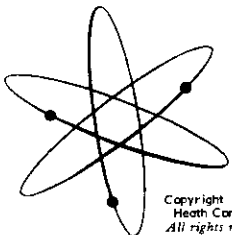


PRICE \$2.00

# HEATHKIT® ASSEMBLY MANUAL



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UTILITY SOLID-STATE VOLTMETER  
MODEL IM-17

595-921-04

Assembly  
and  
Operation  
of the



# UTILITY SOLID-STATE VOLTMETER

Model IM-17



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HEATH COMPANY  
BENTON HARBOR, MICHIGAN 49022



## INTRODUCTION

The Heathkit Model IM-17 Utility Solid-State Voltmeter is a compact, battery-powered voltohmmeter. It is accurate and easy to operate. The copolymer case (with probe storage compartment) makes the meter especially suitable for service calls, as a portable instrument for use in the field, and for general utility use. Its simplicity makes it an ideal construction project for the novice in electronics.

The high input resistance of the Voltmeter on DC voltage ranges places very little loading on a circuit being tested. The 12-position selector switch provides four separate ranges each for DC voltage, AC voltage, and resistance measurements. A DC polarity switch allows up-scale readings for either positive or negative

voltages without the need of reversing test leads. The large 4-1/2 inch meter has four easy-to-read scales. An accessory jack permits you to use the Heathkit high voltage and RF accessory probes.

All these features combine to provide a versatile, accurate, and attractive test instrument that is designed for long and dependable service at minimum cost.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

## PARTS LIST

The numbers in parentheses are keyed to the numbers on the Parts Pictorial (fold-out from Page 3).

To order replacement parts, refer to the Replacement Parts Price List and use the Parts Order Form furnished with this kit.

<u>PART No.</u>	<u>PARTS Per Kit</u>	<u>DESCRIPTION</u>
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<u>PART No.</u>	<u>PARTS Per Kit</u>	<u>DESCRIPTION</u>
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### RESISTORS

1/2 Watt		
(1)1-41	1	10 $\Omega$ (brown-black-black)
1-20	2	10 k $\Omega$ (brown-black-orange)
1-22	2	22 k $\Omega$ (red-red-orange)
1-24	1	33 k $\Omega$ (orange-orange-orange)
1-35	1	1 megohm (brown-black-green)
1-38	2	3.3 megohm (orange-orange-green)

2 Watt		
(2)3-4-2	1	9.1 $\Omega$ 5% (white-brown-gold-gold)

### Precision

NOTE: These may vary somewhat in appearance from the illustration.

(3)2-236	1	990 $\Omega$
2-35	1	9000 $\Omega$ (9 k $\Omega$ )
2-41	1	90 k $\Omega$
2-54	1	200 k $\Omega$
2-51	1	900 k $\Omega$
2-237	1	1.8 megohm
2-52	1	9 megohm

PART No.	PARTS Per Kit	DESCRIPTION
----------	---------------	-------------

**CAPACITORS**

<b>Disc</b>		
(4)21-27	1	.005 $\mu F$
<b>Tubular</b>		
(5)23-91	1	.047 $\mu F$ (1.6 kV)
(6)23-61	1	.05 $\mu F$

**CONTROLS-SWITCHES**

(7)10-201	2	10 k $\Omega$ control
(8)10-229	1	2000 $\Omega$ control (2 k $\Omega$ )
10-78	1	15 k $\Omega$ control
(9)12-80	1	50 k $\Omega$ dual tandem control
(10)60-2	1	6-lug slide switch
(11)60-20	1	9-lug slide switch
(12)63-473	1	12-position rotary switch

**TRANSISTORS-DIODES**

(13)417-118	4	2N3393 transistor (or equivalent)
(14)417-140	1	FET (field effect transistor)
(15)57-27	1	Silicon diode

**SHIELDED CABLE-WIRE**

343-11	1	Shielded cable
341-1	1	Black test lead
341-2	1	Red test lead
344-50	1	Black hookup wire
344-52	1	Red hookup wire
344-59	1	White hookup wire

**HARDWARE**

(16)250-52	6	4-40 x 1/4" screw
(17)254-9	6	#4 lockwasher
(18)252-2	6	4-40 nut
(19)250-229	4	6-32 x 1/4" phillips head screw
(20)253-10	4	Control flat washer
(21)254-4	3	Control lockwasher
(22)252-7	4	Control nut

PART No.	PARTS Per Kit	DESCRIPTION
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**MISCELLANEOUS**

(23)73-46	3	Plastic grommet
(24)214-66	1	1.5 V battery holder
(25)214-67	1	8.4 V battery holder
(26)260-1	1	Alligator clip
(27)436-35	1	Phone jack
439-1	1	Red test probe
439-2	1	Black test probe
(28)455-50	1	Knob bushing
(29)462-252	1	Pointer knob
407-129	1	Meter
85-197-1	1	Circuit board
(30)203-701	1	Panel
95-35	1	Plastic case
(31)490-5	1	Nut starter
390-306	1	Model number label
391-34	1	Blue and white label
597-260	1	Parts order form
597-308	1	Kit Builders Guide
	1	Manual (See front cover for part number.)
		Solder

**BATTERIES**

The following batteries should be purchased at this time for use in the completed kit:

1 C-cell flashlight battery. (NEDA 14).  
 1\* 8.4 volt mercury battery,  
 #1611 M).

\*Representative manufacturers and their type numbers are:

Burgess	H126	Ray-O-Vac	1611M
Eveready	E126	RCA	VS328
Mallory	TR126	Silvertone (Sears)	R6422

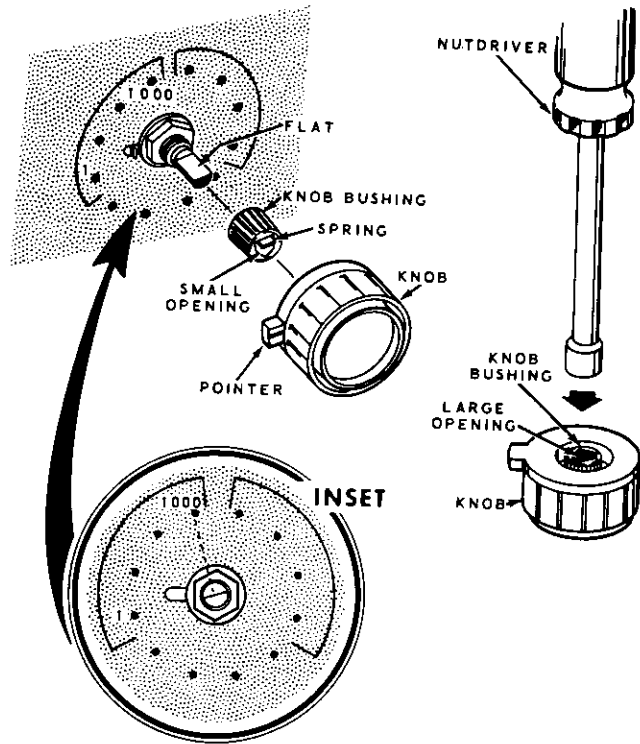
In an emergency a 9-volt zinc carbon battery (also N.E.D.A. #1611) can be used but the result will be short battery life, excessive "zero" drift, and possible battery contact problems.

- ( ) Place the knob on a hard surface; then press the knob bushing firmly into the knob. Use a soft cloth on the work surface to avoid scratching the knob.
- ( ) Press the knob and bushing firmly onto the switch shaft.
- ( ) Make sure the white index line of the knob points to the 1 position in the DC Volts range.

**NOTE:** The blue and white label that is installed in the next step shows the Model number and Production Series number of your kit. Refer to these numbers in all communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

- ( ) Remove the backing from the blue and white label and press the label onto the chassis as shown in Pictorial 9.
- ( ) Check to see that all connections are soldered and that no solder bridges exist between foils on the circuit board. Shake out any solder splashes or wire clippings.
- ( ) Remove the cardboard protector from the meter face.

This completes the assembly of the Voltmeter except for the case which is installed later.



Detail 9B

## CALIBRATION

Refer to Figure 1 and 2 (fold-out from Page 14) for the following steps.

**NOTE:** If the Voltmeter does not seem to operate properly during any of the following tests, turn it off immediately and refer to In Case Of Difficulty on Page 23.

- ( ) Turn the mechanical zero-adjust screw at the bottom of the meter until the meter pointer is directly over the zero indication on the meter face.
- ( ) Set the Voltmeter switches and controls as follows:

- |                              |                            |
|------------------------------|----------------------------|
| SELECTOR SWITCH:             | DC VOLTS/1000              |
| POLARITY:                    | DC+                        |
| POWER:                       | OFF                        |
| ZERO:                        | Center of rotation.        |
| BIAS ADJ (on circuit board): | Maximum counter-clockwise. |
| DC CAL (on circuit board):   | Maximum counter-clockwise. |
| AC CAL (on circuit board):   | Maximum counter-clockwise. |
- ( ) Install the batteries as shown in Pictorial 9. Match the + markings on the batteries to the + markings screened on the circuit board.

## ELECTRICAL ZERO ADJUSTMENT

- ( ) Turn POWER switch to ON and adjust the BIAS ADJ control for an approximately zero meter reading.
- ( ) Turn the ZERO control fully clockwise. This should result in an upscale meter reading.
- ( ) Readjust ZERO control for a zero indication on the meter.
- ( ) Alternate the POLARITY switch between DC+ and DC-. If the meter needle was set exactly on zero, it should remain on zero in either switch position.
- ( ) Set the POLARITY switch to DC- and turn the ZERO control fully counterclockwise. This should cause the meter pointer to move upscale. Readjust the ZERO control for a zero indication on the meter.

