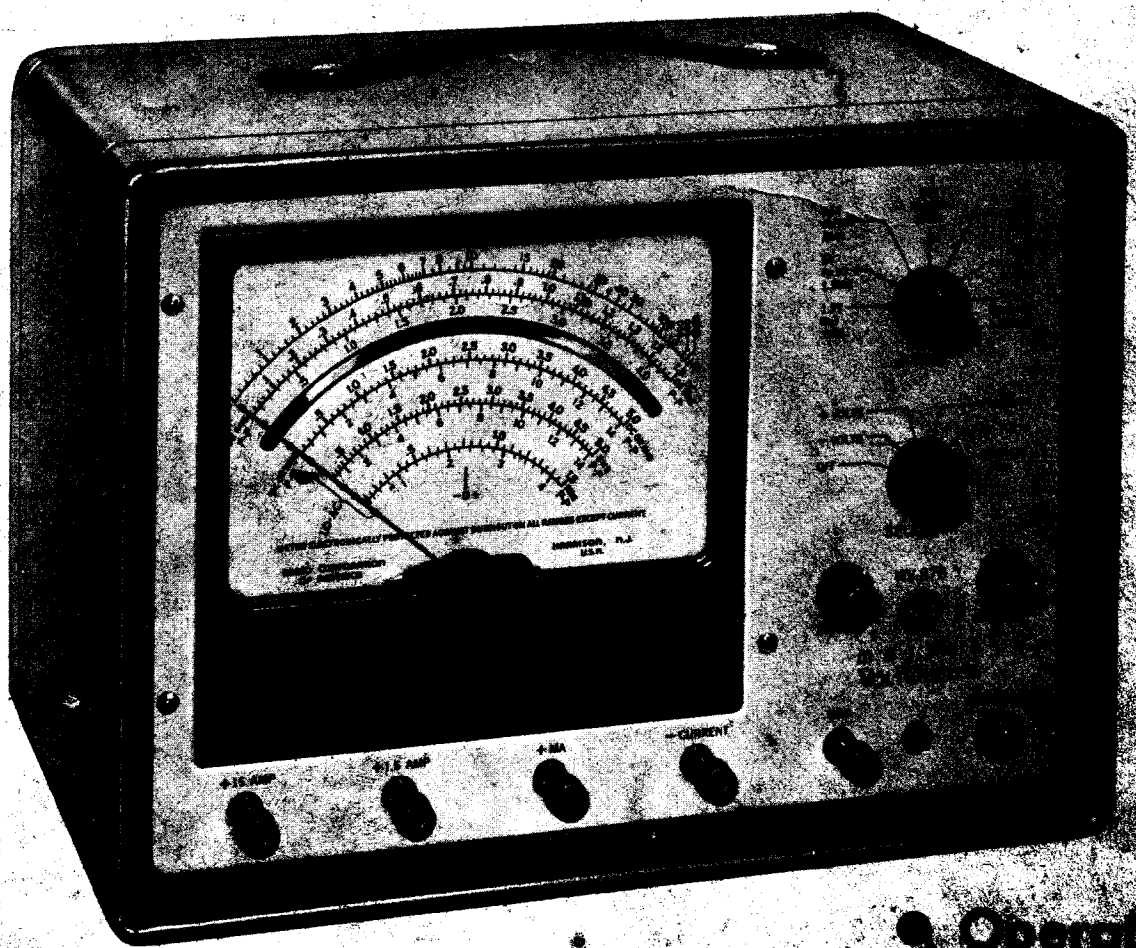
RCA MASTER VOLTOHMYST®

Type WV-87B



- Operation
- Characteristics
- Maintenance
- Appl

RADIO CORPORATION of AMERICA

Safety Precautions

The metal case of this instrument is connected to the ground of the internal circuit. For proper operation, the ground terminal of the instrument should always be connected to the ground of the equipment under test. The WG-299C DC/AC-Ohms Probe and Cable has a shield throughout its entire length which is connected to the instrument ground and case. Always handle the WG-299C by the insulated probe housing.

An important point to remember is that there is always danger inherent in testing electrical equipment which operates at hazardous voltages. Therefore, the operator should thoroughly familiarize himself with the equipment under test before working on it, bearing in mind that high voltages may appear at unexpected points in defective equipment. Additional precautions which experience in the industry has shown to be important are listed below.

1. It is good practice to remove power before connecting test leads to high-voltage points. If this is impractical, be especially careful to avoid accidental contact with equipment racks and other objects which can provide a ground. Working with one hand in your pocket and standing on a properly insulated floor lessens the danger of shock.

2. Filter capacitors may store a charge large enough to be hazardous. Therefore, discharge filter capacitors before attaching test leads.

3. Remember that leads with broken insulation provide the additional hazard of high voltages appearing at exposed points along the leads. Check test leads for frayed or broken insulation before working with them.

4. To lessen the danger of accidental shock, disconnect test leads immediately after test is completed.

5. Remember that the risk of severe shock is only one of the possible hazards. Even a minor shock can place the operator in hazard of more serious risks such as a bad fall or contact with a source of higher voltage.

6. The experienced operator continuously guards against injury and does not work on hazardous circuits unless another person is available to assist in case of accident.

ITEMS

Supplied with WV-87B

1 DC/AC-Ohms Probe and Cable.....Type WG-299C	
1 Cable, Black	1 Cable, Red
1 Slip-On Alligator Clip	2 RCA-6AL5 Tubes
1 VS036 (1.5 V) Battery	1 RCA-12AU7 Tube
1 Instruction Booklet	1 Registration Card

ACCESSORIES

Available on Separate Order

For Measuring AC Voltages at Frequencies from 50 Kc to 250 Mc:
Crystal-Diode Probe.....Type WG-301A

For Increasing DC-Voltage Range to 50,000 Volts:
High-Voltage Probe.....Type No. WG-289
Multiplier Resistor .....Type No. WG-206

TEST AND MEASURING EQUIPMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Instr. WV-87B (1) 11-56
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MASTER VOLTOHMYST
Type WV-87B

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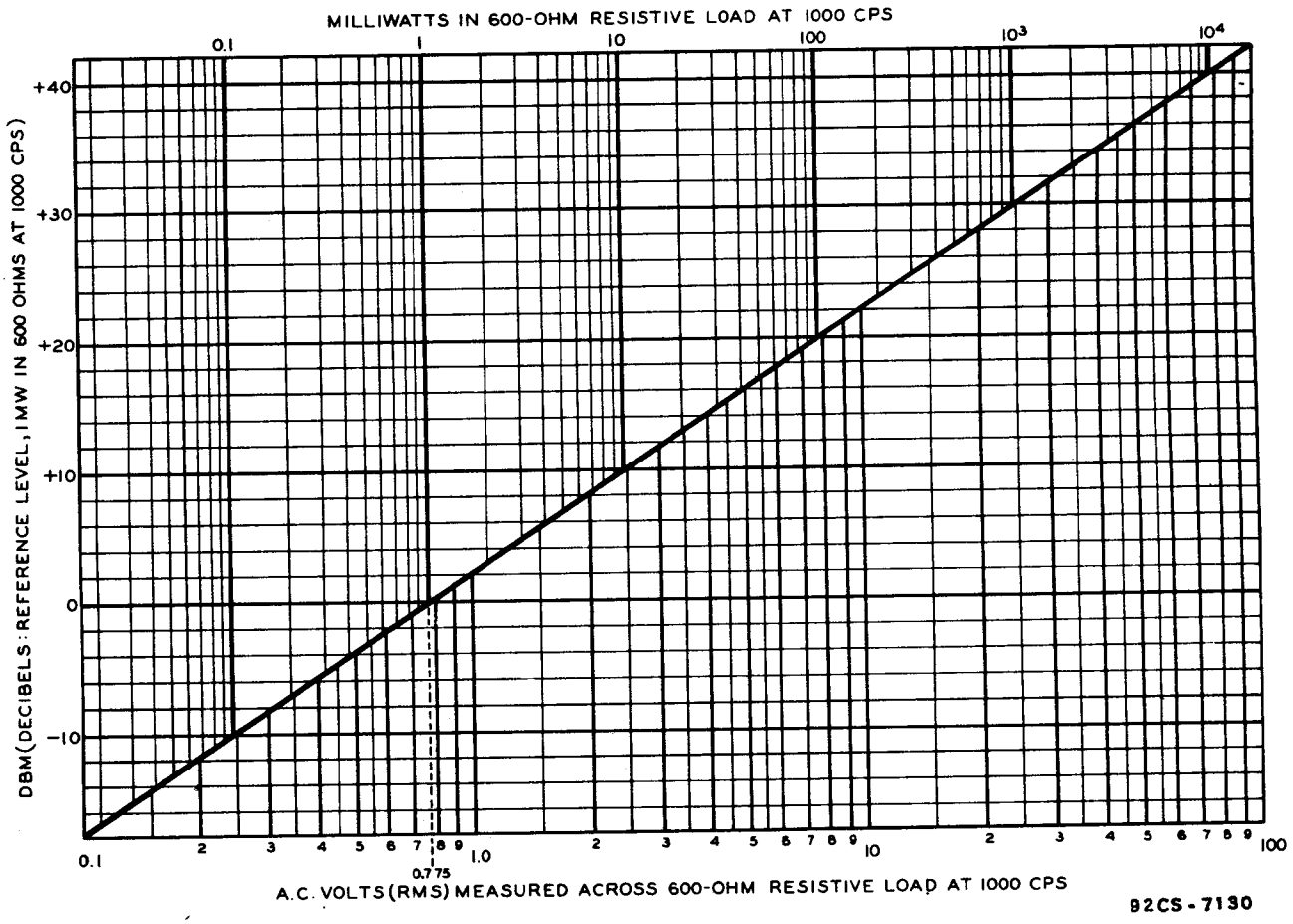

Note: For loads other than 600 ohms, see table on page 16.

