OPERATING INSTRUCTIONS

TYPE 1803-B
VACUUM-TUBE VOLTMETER

. . . . SINCE 1915

manufacturers of

electronic apparatus

for science and industry

GENERAL RADIO COMPANY

CAMBRIDGE 39, MASSACHUSETTS, USA

714-E

OPERATING INSTRUCTIONS

TYPE 1803-B
VACUUM-TUBE VOLTMETER

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GENERAL RADIO COMPANY
275 MASSACHUSETTS AVENUE
CAMBRIDGE 39 MASSACHUSETTS

SALES ENGINEERING OFFICES

NEW YORK: Broad Avenue at Linden
Ridgefield, New Jersey

CHICAGO: 6605 West North Avenue
Oak Park, Illinois

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WASHINGTON: 8055 13th Street
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826 North Victory Boulevard
Burbank, California

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General Radio Company
Service Department
275 Massachusetts Avenue
Cambridge 39, Massachusetts

CANADA
Bayly Engineering, Ltd.
First Street
Ajax, Ontario

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SPECIFICATIONS

VOLTAGE RANGES: 0.1 to 150 v ac in five ranges. Built-in multiplier extends a-c range to 1500 v at audio and ultrasonic frequencies. 0.02 to 500 v dc in six ranges.

ACCURACY: AC: ±3% of full scale, subject to frequency correction above 50 Mc (see Figure 3). Use of multiplier imposes additional ±1% error.
DC: ±3% of full scale on four lowest ranges; ±4% of full scale on two highest ranges.

WAVEFORM ERROR: Instrument is calibrated to indicate rms value of a sine wave on all a-c ranges. On highest ranges it is peak responding, and indication corresponds to either rms value of a sine wave or 0.707 of peak value of complex wave. On distorted waveforms, the percent deviation from rms value may be as large as the percent of harmonics present. On lower ranges, the response departs from peak and

SPECIFICATIONS (Continued)

WAVEFORM ERROR: (Continued)

approaches rms response. When multiplier is used, the voltmeter is not peak responding. The multiplier is adjusted so that the voltmeter indicates one-tenth the rms value of a sine-wave voltage applied to the multiplier.

FREQUENCY ERROR:

Figure 3 shows the ratio of applied to indicated voltage as a function of frequency for various values of indicated voltage. At low voltages, transit time and resonance effects tend to cancel, while at higher voltages the error is due almost entirely to resonance. The resonant frequency is about 430 Mc.

At low frequencies, response drops off because of increasing reactance of the series capacitance of the input circuit. At 40 cps, the drop is 2% or less. At 15 cps the meter indication begins to fluctuate as it tends to follow the voltage change within each cycle.

The response of the multiplier is flat within ±2% up to 40 kc.

INPUT IMPEDANCE:

The equivalent a-c input circuit is a resistance in parallel with a capacitance. At low frequencies, the equivalent parallel resistance is 7.7 megohms. At high frequencies this resistance is reduced by losses in the shunt capacitance. The equivalent parallel capacitance at radio frequencies is 10$\mu\mu$f. At audio frequencies, the capacitance increases to 12$\mu\mu$f. The multiplier input impedance is a resistance of about 9 megohms in parallel with 11$\mu\mu$f.

The d-c input resistance is 111 megohms. By removal of an internal connection, open-grid input can be obtained for the 1.5, 5, 15, and 50-volt ranges.

POWER SUPPLY: 105 to 125 (or 210 to 250) volts, 50 to 60 cps. Power input about 11 watts.

ACCESSORIES SUPPLIED: Spare fuses.

DIMENSIONS: Width 8¼ in., depth 6½ in., height 11¾ in., over-all.

WEIGHT: 9½ lb.

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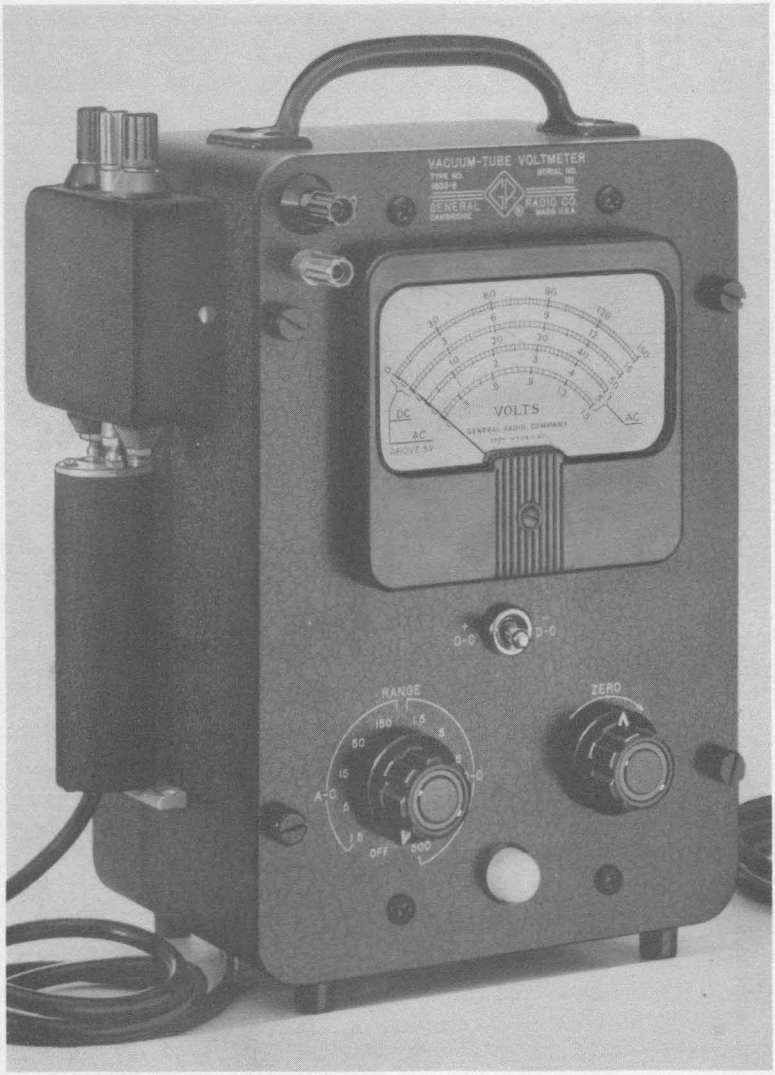

Figure 1. Type 1803-B Vacuum-Tube Voltmeter.