## DC CALIBRATION

- ( ) Set the POLARITY switch to DC+.
- ( ) Turn the SELECTOR switch to DC VOLTS/10.
- ( ) Touch the tip of the DC probe (black) to the positive terminal of the 1.5 V battery and adjust the DC CAL control (on circuit board) for a 1.5 volt meter indication on the black scale, as shown in Figure 3. (If other DC voltages that are known to be more accurate are available, they may be used to further check the DC Calibration.)

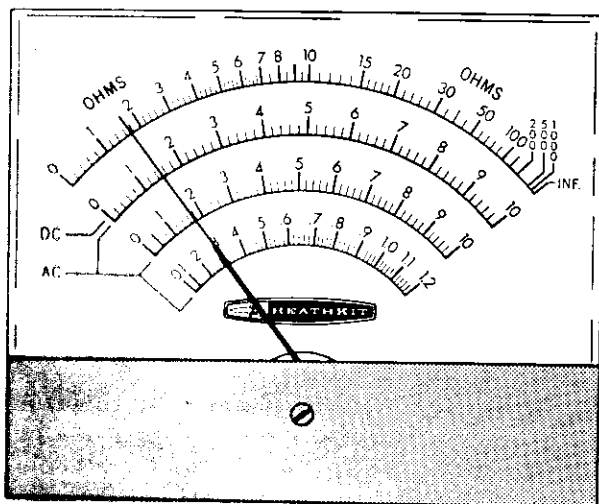


Figure 3

- ( ) Remove the probe tip from the battery and readjust the ZERO control for a zero indication on the meter. Then repeat the previous step.

## AC CALIBRATION

**CAUTION:** Use extreme care when measuring line voltages. Personal shock or instrument damage could result from carelessness.

- ( ) Turn the SELECTOR switch to AC VOLTS/1000 and set the POWER switch to ON.
- ( ) Connect the AC-ohms test leads (black lead and red lead) across the AC line. You can do this most conveniently if you first attach the alligator clip on the black lead to the metal shank of a screwdriver. Then insert the blade of the screwdriver into one of the slotted openings in an electric wall outlet. TAKE CARE NOT TO TOUCH THE TIP OF THE RED PROBE TO THE SCREWDRIVER, and carefully insert the tip of the red probe into the remaining opening in the wall outlet.
- ( ) Adjust the AC CAL control (on the circuit board) for a meter reading of 120 volts on the black scale (this is a reading of 1.2, or one scale division above the numeral 1, as shown in Figure 4). If the line voltage is known to be other than 120 volts, adjust for this value.
- ( ) Disconnect the test leads from the AC line.

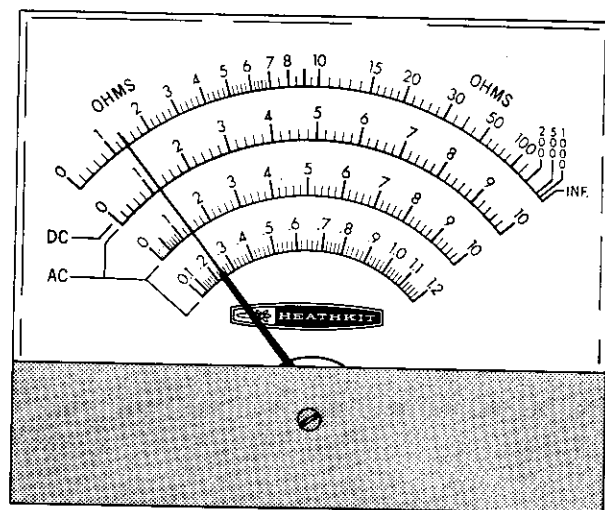


Figure 4

## OHMS ADJUSTMENT

- ( ) Turn the SELECTOR switch to Rx1M. The meter should give an up-scale reading.
- ( ) Adjust the OHMS control for a full scale (INF) reading on the green scale.
- ( ) Touch the tips of the AC-ohms test leads (the red probe and the alligator clip) together; this should cause a zero meter reading. If it does not, turn the ZERO control (with the leads touching) to zero the meter needle. Then separate the leads and repeat the preceding step and this step.
- ( ) Turn the SELECTOR switch to each of the other three resistance ranges. Each range should give a zero indication with the AC-ohms test leads touching each other, and an INF reading with these test leads apart. On the Rx1 range, with the leads touching, observe that there will be a fraction of an ohm circuit resistance.

## FINAL BIAS ADJUSTMENT

- ( ) Turn the SELECTOR switch to one of the DC VOLTS positions.
- ( ) Turn the ZERO control fully clockwise.
- ( ) Adjust the BIAS ADJ control for a reading of 1 on the black 0-10 scale.
- ( ) Turn the ZERO control for a "O" meter reading. NOTE: This setting of the BIAS ADJ control should allow for future adjustments to "O" as the battery voltage decreases over a period of time. When "O" cannot be reached by adjusting the ZERO control, the BIAS ADJ may be reset without disturbing the calibration.
- ( ) Turn the POWER switch to OFF.

This completes the Calibration.

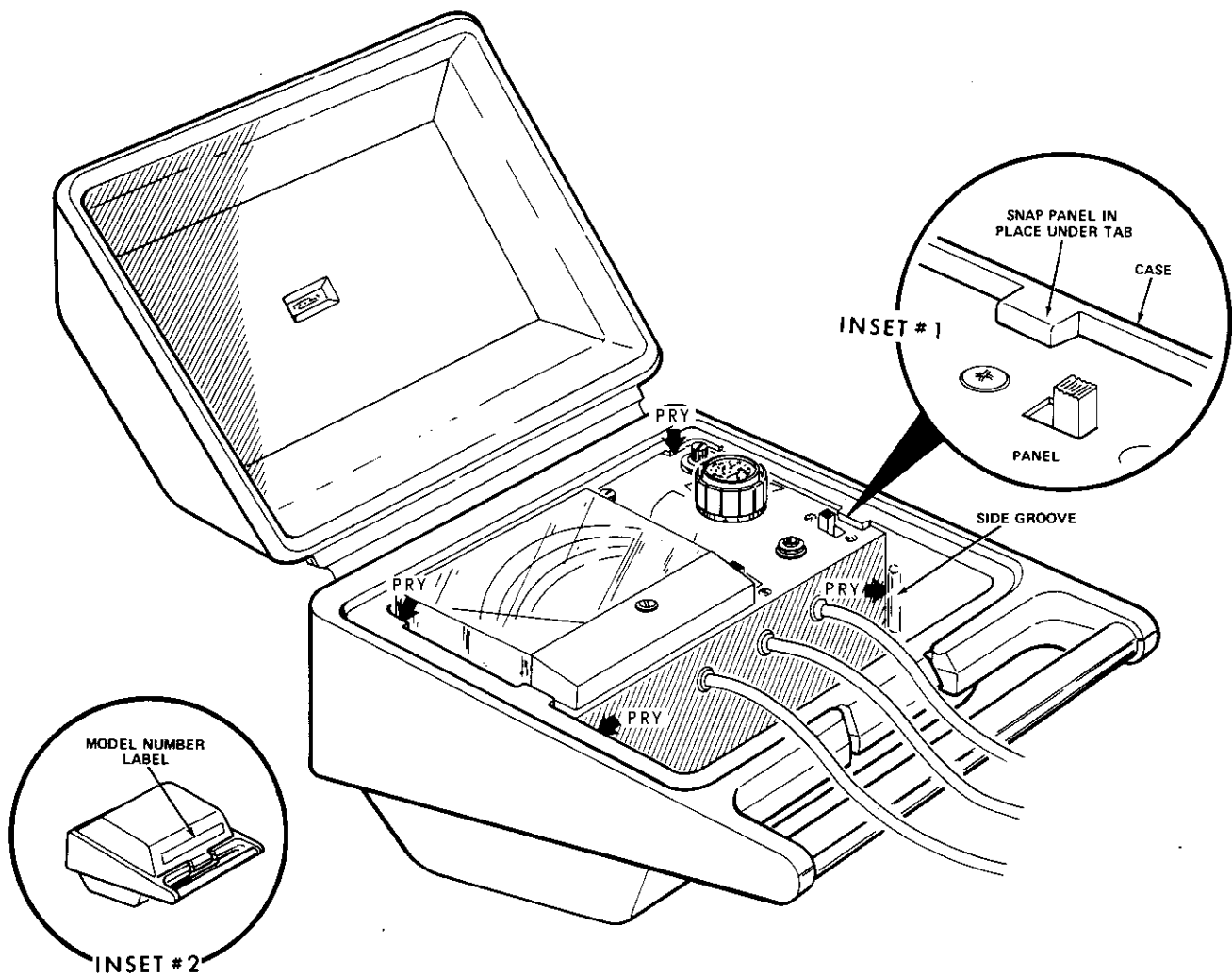
## FINAL ASSEMBLY

Refer to Pictorial 10 for the following steps.

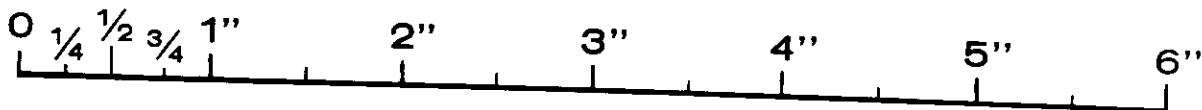
- ( ) Position the panel with the meter face up in the case; then spread the sides slightly to allow the panel to seat on the ledge under the side tabs. Because the case is stiff, you may have to use a screwdriver with a wide blade to pry the sides of the case at the points shown.
- ( ) Press the panel toward the cover "hinge" until it snaps into position.

- ( ) Remove the backing paper from the model number label and fasten the label in the long recess in the outside of the case cover, as shown in inset #2 of Pictorial 10.

This completes the assembly of your Voltmeter.



