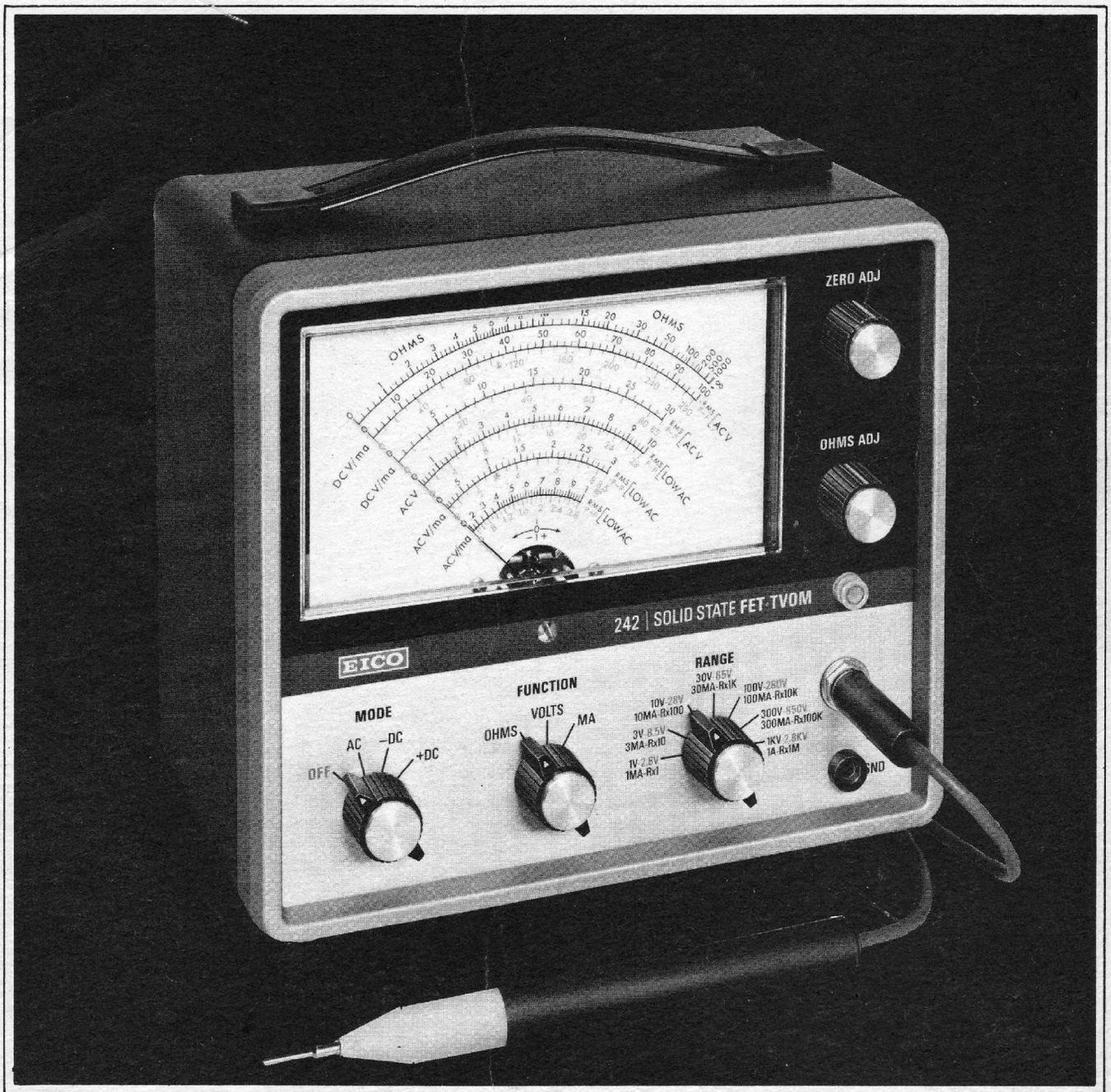


EICO[®]

**242 | Solid State
FET-TVOM**



OPERATING MANUAL

GENERAL DESCRIPTION

The Model 242 TVOM has been designed for bench and field service in testing both vacuum tube and semiconductor circuits. This instrument combines the desirable features of a VTVM and a milliammeter into a single attractively styled cabinet.

FEATURES

1. Readings are made on the 11 scales of the large easy-to-read 6" meter.
2. An extremely wide range of d-c voltages can be measured -- from as low as 0.01 volt up to 1000 volts -- in seven ranges. High voltage range can be extended to 30,000 volts by using the EICO HVP-2 probe (not supplied).
3. An accurate milliammeter circuit permits a wide range of precise a-c and d-c current measurements from 10 microamperes to 1 ampere.
4. The seven a-c voltage ranges cover the full gamut of alternating voltage measurements from 1 volt rms (full scale) to 1000 volts rms (full scale). Each of the five a-c voltage and current scales is calibrated both for rms and peak-to-peak values. Readings are valid for a frequency range of 25 Hz to 2 MHz and can be extended to 250 MHz with EICO RF Probe PRF-11 (not supplied).
5. Seven ohmmeter ranges are available for readings up to 1000 megohms. The ohmmeter circuit operates from a transistor-regulated low voltage source to avoid accidental damage to semiconductors in equipment under test. This feature also prevents transistors in equipment under test from affecting resistance readings.
6. The instrument can be operated either from an a-c power source or from three self-contained 9-volt transistor-type batteries, permitting the use of the TVOM as a completely portable unit at remote locations. Standoffs at the rear of the cabinet provide a convenient storage facility for the a-c line cord when it is not being used.
7. The Model 242 uses the EICO-exclusive Multi-Probe. Only one convenient "hot" probe with a fingertip control is used for all functions, eliminating tangled test leads.
8. A state-of-the-art, FET-input, high-impedance input stage drives the sensitive differential amplifier circuit. The voltage regulated power supply and high-quality 1% multiplier resistors used in this instrument assure stability and accuracy on all ranges. The FET input circuit is completely protected from possible overloads by a fast-acting semiconductor network.

SPECIFICATIONS

DC Voltmeter

Range:	0 to 1, 3, 10, 30, 100, 300, and 1000 volts (+ or -) (extendable to 30,000 volts with EICO HVP-2 Probe)
Input Impedance:	11 megohms
Accuracy:	±3%

AC Voltmeter

Range:	RMS - 0 to 1, 3, 10, 30, 100, 300, and 1000 volts P-P - 0 to 2.8, 8.5, 28, 85, 280, 850 and 2800 volts
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Input Impedance: 1 megohm
Accuracy: $\pm 5\%$ of full scale (with sinusoidal input voltage)
Frequency Response: 25 Hz to 2 MHz (extendable to 250 MHz with EICO RF Probe PRF-11)

DC Current

Range: 0 to 1, 3, 10, 30, 100, and 300 ma, and 1 amp

AC Current

Range: RMS - same as d-c current
 P-P - 0 to 2.8, 8.5, 28, 85, 280, and 850 ma, and 2.8 amps.

Ohmmeter: 0.2 to 1000 megohms in seven ranges

Meter: 6", 200 μ a movement

Power Supply: Transformer isolated, silicon rectifier, zener regulated; three NEDA No. 1604 9-volt batteries for portable use. One 1.5-volt D-size cell for ohmmeter use.

A-C Power Requirements: 105-132 volts, 50/60 Hz, 1.4 VA

Size: 7-1/2" high, 8-1/2" wide, 5" deep

Weight: 6 lbs, 3 oz.

CIRCUIT DESCRIPTION

Basic Metering Circuit

The Model 242 circuit, shown in simplified form in figure 1, consists of an FET source follower stage Q1, driving a differential amplifier formed by NPN silicon transistors Q2 and Q3. Regardless of the parameter being measured (a-c or d-c voltage or current, or resistance), the meter reading is a function of the d-c input applied to FET Q1. The high input impedance of the FET prevents it from loading the inputs at the probe, as well as the switching and attenuating circuits at the front end of the TVOM.

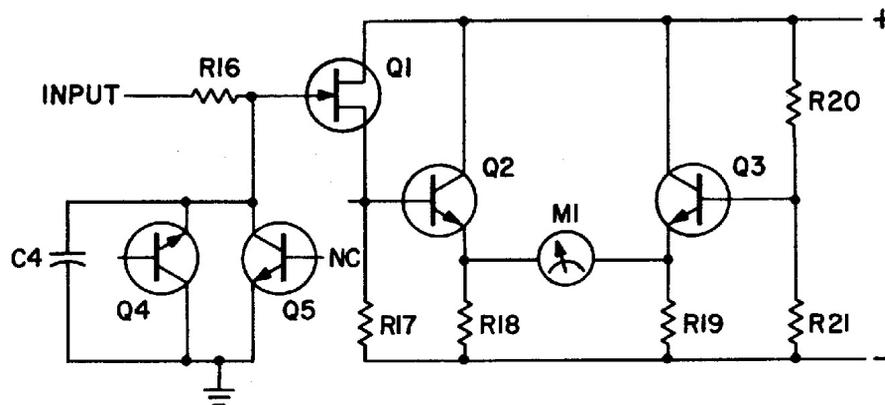


Figure 1. Basic Metering Circuit

When the emitter currents through Q2 and Q3 develop identical voltages across their respective emitter resistors, R18, and R19, the two emitter voltages will be identical. No current will flow through the meter at this time. Note that the base current of Q3 is held constant by voltage divider elements R20 and R21, maintaining the emitter current and hence the voltage developed across R19 at a fixed value.

