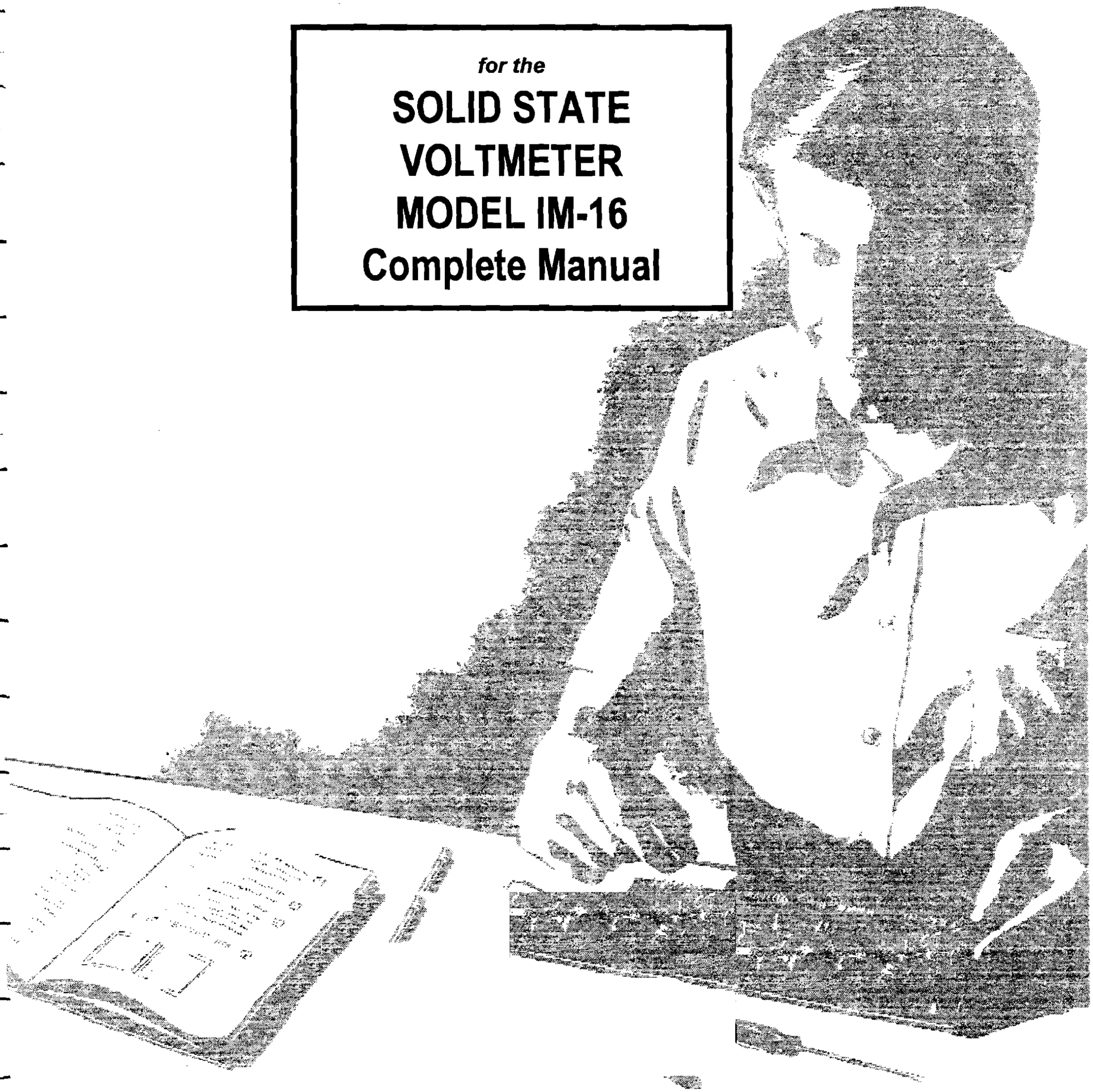
HEATHKIT MANUAL

for the

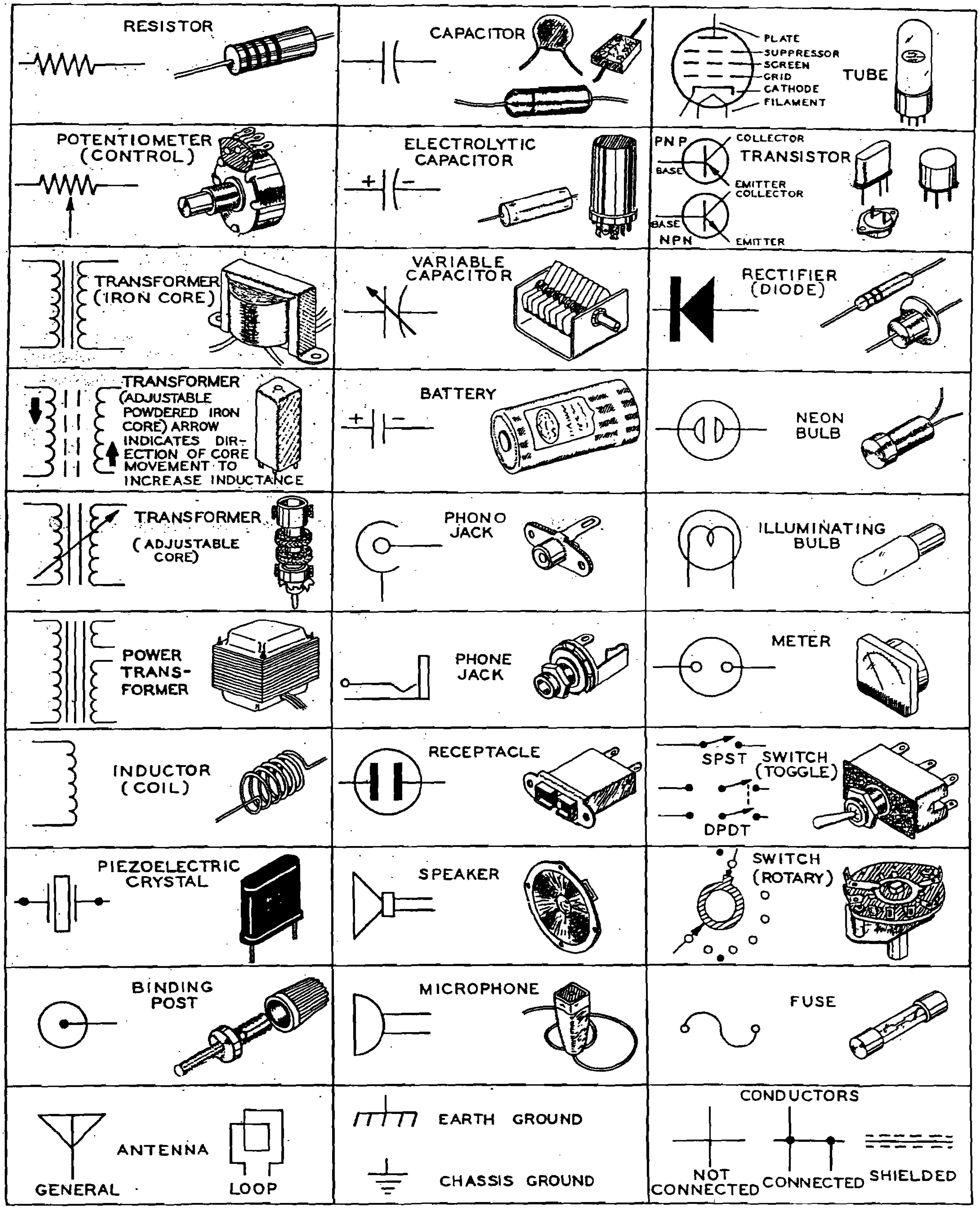
SOLID STATE VOLTMETER MODEL IM-16 Complete Manual



HEATH COMPANY – BENTON HARBOR, MICHIGAN

TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations should prove helpful in identifying most parts and reading the schematic diagrams.



Assembly

and

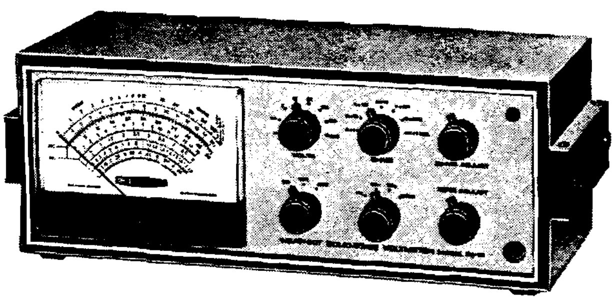
Operation

of the

HEATHKIT

SOLID-STATE VOLTMETER

Model IM-16



HEATH COMPANY
BENTON HARBOR,
MICHIGAN 49022

TABLE OF CONTENTS

INTRODUCTION

The Heathkit Model IM-16 Solid-State Voltmeter combines the features of a vacuum tube voltmeter and the portability of a volt-ohmmeter in an attractively styled cabinet. Operation from the power line or from the internal battery is selected by a single switch. Battery operation permits accurate voltage and resistance measurements at remote locations without an AC power source.

All measurement functions (AC Volts, DC- or DC+ Volts, or Ohms) are selected by one switch. Separate range switches are provided for Volts and Ohms. Voltage readings as low as .01 volt and resistance readings from .2 ohms to over 500 megohms are read on the large 6 inch meter. The separate scales for the lower AC voltage ranges are required to follow diode response at lower applied voltages.

Additional features of the Solid-State Voltmeter include: a printed circuit board and a cable assembly for easy and neat construction, a single test probe to eliminate tangled test leads, and a dual-winding power transformer that allows you to wire the Voltmeter to operate from either a 120 or 240 volt AC power source.

All of these features combine to give you a versatile, attractive, and accurate test instrument 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

NOTE: The numbers in parentheses in the Parts List are keyed to numbers on the Parts Pictorial (fold-out from Page 7).

	PART No.	PARTS Per Kit	DESCRIPTION
	RESISTORS		
	1/2 Watt		
(1)	1-103	1	33 Ω (orange-orange-black)
	1-119	1	560 Ω (green-blue-brown)
	1-13	1	2700 Ω (red-violet-red)
	1-20	2	10 KΩ (brown-black-orange)
	1-22	2	22 KΩ (red-red-orange)
	1-25	2	47 KΩ (yellow-violet-orange)
	1-26	1	100 KΩ (brown-black-yellow)
	1-30	1	270 KΩ (red-violet-yellow)
	1-35	1	1 MΩ (brown-black-green)
	1-38	2	3.3 MΩ (orange-orange-green)
	Precision 1%, 1/2 Watt		
(2)	2-131	1	10 Ω
	2-24	1	90 Ω
	2-29	1	900 Ω
	2-31	1	2162 Ω (2.162 KΩ)
	2-33	1	6838 Ω (6.838 KΩ)
	2-39	1	21.62 KΩ
	2-40	1	68.38 KΩ
	2-42	1	216.2 KΩ
	2-45	1	683.8 KΩ
	2-146	1	2.162 MΩ
	2-147	1	6.838 MΩ
	Precision 1%, 1 Watt		
(3)	2-56-1	1	632.4 KΩ
	2-55-1	1	1.3676 MΩ
	CAPACITORS		
(4)	21-27	1	.005 μfd disc
(5)	23-101	2	.015 μfd tubular
(6)	25-131	1	250 μfd electrolytic
(7)	25-54	1	10 μfd electrolytic
	CONTROLS		
(8)	10-219	2	2000 Ω
(9)	10-57	2	10 KΩ tab mount
10)	12-80	1	50 KΩ dual tandem, tab mount

	PART No.	PARTS Per Kit	DESCRIPTION
	SWITCHES		
(11)	63-433	1	3-position, 1-wafer (Power)
(12)	63-434	1	7-position, 1-wafer (Ohms)
	63-463	1	4-position, 4-wafer (Function)
	63-464	1	8-position, 3-wafer (Volts)
	DIODES-TRANSISTORS-LAMP		
(13)	56-31	1	6.8 volt zener diode
(14)	57-27	4	Silicon diode
(15)	417-118	6	2N3393 transistor
(16)	417-140	1	Field effect transistor (FET)
(17)	412-15	1	Neon pilot lamp
	METAL PARTS		
	90-346-1	2	Cabinet half shell
(18)	200-493	1	Chassis
	203-486-1	1	Front panel
(19)	203-487-1	1	Subpanel
	203-488-1	1	Rear panel
(20)	204-254	1	Battery bracket (1-1/2 volt)
(21)	204-779	1	Battery bracket (9 volt)
(22)	204-759-1	4	End cap
(23)	204-760-1	2	Side rail
	210-34	1	Front panel bezel
	PLASTIC PARTS		
(24)	73-27	4	Grommet (8 halves)
(25)	75-30	1	Line cord strain relief (for round cord)*
	75-71	1	Line cord strain relief (for flat cord)
(26)	211-32	2	Handle
(27)	261-16	1	Cup insulator
(28)	261-28	4	Foot
(29)	261-30	4	Line cord retainer
(30)	413-10	1	Pilot lamp lens
	462-245	4	Pointer knob
	462-246	2	Plain knob

*This strain relief is supplied for use in areas mainly outside the U. S., where 2- or 3-wire round cords are required.

PART No.	PARTS Per Kit	DESCRIPTION
WIRE		
89-23	1	Line cord
134-160	1	Cable assembly
344-59	1	Hookup wire
341-1	1	Black test lead
343-11-1	1	Shielded test lead
PROBE PARTS		
(31) 476-13	1	Front body
(32) 476-14	1	Center body
(33) 476-15	1	Rear body
(34) 477-7	1	Probe tip
(35) 459-6	1	Switch lever
(36) 459-7	1	Insert insulator
(37) 258-53	1	Contact spring
(38) 256-15	2	Rivet
(39) 253-51	1	E washer
#6 HARDWARE		
(40) 250-116	17	6-32 x 1/4" black screw
(41) 250-229	9	6-32 x 1/4" phillips head screw
(42) 250-89	2	6-32 x 3/8" screw
(43) 250-8	8	#6 x 3/8" sheet metal screw
(44) 250-162	4	6-32 x 1/2" screw
(45) 250-303	4	6-32 decorative screw
(46) 250-304	4	6-32 x 7/16" spacer stud
(47) 252-3	12	6-32 nut
(48) 253-2	3	#6 fiber shoulder washer
(49) 254-1	11	#6 lockwasher
(50) 259-1	3	#6 solder lug

PART No.	PARTS Per Kit	DESCRIPTION
OTHER HARDWARE		
(51) 250-52	10	4-40 x 1/4" screw
(52) 252-2	10	4-40 nut
(53) 254-9	10	#4 lockwasher
(54) 252-7	11	Control nut
(55) 253-10	6	Control flat washer
(56) 254-4	3	Control lockwasher
(57) 252-73	1	Speednut
MISCELLANEOUS		
54-177	1	Power transformer
407-125	1	100 microampere meter
85-178-1	1	Circuit board
(58) 431-2	1	2-lug terminal strip
(59) 431-10	1	3-lug terminal strip
(60) 432-33	1	Battery connector
(61) 258-7	1	Battery holder spring
(62) 260-1	1	Alligator clip
260-51	1	Alligator clip with threaded insert
(63) 436-20	1	Phone jack
(64) 438-28	1	Phone plug
(65) 455-50	6	Knob bushing
432-27	1	Line cord plug adapter
490-5	1	Nut starter
391-34	1	Identification label
597-308	1	Kit Builders Guide
597-260	1	Parts Order Form
595-889	1	Manual
		Solder

NOTE: One 1-1/2 volt C-cell battery, and one 9-volt (NEDA1602) battery will be required for operation of this completed volt ohmmeter. You may want to purchase these batteries now, to have them ready when you finish assembling the kit.

STEP-BY-STEP ASSEMBLY

Before you start to assemble this kit, read the Kit Builders Guide for complete information on wiring, soldering, and step-by-step assembly procedures.

CIRCUIT BOARD ASSEMBLY

Components will be installed on the circuit board by following the steps on Pictorials 1 and 2. Position the parts as shown in the Pictorials. Resistors will be called out by resistance value (in Ω, KΩ, or MΩ). The color code will also be given for color-coded resistors. Some precision resistors may be marked in Ω or KΩ. For example, 2162 Ω = 2.162 KΩ. Be sure to install the correct resistor in each step.

START

(✓) Locate the circuit board (#85-178-1) and position it lettered side up as shown in Pictorial 1. Then perform the following steps. Do not solder or cut off any leads until you are directed to do so in a step.

NOTE: The Solid-State Voltmeter can be wired for use with either a 120 volt AC power source or a 240 volt AC power source. Follow either the 120 VOLT WIRING steps or the 240 VOLT WIRING step, whichever applies to your needs.