**PICTORIAL 10**





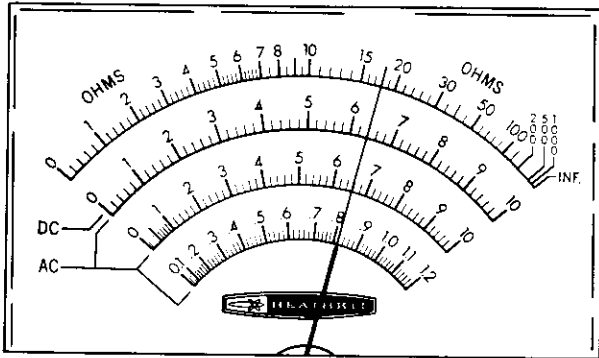
# VOLTMETER USE CHART

REFER- ENCE	SELECTOR SWITCH	USE SCALE	SCALE READING	MULTI- PLIER	ACTUAL VALUE VOLTS/OHMS	USE TEST LEAD*
A	DC VOLTS/1	Black 0-10	6.4	.1	.64 Volts	Gray
A	DC VOLTS/10	Black 0-10	6.4	1.	6.4 Volts	Gray
A	DC VOLTS/100	Black 0-10	6.4	10.	64. Volts	Gray
A	DC VOLTS/1000	Black 0-10	6.4	100.	640. Volts	Gray
B	AC VOLTS/1,2	Red 0-1,2	.64	1	.64 Volts	Red
C	AC VOLTS/10	Red 0-10	6.4	1	6.4 Volts	Red
A	AC VOLTS/100	Black 0-10	6.4	10	64. Volts	Red
A	AC VOLTS/1000	Black 0-10	6.4	100	640. Volts	Red
D	Rx1	Green OHMS	15	1	15 Ohms	Red
D	Rx100	Green OHMS	15	100	1,500 Ohms	Red
D	Rx10k	Green OHMS	15	10,000	150 kΩ**	Red
D	Rx1M	Green OHMS	15	1,000,000	15 megohm**	Red

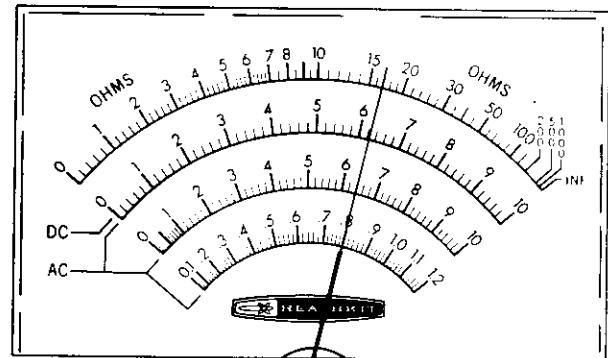
\*In addition to the common (black) test lead,

\*\*kΩ = kilohm (1,000 ohms).

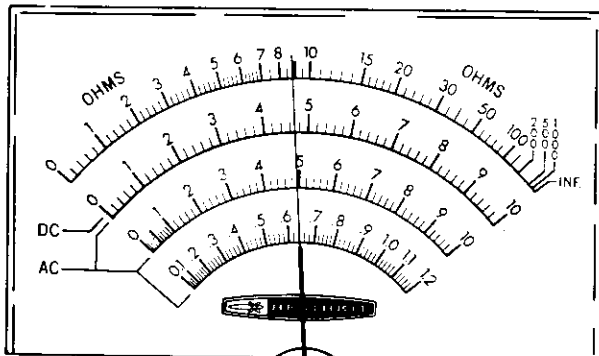
megohm = 1,000,000 ohms.



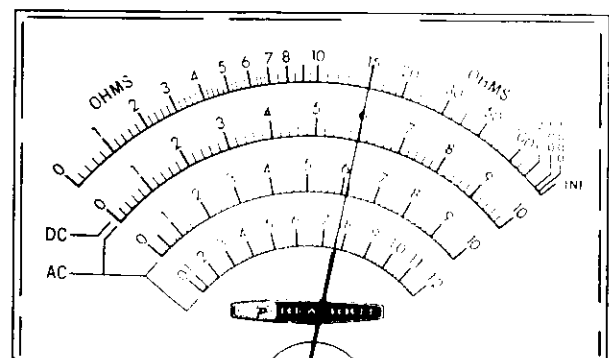
A



C



B



D

## OPERATION

The power consumption of the Solid-State Voltmeter is very low and there is no objection to leaving the instrument turned on continuously during a series of measurements rather than turning it off each time a measurement function is completed. However, to prevent drain on the ohmmeter battery, do not leave the SELECTOR switch set in the OHMS position longer than is necessary to make resistance measurements.

The Voltmeter Use Chart (fold-out from this page) has been included to summarize the following instructions on using the Voltmeter.

**NOTE:** If you are not thoroughly familiar with the measurement of volts and resistance, refer to the Applications section on Page 32, for some practical ways to use the voltmeter.

### SAFETY PRECAUTIONS

**CAUTION:** It is good practice to observe certain basic rules of operating procedure anytime voltage measurements are to be made. Always handle the test probe by the insulated housing only and do not touch the exposed tip portion.

When high voltage measurements are to be made, remove operating power to the unit under test before connecting the test leads. If this is not possible, be careful to avoid accidental contact with nearby objects which could provide a ground return path. When working on high voltage circuits, play safe. Keep one hand in your pocket to minimize accidental shock hazard and be sure to stand on a properly insulated floor or floor covering.

### TEST LEADS

The black test lead with the alligator clip is the common, or negative, lead. It is usually connected to the chassis, or lower voltage point, when you are measuring DC voltage. When you measure AC voltage, or resistance, it can usually be connected to either side of the circuit.

The gray, shielded lead with the black probe is used (with the black test lead) to measure DC voltages only. Connect this lead to the positive (+) or the higher voltage point of the circuit.

The red test lead with the red probe is used (with the black lead) to measure both AC voltage

and resistance. These leads are connected to the two sides of the circuit when measuring AC voltage. To measure resistance, connect the black lead to one side and the red lead to the other side of the circuit or device to be measured.

**NOTE:** If the resistance of a circuit is being measured, and that circuit contains diodes, transistors, or electrolytic capacitors, the test leads must be connected to the circuit correctly (with the test leads correctly polarized) or you will not obtain correct readings. For example, when there is a diode in the circuit, you may obtain two different resistance readings, depending on how you connect the test leads. The lower reading, which will include the forward resistance of the diode, will occur when the black test lead is connected near the cathode end of the diode. The higher reading, which will give the diode's back resistance, will occur when the black lead is connected near the anode of the diode.

### MAKING MEASUREMENTS

Figure 5 shows the scales and markings on the face of the meter. Before making any voltage or resistance measurements with your Voltmeter, be sure to turn the POWER switch ON and check the zero position of the pointer with the POLARITY switch at DC+ and DC-. Turn the ZERO control, if necessary, to zero the meter.

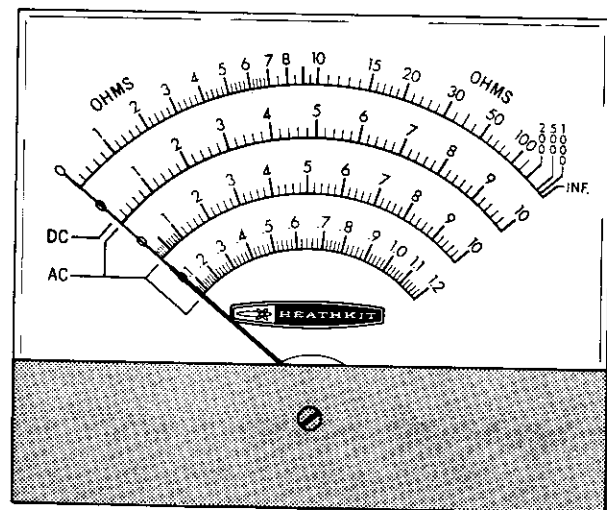


Figure 5

**CAUTION:** When measuring voltage, always set the SELECTOR switch to a range greater than the voltage to be measured, if an approximate voltage is known. If the voltage is completely unknown, set the SELECTOR switch to 1000 and connect the test leads to the circuit to be measured. Then momentarily turn the power on. If the meter moves less than 1/10 of full scale, switch to the next lower range. The maximum voltage that can be safely measured with your Voltmeter is 1000 volts, and this limit must not be exceeded.

### RESISTANCE (OHMS) READINGS

**CAUTION:** Before attaching the test leads for resistance measurements, make sure there is no power on the circuit and that all large capacitors have been discharged.

The SELECTOR switch must be at one of the green Rx positions when making resistance measurements. Make sure the connectors on the test leads are not touching, and turn the OHMS control until the pointer rests over the last green mark (INF) at the right-hand end of the Ohms scale. Do not change the setting of the ZERO control while making resistance measurements.

Resistance is measured by connecting the black test lead and the red test lead to the two ends of the unknown resistance. When using the two middle ranges, if the reading on the green ohms scale is under 1 or over 100, change the SELECTOR switch setting.

A reading of 0 on the Rx1 scale indicates a short circuit, or that the circuit is continuous. A reading of INF (infinity) on the Rx1M scale indicates an open circuit, or a resistance so large that it cannot easily be measured.

The figures on the green Ohms scale are multiplied by 1, 100, 10,000 (10 k), or 1,000,000 (1M), according to the setting of the SELECTOR switch. When this switch is in the Rx100 position, for example, a reading of 6 would indicate 600 ohms, or a reading of 50 would indicate 5000 ohms.

The Rx10k position indicates that the meter scale should be multiplied by 10,000. The last counterclockwise position of the OHMS range switch is marked Rx1M. M means megohm, or 1,000,000 ohms, so the meter reading would be multiplied by 1,000,000.

**NOTE:** Some ohmmeter battery current is drawn whenever the instrument is turned ON and the SELECTOR switch is in one of the Rx positions. To save battery life when you are not using the ohmmeter, NEVER LEAVE THE SELECTOR SWITCH IN THE OHMS POSITION.