Operation of Q2 is controlled by a voltage divider consisting of FET Q1 (acting as a voltage-variable resistor) and R17. When a d-c voltage is applied to the gate of source follower Q1, its source voltage, direct coupled to the base of Q2, changes accordingly. Since Q2 is connected as an emitter follower, its emitter voltage follows the change. This unbalances the voltages between the emitters of Q2 and Q3, deflecting the meter pointer. In this manner, meter deflection is made a function of the d-c voltage applied to the gate of Q1.

Transistors Q4 and Q5 are used in conjunction with resistor R16 to protect FET Q1 from accidental overloads. With the bases of Q4 and Q5 disconnected, they act as high-quality temperature compensated zener diodes. This parallel transistor circuit presents an infinite impedance to input voltages up to approximately 10 volts, but becomes a short circuit to higher voltages. Excess voltages are dropped across R16.

Probe

The EICO Multi-Probe contains a switch and a 1-megohm resistor. When the probe is set to DC, the 1-megohm resistor is connected in series with the probe tip, reducing circuit loading. In the AC/OHMS/MA position, the switch shorts out the resistor, connecting the probe tip directly to the TVOM input.

D-C Volts Input Circuit

Figure 2 shows, in basic form, the d-c input circuit when the TVOM is set for measuring either a positive or negative d-c voltage. A voltage applied to the probe tip passes through resistor R1 in the probe to voltage divider resistors R8 through R13, R7, R6, R5, and R22. Various wafers on the RANGE switch select the proper tap on the voltage divider for the particular voltage being measured. The full-scale voltage that corresponds to each RANGE switch position appears on the front panel of the instrument.

The total resistance of the divider network (including R1) is 11 megohms. The ratio of the resistance from the selected tap to ground, to total voltage divider resistance is identical to the ratio of the voltage present at that tap to the applied voltage. For a RANGE switch setting of 1V and with a d-c input to the TVOM of 1 volt, the ratio is 10 megohms to 11 megohms ($\frac{10}{11}$). In this case, the voltage at the top of R8 is $(\frac{10}{11}) \times 1$ volt or $\frac{10}{11}$ volt. When this voltage is applied through R16 to FET Q1, (and assuming the sensitivity has been properly adjusted with R24) there will be a full-scale deflection on the meter. Similarly, if the RANGE switch setting is 100V and 100 volts is applied to the TVOM, the ratio is 100,000 ohms to 11 megohms, and the voltage at the 100V tap is $100 \times \frac{100,000}{11,000,000}$ or $\frac{10}{11}$ volt, again producing full-scale deflection. Of course, if a lesser voltage is applied on any scale, the meter will deflect accordingly. Thus a 50-volt input on the 100-volt scale produces an output of

$$50 \times \frac{100,000}{11,000,000} \quad \text{or} \quad \frac{5}{11} \quad \text{volt,}$$

causing the meter to deflect half-way, to the 50-volt mark.

A-C Volts Input Circuit

As shown in figure 3, when the Multi-Probe is set to AC/OHMS/MA, the probe switch shorts out R1. The a-c voltage applied to the probe tip passes through contacts on FUNCTION switch S2 and MODE switch S3 and is coupled through blocking capacitor C3 to voltage divider elements R2, R3, and R4. This divider is not used in the lower five a-c ranges. The a-c voltage is applied to a voltage doubler consisting of C1, D1, D2, and C2. Assuming that 1 volt rms is applied to the circuit shown, approximately 2.82 volts dc is developed across C2. This voltage is applied to a voltage divider consisting of R14 and the same resistors used in the d-c volts input circuit (R8 through R13, R7, R6, R5, and R22). As a result, when the RANGE switch is set to 1V, $\frac{10}{11}$ of a volt appears at the 1V tap of the divider. With a-c sensitivity control R23 properly adjusted, there will be a full-scale meter deflection.

Operation of the divider circuit for the lower five a-c ranges is the same as for the d-c input circuit. However, in the 300V and 1KV settings of the RANGE switch, the a-c input signal is divided by the network consisting of R2, R3, and R4 before being rectified. To compensate for the resulting lower output of the voltage doubler in these two ranges, the d-c voltage for the 300V and 1KV ranges is divided in the same ratio as for the 100V range. The correct voltage can then be read on the corresponding (300V or 1KV) calibrated a-c scale.

D-C Milliampere Input Circuit

D-c current measurements ranging from .01 ma (10 microamperes) to 1 ampere can be made with the Model 242. These measurements are made by passing the current through a known resistance, then measuring the voltage drop across it.

Figure 4 shows the input circuit arranged to measure up to 1 milliampere of current. When the test probe and common lead are connected in series with the circuit to be tested, the external current flows through resistors R31 through R34. Assuming that 1 milliampere of current flows, a voltage drop of 1 volt (1 ma x 1000 ohms) is produced. The 1-volt d-c level is then applied through R35 and voltage divider elements R8 through R13, R7, R6, R5, and R22. This 11-megohm network is identical to that used for measuring d-c voltage (as previously described), with R35 replacing probe resistor R1. With $\frac{10}{11}$ volt fed through R13 to FET Q1, full-scale deflection is produced on the 1-ma d-c scale.

When RANGE switch S1 is set to the 3MA position, current flows through the same network (R31 through R34). Assuming that 3 ma of current flows in the external circuit, 3 volts dc is developed across this network. The 3V tap on the voltage divider is automatically selected at this time.

When measuring 10 ma or 30 ma, the external current flows through R31, R32, and R33, again producing 1 volt or 3 volts, respectively. Again, the same two taps are used on the voltage divider to produce the voltage for proper deflection.

Operation is similar on the remaining d-c current scales. In each case, either 1 volt or 3 volts is developed and either of the same two voltage-divider taps is selected.

A-C Milliampere Input Circuit

The a-c milliampere circuit (figure 5) functions similarly to its d-c counterpart. The same resistors (R31 through R34) are used to develop either 1 volt or 3 volts a-c. In this case, the a-c voltage is coupled through blocking capacitor C3 to voltage doubler C1, D1, D2, and C2, where it is rectified to dc. The d-c voltage is then applied to divider resistors R14, R8 through R13, R7, R6, R5, and R22. Again, the proper voltage is tapped off at either the 1V or 3V tap on the voltage divider for proper deflection on any range.

