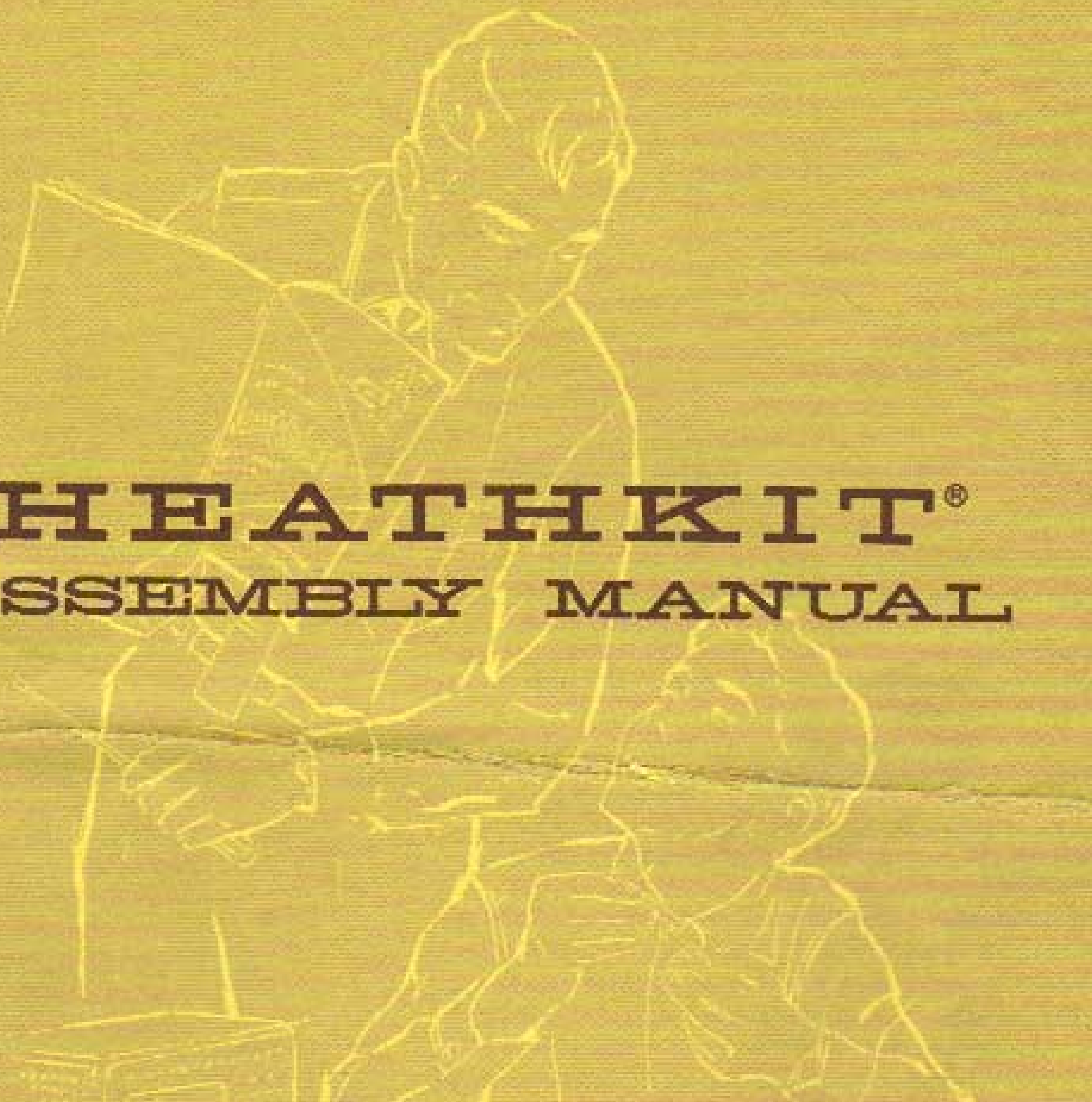
PRICE $2.00

HEATH COMPANY / BENTON HARBOR, MICHIGAN



HEATHKIT®
ASSEMBLY MANUAL

HEATHKIT

UTILITY SOLID-STATE VOLTMETER
MODEL IM-17

595-921-04

HEATH COMPANY PHONE DIRECTORY

The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information	(616) 982-3411
Credit	(616) 982-3561
Replacement Parts	(616) 982-3571
Technical Assistance:	
R/C, Audio, and Electronic Organs	(616) 982-3310
Amateur Radio	(616) 982-3296
Test Equipment, Strobe Lights, Calculators, Clocks, Weather Instruments	(616) 982-3315
Television	(616) 982-3307
Automotive, Marine, Appliances, Security, General Products	(616) 982-3496

YOUR HEATHKIT 90-DAY FULL WARRANTY

During your first ninety (90) days of ownership, Heath Company will replace or repair free of charge — as soon as practical — any parts which are defective, either in materials or workmanship. You can obtain parts directly from Heath Company by writing us or telephoning us at (616) 982-3571. And we'll pay shipping charges to get those parts to you — anywhere in the world.

We warrant that, during the first ninety (90) days of ownership, our products, when correctly assembled, calibrated, adjusted and used in accordance with our printed instructions, will meet published specifications.

If a defective part or error in design has caused your Heathkit product to malfunction during the warranty period, through no fault of yours, we will service it free upon delivery at your expense to the Heath factory, Benton Harbor, Michigan, or to any Heathkit Electronic Center (units of Schlumberger Products Corporation), or through any of our authorized overseas distributors.

You will receive free consultation on any problem you might encounter in the assembly or use of your Heathkit product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

Our warranty, both express and implied, does not cover damage caused by use of corrosive solder, defective tools, incorrect assembly, misuse, fire, customer-made modifications, flood or acts of God, nor does it include re-imbursement for customer assembly or set-up time. The warranty covers only Heath products and is not extended to non-Heath allied equipment or components used in conjunction with our products or uses of our products for purposes other than as advertised.

And if you are dissatisfied with our service — warranty or otherwise — or our products, write directly to our Director of Customer Services, Heath Company, Benton Harbor, Michigan, 49022. Telephone (616) 982-3524. He'll make certain your problems receive immediate, personal attention.

HEATH COMPANY
BENTON HARBOR, MI. 49022

Prices and specifications subject to change without notice.

Assembly

and

Operation

of the

HEATHKIT

UTILITY SOLID-STATE VOLTMETER

Model IM-17

HEATH COMPANY

BENTON HARBOR, MICHIGAN 49022

TABLE OF CONTENTS

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 upscale 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.

PART No.	PARTS Per Kit	DESCRIPTION
RESISTORS		
1/2 Watt		
(1) 1-41	1	10 Ω (brown-black-black)
1-20	2	10 kΩ (brown-black-orange)
1-22	2	22 kΩ (red-red-orange)
1-24	1	33 kΩ (orange-orange-orange)
1-35	1	1 megohm (brown-black-green)
1-38	2	3.3 megohm (orange-orange-green)

PART No.	PARTS Per Kit	DESCRIPTION
2 Watt		
(2) 3-4-2	1	9.1 Ω 5% (white-brown-gold-gold)
Precision		
NOTE: These may vary somewhat in appearance from the illustration.		
(3) 2-236	1	990 Ω
2-35	1	9000 Ω (9 kΩ)
2-41	1	90 kΩ
2-54	1	200 kΩ
2-51	1	900 kΩ
2-237	1	1.8 megohm
2-52	1	9 megohm

PART No.	PARTS Per Kit	DESCRIPTION
CAPACITORS		
Disc		
(4)21-27	1	.005 µF
Tubular		
(5)23-91	1	.047 µF (1.6 kV)
(6)23-61	1	.05 µF
CONTROLS-SWITCHES		
(7)10-201	2	10 kΩ control
(8)10-229	1	2000 Ω control (2 kΩ)
10-78	1	15 kΩ control
(9)12-80	1	50 kΩ 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
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.

PA
N
CA
Di
(4)21
Tu
(5)23
(6)23
CC
(7)10
(8)10
10
(9)12
(10)60
(11)60
(12)63
TR
(13)41
(14)41
(15)57
SH
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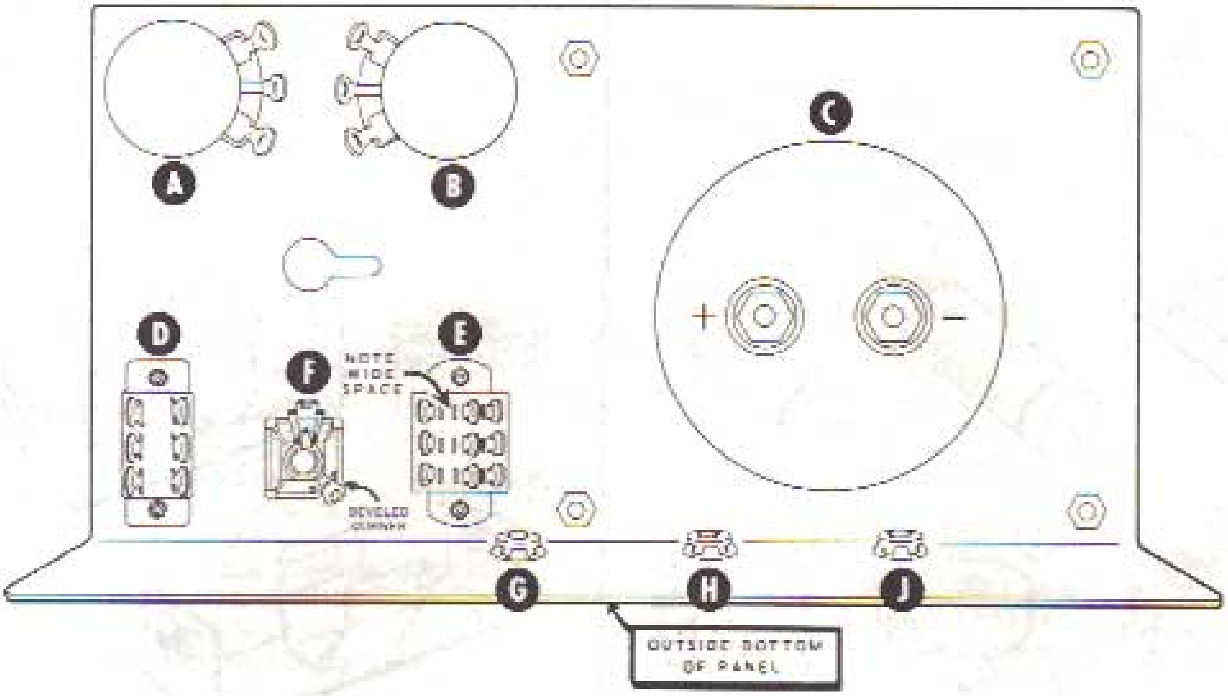
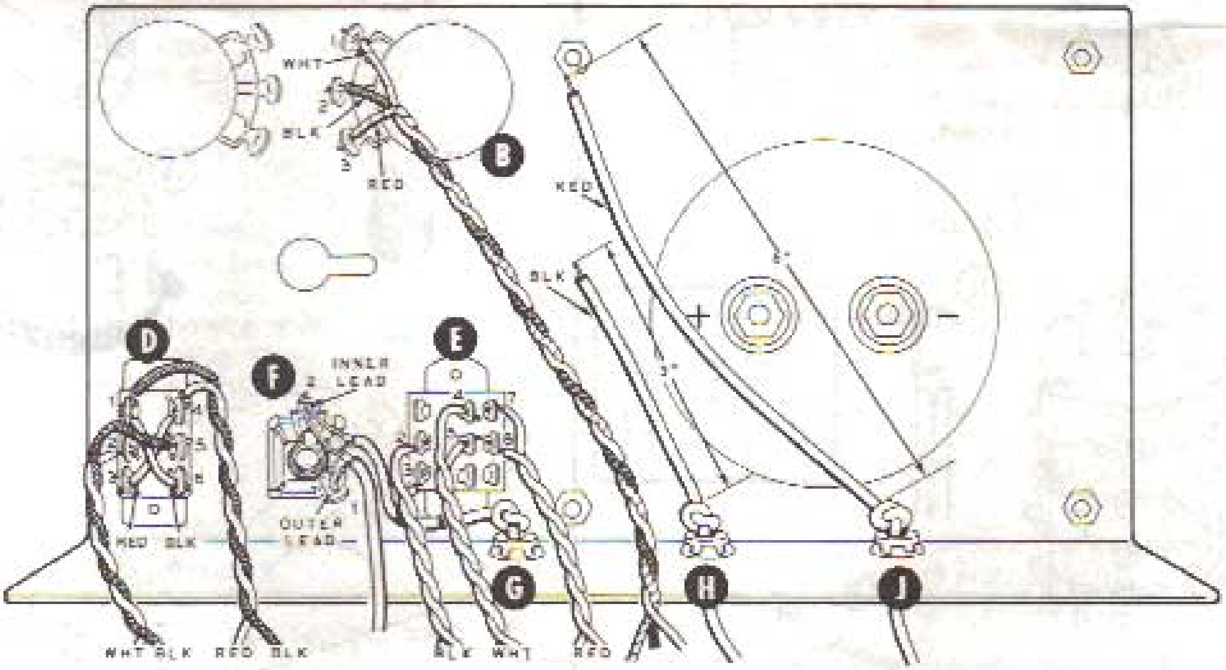


PICTORIAL 6



PICTORIAL 7

STEP-BY-STEP ASSEMBLY

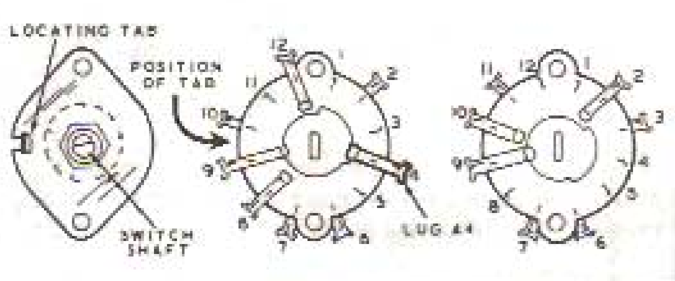
Before starting to assemble this kit, read the Kit Builders Guide for complete information on tools, wiring, soldering, and Step-By-Step Assembly procedures.