### DC Voltage Readings

To measure DC voltage, turn the Voltmeter ON. Use the gray lead with the black probe, and the black lead. The switch can be at DC+ or DC-, depending on whether a positive or a negative voltage is to be applied to the probe tip. This is convenient when measuring voltages at several points in a circuit, some positive and some negative with respect to a common point. The common test lead may remain connected to the common voltage point, and the SELECTOR switch changed to DC+ or DC- for the appropriate polarity.

DC voltages are read on the black meter scale marked 0-10. The markings on the SELECTOR switch refer to the voltage that will give a full-scale reading on the black scale when measuring DC voltage.

The lowest DC VOLTS switch position is marked 1. This means that 1 volt applied to the probe tip will cause a full-scale deflection of the meter pointer, or indicate 10 on the scale. To read voltage in the 1 volt range, read the black 0-10 scale and move the decimal one place to the left. For example, a reading of 2 would indicate .2 volt.

To read voltage on the 10 volt range, read the black 0-10 scale directly.

For the 100 volt range, read the black 0-10 scale and move the decimal one place to the right. For example, a meter reading of 4 would indicate a measurement of 40 volts.

On the 1000 V range, read the black 0-10 scale and move the decimal two places to the right. For example, a meter reading of 3 would indicate 300 volts.

## AC VOLTAGE READINGS

To measure AC voltage, first make sure the power is turned off in the circuit to be measured. Set the SELECTOR switch to one of the AC VOLTS ranges and turn the Voltmeter to ON. Connect the red test lead to one side of the circuit to be measured, and the black test lead to the other side. Then apply power to the circuit.

NOTE: If it is known which wire is the neutral, or common, side of the circuit, the black lead is customarily attached to this point.

The lowest AC VOLTS switch position is marked 1.2 in red. Voltages in this range are read directly on the red 1.2 scale.

When the SELECTOR switch is on the red 10 volt range, read the 0-10 red scale directly.

Use the black 0-10 scale when the SELECTOR switch is on the 100 and the 1000 ranges. To read voltage on the 100 range, read the black scale and move the decimal one place to the right. For example, a reading of 6 would indicate 60 volts.

On the 1000 volt range, read the black scale and move the decimal two places to the right. For example, a reading of 5 would indicate 500 volts.

## VOLTMETER CHARACTERISTICS

### DC Voltage Measurements

The Solid-State Voltmeter has many advantages over the nonelectronic voltmeter. The greatest advantage is its ability to measure voltages without significantly loading the circuit being tested. This characteristic enables the voltage to be measured more accurately. This is especially desirable in such high impedance circuits as resistance coupled amplifiers and AVC (automatic volume control) networks, and on oscillator grids.

To illustrate this advantage of the Solid-State Voltmeter, assume that a resistance-coupled audio amplifier with a 500 k ohm plate load resistor is operating from a 100 volt plate source. See Figure 6.

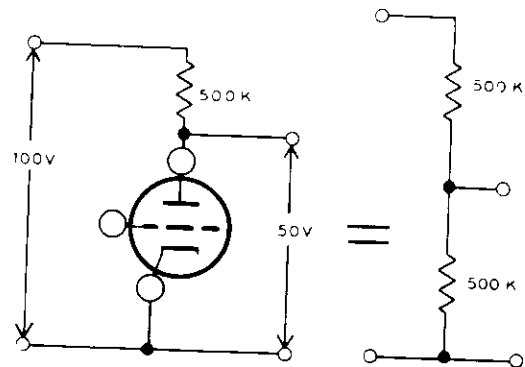


Figure 6

Assuming that the actual plate voltage in this case is 50 volts, the tube therefore acts as a 500 k ohm resistor. When measuring the plate voltage with a conventional 1000 ohms-per-volt meter on the 100 volt scale, the meter represents a 100 k ohm resistor placed in parallel with the tube. See Figure 7. The voltage on the plate, as shown on the meter, would then be 14.3 volts. This large amount of error is caused by the shunt resistance of the meter.

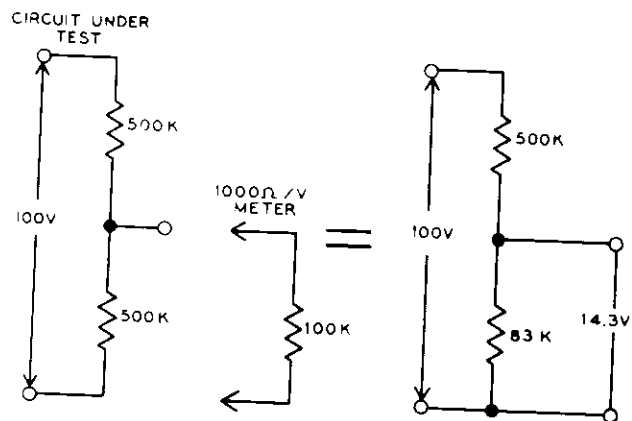


Figure 7

When the Solid-State Voltmeter is used on any scale, the full 11 megohms input resistance is placed in parallel with the tube. See Figure 8. A plate voltage of about 49 volts is then shown on the meter; only 2% lower than the normal operating voltage. Thus more accurate readings in this instance can be obtained only with a high resistance instrument such as the Solid-State Voltmeter.

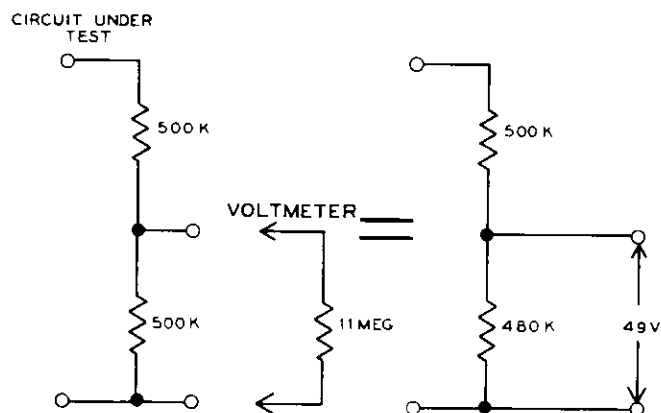


Figure 8

The one volt DC range is very useful when working with fractional voltages in solid state circuits. In this range, scale markings are provided every .02 volt, and you can, in addition, interpolate between marks.

### AC Voltage Measurements

The Heathkit Solid-State Voltmeter is a very sensitive electronic AC voltmeter and, since the human body picks up AC when near any AC wires, the meter will indicate this pickup. Never touch the tip of the probe when the SELECTOR switch is set to the lower voltage ranges. Zero should be set with the probe shorted to the common clip, using the DC+ and DC- positions of the POLARITY switch.

The AC meter scales on the Solid-State Voltmeter are calibrated to read the rms (root-mean-square) value of a pure sine wave. The rms value for a sine wave voltage is .707 times the peak voltage. For complex waveforms, such as square waves, sawtooth waves or pulses, this ratio does not necessarily hold true. The complex waveform in Figure 9, for example, shows a spike that may be several times as large (peak value) as the rms value.

Since the spike is of short duration, the rms value of the overall waveform is barely affected. On the other hand, the square wave would present an rms value equal to the peak value. This voltmeter responds only to the positive peaks of AC voltages. Therefore, when measuring non-symmetrical waveforms, a reversal of the test leads may give a different reading.

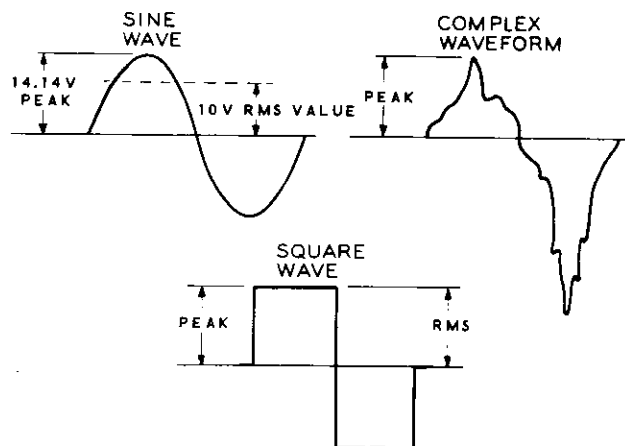


Figure 9

When connecting the Voltmeter to the circuit under test, the Voltmeter input resistance and input capacitance are effectively placed in parallel with the voltage source. In some cases, this can load the circuit and change the actual voltage to be measured. At low frequencies of 50 or 60 Hz, the effects of capacitive loading may usually be disregarded. Thus, the load the Voltmeter presents to the circuit being measured is about the same as a 1 megohm resistor. At higher frequencies, the capacitive reactance decreases.

The amount of loading presented by the input capacitance and resistance of the Voltmeter is determined by the impedance of the circuit being tested. In low impedance circuits, such as 50 to 600 ohm, no noticeable error is introduced in the voltage reading through circuit loading. These circuits will only begin to be loaded at frequencies that approach the upper limit of the Solid-State Voltmeter's frequency response.

Remember, as a general rule, that frequency response and loading may affect the accuracy of your voltage readings. There will be a resistive loading of 1 megohm regardless of frequency. The amount of capacitive loading will depend on the frequency involved. The actual capacitance of the instrument and the leads may also affect the tuning of low capacitance resonant circuits.

You should know the values in the circuit under test and the values of the input resistance and capacitance of the Voltmeter. This will permit you to make valid readings over a wide range of impedances within the full frequency response of the instrument.

## ACCURACY

The accuracy of measurements made with this Voltmeter depends on the accuracy of its calibration and the tolerance of the components used in its circuits. If the Voltmeter is carefully calibrated with precision standards, then the worst case of error would be the sum of component tolerances.