TYPE 1803-B
VACUUM-TUBE VOLTMETER

Section 1
INTRODUCTION

1.1 PURPOSE. The Type 1803-B Vacuum-Tube Voltmeter (Figure 1) is an accurate high-impedance voltmeter designed to meet the majority of voltage-measurement requirements in the laboratory, test shop, and production line. Accuracy is ±3 percent on all but the two highest d-c ranges, where it is ±4 percent. In addition, a built-in multiplier extends the a-c range to 1500 volts at audio and ultrasonic frequencies with an additional error of ±1 percent.

1.2 DESCRIPTION.

1.2.1 GENERAL. For a-c measurements, the voltmeter is a peak-responding instrument calibrated to indicate the rms value of sinusoidal applied voltages. The principal components are a twin-diode rectifier mounted in a probe, followed by a d-c amplifier and indicating meter. For a-c measurements from 150 to 1500 volts, the probe is inserted in a multiplier unit on the side of the instrument, and the voltage is applied to the binding posts on top of the multiplier. The multiplier is a resistor voltage divider that has been compensated to have a response flat to within ±2% up to 40 kc, and is adjusted so that the meter reads one-tenth the rms value of the applied sine wave.

One diode in the probe rectifies the a-c voltage being measured, and the other balances the effect of the initial-velocity current of the first. The d-c amplifier uses a twin-triode tube in a degenerative, balanced circuit.

For d-c measurements the voltage is applied through a ripple filter (and, on the two highest d-c ranges, through a 111-megohm divider) to the a-c amplifier. The balanced amplifier circuit insures a good zero and calibration stability. A polarity switch allows voltage of either polarity to be applied to the high input terminal.

1.2.2 CONTROLS. On the panel of the Type 1803-B are a RANGE switch to select one of the five a-c and six d-c voltage ranges, a ZERO control to establish electrical zero, and a polarity toggle switch to adapt the high input terminal for either positive or negative d-c voltage.

1.2.3 CONNECTIONS. D-C input terminals are standard jack-top binding posts on the front panel. A-C voltages can be applied to the connectors atop the multiplier on the left-hand side of the instrument, as well as to the banana-plug probe tips. Three jacks on the bottom of the multiplier accommodate the probe for storage and provide necessary probe connection for use of the multiplier (refer to paragraph 2.2.3).

Section 2
OPERATING PROCEDURE

2.1 PRELIMINARY OPERATIONS.

2.1.1 MECHANICAL ZERO. Before applying power, check the meter zero and reset if necessary, using the screw-driver adjustment on the meter.

2.1.2 POWER SUPPLY. Connect the power cord to a power source of the voltage and frequency indicated on the nameplate on the voltmeter. The power transformer primaries can be wired for either 115- or 230-volt operation, and connections can be changed quite easily, as described in paragraph 3.3.

2.2 A-C VOLTAGE MEASUREMENTS.

2.2.1 ZERO ADJUSTMENT.

a. Turn the RANGE switch to 1.5 AC, and allow the instrument to warm up for about five minutes.

b. Short-circuit the probe input terminals by connecting the shorting link between the DIRECT and ground (center) terminals atop the multiplier, or by shorting the probe tips.

c. Using the ZERO control, adjust the meter reading to zero. Zero is now adjusted for all a-c ranges.

2.2.2 GROUND. The instrument should usually be grounded, except when the voltage source being measured has neither terminal at ground potential. In such an instance there may be a shock hazard, for the voltmeter panel and case will not be at ground potential.

With the voltmeter ungrounded, voltage of power-line frequency may develop between input terminals and ground. Voltage magnitude depends on power-line grounding, and one polarization of the power plug generally yields lower voltage than the other. Source impedance is about 3 megohms. To reduce the voltage between input terminals and ground when the panel is ungrounded, connect a capacitor or resistor across the affected part of the circuit.

A similar small voltage, which develops across the d-c terminals, can be minimized by orientation of the power plug. Magnitude may be between 2 and 10 mv for the 1.5- to 50-volt ranges, and between 10 and 40 mv for the 150- to 500-volt ranges. To reduce this voltage (circuit conditions permitting), shunt a capacitor (0.01 μf or larger) across the terminals.

2.2.3 MEASUREMENT PROCEDURE.

a. Turn the RANGE switch to the desired full-scale value.

b. Voltages up to 150 volts may be applied either to the probe tips directly or to the probe through the binding posts atop the multiplier as shown in Figure 2A. Either method is satisfactory at low frequencies, but at high frequencies or whenever it is necessary to reduce lead length, the voltage should be applied directly to the probe. For further reduction of lead length, the probe tips can be removed from the probe.

c. Voltages from 150 to 1500 volts in the frequency range from 20 cps to 40 kc should be applied to the 10X terminals atop the multiplier, with the probe plugged directly underneath, as shown in Figure 2B.