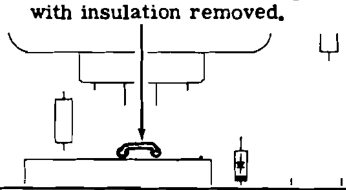
120 VOLT WIRING

(✓) 1" bare wire. Use hookup wire with insulation removed.

(✓) 1" bare wire.

240 VOLT WIRING

( ) 3/4" bare wire. Use hookup wire with insulation removed.



(✓) 10 KΩ (brown-black-orange).

(✓) 10 KΩ (brown-black-orange).

(✓) 3.3 MΩ (orange-orange-green).

(✓) 33 Ω (orange-orange-black).

(✓) 22 KΩ (red-red-orange).

(✓) 47 KΩ (yellow-violet-orange).

(✓) Solder all connections and cut off the excess lead lengths.

CONTINUE

(✓) 100 KΩ (brown-black-yellow)

(✓) 560 Ω (green-blue-brown).

(✓) 2700 Ω (red-violet-red).

NOTE: Precision resistors are identified by resistance value.
MΩ = megohm = 1,000,000 ohm
KΩ = kilohm = 1,000 ohm
Example: 2.162 KΩ = 2162 Ω

(✓) 6.838 MΩ 1% precision.

(✓) 2.162 MΩ 1% precision.

(✓) 683.8 KΩ 1% precision.

(✓) 216.2 KΩ 1% precision.

(✓) 68.38 KΩ 1% precision.

(✓) 21.62 KΩ 1% precision

(✓) Solder all connections and cut off the excess lead lengths.

(✓) 6.838 KΩ 1% precision.

(✓) 2.162 KΩ 1% precision.

(✓) 900 Ω 1% precision.

(✓) 10 Ω 1% precision.

(✓) 90 Ω 1% precision.

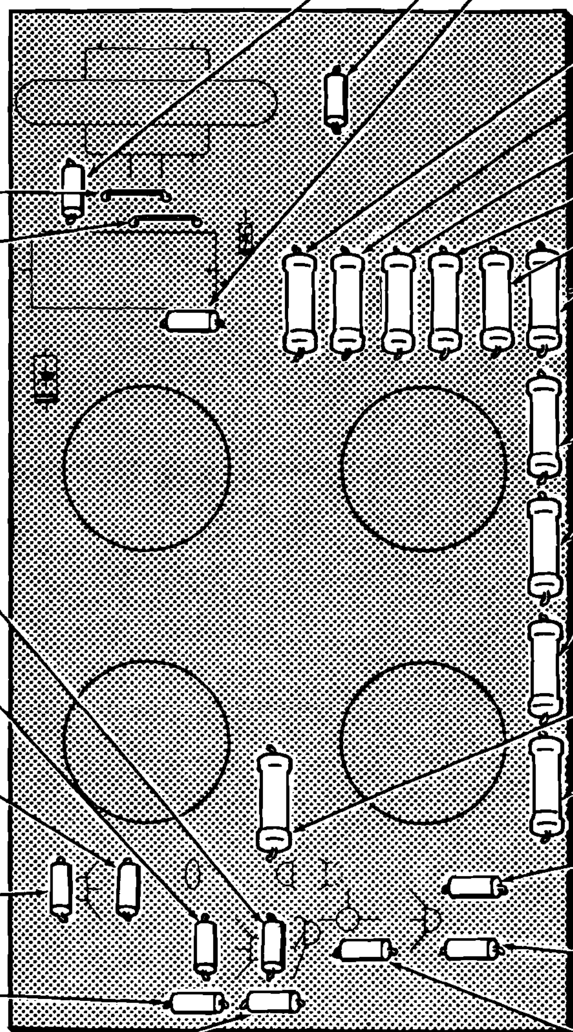
(✓) 22 KΩ (red-red-orange).

(✓) 47 KΩ (yellow-violet-orange).

(✓) 270 KΩ (red-violet-yellow).

(✓) Solder all connections and cut off the excess lead lengths.

PROCEED TO PICTORIAL 2



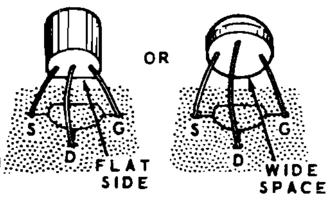
PICTORIAL 1

START

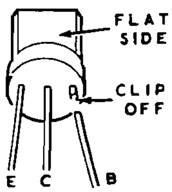
(√) Position the circuit board as shown in Pictorial 2.

The transistors will be installed in the following steps. Solder all leads after each transistor is installed; then clip off the excess lead lengths close to the foil.

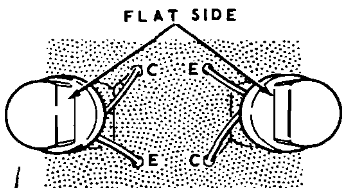
(√) Install the FET (#417-140) at Q1. Place the source (S), drain (D), and gate (G) leads in their proper holes as shown below.



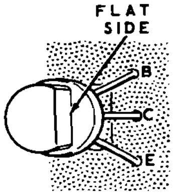
(√) Prepare two 2N3393 (#417-118) transistors by clipping off each base (B) lead. Refer to the illustration below to identify the leads.

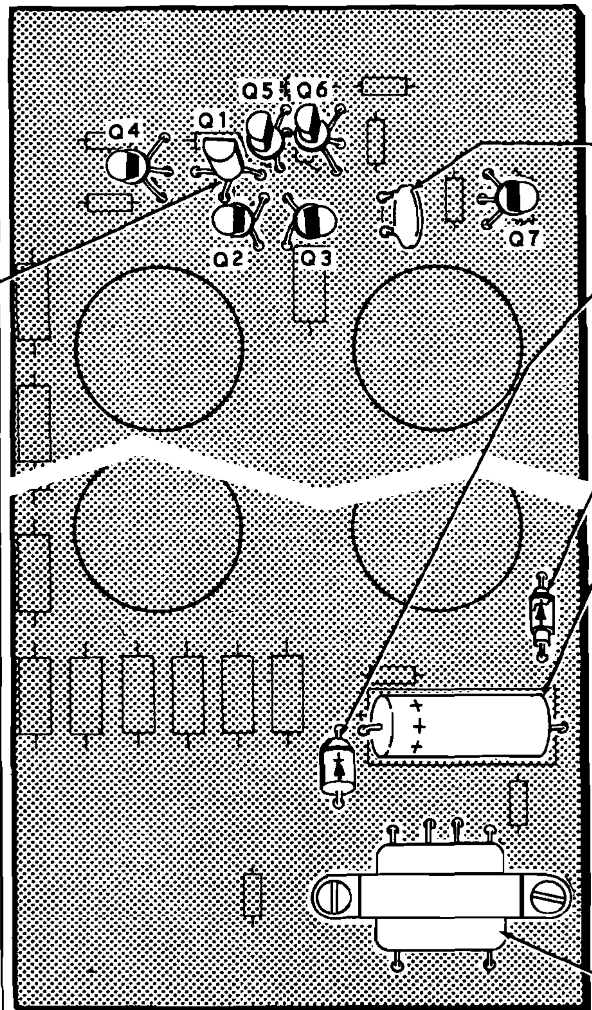


(√) Install the two prepared 2N3393 transistors at Q2 and Q3. Position each transistor so its flat side matches the outline on the circuit board, then insert the leads into the correct holes as indicated by E and C.



(√) Install 2N3393 transistors at Q4, Q5, Q6, and Q7. Match the flat side of each transistor with the outline of the flat on the circuit board, then insert the emitter (E), base (B), and collector (C) leads in their proper holes.

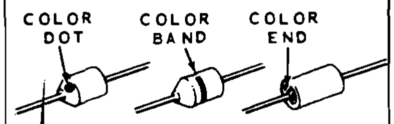




CONTINUE

(√) .005 µfd disc capacitor.

(√) Silicon diode (#57-27). Position the cathode lead as shown. The cathode lead is marked with a color dot, color band, or color end.

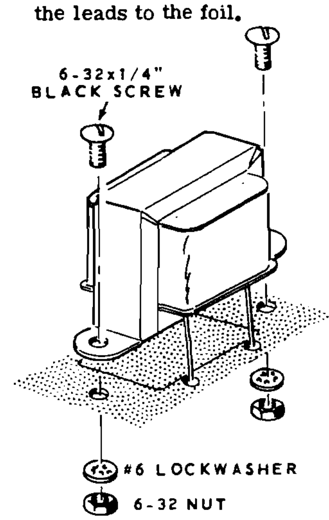


(√) Zener diode (#56-31). Position the cathode lead as shown.

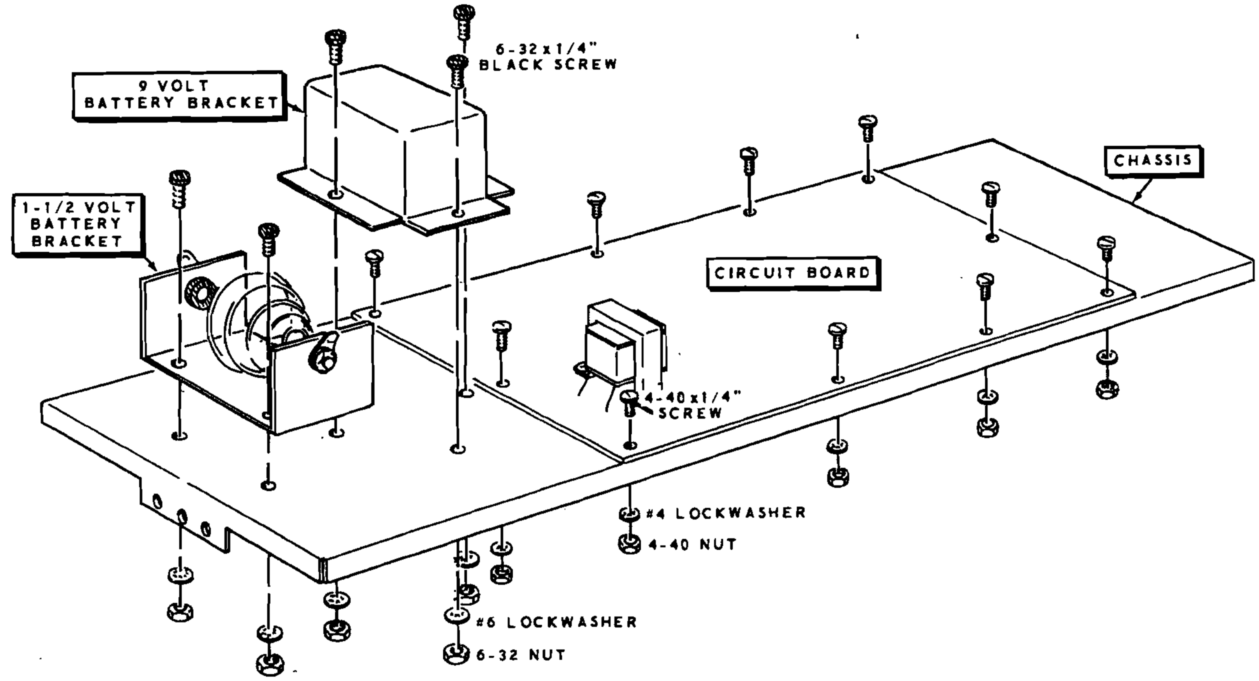
(√) 250 µfd electrolytic capacitor. Position the positive (+) lead of the capacitor as shown by the (+) mark on the circuit board.

(√) Solder all connections and cut off the excess lead lengths. Be sure all leads are soldered, and that no solder bridges exist between foils.

(√) Install the power transformer (#54-177). Place the transformer leads in the proper holes in the circuit board. Secure the transformer to the board with two 6-32 x 1/4" black screws, #6 lockwashers, and 6-32 nuts, as shown below. Then solder the leads to the foil.



PICTORIAL 2



PICTORIAL 3

Refer to Pictorial 3 for the following steps.

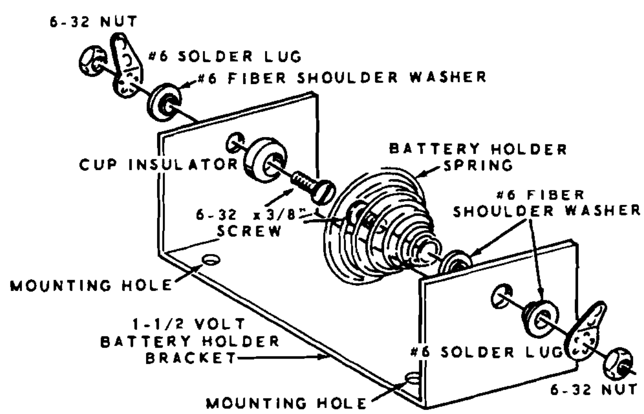
( ) Locate the chassis (#200-493) and position it as shown.

( ) Mount the circuit board to the chassis with ten 4-40 x 1/4" screws, #4 lockwashers, and 4-40 nuts. Do not tighten the screws until all of them are installed.

( ) Mount the 9-volt battery bracket as shown. Use three 6-32 x 1/4" black screws, #6 lockwashers, and 6-32 nuts.

( ) Refer to Detail 3A and install the cup insulator, #6 fiber shoulder washer, and #6 solder lug at one end of the 1-1/2 volt battery bracket. Use a 6-32 x 3/8" screw and a 6-32 nut. Be sure the mounting holes are positioned as shown.

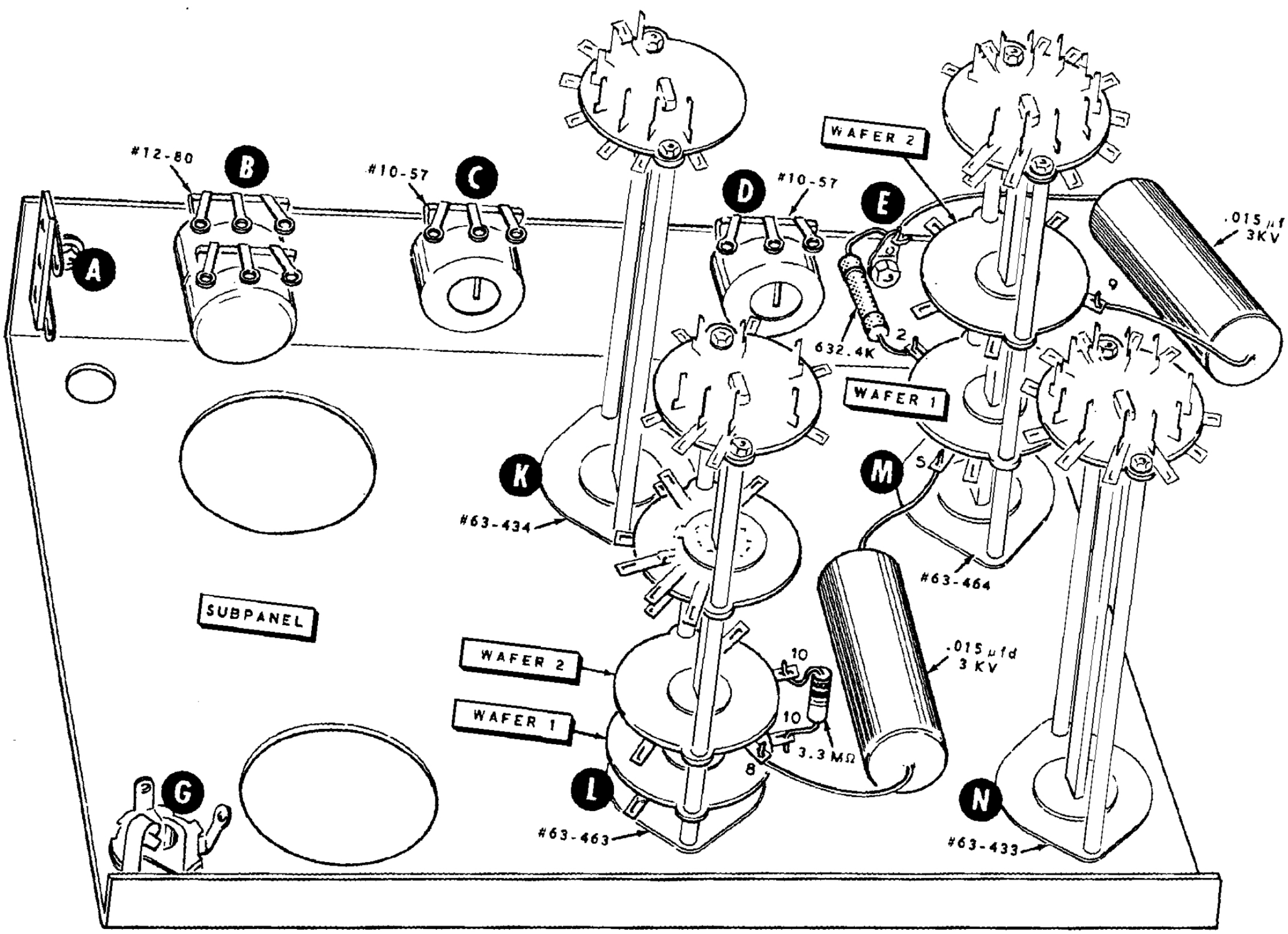
( ) At the other end of the 1-1/2 volt battery bracket, mount the battery holder spring, two #6 fiber shoulder washers, and a #6 solder lug. Use a 6-32 x 3/8" screw and a 6-32 nut.



