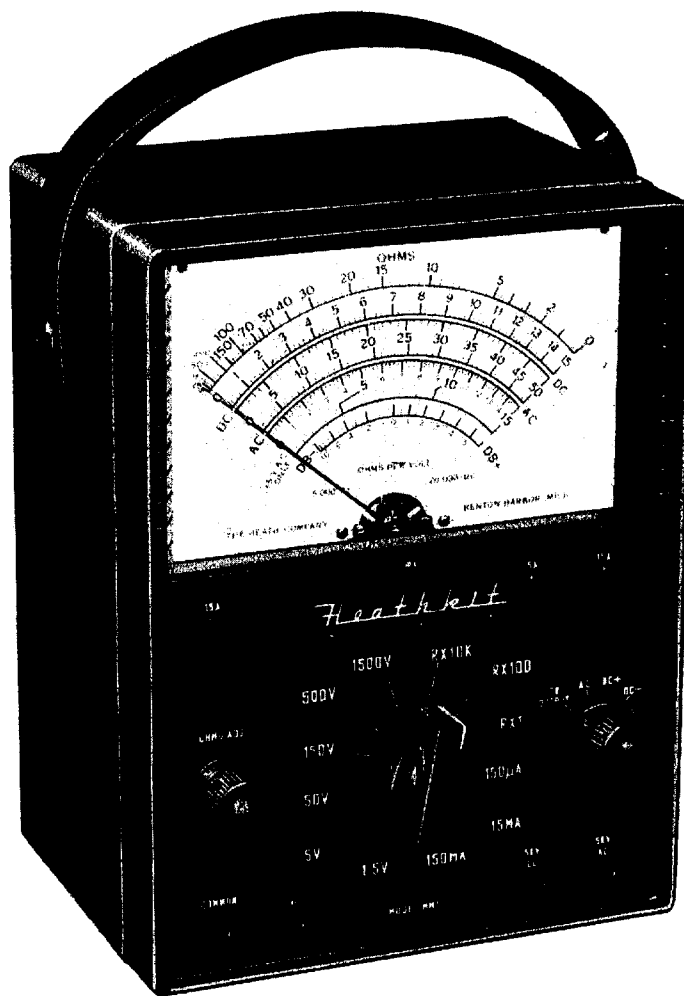


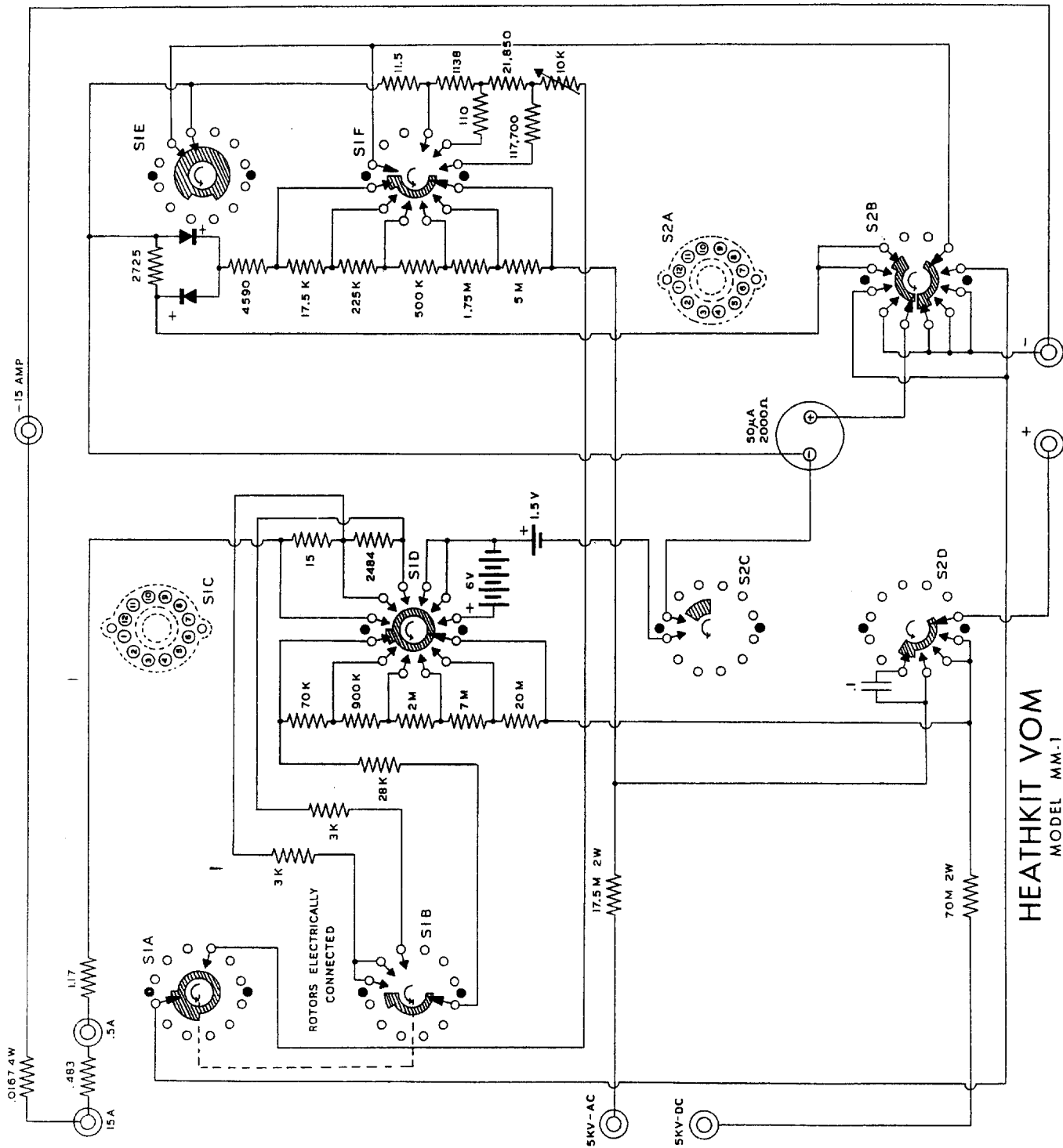
ASSEMBLY AND OPERATION OF THE HEATHKIT VOM

MODEL MM-1



SPECIFICATIONS

Sensitivity.....	20,000 ohm/volt DC, 5000 ohm/volt AC
Range, DC Volts.....	1.5 - 5 - 50 - 150 - 500 - 1500 - 5000
Range, AC Volts.....	1.5 - 5 - 50 - 150 - 500 - 1500 - 5000
Range, Direct Current.....	150 microamperes, 15 - 150 - 500 milliamperes, 15 amperes.
Range, Ohmmeter.....	0.2 ohms to 20 megohms
Range, Decibels.....	-10 to +65 db
Resistors.....	1% precision type
Controls.....	Range switch, Output-AC-DC-Reverse DC switch, Ohms adjust control.
Batteries.....	1 type C cell, 4 Penlite cells
Cabinet.....	Black Bakelite
Dimensions.....	7 1/2" x 5 1/2" x 4"
Net Weight.....	4 lbs.
Shipping Weight.....	6 lbs.



INTRODUCTION

Careful consideration has been given to the assembly and construction of the Heathkit VOM model MM-1. Simplicity and logical assembly procedure has resulted in a minimum number of switch decks and contacts required to fulfill all of the instrument requirements. Proceed carefully with kit construction and be sure of each component's installation, as any error during initial wiring will be difficult to correct later on. The inclusion of the reversed polarity switching adds very little to the wiring and the advantages realized more than offset this. A resistor ring assembly contains a maximum number of resistors in a minimum of space and allows for free access to the components for servicing.

CIRCUIT DESCRIPTION

DC Volts: Referring to the simplified voltmeter circuit shown in Figure 1, you will note the total series resistance including the 2 KΩ of the meter, amount to 100 megohm or 100,000,000 Ω between the +5,000 volt and the negative jacks. Applying ohms law:

$$I = \frac{E}{R} = \frac{5000}{100,000,000} = .00005 \text{ or } 50 \text{ microamperes}$$

of current will flow through the circuit. The meter has a full scale sensitivity of 50 microamperes, consequently it will indicate full scale deflection for an applied voltage of 5 kilovolts. A voltage of 2.5 kilovolts would present the equation:

$$I = \frac{2500}{100,000,000} = .000025 \text{ or } 25 \text{ microamperes}$$

This would deflect the meter to its mid-scale point. The amount of current through the meter becomes a function of the voltage applied to the resistance network. Any particular voltage causes a relative current through the meter and deflects it accordingly. Smaller values of voltage are measured by switching some of the resistance out of the circuit, thus allowing the 50 microamperes needed for full scale meter deflection to be obtained with less voltage across the circuit. The sensitivity of a voltmeter is rated in ohms per volt. This being the amount of resistance in series with the meter which will allow full scale deflection when 1 volt is applied. It is a function of the meter current sensitivity and increases as the amount of current necessary to cause full scale deflection of the meter decreases. The ohms per volt rating is arrived at from the Ohm's law formula:

$$R = \frac{E}{I}$$

In the case of the MM-1, $R = \frac{1 \text{ volt}}{50 \text{ microamperes}} = \frac{1}{.00005}$

or 20,000 ohms per volt. Unlike a VTVM which maintains a constant input impedance, the VOM impedance changes with the range used. On the 500 volt range, the input impedance of the MM-1 will be 10 megohms. This compares very favorably with the average VTVM.