NOTE: The illustrations in the Step-By-Step Assembly section of the Manual are called Pictorials and Details. Pictorials show the overall operation for a group of assembly steps; Details are used in addition to the Pictorials, usually to illustrate a single step. When you are directed to refer to a certain Pictorial "for the following steps," continue using that Pictorial until you are referred to another Pictorial for another group of steps.

ROTARY SWITCH PREWIRING

Refer to Pictorial 1 for the following steps. Note that the two views are of opposite sides of the switch.

NOTE: As illustrated in Detail 1A, a system of letters and numbers is used to identify the rotary switch lugs in the following steps. For example: A4 refers to wafer A, lug 4 of the wafer. Wafer A is nearest the knob end of the switch. Note the position of the locating tab in relation to the numbering of the switch lugs. Wafers C and D have the same numbering system but are not illustrated.



FRONT PLATE | WAFER A (VIEWED FROM SHAFT END) | WAFER B

Detail 1A

Connect one end of each of the following white wires to the rotary switch. Unless the step directs otherwise, leave the other end of each wire free, to be connected later. Be sure to position the free ends of the wires as shown.

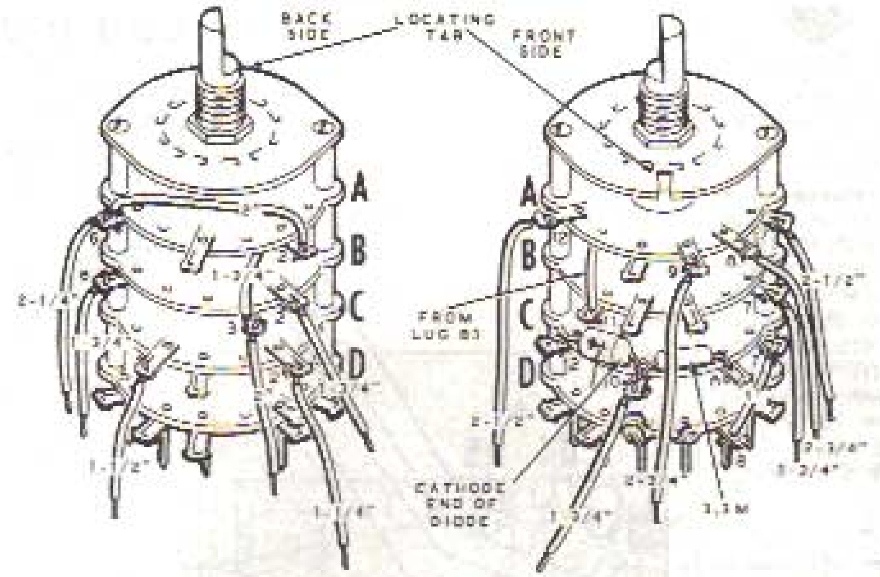
When wiring this kit, you will be instructed to prepare the lengths of wire ahead of time, as in the next step. To prepare a wire, cut it to the indicated length and remove 1/4" of insulation from each end. The wires are listed in the order in which they will be used.

( ) Prepare the following lengths of white hook-up wire (a length scale is provided on the fold-out from Page 17).

1-1/2"	1-3/4"
1-1/4"	1-3/4"
1-3/4"	2-1/4"
2"	2"

	WIRE LENGTH	FROM SWITCH LUG	TO
( )	1-1/2"	C5 (S-1)	Not connected.
( )	1-1/4"	C2 (S-1)	Not connected.
( )	1-3/4"	B6 (S-1)	Not connected.
( )	2"	B3 (NS)	Not connected.
( )	1-3/4"	B3 (S-2)	B11 (S-1).
( )	1-3/4"	B2 (S-1)	Not connected.
( )	2-1/4"	A6 (NS)	Not connected.
( )	2"	A2 (S-1)	A6 (S-2).

( ) Inspect all wires to make sure they are not touching any part of the switch mechanism except the terminals to which they are soldered.



PICTORIAL 1

( ) Prepare the following lengths of white hookup wire:

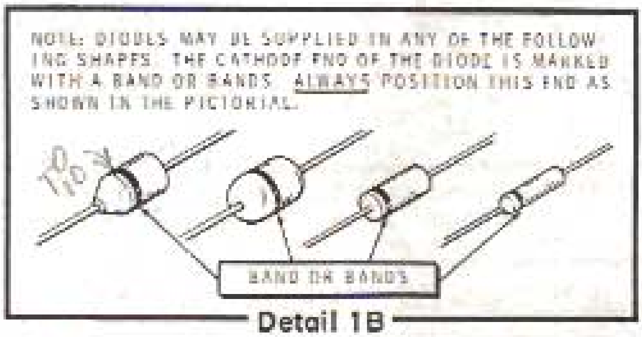
1-3/4"	2-3/4"
1"	2-3/4"
1-3/4"	2-1/2"
2-1/2"	

Connect one end of each of the following white wires to the rotary switch. Leave the other end free to be connected later unless the step directs otherwise. Position the ends as shown.

WIRE LENGTH	FROM SWITCH LUG	TO
( ) 1-3/4"	C10 (NS)	Not connected.
( ) 1"	C7 (S-1)	D8 (S-1).
( ) 1-3/4"	B7 (S-1)	Not connected.
( ) 2-1/2"	A12 (S-1)	Not connected.
( ) 2-3/4"	A9 (S-1)	Not connected.
( ) 2-3/4"	A8 (S-1)	Not connected.
( ) 2-1/2"	A7 (S-1)	Not connected.

( ) Connect a 3.3 megohm (orange-orange-green) resistor between lug C8 (S-1) and lug C10 (NS) of the rotary switch.

NOTE: Refer to Detail 1B to identify the cathode lead of the silicon diode to be installed in the next step.



Detail 1B

( ) Connect the cathode lead of the silicon diode to lug C10 (S-3) and the other lead to lug C12 (S-1) of the rotary switch.

( ) Bend lugs D9 and D10 slightly up toward wafer C.

Set the switch aside. It will be installed later.

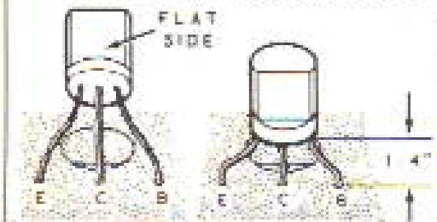
CIRCUIT BOARD ASSEMBLY

Position the circuit board lettered side up on your work surface as shown in Pictorial 2. Then complete each step on Pictorials 2 and 3.

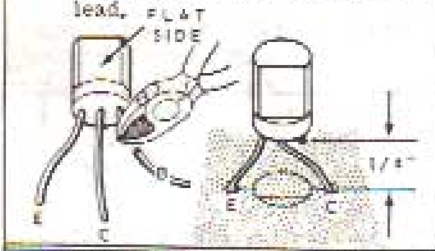
START

NOTE: Solder the mounting tabs of controls and the leads of the transistors and vertically-mounted tubular capacitor as each part is mounted.

( ) 2N3393 transistors at Q2 and Q3 (S-6). To identify the transistor leads, line up the flat side of the transistor with the flat outline drawn on the circuit board. Then insert the leads into their correct holes marked E, C, and B. Position the transistor about 1/4" above the circuit board. Trim off excess leads from the foil side of the board.



( ) Clip the B lead from each of the two remaining 2N3393 transistors. Then install these transistors at Q4 and Q5 (S-4). Trim excess leads on the foil side of the board. Be sure the cut stub of the B lead does not touch the C lead.



( ) 50 kΩ dual control (#12-80). Position the control as indicated on the circuit board (S-2).

( ) 10 kΩ control (#10-201) (S-4).

( ) 10 kΩ control (#10-201) (S-4).

( ) 9 kΩ (precision).

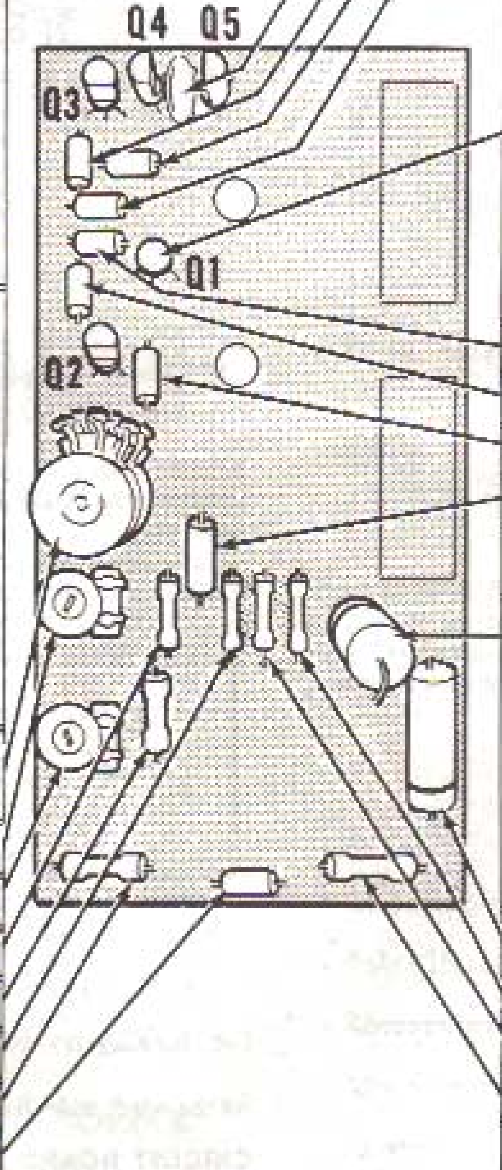
( ) 990 Ω (precision).

( ) 9 MΩ (precision).

( ) 200 kΩ (precision).

( ) 10 Ω (brown-black-black).

( ) Solder all connections and cut off the excess leads.



PICTORIAL 2

CONTINUE

( ) .005 µF disc capacitor.

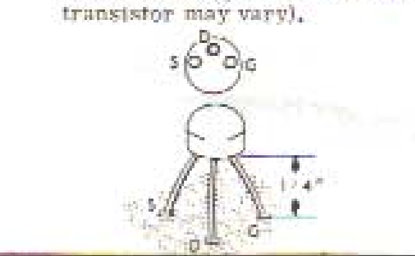
( ) 10 kΩ (brown-black-orange).

( ) 22 kΩ (red-red-orange).

( ) 33 kΩ (orange-orange-orange).

( ) Solder all connections and cut off the excess leads.

( ) F.E.T. (#417-140) (S-3). NOTE: Observe the location of the leads; then line them up with G, D, and S marked on the circuit board. Position the transistor about 1/4" above the circuit board. (The appearance of this transistor may vary).



( ) 22 kΩ (red-red-orange).

( ) 10 kΩ (brown-black-orange).

( ) 3.3 MΩ (orange-orange-green).

( ) 0.1 Ω (white-brown-gold) 2 watt.

( ) Solder all connections and cut off the excess leads.

( ) .047 µF 1600 V tubular (S-1). Note banded end. The other end will be connected later.

( ) .05 µF 400 V tubular. Position the banded end as shown.

( ) 90 kΩ (precision).

( ) 900 kΩ (precision).

( ) 1.8 MΩ (precision).

( ) Solder all connections and cut off the excess leads.

NOTE: You should have a 1 megohm resistor (brown-black-green) remaining. It will be used later.

