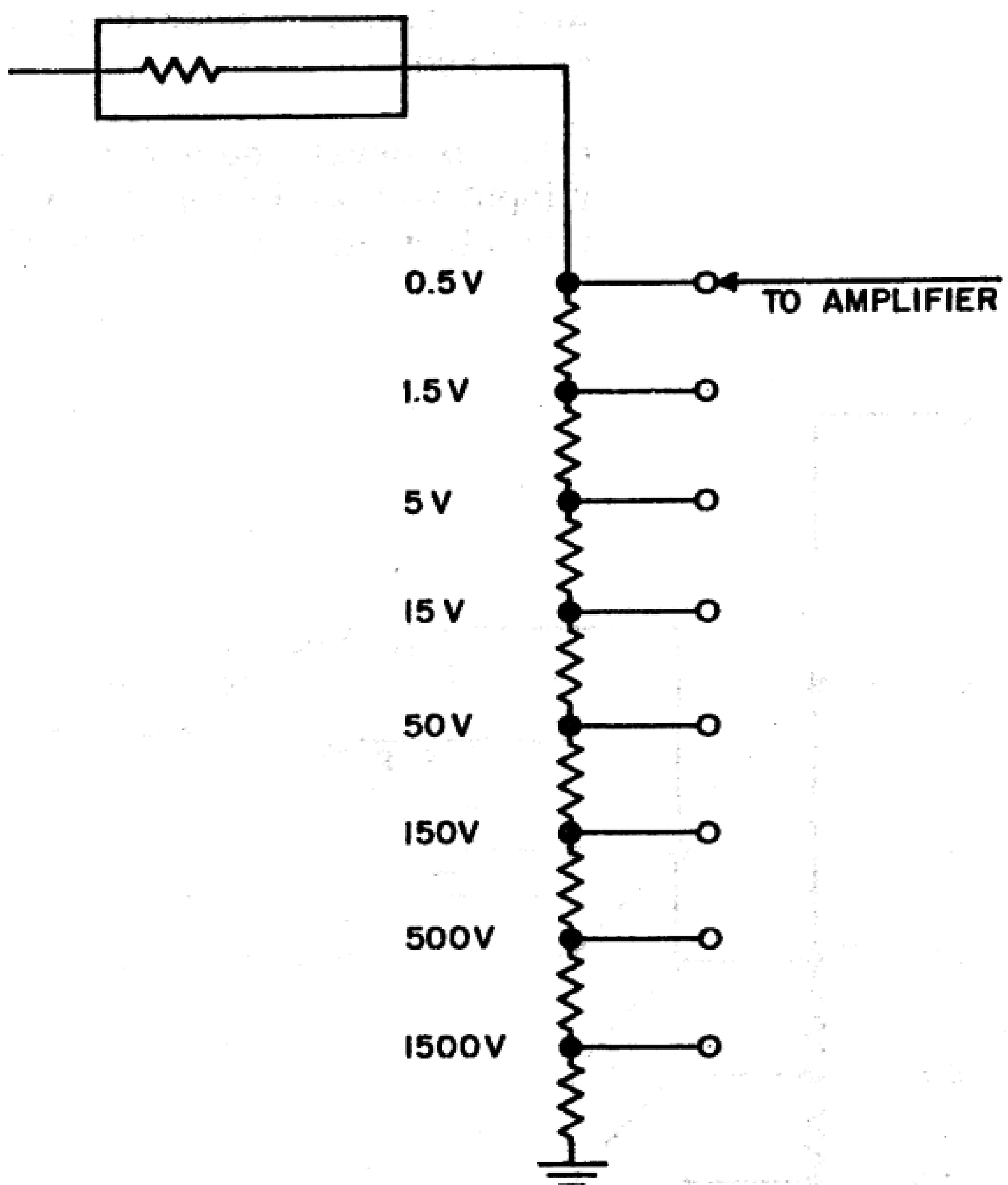

Figure 9. DC Voltmeter Circuit

OHMMETER

When an unknown resistance is connected across the red and black terminals, it is placed in series with a portion of the resistance divider network, as determined by the RANGE SWITCH. Current flow from the internal power supply through these resistances determines the value of the unknown resistance. See figure 10.

The voltage applied to the input grid of the bridge tube is the voltage across the unknown resistance caused by the current flow. The meter deflection is calibrated in terms of resistance.