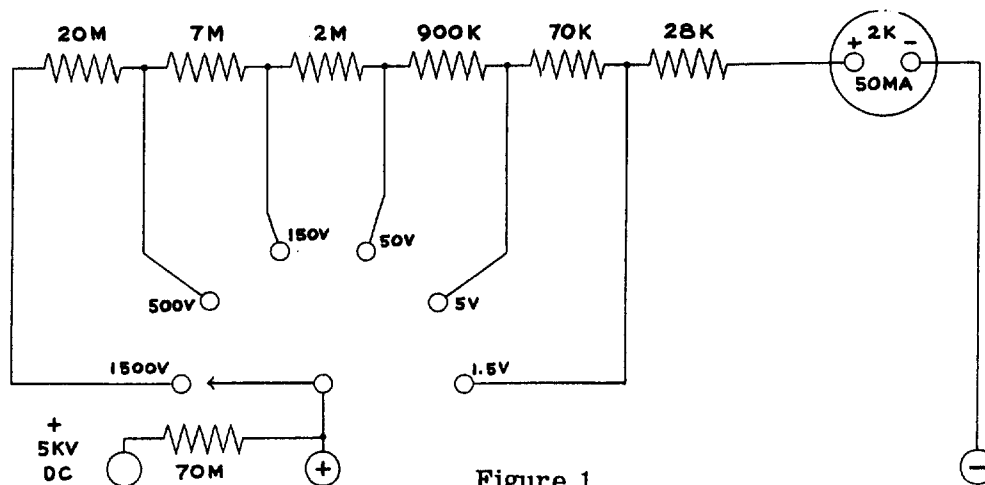


Figure 1

Reverse Polarity, DC Volts: The last position of the function switch is so wired that it effectively reverses the meter connections to the circuit. It affects only the DC volt and current ranges, there being no point in extending the system to cover AC volts or resistance ranges. The circuit eliminates the necessity of changing test lead connections when alternately measuring positive and negative voltages or when measuring current flow in more than one direction. Figure 2 shows the simplified circuit of the reverse polarity range of the MM-1.

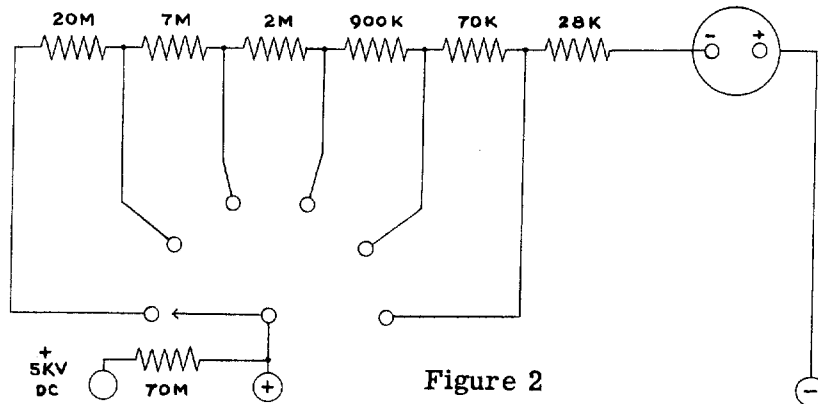


Figure 2

AC Volts: The AC volt range uses a system of resistance multipliers similar to the DC volt ranges, with a metallic rectifier to provide the meter with direct current proportional to the voltage being measured. Metallic rectifiers of a type classified as instrument rectifiers are used because of their small size. However, these are not perfect rectifiers in the sense that some current will pass through them in a reverse direction. If this reverse current were allowed to pass through the meter, it would effectively lower the sensitivity by averaging out a portion of the forward current. By examining Figure 3, you will note the circuit contains two rectifiers.

One in series with the meter and the other connected in the opposite direction by-passing it. The effect is such that one-half cycle of AC passes through the series rectifier and deflects the meter. The other half cycle which could cause some reverse current through the meter, is shunted around it by the second rectifier. Due to the voltage drop through the rectifier and the shunt effect of the circuit on the meter, it is impossible to obtain the same sensitivity on AC as on DC. The AC sensitivity of the MM-1 is 5000 ohms per volt, which is higher than average.

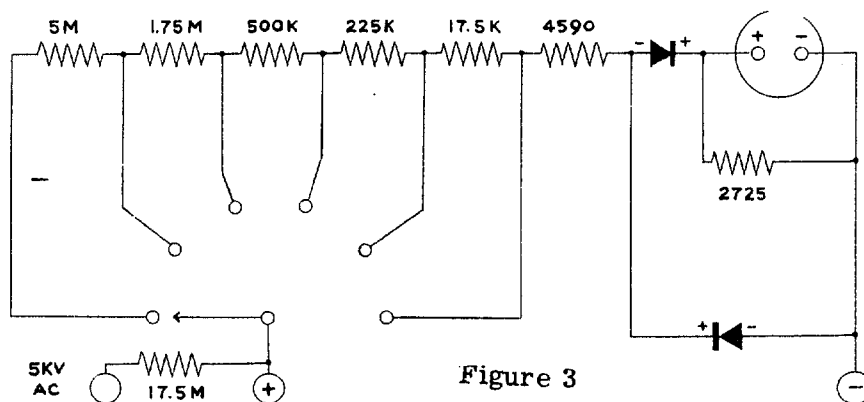
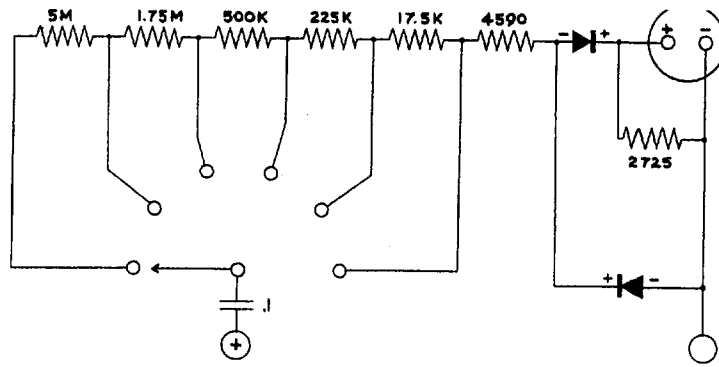


Figure 3

AF Output: The circuit is essentially the same as used for AC volts with the exception that a .1 μ fd condenser is placed in series with the positive jack. See Figure 4. This is necessary to block the DC component when measuring output at a point having both AC and DC present such as the plate of an audio tube. The impedance of the blocking condenser in series with the multipliers will affect the reading of AC volts. The effect will be more apparent at lower voltage ranges and lower frequency of measured voltage. The AF output range is used as a volume level meter by reading the db scale on the meter. The scale is calibrated in standard dbm with zero db = .001 watt in 600 ohms. This establishes the zero reference level at .7746 volts. The Heathkit model MM-1 will cover the range of -10 to +65 db by using the conversion chart shown in another section of this manual.

Figure 4



Microammeter: Figure 5 shows the simplified circuit for the 150 microampere range. The circuit will be readily understood if it is considered as two parallel resistors. The 3 K Ω resistor and the 2 K Ω of the meter total 5 K Ω , whereas the five resistors in the shunt leg of the circuit total 2500 Ω . As the shunt resistance is half the meter resistance, twice the current will pass through it. When sufficient current is supplied to the circuit to pass 50 microamperes through the meter circuit, 100 microamperes will pass through the shunt circuit. The total of shunt and meter currents constitute the 150 microampere range.

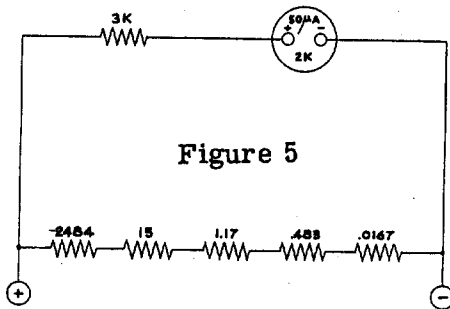
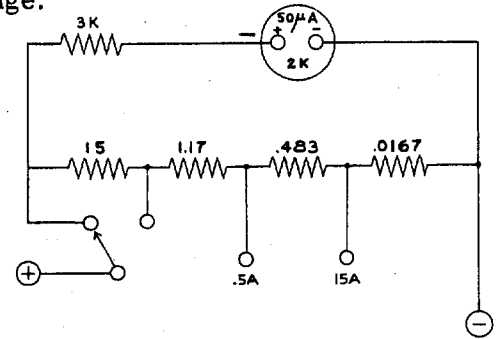


Figure 5

Figure 6



Milliammeter and Ammeter: These ranges use what is known as an Aryton shunt. In this system all shunt resistances are permanently connected in a series circuit. This eliminates the danger of switch contact resistance affecting the shunt accuracy. However, in calculating the shunt resistance necessary, each individual shunt resistor becomes a part of the next higher resistance used in the next lower current range. These in turn are totaled for the next lower current range, etc.

The basic principle of any current multiplier is to by-pass the greater share of current around the meter by use of a low value of shunt resistance. The first step in design is to determine how many times greater the current to be measured is than the normal full scale sensitivity of the meter. For example, to make the MM-1 meter read 15 milliamperes, the meter sensitivity being 50 microamperes, the multiplier necessary to convert 50 microamperes to 15 milliamperes would be:

$$\frac{.015}{.00005} = 300 \text{ times.}$$

As 50 microamperes will still pass through the meter, we need only pass 299 x 50 microamperes through the shunt. Examination of the simplified circuit in Figure 6 will show that we have 5 K Ω in the meter circuit. Consequently the shunt resistance must be 299 x less.

$$\frac{5000}{299} = 16.7 \Omega.$$

If the resistors in the Aryton shunt are added as explained previously, they will be found to be correct for this range. Although the shunt resistances are not affected by switching contacts, the actual current measured passes through the switch. Therefore, the higher current ranges on the MM-1 are brought out to separate jacks to avoid possible current overloads to switches. To measure .5 or 15 amperes, the VOM is set on the 150 milliampere range but the test leads are plugged into the .5 or 15 ampere jacks.