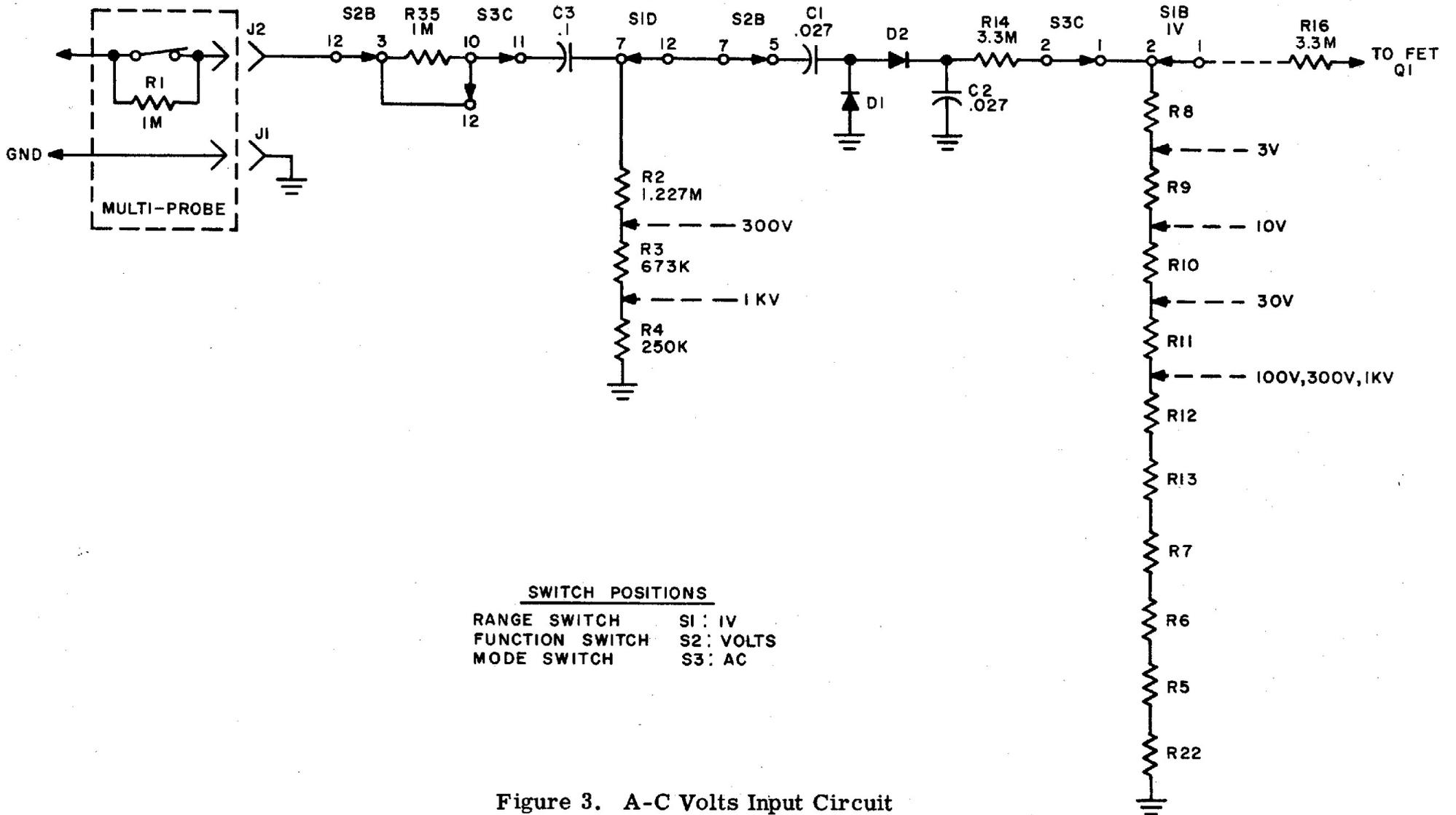


Figure 3. A-C Volts Input Circuit

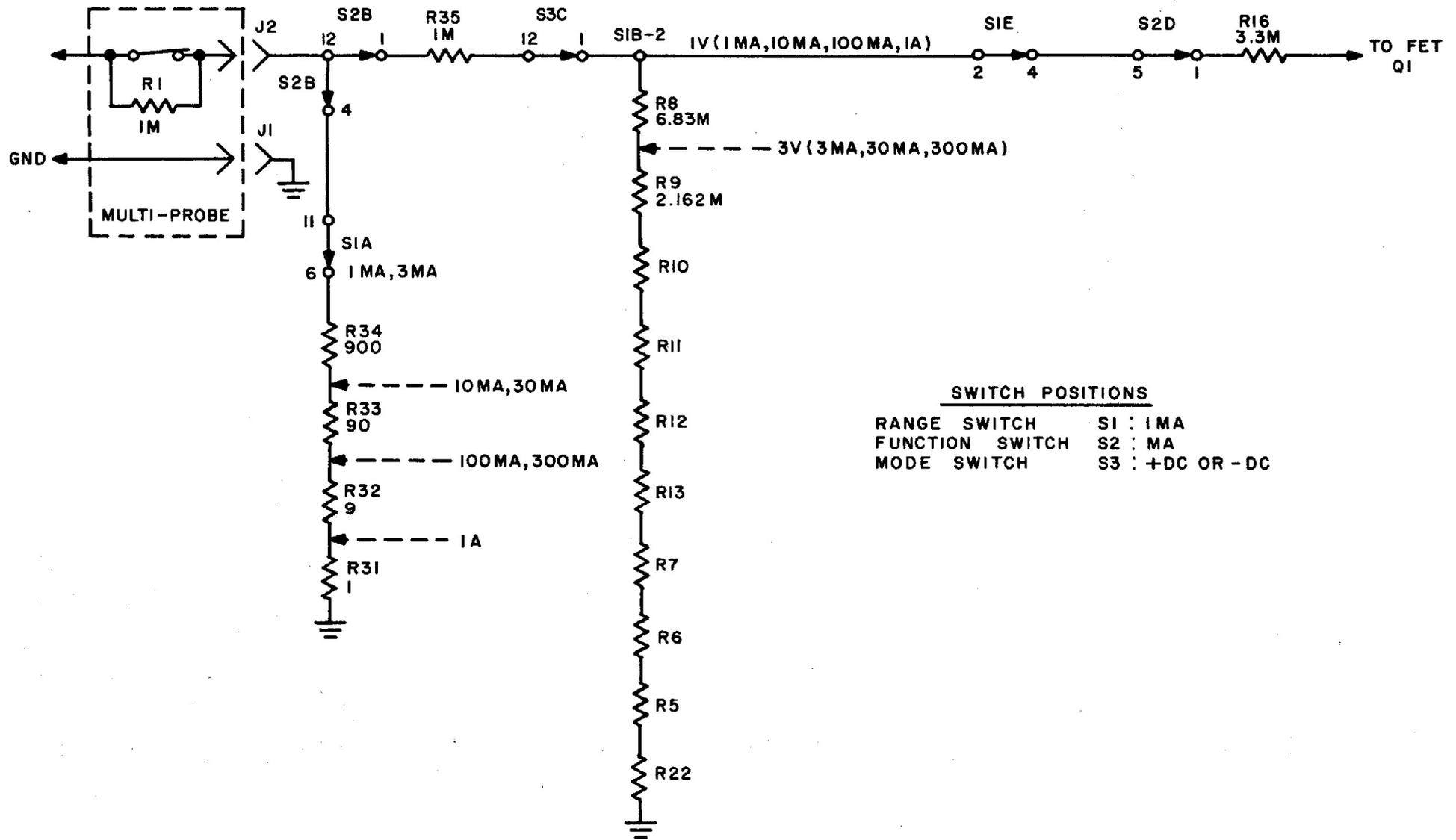


Figure 4. D-C Milliampere Input Circuit

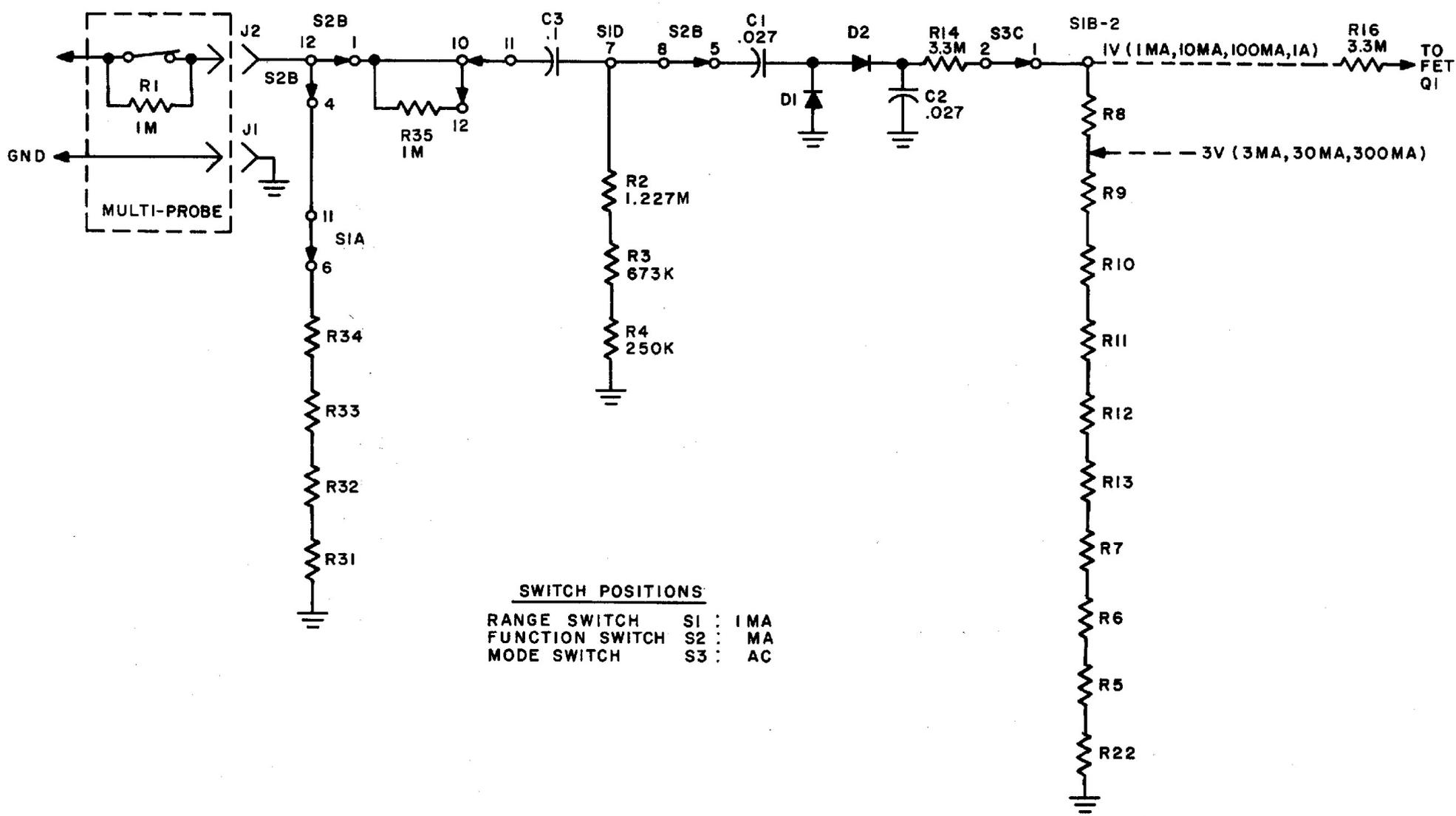


Figure 5. A-C Milliampere Input Circuit

Ohmmeter Input Circuit (See figure 6 on page 10.)