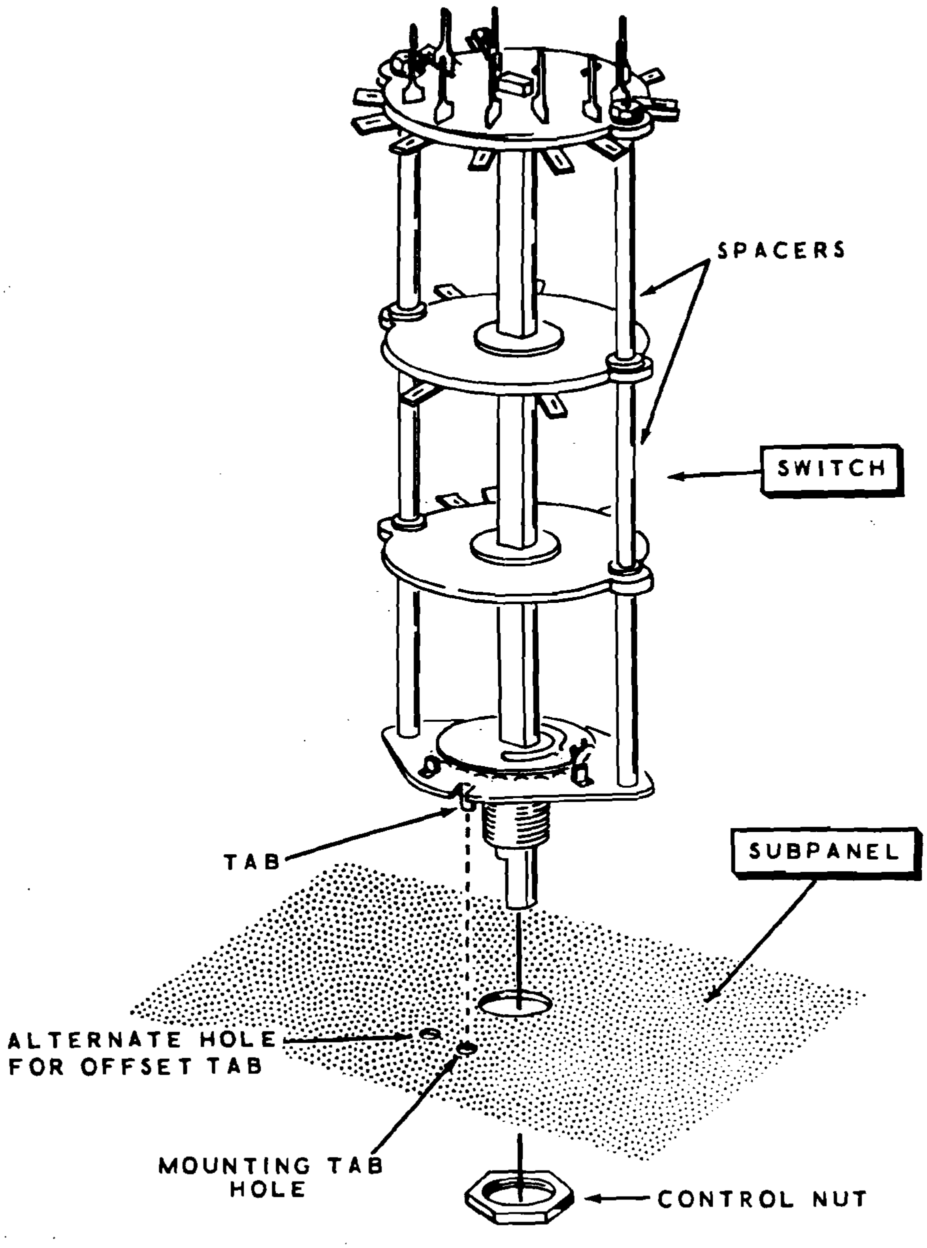
Detail 3A

( ) Mount the battery bracket assembly to the chassis as shown in Pictorial 3. Use two 6-32 x 1/4" black screws, #6 lockwashers, and 6-32 nuts.

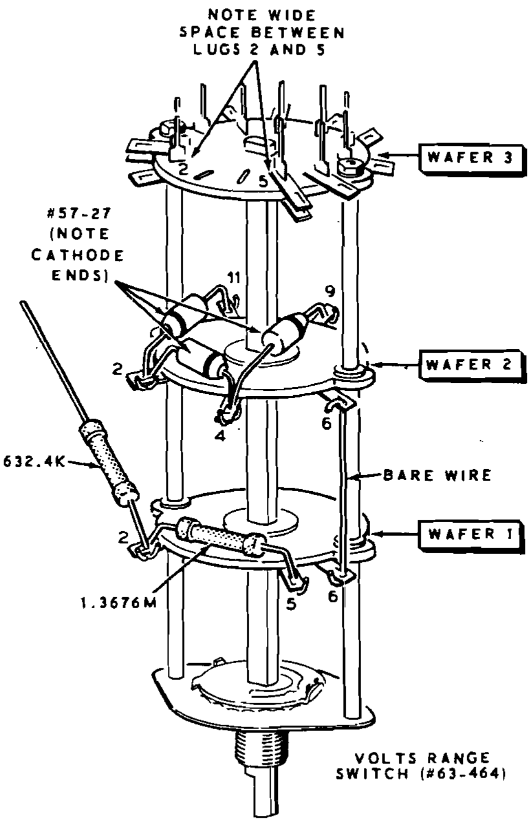
( ) Set the chassis aside temporarily.


#12-80
B
#10-57
C
D
#10-57
E
A
WAFER 2
.015 μfd
3KV
9
632.4K
2
WAFER 1
K
M
5
#63-434
#63-464
SUBPANEL
WAFER 2
10
.015 μfd
3 KV
WAFER 1
10
3.3 MΩ
8
G
L
N
#63-463
#63-433

PICTORIAL 5


SPACERS
SWITCH
TAB
SUBPANEL
ALTERNATE HOLE
FOR OFFSET TAB
MOUNTING TAB
HOLE
CONTROL NUT

Detail 5D



PICTORIAL 4

SWITCH PREWIRING AND SUBPANEL ASSEMBLY

Refer to Pictorial 4 for the following steps.

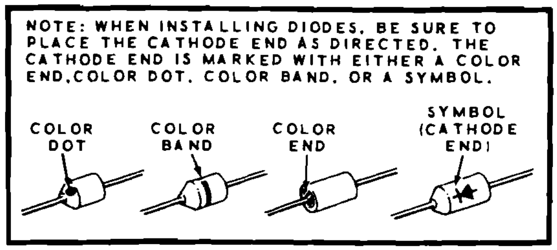
(✓) Locate the 8-position, 3-wafer switch (#63-464) and position it as shown.

(✓) Connect the 1.3676 MΩ 1 watt precision resistor between lug 2 (NS) and lug 5 (NS) on wafer 1 of the switch.

(✓) Cut one lead of the 632.4 KΩ 1 watt precision resistor to 1/2". Connect this lead to lug 2 on wafer 1 (S-2). The other lead of this resistor will be connected later.

(✓) Remove the insulation from a 1-1/4" hookup wire. Connect this bare wire from lug 6 of wafer 1 (S-1) to lug 6 of wafer 2 (S-1).

(✓) Connect the lead from the cathode end of a silicon diode (#57-27) to lug 9 (NS) and the other lead to lug 4 (NS) of wafer 2. Position the diode as shown. Refer to Detail 4A for identification of the cathode lead.



Detail 4A

(✓) Connect the lead from the cathode end of another silicon diode to lug 4(S-2), and the other lead to lug 2 (NS) of wafer 2. Position the diode as shown.

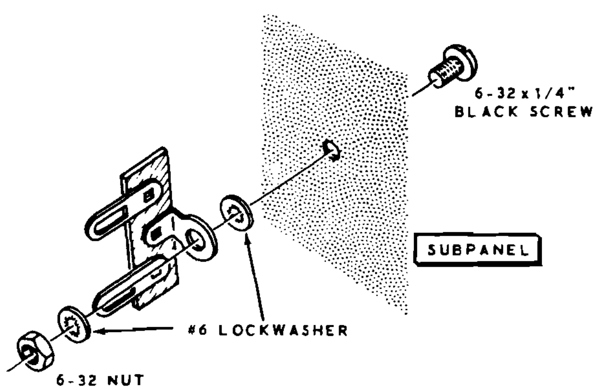
(✓) Connect the cathode lead of the remaining silicon diode to lug 2 (S-2), and the other lead to lug 11 (S-1) of wafer 2. Position the diode as shown.

(✓) Set the switch aside temporarily.

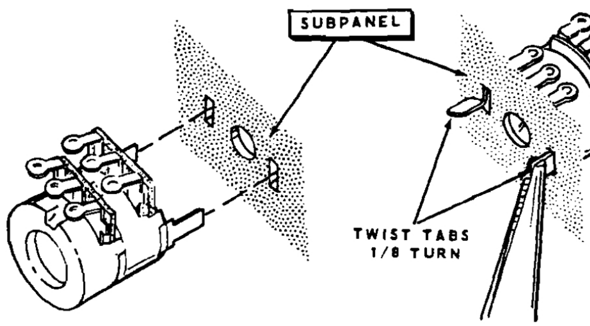
Refer to Pictorial 5 for the following steps.

(✓) Locate the subpanel (#203-487-1) and position it as shown.

(✓) Mount the 2-lug terminal strip at A. Use a 6-32 x 1/4" black screw, two #6 lockwashers, and a 6-32 nut as shown in Detail 5A.



Detail 5A



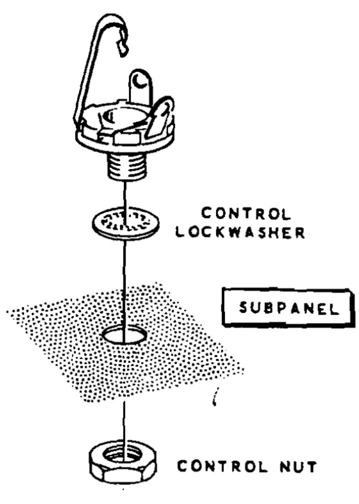
Detail 5B

( ) Mount the 50 KΩ dual tandem tab mount control (#12-80) at B. Refer to Detail 5B and twist the tabs 1/8 turn to secure the control to the subpanel.

( ) In a like manner, mount the two 10 KΩ tab mount controls (#10-57) at C and D.

( ) Install a #6 solder lug at E. Use a 6-32 x 1/4" black screw and a 6-32 nut.

( ) Refer to Detail 5C and install the phone jack at G. Use a control lockwasher and control nut, and position the lugs of the jack as shown in Pictorial 5.



Detail 5C

NOTE: When you mount the switches in the following steps, position the wafer spacers in a line parallel with the edge of the subpanel. Some of the switches supplied with your kit may have tabs that are offset 30 degrees from those shown. Be sure the tab goes in the correct tab hole; then secure the switch to the subpanel with a control nut. See Detail 5D.

( ) Mount the prewired 3-wafer switch (#63-464) at M.

( ) Mount the 4-position, 4-wafer switch (#63-463) at L.

NOTE: The following system will be used to identify switches and their wafer and lug numbers. The letter will identify the switch. The first number will identify the wafer, counting from the knob end of the shaft. The number that follows the dash will identify the lug. For example, M2-4 would refer to switch M, wafer 2, lug 4. The switches, wafers, and lugs are called out on the Pictorials when they are used in accompanying steps.

( ) Connect the free lead of the 632.4 KΩ precision resistor, that comes from M1-2, to solder lug E (NS).

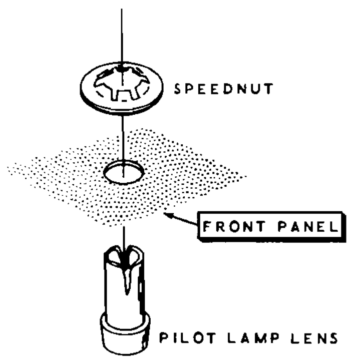
( ) Connect one lead of a .015 μfd 3 KV capacitor to solder lug E (S-2), and the other lead to M2-9 (NS). Position the capacitor as shown in Pictorial 5.

( ) Connect a 3.3 MΩ (orange-orange-green) resistor from L1-10 (S-1) to L2-10 (NS).

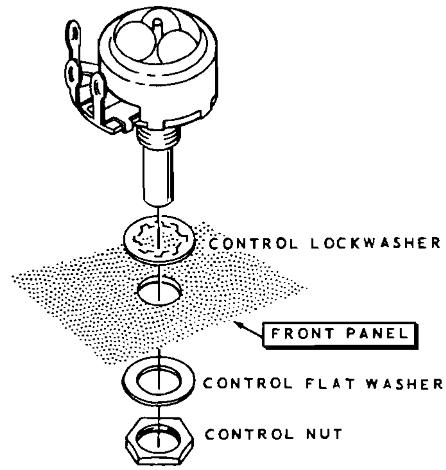
( ) Connect one lead of a .015 μfd 3 KV capacitor to M1-5 (S-2), and the other lead to L2-8 (S-1). Position the capacitor as shown.

( ) Mount the 7-position, 1-wafer switch (#63-434) at K.

( ) Mount the 3-position, 1-wafer switch (#63-433) at N.



Detail 6A



Detail 6B

FRONT PANEL MOUNTING AND WIRING

Refer to Pictorial 6 (fold-out from Page 11) for the following steps.

(√) Locate the front panel and position it as shown. Place a towel or soft cloth on your work surface to avoid scratching the panel.

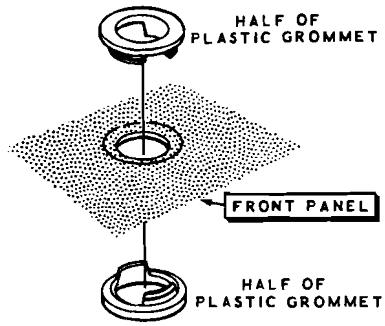
(√) Refer to Detail 6A and install the red pilot lamp lens at F. Press the speednut over the lens and firmly against the inside of the front panel.

(√) Install a 2000 Ω control (#10-219) at H. Use a control lockwasher, control flatwasher, and control nut as shown in Detail 6B. Position the lugs of the control as shown in Pictorial 6.

(√) In a like manner, install the other 2000 Ω control (#10-219) at J.

(√) Install plastic grommets in the four recessed holes at K, L, M, and N. Refer to Detail 6C and press the two halves of each grommet together until they lock in the hole.

(√) Place the front panel against the front of the subpanel so the four switch shafts pass through the plastic grommets. The pilot lamp lens should go into hole F on the subpanel, and the lugs of controls H and J should not touch the edges of the cutouts.



Detail 6C

( ) Secure the subpanel to the front panel with a control flat washer and a control nut on each switch bushing as shown in Detail 6D.

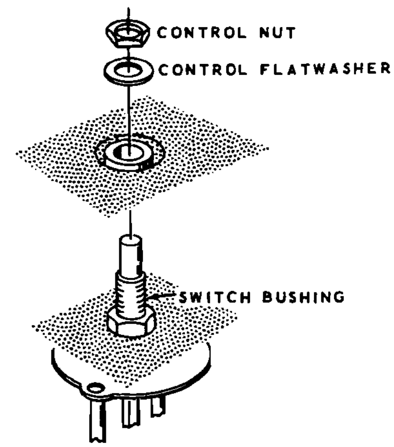
( ) Strip 1-1/2" of insulation from a piece of hookup wire and place this insulation on one lead of the neon pilot lamp.

( ) Insert the pilot lamp into the pilot lamp lens at F. Then connect the insulated lead to lug 1 (NS) and the other lead to lug 2 (NS) of terminal strip A.

( ) Prepare the following six lengths of hookup wire by first cutting each wire to the indicated length, and then removing 1/4" of insulation from each end. The wires are listed in the order in which they will be used.

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

( ) Connect a 4" hookup wire from lug 1 of phone jack G (NS) to lug 2 of control J (NS).



Detail 6D

( ) Connect a 4" hookup wire from lug 2 of phone jack G (S-1) to switch L2-5 (S-1).

NOTE: In the following steps, only one end of each hookup wire will be connected. Each step will call out the wire length, the switch lug, and soldering instruction.

( ) 2-1/2" wire to L3-1 (S-1). Be sure to solder the wire to both the front and rear lugs on wafer 3.

( ) 3" wire to L3-6 (NS).

( ) 3-1/4" wire to L2-12 (S-1).

( ) 3-1/2" wire to L2-10 (S-2).