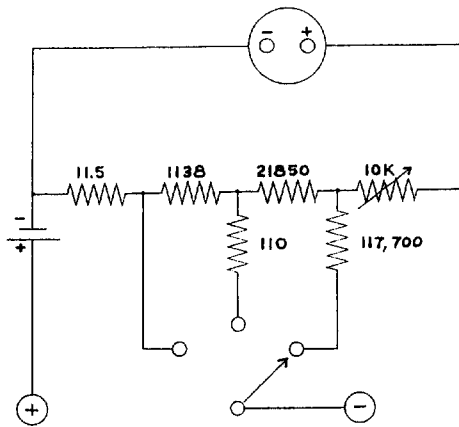


Figure 7

Ohmmeter: The MM-1 uses a potentiometer type ohmmeter circuit. In this type circuit, the external unknown resistor is connected in series with a battery and an internal standard resistor. The meter then acts as a voltmeter to measure the voltage drop developed across the standard resistor. The reading obtained is relative to the resistance being measured. To change resistance ranges, the battery voltage, standard resistance and meter multipliers are switched simultaneously. Figure 7 shows the simplified schematic of the ohmmeter circuit. By means of three ranges, the ohmmeter will cover from .2 ohms to 20 megohms.

PRELIMINARY INSTRUCTIONS AND NOTES

The Heathkit VOM, model MM-1, when constructed in accordance with the instructions in this manual, is a high-quality piece of test equipment, capable of years of trouble-free service. We therefore urge you to take the necessary time to assemble and wire the kit carefully. You will be rewarded with a neat appearing, well-built and dependable instrument.

This manual is supplied to assist you in every way to complete the Heathkit VOM with the least possible chance for error. We suggest that you take a few minutes now and read the entire manual through before any work is begun. This will enable you to proceed with the work much faster when construction is started. The large, fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the construction of the kit. These diagrams are repeated in smaller form within the manual. We suggest that you retain the manual in your files for future reference, both in the use of the Multimeter and for its maintenance.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing,—please obtain them locally if at all possible.

Read the note on soldering on the inside of the back cover. Crimp all leads tightly to the terminal before soldering. Be sure both the lead and the terminal are free of wax, corrosion or other foreign substances. Use only the best rosin core solder, preferably a type containing the new activated fluxes such as Kester "Resin-Five," Ersin "Multicore," or similar types.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROsin CORE RADIO SOLDER" BE PURCHASED.

We strongly urge that you follow the wiring and parts layout shown in the manual. The amount of mounting space is limited and the layout has been designed to take full advantage of it while maintaining isolation of critical circuits.

NOTE: The wiring of the range switch is the most important wiring of the entire kit. It constitutes most of the kit wiring and the rest of the assembly will be found very simple. This Heathkit VOM has been designed so that the range switch may be wired as a separate unit before installation, thereby increasing the ease of instrument construction. Exploded views of the switch and associated wiring are furnished to clarify the wiring involved.

WARNING: Check each step carefully before soldering. One mistake in the switch connections can cascade into the switch wiring, being completely in error throughout. It would require a large amount of work to correct the wiring after it has been completed.

You will note in the exploded switch view, Figure 8, the sections are labeled S1A through S1F corresponding to each side of the three switch decks, starting at the front or shaft end of the switch. The terminals on each deck are numbered in a clockwise direction when viewed from the shaft end. This is common practice in switch construction. However, as we will be looking at the switch from the rear during wiring, the numbering will be found to run counterclockwise. This is mentioned here merely to prevent confusion.

ASSEMBLY AND WIRING OF THE RANGE SWITCH UNIT

(S) means solder.

(NS) means do not solder yet.

- () First review the preceding paragraphs, then refer to Figure 8.
- () Connect a 3" length of wire to S1A1 (S). Leave the end free.
- () Connect a 2" length of wire to S1A9 (S). Leave the end free.
- () Connect a short bare wire from S1B12 (S) to S1B11 (NS).
- () Connect an 8" length of wire to S1D7 (S). Leave the end free.
- () Connect a short bare wire from S1D8 (S) to S1D9 (NS).
- () Connect a 5" length of wire to S1D9 (S). Leave the end free.
- () Connect a short bare wire from S1F12 (S) to S1E11 (NS).
- () Connect a 5" length of wire to S1E11 (S). Leave the end free.

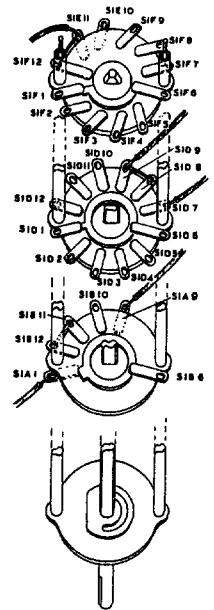


Figure 8

RING ASSEMBLY

- () Study Figure 9 carefully and compare the rings with the figure to identify them. You will note that the A ring is black and the B ring is brown.

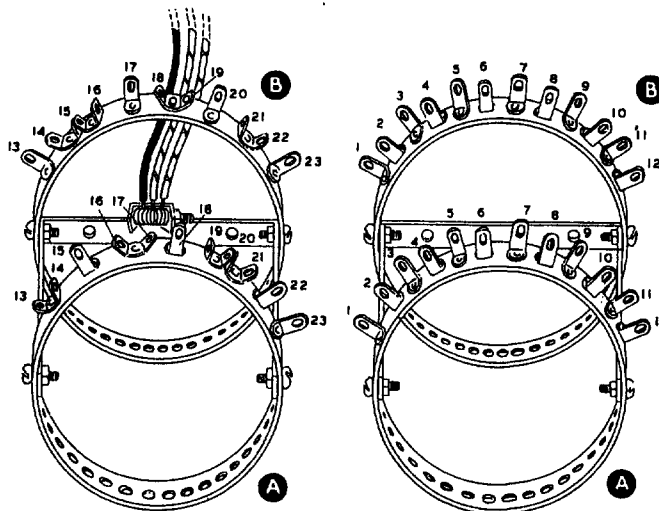


Figure 9

() Mount the rings to the ring bracket as shown in Figure 9, using 3-48 screws and nuts.

NOTE: The rings must be mounted on the ring bracket with the A ring at the open ends of the bracket, the B ring at the closed U of the bracket and the corresponding terminal numbers of the two rings mounted vertically over one another.

() Mount the meter rectifier to the ring bracket with a 3-48 screw and nut. Position as shown in Figure 9.

() The ring assembly is now mounted on the switch. Refer to Figure 10. Place the rings so the side illustrated is toward you. Now examine the switch and turn it until the contacts appear as shown in Figure 10.

() Slide the switch into the ring so that the two studs on the rear of the switch pass through the holes in the ring bracket. Fasten with 4-40 nuts.

NOTE: To make the wiring easier to follow, the switch will be wired in two parts corresponding to the two halves on either side of the switch posts and the ring bracket. Also note the switch and ring numbering illustrated in Figures 8, 9 and 12. The wiring will follow a system based on the switch deck and number. For example, S1D4 refers to the #4 terminal on the range switch, middle deck. B8 refers to the #8 terminal on the B ring. In this particular case, the wire will continue on to B10. Where wires connect in this manner, care should be taken to avoid the in-between terminal B9 as shown in Figure 11. Although bare wire is used throughout the switch wiring, there is ample space to arrange wires to avoid each other. Thus the switch wiring may be done for the most part without the use of spaghetti, resulting in a much neater appearance. The wiring from ring to switch can best be accomplished by feeding the wire through the hole in the ring terminal lug until connection can be made to the switch terminal. Connect to switch terminal, arrange the wire properly to clear other wires or terminals, and finally wrap once around the ring terminal.

() Refer to Figure 10 for the following wiring.

() Connect a bare wire from B13 (NS) to S1F7 (S).

() Connect a bare wire from A15 (NS) to S1F8 (S).

() Connect a bare wire from A17 (NS) to S1F9 (S).

() Run a bare wire from B17 (NS) to S1E10 (NS).

() Run a bare wire from B23 (NS) to S1E10 (S).

() Connect the black wire of the meter rectifier to B23 (NS).

() Connect a bare wire from B18 (NS) to S1D10 (S).

() Connect a bare wire from A18 (NS) to S1B10 (S).

() Connect a bare wire from B20 (NS) to S1B11 (S).

() Connect a bare wire from A21 (NS) to S1D11 (S).

() Connect a bare wire from B22 (NS) to S1D12 (S).

() Connect the red wire of the meter rectifier to A23 (NS).

() Refer to Figure 11 for the following wiring.

() Connect the yellow wire of the meter rectifier to B1 (NS).