The meter movement is accurate to within  $\pm 2$  percent of full scale. On DC, the  $\pm 1$  percent accuracy of the divider resistors must be considered, resulting in an accuracy within  $\pm 3$  percent of full scale. On AC, the rectifier circuit contributes variations which could result in a maximum error of  $\pm 5$  percent of full scale.

The accuracy on the OHMS ranges depends primarily on the multipliers, which are 1%, and the meter movement accuracy of 2%. Because of the nonlinear OHMS scale, the resulting accuracy is not readily expressed in a percentage figure.

NOTE: When comparing this instrument with another voltmeter, consider that the error of the other instrument may be in the opposite direction. Therefore, when comparing two instruments of  $\pm 5\%$  accuracy, the total difference may be  $\pm 10\%$ . Critical comparisons should only be made against certified laboratory standards.

## TRANSPORTING THE METER

Be sure to place the POWER switch in the OFF position when the meter is being carried or transported. This not only avoids battery drain, but shorts the meter terminals together, which has a "damping" effect and protects the meter movement from damage which might be caused by sudden shocks (such as dropping).

NOTE: An Applications section is included in this Manual to provide those who do not have an electronic background with a few basic applications.

# MAINTENANCE

## METER

Because of the delicate nature of the meter movement, no attempt should be made to repair the meter. Such attempts would automatically void the standard warranty coverage of the meter itself.

## BATTERY REPLACEMENT

NOTE: Before you decide that batteries should be replaced, refer to the Final Bias Adjustment procedure on Page 17.

Replace battery E1 (1.5V) whenever you cannot adjust the meter needle to the INF mark on the green scale in any range of RESISTANCE by use of the OHMS control.

Replace battery E2 (8.4V) whenever you cannot adjust the meter needle to 0 on any scale by use of the ZERO control.

## ELECTROSTATIC CHARGE

The clear plastic meter cover has been treated to resist an accumulation of static electricity. However, should a static charge accumulate through repeated polishing or cleaning of the meter cover, the pointer will deflect in an erratic manner, regardless of whether the instrument is turned off or on. This condition can be corrected quickly. Apply a small quantity of liquid dishwashing detergent to a clean, soft cloth and wipe the surface of the meter cover. The accumulated electrostatic charge will immediately disappear. It is not necessary to remove the cover for this correction.

## CHECKING METER COIL CONTINUITY

If you suspect the meter coil has failed, you can check the continuity of the coil with another ohmmeter as follows. (NOTE: Never check the continuity of the meter coil directly with another ohmmeter. The amount of current that would be drawn could seriously overload and probably ruin

the meter coil.) Always use a limiting resistor with a value of at least 10,000  $\Omega$  in series with the other ohmmeter test leads. The value of the resistor will depend upon the ohmmeter battery voltage and the range on which the ohmmeter is being used. NOTE: If a Heath Model IM-25 Solid-State Voltmeter is available, it can be used to check the meter coil directly because of the low voltage and current used.

## TEST LEADS

Because of their constant flexing during use, the test leads are not above suspicion, especially after the Voltmeter has been in use for several years. Erratic or improper DC voltage measurements can sometimes be caused by a fault in the shielded test lead or phone plug or in the connections in the test probe.

## ACCESSORY PROBES

NOTE: The accessory probes are connected to the Voltmeter through the insulated phone jack on the face of the panel near the test leads.

### HIGH VOLTAGE TEST PROBE

A high voltage test probe is available from the Heath Company. This probe will permit the Voltmeter to measure DC up to 30,000 volts, which covers the range of flyback power supply voltages commonly encountered in TV receivers. This probe consists of a red molded housing with a black molded handle. It contains a 2% precision 1090 megohm resistor and provides a DC range multiplication factor of 100 for 11 megohm input voltmeters.

WARNING: When the high voltage test probe is used, the exposed tip of the black test probe must be covered (isolated). One hundredth of the high voltage being tested will be present in the tip of the black probe, making severe shock possible.

### RF TEST PROBE

An RF test probe is available from the Heath Company. This probe will permit the voltmeter to be used for RF measurements up to 90 volts rms (root mean square) as well as RF voltages superimposed on DC potentials up to 1000 volts. The probe response is flat and linear from 1000 Hz to over 100 MHz.

## IN CASE OF DIFFICULTY

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the Service and Warranty section of the "Kit Builders Guide", and to the "Factory Repair Service" information on page 24 of this Manual.

This section of the Manual is divided into three parts: Visual Test, Precautions for Troubleshooting, and the Troubleshooting Chart. Begin your search for any troubles that occur after assembly by carefully following the checks listed in the Visual Tests section. After Visual Tests are completed, refer to the Troubleshooting Chart. Refer to the Service and Warranty sections of the Kit Builders Guide in cases when you are unable to resolve the difficulty. If the Voltmeter is returned to the Heath Company, be sure all parts are included.

NOTE: Refer to the Circuit Board X-Ray View and Panel Photograph (on Pages 29 and 30) for the locations of parts on the circuit board and panel.

### VISUAL TESTS

1. Recheck the wiring. Check for pinched wires. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.
2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering and to solder "bridges" between foils. Therefore, many troubles can be eliminated by reheating all connections to make sure they are soldered as described in the Soldering section of the Kit Builders Guide.
3. Check to be sure that all transistors are in their proper locations. Make sure each transistor lead is connected to the proper point.



4. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial diagrams. It would be easy for example, to install a 33 k $\Omega$  (orange-orange-orange) resistor where a 3.3 megohm (orange-orange-green) resistor should have been installed, or a 900 k $\Omega$  precision resistor instead of a 90 k $\Omega$ .
5. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

If the trouble is still not located after the visual tests are completed, and another voltmeter is available, check the voltage readings against those shown on the Schematic Diagram. **NOTE:** All voltage readings were taken with an 11 megohm input electronic voltmeter. Voltages may vary as much as  $\pm 20\%$ .

**NOTE:** A review of the Circuit Description may help you determine where the trouble is.

#### PRECAUTIONS FOR TROUBLESHOOTING

1. Be cautious when testing transistor circuits that you do not operate the transistors be-

yond their limits. Although the transistors have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than tubes. A vacuum tube, for instance, can often be operated under shorted, zero-bias, excessive-voltage, or high-current conditions for short periods of time without materially damaging the tube, but any one of these same conditions can completely destroy a transistor instantly.

2. Be sure you do not cause any short circuits when making voltage measurements. This would almost certainly cause damage to one or more transistors or diodes.
3. Transistors should be inserted or removed only while the Voltmeter is turned off. If this rule is not followed, transistors may be damaged.
4. Do not operate the instrument with any of the transistors removed, as the resulting imbalance could damage the remaining transistors or the meter.

## FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) If you wish, you can deliver your kit to a nearby Heathkit Electronic Center. These centers are listed in your Heathkit catalog.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heathkit Electronic Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heathkit Electronic Center, please ship it to the factory at Benton Harbor, Michigan and follow the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.

- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan.

Check the equipment to see that all parts and screws are in place. (Do not include wooden cabinets when shipping receivers, tuners, amplifiers, or TV sets, as these are easily damaged in shipment.) Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least **THREE INCHES** of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company  
Service Department  
Benton Harbor, Michigan 49022



## Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE
Completely inoperative.	<ol style="list-style-type: none"> <li>1. Dead battery or poor battery contacts.</li> <li>2. Transistors Q1, Q2, or Q3 defective.</li> <li>3. Meter coil open.</li> </ol>
Zero control has no effect.	<ol style="list-style-type: none"> <li>1. Bias control R15 and R16 misadjusted.</li> <li>2. Transistor Q1 defective.</li> <li>3. Resistor on voltage divider string R5 through R9 and R11 open.</li> <li>4. Zero control R14 open or shorted.</li> </ol>
Inaccurate DC readings.	<ol style="list-style-type: none"> <li>1. DC Calibration control R18 misadjusted.</li> <li>2. Wrong value or defective resistor in voltage divider string R5 through R9 and R11.</li> </ol>
AC (only) Inoperative.	<ol style="list-style-type: none"> <li>1. Diode D1 defective.</li> <li>2. Capacitors C1 (open) or C2 (shorted).</li> <li>3. Resistor R4 open.</li> </ol>
AC Inoperative. (1000 volt range only).	<ol style="list-style-type: none"> <li>1. Resistor R2 open or resistor R3 shorted.</li> </ol>
Inaccurate AC reading.	<ol style="list-style-type: none"> <li>1. AC Calibration control R19 misadjusted.</li> </ol>
Ohmmeter inoperative or inaccurate readings.	<ol style="list-style-type: none"> <li>1. Battery E1 low voltage.</li> <li>2. Transistor Q1 defective.</li> <li>3. Resistors in voltage divider string R4 through R9 or R12 open or shorted.</li> </ol>
Zero shift with leads shorted when turning Function switch through ohmmeter ranges.	<ol style="list-style-type: none"> <li>1. Transistor Q1 defective (needle may move slightly on Rx1, caused by lead resistance).</li> </ol>
Unable to reach 0 meter reading on any scale.	<ol style="list-style-type: none"> <li>1. Readjust bias.</li> <li>2. Replace battery E2 (8.4 V).</li> </ol>
Unable to reach INF on any resistance range.	<ol style="list-style-type: none"> <li>1. Readjust bias.</li> <li>2. Replace battery E1 (1.5 V).</li> </ol>



## SPECIFICATIONS

### DC VOLTMETER

Ranges. . . . .	0-1, 0-10, 0-100, 0-1000 volts full scale.
Input Resistance. . . . .	11 megohms on all ranges.
Accuracy. . . . .	±3% of full scale.