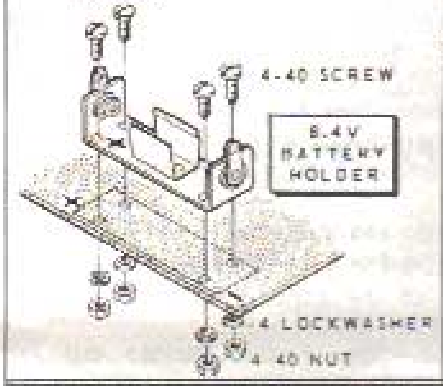
PROCEED TO PICTORIAL 3

START

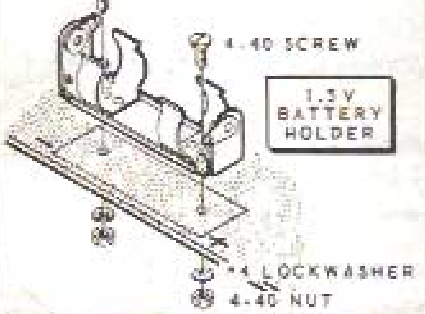
The plastic nut starter that is provided with this kit will help you pick up a nut and start it on the screw threads. Use the larger end for #4 nuts.

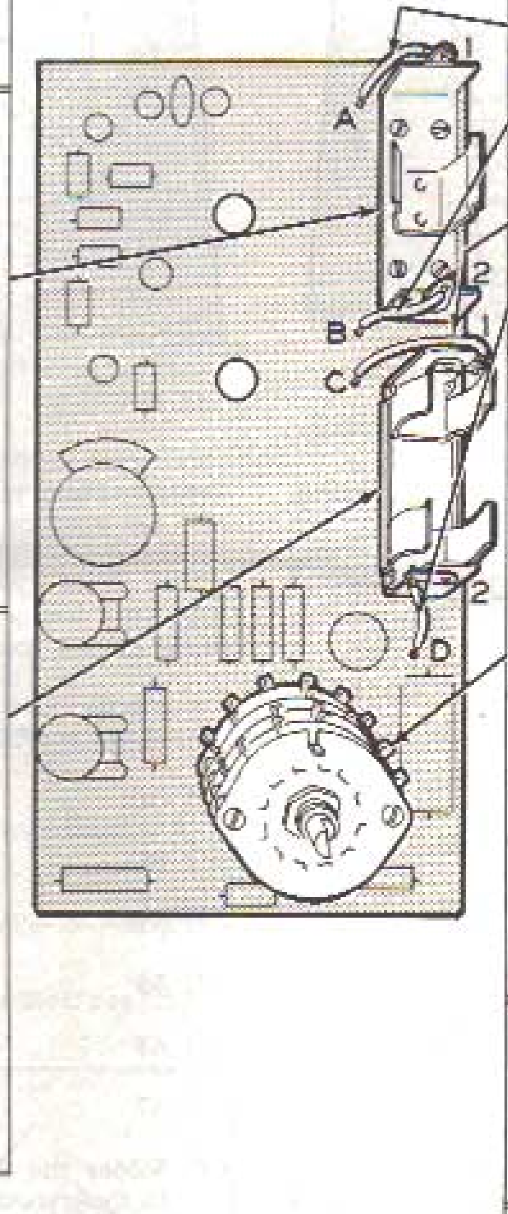
NOTE: When soldering battery holder connections, make sure that solder is confined to the point of connection.

( ) 8.4 V battery holder (#214-67). Position the battery holder as shown and mount it to the circuit board. (Note the + mark on the holder.)



( ) 1.5 V battery holder (#214-66). Position the battery holder as shown and mount it to the circuit board. NOTE: It may be necessary to bend the negative solder lug to keep it from interfering with the vertically-mounted capacitor.





PICTORIAL 3

CONTINUE

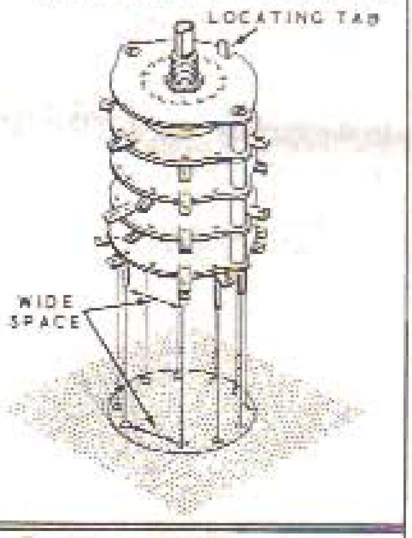
( ) 1-1/4" white wire from lug 1 (S-1) to circuit board hole A (S-1).

( ) 1-1/4" white wire from lug 2 (S-1) to circuit board hole B (S-1).

( ) 1-1/2" white wire from lug 1 (S-1) to circuit board hole C (S-1).

( ) 1" white wire from lug 2 (S-1) to circuit board hole D (S-1).

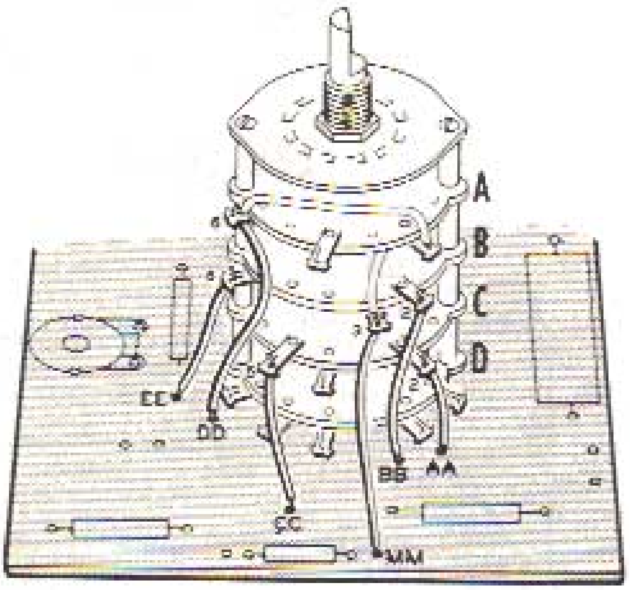
( ) Rotary switch (#63-473). NOTE: If any of the switch mounting lugs are bent, straighten them before installing the switch.



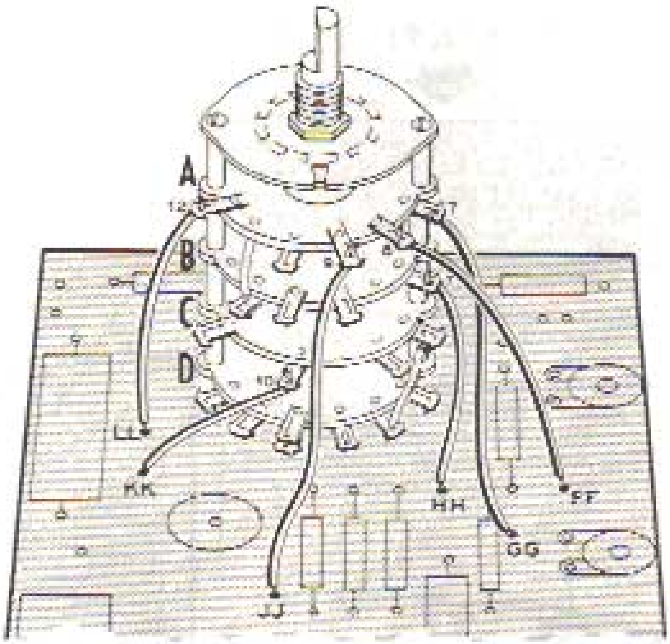
( ) Carefully inspect the switch lugs which are next to the circuit boards. Any lugs which might make contact to other components, causing a short circuit, should be bent away from the board.

( ) Solder all switch pins to the foil. Do not cut off the soldered leads.

FINISH



PICTORIAL 4



PICTORIAL 5

Refer to Pictorial 4 for the following steps.

Place the wires coming from the rotary switch in the circuit board holes as follows:

FROM SWITCH LUG	TO CIRCUIT BOARD
( ) C5	hole CC (NS).
( ) C2	hole AA (NS).
( ) B6	hole EE (NS).
( ) B3	hole MM (NS).
( ) B2	hole BB (NS).
( ) A6	hole DD (NS).

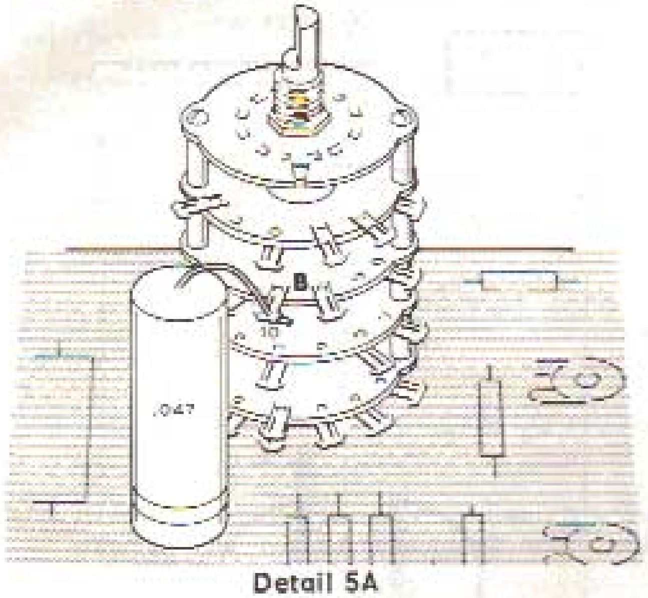
( ) Solder the 6 wires coming from the switch to the circuit board. Trim off any excess wire on the foil side of the board.

Refer to Pictorial 5 for the following steps. Note that the position of the circuit board has been reversed.

Place the wires coming from the rotary switch in the circuit board holes as follows:

FROM SWITCH LUG	TO CIRCUIT BOARD
( ) C10	hole KK (NS).
( ) B7	hole HH (NS).
( ) A12	hole LL (NS).
( ) A9	hole JJ (NS).
( ) A8	hole FF (NS).
( ) A7	hole GG (NS).

( ) Solder the 6 wires coming from the switch to the circuit board. Trim off any excess wire on the foil side of the board.



Detail 5A

( ) Refer to Detail 5A and connect the free lead of the .047 μF 1600 V capacitor on the circuit board to rotary switch lug B10 (S-1).

( ) Make sure that no wires obstruct lugs A10, B9, A4, and C4, to which connections will be made later.

Set the circuit board aside for the present.

PANEL PARTS MOUNTING

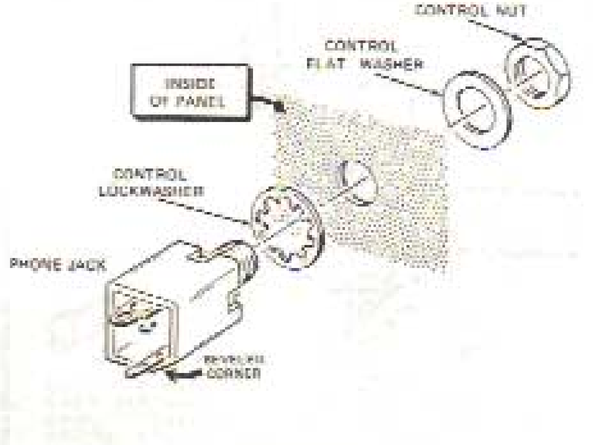
NOTE: Place a soft cloth on your workbench or table to prevent marring the face of the panel during the following steps.

Refer to Pictorial 6 (fold-out from Page 4) for the following steps.

( ) Locate the panel and position it on you work surface as shown.

( ) Refer to Detail 6A, and mount the three plastic grommets at G, H, and J.

Detail 6A

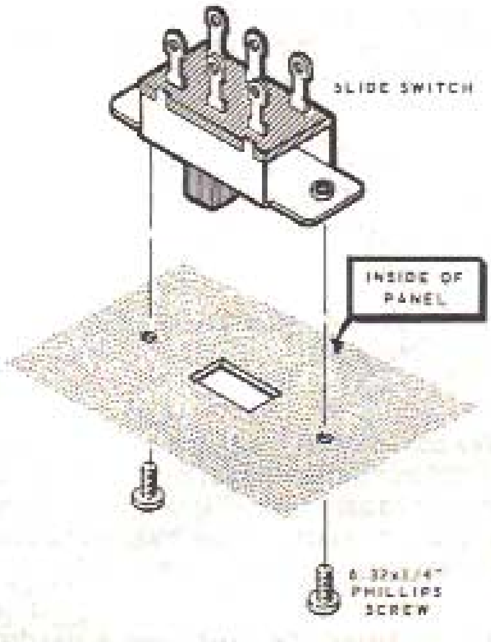


Detail 6B

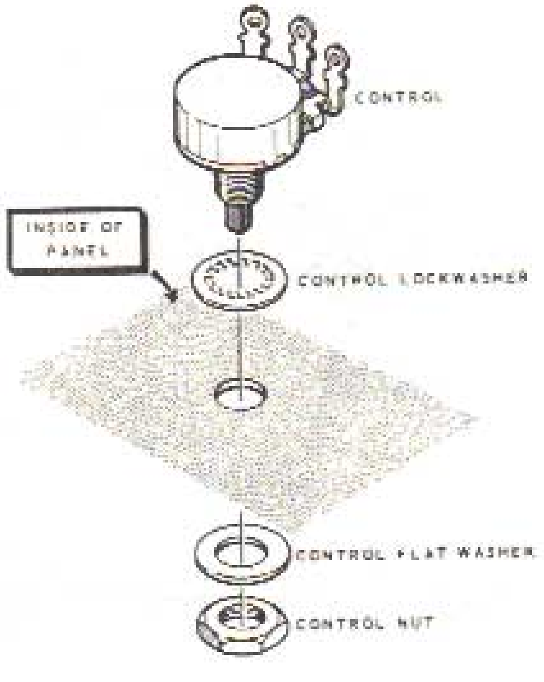
( ) Refer to Detail 6B, and mount the phone jack at F. Use a control lockwasher, a control flat washer, and a control nut. Position the jack as shown.