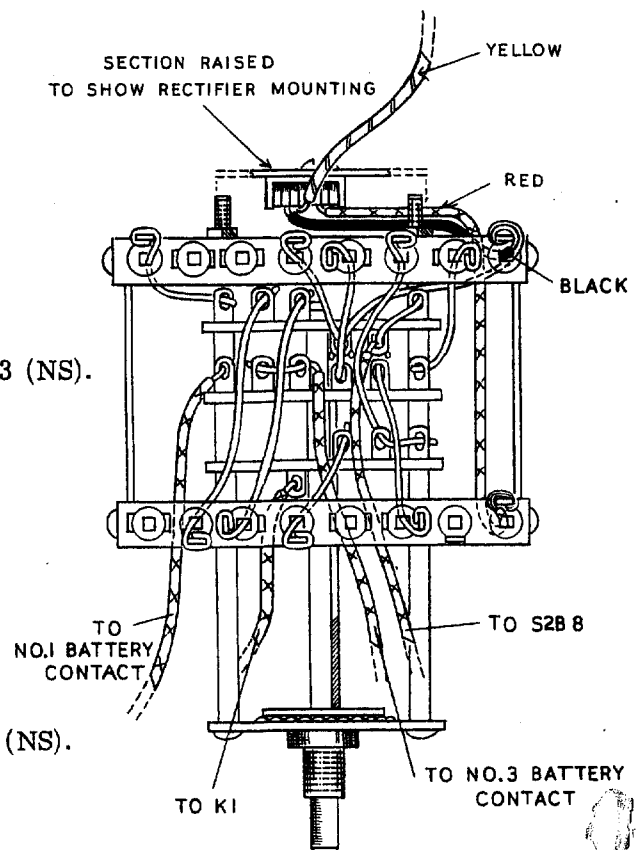
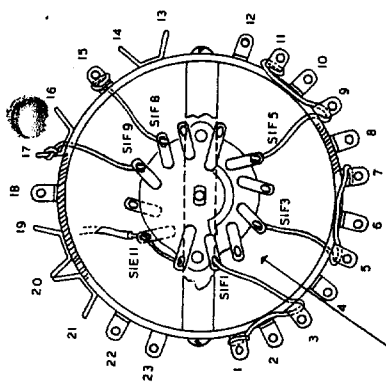
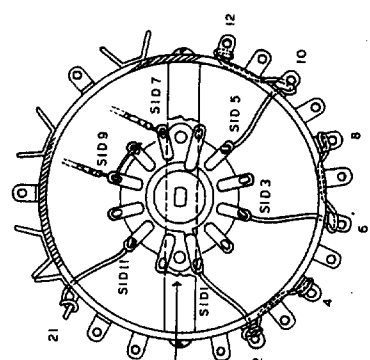


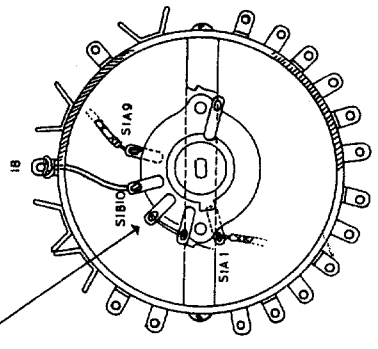
Figure 10



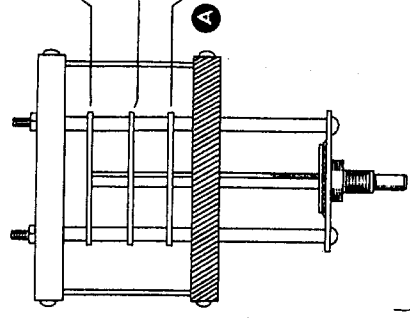
REAR SWITCH DECK
SECTIONS SIE & SIF



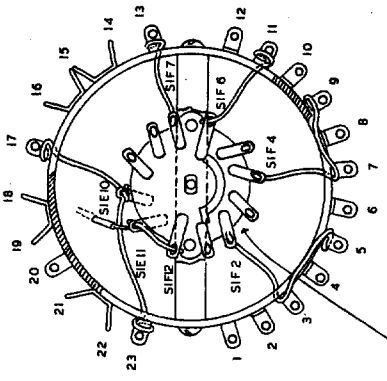
MIDDLE
SWITCH DECK
SECTION SID



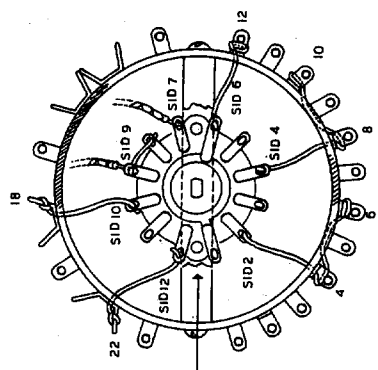
FRONT SWITCH DECK
SECTION SIA & SIB



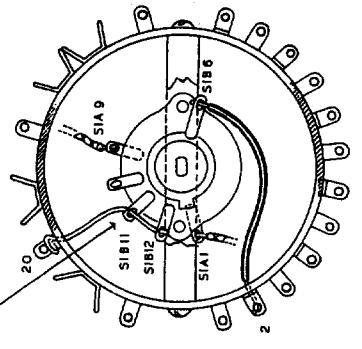
'A' RING WIRING TO SWITCH



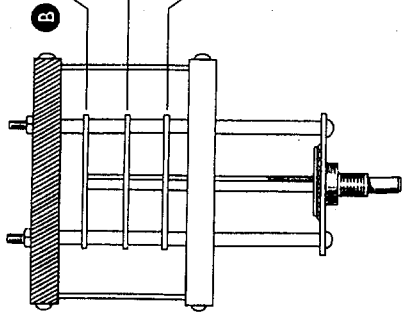
REAR SWITCH DECK
SECTIONS SIE & SIF



MIDDLE
SWITCH DECK
SECTION SID



FRONT SWITCH DECK
SECTION SIA & SIB



'B' RING WIRING TO SWITCH

Figure 12

NOTE: In the following wiring where connections are made to two terminals on the rings, the easiest method of doing so is as follows. Run the bare wire through the hole in the first terminal mentioned and connect to the proper switch terminal. Arrange the wire to clear. On the other end, bring the wire around the outside of the lug as shown in Figure 11, to the last terminal mentioned and wrap one turn around the terminal. Make sure the wire clears the terminal between the two connections.

- () Connect a bare wire from A2 (NS) to S1D1 (S) and to A4 (NS).
- () Connect a bare wire from A3 (NS) to S1F1 (S) and to A1 (NS).
- () Connect a bare wire from B3 (NS) to S1F2 (S) and to B5 (NS).
- () Connect a bare wire from B4 (NS) to S1D2 (S) and to B6 (NS).
- () Connect a bare wire from A5 (NS) to S1F3 (S) and to A7 (NS).
- () Connect a bare wire from A6 (NS) to S1D3 (S) and to A8 (NS).
- () Connect a bare wire from B7 (NS) to S1F4 (S) and to B9 (NS).
- () Connect a bare wire from B8 (NS) to S1D4 (S) and to B10 (NS).
- () Connect a bare wire from A9 (NS) to S1F5 (S) and to A11 (NS).
- () Connect a bare wire from A10 (NS) to S1D5 (S) and to A12 (NS).
- () Connect a bare wire from B11 (NS) to S1F6 (S).
- () Connect a bare wire from B12 (NS) to S1D6 (S).
- () Connect a bare wire to S1B6 (S). Cover with a 2 3/8" length of spaghetti and connect to B2 (NS). Run wire as shown in Figure 11.

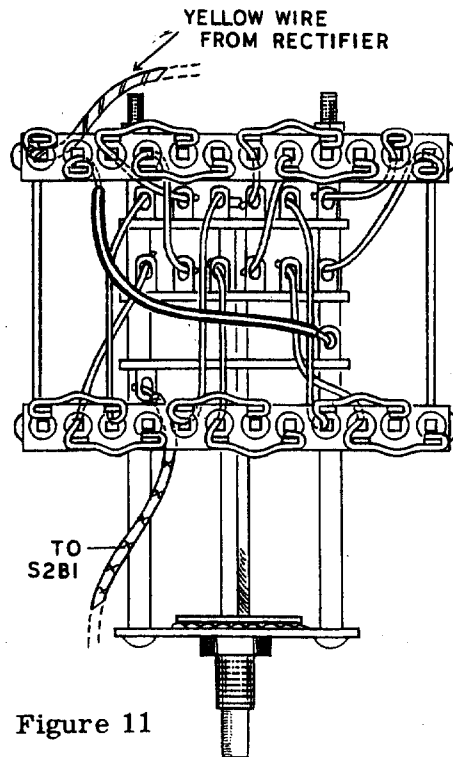


Figure 11

RESISTOR ASSEMBLY

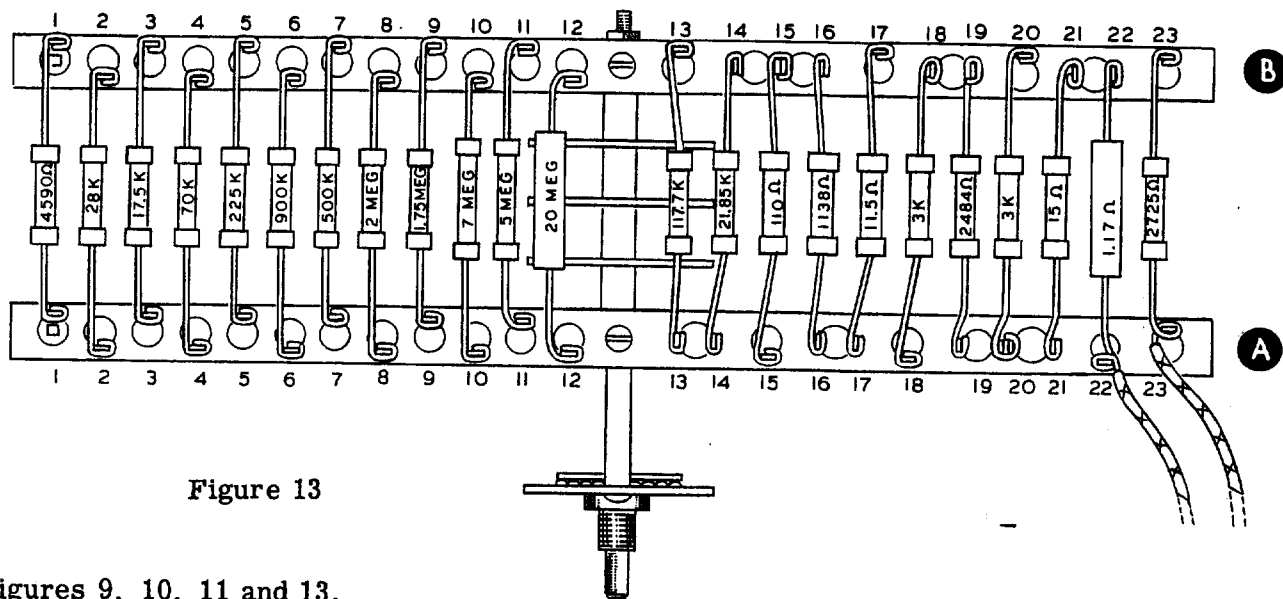


Figure 13

See Figures 9, 10, 11 and 13.