CAPACITANCE MEASUREMENTS

The theory of capacitance measurement is similar to that of the ohmmeter, with the impedance of the unknown capacitor replacing the unknown resistance. However, as an AC voltage is needed to measure the capacitance and as only DC can be applied to the METER, some means must be used to rectify the AC. The AC voltage tapped off the voltage divider network is fed to the input triode of the bridge acting as a cathode follower, then rectified by CR3 and applied to the METER.

MAINTENANCE

The Model 209C Vacuum Tube Voltmeter is built of quality components by skilled craftsmen and should require no maintenance other than preventive maintenance. Preventive maintenance consists of general good practice, such as periodic inspection for loose switch knobs, unseated vacuum tubes, loose or frayed wires, etc. It is suggested that if the instrument should need maintenance, that the factory service department or one of our authorized service stations be contacted for service or advice.

CALIBRATION

The Model 209C VTVM is accurately calibrated and passes a close inspection at the factory. Normally no re-calibration is necessary nor is it desirable. If, however, due to mechanical or electrical damage it is necessary to replace any components, it is obligatory to re-calibrate. To re-calibrate proceed as follows:

1. Connect the unit to a 115 volt, 60 cycle power supply. Allow 5 minutes warmup time.
2. Adjust the screwdriver control on the face of the METER so that the pointer indicates zero. Do this with the FUNCTION SELECTOR in the MA position.
3. Set the FUNCTION SELECTOR to the + DC V position and the RANGE SWITCH to the 0. 5 position.
4. Rotate the ZERO ADJ (on the front panel) (R45 in the schematic) so that the METER pointer is in the zero position.
5. Apply 0.5 ±1% volt to the DC PROBE and the BLACK TEST LEAD.
6. Adjust the DC CAL (R32 - screwdriver adjustment on side of case) for a METER indication of 0. 5 volt. See figure 11.
7. Set the RANGE SWITCH on the 1.5 position. Check zero adjustment.
8. Apply 1. 5 ± 1% volts dc to the DC PROBE and the BLACK TEST LEAD.
9. Check the METER for an indication of 1. 5 ± 2% volts. This is a correct indication and therefore skip steps 9 through 14. If the METER indication is <u>not</u> 1. 5 volts, proceed as follows:
10. Remove resistor (R26) mounted on top of the RANGE SWITCH.
11. Connect a resistance substitution box in series with the 5. 11 resistor (R25) and the white-yellow lead located on the RANGE SWITCH.
12. Adjust the resistance substitution box for a 1. 5 METER indication.
13. Solder an appropriate resistor (330 ohms to 1K) into the circuit in place of the R26 previously removed.
14. Check METER for proper indication of 1. 5.
15. Set the FUNCTION SELECTOR to the MA position and the RANGE SWITCH to the 0. 5 position.
16. Apply 0. 5 ±1% MA to the RED TEST LEAD and the BLACK TEST LEAD.
17. Adjust MA CAL (R27) for an 0. 5 MA indication on the METER. See figure 11.
18. Set the FUNCTION SELECTOR to the AC RMS position and the RANGE SWITCH to the 150 position.
19. Adjust ZERO ADJ for zero indication on the METER.
20. Set the RANGE SWITCH to the 0. 5 position.
21. Adjust AC ZERO ADJ (R37) for a zero indication on the METER.
22. Set the RANGE SWITCH to the 150 position.
23. Apply 150 ±1% volts to the RED TEST LEAD and the BLACK TEST LEAD.
24. Adjust AC RMS CAL (R33) for a 150 volt indication on the METER.
25. Set the FUNCTION SELECTOR to the AC P-P position and the RANGE SWITCH to the 150 position.
26. Apply 500 ±1% volts peak-to-peak or 176. 8 ±1% RMS to the RED TEST LEAD and the BLACK TEST LEAD.
27. Adjust AC P-P CAL for a 500 volt indication on the METER.