( ) Position the wires toward the rear of the switch.

CABLE ASSEMBLY WIRING

Refer to Pictorial 7 for the following steps.

NOTE: In the following steps, the cable assembly wires will be connected to components that are mounted on the subpanel. Notice that the cable assembly has various colored wires from each of the ten breakouts. Breakout #1 has nine wires. Refer to the Pictorial for the position of wires and location of connections.

Connect the wires from breakout #1 as follows:

(✓) White-orange to lug 1 of control J (S-1).

(✓) White-yellow to lug 2 of control J (S-2).

(✓) White-red to lug 3 of control J (S-1).

(✓) White-green to L1-5 (S-1).

(✓) Black to L3-4 (S-1).

(✓) Orange to L3-5 (S-1). Be sure to solder the wire to both the front and rear lugs on wafer 3.

(✓) Violet to L3-6 (S-2).

The green and blue wires from breakout #1 and the white-yellow wire from breakout #2 will be connected later.

Connect the wires from breakout #3 as follows:

(✓) Brown to L3-12 (S-1).

(✓) Red to L3-3 (S-1).

Connect the wires from breakout #4 as follows:

(✓) Both blue wires to lug 1 of control H (S-2).

(✓) Green to lug 2 of control H (S-1).

(✓) Yellow to lug 3 of control H (S-1).

The gray wire and the white-brown wire from breakout #4 will be connected later.

Connect the wires from breakout #5 as follows:

(✓) Gray to lug 3 of control B (S-1).

(✓) White-red to lug 2 of control B (S-1).

(✓) White-orange to lug 5 of control B (S-1).

(✓) White-brown to lug 4 of control B (NS).

(✓) Either white-blue to lug 2 of terminal strip A (S-2).

(✓) Other white-blue to lug 1 of terminal strip A (S-2).

Connect the wires from breakout #6 to control C as follows:

(✓) Orange to lug 2 (S-1).

(✓) Both violet to lug 3 (S-2).

Connect the wires from breakout #7 to control D as follows:

(✓) Brown to lug 2 (S-1).

(✓) Violet to lug 3 (S-1).

The yellow wire and the white wire from breakout #7 will be connected later.

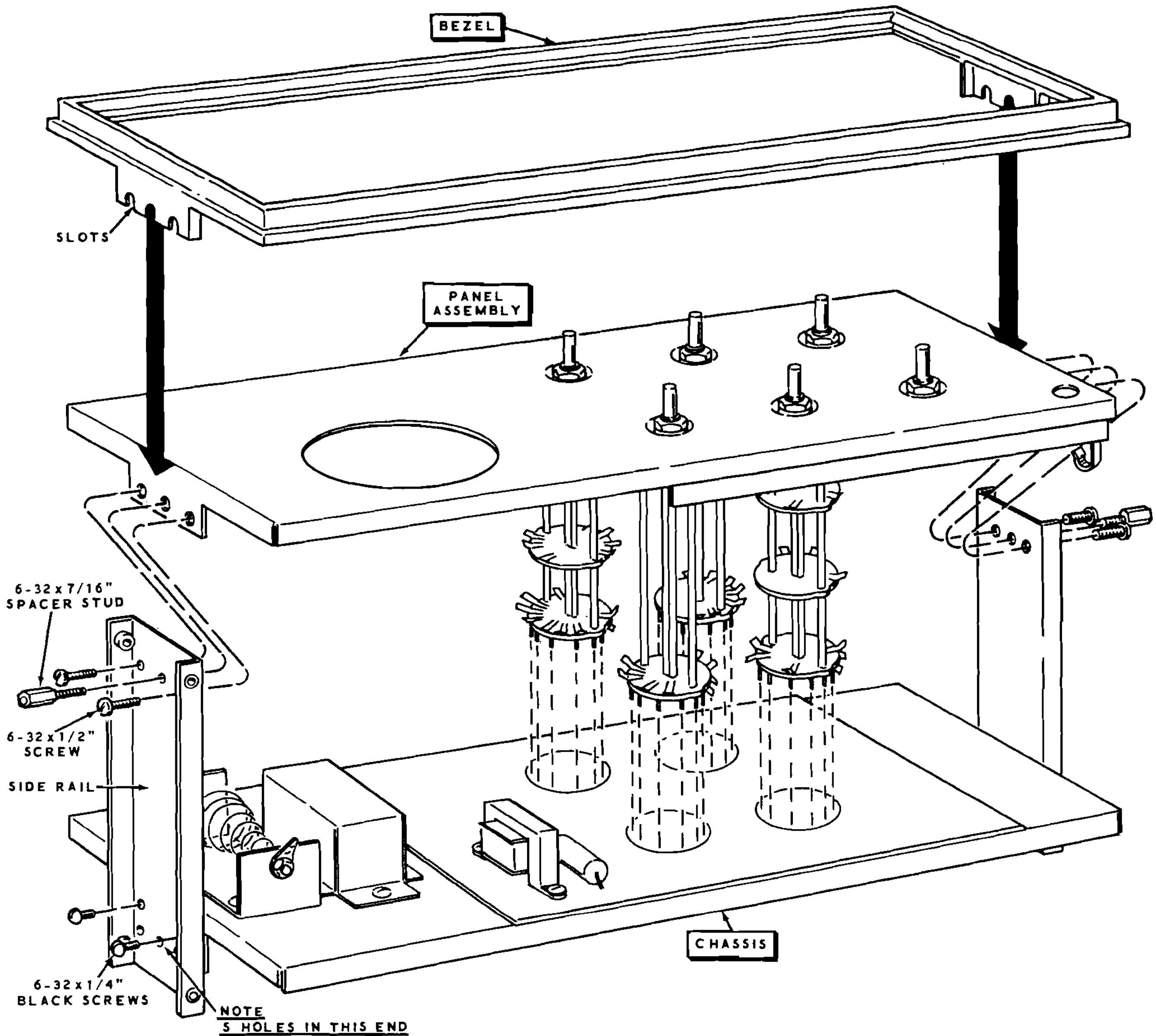
(✓) Connect the white-green wire from breakout #8 to switch M2-9 (S-3).

Wires from the remaining breakouts will be connected later.

(✓) Connect the lead from the positive (+) end of a 10 μfd electrolytic capacitor to lug 1 of phone jack G (S-2). Connect the other lead to lug 4 of control B (S-2).

(✓) Carefully examine all connections. Every lug that has a wire or lead attached to it should have been soldered. There should be no blank lugs on wafers 1, 2, and 3 of switch L, or on wafers 1 and 2 of switch M. No connections should have been made to any of the lugs on the end wafers of any switch.

(✓) Set the front panel assembly aside.



PICTORIAL 8

FRONT PANEL ASSEMBLY INSTALLATION

Refer to Pictorial 8 for the following steps.

(✓) Locate the chassis assembly and position it as shown in the Pictorial.

(✓) Mount a side rail at each end of the chassis. Use two 6-32 x 1/4" black screws in the holes indicated in the Pictorial.

(✓) Position the front panel assembly over the chassis and line up the pins of the four switches with the corresponding holes in the circuit board. Then very carefully insert the pins into the holes as you lower the panel assembly into place.

(✓) Place the bezel over the front panel with the slotted ends between the side rails and the panel.

(✓) Secure the front panel and bezel to the side rails. Use a 6-32 x 7/16" spacer stud and two 6-32 x 1/2" screws at each end of the panel.

CIRCUIT BOARD WIRING

Refer to Pictorial 9 (fold-out from Page 15) for the following steps.

In the next four steps you will connect the four hookup wires that come from VO switch L to the circuit board. The circuit board holes for these wires are lettered to indicate the switch lug and wafer from which they come. These steps will call out the connections in the same way. Pass the end of each wire through its hole in the circuit board; then solder the end of the wire on the foil side and clip off any excess wire ends.

(√) VO switch lug 10 wafer 2 (S-1).

(√) VO switch lug 12 wafer 2 (S-1).

(√) VO switch lug 1 wafer 3 (S-1).

(√) VO switch lug 6 wafer 3 (S-1).

In the following steps you will connect the wires from the cable assembly to the circuit board. Each step will call out the wire color. Pass the end of the wire through the hole marked with the wire color. Solder each wire on the foil side of the circuit board,and clip off any excess wire ends.

(√) Gray to GRAY (S-1).

(√) White-brown to WHT/BRN (S-1).

(√) White-yellow to WHT/YEL (S-1).

(√) Green to GRN (S-1).

(√) Blue to BLU (S-1).

(√) Yellow to YEL (S-1).

(√) White to WHT (S-1).

(√) Shorter white-blue to inner WHT/BLU (S-1).

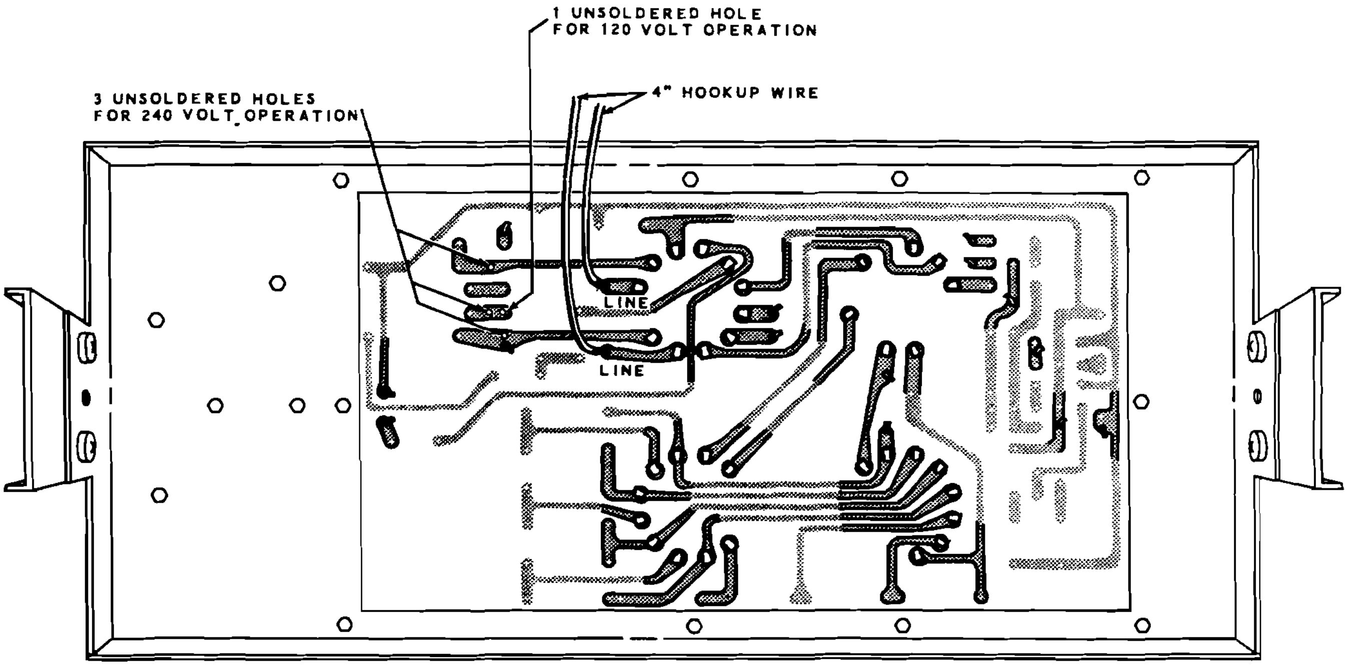
(√) Longer white-blue to WHT/BLU hole nearest the edge of the circuit board (S-1).

(√) Locate the 9-volt battery connector and connect its leads to the circuit board holes marked BATT: Connect the red lead to + (S-1) and the black lead to – (S-1).

(√) Position the unit as shown in Detail 9A for the following steps.

(√) Remove 1/4" of insulation from each end of two 4" hookup wires.

(√) Connect one end of either 4" wire to a hole marked LINE on the foil side of the circuit board (S-1). Then connect the other 4" wire to the other hole marked LINE (S-1). The other ends of these wires will be connected later.



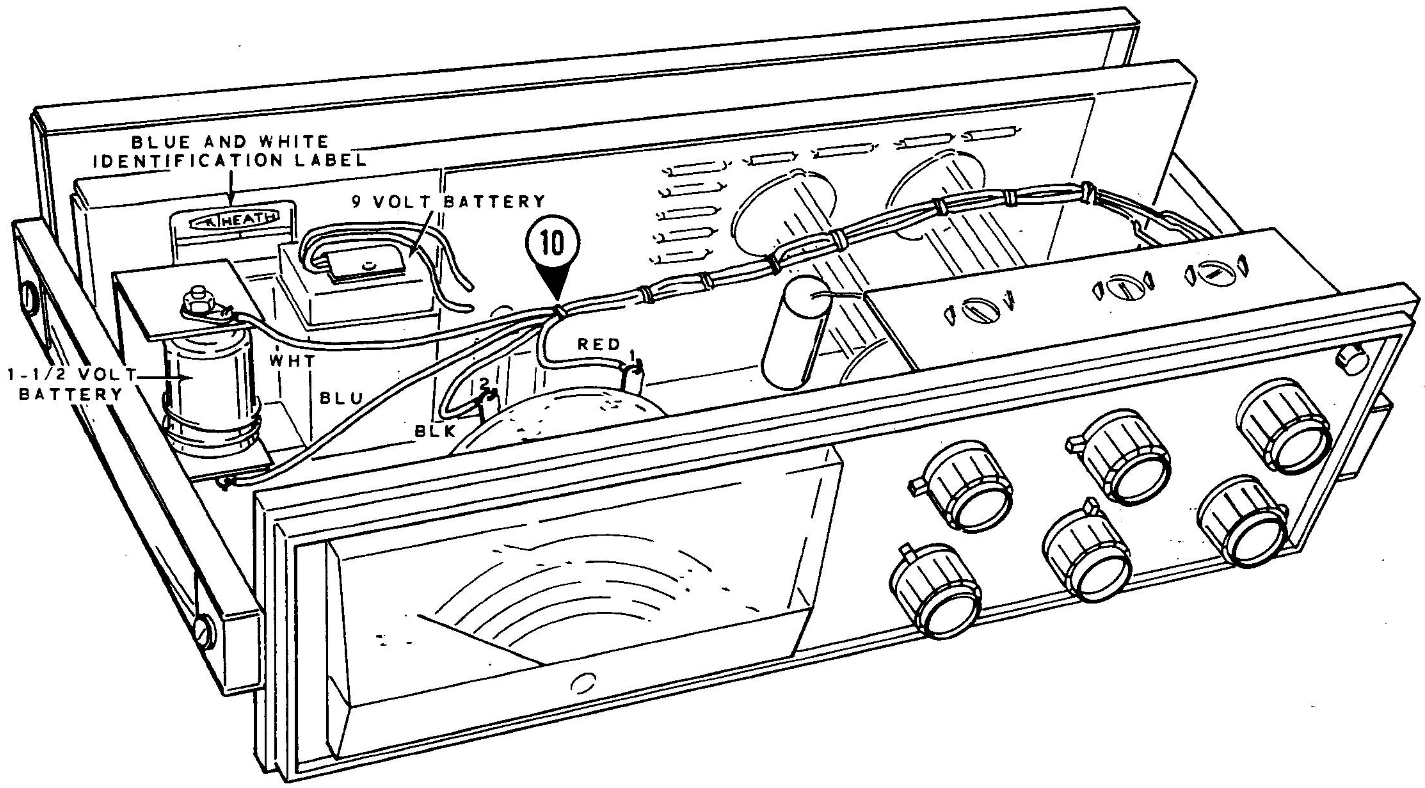
Detail 9A

(✓) Solder all switch pins to the circuit board foil. Do not cut off the switch pins.