- () Connect a 4590 Ω resistor from A1 (S) to B1 (S).
- () Connect a 28 K Ω resistor from A2 (S) to B2 (S).
- () Connect a 17.5 K Ω resistor from A3 (S) to B3 (S).
- () Connect a 70 K Ω resistor from A4 (S) to B4 (S).
- () Connect a 225 K Ω resistor from A5 (S) to B5 (S).
- () Connect a 900 K Ω resistor from A6 (S) to B6 (S).
- () Connect a 500 K Ω resistor from A7 (S) to B7 (S).
- () Connect a 2 megohm resistor from A8 (S) to B8 (S).
- () Connect a 1.75 megohm resistor from A9 (S) to B9 (S).
- () Connect a 7 megohm resistor from A10 (S) to B10 (S).
- () Connect a 5 megohm resistor from A11 (S) to B11 (NS).
- () Connect a 20 megohm resistor from A12 (S) to B12 (NS).
- () Connect a 117.7 K Ω resistor from A13 (NS) to B13 (S).
- () Connect a 21.85 K Ω resistor from A14 (S) to B14 (S).
- () Connect a 110 Ω resistor from A15 (S) to B15 (S).
- () Connect a 1138 Ω resistor from A16 (S) to B16 (S).
- () Connect an 11.5 Ω resistor from A17 (S) to B17 (S).
- () Connect a 3 K Ω resistor from A18 (S) to B18 (S).
- () Connect a 2484 Ω resistor from A19 (S) to B19 (S).

- () Connect a 3 K Ω resistor from A20 (S) to B20 (S).
- () Connect a 15 Ω resistor from A21 (S) to B21 (S).
- () Connect a 1.17 Ω resistor from A22 (NS) to B22 (S).
- () Connect a 2725 Ω resistor from A23 (NS) to B23 (NS).
- () Connect a 3" length of wire to A23 (S). Leave the end free.
- () Connect a 3" length of wire to A22 (S). Leave the end free.

Temporarily set the range switch aside.

FUNCTION SWITCH WIRING

NOTE: The function switch when mounted has very little clearance between it and the side of the case. Consequently the wiring along the side of the switch, numbering from 1 to 6, must be kept close to the switch and the switch terminals must not be bent outward. See Pictorial 1 and Figure 14.

- () Connect a bare wire to S2B2 (S). Run wire down below the switch deck to clear S2B3 and over to S2B4, 5, and 6. Solder all but S2B6.
- () Connect a bare wire from S2B11 (S) to S2B12 (NS).
- () Connect a bare wire from S2D5 (S) to S2D6 (NS).
- () Connect a bare wire to S2B7 (S). Cover wire with a 2" length of spaghetti and run under switch deck to S2B1 (NS). See Figure 14.

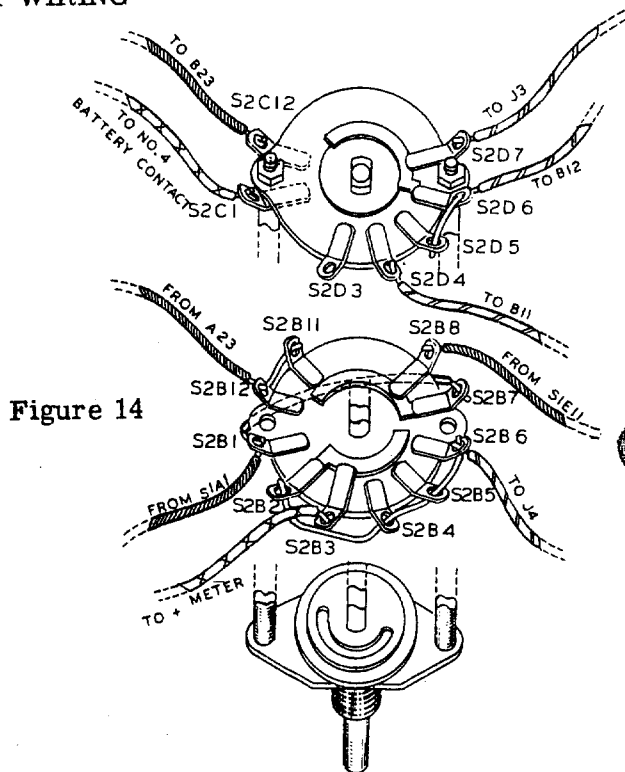


Figure 14

ASSEMBLY AND WIRING

- () Mount the function switch as shown in Pictorial 1, using a lockwasher under the panel, a flat washer and control nut on top.
- () Connect a wire 4" long to S2B3 (S). Leave the end free.
- () Connect a wire 2 1/2" long to S2C1 (S). Leave the end free.
- () Insert jack connectors in J1 through J7 as shown in Figure 15.
- () Connect a wire from S2B6 (S) to J4 (NS).
- () Connect a wire from J4 (S) to J7 (NS).
- () Connect a wire from S2D7 (S) to J3 (S).
- () Connect the .483 Ω shunt resistor from J5 (NS) to J6 (NS).

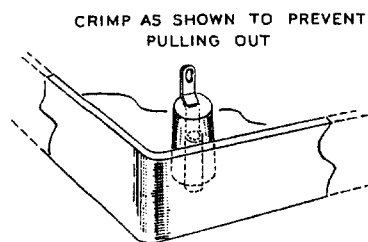
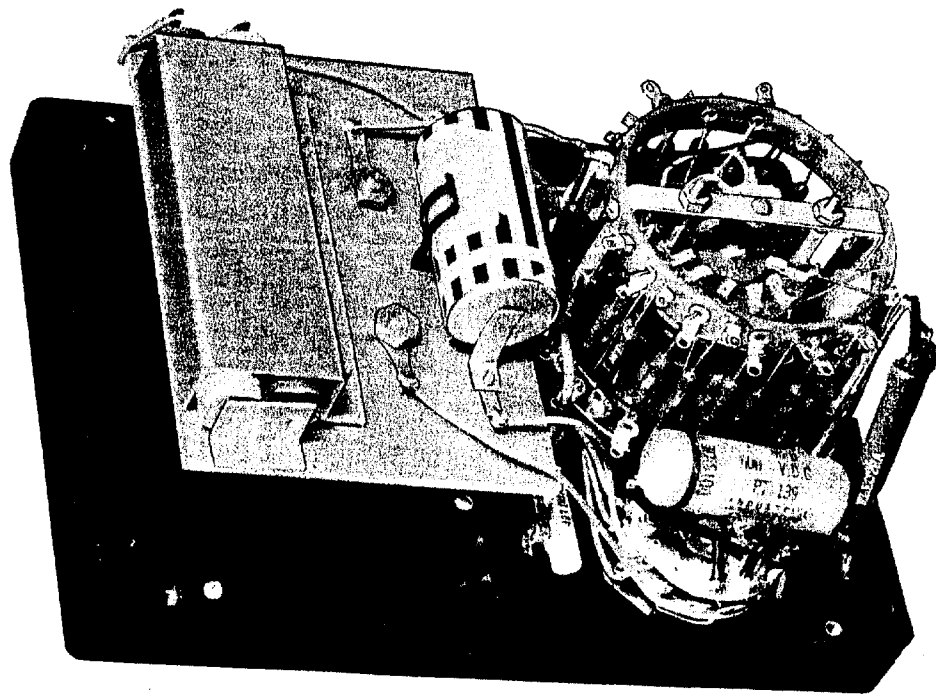
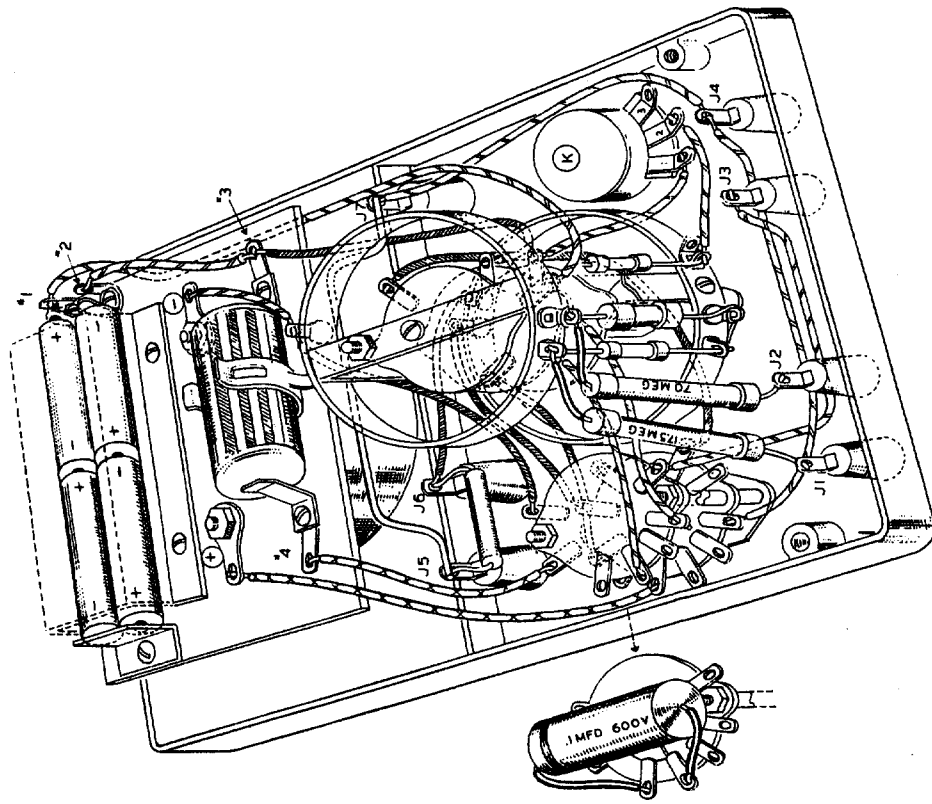


Figure 15



PICTORIAL 1

() Connect the .0167 Ω shunt resistor from J5 (S) to J7 (S).