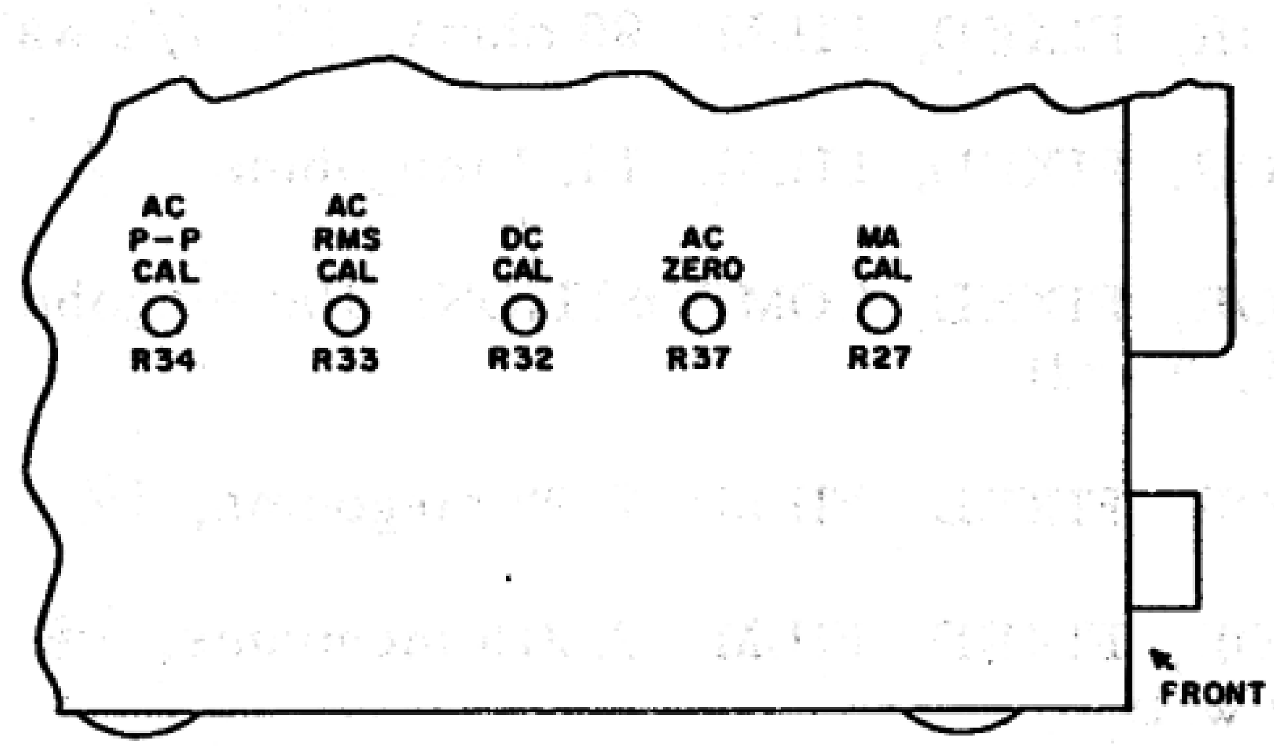

Figure 11. Calibration Controls

INTRODUCTION

Reference designations are assigned to identify all parts of the Model 209C Vacuum Tube Voltmeter. These designations are used in the parts list and schematic wiring diagram. The letter prefix of a reference designation indicates the kind of part -- resistor, capacitor, electron tube, et cetera.

REF. DESIG.	NOTE	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
C1		CAPACITOR, FIXED PAPER: .047µf, 20%, 400 volts	3105-387	.75
C2		CAPACITOR, FIXED, MYLAR: .01 µf, 5%, 200 volts	3090-204	.67
C3		CAPACITOR, FIXED, MYLAR: .018 µf, 5%, 600 volts, tubular	3090-614	.67
C4		CAPACITOR, FIXED, MYLAR: .47 µf, 10%, 100 volts, tubular	3090-7	.66
C5		CAPACITOR, FIXED, ELECTROLYTIC: 20 µf, 250 volts	3085-74	.97
C6		Same as C5		
C7		CAPACITOR, FIXED, ELECTROLYTIC: 100 µf, 25 volts, tubular	3085-256	.94
C8		Same as C3		
D1		SEMI-CONDUCTOR DEVICE, DIODE: SC-6, 600 PIV.	3870-101	1.55
D2		SEMI-CONDUCTOR DEVICE, DIODE: SS-05 (50V PIV.)	3870-144	.95
D3		Same as D1		
M1		METER: 170 µa ± 2%, 1000 ohms, +0% -20%	220-195	32.19
R1		RESISTOR, FIXED, FILM: 6.84 megohms, 1%, 1 watt	18539-55	.74
R2		RESISTOR, FIXED, FILM: 2.16 megohms, 1%, 1/2 watt	18537-277	.40
R3		RESISTOR, FIXED, FILM: 684K ohms, 1%, 1/2 watt	18537-276	.40
R4		RESISTOR, FIXED, FILM: 216K ohms, 1%, 1/2 watt	18537-278	.40
R5		RESISTOR, FIXED, FILM: 68.4K ohms, 1%, 1/2 watt	18537-279	.40
R6		RESISTOR, FIXED, FILM: 21.6K ohms, 1%, 1/2 watt	18537-275	.40
R7		RESISTOR, FIXED, FILM: 9K ohms, 1%, 1/2 watt	18537-44	.81
R8		RESISTOR, FIXED, FILM: 900 ohms, 1%, 1/2 watt	18537-4	.59
R9		RESISTOR, FIXED, FILM: 90 ohms, 1%, 1/2 watt	18537-45	.81
R10		RESISTOR, FIXED, FILM: 14.2 megohms, 1%, 1 watt	18539-61	.74
R11		RESISTOR, FIXED, COMPOSITION: 100 megohms, 10%, 2 watt	18437-102	.60
R12		RESISTOR, FIXED, FILM: 7.92 megohms, 1%, 1 watt	18539-60	.64
R13		RESISTOR, FIXED, FILM: 2.315 megohms, 1%, 1/2 watt	18537-272	.40
R14		RESISTOR, FIXED, FILM: 692K ohms, 1%, 1/2 watt	18537-273	.40