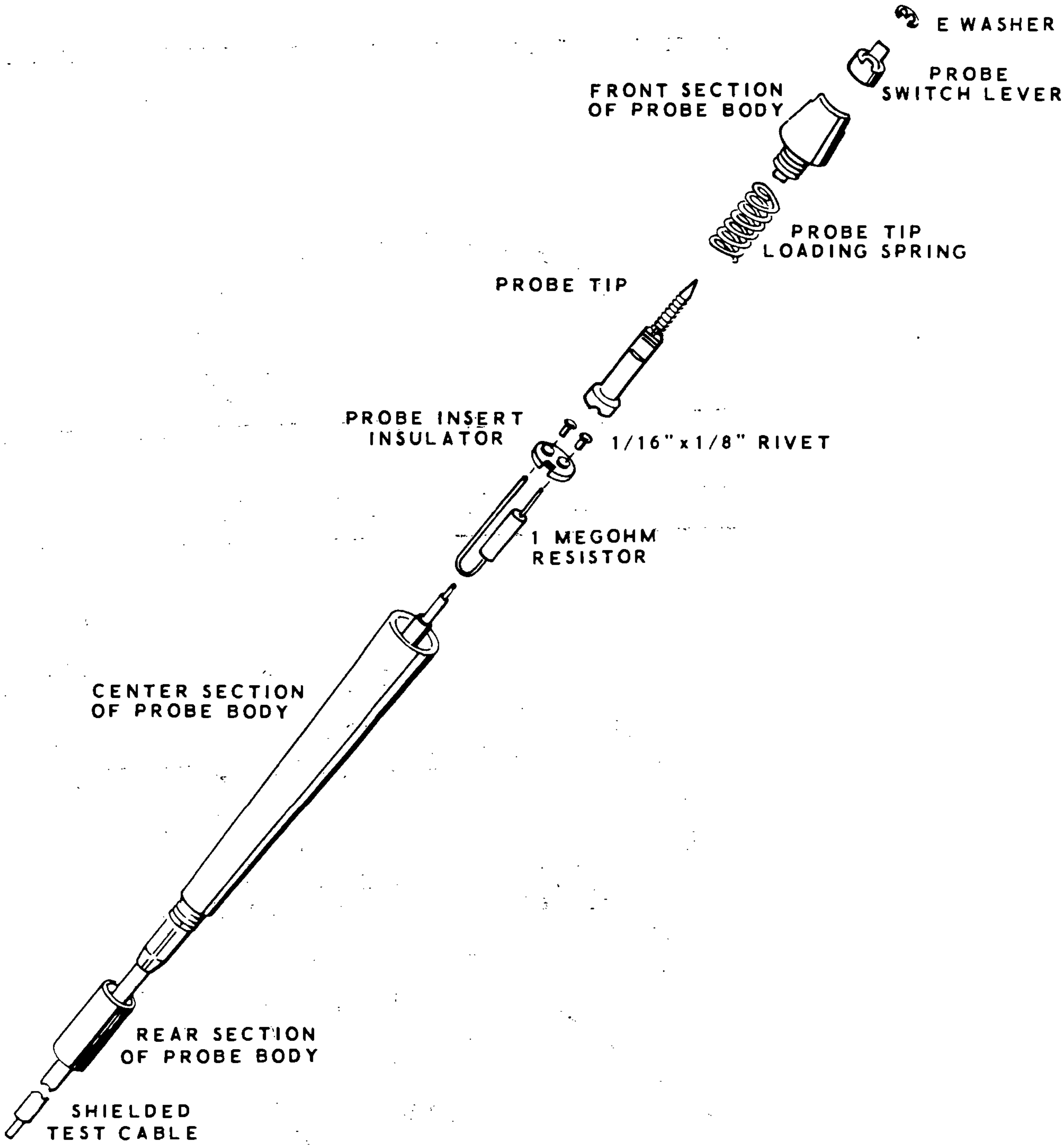
(✓) Check the circuit board carefully to be sure all connections are properly soldered, and that no solder bridge has been made between the foils. Detail 9A shows the locations of switch pins and ends of interconnecting wires that were soldered in the preceding steps.

NOTE: If your Voltmeter was wired for 120 volt operation, there should be only one unsoldered hole on the circuit board. If wired for 240 volt operation, there should be only 3 unsoldered holes. (See Detail 9A.)

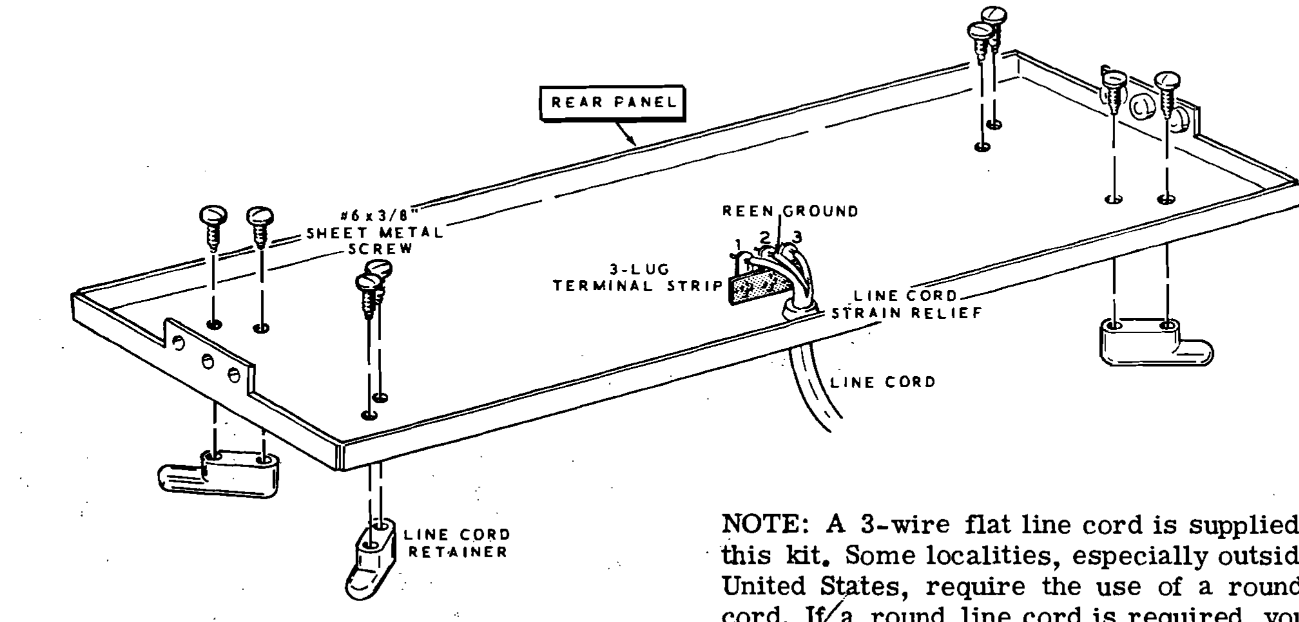
(✓) Set the unit aside temporarily.



PICTORIAL 12



PICTORIAL 13



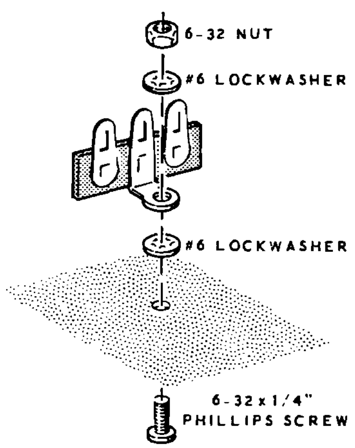
PICTORIAL 10

REAR PANEL ASSEMBLY, WIRING, AND INSTALLATION

Refer to Pictorial 10 for the following steps.

(√) Install a line cord retainer at each corner of the rear panel as shown. Use two #6 x 3/8" sheet metal screws for each retainer.

(√) Mount a 3-lug terminal strip on the rear panel. Use a 6-32 x 1/4" phillips head screw, two #6 lockwashers, and a 6-32 nut. Place a lockwasher on each side of the terminal strip mounting foot as shown in Detail 10A.



Detail 10A

NOTE: A 3-wire flat line cord is supplied with this kit. Some localities, especially outside the United States, require the use of a round line cord. If a round line cord is required, you can purchase one from a local dealer. The following steps will apply to either type.

(√) Separate the three leads of the line cord for about 1". Twist the fine wire strands of each lead and apply a thin film of solder to hold the strands together.

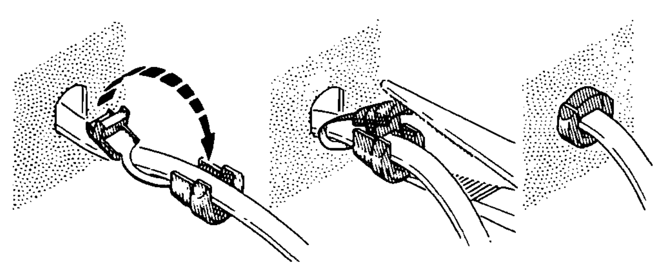
(√) Pass the end of the line cord through the hole in the rear panel.

(√) Connect the green (ground) lead to lug 2 of the terminal strip (S-1).

(√) Connect one of the other line cord leads to lug 1 (NS) and the remaining lead to lug 3 (NS) of the terminal strip.

(√) Install the line cord strain relief as shown in Detail 10B. The strain relief shown is for the flat line cord supplied with the kit. If a round line cord is used, the other strain relief must be used in this same manner.

(√) Wrap the line cord around the four line cord retainers.



Detail 10B

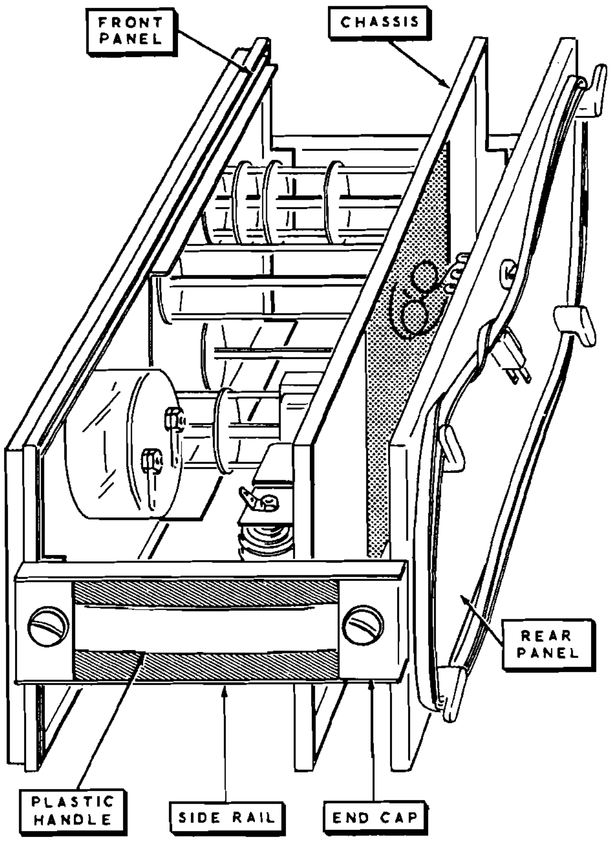
Refer to Pictorial 11 for the following steps.

( ) Position the rear panel behind the chassis as shown in Detail 11A.

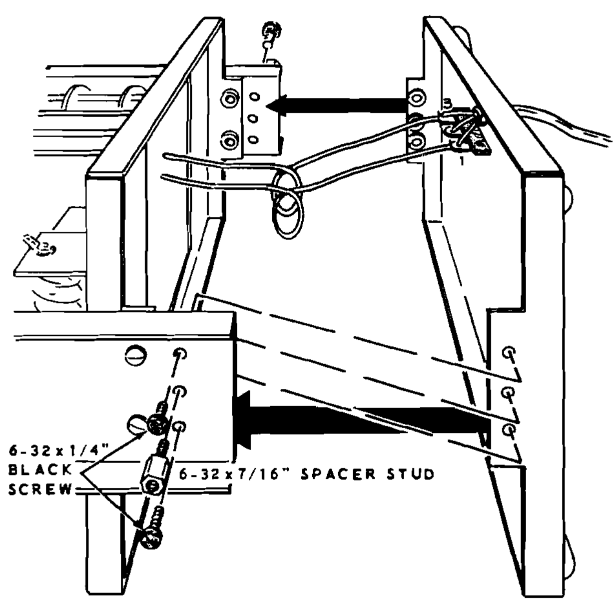
( ) Connect one of the hookup wires that come from LINE on the circuit board to lug 1 on the rear panel terminal strip (S-2). Then connect the other LINE wire to lug 3 on the terminal strip (S-2). Form a loop in each of these wires as shown.

( ) Install the rear panel behind the chassis. Secure the rear panel to the side rails with a 6-32 x 7/16" spacer stud and two 6-32 x 1/4" black screws at each end.

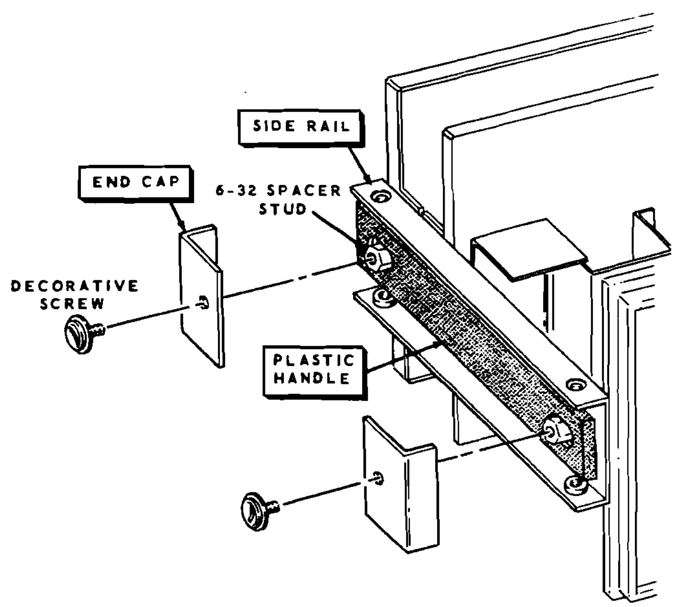
( ) Remove the protective tape from the plastic handles; then install a handle (textured side out) and two end caps in the side rail at each end of the unit. See Detail 11B. Use a coin to tighten the decorative screws into the spacer studs.



PICTORIAL 11



Detail 11A



Detail 11B

METER-KNOBS-BATTERY INSTALLATION

Refer to Pictorial 12 (fold-out from Page 16) for the following steps.

Meter Installation

NOTE: There may be a shorting wire between the terminals of the meter. If so, remove this wire. Then check for tightness of the hardware on the meter terminals. If either solder lug is loose, hold the inner nut with a thin open-end wrench or long-nose pliers while you tighten the outer nut. Be sure the terminal screw does not turn as you tighten the nut.

( ) Install the meter in the front panel as shown in Detail 12A. Use the four lockwashers and nuts that are supplied with the meter. Do not overtighten the nuts.

Connect the red and the black wires from breakout #10 of the cable assembly to the meter as follows:

( ) Red to lug 1 (marked +) (S-1).

( ) Black to lug 2 (S-1).

Connect the blue and the white wires from breakout #10 of the cable assembly to the 1-1/2 volt battery holder solder lugs as follows:

( ) Blue wire to the negative (bottom) solder lug (S-1).

( ) White wire to the positive (top) solder lug (S-1).

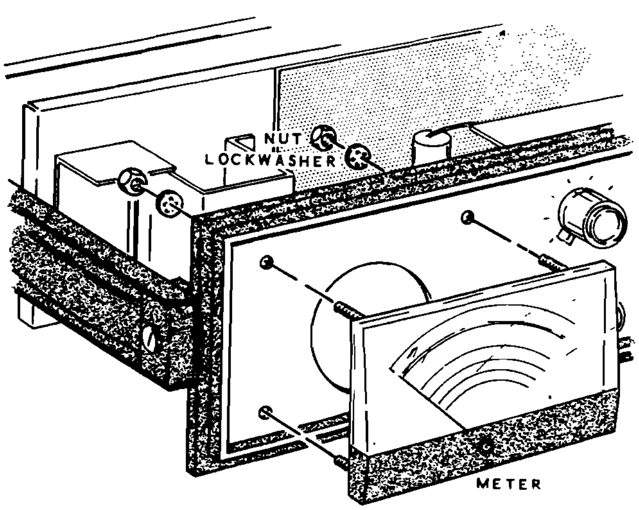
Knob Installation

The knobs supplied with this kit use knob bushings that provide permanent, positive gripping without the use of setscrews.

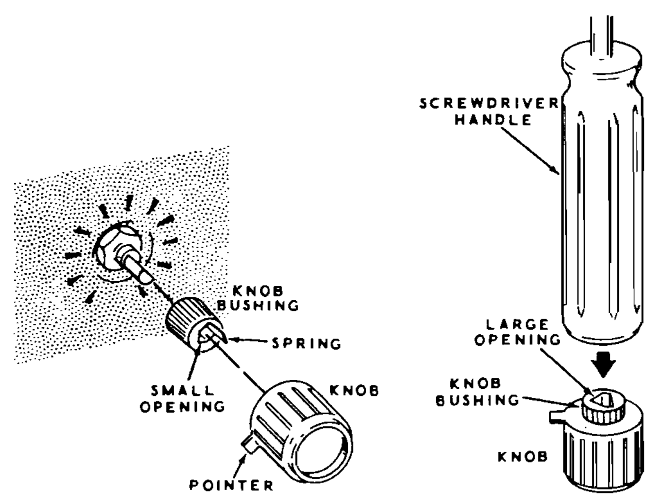
In the following steps you will install a knob on each of the two control shafts and the four switch shafts as shown in Pictorial 12 and Detail 12B. Perform these steps carefully, as a knob bushing is very difficult to remove from a knob once it is fully inserted. Place a towel or soft cloth on your work surface to avoid scratching the knobs.