2.2.4 MAXIMUM D-C POTENTIALS. The maximum d-c voltage that should be applied to the probe terminals is 300 volts with negative polarity on the high terminal, and 300 volts peak (including any impressed ac) with positive polarity on the high terminal.

The maximum d-c voltage that may be applied to the 10X multiplier terminals is a total of 1500 volts dc and ac rms.

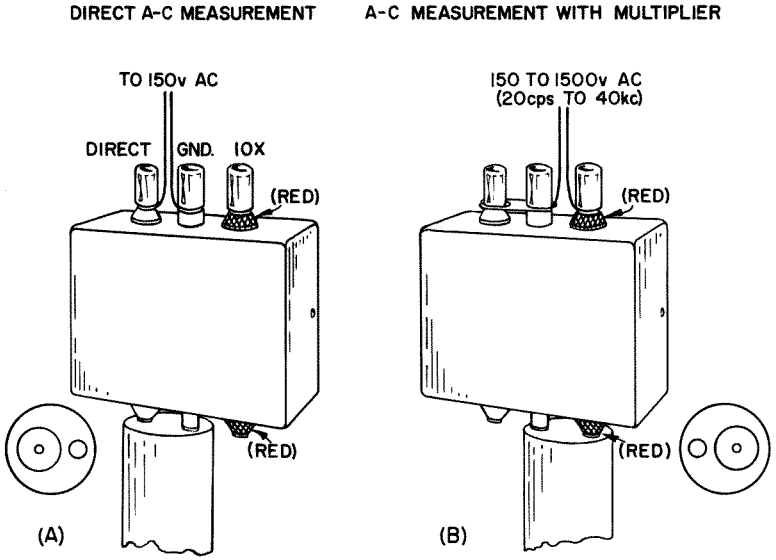

Figure 2. Connections for A-C Measurements.

2.2.5 A-C METER SCALES. The two outer scales, which are linear, are used for a-c voltages above 5 volts. The two nonlinear inner scales are for a-c voltages of 5 volts or less.

2.3 D-C VOLTAGE MEASUREMENTS.

2.3.1 ZERO ADJUSTMENT. Turn the RANGE switch to the 1.5 D-C range and let the instrument warm up for about five minutes.

The zero reading with the voltage source connected across the D-C input terminals depends on the value of the resistance of the source, for the grid current of the d-c amplifier tube flows through the combination of the voltage-source resistance and any internal resistance connected across the input terminals. For greatest accuracy, zero the meter with a resistance equal to the source resistance connected across the input terminals. However, if the source resistance is 1 megohm or less, zero adjustment with the input terminals short-circuited will cause only a negligible error on any of the ranges. When the zero is adjusted, it is adjusted for all d-c ranges.

2.3.2 GROUND. It is usually advisable to ground the instrument. If neither terminal of the voltage source is at ground potential, observe the precautions of paragraph 2.2.2.

2.3.3 MEASUREMENT PROCEDURE.

a. Turn the RANGE switch to the desired full-scale value.

b. Apply the d-c voltage to be measured (up to 500 volts) to the D-C binding posts on the front panel. Connect the ground or low-potential side of the voltage source to the ground binding post.

Set the toggle switch below the meter to the position corresponding to the polarity of the lead connected to the high binding post.

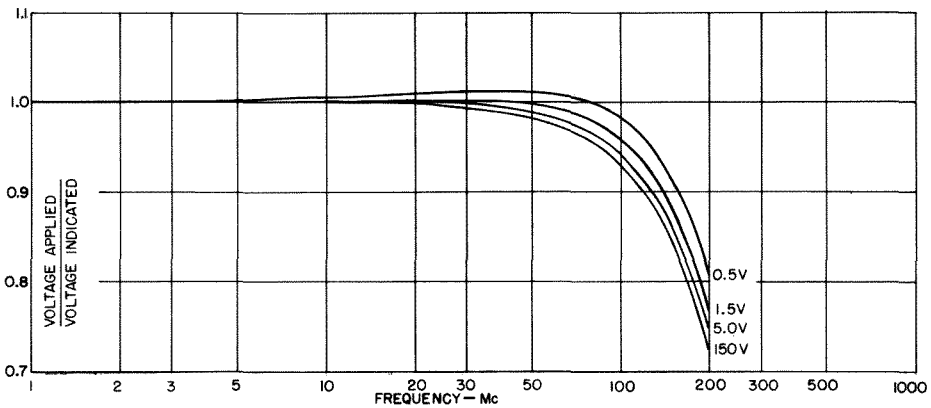

Figure 3. Ratio of Applied Voltage to Indicated Voltage as a Function of Frequency for Various Values of Indicated Voltage.

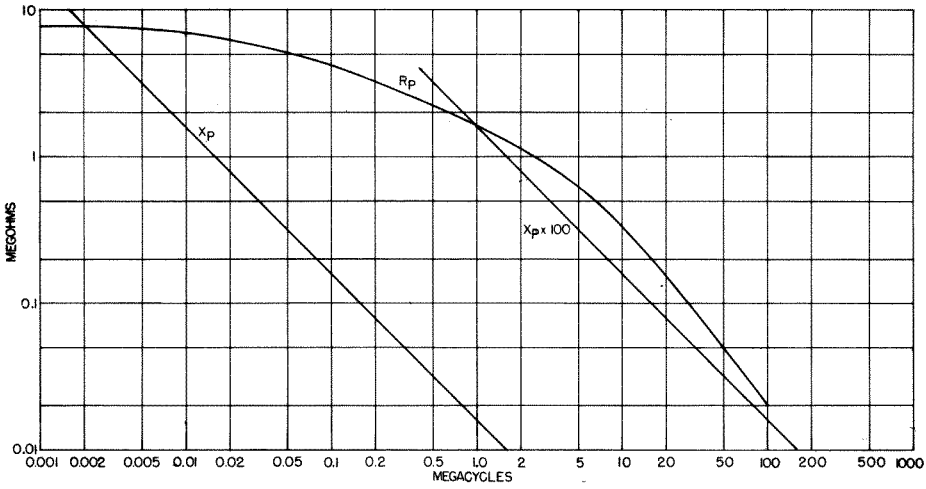

Figure 4. Resistive and Reactive Components of the Input Impedance of the Type 1803-B Vacuum-Tube Voltmeter.