Figure 1. Graph for conversion of rms voltages to dbm values

General Description

The WV-87B Master VoltOhmyst* is an all-electronic voltmeter designed to measure directly the peak-to-peak values of complex waveforms and the rms values of sine waves on separate scales. The instrument also reads dc voltage, resistance, and direct current, employing vacuum tubes on all functions except current measurement to insure good sensitivity and stability. For dc-voltage measurements, an input resistance of 11 megohms minimizes loading of the circuit under test. When used to measure ac voltages, the WV-87B has a maximum rated input of 4200 peak-to-peak volts and 2000 rms volts. The instrument will also measure dc voltages up to 1500 volts, resistances up to 1000 megohms, and direct current up to 15 amperes.

Calibration of the Master VoltOhmyst in peak-to-peak voltage values as well as rms voltage values is a desirable feature for applications such as television, radar, and other pulsed electronic systems where complex waveforms are encountered. As the meter reading is proportional to the full peak-to-peak value of the waveform, a better indication of the true value of the voltage is given than is possible with voltmeters which respond only to the positive or negative peak of the waveshape. (See "AC Voltage Measurements," page nine.)

The instrument is frequency compensated for ac-voltage ranges up to and including the 500-volt range (500 rms volts or 1400 peak-to-peak volts) and can be used at frequencies up to approximately 3 megacycles, depending upon the impedance of the source voltage. The extended frequency range of the Master VoltOhmyst, coupled with its high sensitivity, make it a convenient and reliable device for use in rf applications. When the auxiliary WG-301A Crystal-Diode Probe is used, the useable frequency range is extended to 250 megacycles. The WV-87B has an over-all accuracy of ±3% of full scale on ac-voltage measurements.

An input resistance of 11 megohms on all dc-voltage ranges allows the WV-87B to be used in circuits where instruments with a lower impedance would result in loading of the circuit under test and a resultant error in reading the operating voltage. The 11-megohm input resistance also has the advantage of not being so high as to impair the stability of the instrument. The over-all accuracy of the Master VoltOhmyst on dc-voltage measurements is ±3% of full scale.

*Trade-Mark "VoltOhmyst" Reg. U. S. Pat. Off.

When used to measure resistance, the WV-87B will read from 0.2 ohm to 1000 megohms in seven ranges. Convenient midscale values are set at 10, 100, 1000, 10,000 and 100,000 ohms and at 1 and 10 megohms.

On measurements of direct current, the meter will read from 10 microamperes to 15 amperes with an accuracy of ±3% of full scale. Current is read on nine ranges of from 0 to 0.5, 1.5, 5, 15, 50, 150, and 500 milliamperes and from 0 to 1.5 and 15 amperes.

Additional features of the WV-87B include provision for zero-centering of the meter pointer, a useful adjustment for checking FM discriminator alignment and the polarity and condition of bias cells; two separate scales for low-voltage ac measurements; a mirror-backed meter scale to reduce meter-pointer parallax; circuit design which permits measurement of the ac component of a dc voltage or the dc component of an ac signal; and large, easily read meter scales stamped in black and red for direct reading of rms, peak-to-peak, and dc voltage values. Circuit design also prevents any dc-loading effect when the WV-87B is used to measure ac voltages.

The WV-87B is supplied with the RCA WG-299C DC/AC-Ohms Probe and Cable. The WG-299C is a slim, compact probe which is used for ac- and dc-voltage and ohms measurements. A sliding switch built into the probe housing provides for switching the probe to the desired measurement function. The front end of the WG-299C is designed to accommodate the RCA WG-301A Crystal-Diode Probe, which slips onto the WG-299C to form a sturdy, insulated high-frequency probe. An especially flexible coaxial cable is used to connect the probe to the WV-87B. DC voltages up to 50,000 volts may be measured with the Master VoltOhmyst when the auxiliary WG-289 High-Voltage Probe is used.

Two cables, one red for the positive connection and one black for the negative connection, are used for all direct-current measurements. Each is provided with an alligator clip.

The RCA WV-87B Master VoltOhmyst is a versatile instrument, designed to give quality performance. A reliable measuring device, it enables the user to make a wide variety of accurate electrical measurements in all kinds of electrical equipment.

Input Resistance (With WG-299C set to "DC"):
All Ranges ..... 11 megohms
Sensitivity on 1.5-V Range ..... 7.3 megohms/volt
Over-all Accuracy ..... ±3% of full scale

AC Voltmeter:

Ranges:

RMS Values of Sine Waves ..... { 0 to 1.5, 5 volts on separate LO-AC scales; 0 to 15, 50, 150, 500, 1500 volts ▲

Peak-to-Peak Values of Sine Waves & Complex Waves ..... { 0 to 4, 14 volts on separate LO-AC scales; 0 to 42, 140, 420, 1400, 4200 volts ▲

Over-all Accuracy ..... ±3% of full scale
Input Resistance and Capacitance
(With WG-299C set to "AC-Ohms")
1.5, 5, 15, 50, 150-V Ranges .... 0.83 meg. shunted by 85 μμf
500-V Range ..... 1.3 meg. shunted by 80 μμf
1500-V Range ..... 1.5 meg. shunted by 75 μμf

Frequency Response:

(Flat at Power-Line Frequencies up to 1500 Volts)
(With WG-299C set to "AC-Ohms"*):

For source impedances of approximately 100 ohms or lower ..... 30 cps to 3 Mc□

For source impedances of approximately 1000 ohms or lower ..... 30 cps to 500 Kc△

With Crystal-Diode Probe WG-301A* { within ±10% from 50 Kc to 250 Mc

Pulse-Response Capability ..... (See Fig. 9)

Ohmmeter:

0 to 1000 Megohms in 7 Ranges: Rx1, Rx10, Rx100, Rx1000, Rx10K, Rx100K, Rx1MEG

Average Voltage Drop Across Meter .. approx. 0.5 volt for full-scale readings on all ranges

Over-all Accuracy ..... ±3% of full scale

Meter Movement:

Direct Current for Full-Scale Deflection ..... 200 μamp

Tube Complement 2 RCA-6AL5, 1 RCA-12AU7

Power Supply:

AC-Voltage Rating ..... 105-125 volts
Frequency Rating ..... 50/60 cps
Power Consumption (Approx.) ..... 5 watts
Battery (1.5-volt cell) ..... 1 RCA VS036

Maximum Input Voltages:

DC Voltage (no ac voltage present) ..... 1500 volts
AC Voltage (no dc voltage present):
RMS for Sine Waves ..... 1500 volts
Peak-to-Peak for Sine Waves ..... 4200 volts
Peak-to-Peak for Complex Waves ..... 2000 volts
Sum of Combined DC and AC Peak Voltage ..... 2000 volts

Mechanical

Over-all Dimensions:

Height ..... 10 inches
Width ..... 13½ inches
Depth ..... 7 inches

Weight ..... 8 pounds

Finish ..... { blue-gray hammeroid case, satin-aluminum panel

▲ CAUTION: See Maximum Input Voltages.

*For ac-voltage ranges up to and including the 500-volt range (500 rms volts or 1400 peak-to-peak volts).

□ Response is up about 10% at 3 Mc.

△ Response is up about 10% at 500 Kc.

● Available on separate order.

■ DC voltage from either positive or negative current terminal to ground must not exceed 1500 volts.

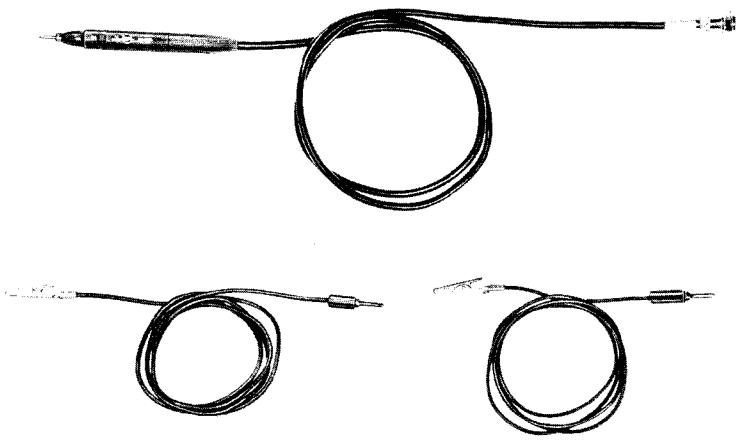

Figure 2. Probes and cables for use with WV-87B

Functions of Controls and Terminals

SELECTOR control—Turns power off when in "OFF" position; selects operating function of instrument when switched to other positions.

RANGE control—Permits choice of range for current, voltage, or resistance measurement.

ZERO ADJ control—Used to position the meter pointer at either the left-hand "0" position or, when SELECTOR control is set to "+VOLTS", to the zero-center "—0+" position.

OHMS ADJ control—Used to position the meter pointer at the extreme right line on the "R" scale when SELECTOR control is in "OHMS" position.

+15 AMP terminal—Red current cable is plugged in here when current to be measured lies within range of 1.5 to 15 amperes.