NOTE: The .0167 Ω shunt resistor consists of a heavy piece of Manganin wire cut exactly to length and spaced so that it may be soldered between the two terminals J5 and J7 without excess length on either side. In soldering this wire, it must be soldered exactly at the junction points to the jack terminals with no excess solder splattered along the wire as this will change the resistance of the shunt. It also must be positioned as shown to leave clearance for the range switch.

() Mount the range switch assembly in position as shown in Pictorial 1 with the side having the 20 megohm and the 117.7 K Ω resistors toward the bottom of the panel.

() Connect the wire coming from S1A1 on the range switch to S2B1 (S) on the function switch.

() Connect the wire coming from A23 on the resistor ring to S2B12 (S).

() Connect the wire coming from A22 on the resistor ring to J6 (S).

() Connect the wire coming from S1E11 to S2B8 (S).

() Connect a wire from S2C12 (S) to B23 (NS).

() Connect a wire 3" long to B23 (S). Leave the end free.

() Connect a wire from S2D6 (S) to B12 (NS).

() Connect a wire from S2D4 (NS) to B11 (NS).

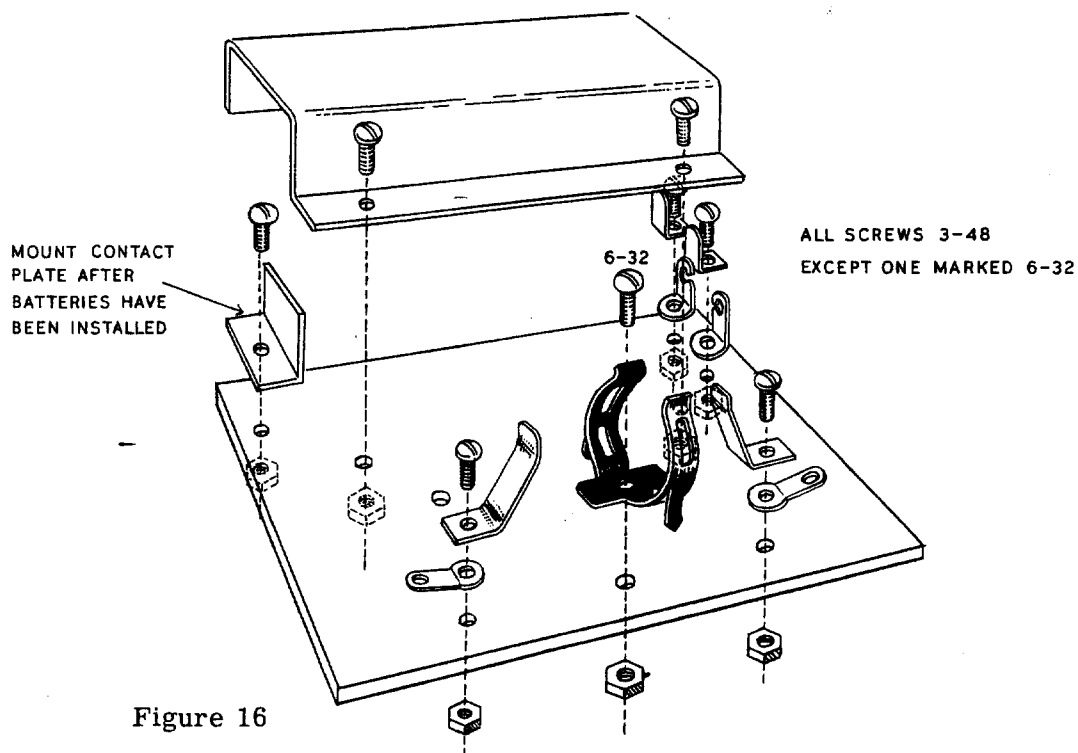


Figure 16

() Connect a .1 μ fd condenser from S2D3 (S) to S2D4 (S). Use spaghetti on both leads and position the capacitor as shown in Pictorial 1.

() Mount the 10 K Ω ohms-adjust control K as shown in Pictorial 1.

() Connect the wire coming from S1A9 to K1 (S).

- () Connect a wire from A13 (S) to K2 (S).
- () Assemble the battery panel as shown in Figure 16 and Pictorial 1, using 3-48 screws and nuts and placing a small solder lug under the battery contacts 1, 2, 3, and 4.
- () Remove one nut and the solder lug from each meter terminal. Place the battery panel over the terminals and replace the lugs and nuts as shown in Pictorial 1.
- () Connect the wire coming from S2B3 to the positive (+) meter lug (S). That will be the left-hand meter lug when looking at the back of the meter with the panel in the up-right position.
- () Connect the wire coming from S2C1 to the #4 battery contact (S).
- () Connect the wire from B23 to the negative (-) meter lug (S).
- () Connect the wire coming from S1D7 to the #1 battery contact (S).
- () Connect the wire coming from S1D9 to the #3 battery contact (NS).
- () Connect a wire from the #3 battery contact (S) to the #2 battery contact (S).
- () Connect a 17.5 megohm 2 watt resistor from J1 (S) to B11 (S). Use sleeving on this end and position to clear other contacts and the case when assembled. See Pictorial 1.
- () Connect a 70 megohm 2 watt resistor from J2 (S) to B12 (S) following the same process as described in the previous step.

This completes the wiring of your Heathkit MM-1 VOM.

BATTERY INSTALLATION

- () Install the 1.5 volt C cell in the battery clamp with the positive end toward the #3 battery contact.
- () Install the four Penlite cells as shown in Pictorial 1, observing polarity and secure them by mounting the battery contact plate with a 3-48 screw.

CASE ASSEMBLY

- () You will note a depression in one side of the case. This is to clear the function switch when the case and panel are assembled. Place the panel assembly over and onto the case so that the function switch slides down into this depression.
- () Using the four 2 1/4" 6-32 screws and split lockwashers, mount the panel to the case by placing screw through the holes in the back of the case and screwing the panel down.

CAUTION: Do not use too much tension as this may cause warping or breakage of the case.

- () Assemble the handle to the case, using the two special screws provided.

See Figure 17 on fold-in drawing for test lead assembly.

TESTING THE COMPLETED INSTRUMENT

Before the MM-1 is used on equipment having large voltages or currents present, it should be thoroughly checked to make sure all functions are operating correctly.

OHMMETER

Set the function switch to DC+ and the range switch to RX1. Short the test leads and rotate the OHMS ADJ. control. The meter should read from slightly below full scale to above full scale. Repeat this procedure on each ohm range. If the meter does not read or shows a violent deflec-

tion of the pointer, **IMMEDIATELY** cease any further tests and refer to the section of the manual entitled, **IN CASE OF DIFFICULTY**. This also applies to the following tests.

DC VOLTMETER

Set the function switch to DC+ and the range switch to 1500 V. Connect a 1.5 volt battery across the test leads and decrease the range switch voltage on the MM-1 in steps. From a barely perceptible indication the meter should read progressively higher amounts until full scale deflection is reached on the 1.5 V range. Set the function switch to DC-, reverse the battery connections and repeat the process.

AC VOLTMETER

Set the function switch to AC volts and using a low voltage source of AC such as a filament transformer, repeat the same process used on the DC ranges. Do not try the 1.5 volt range directly on the transformer; connect a potentiometer of about 50 to 100 ohms across the transformer secondary, then make the MM-1 connections to one side and the center tap of the potentiometer. Using a higher range of the MM-1, adjust the potentiometer to read below 1.5 volts, then switch the MM-1 to the 1.5 volt range for test. The DB OUTPUT ranges can be checked with the same setup used for AC. However, the meter will read lower due to the reactance of the condenser in the MM-1.

CURRENT RANGES

The current ranges can be checked by inserting the instrument in series with circuits drawing known amounts of current. Always start with the highest current range of the MM-1 and work downward, being especially careful on the 150 μ A range.

APPLICATIONS

A VOM has three distinct advantages over a vacuum tube voltmeter:

1. It is completely portable, requiring no source of power for operation.
2. It may be operated in RF fields that would affect the reading of a VTVM.
3. It is capable of reading a wide range of current.

Another point which is not often considered with a VOM is the input impedance. As was previously mentioned, the input impedance varies with the range used. If there is sufficient voltage being measured, the VOM will exceed the VTVM in input impedance. For example, the input impedance on the 5000 volt range is 100 megohms. Although voltages of this magnitude are seldom encountered, it is sometimes helpful to make the reading on a higher range. The meter will then read on the lower part of the scale. Although the meter accuracy falls off toward zero, the increased input impedance may compensate for this error. This system should be used only when the voltage being measured is in a high impedance circuit and the loading of the VOM might cause quite an error. If the greater part of the readings are taken on the 500 volt range, the VOM impedance will be 10 megohms which is approximately the same as the average VTVM.

DC VOLTAGE

To measure DC volts, plug the black test lead into the common or minus test jack and the red test lead into the adjacent plus jack. The function selector switch should be set to DC+ and the range switch to a range higher than the voltage being measured. The voltages marked on the range switch refer to full scale deflection of the meter for that specified voltage. If the voltage being measured is unknown, set the range switch for the highest voltage range first. The black test lead should be connected to the negative ground side of the circuits and the red test lead to the positive side.