The ohmmeter circuit uses a constant current source consisting of transistor Q6, OHMS ADJ control R25, resistor R15, and a 1.5-volt battery. This circuit maintains the current through collector load resistor R22 constant. OHMS ADJ control R25 sets the base bias for Q6 so that, with no external resistance connected, $\frac{10}{11}$ volt is applied to the gate of FET Q1, producing full-scale deflection (∞ on the meter face).

In figure 6, the ohmmeter is shown in the Rx10 position. If an external 100-ohm resistor is connected between the probe tip and common lead, it reduces the voltage at the gate of Q1 to one-half its original value. (This is shown in the equivalent voltage circuit in figure 6.) Thus, measurement of 100 ohms on the Rx10 scale causes the meter to point to the half-way mark, 10, on the OHMS scale. As the external resistance is decreased in value, less voltage is fed to the gate and a lower ohms reading is obtained.

As shown in figure 6, the resistance connected in series with the constant voltage source increases by a factor of 10 as the RANGE switch is rotated from Rx1 to Rx1M. In this manner, the range of the ohmmeter scale is extended to cover very-high-resistance values (readable to 1000 megohms).

Zero-adjust Circuit

The TVOM zero adjust circuit is shown in simplified form in figure 7. FET Q1 and differential amplifier Q2 and Q3 operate from a d-c supply voltage derived either from a 9-volt battery or a transformer-powered, half-wave rectifier. In either case, the voltage is regulated by zener diode D4.