2.3.4 INPUT RESISTANCE. The input resistance at the d-c terminals is normally 111 megohms. When it is essential to have an input resistance higher than 111 megohms, the input can be applied directly through the ripple filter to the grid of the d-c amplifier tube for the first four ranges (1.5, 5, 15, and 50 volts full-scale). To do this, unsolder the bus wire (B, Figure 6) from the high input terminal. The regular input terminals are still used, but the effective input resistance is determined only by the insulation resistance of the input circuit. With this connection, the entire grid current of the amplifier tube (about 1.5×10^{-9} amperes) flows through the voltage source. For the 150- and 500-volt ranges, the input resistance remains at 111 megohms.

2.3.5 METER SCALES. Read all d-c voltages on the two outer scales of the meter.

Section 3
SERVICE AND MAINTENANCE

3.1 GENERAL. This service information, together with the information given in other sections, should enable the user to locate and correct ordinary difficulties resulting from normal use. Major service problems should be referred to our Service Department, which will cooperate as much as possible by furnishing information as well as any replacement parts needed.

When notifying our Service Department of any difficulties in operation or service of the instrument, always mention the serial and type numbers. Also include in correspondence a complete report of trouble encountered, as well as any information concerning the use of the instrument and steps taken to avoid the trouble.

Before returning an instrument or parts for repair, please write to our Service Department, requesting a Returned Material Tag, which includes shipping instructions. Use of this tag will insure proper handling and identification when an instrument or part is returned for repair. A purchase order covering repair of material returned should also be forwarded to avoid any unnecessary delay.

3.2 ACCESS TO COMPONENTS. For access to tubes and other components, merely remove the four black thumb screws from the edges of the front panel, and slide the instrument out of the cabinet. For access to the tube and components in the probe, remove the two screws at the end of the probe and slide back the cylindrical shield.

The probe circuit is connected to the d-c amplifier circuit by a three-wire shielded cable. When the probe is attached to the multiplier, the cable can be stored in the cabinet. Cable leads are furnished with spade terminals, so that the cable may be easily disconnected from the chassis for complete removal of the cabinet.

3.3 POWER-TRANSFORMER CONNECTIONS. The transformer primaries can be connected for either 115- or 230-volt operation. The a-c line is connected, through the power switch and fuses, to power-transformer terminals 1 and 4. For 115-volt operation, connect terminal 1 to terminal 3 and terminal 2 to terminal 4. For 230-volt operation, connect terminal 2 to terminal 3.

When changing transformer connections, be sure to reverse the nameplate on the cabinet near the cord and replace the two line fuses with fuses of the proper rating (refer to Parts List).

3.4 RECALIBRATION PROCEDURE. If there is indication that any single range is in error, use an accurate resistance bridge to check that R21 through R29 are within the tolerances given in the Parts List with the RANGE switch OFF. If it is necessary to recalibrate the voltmeter, proceed as outlined below. You will need, for recalibration, (1) a source of a-c voltage with a pure sine waveform, and (2) a source of d-c voltage. Both sources should be at least 1.5 volts.

a. Adjust the mechanical meter zero with the instrument off.

b. Carefully set the panel ZERO control and recheck the zero frequently during recalibration. Adjust the zero on the 1.5-volt ranges, with appropriate terminals shorted.

c. With the RANGE switch at 1.5 A-C, and with the standardized 60-cps a-c voltage applied to the probe terminals, adjust R19 (potentiometer closest to panel) for correct meter reading. Consult the specifications for tolerances when checking other readings.

d. Switch the RANGE switch to 1.5 D-C and recheck zero. With a standardized voltage of 1.5 volts dc applied to the D-C terminals on the front panel, adjust R20 for correct meter reading. Consult the specifications for tolerances when checking other readings.

e. To adjust the a-c multiplier, calibrate the meter scale to 15 volts ac. Plug the probe into the 10X jacks. Apply 150 volts, 60 cps to the 10X terminals. Adjust R101 (cabinet on inside wall) until meter reads 15 volts, +1% (15.15 volts).

3.5 REPLACEMENT OF VOLTMETER TUBE. If the Type 6SU7-GTY voltmeter tube is replaced or if the range of the panel ZERO control is insufficient, proceed as follows:

a. Remove the 6AL5 tube from the probe (refer to paragraph 3.2), short-circuit the probe input terminals, and set the RANGE switch to 1.5 A-C.

b. Plug in a replacement voltmeter tube and allow it to operate for at least an hour before proceeding further.

c. Short-circuit the grids (pins 1 and 4) of the voltmeter tube to the chassis.

d. With the RANGE switch at 1.5 A-C, adjust the panel ZERO control for a reading of five divisions as indicated on the top (15) scale of the meter.

e. Remove the short circuit from pin 1 of the tube socket. The meter reading should not drop more than five divisions. If it does, select another 6SU7-GTY tube and repeat steps b through e.

f. Remove the short circuit from pin 4 of the tube socket and note that the meter reading is within 2 to 8 divisions as indicated on the top (15) scale of the meter (i.e., within three divisions of the indication with both grids shorted). If these limits are exceeded, selected another 6SU7-GTY.

g. Short-circuit the panel D-C terminals and turn the RANGE switch to 1.5 D-C. Throw the polarity switch to +D-C. Adjust the zero with the panel ZERO

control. The pointer on the ZERO knob should be within about 90 degrees of its center position, or such that there is enough adjustment left on either side of the zero setting. Remove the short circuit from the D-C terminals. The meter indication should increase by no more than 0.16 volt. If these limits are exceeded, replace the tube and repeat steps a through g.

h. Recheck the a-c and d-c calibrations (refer to paragraph 3.4).