+1.5 AMP terminal—Red current cable is plugged in here when current to be measured is between 500 milliamperes and 1.5 amperes.

+MA terminal—Red current cable is plugged in here when current to be measured is 500 milliamperes or less.

—CURRENT terminal—Serves as common negative terminal for all current measurements.

GND terminal—Is connected directly to chassis of WV-87B and serves as common return point for all resistance and ac-dc voltage measurements. Ground cable is inserted here and connected to circuit under test.

VOLTS OHMS terminal — The WG-299C DC/AC-Ohms Probe and Cable is connected here for all ac- and dc-voltage and ohms measurements. Ground cable must be plugged into the GND terminal and connected to the circuit under test.

Operation and Applications

Use of WG-299C Probe

The WG-299C DC/AC-Ohms Probe and Cable is designed for use on ac- and dc-voltage and ohms measurements. The probe is equipped with a sliding switch in the probe housing which provides either direct feed-through of the test signal to the VoltOhmyst or for ac isolation of the VoltOhmyst input circuits from the test circuit. When the switch is set to the "DC" position, a one-megohm isolating resistor is connected in series with the probe and cable, permitting use on dc-voltage measurements. When the switch is set to the "AC-Ohms" position, the resistor is shorted out, permitting use on ac-voltage and ohms measurements. Always set the sliding switch to the correct function position before taking measurements.

Preliminary Adjustments:

To prepare the WV-87B for use, make the following connections and adjustments:

1. Connect the WG-299C Probe and Cable to the "VOLTS OHMS" connector and connect the ground cable to the "GND" terminal. Set the probe switch to "DC".

2. Plug the power cord into an ac outlet supplying 105-125 volts at 50/60 cycles, and adjust the controls as follows:

a. Turn the function selector to "+VOLTS" position and allow several minutes for the instrument to warm up.

b. Adjust the ZERO ADJ control to position the meter pointer at the left-hand "0".

NOTE: The meter pointer should rest at the left-hand zero mark when power is removed from the Volt-Ohmyst. If the pointer comes to rest above or below this mark, readjust the mechanical zero, as described in the "Maintenance" section.

c. Turn the function selector to the "OHMS" position. The pointer should deflect to approximately full scale.

d. Rotate the OHMS ADJ control to position the pointer at the last line on the "R" scale.

e. Turn the function selector to the "AC VOLTS" position. If the meter pointer does not rest at the left-hand zero when the range switch is set to "1.5V", rotate the AC ZERO adjustment in back of the case to bring the pointer to zero. This adjustment may require resetting over a period of time due to tube and component aging in the VoltOhmyst. The instrument is now ready for use.

DC-Voltage Measurements:

CAUTION: Maximum input voltages must not be exceeded. See "Specifications," page 6.

Set the switch on the WG-299C DC/AC-Ohms Probe to "DC" for all dc-voltage measurements.

The WV-87B has seven dc-voltage ranges: 0 to 1.5, 5, 15, 50, 150, 500, and 1500 volts. Although the meter is protected against burn-out under ordinary overloads, it is good practice to make a trial measurement at a range setting higher than the voltage expected. Continued or repeated overloads may impair the accuracy of the movement. To measure dc voltages, proceed as follows:

1. Set the function selector to "+ VOLTS" or to "— VOLTS", as required.
2. Connect the clip of the ground cable to ground.

CAUTION: See first paragraph of "Safety Precautions," page 2.

3. Set the range selector to a range position higher than the voltage to be measured.
4. Touch or connect the probe tip to the high side of the source voltage.
5. Reset range selector to a position which gives a reading nearest to full scale.
6. Read the dc voltage from the scale corresponding to the range selector setting.

Zero-Center Indication:

Zero-center indication is frequently useful because it allows observation of either positive or negative dc-voltage excursions without the necessity of resetting the function selector.

1. Set the function selector to "+ VOLTS".
2. Rotate the ZERO ADJ control to position the pointer at the center "—0+".
3. Set the range selector to a position at least twice the voltage to be measured.
4. After a test reading has been made, the range control may be set to the lowest position which allows the pointer to remain on the scale.

Resistance Measurements:

Set the switch on the WG-299C to "AC-Ohms" for all resistance measurements. Before making resistance measurements, remove all power from the equipment under test so that no voltages are present.

1. Set the function selector to the "OHMS" position.
2. Set the range selector to the "R x 10" position.
3. Short the probe tip to the ground cable and adjust the ZERO ADJ control to position the pointer at the left-hand zero, if necessary.
4. Separate the probe tip from the ground cable. The meter pointer should deflect to full scale. If the meter pointer does not deflect to exactly full scale, use the OHMS ADJ control to obtain full deflection.
5. Connect the clip of the ground cable to one terminal of the resistance to be measured.
6. Touch or connect the Ohms Probe to the other terminal of the resistance to be measured.
7. Reset the range control to give a convenient deflection on the "R" (ohms) scale.
8. Multiply the reading on the "R" scale by the factor indicated by the range control setting.

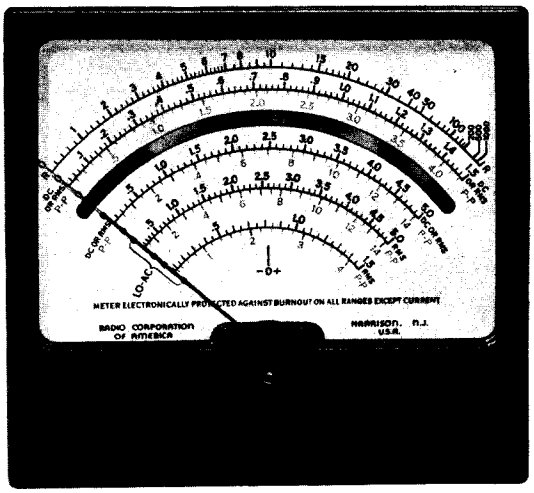

Figure 3. Details of WV-87B scales

CAUTION: Low-current, low-resistance devices, such as thermocouples and meter movements, may be damaged unless a range higher than "R x 10" is used because the WV-87B applies up to 1.5 volts across the resistance under measurement when the range control is set at "R x 1" or "R x 10".

Measurement of Resistance Values Above 1000 Megohms:

The leakage resistance of small mica and paper capacitors is usually above 1000 megohms. The circuit shown in Figure 4 can be used to measure resistance values above 1000 megohms. An external dc-voltage source between 20 and 500 volts is utilized to obtain a measurable pointer deflection. Make circuit connections as shown in Figure 4 and proceed as follows:

1. Set function selector to "+ VOLTS" and measure the voltage at point B.

2. Measure the voltage at point A.

3. Compute the unknown resistance from the following formula:

$$Rx(\text{megohms}) = \frac{11\ [(\text{Volts at "A"}) - (\text{Volts at "B"})\ ]}{(\text{Volts at "B"})}$$

EXAMPLE: The value of an unknown resistance is to be determined with the circuit of Figure 4. An external voltage of 500 volts is applied. The WV-87B measures 2.5 volts at "B", and 500 volts at "A". Then,

$$Rx = \frac{11\ (500\text{-}2.5)}{2.5} = 2200 \text{ megohms (approx.)}$$

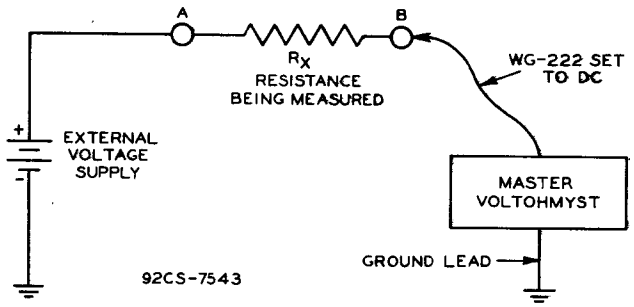

Figure 4. Circuit for measurement of resistance values above 1000 megohms

AC-Voltage Measurements:

CAUTION: Maximum input voltages must not be exceeded. The accuracy of meter indications is dependent upon the frequency of the ac voltage being measured, the waveshape, repetition rate, and the impedance of the voltage source. See "Specifications", page 6 and section below for additional information.

Set the switch on the WG-299C to "AC-Ohms" for all ac-voltage measurements.

1. Set the function selector to "AC VOLTS".

2. Adjust the ZERO ADJ control if necessary to position the meter pointer at the left-hand "0".

3. Set the range control to a position considerably higher than the voltage to be measured.

4. Connect the ground cable to the ground side of the voltage to be measured.

5. Touch or connect the probe tip to the high side of the source voltage.

6. Reset the range control for a convenient deflection.

7. Read the ac voltage from the scale corresponding to the range control setting.

The meter scales of the WV-87B are calibrated in both rms and peak-to-peak voltages and are easily distinguished by their red and black colors. When values of sine waves are measured, for example, rms voltages are read from the black divisions and the corresponding values in peak-to-peak volts (equal to 2.83 times the rms voltage) are read from the red divisions. If the function selector is set at "15V" and a sine wave of 10 rms volts is applied to the instrument, the meter pointer will indicate 10 rms volts on the black scale and 28.3 peak-to-peak volts on the red scale. This time-saving feature makes the usual interpolation from one scale to another unnecessary.

Full-scale values for rms voltages are 1.5, 5, 15, 50, 150, 500, and 1500 volts. AC voltages from 0 to 1.5 rms volts (0 to 4 peak-to-peak volts) are read on the lower scale marked "LO-AC". Higher voltages, up to 1500 rms volts, are read on the two upper voltage scales.