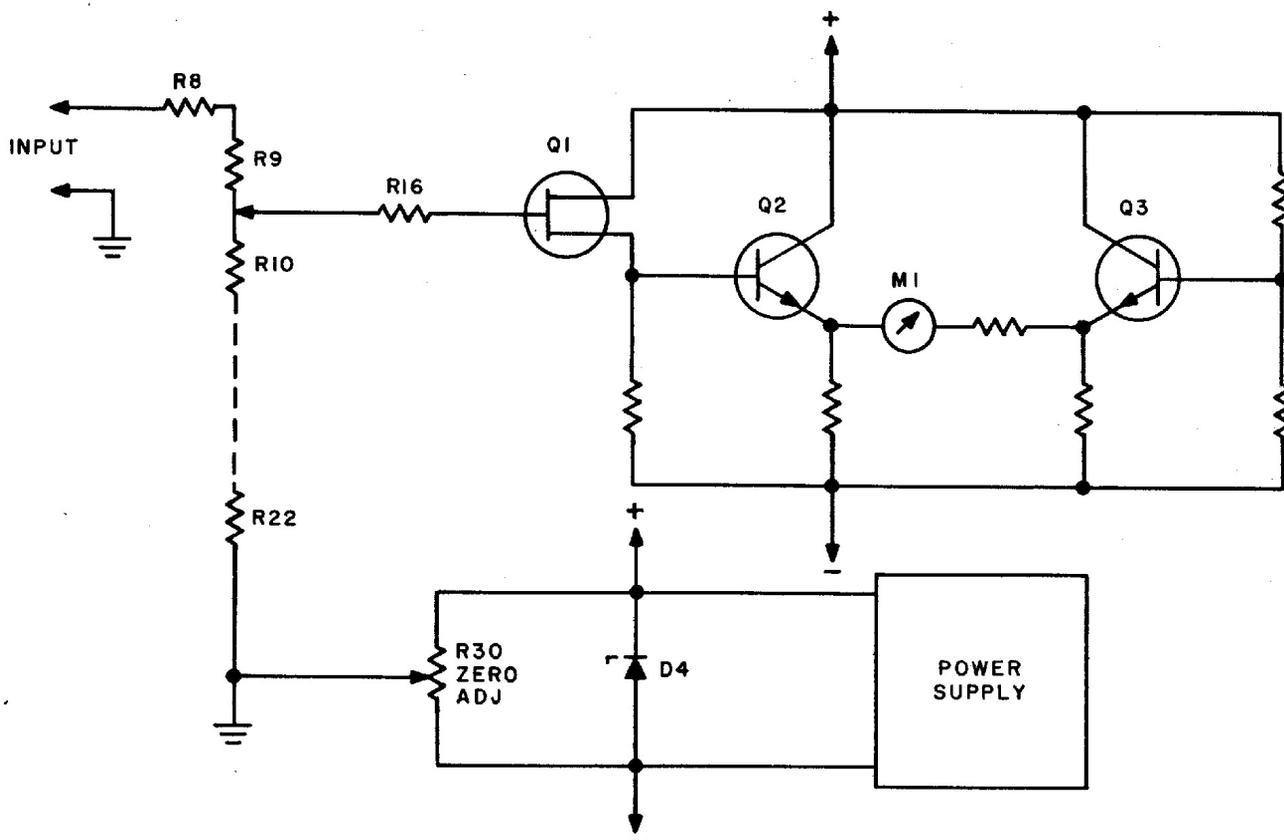


Figure 7. Operation of Zero Adjust

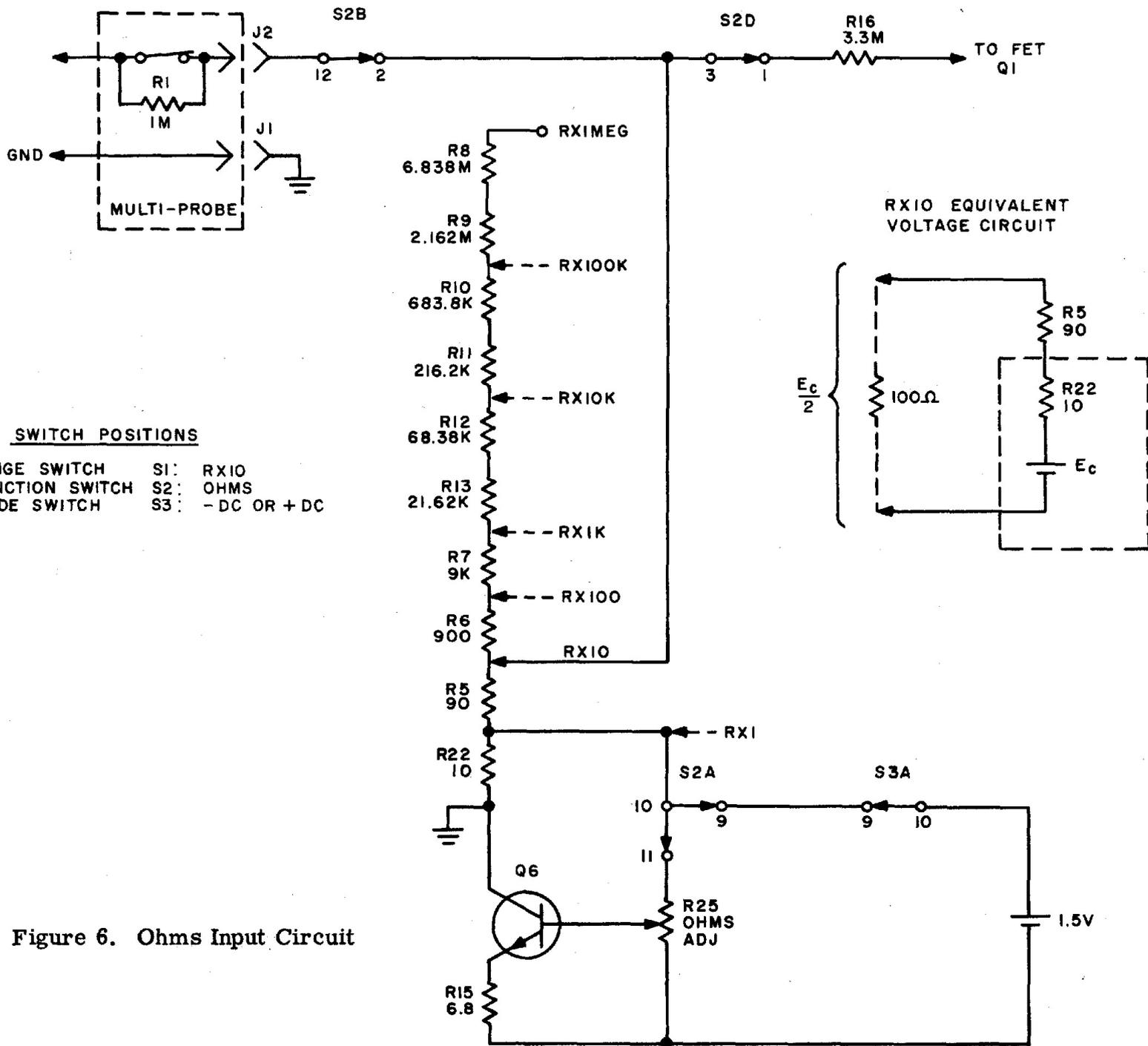


Figure 6. Ohms Input Circuit

Neither end of the supply voltage is grounded. However, the arm of ZERO ADJ control R30, connected across the power supply, is grounded. As a result, the gate bias of FET Q1 may be shifted in either direction by adjustment of R30, since the circuit is completed through R16 and the voltage divider network. Variation of the gate voltage of Q1 results in a variation of the voltage at the emitter of Q2. When the emitter voltage of Q1 is matched precisely to the emitter voltage of Q3, the meter is zeroed.

OPERATING CONTROLS AND INDICATORS

Table 1 lists the operating controls and indicators on the Model 242 and indicates their functions.

Table 1. Controls and Indicators

Item	Function
MODE switch S3 NOTE When measuring resistance, this switch must be set either to -DC or +DC	Selects type of supply to be measured (AC, -DC, or +DC).
FUNCTION switch S2	Selects factor to be measured (OHMS, VOLTS or MA).
RANGE switch S1	Selects the full-scale range for a-c or d-c voltage and current measurements, and the multiplier for ohms measurements.
ZERO ADJ control R30 (10 turn)	Adjusts the meter to left end zero position or, when desired, to zero center mark.
OHMS ADJ control R25 (10 turn)	Used to set meter pointer precisely to full-scale (open circuit) prior to making OHMS measurements.
Probe jack J2	Provides plug-in connection for EICO Multi-Probe.
GND jack J1	Provides plug-in connection for ground lead.
Neon lamp I1	When lit, indicates that a-c power is turned on.
LINE-BATTERY switch S4	Selects either a-c line or internal batteries as power source.

OPERATION

Preliminary Adjustment

Before applying a-c or battery power to the Model 242, place the instrument on a level surface and check that the meter pointer rests on the left-hand zero scale marks. If not, using a fine screwdriver, VERY CAREFULLY adjust the meter zero screw (located directly below the meter movement on the front panel) until the pointer does rest on the zero mark.

NOTE

If possible, it is preferable that the meter lugs be shorted to one another for this mechanical adjustment. Be sure to remove the short before proceeding.

A-C Power Application

a. With the slide switch at the rear of the cabinet set to LINE and the Multi-Probe and ground leads inserted in their respective receptacles on the front panel, plug the line cord into a 105-132 volt a-c 50-to-60 Hz outlet. Note that for safety sake the Model 242 is equipped with a 3-wire plug. If you do not have a 3-wire receptacle, use a 3-to-2 pin adapter, but be sure to connect the ground lead on the adapter to a nearby ground.

CAUTION

Do NOT plug the Model 242 into a source of higher voltage or different frequency (or into a d-c outlet), for the instrument will be damaged.

b. Rotate the MODE switch out of the OFF position. The front panel neon lamp will light to indicate that power is applied.

Battery Operation

a. When using the Model 242 as a portable instrument, set the slide switch at the rear of the cabinet to BATTERY and move the MODE switch out of the OFF position.

NOTE

The front panel neon lamp does not normally light during battery operation. It will light only if the line cord remains plugged into an a-c outlet.

D-C Voltage Measurements

a. Rotate the end of the Multi-Probe until the detent locks in the DC position. (The Multi-Probe end can be rotated either way.)

b. Set the FUNCTION switch to VOLTS and the MODE switch to either -DC or +DC depending on the polarity of the voltage to be measured.

c. Set the RANGE switch so that full scale is higher than the voltage to be measured. If in doubt, always start at the HIGHEST range and progress downward until a usable indication is obtained. Note that all d-c readings are made at the two uppermost black voltage scales (0 to 30 and 0 to 100). Use the 0 to 30 scale for RANGE switch settings of 3V, 30V, and 300V. Use the 0 to 100 scale for RANGE switch settings of 1V, 10V, 100V, and 1KV.

d. Short the ground lead to the Multi-Probe tip and adjust the ZERO ADJ control until the meter indicates precisely zero.

e. Connect the ground lead to the ground (or common) of the circuit under test and the probe tip to the voltage source to be measured.

A-C Voltage Measurements

a. Rotate the end section of the Multi-Probe until the detent locks in the AC/OHMS/MA position.

b. Set the FUNCTION switch to VOLTS and the MODE switch to AC.

c. Set the RANGE switch to a range higher than the voltage to be measured. If in doubt, always start at the HIGHEST range and progress downward until a usable indication is obtained. Note that there are five a-c scales on the meter. The black numbers on each scale represent rms values; the red numbers are peak-to-peak values. The RANGE switch settings are similarly marked in black (rms) and red (peak-to-peak). Select the appropriate a-c scale to read as follows:

1. When the RANGE switch is set to position 1V-2.8V, 3V-8.5V, or 10V-28V, use the corresponding direct reading scale (from the bottom scale to the top scale, respectively).

2. In the 30V-85V and 300V-850V positions of the RANGE switch, use the 0-30V rms (0-85V peak-to-peak) scale.

3. In the 100V-280V and 1KV-2.8KV positions of the RANGE switch, use the upper 0-100V rms (0-280V peak-to-peak) scale.

d. Short the ground lead to the probe tip and adjust the ZERO ADJ control until the meter indicates precisely zero.

e. Connect the ground lead and probe tip to the circuit being measured and read the rms or peak-to-peak value on the appropriate scale.

NOTE

Peak-to-peak indications are valid regardless of the waveforms being measured. However, rms readings are valid only for sine waves.

D-C Current Measurements

a. Rotate the end of the Multi-Probe until the detent locks in the AC/OHMS/MA position.

b. Set the FUNCTION switch to MA and the MODE switch to +DC.

c. Set the RANGE switch so that full scale is higher than the current to be measured. If in doubt, always start at the HIGHEST range and work downward. Note that all d-c current readings are made at the two uppermost black scales (0 to 30 and 0 to 100). Use the 0 to 30 scale for RANGE switch settings of 3MA, 30MA, and 300MA. Use the 0 to 100 scale for RANGE switch settings of 1MA, 10MA, 100MA, and 1A.

d. Short the ground lead to the Multi-Probe tip and adjust the ZERO ADJ control until the meter indicates zero.

e. Connect the common test lead and the test probe IN SERIES with the circuit being tested. The test probe should be connected to the POSITIVE end of the circuit and the common test lead to the NEGATIVE end. Use a RANGE switch setting that results in at least 1/4-scale pointer deflection.

A-C Current Measurements

A-c current is measured similar to d-c current. Set the Multi-Probe to AC/OHMS/MA and the FUNCTION switch to MA. In this case, however, position the MODE switch to AC. Use the TWO LOWEST SCALES for all a-c current measurements: the 0-1 scale for RANGE switch settings of 1MA, 10MA, 100MA, and 1A; the 0-3 scale for RANGE switch settings of 3MA, 30MA, and 300MA. In this case, lead polarity is not important.

Ohmmeter Measurements

a. Rotate the end of the Multi-Probe until the detent locks in the AC/OHMS/MA position.

b. Place the FUNCTION switch in the OHMS position and the MODE switch to either -DC or +DC. The meter should indicate up-scale.

c. Set the RANGE switch to RX100 and short the ground lead to the probe tip. Adjust the ZERO ADJ control until the meter indicates zero. Do not change the zero adjustment for any other RANGE switch setting.

d. Remove the ground-lead from the probe tip, then adjust the OHMS ADJ control until the meter indicates exactly on the extreme right hand mark (∞) on the top scale.

e. Remove power from the equipment under test to avoid damaging the Model 242.

f. Connect the ground lead and probe tip across the resistance to be measured. Set the RANGE switch for the most appropriate deflection. Multiply the reading on the OHMS scale by the factor indicated by the RANGE switch setting.

g. When not in use, place the FUNCTION switch away from OHMS to avoid draining the internal D cell unnecessarily.