( ) Refer to Detail 6C, and mount the 6-lug slide switch at D using two 6-32 x 1/4" phillips screws.

( ) In a similar manner, mount the 9-lug slide switch at E using two 6-32 x 1/4" phillips screws. Position the wide space between the switch lugs as shown in the Pictorial.



Detail 6C



Detail 6D

(✓) Refer to Detail 6D, and mount the 15 kΩ control at A using a control lockwasher, a control flat washer, and a control nut. Position the control as shown.

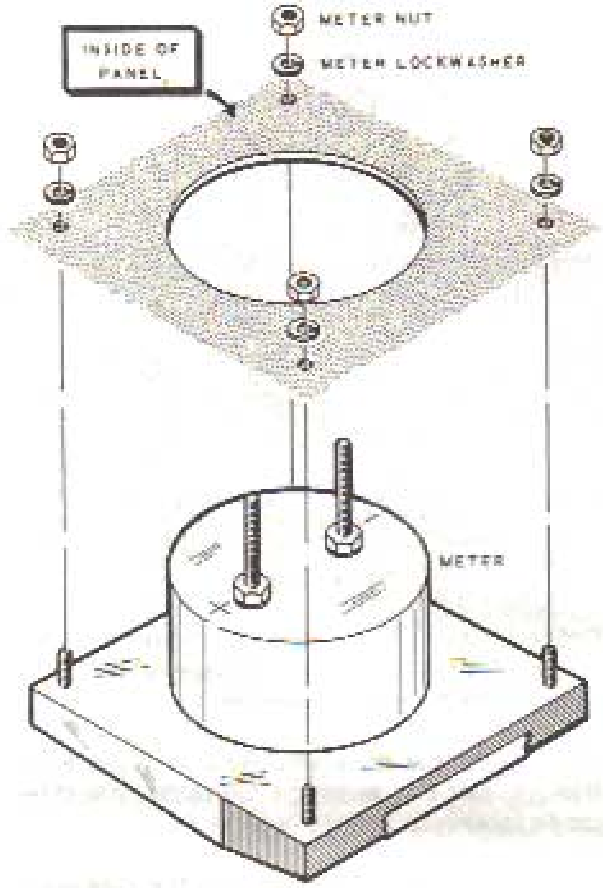
(✓) In a similar manner, mount the 2000 Ω (2 k) control at B using a control lockwasher, a control flat washer, and a control nut.

NOTE: The hardware necessary for mounting the meter is packaged with the meter and will be referred to as "meter hardware."

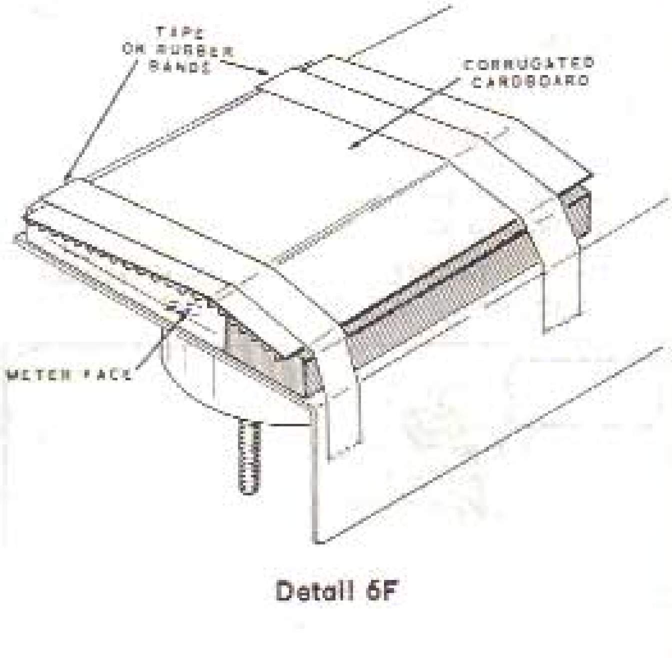
(✓) Remove the spring shorting wire from the meter terminals.

(✓) Refer to Detail 6E, and mount the meter at C. Use the meter hardware. Save the remaining meter hardware for use later. Do not damage the plastic meter case by overtightening the nuts.

(✓) Refer to Detail 6F, and tape a cardboard protector to the face of the meter.



Detail 6E



Detail 6F

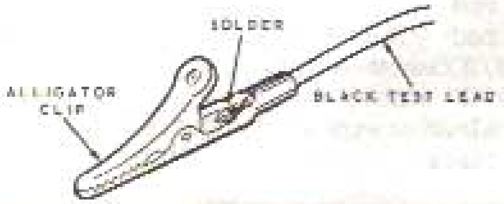
Detail 7A

PANEL WIRING

Refer to Pictorial 7 (fold-out from Page 4) for the following steps.

( ) Refer to Detail 7A, and prepare the red and black test leads.

( ) Refer to Detail 7B and solder an alligator clip to one end of the black test lead.



Detail 7B

( ) Insert the other end of the black test lead through grommet H, and tie a knot approximately 3" from this end of the lead.

Prepare the black test probe in the following manner.

( ) Cut a 5-1/2" length from the shielded cable and put it aside for later use.

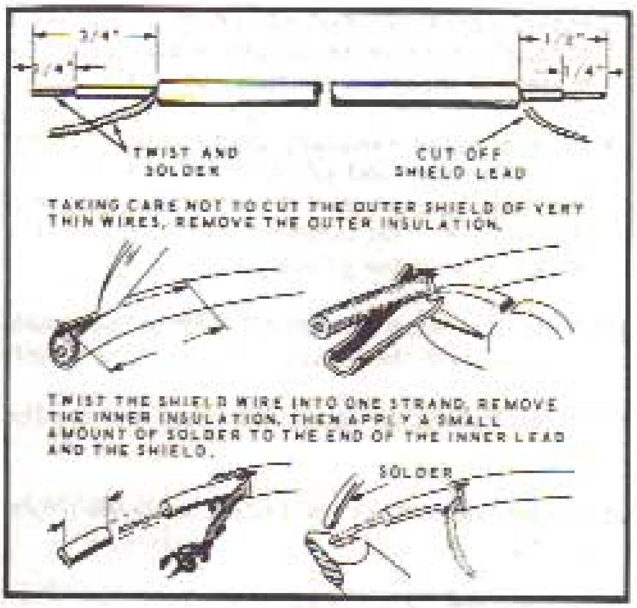
( ) Refer to Detail 7C, and prepare the remaining length of shielded cable.

Refer to Detail 7D for the following steps.

( ) Cut one lead of a 1 megohm (brown-black-green) resistor to a length of 3/8". Connect this lead to the end of the shielded cable without shielded lead (S-1).

( ) Disassemble the black probe.

( ) Insert the end of the cable with shielded lead through the black probe handle starting from the threaded end. Pull the cable until the resistor approaches the probe handle, as shown.



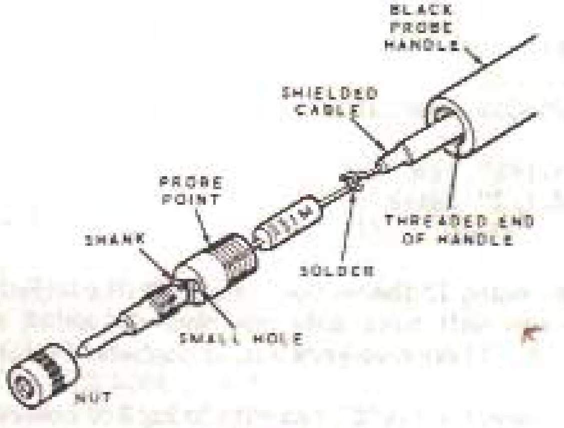
Detail 7C

( ) Cut the free end of the resistor to a length of 1/2". Insert this lead into the open end of the probe point so that approximately 1/4" extends out through the small hole. About half the length of the resistor will be inside the probe point.

( ) Wrap the resistor lead coming from the small hole around the shank as shown.

( ) Place the nut on the probe point and tighten it. This will hold the end of the resistor lead in place.

( ) Screw the black probe handle onto the probe point.



Detail 7D

( ) Insert the loose end of the shielded cable through grommet G, and tie a knot approximately 3 inches from this end of the cable.

( ) In a similar manner, install the red test probe on one end of the red test lead. No resistor is used, and the inner conductor of the red test lead is inserted directly into the small hole of the probe point.

( ) Wrap the wire lead coming from the small hole around the shank of the probe point.

( ) Place the nut on the probe point and tighten it.

( ) Screw the red probe handle onto the probe point.

( ) Insert the other end of the red test lead through grommet J, and tie a knot approximately 6" from the end of the lead.

( ) Connect the inner lead of the shielded cable to lug 2 (NS), and the shield lead to lug 1 (NS), of phone jack F.

( ) Refer to Detail 7E, and prepare a 5-1/2" shielded cable as shown.

Detail 7E

( ) Connect the inner lead at one end of the 5-1/2" shielded cable to lug 2 (S-2), and the shield lead to lug 1 (S-2), of phone jack F. The other end will be connected later.

( ) Prepare the following lengths of hookup wire:

5-1/2" red
6-1/2" black
6" white

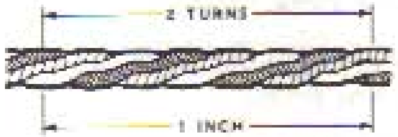
NOTE: many of the wires installed in the following steps will have only one end connected at this time. Their free ends will be connected later.

( ) Connect a 5-1/2" red wire to lug 3 of control B (S-1).

( ) Connect 6-1/2" black wire to lug 2 of control B (S-1).

( ) Connect 6" white wire to lug 1 of control B (S-1).

( ) Refer to Detail 7F, and twist together the three wires connected to control B. The wires should be twisted approximately two turns per inch.



Detail 7F

( ) Prepare the following lengths of hookup wire:

4" red
4" red
4-1/2" white
4-1/2" white
4" black
4" black

NOTE: You may find it easier to solder the lugs of slide switch E in the following steps if, before you connect the wires, you bend the outer rows of lugs outward slightly.

( ) Connect one end of a 4" red wire to lug 8 of slide switch E (S-1).

( ) Connect one end of a 4" red wire to lug 7 of slide switch E (S-1).

( ) Twist together the two red wires connected to slide switch E to form a twisted pair.

( ) Connect a 4-1/2" white wire to lug 5 of slide switch E (S-1).

( ) Connect a 4-1/2" white wire to lug 4 of slide switch E (S-1).

( ) Twist together the two white wires connected to slide switch E to form a twisted pair.

( ) Connect a 4" black wire to lug 3 of slide switch E (S-1).

( ) Connect a 4" black wire to lug 2 of slide switch E (S-1).

( ) Twist together the two black wires connected to slide switch E to form a twisted pair.

(✓) Prepare the following lengths of hookup wire:

1" red
1" black
3-1/2" red
3-1/2" black
3-1/2" black
4-3/4" white

(✓) Connect a 1" red wire between lugs 3 (S-1) and 4 (NS) of slide switch D.

(✓) Connect a 1" black wire between lugs 1 (NS) and 6 (S-1) of slide switch D.

(✓) Connect a 3-1/2" red wire to lug 4 of slide switch D (S-2).

(✓) Connect a 3-1/2" black wire to lug 1 of slide switch D (S-2).

(✓) Twist together the red from lug 4 and black wire from lug 1 of slide switch D.

(✓) Connect a 3-1/2" black wire to lug 5 of slide switch D (S-1).

(✓) Connect a 4-3/4" white wire to lug 2 of slide switch D (S-1).

(✓) Twist together the black wire from lug 5 and white wire from lug 2 of slide switch D.

CIRCUIT BOARD WIRING

Refer to Pictorial 8 (fold-out from this Page) for the following steps.

(✓) Prepare the following lengths of hookup wire:

1" white
1-1/4" white
3" red
3" black

(✓) Connect a 1" length of white wire from lug 5 of the Bias Adj control (S-1) to circuit board hole M (S-1).

(✓) Connect a 1-1/4" length of white wire from lug 1 of the Bias Adj control (S-1) to circuit board hole L (S-1).

(✓) Connect one end of a 3" red wire to hole F in the circuit board (S-1).

(✓) Connect one end of a 3" black wire to hole E in the circuit board (S-1).