Examples of typical voltage waveforms found in television circuits are shown in Figure 5. Examples of other types of basic waveforms which can be measured by the WV-87B are given in Figure 7.

The instrument has a maximum rated input for non-symmetrical waveforms of 2000 peak-to-peak volts. Sine waves and symmetrical complex waves up to 4200 peak-to-peak volts can be measured with somewhat reduced frequency response. (See Maximum Input Voltages and footnotes under "Specifications".)

(Continued on page 13)

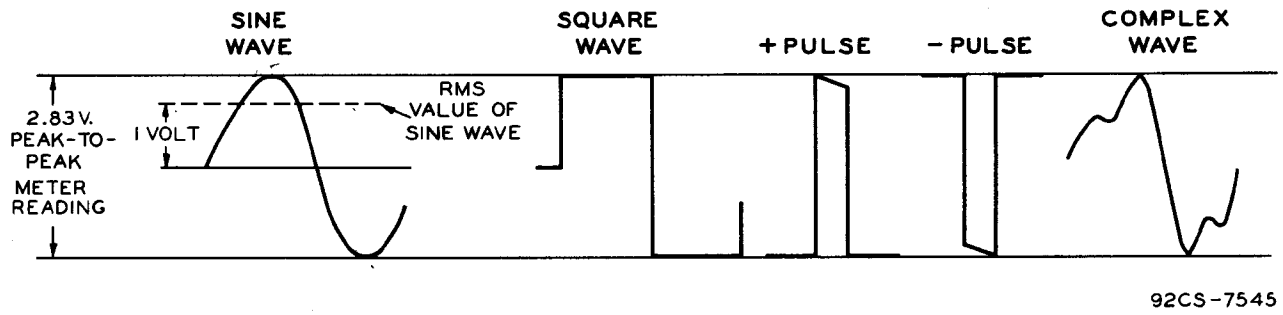

Figure 5. Typical voltage waveforms

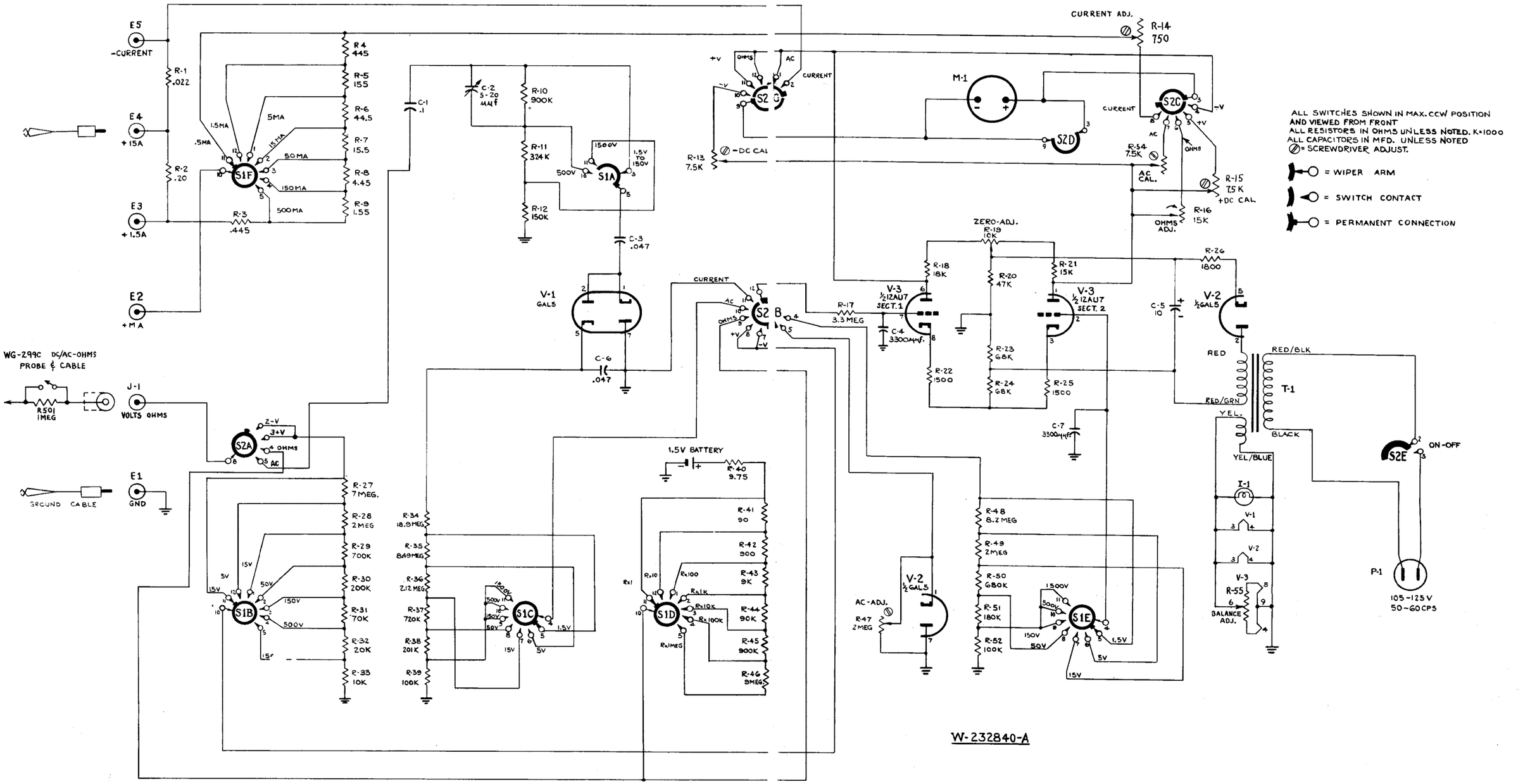

Figure 6. Schematic diagram of WV-87B

Replacement Parts List

WV-87B Master VoltOhmyst

When ordering Replacement Parts, include serial and code numbers of instrument. Order replacement parts, by RCA stock number, through a local RCA distributor.

Symbol No.	Description	Stock No.
	Capacitors	
C1	Paper: 0.1 μf ±20%, 1600 v	94016
C2	Ceramic, trimmer: 5-20 μμf	55301
C3	Paper: 0.047 μf ±20%, 400 v	73553
C4	Mica: 3300 μμf ±20%, 500 v	39664
C5	Electrolytic: 10 μf −10% +100%, 250 v	93869
C6	Paper: 0.047 μf ±20%, 400 v	73553
C7	Mica: 3300 μμf ±20%, 500 v	39664
	* * * * * *	
E1–E5	Post, binding: blue	212151
I1	Lamp, pilot: clear, 6-8 v	11765
J1	Connector: microphone type, male	96257
M1	Meter: complete with plastic case	213523
P1	Cord, power: 74½" long, with male plug	70392
	Resistors	
R1	Special: 0.022 ohms ±1%	93999
R2	Carbon film: 0.2 ohms ±1%, 1 w	94000
R3	Special: 0.445 ohms ±1%	94001
R4	Carbon film: 445 ohms ±1%, ½ w	94002
R5	Carbon film: 155 ohms ±1%, ½ w	94003
R6	Carbon film: 44.5 ohms ±1%, ½ w	94004
R7	Carbon film: 15.5 ohms ±1%, ½ w	94005
R8	Carbon film: 4.45 ohms ±1%, ½ w	94006
R9	Carbon film: 1.55 ohms ±1%, ½ w	94007
R10	Carbon film: 900,000 ohms ±1%, 1 w	59536
R11	Carbon film: 324,000 ohms ±1%, ½ w	94008
R12	Carbon film: 150,000 ohms ±1%, ½ w	56483
R13	Variable: 7500 ohms ±20%, 2 w	93839
R14	Variable: wire wound, 750 ohms ±20%, ½ w	94015
R15	Variable: 7500 ohms ±20%, 2 w	93839
R16	Variable: 15,000 ohms ±20%, ½ w	213527
R17	Composition: 3.3 meg ±5%, ½ w	502533
R18	Composition: 180,000 ohms ±5%, ½ w	502138
R19	Variable: 10,000 ohms ±20%, ½ w	213528
R20	Composition: 47,000 ohms ±5%, ½ w	502347
R21	Composition: 15,000 ohms ±5%, ½ w	502315
R22	Composition: 1500 ohms ±5%, ½ w	502215
R23 R24	Composition: 68,000 ohms ±5%, ½ w	502368
R25	Composition: 1500 ohms ±5%, ½ w	502215
R26	Composition: 1800 ohms ±5%, ½ w	502218
R27	Carbon film: 7 meg ±1%, 1 w	59538
R28	Carbon film: 2 meg ±1%, ½ w	59540
R29	Carbon film: 700,000 ohms ±1%, ½ w	59541
R30	Carbon film: 200,000 ohms ±1%, ½ w	56733
R31	Carbon film: 70,000 ohms ±1%, ½ w	59542
R32	Carbon film: 20,000 ohms ±1%, ½ w	59177
R33	Carbon film: 10,000 ohms ±1%, ½ w	55665
R34	Carbon film: 18.9 meg ±1%, 1 w	94009
R35	Carbon film: 8.49 meg ±1%, 1 w	94010
R36	Carbon film: 2.12 meg ±1%, ½ w	94011
R37	Carbon film: 720,000 ohms ±1%, ½ w	94012
R38	Carbon film: 0.201 meg ±1%, ½ w	94013
R39	Carbon film: 100,000 ohms ±1%, ½ w	72893
R40	Carbon film: 9.75 ohms ±1%, 1 w	96613
R41	Carbon film: 90 ohms ±1%, 1 w	96614
R42	Carbon film: 900 ohms ±1%, ½ w	54197
R43	Carbon film: 9000 ohms ±1%, ½ w	56723
R44	Carbon film: 90,000 ohms ±1%, ½ w	56725
R45	Carbon film: 900,000 ohms ±1%, ½ w	210155
R46	Carbon film: 9 meg ±1%, 1 w	55862
R47	Variable: 2 meg ±20%, ½ w	59534
R48	Composition: 8.2 meg ±5%, ½ w	502582
R49	Composition: 2 meg ±5%, ½ w	502520
R50	Composition: 680,000 ohms ±5%, ½ w	502468
R51	Composition: 180,000 ohms ±5%, ½ w	502418
R52	Composition: 100,000 ohms ±5%, ½ w	502410
R55	Variable: wire wound, 6 ohms, 1 w	213520
	* * * * * *	
S1	Switch: rotary, 7 positions, 4 sections, 6 circuits	213525
S2	Switch: rotary, 6 positions, 3 sections, 7 circuits	213524
T1	Transformer: power, 117 v, 50-60 cps	213526
	Cable: black, for ground and current	43914
	Cable: red, for current	93725
	Clip, alligator: "slip-on" type	59410
	Insulator: black, vinyl, for alligator clip	204717
	Jewel: for pilot lamp	54660
	Knob, control: large, blue	59543
	Knob, control: small, blue	98481
	Socket: for pilot lamp	57760
	Socket: tube, 7-pin	94925
	Socket: tube, 9-pin	94926
	WG-299C DC/AC-Ohms Probe and Cable	
	Bushing, probe tip	212161
	Connector, internal	210190-A
	Connector, single conductor, female, with set screw	203574
	Shell: for front section	210195-A
	Shell: for center section, includes shield, bushing, and insulator	213664
	Shell: for rear section	210202-A
	Spring, coil: for front end	210197
	Spring: for switch contact, with insulator	213665
	Tip: silver plated, includes switch slide and 1-meg resistor	212160
	Washer: for probe tip	212163