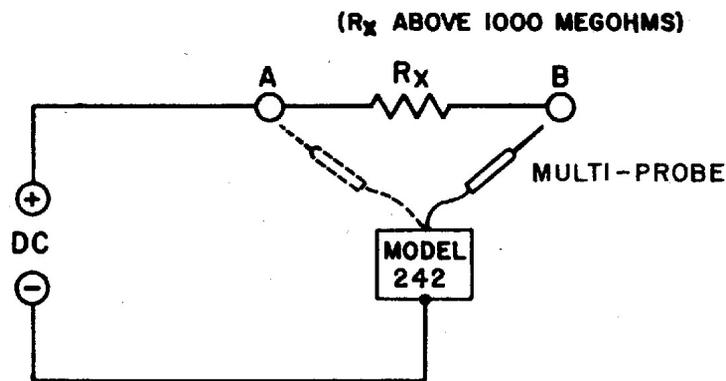


Figure 8

Resistance Measurements Above 1000 Megohms.

The upper limit of direct resistance measurement of this instrument is 1000 megohms. The leakage resistance of small paper and mica capacitors usually exceeds this value. To measure resistance above 1000 megohms, an external d-c source between 20 and 500 volts can be used to obtain a measurable meter deflection. The circuit connection is shown in figure 8 and the procedure is as follows:

1. Set the FUNCTION switch to +DC, and the Multi-Probe to DC. Place the RANGE switch at a range that encompasses the voltage of the power supply used.
2. Measure and record the voltage at point A, and then the voltage at point B.
3. Compute the value of the unknown resistor from the following formula:

$$R_x \text{ (megohms)} = \frac{11 [(\text{volts at point A}) - (\text{volts at point B})]}{(\text{volts at point B})}$$

EXAMPLE: Assume that the power supply used is 300 volts, and the Model 242 measures 300 volts at point A and 1.1 volts at point B. Then

$$R_x = \frac{11 (300 - 1.1)}{1.1} = 3000 \text{ megohms (approximate)}$$

Zero Center Operation.

Zero center indications allow observation of either positive or negative voltage excursions without resetting the FUNCTION switch. To prepare the instrument for such operation, place the FUNCTION switch in the +DC position and adjust the ZERO ADJ control (with the ground lead connected to the probe tip) clockwise until the meter needle rests on the -0+ mark at the bottom of the meter scale. If the meter does not deflect to midscale, use the -DC position for your tests. Set the RANGE switch to a position at least twice the voltage being measured, and then to the lowest range that permits the meter needle to remain on scale with the voltage applied. The value of

positive voltage indicated (meter deflection to the right) is obtained by subtracting half the RANGE selector value from the d-c voltage reading on the appropriate scale. The value of the negative voltage (meter deflection to the left) is obtained by subtracting the d-c voltage reading on the appropriate scale from half the RANGE setting. (The polarities are reversed if the -DC function position is used.)

CAUTION: Although the Model 242 is protected against meter burn-out under normal operating conditions, repeated overloads may impair the accuracy of the meter movement that results from slamming the needle against the limit stops. For this reason, on either ac or dc, always start with a range setting GREATER than the voltage you expect to measure. Always pay attention to polarities when measuring d-c voltage.

DB Measurements

To avoid overcrowding of the meter scales, there is no dB scale on the meter. Another reason for the absence of a dB scale is that there are many different reference levels in use, and each reference level results in a different scale. Figure 9 is a graph for one accepted level--namely 0.775 volt across 600 ohms resistive load (1 milliwatt). Using this graph will allow you to conveniently convert rms a-c voltages to dB readings. These readings are also referred to as DBM.

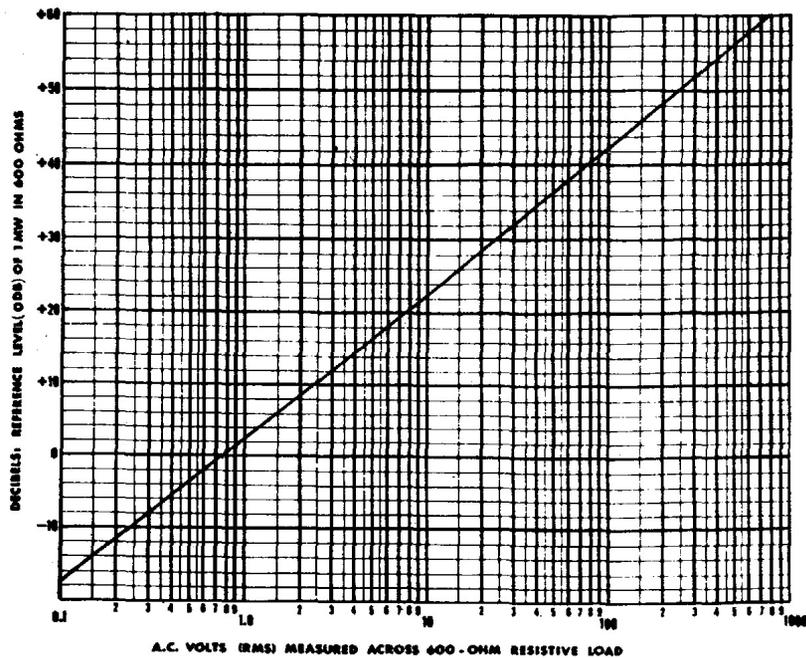


Figure 9

The dB values read on Figure 9 are correct only when the voltage indication is taken across a 600-ohm load. If the readings have not been taken across a 600-ohm load, the dB values read from the chart must be corrected by adding algebraically to it, the correction increment specified in Table 2 for the particular resistive load. If the resistor you are measuring is not found in this table, the correction increment can be found as follows:

Correction increment = $10 \log (600/R)$, where R is the resistive load used.

All dB measurements must be made on a sine wave to avoid waveform error.

Table 2. Correction Increment for Various Loads

Load Res.	DB Added	Load Res.	DB Added
600	0	150	+ 6.0
500	+0.8	50	+10.8
300	+3.0	15	+16.0
250	+3.8	8	+18.8
		3.2	+22.7

CALIBRATION

The Model 242 is shipped fully calibrated and tested, and requires no further adjustment. If it should ever be necessary to recalibrate the unit, proceed as described below.

A-C Calibration

- a. Remove the two round plugs at the left side of the cabinet.
- b. Set the FUNCTION switch to VOLTS and the MODE switch to AC.
- c. Set the RANGE switch to a setting that covers a known level of a-c voltage to which you have access. This may be either the accurately known power line, a power supply that delivers some known level of ac, or a metered audio generator such as the EICO Model 378.
- d. Connect the Multi-Probe and associated ground lead to the Model 242.
- e. Connect the Multi-Probe tip (set to AC/OHMS/MA) to one side of the a-c source and the ground lead to the other side.
- f. With the a-c source turned on, check that the Model 242 indicates the correct voltage. If not, adjust R23 (accessible through the LOWER hole on the left side of the cabinet) until the meter reads the correct value.

NOTE

For maximum accuracy, select a voltage that produces almost full-scale deflection. It is preferable to calibrate on the 30V or 100V ranges, although any range may be used.

D-C Calibration

Some known level of dc, such as a single fresh dry cell (1.55 volts) or an accurate metered adjustable d-c power supply such as the EICO Model 1025 must be used. Proceed as follows:

- a. Set the Multi-Probe to DC.
- b. Set the FUNCTION switch to VOLTS and the MODE switch to -DC.
- c. Set the RANGE switch to the 3V position.
- d. Connect the Multi-Probe tip to the negative terminal of the battery or power supply and the ground lead to the positive terminal. Adjust R24 (accessible through the UPPER hole on the left side of the cabinet) until the meter reads the correct value. This one adjustment suffices for all ranges and for both -DC and +DC modes.

Ohmmeter Function.

No separate calibration is required for the OHMS function range.

To check for ohmmeter leakage (if any), proceed as follows. This also checks the condition of the ohmmeter battery.

1. Place the FUNCTION switch to OHMS.
2. Place the RANGE switch in the R x 1 position. The meter pointer should deflect to the right. Operate the OHMS ADJ control for an exact full-scale indication. If your meter does not deflect full-scale, replace the 1-1/2-volt ohmmeter battery.
3. Rotate the Multi-Probe tip to the AC/OHMS/MA position. Short the tip to the ground lead. The meter should drop to zero. Adjust the ZERO ADJ until it does. It may be necessary to repeat this procedure until the meter pointer rests at both full scale and zero as the probe tip is grounded and ungrounded. On battery operation, the meter may not be capable of being zeroed. This indicates defective 9-volt batteries.
4. Isolate the probe tip and set the RANGE switch to R x 1. The pointer should indicate exactly full scale.
5. Without touching the OHMS ADJ control, place the range switch in the R x 1M position. If the meter pointer drops away from the full-scale position, there is excessive leakage in the ohmmeter circuit and it should be thoroughly checked.