3.6 REPLACEMENT OF DIODE. If the Type 6AL5 diode is replaced or if the meter zero cannot be set with the panel ZERO control, proceed as follows:

a. Plug in a replacement voltmeter tube and allow it to operate for at least an hour before proceeding further.

b. Remove the Type 6AL5, short-circuit the probe input terminals and set the RANGE switch to 1.5 A-C.

c. Turn the panel ZERO control to obtain a reading of eight divisions as indicated on the top (15) scale of the meter.

d. Install the 6AL5 tube and allow one minute for it to stabilize. The reading should not change more than eight divisions, and the panel ZERO control should be within 90 degrees of its center position when it is reset for meter zero. If these values are not met, replace the tube and repeat steps a through d.

e. Recheck the a-c calibration (refer to paragraph 3.4).

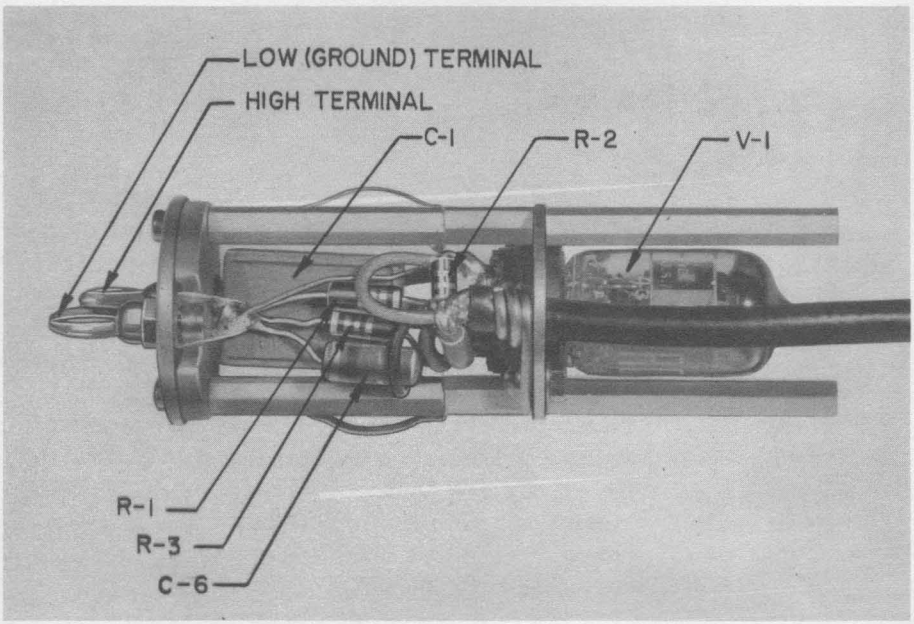

Figure 5. Probe Interior View.

3.7 TROUBLE-SHOOTING PROCEDURE. The following table lists some of the more common difficulties with instruments of this type, with suggestions for correcting them.

INDICATION	TROUBLE	REMEDY
Panel lamp does not light.	Loose or defective fuses, defective power switch or transformer.	Check that fuses are tight in clips, check S2 for continuity, check transformer voltages against Table 2.
Meter does not read with a-c voltage applied but ZERO control functions.	Short circuit in C5.	Replace.
	Defective 6AL5.	Replace tube (refer to paragraph 3.6).
	Probe shield or cable leads broken.	Check continuity.
Meter does not read with voltage applied and ZERO control does not function.	Defective 6SU7-GTY.	Replace tube (refer to paragraph 3.5).
	Defective 6X4.	Replace tube.
	Short circuit in C4.	Replace.
Meter Erratic	Defective 6AL5.	Replace tube (refer to paragraph 3.6).
	Defective 6SU7-GTY.	Replace tube (refer to paragraph 3.5).
	Broken probe shield or lead.	Check continuity.
Meter reads with voltage but zero cannot be adjusted with ZERO control.	Mechanical zero not set.	With instrument OFF, check mechanical zero (screwdriver adjustment at center of meter cover).
	Sticky meter.	Tap meter cover lightly and check that pointer does not shift reading.
	Defective 6AL5.	Replace tube (refer to paragraph 3.6).
	Defective 6SU7-GTY.	Replace tube (refer to paragraph 3.5).

(Continued)

3.7 TROUBLE-SHOOTING PROCEDURE (Continued).

INDICATION	TROUBLE	REMEDY
Meter reads with dc applied to probe.	Leakage in C1.	Short-circuit probe terminals, and set meter to zero. Then remove short and connect a 45-v battery to the probe with negative terminal of battery connected to HIGH probe terminal. If reading exceeds 0.25 v, replace C1.