(Continued from page 9)

Reliable ac voltmeter readings can be assured only if the characteristics of the voltmeter are compatible with the characteristics of the circuit under test. When the WV-87B is used to measure ac voltages, the "Specifications" on page 6 should be considered. Information on input resistance and capacitance, frequency response, and pulse response is given.

It should be remembered that when the instrument is connected to any voltage source it may cause a loading effect on the circuit and result in a reduced voltage at the test point. When the instrument is not used in accordance with the conditions given under "Specifications", the normal operating voltages of the circuit may change, resulting in an erroneous reading of normal operating voltages.

For example, inaccurate readings of normal circuit conditions can be obtained from any one or a combination of the following conditions:

1. Where the impedance of the test circuit is higher than the impedance of the voltmeter. This condition will cause loading of the circuit to a degree dependent upon the ratio of the circuit impedance to the voltmeter impedance. As this ratio increases, the loading effect of the voltmeter is increased with a corresponding change in the normal operating conditions of the circuit.

2. If the capacitance of the circuit is low in relation to the input capacitance of the voltmeter.

3. If the frequency of the source voltage is higher than the upper frequency rating of the voltmeter.

4. If the voltage waveform in the test circuit consists of narrow pulses with a low repetition rate.

The last of these four conditions needs careful consideration in order to interpret correctly the peak-to-peak readings of the Master VoltOhmyst. The values of the circuit capacitors and resistors used in the peak-to-peak rectifier circuit of the WV-87B have been chosen to give a discharge time which will provide a reliable peak-to-peak reading over its specified frequency range. If narrow pulses having a low repetition rate are applied to the rectifier cricuit, the discharge rate may be so fast that the capacitors have dissipated an appreciable percentage of their peak charge by the time the next pulse is applied. As a result, both the rms and peak-to-peak voltage indications will be lower than the true value of the applied voltage.

Direct-Current Measurements:

When the WV-87B is used for measurement of direct current, it is not necessary that the instrument be plugged into the power line. The following precautions should be observed, however, to avoid damage to the meter movement.

a. Do not subject the meter to any overload. The meter is *not* protected against burn-out on current measurements and improper use may permanently damage the meter movement.

b. When a current of unknown value is to be measured, the instrument should be set up at least one range higher than the range on which the unknown current is expected to be measured. A trial measurement should be made and the range reduced to a scale which gives a reading nearest to full-scale deflection.

c. Do not apply ac voltages at any of the current terminals. The instrument should be used to measure current in dc circuits only.

d. Make sure the dc voltage of the circuit in which the instrument is connected is not greater than 1500 volts as measured from either the positive or negative current points to ground.

1. Connect the black current cable to the jack marked "—CURRENT" and the red current cable to one of the three positive current jacks, depending upon the estimated value of the current to be measured.

2. Turn the SELECTOR control to the "CURRENT" position.

3. For currents of 150 milliamperes or less, the RANGE control should be set at the "500MA" position and the red current cable connected to the "+MA"

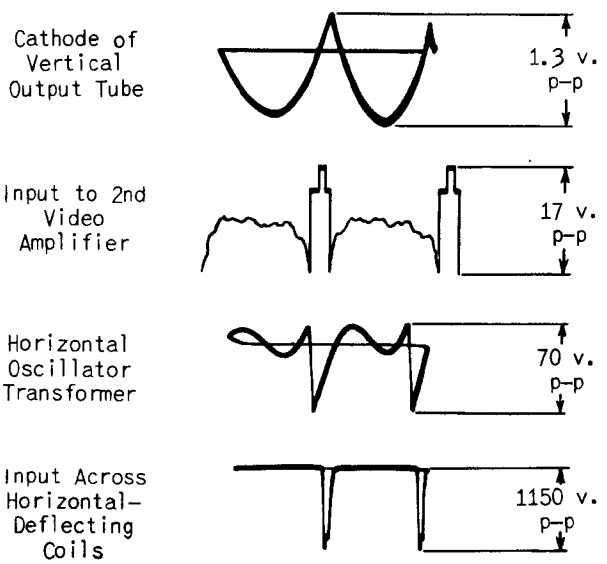

Figure 7. Typical television voltage waveforms

terminal for a trial measurement. For trial measurement of higher currents, the red current cable should be connected to either the "+1.5A" or "+15A" terminals.

4. Remove power from the equipment in which the measurement is to be made.

5. Connect the two current cables in series with the circuit in which the current is to be measured as follows. Break the circuit at a convenient point and connect the black current cable to the negative lead or terminal of the opened circuit and the red current cable to the positive lead or terminal. This procedure should place the instrument directly in series with the circuit.

6. Apply power to the circuit and observe the reading on the appropriate scale, as determined by the current jack employed and the setting of the RANGE control. All direct currents are read on the upper two voltage scales.

7. If necessary, readjust the RANGE control or change the current terminal setting to give a reading on a lower scale which is nearest to full-scale deflection of the meter pointer.

Figure 8 shows a typical circuit and points at which the instrument may be inserted for direct-current measurement. It should be noted that points C and D are in leads containing circulating rf current and, therefore, should not be used. Screen current, for example, can be read by inserting the instrument at "E", plate current may be read by inserting the meter at "F", which are below the rf by-pass points, and the combined screen and plate currents may be measured by inserting the instrument at "G"

In all three cases, the black current cable should be connected to terminals marked "—" and the red current cable to terminals marked "+". Total tube current can be measured by inserting the instrument in the cathode lead at point "B", with the black cable at terminal "—", and the red cable at terminal "+". Normal polarity is reversed in the grid circuit where a negative bias is applied and the direction of current flow is toward the ground point. Here, the black cable is connected at "A" to terminal "—" and the red cable to terminal "+".

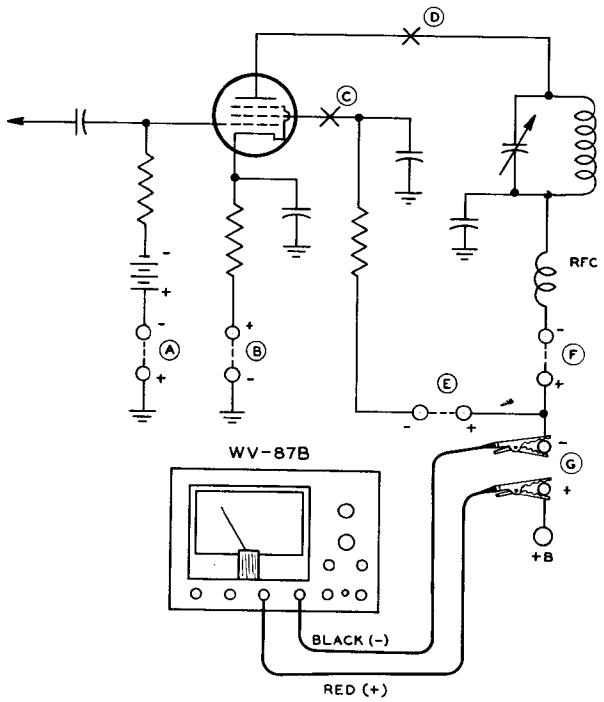

Figure 8. Current measurements in typical circuit

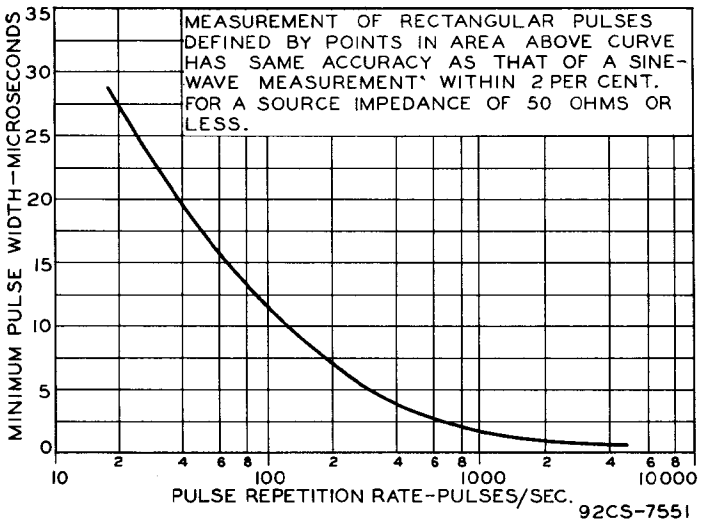

Figure 9. Pulse-response capability of WV-87B

Special Applications

In addition to maintenance and service applications of the WV-87B in ac, dc, af, and pulsed electronic and electro-mechanical equipment, the instrument may be used with versatility in numerous special applications. The special applications described below will help to illustrate the wide range of usefulness of the instrument.