(✓) Twist these two wires together to form a twisted pair. Position them as shown.

(✓) Connect the free end of the black test lead to circuit board hole K (S-1).

Connect the twisted wires from control B as follows:

(✓) Red wire to lug 2 on the Bias Adj control (S-1).

(✓) White wire to lug 6 on the Bias Adj control (S-1).

(✓) Black wire to circuit board hole N (S-1).

Connect the wires from switch E to the circuit board as follows:

(✓) Either white wire to hole P (S-1), and the other white wire to hole R (S-1).

(✓) Either black wire to hole T (S-1), and the other black wire to hole S (S-1).

(✓) Either red wire to hole W (S-1), and the other red wire to hole U (S-1).

(✓) Connect the loose end of the red test lead to lug B9 of the rotary switch (S-1).

Connect the red and black twisted pair from slide switch D as follows:

(✓) Red wire to circuit board hole J (S-1).

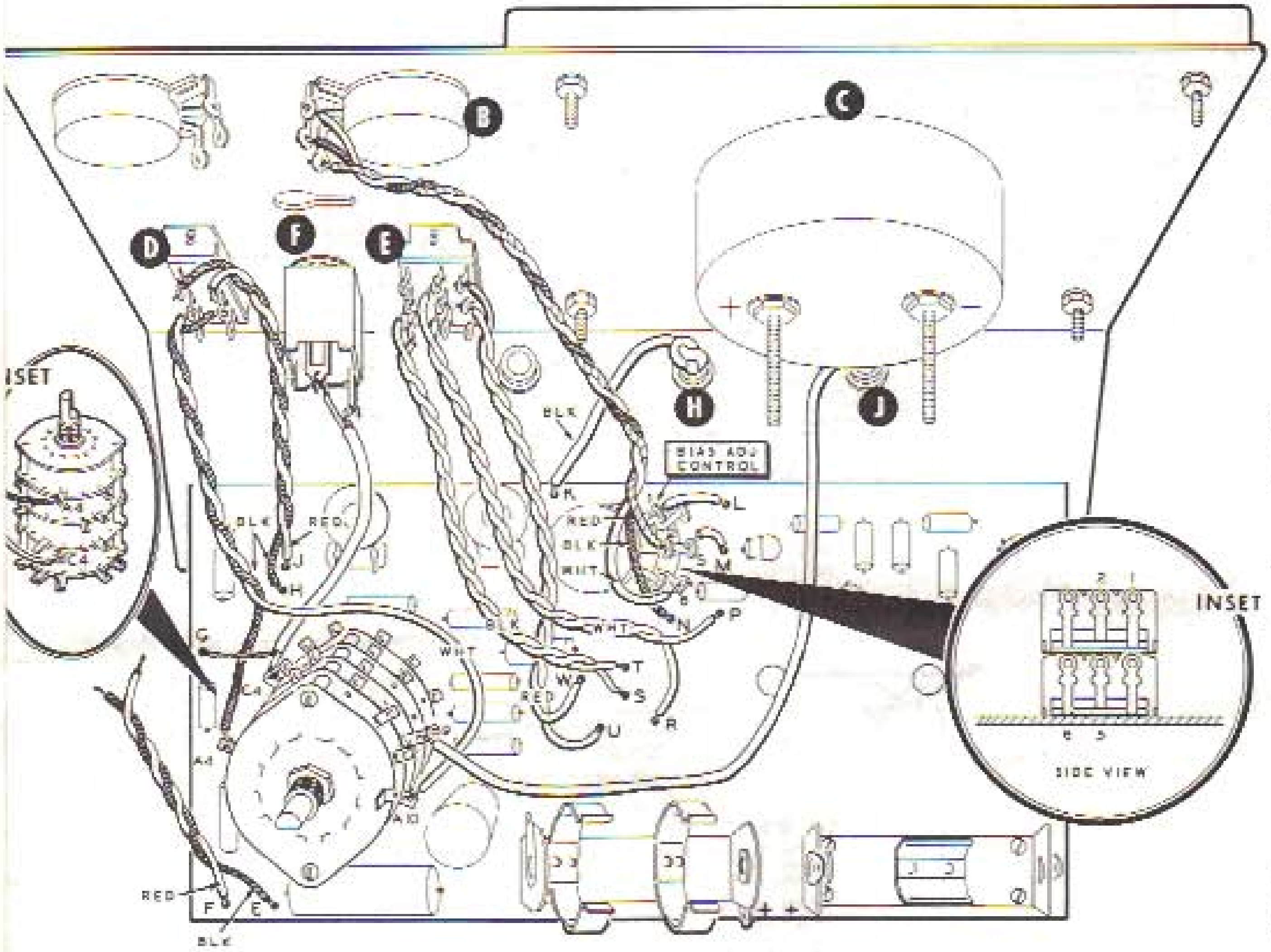
(✓) Black wire to circuit board hole H (S-1).

Connect the black and white twisted pair from slide switch D to the rotary switch as follows:

(✓) White wire to lug A10 (S-1).

(✓) Black wire to lug A4 (S-1).

(✓) Connect the inner lead of the 5-1/2" shielded cable from phone jack F to lug C4 of the rotary switch (S-1), and the shield to circuit board hole G (S-1).



PICTORIAL 8

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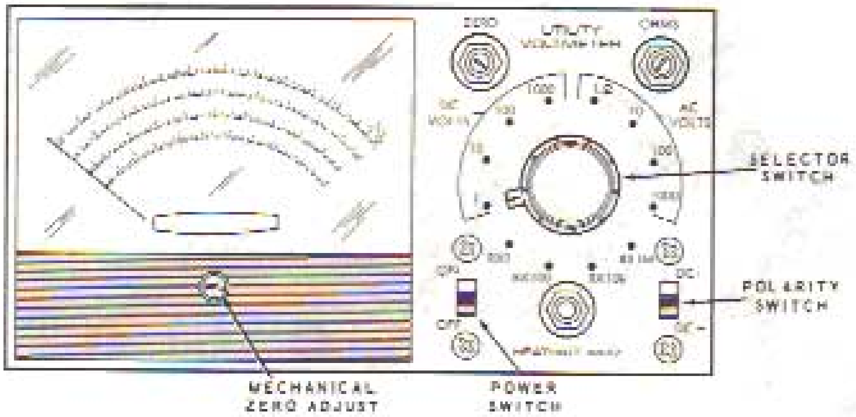


FIGURE 1

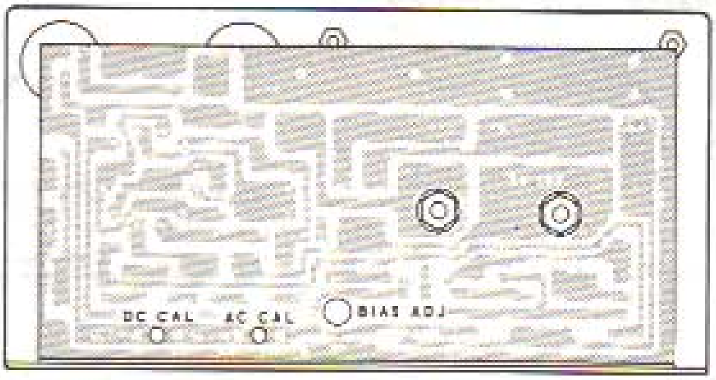
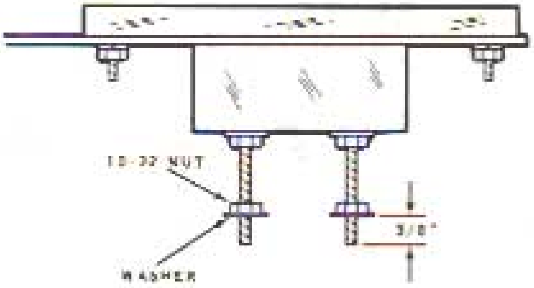


FIGURE 2

FINAL WIRING

Refer to Pictorial 9 for the following steps.

( ) Refer to Detail 9A and thread a meter nut onto each meter stud. Then place a meter washer on each stud.



Detail 9A

( ) Position the circuit board so the rotary switch shaft extends through its hole in the panel and the meter studs extend through the circuit board holes.

( ) Adjust the two meter nuts so the circuit board is parallel to the front panel as shown in the inset drawing on the Pictorial.

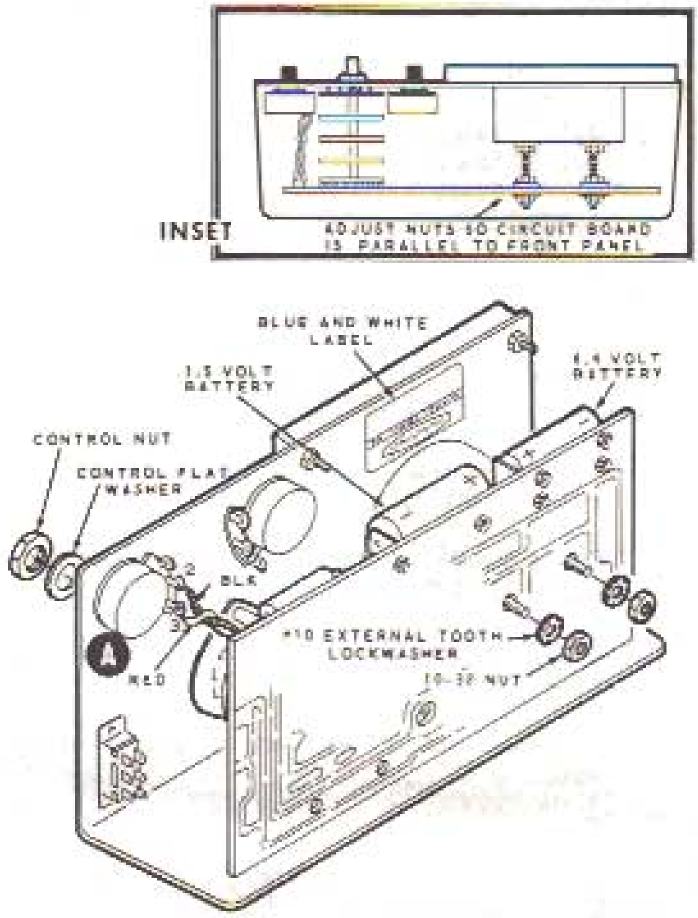
( ) Place a meter lockwasher and a meter nut on each of the two studs extending from the circuit board. Leave the nuts loose.

( ) Secure the rotary switch to the panel. Use a control flat washer and a control nut.

( ) Tighten the nuts on the meter studs. CAUTION: Do not overtighten the nuts as the circuit board can be damaged.

( ) Connect the red wire from hole F of the circuit board to lug 3 of control A (S-1).

( ) Connect the black wire from hole E of the circuit board to lug 2 of control A (S-1).



PICTORIAL 9

Refer to Detail 9B for the following steps.

( ) With a pair of pliers, rotate the shaft of the rotary switch so its flat side is facing the 1000 position in the DC Volts range, as shown. NOTE: Be sure to leave the shaft in this position for the following steps.

( ) Press the knob bushing onto the shaft. Note the location of the spring.

( ) Position the knob with the pointer directed towards the 1 position in the DC Volts range and press the knob firmly onto the knob bushing.

( ) Carefully remove the knob bushing and knob together.

( ) 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.

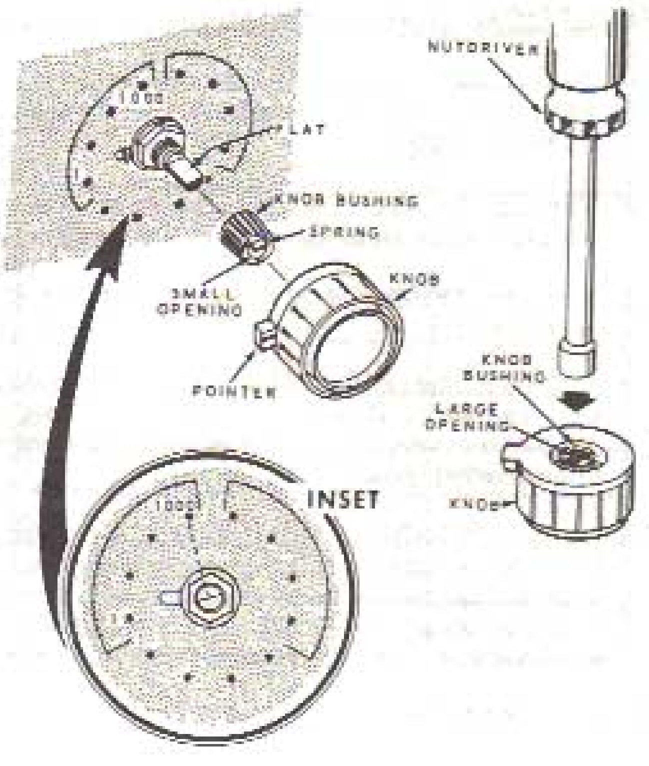
NOTE: The blue and white label that is installed in the next step shows the Model number and Production Series number of your kit. Refer to these numbers in all communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

( ) 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.)