3.8 TEST VOLTAGES. Table 1 and Table 2 list voltages to be used in trouble-shooting.

TABLE 1. TUBE PIN VOLTAGES

TUBE (TYPE)	PIN	VOLTS DC (A)	VOLTS DC (B)	TUBE (TYPE)	PIN	VOLTS DC (A)	VOLTS DC (B)
V1 (6AL5)	2	-0.78 (c)	-0.65	V2 (6SU7-GTY) (Cont.)	5	173	
	6	-0.84 (c)	-0.27		6	1.25	
	7	-0.86 (c)	-0.74		8	-0.20 (c)	-0.20
V2 (6SU7-GTY)	1	-0.85 (c)	-0.3	V3 (6X4)	1	-300	
	2	173			6	-300	
	3	1.0			7	173	
	4	-0.75 (c)	-0.27				

TABLE 2.
TRANSFORMER VOLTAGES

TERMINALS	VOLTS AC (D)
1-2	117
9-10	6.4
11-12	6.4
13-14	410

NOTES

(A) Measured with 20,000-ohm/volt d-c meter from pin to ground.
(B) Measured with d-c vacuum-tube voltmeter such as General Radio Type 1800 or 1803, with 10-megohm input.
(C) Measured with d-c vacuum-tube voltmeter with open-grid input.
(D) Measured with 1000-ohm-volt a-c meter between terminals indicated.

Line voltage: 117 volts.
ZERO control at center of rotation.
RANGE switch at 1.5 A-C.
Readings subject to ±10% variation.

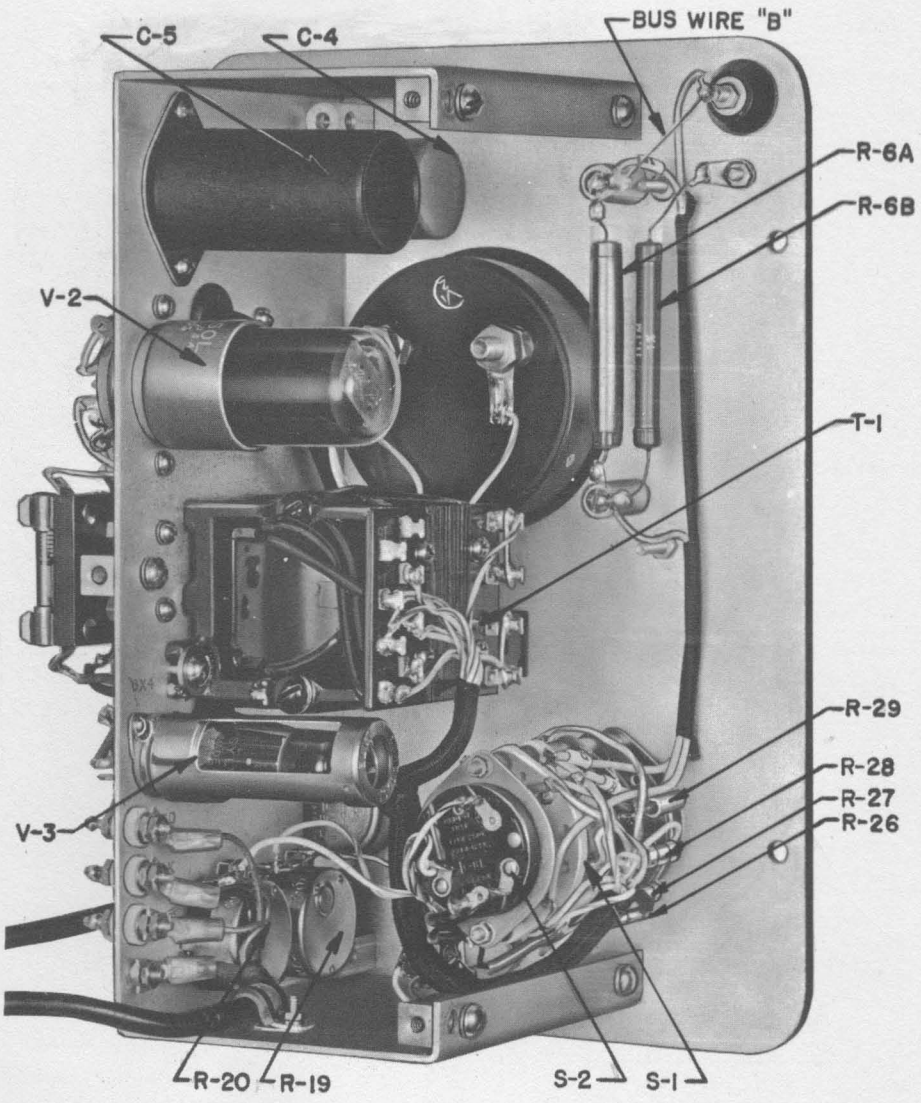

Figure 6. Rear Interior View
of the Type 1803-B Vacuum-Tube Voltmeter.