Oscillator Grid-Bias Measurement. The negative dc voltage developed at the grid of an oscillator tube is proportional to the amplitude of oscillation. The impedance of these circuits is usually high and any test instrument inserted into the oscillator must be of sufficiently high impedance so as not to change appreciably the total value of the circuit impedance. The WV-87B is well suited to measurements of this nature. To measure grid bias, the instrument should be set up on the appropriate dc-voltage range and the DC Probe used for the bias measurement.

Comparative voltage readings should be taken on each band of a multi-band receiver and the main tuning capacitor should be rotated through each band while the bias is being measured.

AVC-Voltage Measurements. The WV-87B can be used to measure avc voltage at the diode-load resistor, along the avc bus, or at the grids of the controlled tubes.

Output Indication. The Master VoltOhmyst is a useful instrument for measuring output in the alignment of radio and television receivers. In these applications, the probe switch is set to "DC" and is connected to the load resistor of the second detector in AM and TV receivers while the circuit components are adjusted for optimum output. In an FM receiver, the probe is connected to the limiter load resistor. The zero-center feature of the WV-87B is particularly useful in alignment of FM discriminators.

Bias-Cell Voltage Measurements. These small voltages can be measured accurately by the WV-87B. The expanded voltage scale of 0 to 5 volts provides easy-to-read indications of small voltages, an important feature where bias voltages are critical.

Detection of Gassy Tubes. Gassy tubes frequently may pass the check of an ordinary tube tester but cause improper functioning of equipment in which they are installed. The presence of gas in an output tube or avc-control tube, for example, can impair the function of the entire receiver. If a tube is gassy, measurement of the grid bias in an RC-coupled circuit will indicate an abnormal value of bias.

Insulation-Resistance Measurements. Current leakage through the dielectric of capacitors and insulation of coils, transformers, cables, and other components can be measured with the WV-87B in terms of resistance. Values of leakage resistance above 1000 megohms can be measured with the circuit shown in Figure 4.

When making resistance measurements, the WG-299C probe of the WV-87B is always positive with respect to the ground cable. This arrangement facilitates the measurement of leakage resistance in components such as electrolytic capacitors where polarity must be observed.

DBM Measurements. The graph on page 4 can be used to determine dbm values corresponding to rms ac-voltage values across a 600-ohm resistive load. A dbm value is defined as the number of decibels above or below a reference level of 1 milliwatt in 600 ohms at 1000 cycles. Zero dbm, therefore, would indicate a power level of 1 milliwatt; 10 dbm, 10 milliwatts; and 20 dbm, 100 milliwatts.

Because dbm are defined with respect to a 600-ohm load, power levels correspond to voltage values. DBM can be measured in terms of rms voltages across a 600-ohm resistive load. For example, 0.775 rms volt indicates 0 dbm and 7.75 rms volts indicate 20 dbm. While these measurements must be made with a sine waveform to avoid waveform error, any frequency can be used which is within the range of the WV-87B The decibel and ear-response curves have their closest correlation at 1000 cycles.

The graph provides rapid conversion of rms voltages to corresponding dbm values. Associated power levels can be read along the top of the graph. If the rms voltage is measured across a resistive load other than 600 ohms, the correction factors given below must be added algebraically to the dbm values read from the graph in Figure 1. For resistive loads not given in the table, the following formula should be used for determining the correction factor:

$$\text{Correction Factor} = 10 \log \frac{600}{R}$$

where R is the load in ohms. If R is greater than 600 ohms, the correction factor is negative.

Resistive Load at 1000 cps	DBM*
600	0
500	+0.8
300	+3.0
250	+3.8
150	+6.0
50	+10.8
15	+16.0
8	+18.8
3.2	+22.7

* DBM is the increment to be added algebraically to the dbm value read from Figure 1, page 4.

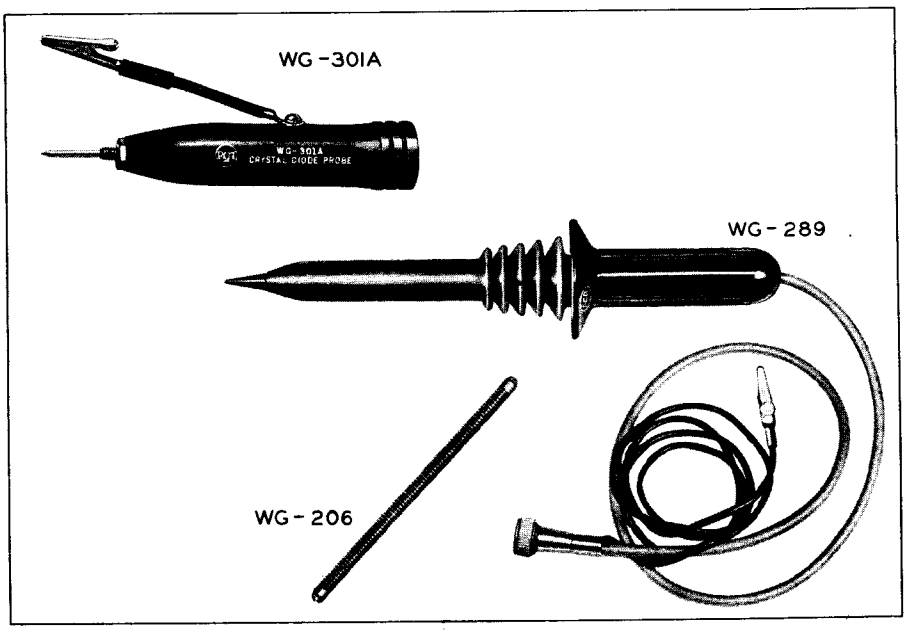

Figure 10. Accessories available on separate order

Accessories

Available on Separate Order

When the WG-301A Crystal-Diode Probe is used with the Master VoltOhmyst, the usable frequency range is extended to 250 megacycles. This probe consists of a germanium rectifier and an RC network in a polystyrene housing. The probe, which slips onto the front of the WG-299C DC/AC-Ohms Probe and Cable, eliminates an extra cable.

The WG-301A may be used in rf circuits of up to 20 rms volts in the presence of dc voltage as high as 250. The over-all frequency range of the probe is from 50 Kc to 250 Mc. All voltage readings are made on the dc scales in terms of rms volts for sine waves.

DC voltages as high as 50,000 volts can be measured directly by the WV-87B when the WG-289 High-Voltage Probe is used. The probe uses the WG-206 Multiplier Resistor, of 1090 megohms, to present an over-all voltmeter input resistance of 1100 megohms. With a multiplying factor of 100, the Master VoltOhmyst provides six full-scale positions of 150, 500, 1500, 5000, 15,000, and 50,000 volts. The 150,000-volt scale should not be used. This extremely high input impedance is especially desirable when it is necessary to measure voltages found in phototube, television, and other high-impedance circuits which would not function properly if loaded down by a low-impedance voltmeter.

The WG-289 High-Voltage Probe offers distinct advantages in high-voltage circuits as well as low-voltage circuits characterized by high impedance or poor regulation.

Circuit Description

The operation of the Master VoltOhmyst centers around a vacuum-tube bridge circuit using a 12AU7 twin-triode. (See Schematic Diagram, pages 10 and 11.) When this bridge is properly balanced, the voltages at the two plates will be equal and the 200-microampere meter, connected between the plates, will read zero.

When a positive voltage is applied to the grid of triode section 1, the current through the left half of the bridge is increased, causing the voltage at the plate of this section to decrease. This current also flows through the common cathode resistor, increasing the voltage drop across it, and biasing the grid of triode section 2 in a negative direction. This causes a voltage increase at the plate of triode section 2. The difference in potential across the meter causes current to flow through the meter from the plate of section 2 to the plate of section 1.

When the WV-87B is used to measure ac voltage, the voltage is first rectified by an RCA-6AL5 twin-diode which serves as a full-wave peak-to-peak rectifier. This tube, shown as V-1 on the schematic diagram, has associated components chosen to give the circuit a long time constant. When the ac signal swings negative, C-3 is charged through the right-hand diode section (Pins 1 and 7) to the negative peak value of the voltage. As the voltage starts in a positive direction, this diode section becomes nonconducting and the charge on C-3 is prevented from discharging. As the ac signal swings positive, the positive peak is added in series with the charge on C-3 and is applied to the plate of the left-hand diode section, (Pins 2 and 5). C-6 is charged to a value equal to the sum of the positive and negative peaks. Because of the relatively long time constant of the circuit, the voltage across C-6 will be maintained at the peak-to-peak value of the applied ac voltage. This charge is then applied as a dc voltage to the grid of triode section 1 of the 12AU7 bridge tube and the circuit action is the same as described above.