REF. DESIG.	NOTE	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
R15		RESISTOR, FIXED, FILM: 218K ohms, 1%, 1/2 watt	18537-274	.40
R16		RESISTOR, FIXED, FILM: 100K ohms, 1%, 1/2 watt	18694-485	.40
R17		RESISTOR, FIXED, FILM: 684 ohms, 1%, 1/2 watt	18537-224	.40
R18		RESISTOR, FIXED, FILM: 216 ohms, 1%, 1/2 watt	18537-223	.40
R19		RESISTOR, FIXED, FILM: 68.4 ohms, 1%, 1/2 watt	18537-222	.40
R20		RESISTOR, FIXED, FILM: 21.6 ohms, 1%, 1/2 watt	18537-221	.40
R21		RESISTOR, FIXED, FILM: 6.84 ohms, 1%, 1/2 watt	18537-220	.40
R22		RESISTOR, FIXED, WIRE WOUND: 2.16 ohms, 1%, 1/2 watt	18525-839	1.30
R23		RESISTOR, FIXED, WIRE WOUND: .684 ohms, 1%, 1/2 watt	18525-838	1.30
R24		RESISTOR, FIXED, WIRE WOUND: .316 ohms, 1%, 3/4 watt or larger	18575-488	1.30
R25		RESISTOR, FIXED, FILM: 5.11K ohms, 1%, 1/2 watt	18694-361	.40
R26		RESISTOR, FIXED, COMPOSITION: (Calibration) 620 ohms nom. 330/1K (1/2 watt)		
R27		RESISTOR, VARIABLE: 3000 ohms	16925-435	.88
R28		RESISTOR, FIXED, COMPOSITION: 1 megohm, 10%, 1/2 watt	18415-102	.38
R29		RESISTOR, FIXED, FILM: 4.64 megohms, 1%, 1/2 watt	18694-645	.40
R30		RESISTOR, FIXED, COMPOSITION: 10K ohms, 10%, 1/2 watt	18413-102	.38
R31		RESISTOR, FIXED, FILM: 1.33 megohms, 1%, 1/2 watt	18694-593	.40
R32		Same as R27		
R33		Same as R27		
R34		Same as R27		
R35		RESISTOR, VARIABLE: 5K ohms, 20%, 1/2 watt (ohms adjust)	16925-556	.85
R36		RESISTOR, FIXED, COMPOSITION: 68K ohms, 10%, 1/2 watt	18413-682	.38
R37		RESISTOR, VARIABLE: 10,000 ohms	16925-433	.76
R38		RESISTOR, FIXED, COMPOSITION: 82K ohms, 10%, 1/2 watt	18413-822	.36
R39		RESISTOR, FIXED, COMPOSITION: 91 ohms, 5%, 1/2 watt	18410-911	.38
R40		RESISTOR, FIXED, FILM: 11 ohms, 1%, 1/2 watt	18694-105	.40
R41		RESISTOR, FIXED, FILM: 10 ohms, 1%, 2 watt	18698-101	.86