( ) Locate the two plain knobs (without pointers). Place these knobs on a table or other hard surface; then press a knob bushing into each of the two knobs. See the right-hand drawing in Detail 12B.

( ) Install the two plain knobs on the control shafts at Ohms Adjust and Zero Adjust.



Detail 12A



Detail 12B

( ) Push a knob bushing part way onto each of the four switch shafts. Then turn each of the four shafts to the full counterclockwise position.

( ) At one of the four switch locations, line up the pointer of a knob with the full counterclockwise marking on the panel. Then press the knob slightly onto the knob bushing.

( ) Turn the knob clockwise to each of the switch stop positions. Check to see that the pointer lines up with each panel marking.

NOTE: Perform the next three steps only if the pointer does not line up at each switch marking.

1. ( ) Turn the knob pointer to a mid-position marking on the panel.

2. ( ) Remove the knob from the bushing and turn it slightly to line up the pointer with the mid-position marking.

3. ( ) Press the knob slightly onto the knob bushing. Then turn the knob to each switch position and recheck the pointer alignment. If more than a slight error is noticed at either end position, repeat these three steps.

( ) Carefully remove the knob bushing and knob together.

( ) Place the knob on a table or other hard surface, then press the knob bushing firmly into the knob. Use a towel or soft cloth on the work surface to avoid scratching the knob.

( ) Press the knob and bushing firmly onto the switch shaft.

( ) Repeat the above Knob Installation steps to install knobs on the remaining switch shafts.

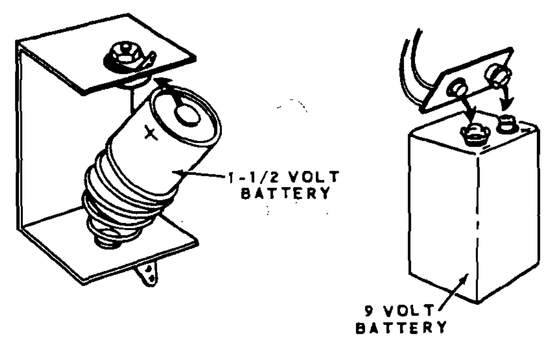
NOTE: Each of the four pointer knobs is now made to match the panel markings at a particular location. If it becomes necessary to remove the knobs at any time, be sure to replace them on their proper shafts.

Battery Installation

Before you install the batteries in your Voltmeter, turn all four switch knobs fully counterclockwise.

NOTE: The 9-volt battery is required for portable operation of the Voltmeter. The 1-1/2 volt battery is required for the Ohms function, whether the unit is being operated from the power line or from the internal 9-volt battery. These batteries are available at your local radio or electronics supply store.

( ) Install the 1-1/2 volt C-cell battery in its bracket. First insert the (-) end of the battery into the battery contact spring. Then press on the battery until its (+) end slips into the positive terminal cup insulator. See Detail 12C.



Detail 12C

( ) Place the 9-volt battery in its bracket. Then snap the battery connector onto the battery terminals. Note that the connector will fit only one way on the battery terminals. The 9-volt battery you use may be loose in the bracket. If so, wedge a small piece of cardboard between the bracket and battery to hold the battery in place.

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

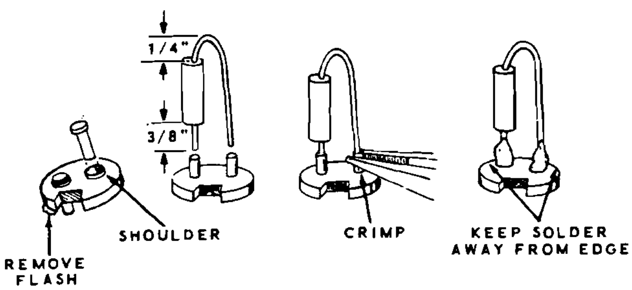
( ) Carefully peel away the backing paper from the blue and white label. Then press the label onto the chassis (or other location).

PROBE ASSEMBLY

Refer to Pictorial 13 (fold-out from Page 16) for the following steps.

( ) Locate the probe insert insulator. If necessary, remove any "flash" or sharp edge from the insert insulator with a file or penknife.

( ) Locate the two small rivets and the remaining 1 megohm (brown-black-green) resistor shown in Detail 13A. Insert the rivets into the holes in the insulator so that the head of each rivet rests on the small shoulder around the hole in the insulator. Now turn the insulator over and lay it flat on the workbench.



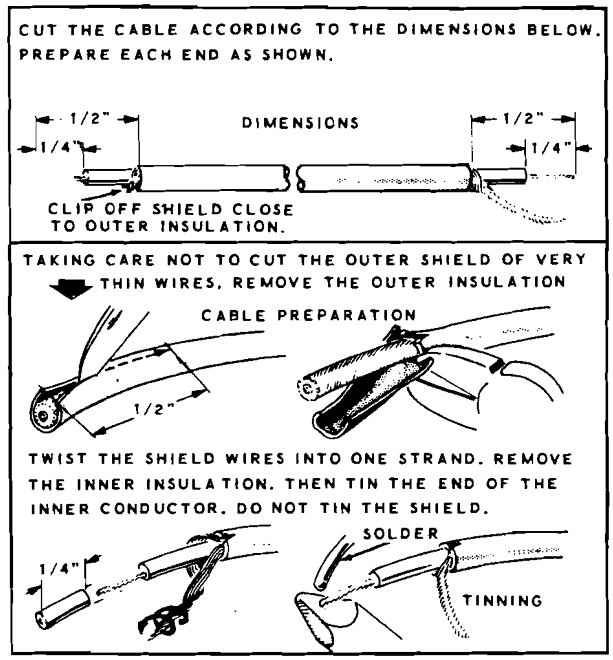
Detail 13A

( ) Cut one resistor lead to 3/8". Bend the other lead over and cut it flush with the first lead as shown in Detail 13A. Squeeze the leads together so that they line up with the rivet holes.

NOTE: Before proceeding further, check the position of the resistor on the insulator. With the notch in the insulator facing you, the resistor should be on the left-hand side as shown in Detail 13A.

( ) Insert the resistor leads into the rivets and lightly crimp the rivets with long-nose pliers or diagonal cutters to hold the resistor.

( ) Solder the resistor leads to the rivets. Make sure the resistor is square with the insert insulator and that the solder flows down the rivet to hold the rivet tight against the shoulder. NOTE: Keep solder away from the edge of the insert insulator to provide clearance for the internal shoulder of the probe center section.

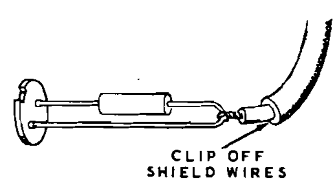


Detail 13B

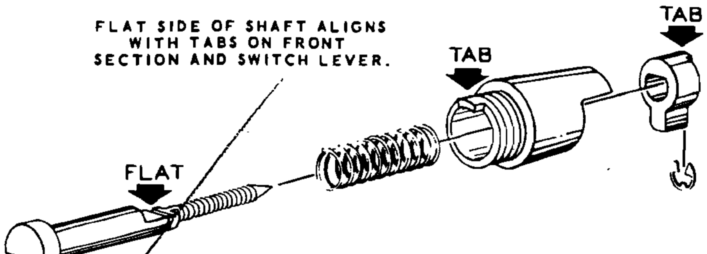
Refer to Detail 13B and prepare the shielded cable as shown.

NOTE: In the following steps, take special care to avoid melting or cutting the inner plastic insulation of the shielded cable. When soldering, hold the wire with long-nose pliers near the insulation to conduct the heat away from the plastic insulation.

( ) Wrap the end without the shield around the curved lead of the resistor and solder as shown in Detail 13C. Use only enough heat to cause a good solder connection, being careful not to melt the inner insulation of the shielded cable.



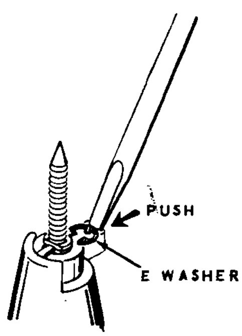
Detail 13C



Detail 13D

( ) Refer to Detail 13D for assembly of the front section of the probe. Check the probe tip for burrs and, if necessary, remove any burrs before assembly. Assemble the probe tip, the spring, the front section of the probe body, and the switch lever as shown.

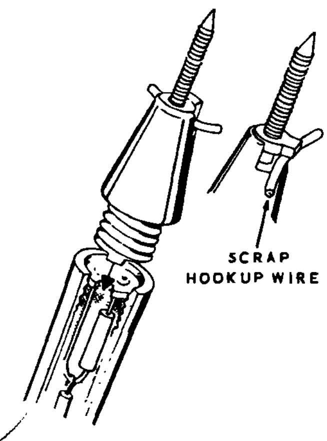
( ) Push the switch lever flush against the front section of the probe body so that the small retaining ring notch in the spike is exposed. While holding the spike in firmly against the spring pressure with one hand, use a screwdriver or penknife to insert the retaining E washer into the notch in the spike as shown in Detail 13E. When this E washer is securely in place, the spike will be locked to the front section of the probe body.



Detail 13E

Refer to Detail 13F for final assembly of the test probe.

( ) Pull the switch lever forward against the spring tension and temporarily insert a scrap piece of hookup wire between the switch lever and the front section of the probe body.



Detail 13F

( ) Slip the center section of the probe body onto the shielded cable.

( ) Gently pulling the shielded cable from the back of the center section, align the insert insulator flush with the front of the center section. Do not pull the insert insulator all the way into its final shoulder seat.

( ) Insert the tab on the front section of the probe body into the notch in the insert insulator. Holding the front section stationary, screw the center section onto the front section, thus pushing the insert insulator down to its final seat. It is imperative that the final probe assembly be carried out in this manner; otherwise, proper connection between the rivet heads and the front section of the probe will not be made.

( ) Remove the scrap hookup wire.

NOTE: If the gap between the front and middle sections is not considerably less than 1/16", the tab is not properly seated in the notch and the above steps must be repeated. Also, when properly assembled, the switch lever will noticeably "detent," or drop into place at both extreme switch positions.

( ) Slip the rear section of the probe onto the cable and screw it onto the center section.

This completes the assembly of the test probe. The phone plug and alligator clip will now be assembled.

( ) Strip 1/2" of insulation from both ends of the black test lead.

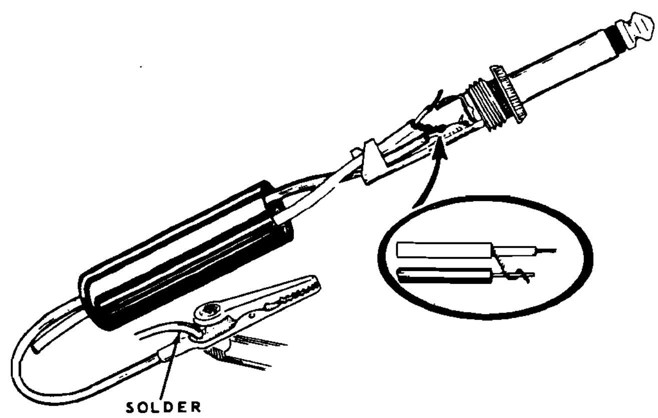
( ) Unscrew the cap from the phone plug.

( ) Insert the test lead cable and the free end of the shielded cable through the phone plug cap.

( ) Now twist the shield wires of the shielded cable and the wires at the end of the black test lead firmly together and melt a small amount of solder on the combined wires as shown in Detail 13G. Also melt a small amount of solder on the inner conducting wire of the shielded cable. Take care not to melt the inner insulation.

In the following step, you will connect the prepared cables to the phone plug as shown in Detail 13G. To avoid overheating the cable insulation, first apply a film of solder to the phone plug terminals and heat thoroughly; then hold the wires to the phone plug and apply just enough heat to melt the solder.

( ) Refer to Detail 13G and solder the two twisted wires to the phone plug. Be careful not to melt or burn the inner plastic insulation of the shielded cable. Then solder the inner wire of the shielded cable as shown.



Detail 13G

Be sure the phone plug body will still fit over the wires. Use only enough heat to melt the solder and make a good connection.

( ) After the wires have completely cooled, use pliers to bend the tabs on the phone plug over lightly to secure the black cable. Then screw the cap onto the phone plug.

( ) Melt a small amount of solder on the strands of the free end of the black test lead and solder it to the alligator clip as shown.

This completes the phone plug assembly.

CALIBRATION

Three internal adjustments are required to calibrate the Solid-State Voltmeter. These adjustments are: Bias, DC Cal, and AC Cal. The Bias adjustment provides the correct DC gate voltage to the field effect transistor, while the DC Cal and AC Cal adjust the sensitivity of the circuit.

The calibration of your Voltmeter must be done carefully and accurately, since these adjustments determine the overall accuracy of the instrument. Refer to Figures 1 and 2 (fold-out from Page 25) for location of the adjustments, controls, and switches.

If at any time you do not obtain the results indicated in a step, refer to the In Case Of Difficulty section on Page 30. Locate and repair any problem before you continue with the adjustments.

BIAS ADJUSTMENT

( ) Turn the three internal controls (AC Cal, DC Cal, and Bias) fully counterclockwise.

( ) Set the front panel switches and controls as follows:

VOLTS switch. . .fully counterclockwise
OHMS switch. . . .fully counterclockwise
OHMS ADJUST control. .fully counterclockwise.
POWER switch. . .OFF
FUNCTION switch. . .DC+
ZERO ADJUST control. . .center of rotation (See the following Note.)

NOTE: The OHMS ADJUST and ZERO ADJUST controls have 10-turn planetary drives. To set the ZERO ADJUST control to the center of its rotation, first turn the knob all the way in one direction (until the three balls in the rear of the control stop turning). Then attach a small piece of tape to the knob and turn the knob five revolutions in the opposite direction and remove the tape.

( ) Check the position of the meter pointer. If it does not rest directly over the "0" marks at the left end of the scales, turn the meter zero screw with a small screwdriver. The meter zero screw should only be adjusted during the calibration of the instrument.

( ) Plug the probe phone plug into the input jack, and turn the probe switch to DC. Clip the common test lead to the probe tip.

( ) Connect the line cord plug to an AC outlet. (120 volt if you wired the Voltmeter for 120 volt operation, or 240 volt if wired for 240 volt operation.)

( ) Turn the POWER switch to LINE. The meter pointer should deflect off-scale to the left.

( ) Very slowly turn the BIAS adjustment until the meter indicates "0".

( ) Turn the ZERO ADJUST control fully clockwise. The meter should indicate approximately 1.5 on the black 15 scale.

( ) Turn the ZERO ADJUST control counterclockwise until the meter indicates zero. Then change the FUNCTION switch to DC-, and continue to turn the ZERO ADJUST control until fully counterclockwise. The meter should again indicate approximately 1.5 on the black 15 scale.

( ) Return the ZERO ADJUST control to the center of its rotation where the meter indicates zero. Set this control carefully so the meter remains at zero while changing the FUNCTION switch back and forth between DC- and DC+.

DC CALIBRATION

The DC calibration of the Voltmeter can be made with a fresh (unused) C-cell battery. However, if a highly accurate voltmeter or a dependable .5 volt reference voltage is available, calibration accuracy may be improved.

A fresh C-cell battery should measure 1.55 volts. The red dot at the right-hand end of the 15 scale indicates this 1.55 volts when the VOLTS range switch is in the 1.5 position. Perform the following steps to calibrate the DC scale with a fresh C-cell battery. You may use the ohms battery for these steps.

( ) Turn the VOLTS range switch to 1.5, and the FUNCTION switch to DC+. Zero the meter with the ZERO ADJUST control.

( ) Touch the common test lead to the negative end, and the probe tip to the positive end of the C-cell battery.

( ) Carefully adjust the DC Cal control until the meter pointer rests over the red dot at the right of the 15 scale.

DC calibration is now complete. If you have another accurate voltmeter or reference voltage, you may wish to check the DC calibration by comparison.

AC CALIBRATION

An AC voltage source and another AC voltmeter are required for accurate AC calibration. However, the AC line voltage may be used for nominal accuracy, as described in the following steps.

( ) Turn the FUNCTION switch to AC, and the test probe switch to the AC position.

( ) Set the VOLTS range switch to 150 if your Voltmeter was wired for 120 volt operation (500 if wired for 240 volt operation).

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

NOTE: The common test lead will connect one side of the power source directly to the subpanel in the Voltmeter. Be sure to connect the common test lead to the ground side of the voltage source. Use a screwdriver with an insulated handle to make AC Cal adjustments on the subpanel.

( ) Connect the common test lead to the ground side of the AC power line, and the test probe tip to the hot side of the power line.

( ) Carefully adjust the AC Cal control until the meter indicates the line voltage.

( ) Disconnect the test probe and common lead from the power source.

If you have an accurate AC voltmeter, you can check the AC calibration of your Voltmeter by first checking the source voltage with one voltmeter and then with the other. Adjust your IM-16 Voltmeter AC Cal control for an identical reading. Always calibrate on the 50 volt, or higher, scale.