BATTERY REPLACEMENT

To determine if the 9-volt batteries are usable, set the rear-mounted slide switch to **BATTERY** and the **RANGE** switch to any voltage range. Set the Multi-Probe to **AC/OHMS/MA**. Connect the test leads to each other. Adjust the meter to zero. If this adjustment cannot be made, the 9-volt batteries need replacement. The 1-1/2-volt battery should be replaced if the meter cannot be set to zero on the lowest resistance ohmmeter range when the test leads are connected to each other.

Do not permit an exhausted battery to remain in the instrument case as the chemicals released from an exhausted battery may corrode the connectors and surrounding components.

1. Remove the four screws at the rear of the case. Two of these screws are long ones for mounting the a-c line cord and supports. Slide the case off.
2. The 1-1/2-volt ohmmeter battery is mounted at the right side of the rear subchassis in its own holder. The battery should be replaced with a comparable cell, observing the polarity (positive side up). See figure 10.
3. The three 9-volt transistor radio batteries for field power (portable use) are held in place with a metal bracket to the rear subchassis. Loosen the bracket screws. Remove and replace all three batteries when required. The three are in parallel and if only one is replaced, the others will drain the good one and also ruin it. Conventional polarized battery clips are used here. Tighten the batteries back in place.
4. A switch on the rear panel determines whether the Model 242 is operated on the power line or on the internal batteries. Place this switch in the appropriate position (**LINE** or **BATTERY**).

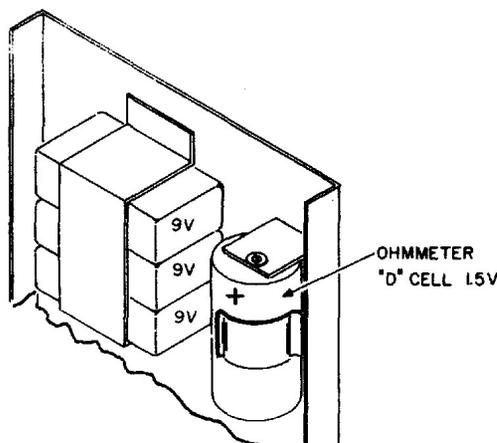


Figure 10. Location of Batteries

CLEANING THE CASE AND METER.

A lightly soaped moist cloth can be used to clean both the case and meter face. **DO NOT** use detergents or an abrasive cleaner as the surfaces may be damaged.

MAINTENANCE

To gain access to the chassis, remove the four screws at the rear of the cabinet. (Two of these support the line cord while in storage or during battery operation.) Carefully slide the chassis out of the cabinet by pulling on the frame.

Remove the four screws (two at each side) that fasten the rear panel to the instrument. Swing the panel back and down to expose the interior of the unit. To get to the MODE switch, remove the two screws that fasten the left side panel to the front panel and gently move the panel aside. Be careful not to break any leads while removing this panel. The two calibration controls are mounted on this panel. To gain access to the RANGE switch, remove the right side panel in the same way.

An understanding of circuit operation will greatly facilitate trouble localization. Before attempting to replace any parts, study the text and simplified diagrams presented under CIRCUIT DESCRIPTION until you thoroughly understand the circuit in question.

The electronics circuit is on a PC board that mounts to the meter lugs. To remove the PC board, first swing the rear panel back out of the way, then unfasten the two meter nuts. Each component is clearly identified by printed designations on the component side of the board. If any components are replaced, carefully unsolder the leads from the foil side of the board and replace the component, being sure that you create no solder bridges. Be careful not to apply so much heat that the copper foil lifts from the board.

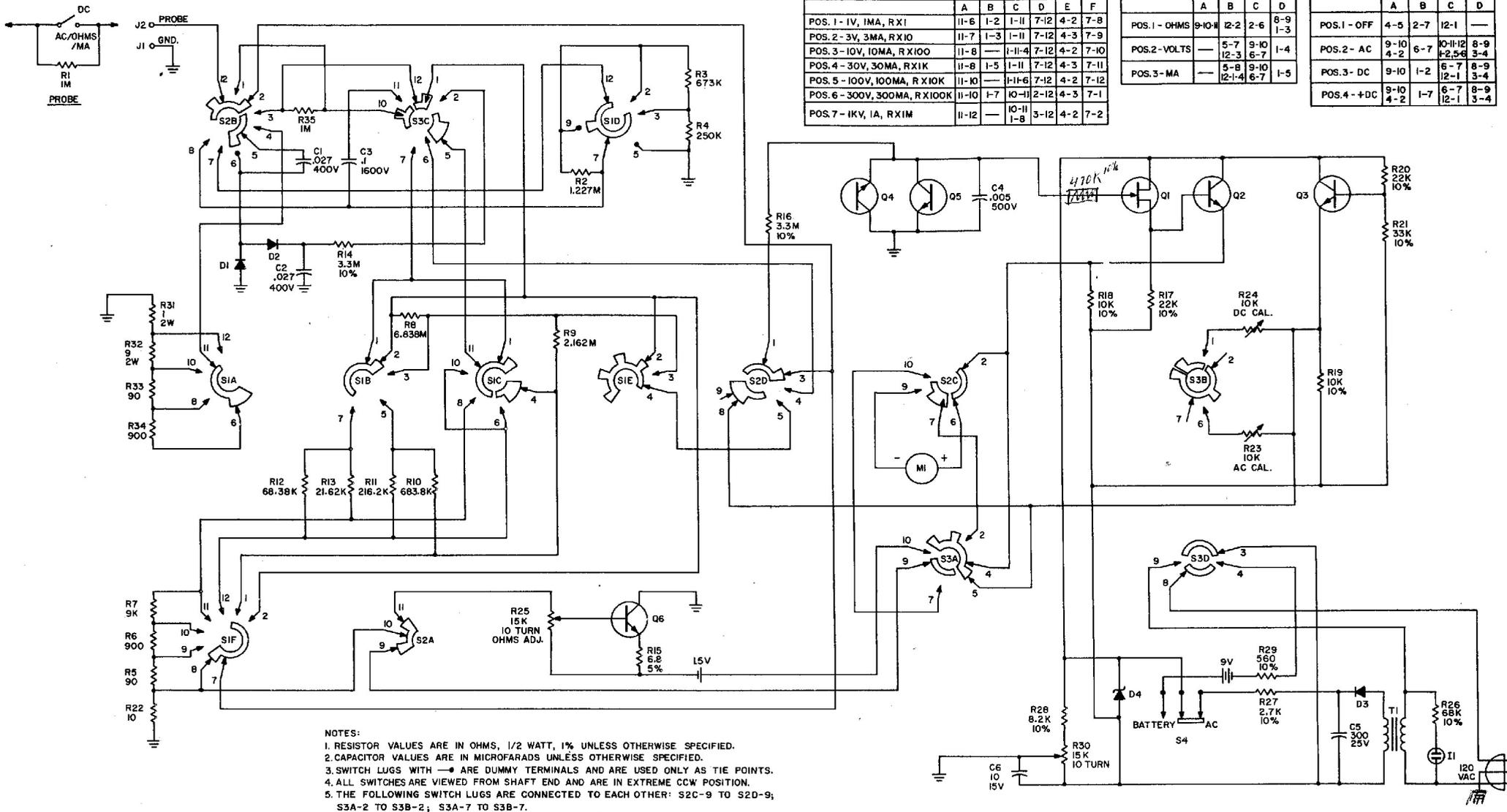
Voltage Measurements

Table 3 specifies the various voltages to be found in the circuit.

Remove one lead of each resistor from the board and check it for correct value. Use an in-circuit capacitance checker to test the capacitors.

Table 3. Voltage Measurements

Q1	Q2	Q3	Q6						
gate - 1.0	base - 4.5	base - 4.5	base - 0.5						
drain - 6.8	collector - 6.8	collector - 6.8	collector - 0						
source - 4.5	emitter - 3.7	emitter - 3.7	emitter - 1						
D3 cathode: 22 volts $\pm 3\%$ D4 cathode: 6.8 volts $\pm 10\%$									
NOTES									
1. Above voltages are measured with respect to negative (-) lead on C5.									
2. Set front panel controls as follows: <table style="margin-left: 100px; border: none;"> <tr> <td>MODE:</td> <td>+DC</td> </tr> <tr> <td>FUNCTION:</td> <td>VOLTS</td> </tr> <tr> <td>RANGE:</td> <td>100V</td> </tr> </table>				MODE:	+DC	FUNCTION:	VOLTS	RANGE:	100V
MODE:	+DC								
FUNCTION:	VOLTS								
RANGE:	100V								
3. Set FUNCTION switch to OHMS to measure voltages at Q6.									
4. Voltage at common Q4 emitter and Q5 collector should rise to a maximum of 10 volts dc (preferably less) and remain there as the input voltage is increased (measured with respect to common lead).									