REF. DESIG.	NOTES	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
R42		RESISTOR, FIXED, COMPOSITION: 56K ohms, 10%, 1/2 watt	18413-562	.38
R43		Same as R42		
R44		RESISTOR, FIXED, COMPOSITION: 1000 ohms, 10%, 1/2 watt	18412-102	.38
R45		RESISTOR, VARIABLE: 50K ohms, 20%, 1/2 watt	16925-555	.85
S1		SWITCH, ROTARY: range, 4 section, 8 position	19912-579	3.60
S2		SWITCH, ROTARY: function, 5 section, 8 position	19912-578	4.50
T1		TRANSFORMER: power	20800-265	3.91
V1		TUBE: 12AT7, aged	20877-31	4.45
V2		TUBE: 6AL5, aged	20877-32	3.69
		BOOKLET: instructions	2490-513	3.00
		CASE ASSEMBLY	3145-587	11.86
		CORD: AC line and plug assembly, 3 conductor	3675-34	1.50
		FOOT: rubber	6050-23	.23
		HANDLE: battle ship grey, mechanism burnished nk. pl. steel	8330-113	.88
		JACK, TIP: red nylon	10300-55	.62
		JACK, TIP: black nylon	10300-56	.62
		KNOB: with indicator, black, brass bushing, hole for 1/4" shaft	11505-154	1.85
		LEAD ASSEMBLY: red	12450-379	1.16
		LEAD ASSEMBLY: black	12450-383	1.12
		LEAD ASSEMBLY: DC	12450-401	2.50
		LEAD ASSEMBLY: for probe	12450-402	1.26
		PROBE ASSEMBLY: AC	16970-79	14.75

NOTE: A minimum billing charge of $3.50 will be assessed for any parts order.
Prices are subject to Change without notice.


ALT DRAWING NUMBER
902-444 W
ALL MA, OHMS, CAPACITY
P-P 1500V RMS 500, 1500V
RED
S1
FUNCTION
OFF
MA
+DC V
-DC V
AC RMS
AC P-P
OHMS
CAPACITY
ALL
DC V
DC PROBE
R 28
1M
S2
RANGE
VOLTS-MA
OHMS
CAPACITY
0.5
1.5
X 1M
X 10 PF
5.0
X 100 K
X 100 PF
15
X 10 K
X 1000 PF
50
X 1 K
X .01 MFD
150
X 100
X 0.1 MFD
500
X 10
X 1 MFD
1500
X 1
X 10 MFD
ALL MA, OHMS, CAPACITY
P-P 1500 V RMS 500, 1500 V
BLACK
RMS 1.5-150 V
P-P 5.0-500 V
AC PROBE
C1
047
V2
6AL5
R 10
14.2 M
C8
.018
M1
200 µA
1 K
CAPACITY OHMS ADJ
R 35
5K
C2
.01
C4
.47
C3
0.018
R29
4.64M
CR3
SC6
R30
10K
R 31
1.33M
MA CAL R 27 3K
P-P CAL R34 3K
RMS CAL R33 3K
0.5 V CAL R32 3K
R26 NOM 620Ω
1.5 V CAL
R 25 5.11 K
R1 6.84M
R2 2.16M
R3 684 K
R5 68.4 K
R4 216 K
R7 9K
R6 21.6K
R8 900Ω
R9 90Ω
R12 7.92 M
R13 2.32 M
R14 692 K
R15 218 K
R16 100 K
R17 684Ω
R18 216Ω
R19 68.4Ω
R20 21.6Ω
R21 6.84Ω
R22 2.16Ω
R23 .684Ω
R24 .316Ω
R11
100M
+80 V
V1
12AT7
R44
1K
R 42
56 K
R 43
56 K
ZERO ADJ
R 45
50 K
-80 V
CR1
SC 6
R 36
68 K
AC ZERO ADJUST
R 37
10K
C5
20µF
250 V
R 38
82 K
C6
20µF
250 V
T1
135 V
.01 A.
6.3 V
0.3 A.
115 V
60 ~
R41
10 Ω
CR2
SS 05
R39
91 Ω
R 40
11 Ω
C 7
100µF
25 V
PANEL CONTROL
INTERNAL CONTROL
1 UNLESS OTHERWISE SPECIFIED, RESISTORS ARE SHOWN IN OHMS.
K=1000 Ω
M=1,000,000 Ω
2. CAPACITANCES ARE IN MICROFARADS.
3. = FRONT PANEL MARKING.
4. NO CONNECTION
5. CONNECTION
SCHEMATIC WIRING DIAGRAM-MODEL 209 C