When the ac-signal rectifier is connected, however, contact potential within the tube causes a small amount of voltage to appear at the left-hand grid of the 12AU7, resulting in a slight unbalance of the bridge and a small meter deflection. To counteract this effect, a diode section of another 6AL5 is connected to the other grid of the bridge tube. The bucking potential of this second diode section is used to correct for the contact potential of the ac-signal rectifier. This bucking potential may be adjusted to the exact required value by means of a potentiometer connected across the second diode section.

When the instrument is set up to measure resistance, ac voltage or dc voltage, it is impossible for any voltage applied to the test probes to be applied directly to the meter itself. As shown in the schematic diagram, the meter is isolated from the source voltage by the 12AU7 bridge tube. This current limitation of the 12AU7 and its associated components decreases the danger of overloading the meter. This protective function is not provided for current measurements, however, since the meter is used as a direct-measurement device.

Maintenance

(See "Safetv Precautions", page 2)

General

The WV-87B Master VoltOhmyst is manufactured, tested, and calibrated under strict engineering supervision. If the instrument should require adjustment or repairs, the precedures outlined below should be followed.

A schematic diagram of the WV-87B is shown in Figure 6 and locations of calibration controls are shown in Figure 11. If it becomes necessary to replace any of the component parts, only RCA replacement parts or their equivalents should be used. When ordering replacement parts for the Master VoltOhmyst, consult the Replacement Parts List on page 12 and specify the code and serial numbers of the instrument as well as the stock number of the replacement part.

Zero Setting of Pointer

Mechanical Adjustment:

The meter pointer should rest at the left-hand zero mark when the SELECTOR control is turned to the "OFF" position. If the pointer should come to rest at a deflected position, the position may be corrected mechanically by adjusting the small screw on the front of the meter case.

Electrical Balance Check:

1. Set the SELECTOR control to "+VOLTS" and allow the WV-87B to warm up for 15 minutes.
2. Rotate the ZERO ADJ control. It should be possible to set the meter pointer at either zero or 65% of full-scale deflection on any range.
3. Set the SELECTOR control to "—VOLTS".
4. Rotate the ZERO ADJ control. It should be possible to set the meter pointer at either zero or 15% of full-scale deflection on any range.
5. If necessary, adjust R55 to obtain proper deflection. If the total "Zero Adj" range is greater than 80%, adjust R55 so the pointer can be set at points proportionately higher than 65% and 15%.

Calibration

The calibration of the WV-87B should be checked after any internal adjustments are made or after any of the component parts are replaced. If recalibration is necessary, the instrument can be recalibrated as follows:

NOTE: The accuracy of calibration cannot exceed the accuracy of the standards employed.

Direct-Current Calibration:

1. Check the mechanical zero position of the pointer. If necessary, rezero as described above.
2. Set the SELECTOR control on "CURRENT" and the RANGE control on "50MA".
3. Connect the red current cable between the "+MA" jack and the positive terminal of a dc supply which can be adjusted to deliver exactly 25 milliamperes. Connect the black current cable between the "—CURRENT" jack and the negative terminal of the dc supply.
4. With a current of 25 milliamperes registering on the meter, rotate the current-adjustment control, R14, with a screw driver for a reading of approximately half scale.
5. Supply exactly 50 milliamperes and readjust R14 for a reading of exactly 50 milliamperes. Check all other milliampere ranges for a full-scale accuracy of ±3%.
6. Remove the red current cable from the "+MA" jack and insert it into the "+1.5AMP" jack. Supply exactly 1.4 amperes. The WV-87B should read between 1.37 and 1.43 amperes. The 15-ampere range should also be checked for a full-scale accuracy of ±3%.

DC-Voltage Calibration:

1. Turn the SELECTOR control to "+VOLTS" and allow the WV-87B to warm up for at least 15 minutes.
2. Check the line voltage. The WV-87B should be calibrated at 117 volts, 60 cycles.
3. Rotate the ZERO ADJ control to bring the pointer exactly to zero. This control should not be readjusted during the rest of the calibrating procedure.
4. Set the RANGE control on "50V".
5. Connect the ground cable clip to the negative terminal of a dc source supplying exactly 48 volts. Connect the WG-299C to the positive terminal of the source voltage.
6. With a screw driver, adjust the "+DC CAL" potentiometer (R15) to bring the pointer exactly to the 48-volt mark on the scale. (See Figure 11 for location of calibrating controls.)
7. Reverse the test-lead connections at the voltage source.
8. Set the SELECTOR control to the "—VOLTS" position.
9. With a screw driver, adjust the "—DC CAL" potentiometer (R13) to bring the pointer exactly to the 48-volt mark on the scale.
10. Check the remaining dc-voltage ranges against other dc sources of known accuracy which provide full-scale deflection.

AC-Calibration Check:

The procedure for ac calibra tion is as follows.

1. Set the WG-299C switch to the "AC-Ohms" position.
2. Set the SELECTOR control to "AC VOLTS".
3. Set the RANGE control to "1.5" volts.
4. Set the probe switch to "AC-Ohms" and short the tip to the ground clip. Adjust the AC ZERO potentiometer (R47) so that the pointer rests exactly at zero. The potentiometer is located on the rear of the chassis and is accessible through an opening in the rear of the cabinet.
5. Turn the RANGE control through the remaining scale settings. The meter pointer should remain at zero while the RANGE control is changed. If the pointer cannot be adjusted to zero, or if it moves away from the zero setting as the RANGE control is changed, interchange the two 6AL5 tubes. If this fails to correct the difficulty, one or both of the 6AL5 tubes should be replaced. (See Section on Tube Replacement.)
6. Set the RANGE control to "150V".
7. Apply exactly 144 volts, 60 cps between the ground lead and the tip of the WG-299C Probe. The meter should read within 3% of the applied ac voltage. If it does not, the values of the circuit components should be checked.
8. Check the remaining voltage ranges for accuracy at full-scale deflection. They should read within 3% of the applied ac voltage.

AC-Compensation Adjustment

1. Turn the SELECTOR control to "AC VOLTS".
2. Set the RANGE selector on "150V".
3. Set meter pointer at zero.
4. Apply exactly 150 volts at a frequency of approximately 100 Kc between the ground cable and the WG-299C. With a screw driver, adjust the ceramic trimmer (C2) until the pointer reads exactly 200 volts.

Ohms Adjustment

NOTE: The battery must be installed for all resistance measurements.

1. Set the SELECTOR control to "+VOLTS" and make certain the pointer is at zero.
2. Turn the SELECTOR control to the "OHMS" position.
3. Set the RANGE control to "RX1".
4. Adjust the OHMS ADJ control for full-scale deflection.
5. Turn the RANGE switch to the "RX1MEG" position. The meter pointer should read above 1000 on the resistance scale. If the pointer indicates a lower value, there is excessive leakage in the ohmmeter circuit.

If it is necessary to readjust the OHMS ADJ control when changing from a low-range position to the "RX1MEG" position, the battery should be checked. If the difficulty remains, refer to the section on Tube Replacement below.

Tube Replacement

All tubes supplied originally with the WV-87B have been thoroughly aged by operating them for several hours before installation in the instrument. This preliminary conditioning of a new tube helps to insure stability and dependable performance.

If a new tube is installed without prior aging, it may be necessary to rezero the instrument when it is switched from the lowest to the highest dc-voltage range. This operating inconvenience may be corrected by aging the tube as follows.

Before installing a new 12AU7 in the bridge circuit, age the tube in an external set-up under the following conditions. Operate the heater at 6.3 volts ac. Tie the grids and cathodes together and operate at zero volts. Apply 115 volts dc to the plates. Age the tube in this manner for a minimum of 12 hours before installing it in the instrument. Then, recheck instrument calibration

An alternate, and usually satisfactory, aging procedure consists of operating the new tube in the WV-87B for approximately 36 hours, after which time the instrument may be recalibrated.

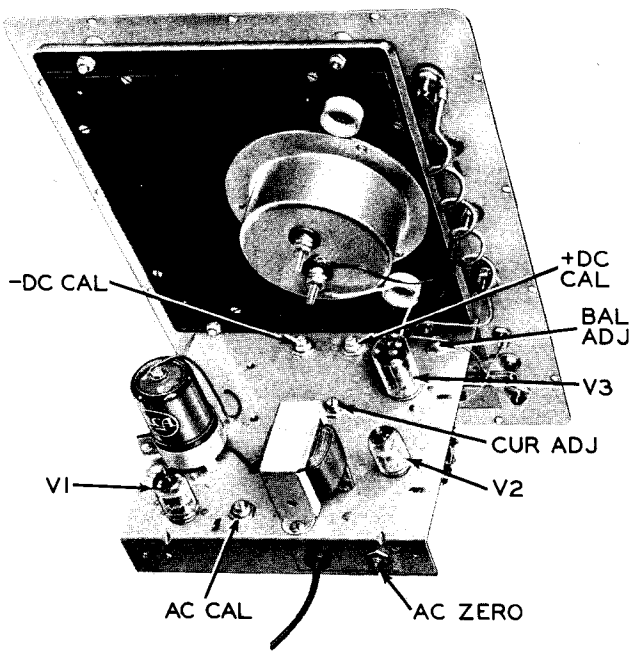

Figure 11. Locations of tubes and calibration controls

If this procedure is unsatisfactory, the first aging procedure should be followed.