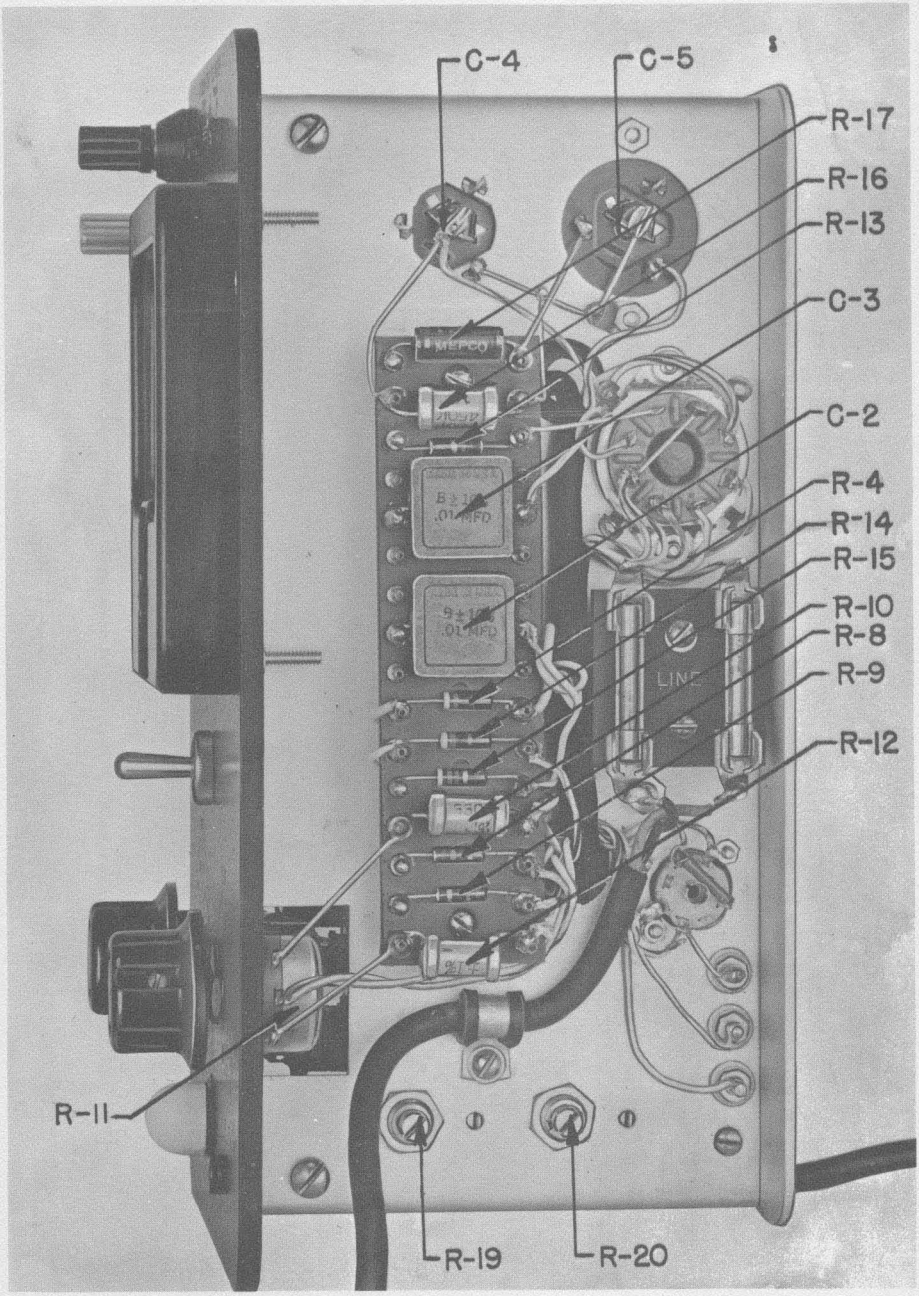

Figure 7. Side Interior View
of the Type 1803-B Vacuum-Tube Voltmeter.

Section 4
PARTS LIST

						PART NO. (NOTE A)
RESISTORS (NOTE B)	R1	47	M	±10%	½ w	REC-20BF
	R2	15	M	± 5%	½ w	REC-20BF
	R3	47	M	±10%	½ w	REC-20BF
	R4	47		± 5%	½ w	REC-20BF
	R5	15	M	± 5%	½ w	REC-20BF
	R6A	100	M		2 w	1803-307
	R6B	11.1	M		2 w	
	R8	18	M	± 5%	½ w	REC-20BF
	R9	18	M	± 5%	½ w	REC-20BF
	R10	330	k	± 1%	½ w	REF-2
	R11	200	k	±10%		POSC-7
	R12	330	k	± 1%	½ w	REF-2
	R13	15	M	± 5%	½ w	REC-20BF
	R14	47		± 5%	½ w	REC-20BF
	R15					
	R16	450	k	± 1%	½ w	REF-2
	R17	820	k	± 1%	½ w	REF-2
	R18	15		±10%	½ w	REW-3C
	R19	2	k	±10%		POSW-3
	R20	2	k	±10%		POSW-3
	R21	5.5	k	± 1%	½ w	REF-2
	R22	29.2	k	± 1%	½ w	REF-2
	R23	96	k	± 1%	½ w	REF-2
	R24	336	k	± 1%	½ w	REF-2
	R25	1.015	M	± 1%	½ w	REF-2
	R26	4	k	± 1%	½ w	REF-2
	R27	21.1	k	± 1%	½ w	REF-2
	R28	70.4	k	± 1%	½ w	REF-2
	R29	241.4	k	± 1%	½ w	REF-2
	R101	3	M	±20%		POSC-11
	R102	3	M	± 1%	1 w	REF-2-2
	R103	3	M	± 1%	1 w	REF-2-2
	R104	1	M	± 1%	½ w	REF-2

PARTS LIST (Cont.)

			PART NO. (NOTE A)
CAPACITORS (NOTE C)	C1	0.01 ±10%	COM-41B
	C2	0.01 ±10%	COM-35B
	C3	0.01 ±10%	COM-35B
	C4	20 450 dcwv	COE-5
	C5	20 450 dcwv	COE-5
	C6	47 $\mu\mu$f ±10%	COC-21, N750
	C101	2.2 $\mu\mu$f ±10% 500 dcwv	COC-1
	C102	3.3 $\mu\mu$f ±10% 500 dcwv	COC-1
MISCELLANEOUS	F1	FUSE, 0.2 amp Slo-Blo Type 3AG (for 115 v)	FUF-1
	F1	FUSE, 0.1 amp Slo-Blo Type 3AG (for 230 v)	FUF-1
	F2	FUSE, 0.2 amp Slo-Blo Type 3AG (for 115 v)	FUF-1
	F2	FUSE, 0.1 amp Slo-Blo Type 3AG (for 230 v)	FUF-1
	M1	METER, 0.2 ma	MEDS-70
	P1	PILOT LAMP, Mazda # 44	2LAP-939
	S1	SWITCH }	SWRW-114
	S2	SWITCH }	
	S3	SWITCH, dpdt	SWT-335
	T1	POWER TRANSFORMER	345-449

NOTES:

(A) General Radio Part No. designations are as follows:

COC - Capacitor, ceramic
COE - Capacitor, electrolytic
COM - Capacitor, mica
POSC - Potentiometer, composition
POSW - Potentiometer, wire-wound
REC - Resistor, composition
REF - Resistor, film

(B) All resistances are in ohms, except k = kilohms, M = megohms.