### AC VOLTMETER

Ranges. . . . .	0-1.2, 0-10, 0-100, 0-1000 volts full scale.
Input Resistance. . . . .	1 megohm on all ranges.
Input Capacitance. . . . .	Approximately 100 pF (38 pF on 1000 V range).
Accuracy. . . . .	±5% of full scale.
Frequency Response. . . . .	±1 dB 10 Hz to 1 MHz (from low source impedance).

### GENERAL

Ohmmeter Ranges. . . . .	Rx1, Rx100, Rx10k, Rx1M.
Ohms Circuit Power Supply. . . . .	1.5 volts (C-Cell, NEDA #14).
Amplifier Circuit Power Supply. . . . .	8.4 volt Mercury Cell (NEDA #1611).
Meter. . . . .	4-1/2", 200 $\mu$ A, 100 degree movement.
Transistor-Diode Complement. . . . .	1 - FET (field effect transistor). 4 - silicon transistors (2N3393 or equivalent). 1 - silicon diode.
Dimensions (overall) . . . . .	9-3/8" wide x 5-3/8" high x 9" deep.
Net Weight . . . . .	2-1/2 lbs.

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

## CIRCUIT DESCRIPTION

The Selector switch of the Voltmeter is used to select the correct circuit and desired range for each type of measurement. The AC-ohms test lead and the DC test probe are both connected to the switch, and the common test lead is connected to the circuit ground. This ground includes the ground foil of the circuit board, which is connected through the wiring to the panel.

### DC

Isolation resistor R1 is in the DC Volts circuit for all DC Volts measurements. The DC Volts circuit includes a series of precision resistors (R5-R11) arranged as a voltage divider. The Selector switch connects the amount of resistance required for a specific range. The selected portion of the voltage is applied to the gate (G) of FET (field effect transistor) Q1, the DC input source follower. The FET provides isolation between the input voltage divider and the balanced bridge circuit. Because of the FET's high input impedance and low output impedance, it couples the DC input to the balanced bridge circuit without loading the voltage divider. The output of the FET is applied to the base of Q2, which is part of a balanced, emitter follower, current amplifier (Q2 and Q3).

The insulated phone jack on the face of the panel bypasses R1 and connects the accessory probe input directly to the DC-volts circuit.

### AC

With the Selector switch in one of the AC Volts ranges, the test voltage is applied across voltage divider R2 and R3 to insure that on higher AC voltage ranges, no more than 100 volts appears at the anode of AC rectifier D1. At the AC rectifier, the test voltage is changed to a DC voltage which is proportional to the applied AC test voltage. Capacitor C2 is used at the output of the AC rectifier to hold the applied pulsating DC voltage at its peak value, so that the Voltmeter responds to the positive peak voltage regardless of the test voltage waveform.

The rectified AC test voltage is applied through AC isolation resistor R4 to a voltage divider, consisting of R5, R6, R7, R8, R9, and R11, where a portion of the rectified AC test voltage is selected and applied to the output circuits as previously described for the DC voltage measurement.

### OHMS

The ohmmeter section of the Voltmeter uses 1.5 volt battery E1 connected in series with the voltage divider network (R5, R6, R7, R8, R9, and R12) and the resistance to be measured. The ratio between the ohmmeter voltage divider network resistors and the resistance being measured determines the portion of the ohmmeter battery voltage that is applied to the output circuits as previously described for the DC voltage measurement.

### METER

For all measurement functions, a voltage is applied to the gate of the FET and its balanced bridge circuit. In each instance, this voltage is dependent upon the voltage or resistance being measured. When there is zero voltage at the input of the balanced bridge circuit, transistors Q2 and Q3 draw the same amount of emitter current; therefore, each emitter is at the same potential and the meter connected between them will not deflect.

When a positive voltage is applied to Q2, it draws more current than Q3, causing a difference in emitter potential between these two transistors. Since the meter is connected between the two emitters, a current then flows through the meter movement. The meter pointer responds proportionally to this current, indicating the value of the voltage or resistance being measured. The DC+ and DC- switch positions are used to reverse the meter connections between the emitters so that both positive and negative DC voltages can be measured without reversing the test leads.

The meter terminals are shorted together by the Power switch in its OFF position. This protects the meter movement from damage due to sudden shocks.

### BATTERIES

The 8.4 volt battery supplies the operating voltage to Q1, Q2, and Q3. Any change in the battery



potential will affect the conduction of Q2 and Q3 equally and therefore will not affect the difference in emitter potential. The maximum conduction characteristics of Q2 and Q3, as used in this Voltmeter circuit, is such that the voltage applied to the meter terminals will not be large enough to damage the meter movement. This is one of the primary advantages of this type of circuit. The meter movement cannot be burned out by inadvertently measuring a voltage that is higher than the Selector switch setting. However, if excessive voltage is applied, the pointer may be bent

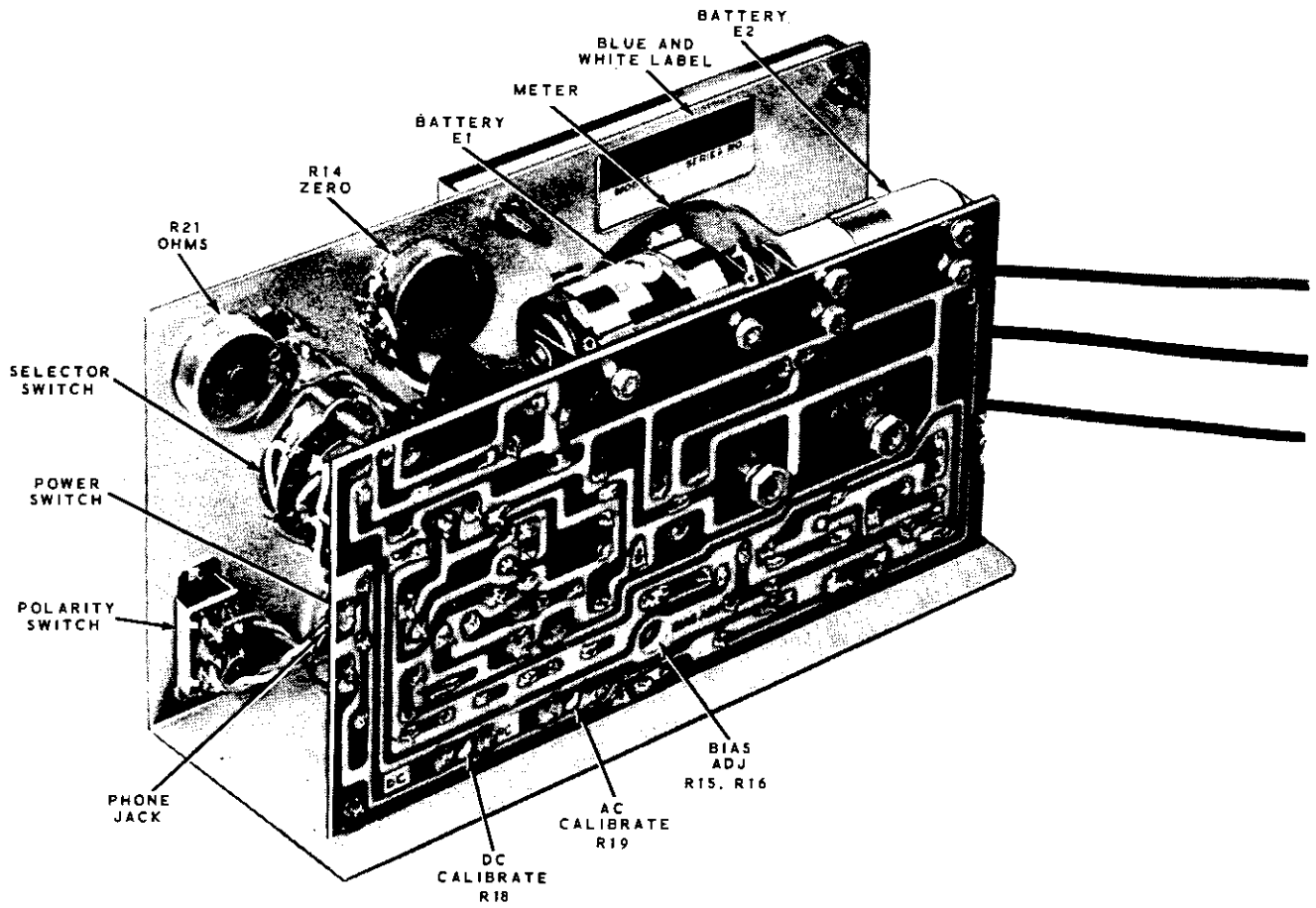
as it hits against the stop. Caution must also be exercised to avoid applying any test voltage to the test probe when the Selector switch is set in the Ohms position.

Battery E1 is connected into the circuit when the Selector switch is in any of the Rx positions. It provides enough current for a full-scale meter indication. Avoid needless battery drain by placing the switch in one of the volts positions when resistance measurements are not being made.