( ) 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.

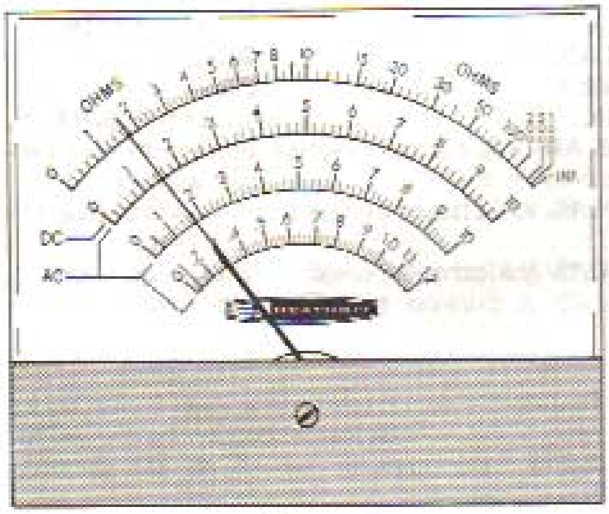


Figure 3

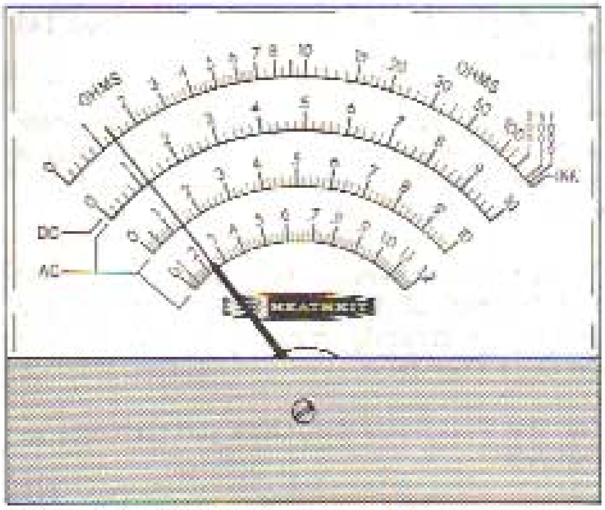


Figure 4

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

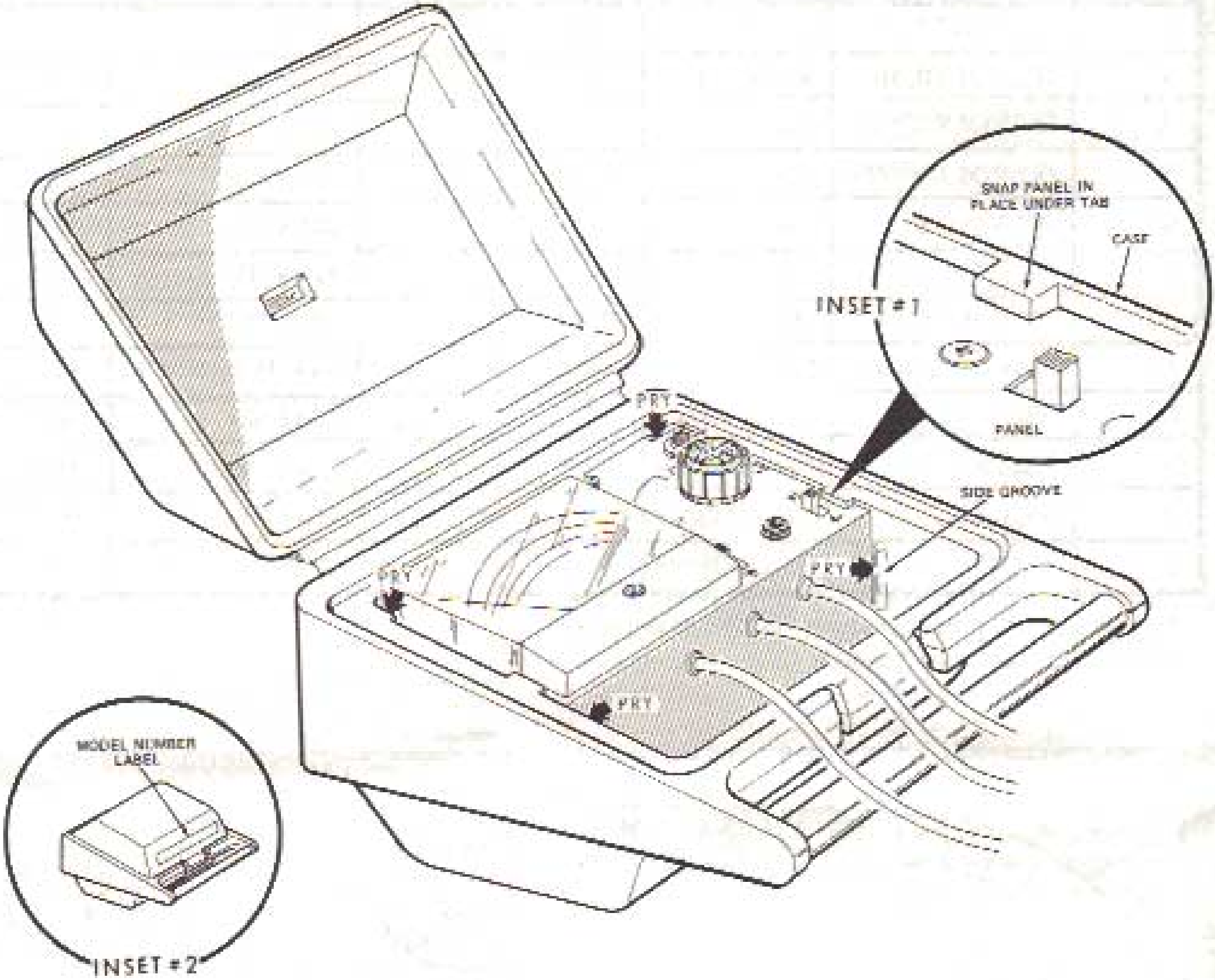
Refer to Pictorial 10 for the following steps.

( ) 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.

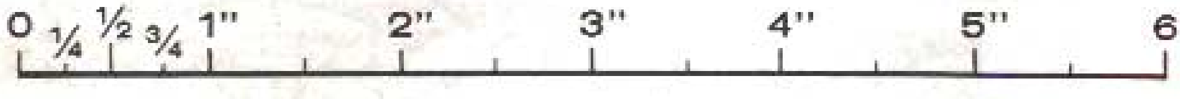
( ) Press the panel toward the cover "hinge" until it snaps into position.

( ) 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.



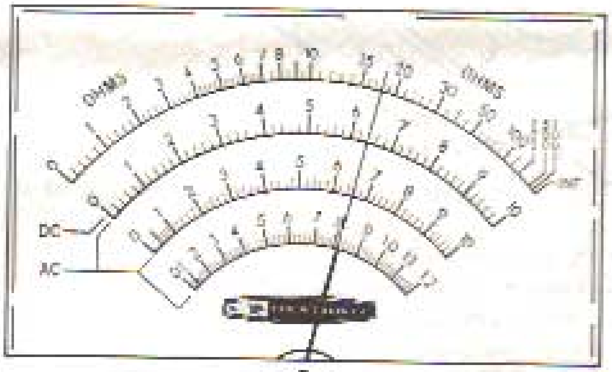
PICTORIAL 10



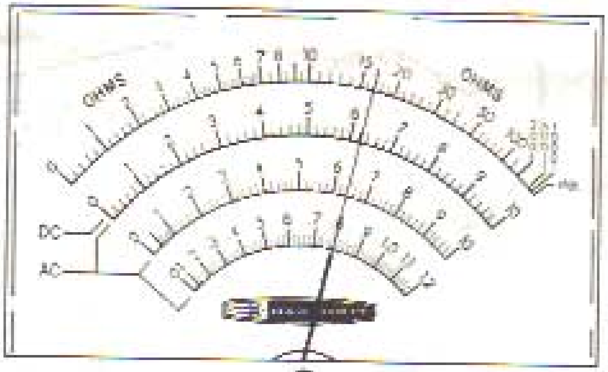
VOLTMETER USE CHART

REFERENCE	SELECTOR SWITCH	USE SCALE	SCALE READING	MULTIPLIER	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

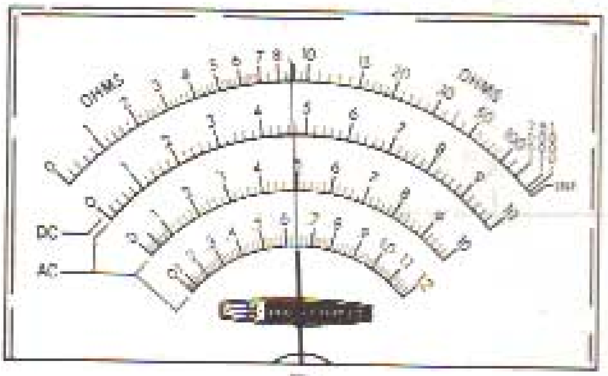
*In addition to the common (black) test lead.
**kΩ = kilohm (1,000 ohms).
megohm = 1,000,000 ohms.



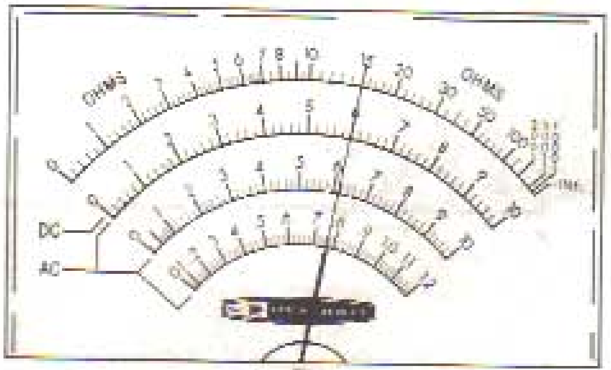
A



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.

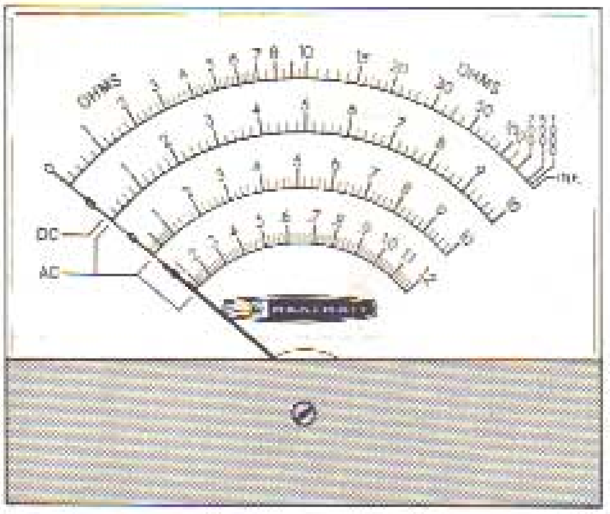


Figure 5

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.

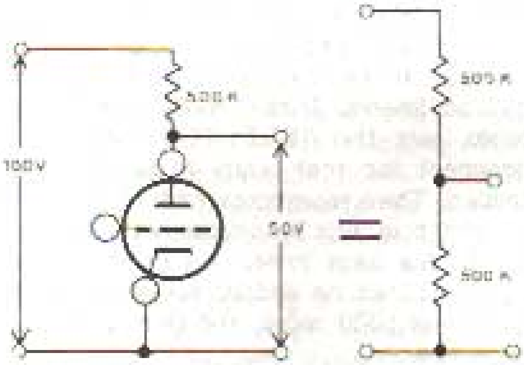


Figure 6

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.

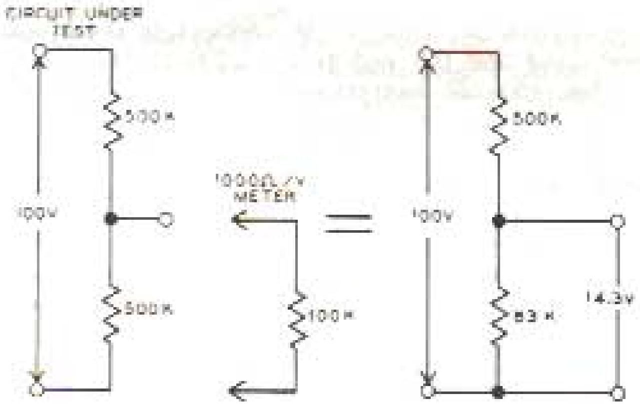


Figure 7

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.