CAUTION: THESE CONNECTIONS MUST BE MADE WITH THE EQUIPMENT UNDER TEST TURNED OFF. If the meter reads backward, the voltage is opposite in polarity than supposed. It is not necessary on the MM-1 to reverse the test leads. Turn the selector switch to the DC- position. The meter will now read up-scale. The meter scale is marked in black for DC, 0-15 and 0-50 volts. To read 1.5 volts, the reading is taken on the 0-15 scale and the decimal point moved one place to the left. To read 150 or 1500 volts, the reading is taken on the same scale and one or two zeros added. The same factors apply to read 5, 500 or 5000 volts on the 0-50

volt scale. To read 5000 volts DC, the red test lead is moved from the plus jack to 5KV DC jack and the range switch set to the 1500 volt position.

WHEN THE METER IS USED ON VOLTAGES OF THIS MAGNITUDE, HAVE ALL CONNECTIONS SET UP BEFORE TURNING EQUIPMENT ON AND DO NOT TOUCH THE METER, TEST LEADS OR ANYTHING ASSOCIATED WITH THE CIRCUIT WHILE THE CURRENT IS ON. It is not recommended that the meter be left connected in the circuits having very high voltages.

AC VOLTAGE

The function selector switch is placed in the AC position and the range switch set to the desired voltage range. The test leads remain in the same jacks used for DC. AC voltage is read on the red scales of the meter and the same method of reading the scale applies that was used for DC with one exception. 1.5 volts AC is read on a separate scale marked 1.5 VAC. It is not necessary to observe polarity when connecting the test leads. However, the same precaution of connecting the leads with the equipment OFF applies. To measure 5KV AC, the red test lead is moved from the plus jack to 5KV AC jack and the range switch is set to the 1500 volt position. HAVE ALL CONNECTIONS PRE-SET AND DO NOT TOUCH METER, TEST LEADS OR ANYTHING ASSOCIATED WITH THE CIRCUIT WHILE CURRENT IS ON. It is not recommended that the meter be left connected in the circuits carrying high voltage.

OUTPUT - DB

With the test leads in the common and plus jacks, set the function switch to DB OUTPUT position and the range switch to the desired voltage position. As explained in the section on circuit description, a .1 μ fd condenser is now placed in series with the normal AC voltage ranges. This blocks the DC component present at points such as the plate of an audio amplifier tube, allowing only the audio voltage to be measured. When aligning a radio receiver, it is usually necessary to have some visual indication of receiver output. For this purpose, the output meter may be connected from the plate of the last audio tube to ground.

DECIBELS

Because the human ear does not respond to volume of sound in proportion to signal strength, a unit of measure called the "bel" was adopted. The bel is more nearly equivalent to human hearing ratios. Normally the reading is given in 1/10 of a bel, or decibel. Two reference levels are commonly used, .001 watt in 600 ohms and .006 watt in 500 ohms. The first one establishes the zero reference level at .7746 volts and the second at 1.732 volts. The Heathkit MM-1 uses the standard of 1 milliwatt into a 600 ohm line as zero db. This corresponds to .7746 volt AC on the 0 to 1 1/2 volt scale. From this figure the various AC ranges of the MM-1 may be converted to db by the following chart.

AC VOLT SCALE

0-1.5 volts
0-5 volts
0-50 volts
0-150 volts
0-500 volts
0-1500 volts

DB SCALE

Read db directly
Add 10 db to the reading
Add 30 db to the reading
Add 40 db to the reading
Add 50 db to the reading
Add 60 db to the reading

If it is desired to measure decibels as 6 milliwatts in 500 ohms, subtract 8 db from the reading obtained on the MM-1.

OHMMETER

To use the ohmmeter ranges, the function selector switch is set to the DC+ position and the range switch to any of the three ohm ranges, RX1, RX100, or RX10K. The test leads are inserted in the common and plus jacks. With the instrument thus adjusted, short the test leads together and vary the OHMS ADJ. control to obtain full scale reading on the meter. The unknown resistance is now connected across the test leads. On the RX1 range, the scale is direct reading, for the RX100 and RX10K, the scale reading is multiplied by 100 or 10,000.

CAUTION: Do not connect the ohmmeter into any circuit having voltage present.

MICROAMMETER - MILLIAMMETER - AMMETER

To measure current, the function selector switch may be set to the DC+ or DC- position, depending upon the direction of current flow. The test leads are then connected in series with the load circuit, never parallel, as this would put the meter across the voltage supply. Damage to the meter will invariably result. To measure very small amounts of current such as tube grid current, the range switch is set to the 150 μ A position and the test leads inserted in the common and plus jacks.

CAUTION: It is advisable to set the range switch to the 150MA position first to be sure there is not a higher current than expected at the point under test.

The readings for 150 microamps, 15 milliamps, 150 milliamps and 15 amperes are made on the 0 to 15 DC volt scale. The .5 ampere readings are made on the 0 to 50 volt scale. With the test leads in the common and plus jacks, the readings from 150 microampere to 150 milliampere are made by use of the range switch. To measure .5 to 15 ampere, set the range switch to the 150MA position. Insert the black test lead in the -15A jack and the red test lead in the jack marked .5A or 15A. If the meter reads backward, set the function switch from DC+ to DC- to correct for the current polarity.

SPECIAL APPLICATIONS

CURRENT APPLICATIONS:

A readable indication of two microamperes can be obtained on the MM-1 making it possible to read grid current on most tubes and base or collector current on transistors. The 15 milliamperere range will measure plate and screen current of receiving tubes, emitter current of transistors and relay sensitivity. The 150 and 500 milliamperere ranges may be used to measure total power supply current, bleeder currents, plate current of transmitters or audio power tubes and battery radio current drain. The 15 ampere range may be used in automotive work to test current requirements of accessories such as heaters, radios, individual headlights, etc. It may be used to check the output of battery chargers.

AUTO RADIOS:

By checking the current drawn by an auto radio against the manufacturer's specifications, it is usually possible to determine if trouble is due to defective vibrators, internal shorts or open circuits, without removing the radio.

FM ALIGNMENT:

The MM-1 may be used as a visual indicator to align the IF stages of an FM receiver. To accomplish this, open the grid of the limiter stage and connect the MM-1 as a microammeter in series at this point. The polarity reversal switch will correct for reversed connections. Feed a signal into the receiver in the normal manner and tune the IF stages for minimum indication on the MM-1.

DC VOLTAGE APPLICATIONS

The high sensitivity of the MM-1 makes it possible to obtain a reading on AVC circuits thus determining whether they are operating properly. It also can be used to measure the bias of a power detector or plate voltage of high Mu tubes with reasonable accuracy where an insensitive meter would read low due to the high impedance of the circuit.

Besides the standard uses of a VOM in radio service work to measure plate, screen, cathode or grid voltages, it may be used to test batteries for voltage output, auto lighting and ignition systems. Fuses used in DC circuits may be tested by checking for voltage on each side of the fuse.

OHMMETER APPLICATIONS

CAUTION: When using the ohmmeter always be sure no voltage is present. Either turn off the equipment and discharge any condensers present or remove the component to be tested.

The ohmmeter can be used to ascertain the resistance of unknown resistors, potentiometers, ballast tubes or line dropping cords. It can be used to test for faulty ground connections or to

test fuses and all types of bulbs for continuity. Inductances such as RF coils and chokes, power or audio transformers can be tested for open circuits and tubes can be checked for open filaments.

CONDENSER TESTING:

Any good paper or oil condenser should show an infinite resistance on the RX10K range. If the condenser has a large capacity, it will show one kick on the meter as the condenser charges, then read infinite resistance.

When testing electrolytic condensers, connect the positive meter lead to the plus side of the condenser. A good electrolytic condenser will show a large deflection of the meter which will slowly return to a relatively high resistance. A high voltage electrolytic condenser should show a reading of .5 to over 1 megohm and a low voltage condenser should show a reading of .1 to over .5 megohms.

Further condenser measurements will be covered under AC VOLTAGE APPLICATIONS.

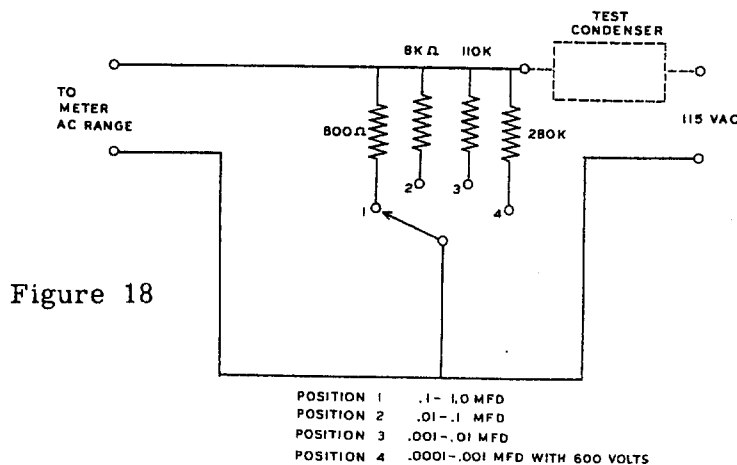
AC VOLTAGE APPLICATIONS:

The AC ranges can be used to read filament voltages, power transformer output, line voltage or can be connected directly across the voice coil of a speaker for visual indication of receiver output during alignment. By switching to OUTPUT-DB position, audio voltages may be checked at points carrying DC potentials. House fuses or any fuses in AC circuits can be tested without removal, by measuring for voltage on both sides of the fuse.

CAPACITY MEASUREMENTS:

A rough indication of the capacity of paper or oil condensers can be made by the following method. All readings are made on the 0-15 DC volt scale with the meter switches set for 50 volts AC. The readings are made directly on the scale from 0 to 10 volts. Each volt corresponds to a unit of capacity from 1 to 10. For example, when the instrument is set up to read .001 to .01 μfd , a .007 condenser will read approximately 7 volts.