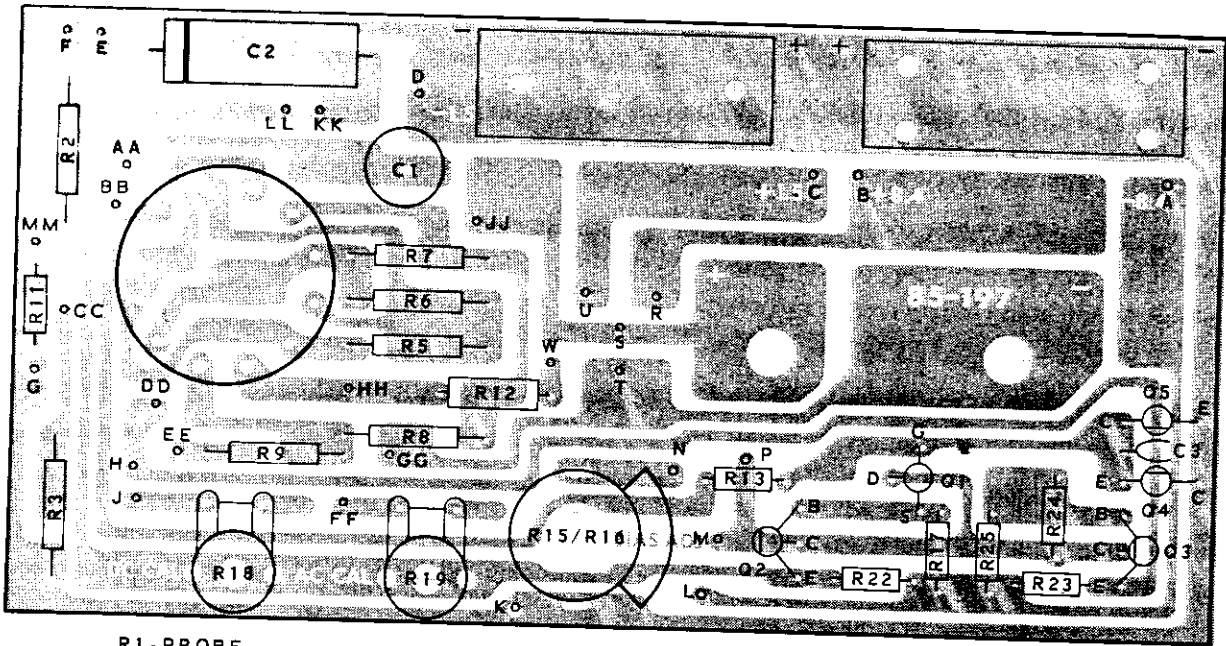
## FUNCTIONAL PARTS LIST

- R1 - Isolation resistor in DC probe.
- R2, R3 - Input voltage divider for AC. Divides the input voltage of the highest AC range so that no more than 100 volts appears at the anode of D1.
- R4 - Isolation resistor for AC. Voltage dropping resistor.
- R5 - R12 - DC voltage dividers: R5-R9 and R11, AC voltage dividers: R5-R9 and R11, Ohms voltage dividers: R5-R9 and R12.
- R13 - Current limiter for the protection of Q1 (and Q4, Q5). Acts with C3 as a low pass filter to prevent AC from reaching the gate of Q1.
- R14, R15, R16 - Voltage divider across the power supply. Determines the bias to the gate of Q1 (the meter needle is adjusted to 0 by R14, the panel Zero control).
- R17 - Source resistor for Q1.
- R18 - Variable resistance in series with the meter for DC calibration. Mounted on the circuit board.
- R19 - Variable resistance in series with the meter for AC calibration. Mounted on the circuit board.
- R21 - Variable resistance in series with the meter for Ohms full-scale calibration. Mounted on the panel.
- R22, R23 - Emitter (load) resistors for Q2 and Q3.
- R24, R25 - Voltage divider across the power supply to provide proper bias voltage to the base of Q3.
- C1 - Input coupling capacitor. Blocks DC while passing AC to the input AC divider (R2 and R3).
- C2 - Charges with the rectified AC from D1.
- C3 - Acts with R13 as a low-pass filter to prevent AC from reaching the gate of Q1.
- D1 - Diode rectifier to convert AC input voltages to DC.
- Q1 - FET DC input source follower. Provides isolation between the input dividers (R5-R11) and the output circuit. Provides high input impedance and low output impedance. Couples the input to the amplifier circuit without loading the voltage dividers.
- Q2, Q3 - Balanced emitter follower-power amplifier. Provides sufficient power gain to operate the 200  $\mu$ A meter.
- Q4, Q5 - Connected back-to-back as 9 volt zener protection diodes. When the voltage at the gate of Q1 exceeds 9 volts (either polarity) conduction occurs through the appropriate diode, causing a voltage drop across R13. Current limiting action of R13 provides some degree of protection to Q4 and Q5.

# PHOTOGRAPH

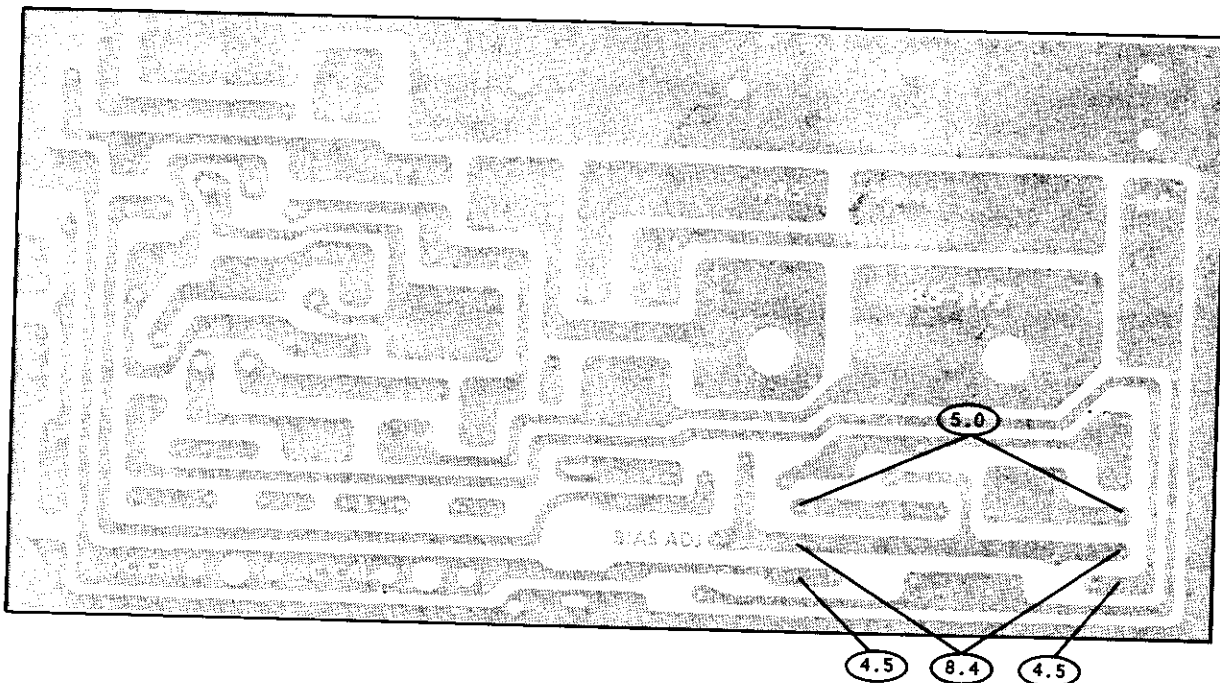


# CIRCUIT BOARD X-RAY VIEW (VIEWED FROM FOIL SIDE)



- R1-PROBE
- R4-SWITCH
- R14-ZERO ADJ.
- R21-OHMS ADJ.
- D1-ON SWITCH

## VOLTAGE CHART



# REPLACEMENT PARTS PRICE LIST

To order parts, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to Replacement Parts in the Kit Builders Guide.

PART No.	PRICE Each	DESCRIPTION	PART No.	PRICE Each	DESCRIPTION
<b>RESISTORS</b>			<b>SHIELDED CABLE-WIRE</b>		
<b>1/2 Watt</b>			343-11	.10/ft	Shielded cable
1-41	.10	10 $\Omega$	341-1	.05/ft	Black test lead
1-20	.10	10 k $\Omega$	341-2	.05/ft	Red test lead
1-22	.10	22 k $\Omega$	344-50	.05/ft	Black hookup wire
1-24	.10	33 k $\Omega$	344-52	.05/ft	Red hookup wire
1-35	.10	1 megohm	344-59	.05/ft	White hookup wire
1-38	.10	3.3 megohm	<b>HARDWARE</b>		
<b>2 Watt</b>			250-52	.05	4-40 x 1/4" screw
3-4-2	.25	9.1 $\Omega$ 5%	254-9	.05	#4 lockwasher
<b>Precision</b>			252-2	.05	4-40 nut
2-236	.20	990 $\Omega$	250-229	.05	6-32 x 1/4" phillips head screw
2-35	.20	9000 $\Omega$ (9 k $\Omega$ )	253-10	.05	Control flat washer
2-41	.20	90 k $\Omega$	254-4	.05	Control lockwasher
2-54	.20	200 k $\Omega$	252-7	.05	Control nut
2-51	.20	900 k $\Omega$	<b>MISCELLANEOUS</b>		
2-237	.20	1.8 megohm	73-46	.10	Plastic grommet
2-52	.35	9 megohm	214-66	1.00	1.5 V battery holder
<b>CAPACITORS</b>			214-67	.75	8.4 V battery holder
<b>Disc</b>			260-1	.15	Alligator clip
21-27	.10	.005 $\mu$ F	436-35	.70	Phone jack
<b>Tubular</b>			439-1	.45	Red test probe
23-91	.50	.047 $\mu$ F (1.6 kV)	439-2	.45	Black test probe
23-61	.15	.05 $\mu$ F	455-50	.10	Knob bushing
<b>CONTROLS-SWITCHES</b>			462-252	.30	Pointer knob
10-201	.35	10 k $\Omega$ control	407-129	9.00	Meter
10-229	.45	2000 $\Omega$ control (2 k $\Omega$ )	85-197-1	1.50	Circuit board
10-78	.45	15 k $\Omega$ control	203-701	1.20	Panel
12-80	1.65	50 k $\Omega$ dual tandem control	95-35	2.60	Plastic case
60-2	.25	6-lug slide switch	331-6	.15	Solder
60-20	.55	9-lug slide switch	490-5	.10	Nut Starter
63-473	4.00	12-position rotary switch	390-306	.35	Model number label
417-118	.55	2N3393 transistor (or equivalent)		2.00	Manual (See front cover for part number.)
417-140	1.50	FET (field effect transistor)			
57-27	.60	Silicon diode			

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.