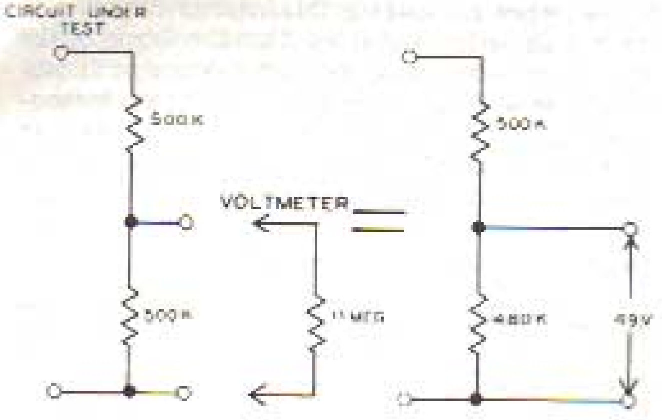


Figure 8

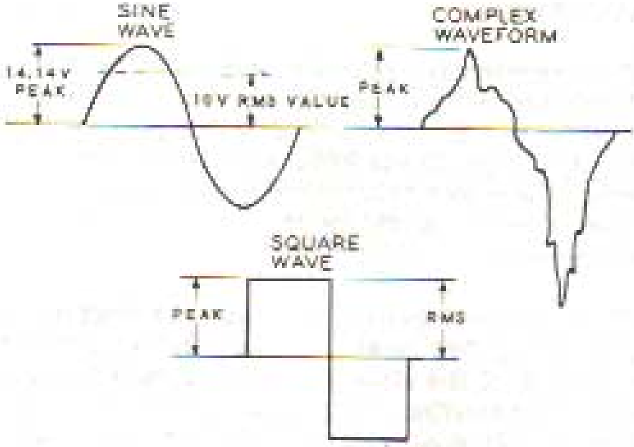


Figure 9

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.

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 ±2 percent of full scale. On DC, the ±1 percent accuracy of the divider resistors must be considered, resulting in an accuracy within ±3 percent of full scale. On AC, the rectifier circuit contributes variations which could result in a maximum error of ±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 ±5% accuracy, the total difference may be ±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 Ω 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 hundreth 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 kΩ (orange-orange-orange) resistor where a 3.3 megohm (orange-orange-green) resistor should have been installed, or a 900 kΩ precision resistor instead of a 90 kΩ.

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 ±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 beyond 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.	1. Dead battery or poor battery contacts. 2. Transistors Q1, Q2, or Q3 defective. 3. Meter coil open.
Zero control has no effect.	1. Bias control R15 and R16 misadjusted. 2. Transistor Q1 defective. 3. Resistor on voltage divider string R5 through R9 and R11 open. 4. Zero control R14 open or shorted.
Inaccurate DC readings.	1. DC Calibration control R18 misadjusted. 2. Wrong value or defective resistor in voltage divider string R5 through R9 and R11.
AC (only) Inoperative.	1. Diode D1 defective. 2. Capacitors C1 (open) or C2 (shorted). 3. Resistor R4 open.
AC Inoperative. (1000 volt range only).	1. Resistor R2 open or resistor R3 shorted.
Inaccurate AC reading.	1. AC Calibration control R19 misadjusted.
Ohmmeter inoperative or inaccurate readings.	1. Battery E1 low voltage. 2. Transistor Q1 defective. 3. Resistors in voltage divider string R4 through R9 or R12 open or shorted.
Zero shift with leads shorted when turning Function switch through ohmmeter ranges.	1. Transistor Q1 defective (needle may move slightly on Rx1, caused by lead resistance).
Unable to reach 0 meter reading on any scale.	1. Readjust bias. 2. Replace battery E2 (8.4 V).
Unable to reach INF on any resistance range.	1. Readjust bias. 2. Replace battery E1 (1.5 V).

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 μA, 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.

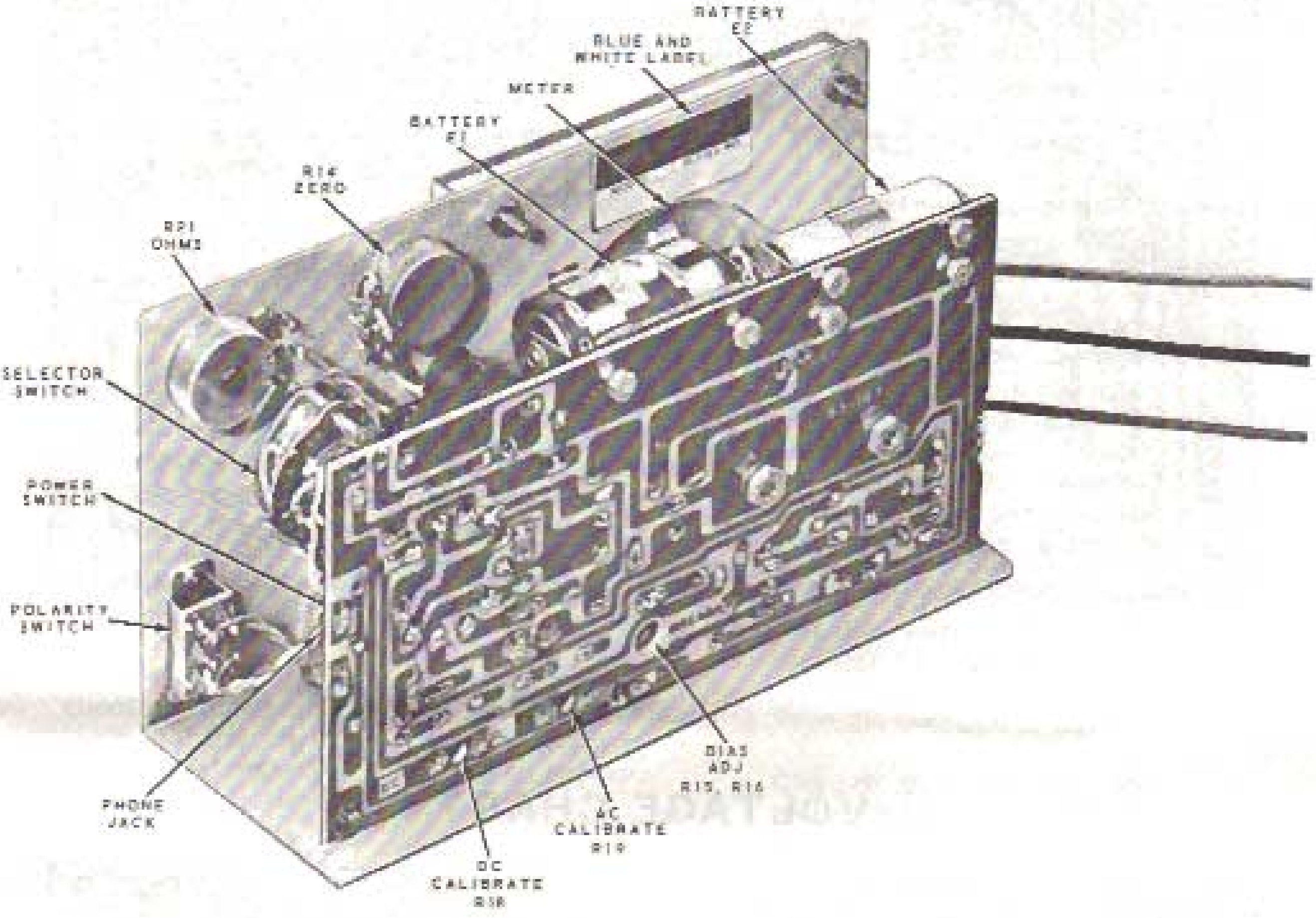
D1 - Diode rectifier to convert AC input voltages to DC.

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 μA meter.

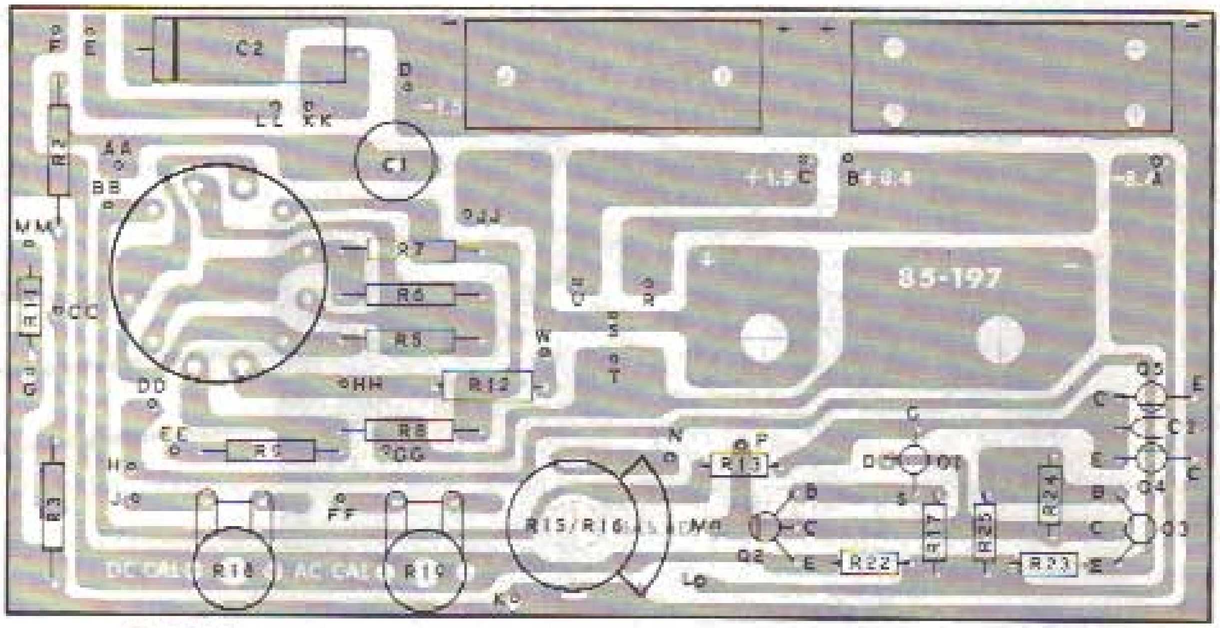
Q4, Q5 - Connected back-to-back as 9 volt zener protection diodes. When the voltage at the gate of Q1 exceeds 9 volts (either polarity) conduction occurs through the appropriate diode, causing a voltage drop across R13. Current limiting action of R13 provides some degree of protection to Q4 and Q5.

PHOTOGRAPH


BATTERY
E2
BLUE AND
WHITE LABEL
METER
BATTERY
E1
R14
ZERO
RP1
OHMS
SELECTOR
SWITCH
POWER
SWITCH
POLARITY
SWITCH
PHONE
JACK
DC
CALIBRATE
R18
AC
CALIBRATE
R19
BIAS
ADJ
R15, R16

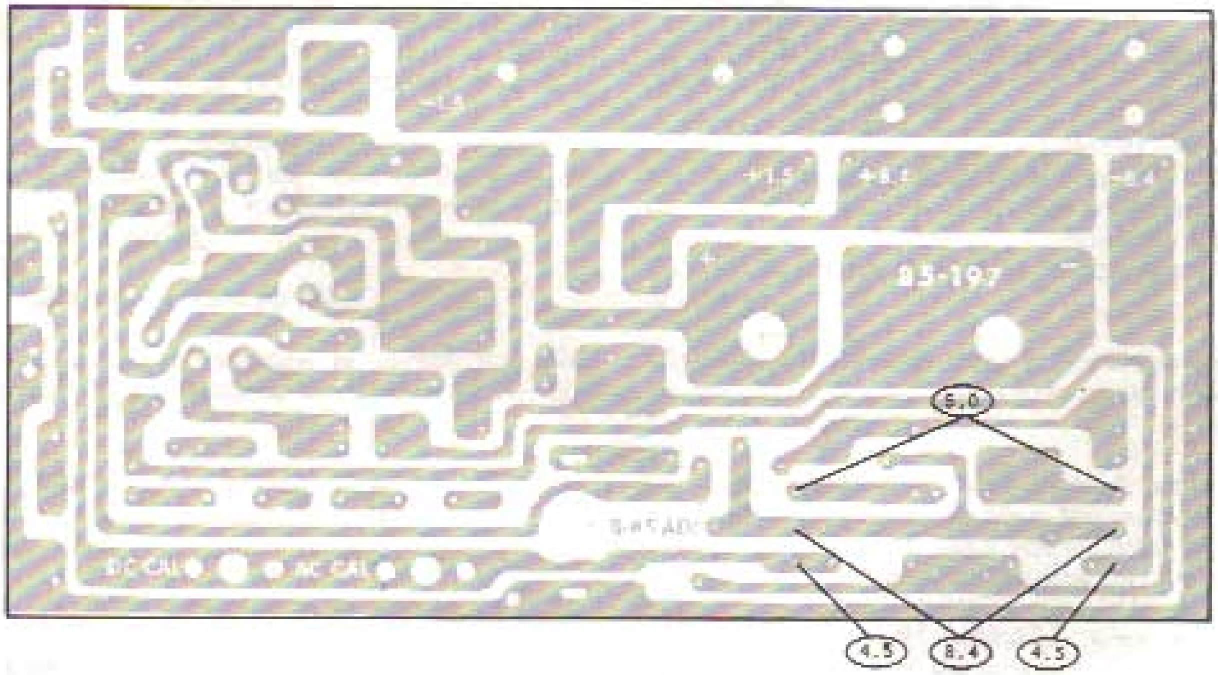
CIRCUIT BOARD X-RAY VIEW

(VIEWED FROM FOIL SIDE)