OHMS ADJUSTMENT

After the Bias Adjust and ZERO ADJUST controls have been properly set for DC voltage measurements, the OHMS ADJUST control will calibrate the ohmmeter circuit for resistance measurements. In the following steps you will adjust and check the ohmmeter operation.

( ) Set the FUNCTION switch to Ohms, and the OHMS range switch full clockwise to RX-1 MEG.

( ) Turn the OHMS ADJUST control clockwise until the meter pointer rests over the last mark at the right-hand end of the green Ohms scale.

( ) With the test probe switch in the AC-OHMS position, touch the probe tip to the common test lead. The meter should return to zero.

( ) Turn the test probe switch to the DC position and again touch the probe tip to the common lead. The meter should now indicate approximately 1 on the Ohms scale. This is the 1 megohm resistance in the probe, and its tolerance may result in a reading slightly different from 1 megohm.

( ) Change the OHMS range switch to RX 100K. The meter should now indicate approximately 10 when the probe tip is touched to the common lead.

( ) Turn the OHMS range switch to RX1, and the probe switch to the AC-OHMS position. Touch the probe tip to the common lead and the meter should indicate almost zero. Note that the resistance of the test leads may be as much as .2 ohms, which is indicated on the meter. This is a normal condition, and this test lead resistance should be considered in critical low resistance measurements.

Your Voltmeter is now completely calibrated. Proceed to the Final Assembly instructions that follow.

FINAL ASSEMBLY

Refer to Pictorial 14 for the following steps.

( ) Place one of the cabinet shells over the Voltmeter chassis with the sloping edge of the shell toward the front. Secure the cabinet shell to the side rails with two 6-32 x 1/4" phillips head screws at each end as shown in Pictorial 14.

( ) Turn the Voltmeter over and install the other cabinet shell. Use two 6-32 x 1/4" phillips head screws at each end.

( ) Refer to Detail 14A and install a plastic foot near each corner on the bottom cabinet shell. Remove the paper backing; then press the foot onto the cabinet shell in the position shown. A plastic foot can be moved, if necessary, up to one-half hour after the backing is removed. After this, the adhesive permanently bonds the foot to the cabinet shell.

This completes the assembly of your kit. The following pages present information on Operation to help you make the best use of your Voltmeter.

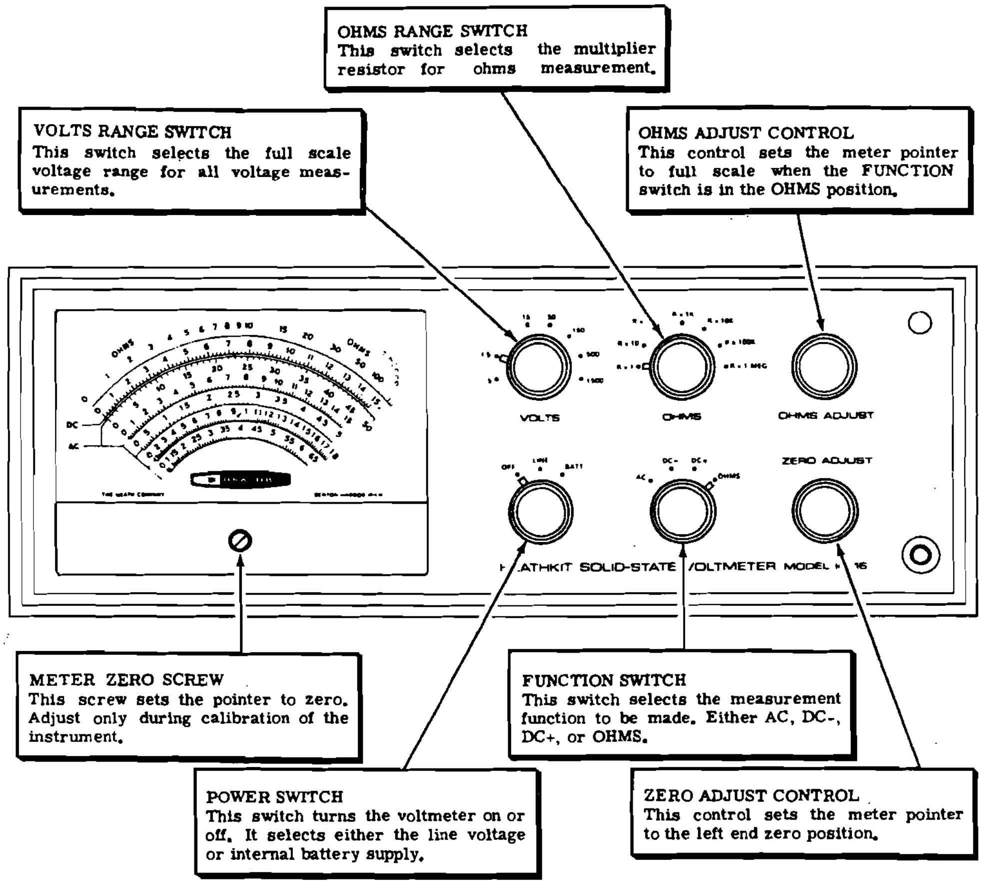


FIGURE 1

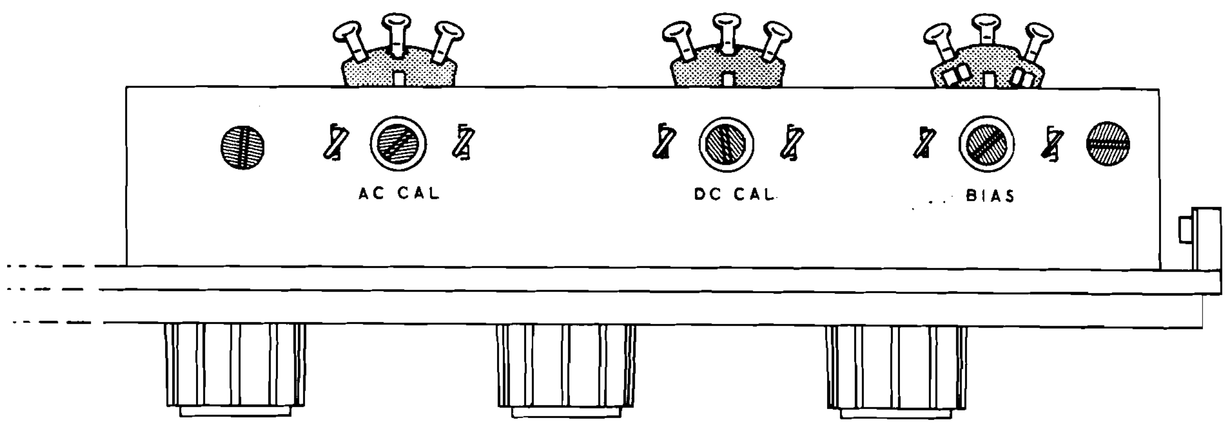
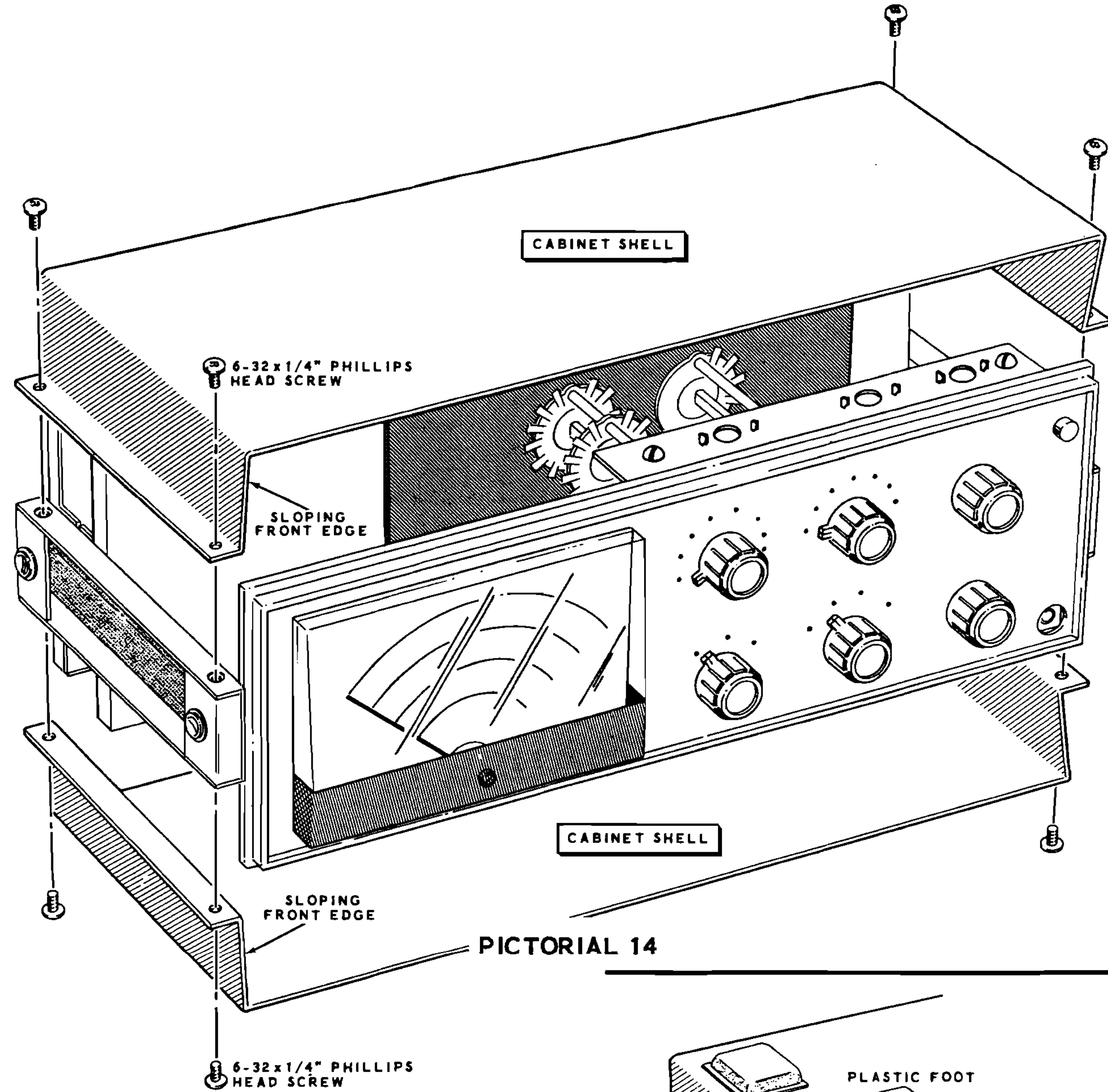
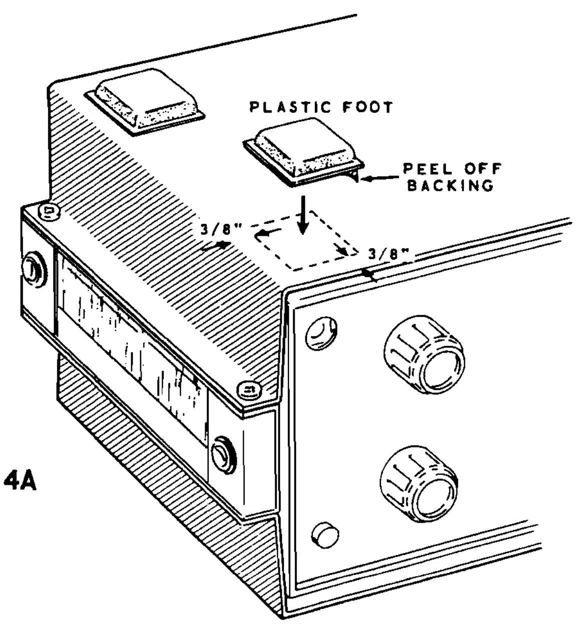


FIGURE 2



PICTORIAL 14



Detail 14A

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 the daily work period rather than turning it off each time a measurement function is completed, when operating from a power line. However, to prevent drain on the ohmmeter battery, do not leave the FUNCTION switch set in the OHMS position longer than is necessary to make resistance measurements.

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.

COMBINATION PROBE

The combination AC-OHMS/DC test probe eliminates two of the usual three test jack installations on the Voltmeter front panel. The probe switch should be set to AC-OHMS for all AC voltage measurements, and resistance measurements. The DC position of the probe switch is used only for DC voltage measurements. The probe can be clipped onto any lead in the circuit, by installing the alligator clip on the threaded probe tip as shown in Figure 3.

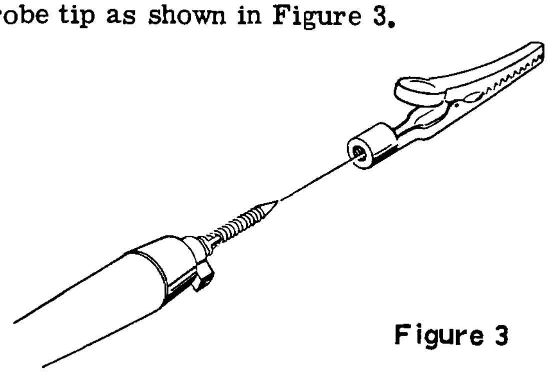


Figure 3

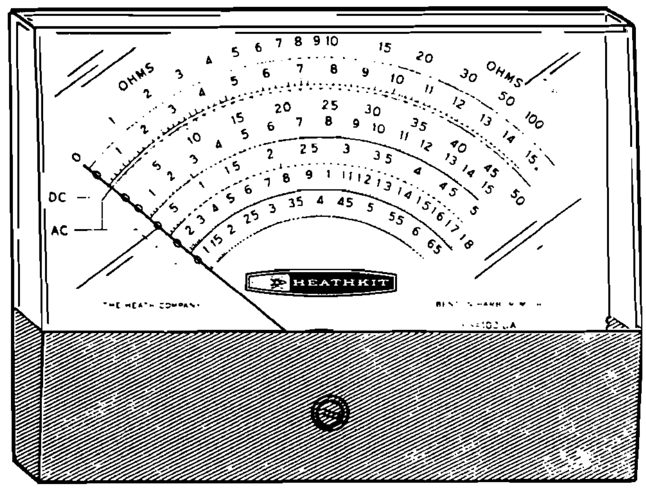


Figure 4

READING THE METER

Figure 4 shows the scales and markings on the face of the meter. Before making any voltage or resistance measurements with your Voltmeter, be sure to check the zero position of the pointer with the FUNCTION switch at DC+ and DC-. Turn the ZERO ADJUST control, if necessary, to zero the meter.

Resistance (Ohms) Readings

The probe switch must be in the AC-OHMS position, and the FUNCTION switch at OHMS, when making resistance measurements. Turn the OHMS ADJUST control until the pointer rests over the last green mark at the right-hand end of the Ohms scale. Do not change the setting of the ZERO ADJUST control while making resistance measurements.

The figures on the green Ohms scale are multiplied by 1, 10, 100, etc., according to the setting of the OHMS range 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 RX 1K position indicates that the meter scale should be multiplied by 1000 (K = 1000). RX 100K would multiply the reading by 100,000, etc. The last clockwise position of the OHMS range switch is marked RX 1 meg. Megohm means 1,000,000 ohms, so the meter reading would be multiplied by 1,000,000.

Resistance is measured by clipping the common test lead and the test probe tip to the two ends of the unknown resistance. The OHMS range switch is then turned to a position where a clear reading is given on the meter. Multiply the reading as indicated by the switch position.

NOTE: Although a battery is used to measure resistance, the indication is obtained through the electronic meter circuit; therefore the instrument must be turned on. Some ohmmeter battery current is drawn whenever the instrument is turned on and the FUNCTION switch is in the OHMS position. To save battery life when you are not using the ohmmeter, NEVER LEAVE THE FUNCTION SWITCH IN THE OHMS POSITION.

DC Voltage Readings

For DC voltage measurements, the probe switch must be in the DC position. The FUNCTION 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 FUNCTION switch changed to DC+ or DC- for the appropriate polarity.

DC voltages are read on either of the two black meter scales, which are marked 0-15 and 0-50. The markings on the VOLTS range switch refer to the voltage that will give a full-scale reading on either of the black scales when measuring DC voltage.

The lowest VOLTS range switch position is marked .5. This means that .5 volt applied to the probe tip will cause a full-scale deflection of the meter pointer, or indicate 50 on the scale. To read voltage in the .5 volt range, read the 50 scale and move the decimal two places to the left. For example, a reading of 20 would indicate .2 volt.

To read voltage on the 1.5 volt range, read the 15 scale and move the decimal one place to the left. For example, a meter reading of 8 would indicate an actual measurement of .8 volt. For the 5 volt range, read the 50 scale and move the decimal one place to the left. For example, a meter reading of 40 would indicate a measurement of 4 volts.