# CUSTOMER SERVICE

## REPLACEMENT PARTS

If you need a replacement part, please fill in the Parts Order Form that is furnished and mail it to the Heath Company. Or, if you write a letter, include the:

- Part number and description as shown in the Parts List.
- Model number and Series number from the blue and white label.
- Date of purchase.
- Nature of the defect.

Please do not return parts to the factory unless they are requested. Parts that are damaged through carelessness or misuse by the kit builder will not be replaced without cost, and will not be considered in warranty.

Parts are also available at the Heathkit Electronic Centers listed in your catalog. Be sure to provide the Heath part number. Bring in the original part when you request a warranty replacement from a Heathkit Electronic Center.

NOTE: Replacement parts are maintained specifically to repair Heathkit products. Parts sales for other reasons will be declined.

## TECHNICAL CONSULTATION

Need help with your Heathkit? . . . . Self-Service? . . . . Construction? . . . . Operation? . . . . Call or write for assistance. You'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek. . . please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

## REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit C.O.D. for the service and shipping charges. (This will reduce the possibility of delay.)

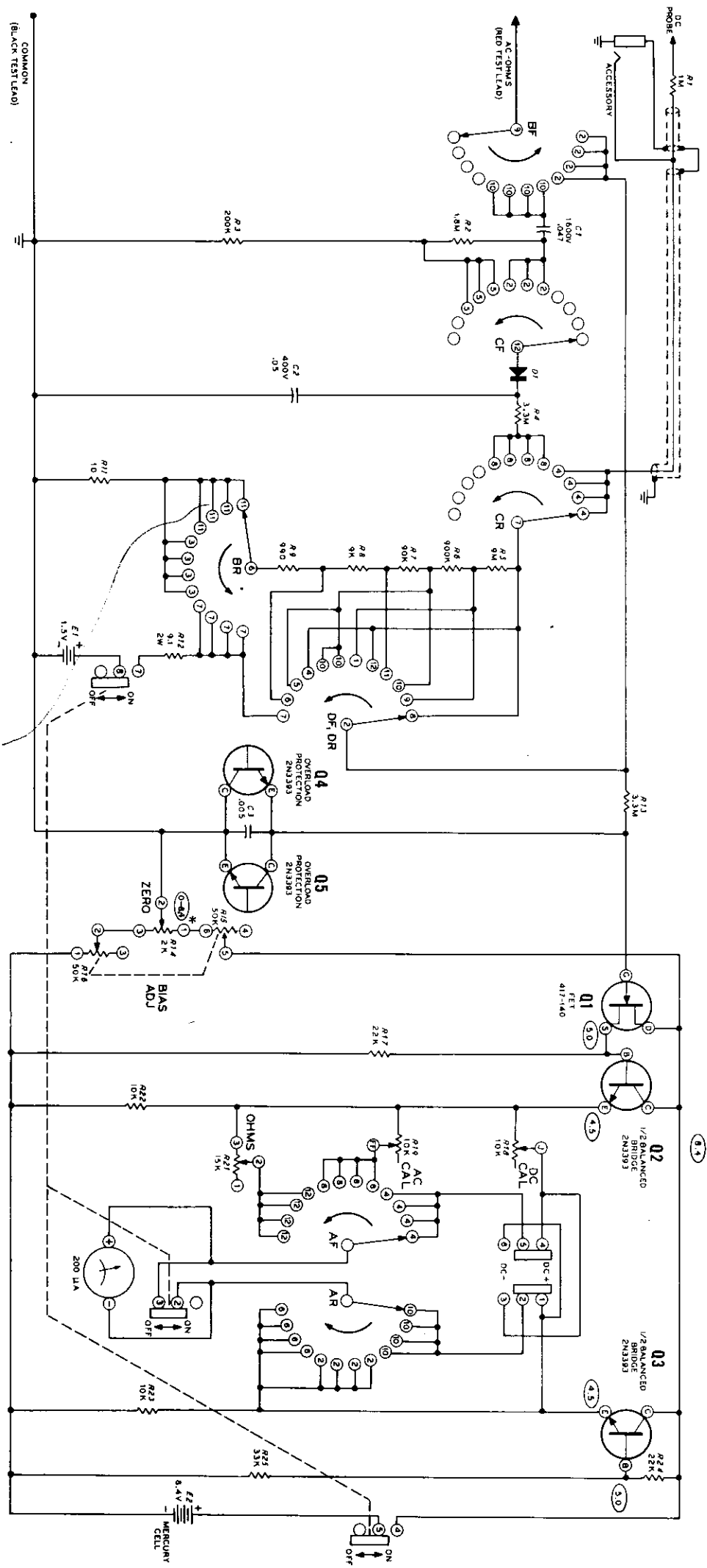
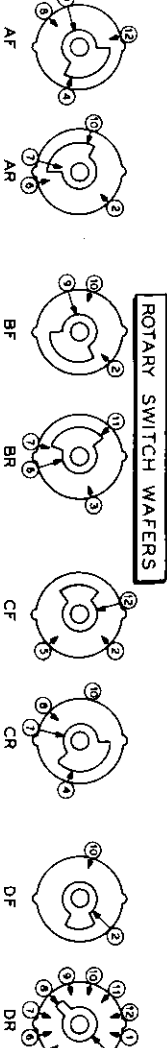
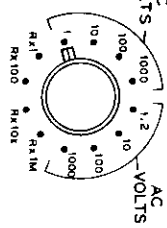
Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment.) Place the equipment in a strong carton with at least **THREE INCHES** of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company  
Service Department  
Benton Harbor, Michigan 49022



**SCHEMATIC OF THE  
HEATKIT®  
UTILITY SOLID STATE VOLTMETER  
MODEL IM-17**



- NOTES**
1. ROTARY SWITCH IS SHOWN IN 1 VOLT DC POSITION.
  2. F - FRONT, R - REAR, C - CLOCKWISE ROTATION.
  3. DC SWITCH SHOWN IN "DC" POSITION.
  4. ON-OFF SWITCH SHOWN IN "OFF" POSITION.
  5. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE.
  6. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE.
  7. RESISTOR VALUES ARE IN OHMS IN -100Ω, M - 1,000Ω, K - 10,000Ω.
  8. THIS SYMBOL INDICATES DC VOLTS TO NEGATIVE SIDE OF ELECTRONIC VOLTMETER. READINGS MAY VARY BY 1%.
  9. ELECTRONIC VOLTMETER READINGS MAY VARY BY 1%.
  10. RESISTORS NOT NUMBERED COLLECTIVELY.
  11. \* - REFERS TO SETTING OF BIAS AND ZERO CONTROLS.

# APPLICATIONS

## AUTOMOBILE TESTS

Automobile electrical circuits may be checked for both voltage and circuit continuity. Usually most of the metal parts of the automobile are connected together and serve as one side of the circuit for both the DC and the resistance tests. Because many automobile wires run in wiring harnesses and the wire ends may be a long distance apart, it is usually more convenient to make voltage tests than continuity tests.

For example, if the replacement of a lamp bulb does not restore a lighting circuit to operation:

- ( ) Set the Voltmeter Power switch ON, and the Selector switch to DC 100 (for a 12 volt system) or DC 10 (for a 6 volt system).
- ( ) Turn the automobile light switch on.
- ( ) Connect the alligator clip on the black meter lead to a convenient metal part of the automobile body.
- ( ) Touch the tip of the black probe to the insulated center terminal of the lamp socket. If the meter does not indicate the proper voltage, additional voltage or continuity tests will indicate whether the socket, wiring, or switch is faulty.

## VOLTAGE TESTING

**CAUTION:** Always be very careful when checking electrical circuits with power applied to them. Severe electrical shock or damage to the Voltmeter can easily result from a moment's carelessness. When you have a test probe in one hand, keep the other hand in your pocket.

2. Turn the toaster's power switch on. This is done by pressing down on the lever until it latches.

3. Set the Voltmeter POWER switch at ON and the SELECTOR switch at Rxl.

4. Clip the black lead to one prong of the line cord plug (make sure the clip touches only one prong), and touch the red probe to the other prong of the line cord plug.

5. If the meter needle remains at INF, there is an open circuit somewhere in the toaster.

6. Remove the housing from the toaster and check the continuity of each line cord wire from the plug to where the wire connects inside the toaster. If there are no breaks, the meter needle will move to zero.

7. Check the continuity of the heating element by touching the black lead to one of its terminals and the red probe to the other terminal. If the element is good, you will get a meter reading between 10 and 20 which indicates a resistance between 10 and 20 ohms.

8. If the heating element checks good, the toaster's power switch is probably faulty. Connect the Voltmeter leads across the switch and turn the toaster on and off several times by pressing and releasing the switch several times. If the meter needle stays at INF, the switch is faulty.

9. Repair or replace the faulty part.

The purpose of this section is to provide those who do not have an electronic background with a few basic applications. These applications will include examples of how this Voltmeter could be used to troubleshoot some items commonly found around your home.

Two types of testing will be discussed: continuity testing, which is performed with the power turned off in the unit being tested; and voltage testing, which is performed with the power turned on.

## CONTINUITY TESTING

Continuity testing is a type of circuit checking that uses the resistance ranges of your Voltmeter to tell you whether there is a complete path in a circuit through which an electric current can flow. If there is not a complete path, these tests will help you find the place where the path is broken (usually a faulty part or broken connection).

Continuity tests may be applied to many household electrical devices such as electric irons, heating pads, waffle irons, lamps, extension cords, etc. The following steps use a toaster as an example, but the same principles, and most of the same steps, would also apply to other devices.

**CAUTION:** Never use the resistance ranges of your voltmeter to test any device while it has power applied to it; this would seriously damage the Voltmeter.

1. **CAUTION:** Unplug the toaster from the 120 VAC outlet.