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

VOLTAGE CHART



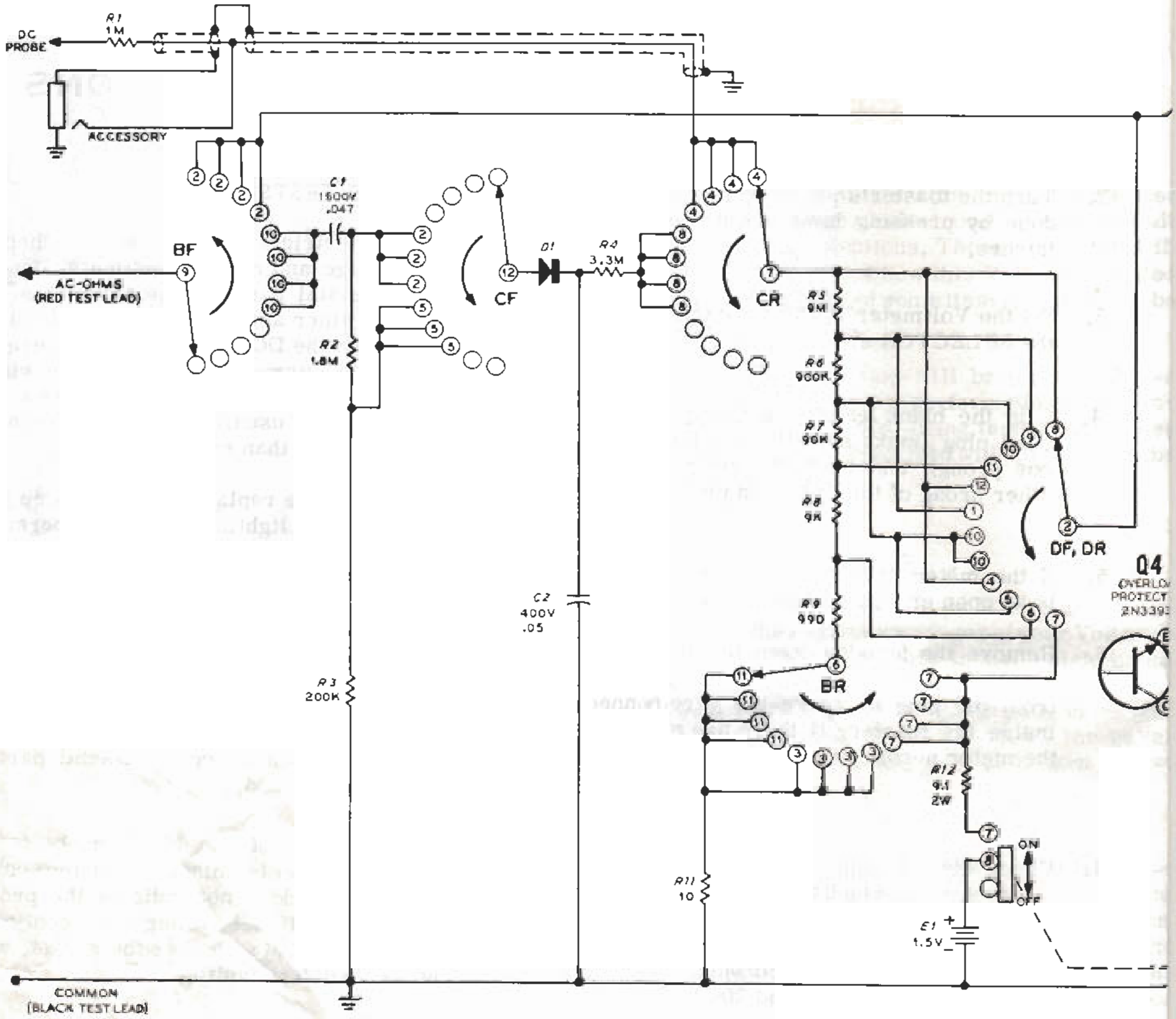
REPLACEMENT PARTS PRICE LIST

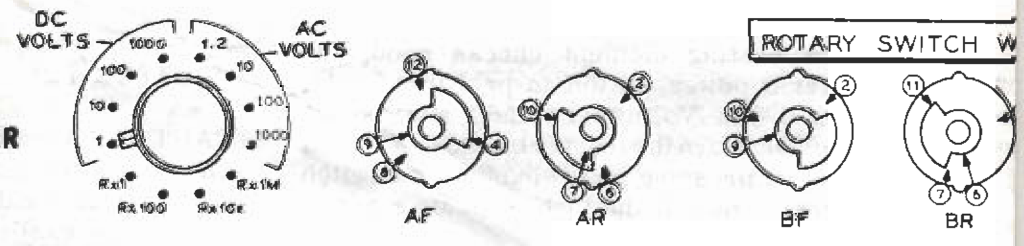
To order parts, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to Replacement Parts in the Kit Builders Guide.

PART No.	PRICE Each	DESCRIPTION
RESISTORS		
1/2 Watt		
1-41	.10	10 Ω
1-20	.10	10 kΩ
1-22	.10	22 kΩ
1-24	.10	33 kΩ
1-35	.10	1 megohm
1-38	.10	3.3 megohm
2 Watt		
3-4-2	.25	9.1 Ω 5%
Precision		
2-236	.20	990 Ω
2-35	.20	9000 Ω (9 kΩ)
2-41	.20	90 kΩ
2-54	.20	200 kΩ
2-51	.20	900 kΩ
2-237	.20	1.8 megohm
2-52	.35	9 megohm
CAPACITORS		
Disc		
21-27	.10	.005 μF
Tubular		
23-91	.50	.047 μF (1.6 kV)
23-61	.15	.05 μF
CONTROLS-SWITCHES		
10-201	.35	10 kΩ control
10-229	.45	2000 Ω control (2 kΩ)
10-78	.45	15 kΩ control
12-80	1.65	50 kΩ dual tandem control
60-2	.25	6-lug slide switch
60-20	.55	9-lug slide switch
63-473	4.00	12-position rotary switch
417-118	.55	2N3393 transistor (or equivalent)
417-140	1.50	FET (field effect transistor)
57-27	.60	Silicon diode

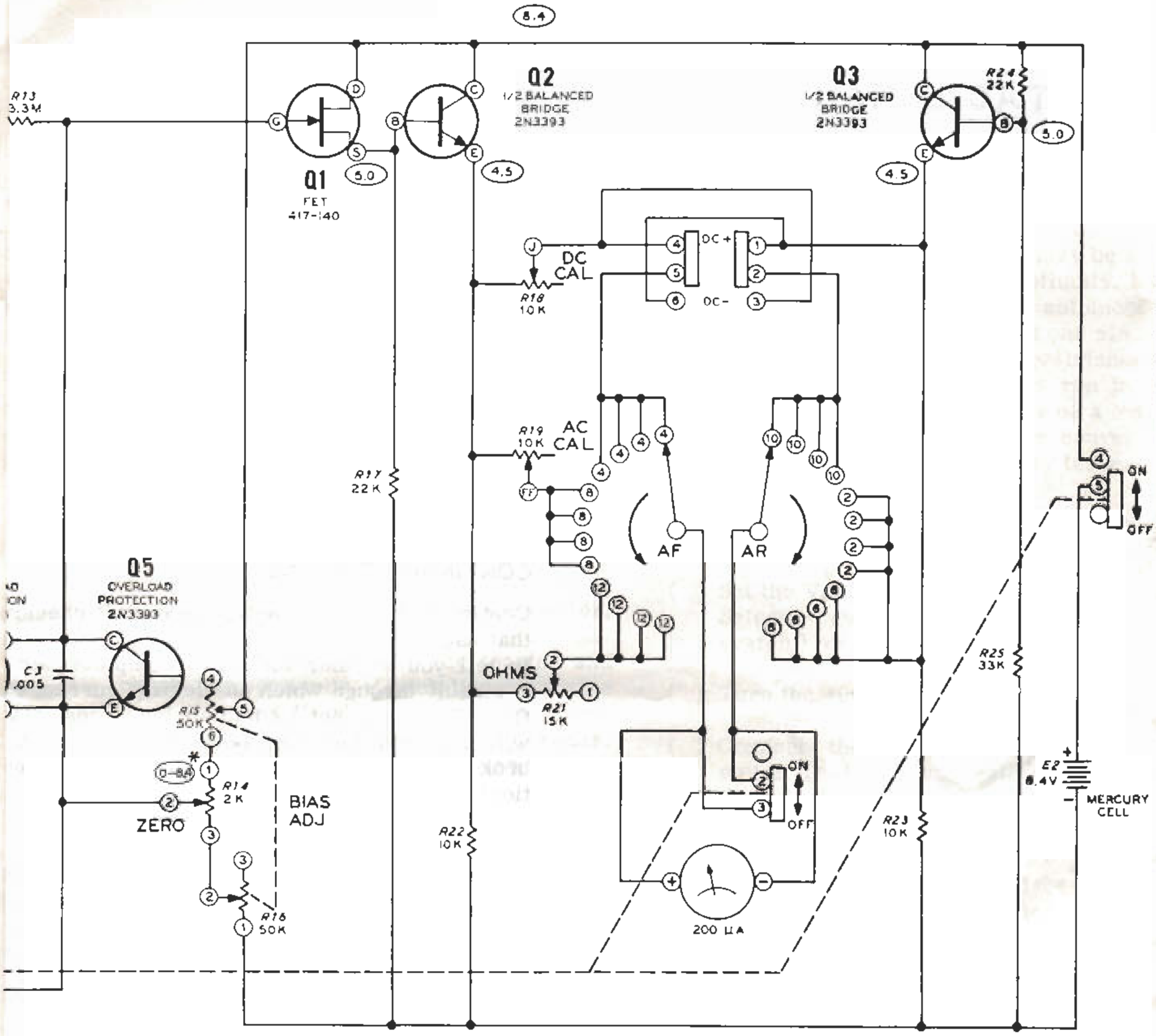
PART No.	PRICE Each	DESCRIPTION
SHIELDED CABLE-WIRE		
343-11	.10/ft	Shielded cable
341-1	.05/ft	Black test lead
341-2	.05/ft	Red test lead
344-50	.05/ft	Black hookup wire
344-52	.05/ft	Red hookup wire
344-59	.05/ft	White hookup wire
HARDWARE		
250-52	.05	4-40 x 1/4" screw
254-9	.05	#4 lockwasher
252-2	.05	4-40 nut
250-229	.05	6-32 x 1/4" phillips head screw
253-10	.05	Control flat washer
254-4	.05	Control lockwasher
252-7	.05	Control nut
MISCELLANEOUS		
73-46	.10	Plastic grommet
214-66	1.00	1.5 V battery holder
214-67	.75	8.4 V battery holder
260-1	.15	Alligator clip
436-35	.70	Phone jack
439-1	.45	Red test probe
439-2	.45	Black test probe
455-50	.10	Knob bushing
462-252	.30	Pointer knob
407-129	9.00	Meter
85-197-1	1.50	Circuit board
203-701	1.20	Panel
95-35	2.60	Plastic case
331-6	.15	Solder
490-5	.10	Nut Starter
390-306	.35	Model number label
	2.00	Manual (See front cover for part number.)

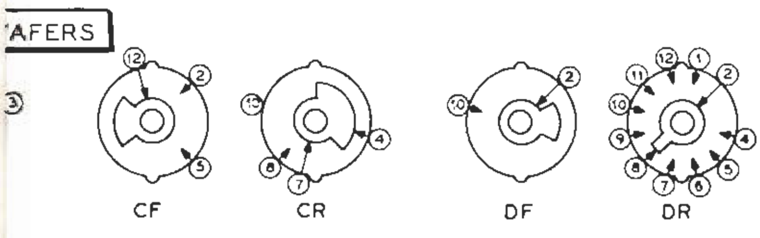
The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your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





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





NOTES

1. ROTARY SWITCH IS SHOWN IN 1 VOLT DC POSITION.
2. F = FRONT, R = REAR.
3. ARROWS INDICATE CLOCKWISE ROTATION.
4. DC SWITCH SHOWN IN "DC+" POSITION.
5. ON-OFF SWITCH SHOWN IN "OFF" POSITION.
6. ALL CAPACITOR VALUES IN μF.
7. ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE.
8. RESISTOR VALUES ARE IN OHMS (K = 1000, M = 1 000,000).
9. ⬭ THIS SYMBOL INDICATES DC VOLTS TO NEGATIVE SIDE OF E2 MEASURED WITH AN 11 MEGOHM INPUT IMPEDANCE ELECTRONIC VOLTMETER. READINGS MAY VARY BY 10%.
10. RESISTORS NOT NUMBERED CONSECUTIVELY.
11. * DEPENDS ON SETTING OF BIAS ADJ AND ZERO CONTROLS.

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