The circuit below will cover the capacity range of .001 to 1.0 μfd using the 115 volt line. If it is desired to measure 100 to 1000 μfd capacitors, another switch position with a resistor of 280 K Ω must be added and the test voltage must be increased to 600 volts.



CAUTION: Before testing any condenser, place the range switch on a higher voltage position than the voltage being used to protect the meter in the event the condenser under test is shorted. If the meter does not read the full applied voltage, the condenser is good and the MM-1 should be set as described above.

Do not attempt to measure electrolytic condensers by this method as the applied AC will damage the condenser.

MAINTENANCE

The MM-1 should be treated with the care due any precision instrument. It should never be placed in a position where it will be subject to heavy mechanical shock or vibration, as this will damage the meter. Any time the batteries run down, they must be replaced immediately before they leak chemicals which will damage other components in the instrument. If the MM-1 is to be stored for a period of time, the batteries should be removed.

The meter pointer must be set at zero by means of the zero adjust screw on the panel.

IN CASE OF DIFFICULTY

Due to the large number of connections that must be made to the switches and resistor ring, there is a possibility that wiring errors have been made. The wiring should be rechecked carefully against the pictorials and schematic. Often having a friend check the wiring will reveal a mistake consistently overlooked.

Inspect all connections carefully, making sure that no wires are in contact with each other or terminals that should not be and that no connections are loose at jacks or terminals

There is a chance that a resistor has become damaged in soldering. If another ohmmeter is available, the resistors should be individually checked. They should read close to the resistance marked on them. Be sure to disconnect one lead from the meter before doing this.

If one or two functions or ranges of the instrument are inoperative and the rest functioning correctly, the defective section should be traced through the instrument from point to point using the schematic as a reference.

This procedure will reveal whether the trouble is due to wiring, switching or to defective components. As previously mentioned, if an ohmmeter or any other indicator having voltage present is used in tracing circuits, one lead of the MM-1 meter should be disconnected first.

In the event that the ohmmeter cannot be adjusted to read full scale, it is likely that one or more of the batteries are low. Remove the batteries and test them on the 1.5 volt DC range of the MM-1. Also check the battery contacts.

Another source of trouble often overlooked is the test leads being open. This can be quickly checked by setting the MM-1 to an ohmmeter range and shorting the test leads. The meter should show an indication. Flex the leads to be sure they are continuous under all conditions. If the meter itself is suspected of causing trouble, it may be tested by connecting a 1.5 volt battery in series with 50,000 ohms across its terminals. It should read approximately 3/4 full scale.

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

- A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
- B. Identify the type and model number of kit in which it is used.
- C. Mention the order number and date of purchase.
- D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

If, after applying the information contained in this manual and your best efforts on the unit, you are still unable to obtain proper performance from the instrument, it is suggested that you take advantage of the technical facilities which the Heath Company makes available to its customers.

The Technical Consultation Department is maintained for the purpose of providing Heath customers with a personalized technical consultation service; this service is available to you without charge. The technical consultants are thoroughly familiar with all details of the instrument and can usually localize the trouble from a suitable description of the difficulty encountered. It is, of course, necessary that you provide full and complete information concerning your problem when writing to the Technical Consultation Department for assistance. For instance, clearly identify the kit involved, giving the purchase date and, if possible, the invoice number; describe in detail the difficulty that you have encountered; state what you have attempted to do to rectify the trouble, what results have been achieved, and include any information or clues that you feel could possibly be of value to the consultant who handles your problem. Failure to provide complete descriptive details may lead to incorrect assumptions on the part of the consultant and needless delay in the solution to your problem. Quite frequently, when the information given the consultants is complete, concise and reliable, a diagnosis of the difficulty can be made with confidence and specific instructions given for its correction. If replacement of a component is involved in the correction, the component will be shipped to you, subject to the terms and conditions of the Warranty.

The Factory Service facilities are also available to you, in case you are not familiar enough with electronics to provide our consultants with sufficient information on which to base a diagnosis of your difficulty, or in the event that you prefer to have the difficulty corrected in this manner. You may return the complete instrument to the Heath Company for inspection and necessary repairs and adjustments. You will be charged a fixed fee of \$5.00, plus the price of any additional parts or material required. However, if the instrument is returned within the Warranty period, parts charges will be governed by the terms of the Warranty. State the date of purchase and give invoice number, if possible.

Local Service by Authorized Heathkit Dealers is also available and often will be your fastest, most efficient method of obtaining service for your Heathkits. Although you may find charges for local service somewhat higher than those listed in Heathkit manuals (for factory service), the amount of increase is usually offset by the transportation charges you would pay if you elected to return your kit to the Heath Company.

Heathkit dealers will honor the regular 90 day Heathkit Parts Warranty on all kits, whether purchased through a dealer or directly from Heath Company. It will be necessary that you verify the purchase date of your kit by presenting your copy of the Heath Company invoice to the authorized dealer involved.

Under the conditions specified in the Warranty, replacement parts are supplied without charge; however, if your local dealer assists you in locating a defective part (or parts) in your Heathkit, or installs a replacement part for you, he may charge you for this service.

Heathkits purchased locally and returned to Heath Company for service must be accompanied by your copy of the dated sales receipt from your authorized Heathkit dealer in order to be eligible for parts replacement under the terms of the Warranty.

THESE SERVICE POLICIES APPLY ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned NOT repaired.

For information regarding modifications of Heathkits for special applications, it is suggested that you refer to any one or more of the many publications that are available on all phases of electronics. They can be obtained at or through your local library, as well as at most electronic outlet stores. Although the Heath Company welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for specific purposes. Therefore, such modifications must be made at the discretion of the kit builder, according to information which will be much more readily available from some local source.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted.

ATTACH A TAG TO THE INSTRUMENT GIVING
NAME, ADDRESS AND TROUBLE EXPERIENCED.

Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

All prices are subject to change without notice. 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.

WARRANTY

Heath Company warrants that for a period of three months from the date of shipment, all Heathkit parts shall be free of defects in materials and workmanship under normal use and service and that in fulfillment of any breach of such warranty, Heath Company shall replace such defective parts upon the return of the same to its factory. The foregoing warranty shall apply only to the original buyer, and is and shall be in lieu of all other warranties, whether express or implied and of all other obligations or liabilities on the part of Heath Company and in no event shall Heath Company be liable for any anticipated profits, consequential damages, loss of time or other losses incurred by the buyer in connection with the purchase, assembly or operation of Heathkits or components thereof. No replacement shall be made of parts damaged by the buyer in the course of handling or assembling Heathkit equipment.

NOTE: The foregoing warranty is completely void and we will not replace, repair or service instruments or parts thereof in which acid core solder or paste fluxes have been used.

HEATH COMPANY

PARTS LIST

<u>PART No.</u>	<u>PARTS Per Kit</u>	<u>DESCRIPTION</u>	<u>PART No.</u>	<u>PARTS Per Kit</u>	<u>DESCRIPTION</u>
Resistors			Hardware		
2-8B	1	17.5 megohm 2 watt	204-59	1	Ring mounting bracket
2-9B	1	70 megohm 2 watt	205-M29	1	Battery contact plate
2-16	1	7 megohm	208-2	1	Battery clamp
2-26A	1	20 megohm 1 watt	214-M1	1	Battery housing
2-51	1	900 K Ω	250-2	12	3-48 x 1/4" screw
2-60	1	.483 Ω	250-31	1	6-32 x 1/4" screw
2-61	1	1.17 Ω	250-39	2	Handle screw
2-62	1	11.5 Ω	250-42	4	6-32 x 2 1/4" case screw
2-63	1	15 Ω	252-1	12	3-48 nut
2-64	1	110 Ω	252-2	2	4-40 nut -
2-65	1	1138 Ω	252-3	1	6-32 nut
2-66	1	2484 Ω	252-7	3	Control nut
2-67	1	2725 Ω	253-10	3	Control flat washer
2-68	2	3 K Ω	254-1	1	#6 internal tooth lockwasher
2-69	1	4590 Ω	254-4	3	Control lockwasher
2-70	1	17.5 K Ω	254-8	4	#6 split lockwasher
2-71	1	21,850 Ω	258-5	2	Battery contact spring, small
2-72	1	28 K Ω	258-6	2	Battery contact spring, large
2-73	1	70 K Ω	259-6	4	Solder lug
2-74	1	117,700 Ω	260-1	1	Alligator clip
2-75	1	225 K Ω	437-1	7	Jack insert
2-76	1	500 K Ω	438-13	2	Banana plug assembly, less insulator
2-78	1	1.75 megohm			
2-79	1	2 megohm			
2-80	1	5 megohm			
3-M3D	1	.0167 Ω	Meter-Case-Batteries		
10-31	1	10 K Ω potentiometer	407-23	1	Meter panel assembly
			408-M5	1	Case
			418-1	1	1.5 v cell size C
			418-3	4	1.5 v cell size AA
Condensers-Rectifiers			Miscellaneous		
23-11	1	.1 μ fd 600 v condenser	211-2	1	Handle
57-11	1	CX2C2D rectifier	340-2	1	length #20 bare wire
Knobs-Insulators-Switches			341-1	1	length Black test lead
63-56	1	2-deck rotary switch	341-2	1	length Red test lead
63-68	1	3-deck rotary switch	346-1	1	length Spaghetti
70-5	1	Banana plug insulator, black	439-1	1	Red test prod
70-6	1	Banana plug insulator, red	344-1	1	roll Hookup wire
75-13	1	Battery mounting plate	595-80	1	Manual
100-28	1	A resistor ring			
100-29	1	B resistor ring			
462-13	1	Round knob			
462-17	1	Pointer knob			
462-24	1	Square knob			