S1 RANGE SWITCH						
	A	B	C	D	E	F
POS. 1 - IV, 1MA, RX1	11-6	1-2	1-11	7-12	4-2	7-8
POS. 2 - 3V, 3MA, RX10	11-7	1-3	1-11	7-12	4-3	7-9
POS. 3 - 10V, 10MA, RX100	11-8	—	1-11-4	7-12	4-2	7-10
POS. 4 - 30V, 30MA, RX1K	11-8	1-5	1-11	7-12	4-3	7-11
POS. 5 - 100V, 100MA, RX10K	11-10	—	1-11-6	7-12	4-2	7-12
POS. 6 - 300V, 300MA, RX100K	11-10	1-7	10-11	2-12	4-3	7-1
POS. 7 - 1KV, 1A, RX1M	11-12	—	10-11	3-12	4-2	7-2

S2 FUNCTION SWITCH				
	A	B	C	D
POS. 1 - OHMS	9-10-11	12-2	2-6	8-9 1-3
POS. 2 - VOLTS	—	5-7	9-10	1-4
POS. 3 - MA	—	5-8	9-10	1-5
		12-1-4	6-7	

S3 MODE SWITCH				
	A	B	C	D
POS. 1 - OFF	4-5	2-7	12-1	—
POS. 2 - AC	9-10	4-2	6-7	10-11/12 #2, 5-6
POS. 3 - DC	9-10	1-2	5-7	8-9 12-1 3-4
POS. 4 - +DC	9-10	4-2	1-7	8-9 12-1 3-4

NOTES:
 1. RESISTOR VALUES ARE IN OHMS, 1/2 WATT, 1% UNLESS OTHERWISE SPECIFIED.
 2. CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
 3. SWITCH LUGS WITH — ARE DUMMY TERMINALS AND ARE USED ONLY AS TIE POINTS.
 4. ALL SWITCHES ARE VIEWED FROM SHAFT END AND ARE IN EXTREME CCW POSITION.
 5. THE FOLLOWING SWITCH LUGS ARE CONNECTED TO EACH OTHER: S2C-9 TO S2D-9;
 S3A-2 TO S3B-2; S3A-7 TO S3B-7.

SCHEMATIC DIAGRAM

PARTS LIST

PRICE EA.	STOCK NO.	SYM. NO.	DESCRIPTION	QTY	PRICE EA.	STOCK NO.	SYM. NO.	DESCRIPTION	QTY	PRICE EA.	STOCK NO.	SYM. NO.	DESCRIPTION	QTY	PRICE EA.	STOCK NO.	DESCRIPTION	QTY	
RESISTORS																			
.08	10400	R18,19	car., 10K, 1/2W, 10%	2	2.96	30099	T1	power	1	.08	54018		terminal strip, 4 post, w/gnd	1	1.50	66213	manual, operating	1	
.08	10413	R27	car., 2.7K, 1/2W, 10%	1						.14	54025		terminal strip, 4 post, 3 right	1	2.00	66474	manual, assembly	1	
.09	10422	R26	car., 68K, 1/2W, 10%	1	HARDWARE					.11	54074		terminal strip, 3 post, right	1	3.34	80236	front panel	1	
.11	10424	R17,20	car., 22K, 1/2W, 10%	2	.01	40000		nut, hex, #6-32 x 1/4	2	.09	54085		terminal strip, 3 post 2 right, CSA	1	.66	81580	bracket, battery	1	
.08	10428	R21	car., 33K, 1/2W, 10%	1	.02	40001		nut, hex, 3/8-32 x 1/2	5	SWITCHES									
.09	10433	R29	car., 560Ω, 1/2W, 10%	1	.01	40007		nut, hex, #4-40 x 1/4	10	9.18	60221	S1	rotary, range	1	.42	81593	bracket, left	1	
.08	10452	R28	car., 8.2K, 1/2W, 10%	1	.04	40034		nut, tinerman, #4	4	7.44	60222	S3	rotary, mode	1	1.23	81594	subpanel, rear	1	
.09	10457	R14,16	car., 3.3M, 1/2W, 10%	2	.04	40035		nut, hex, #6-32 x 3/16	1	7.32	60223	S2	rotary, function	1	1.23	81595	subpanel, front	1	
.08	10568	R15	car., 5.8Ω, 1/2W, 5%	1	.04	40035		nut, hex, #6-32 x 3/16	1	.26	62000	S4	slide, dpdt	1	.53	81596	bracket, right	1	
.41	11027	R4	car., dep., 250K, 1/2W, 1%	1	.05	41024		screw, set, #8-32 x 1/4	1	METER									
.41	11037	R6,34	car., dep., 900Ω, 1/2W, 1%	2	.01	41035		screw, #6 x 1/4, P.K., b.h.	8	16.45	71020	M1	200 ua, 600-1000Ω	1	.12	82105	line cord, clamp	1	
.44	11038	R7	car., dep., 9K, 1/2W, 1%	1	.03	41061		screw, set, #8-32 x 3/16	1	DIODES & TRANSISTORS									
.41	11044	R5, 33	car., dep., 90Ω, 1/2W, 1%	2	.01	41073		screw, #6 x 1/4, P.K., b.h., black oxide	2	2.24	83040	D3	diode, 2a, 100 PIV	1	n/c	89858	handle hardware	2	
.39	11133	R8	car., dep., 6.838M, 1/2W, 1%	1	.01	41091		screw, #4-40 x 1/4, f.h.	12	1.80	93041	D4	diode, zener, 250 mw, 6.8V, 10%	1	1.80	89881	probe body, screened	1	
.39	11134	R9	car., dep., 2.162M, 1/2W, 1%	1	.01	41140		screw, #6-32 x 1/4, r.h., phillips, type F	10	BULB									
.39	11135	R10	car., dep., 683.6K, 1/2W, 1%	1	.01	41143		screw, #4-40 x 3/8, f.h.	2	.66	97715	II	neon	1	SHEET METAL & MISCELLANEOUS				
.39	11136	R11	car., dep., 216.2K, 1/2W, 1%	1	.01	41191		screw, #6 x 1", P.K., b.h., black oxide	2	.09	46016		foot, rubber	4	<div style="border: 1px solid black; padding: 5px;"> Prices and specifications subject to change without notice. To order replacement parts, remit with order; specify part number and descriptions. Add \$1.00 for mailing and handling; if a power transformer is included in the order, add instead \$1.50 for mailing and handling. </div>				
.39	11137	R12	car., dep., 68.38K, 1/2W, 1%	1	.02	42000		washer, lock, 3/8	2	.12	47002		spring	1					
.39	11138	R13	car., dep., 21.62K, 1/2W, 1%	1	.01	42001		washer, flat, 3/8	5	.07	48005		3/8 plug button, black oxide	2					
.39	11158	R9	car., dep., 673K, 1/2W, 1%	1	.01	42007		washer, lock, #4	10	.02	51300		solder lug, p.c. board	11					
.39	11081	R1,35	car., dep., 1M, 1/2W, 1%	2	.01	42012		washer, star	1	1.08	56523		battery bracket	1					
.64	11723	R2	car., dep., 1.227M, 1W, 1%	1	.01	42021		washer, fiber, special	1	.12	56537		battery connector	3					
1.48	13008	R22	w.w., 100, 1/2W, 1%	1	.01	42024		washer, fiber, special	1	2.10	57009		line cord, 3-conductor	1					
2.28	13760	R32	w.w., 90, 2W, 1%	1	.01	42024		washer, fiber, special	1	.07/ft	58403		single-conductor shielded cable, 4 ft.						
3.00	13701	R31	w.w., 1Ω, 2W, 1%	1	.03	42031		washer, shoulder, fiber, 3/8	1	.05/ft	58408		black single-conductor cable, 4 ft.						
POTENTIOMETERS																			
.73	10915	R23,24	10K, linear	2	.04	42034		washer, flat, #6, 1-3/32, o.d., black	2	JACKS, KNOBS & TERMINAL STRIPS									
3.11	18188	R25,30	15K, linear, 10 turns	2	.02	43003		lug, solder, 1/4	1	.65	50983		phone jack	1	.89	50044	jack, banana, black, insulated	1	
CAPACITORS																			
1.12	20690	C3	mylar, .1 mfd, 1600V, 10%	1	.10	44002		spacer, fiber, special	1	.96	51001		phone plug	1	.62	51005	plug, banana	1	
.24	20107	C1,2	mylar, .027 mfd, 400V, 10%	2	.08	44003		spacer, fiber, special	1	.17	51502		clip, alligator	1	.79	53108	knob, 3/4" dia.	2	
.16	22511	C4	disc, cer., 5000pF, 500V, 50% Z5P	2	.24	44011		spacer, #6, .565 long, black	2	.85	53109		knob, bar	3	.07	54014	terminal strip, 3 post, 2 left	1	
.78	23033	C6	elec., 10 mfd, 15V	1															
.78	23057	C5	elec., 300 mfd, 30V	1															