If it becomes necessary to replace a 6AL5, the tube can be aged for a minimum period of 36 hours by operating it in the instrument. After this period of time, the calibration should be checked according to the procedure outlined under "AC Calibration Check".

Battery Testing

CAUTION: Do not allow exhausted cells to remain inside the case of the WV-87B as chemicals from deteriorated cells may damage the instrument.

The battery should be tested frequently to insure accuracy of resistance measurements. It may be tested as follows.

1. Turn SELECTOR control to "OHMS".
2. Set RANGE control to "RX1" position.
3. Rotate the OHMS ADJ control to bring the pointer to full scale deflection.
4. Short the Ohms Cable to the Ground Cable for about 10 seconds.
5. Open the short circuit and observe the scale indication. Any appreciable deviation from full-scale deflection indicates weak cells which should be replaced.

Trouble-Shooting the WV-87B

The trouble-shooting data given below are designed to aid the technician in servicing the WV-87B. The troubles described are those which have the most obvious symptoms. Because it is impossible to list all possible troubles, the technician should use the schematic diagram to trace down unlisted troubles.

If difficulty is experienced, it is important that the instrument be checked on all ranges and all functions before repairs are attempted. Examination of the schematic diagram will show that the voltage divider network used for resistance measurements is not used when the instrument is switched for voltage measurements. Similar differences in other circuits also will be evident. For example, V1, the ac-signal rectifier, and its associated circuitry are used only when the WV-87B is switched to "AC VOLTS" and is out of operation on ohms and dc-voltage measurements. Also, the resistor network around S1B is employed only on dc-voltage measurements, and the resistor network around S1C is used only on ac-voltage measurements. Another point to remember is that the current functions do not employ vacuum tubes, and are independent of the other functions. A complete performance check can thus aid greatly in isolating the trouble to one or two sections of the instrument.

When trouble is encountered, a visual check of wiring should be made first. All wiring and solder joints should be inspected closely. Shorted leads or burned components may indicate quickly where the trouble is. The causes and possible remedies listed are given in probable order of occurrence. The description of the trouble should be located in the bold-face type and possible causes checked in the order listed.

When soldering to or near the switches, care should be taken to prevent overheating or mechanically scraping the precision resistors in the divider networks. Excessive heating may permanently change the value of the resistors and result in inaccurate meter readings. A pair of long-nose pliers may be clamped to the lead between the resistor being soldered and the point of connection to dissipate as much heat as possible. Care should also be taken to prevent twisting or loosening of the switch contacts and to prevent solder from getting down into the switch. Contacts may be cleaned with cigarette-lighter fluid.

General

Instrument fails to operate on all functions except current; tubes do not light.

1. Line cord broken or not making contact at outlet.
2. Switch section S2E defective.
3. T1 defective. Check continuity of windings and resistance to ground.

Instrument fails to operate on all functions except current; tubes light, ZERO ADJ does not work.

1. Broken lead in ground cable or E1 defective.
2. V2 or V3 defective. Replace as described under section "Tube Replacement."
3. Open or short circuit in V3 bridge circuit. Check out with Ohmmeter. Check R26, C5, T1 secondary, and meter leads.
4. Switch section S2A, S2B, or S2C defective.

Meter pointer sticks.

1. Cracked or broken jewel bearing in meter. NOTE: Individual replacement parts for meter movement are not available. Meter should be returned for repairs or replaced with new meter.
2. Scale plate or meter is loose and is striking pointer. Remove meter from meter case and tighten mounting screws.

Meter pointer bangs hard left or right, depending upon setting of function switch.

1. Open or short circuit in bridge circuit.

Intermittent operation on all functions.

1. Loose or broken connections in cables. Check by flexing cables and observing meter readings.
2. Wiper contact on S2A, S2B, or S2C defective.
3. Loose or broken connection in bridge circuit wiring, including meter terminals. With power applied, probe wiring, connections, and components with insulated probe. NOTE: See "Safety Precautions," page 2.
4. V2 or V3 defective. Replace tubes as described under "Tube Replacement."

ZERO ADJ control erratic in operation.

1. Potentiometer R19 defective. Replace with new control. NOTE: First, make sure mechanical zero of meter pointer is correct. See "Zero Setting of Pointer."

Ohms Function

Instrument fails to operate on OHMS; works normally on ac- and dc-voltage measurements.

1. Battery exhausted or not making contact.
2. Defective wiper contact on switch section S1D.
3. "Ohms" contact on S2A defective.
4. Open circuit in resistor network or burned out resistor around switch section S1D. Check continuity of network R40 through R46. NOTE: This network is made up of resistors which are added in series as switch is rotated. Therefore, one faulty resistor may cause improper operation on one or more ranges.
5. Loose or broken "Ohms" contact on switch section S2A, S2B, or S2C.

OHMS ADJ fails to give infinity setting on "R" scale

1. Battery exhausted.
2. OHMS ADJ potentiometer, R16 defective.
3. V3 defective.

Resistance readings inaccurate on some or all "ohms" ranges.

1. One or more resistors in network around switch section S1D have changed value.
2. Excessive leakage in "ohms" circuit. Check switch wafers on S1D and S2B for dirt or damage. NOTE: High humidity may cause leakage and inaccurate readings on high ohms scales. Bake out inside of instrument with light bulb.
3. Poor contact from ground jack to ground bus on chassis.
4. Shorted wiring in resistor network around S1D.
5. Faulty or high-resistance connections in "ohms" circuit.

Meter pointer moves off infinity mark when range switch is changed.

1. Replace V3 with 12AU7 having low value of gas current. See "Tube Replacement." NOTE: A small deviation should be considered acceptable.
2. Exessive leakage in ohms circuit, possibly caused by high humidity. Check by baking out for several hours with light bulb. Do not overheat and damage capacitors.

AC-Voltage Function

Instrument fails to operate on any ac-voltage range; works normally on OHMS and DC VOLTS.

1. V1 defective. See "Tube Replacement."
2. AC volts contact on S2A, S2B, or S2C may be defective.
3. Faulty wiper contact on S1A.
4. Open or short circuit in circuitry associated with V1. Check out wiring and components values with ohmmeter.
5. C1 or C3 open, C6 shorted, or R34 open.

Meter pointer moves off zero when ranges are changed.

1. "AC Zero" potentiometer out of adjustment. Readjust as described under "AC Calibration Check." If adjustment cannot be made, then
2. Interchange V1 and V2 or replace one or both tubes. See "Tube Replacement."
3. Resistor network around S1E is defective. Check continuity and values with ohmmeter.

AC-voltage readings inaccurate on some or all ac ranges; performance on ohms and dc-voltage ranges is normal.

1. Resistor network around switch S1C defective. Check values with ohmmeter.
2. Defective contacts or wipers or excessive leakage in S1C. Check for loose or dirty contacts.
3. V1 defective. Install new 6AL5. See "Tube Replacement."
4. C6 leaky.
5. R34 changed in value.

If instrument is inaccurate on 500 and 1500 volt ranges only, check R10, R11, R12, and C2. If inaccurate on 1.5-volt range only, replace V1. See "Tube Replacement."

DC-Voltage Function

Instrument fails to operate on any range of "+VOLTS" or "—VOLTS"; works normally on ohms and ac volts.

1. Probe is defective. Try measuring low dc-voltage with probe switch set to "AC-OHMS".
2. DC-voltage contacts on switch sections S2A, S2B, or S2C are defective. Check for loose or broken contacts.

Instrument fails to operate on any range of "+VOLTS" but normal on "—VOLTS" or vice versa; works normally on ohms and ac volts.

1. Potentiometer R15 or R13 defective. Check out with ohmmeter.
2. Defective contacts on switch sections S2A, S2B, or S2C. Check switches for loose or broken contacts.

Voltage readings inaccurate on "+VOLTS", "—VOLTS", or both; ac voltage and resistance readings are correct.

1. R13 and R15 out of adjustment. Reset as described under "DC Voltage Calibration."
2. Isolating resistor in probe has changed value. Measure resistance on OHMS function. NOTE: If one or more of the low-value resistors in the network around S1B have changed value, it is possible that the meter reading may be inaccurate on the 500 and 1500 volt ranges but the inaccuracy may not be apparent on the lower ranges.

DC-voltage readings incorrect; resistance readings correct.

1. Resistance in network around S1B has changed value. Check out with ohmmeter and replace defective resistors.
2. Switch contacts on S1B, or S2A defective. Check for loose or broken contacts, or foreign material.

Instrument fails to function on DC-voltage measurements; works normally on ohms function.

1. S1B network open.

Current Function

Instrument fails to operate on any CURRENT range. AC and DC volts, and OHMS normal.

1. Switch contact on S2C defective.

Instrument fails to operate on +Ma current range; +1.5A and +15A range normal.

1. Faulty wiper contact on S1F.
2. Check +Ma terminal for broken lead.

Instrument operates only on low current ranges, or no operation on any current range; AC and DC voltages, and ohms normal.

1. Resistor network R1 through R9 defective. Check out with ohmmeter.
2. Switch contact on S1F or S2C defective.

Need Transformer.
P2944

Remove 16 turns
Sec. 6.3 Volts