(C) All capacitances are in microfarads, except $\mu\mu$f = micromicrofarads.

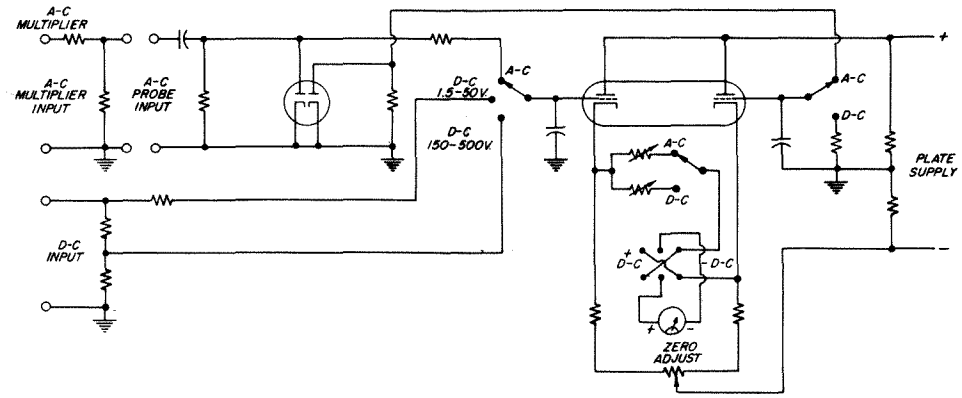

Figure 8. Elementary Diagram for the Type 1803-B Vacuum-Tube Voltmeter.

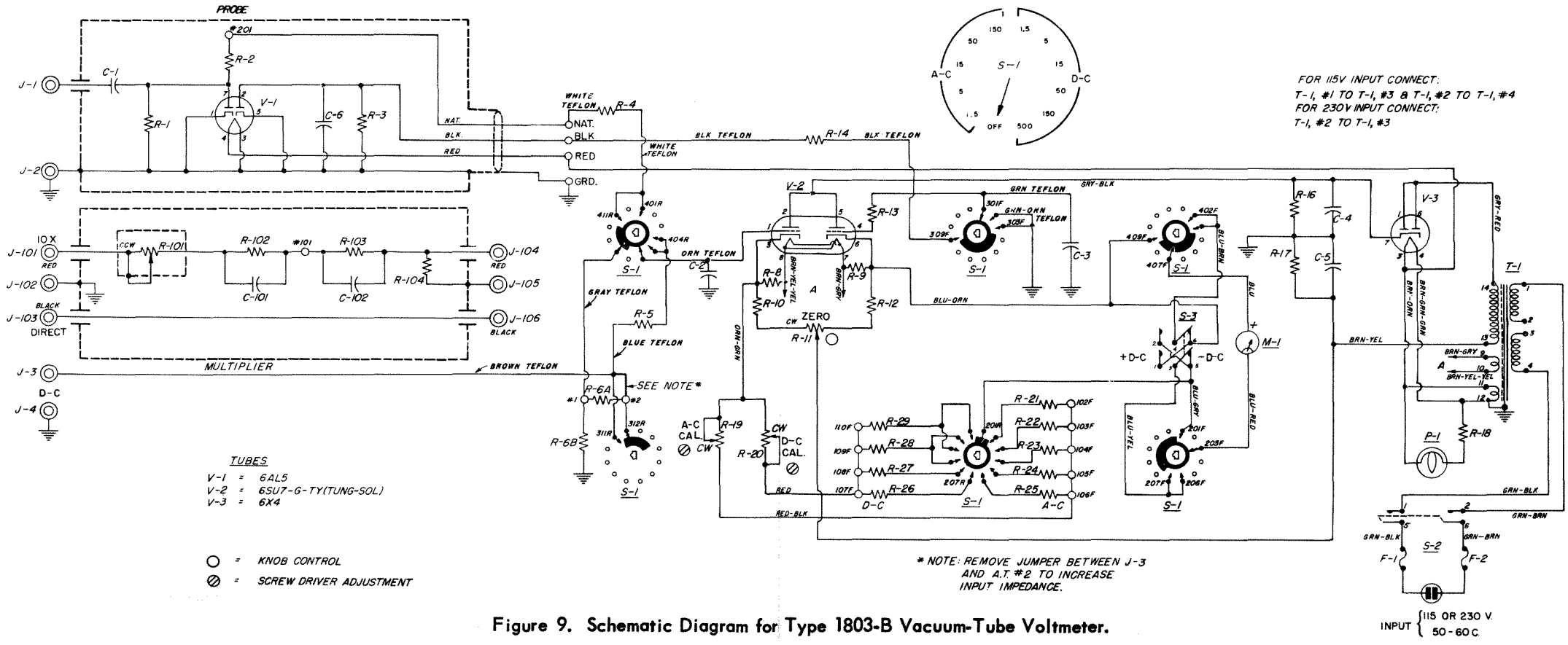

Figure 9. Schematic Diagram for Type 1803-B Vacuum-Tube Voltmeter.