On the 15 V range, read the 15 scale directly. On the 50 V range, read the 50 scale directly. On the 150 V range, read the 15 scale and move the decimal one place to the right. For example, a meter reading of 13 would indicate 130 volts. On the 500 V range, read the 50 scale and move the decimal one place to the right. For example, a meter reading of 40 would indicate 400 volts. When using the 1500 V range, use the 15 scale and move the decimal two places to the right. For example, a meter reading of 12 would indicate 1200 volts.

AC VOLTAGE READINGS

The FUNCTION switch and the probe switch must be in the AC position for AC voltage measurements. With the VOLTS range switch in one of the four clockwise positions (50, 150, 500, or 1500), AC voltages are read on one of the two black scales, in the same manner as DC voltages. For the four lower AC voltage ranges (.5, 1.5, 5, or 15), separate scales, printed in red, are provided.

When the VOLTS range switch is in the .5 position, AC voltage is read directly on the bottom red scale of the meter. Note that this scale extends to .65 and the .5 reading is approximately 2/3 of full scale. Thus, the .5 volt AC range is actually extended to .65 volts.

In the 1.5 position of the VOLTS range switch, AC voltage is read directly on the second red scale from the bottom. This scale extends the 1.5 volt range to 1.8 volts.

Read the third and fourth red scales (5 and 15) directly when the VOLTS range switch is in the 5 and 15 positions respectively. The black 50 scale is read directly for the 50 volt AC range, or multiplied by 10 for the 500 volt AC range.

The black 15 scale is used for the 150 and 1500 positions of the VOLTS range switch. For the 150 volt range, multiply the reading by ten. For the 1500 volt range, multiply the reading by 100.

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 networks, and on oscillator grids.

To illustrate this advantage of the 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 5.

Assuming that the actual plate voltage in this case is 50 volts, therefore, the tube 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 5A. 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.

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 5B. 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.

AC VOLTAGE MEASUREMENTS

To measure AC voltage with the Voltmeter, set the FUNCTION switch and the probe switch to AC.

Set the VOLTS range 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 VOLTS range switch to 1500. Then touch the test probe to the point in the circuit where the voltage is to be measured. If the meter moves less than 1/2 of full scale, switch to the next lower range. The maximum AC voltage that can be safely measured with your VOM is 1500 volts, and this limit must not be exceeded.

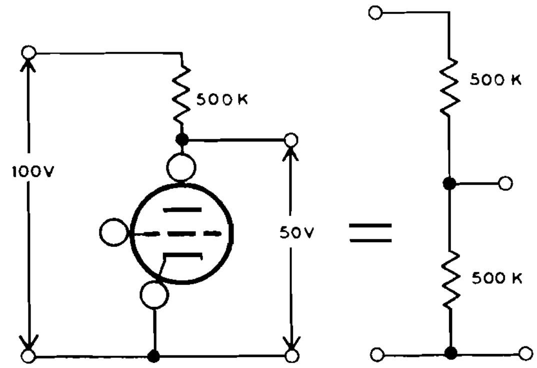


Figure 5

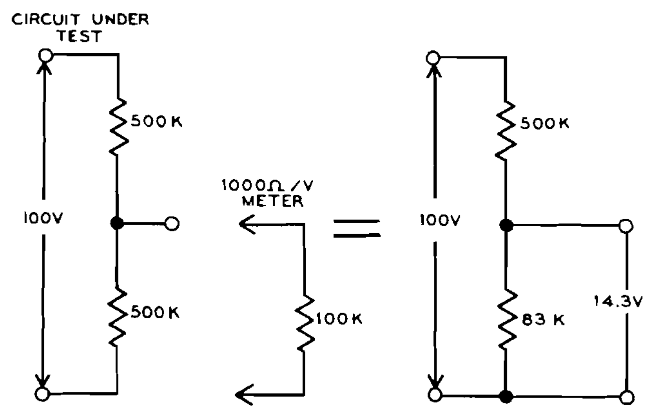


Figure 5A

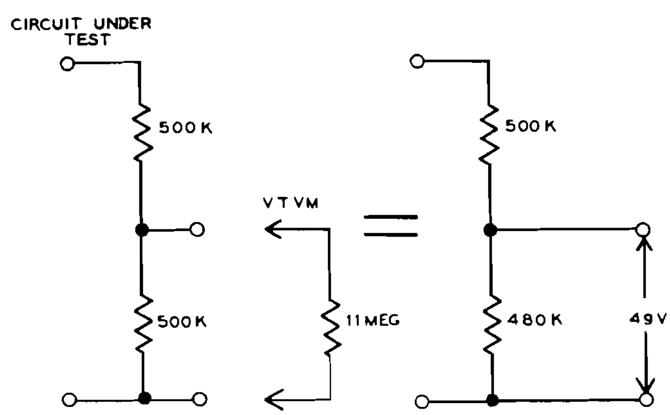


Figure 5B

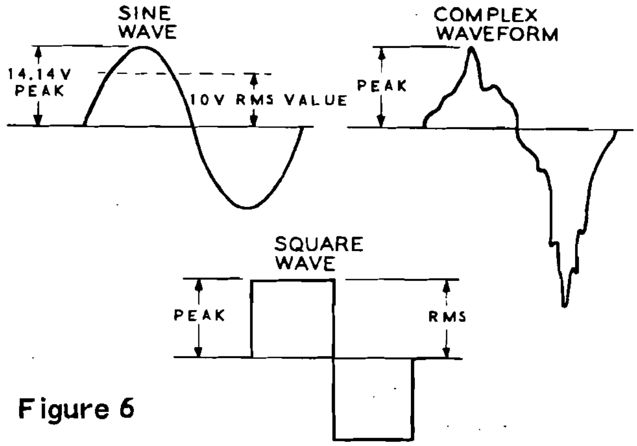


Figure 6

The AC meter scales 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 6, 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. The voltmeter responds only to the positive peaks of AC voltages. Therefore, when measuring nonsymmetrical 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 capacitance loading may usually be disregarded. Thus, the load the Voltmeter presents to the circuit being measured is about the same as 1 megohm resistor. At higher frequencies, the capacitive reactance decreases. At 10 kHz for example, it is approximately 100 K ohm. Such a value may seriously affect the voltage at the point of measurement.

The amount of loading presented by the input capacitance and resistance of the Voltmeter to the circuit being tested 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.

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 VOLTS Range 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 Function switch.

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.

IN CASE OF DIFFICULTY

This section of the Manual is divided into two parts. The first part, titled General Troubleshooting Information, describes what to do about any difficulties that may occur right after the Voltmeter is assembled.

The second part, a Troubleshooting Chart, is provided to assist in servicing if the General information does not clear up the problem, or if difficulties occur after the Voltmeter has been in operation for some time. This Chart lists a number of possible difficulties that could arise, and lists several possible causes.

Before starting any troubleshooting procedure, try to narrow the problem down to a specific area by trying the various functions of the instrument.

GENERAL TROUBLESHOOTING INFORMATION

The following paragraphs deal with the types of difficulties that may show up right after a kit is assembled. These difficulties are most likely to be caused by assembly errors or faulty soldering. These checks will help you locate any error of this type that might have been made.

NOTE: Refer to the Kit Builders Guide for Service and Warranty information.

1. Recheck the wiring. It may be helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the builder.
2. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the soldering section of the Kit Builders Guide.
3. Check the values of the parts. Be sure that the proper part has been wired into the circuit, as shown in the Pictorial diagrams and as called out in the wiring instructions. Pay special attention to resistor values, since there are many resistors of similar value, and they are easily interchanged.
4. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.
5. Check for solder bridges between circuit board foils.
6. If, after careful checks, the trouble is still not located, and another voltmeter is available, check voltage readings in the circuits of your Voltmeter against those shown on the Voltage Chart (fold-out from Page 40) and Schematic. NOTE: All voltage readings were taken with an 11 megohm input voltmeter. Voltages may vary as much as ±10%.
7. A review of the Circuit Description on Page 34, and a study of the Schematic (fold-out from Page 43 will also help you locate a difficulty in the Voltmeter. Refer to the X-Ray view of the circuit board on (fold-out from Page 40) to help locate parts.

Troubleshooting Chart

DIFFICULTY	POSSIBLE CAUSE
Completely inoperative in either Line or Batt position of the Power switch.	NOTE: Possible causes 1, 2, 3, and 4 would only cause trouble in the LINE position of the Power switch. 1. Power transformer. 2. Diode D4. 3. Capacitor C4. 4. Resistor R31. 5. Zener diode D5 shorted. 6. Meter coil open. 7. Transistors Q5 and Q6. 8. Dead batteries (Batt position of Power switch only).
Zero control has no effect.	1. FET Transistor Q1. 2. Zero control R19. 3. Bias control R18 and R20 misadjusted. 4. Resistor on voltage divider string, R4 through R14.
Inaccurate DC readings.	1. DC Calibration control R26 misadjusted. 2. Probe switch in wrong position. 3. Wrong value or defective resistor in the voltage divider string, R4 through R14.
AC inoperative.	1. Resistor R15. 2. Diode D1. 3. Capacitors C1 or C2. 4. Resistor in AC input voltage divider R2, R3. 5. Resistors in voltage divider string R4 through R14. 6. Transistors Q2 or Q3.
AC inoperative (500-1500 ranges only).	1. Diodes D2, D3. 2. Resistors R2, R3.
Inaccurate AC readings.	1. Probe switch in wrong position. 2. AC Calibration control R25 misadjusted.
Ohmmeter inoperative or inaccurate readings.	1. Probe switch in wrong position. 2. Transistor Q7. 3. Battery E2 weak. 4. Resistors in voltage divider string R4 through R14.
Zero shift when turning Range switch.	1. FET Transistor Q1.

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.

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

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.

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 30 volts; its response is substantially flat from 1000 Hz to 100 MHz. A built-in isolating capacitor permits a DC voltage range of up to 500 volts. It uses a printed circuit board for easy assembly and its housing is of polished aluminum with polystyrene insulation.

SPECIFICATIONS

DC VOLTMETER

Eight Ranges	.5, 1.5, 5, 15, 50, 150, 500, 1500 volts.
Input Resistance	11 megohms on all ranges.
Accuracy	± 3% of full scale.

AC VOLTMETER

Eight Ranges	.5, 1.5, 5, 15, 50, 150, 500, 1500 volts.
Input Resistance	1 megohm.
Accuracy	± 5% full scale.
Frequency Response	±2 dB from 20 Hz to 1 MHz.

OHMMETER

Seven Ranges	x1 (10 Ω center scale), x10, x100, x1K, x10K, x100K, x1 megohm.

INPUT

Probe with shielded cable	AC-OHMS/DC switch in probe. Single plug for probe and common connections. Circuit ground isolated from cabinet.

POWER SUPPLIES

Amplifier Circuit	
Power Line	105-125/210-250 volts, 50/60 Hz, AC.
Battery	9 volt, NEDA 1602 or equivalent.
Ohms Circuit	
Battery	1.5 volt (one C-cell).

GENERAL

Voltage Dividers	1 percent precision resistors.
Meter	6", 100 μA, 100 degree movement.
Transistor-Diode Complement	1-Field effect transistor (FET). 6- 2N3393 silicon transistors. 1- 6.8 volt zener diode. 4- silicon diodes.
Color	Beige, velvet finish.
Dimensions	16-3/8" long x 7-3/4" deep x 5-7/8" high.
Net Weight	7-1/2 lbs. (with batteries)

CIRCUIT DESCRIPTION

For a more complete understanding of the circuits, refer to the Schematic Diagram (fold-out from Page 43) while you read this Circuit Description. Several partial schematics are provided to help explain individual circuits.

The Solid-State Voltmeter consists of the following four major sections, which will be described separately in this Circuit Description.

1. Probe.
2. Three input circuits.
3. Output circuit.
4. Power supply.

PROBE

The combination AC-OHMS/DC probe contains a switch and a 1 megohm resistor. When the probe switch is in the DC position, the 1 megohm resistor (R1) is connected in series between the probe tip and the input jack of the Voltmeter. This resistor reduces the loading of circuits under test. In the AC-OHMS position, the probe switch bypasses resistor R1, eliminating it from the circuit. A voltage applied to the probe tip is connected through the input jack to the Function switch.

INPUT CIRCUITS

The three input circuits (AC Volts, DC Volts, and Ohms) are shown on the left-hand side of the Schematic. These circuits perform the switching, attenuating, and rectifying required to supply the correct voltages to the output circuits that are drawn on the right-hand side of the Schematic. Approximately .5 volt is required at the gate of input transistor Q1 for full-scale deflection of the meter. Voltages greater than .5 are attenuated in the input circuits.

DC Volts Input Circuit (Figure 7 fold-out from Page 26)

When the probe and Function switch are set to measure DC volts, a voltage applied to the probe tip passes through resistor R1 in the probe to the voltage divider circuit that consists of resistors R4 through R14. Wafer 3 of the Volts range switch selects the proper tap on the voltage divider for the voltage being measured. Each position of the Volts range switch is marked on the front panel to indicate the full-scale voltage for that position.

The total resistance of the divider network is fixed at 10 megohms. The ratio between the total divider resistance and the resistance from a selected tap to common, is the ratio in which the applied voltage is divided at that tap. For example, if the Volts range switch is in the 500 position, there is a resistance of 10,000 ohms from the tap to common. This is one-thousandth of the 10 megohm total divider resistance and the input voltage will be divided in the same ratio. Thus, if 500 volts is applied to the input, .5 volt will appear at the 500 tap of the voltage divider.

The voltage from the divider tap passes through wafer 4 of the Function switch and resistor R16 to input transistor Q1. In the .5 position of the Volts range switch the applied voltage is not divided since .5 volts is required at the gate of transistor Q1 for full-scale deflection of the meter.

AC Volts Input Circuit (Figure 8 fold-out from Page 35)

With the probe and Function switch set to measure AC volts, resistor R1 (in the probe) is bypassed. An AC voltage applied to the probe tip passes through the input jack and capacitor C1 to wafer 1 of the Volts range switch. Capacitor C1 prevents passage of DC voltage so AC voltage components in DC circuits may be measured.

In the first six positions of the Volts range switch (.5 through 150) the AC voltage passes through wafers 1 and 2 of the switch and is rectified by diode D1. In the 500 and 1500 positions of the switch, diodes D2 and D3 form a series rectifier circuit with D1. The three series diodes are capable of handling the higher voltages on these two ranges. On the 1500 range, the input voltage is divided in a ratio of approximately 3 to 1 by resistors R2 and R3 before reaching the diodes. These resistors also form a DC return path for the diode circuit in all positions of the Volts range switch.

The rectified output voltage from diode D1 charges capacitor C2 to the positive peak value of the AC voltage. This DC voltage then passes through resistor R15 to the voltage divider circuit of resistors R4 through R14. The voltage divider function is the same as for the DC volts input circuit, with one exception. Since the AC input voltage on the 1500 volt range was divided by resistors R2 and R3 in the ratio of approximately 3 to 1, the DC (rectified AC) voltage is divided in the same ratio as the 500 volt range. The voltage from the divider then passes through wafer 4 of the Function switch, and resistor R16, to transistor Q1 and the output circuit.

Ohmmeter Circuit (Figure 9 fold-out from Page 39)

When the Function switch is in the Ohms position, battery E2, resistor R33, and transistor Q7 form a constant current power supply. Ohms Adjust control R17 sets the base bias for transistor Q7 so the voltage across R14 (approximately 150 mA) coupled to transistor Q1, will cause a full-scale deflection of the meter.

Assume the Ohms range switch to be in the Rx1 position, and the Ohms Adjust control set for full-scale meter deflection. If an external resistance (R_X) of 10 ohms is connected between the probe tip and the common lead, it would parallel the internal 10 ohm resistor (R14) and result in a resistance of 5 ohms. Since the current in this circuit is constant, the voltage would be reduced proportionately, causing the meter to read half scale.

Note that the center mark on the Ohms scale is 10, but the other divisions are not in proportion (not linear).

For other positions of the Ohms range switch, the internal resistance between the divider tap and common always adds up to a multiple of ten, and is equal to the center scale reading of the meter.

Input Transistor Q1

Transistor Q1 is a field effect transistor (FET). The high input impedance of the FET keeps it from loading the input switching and attenuating circuits. A constant current source, transistor Q4, is used in place of a resistor in the source (S) circuit of FET Q1.

Since the electrical operating characteristics of FET transistors vary widely from one transistor to another, a Bias Adjust control and a Zero Adjust control are provided. The dual Bias Adjust control, R18 and R20, determines the DC voltage range available to bias the gate (G) of Q1. Zero Adjust control R19 is used as a finer gate bias adjustment so that the meter pointer can be set to the left end zero mark when no signal voltage is passed through the input switching and attenuating circuits.

Transistors Q2 and Q3, with resistor R16, are used to protect FET Q1 and the output circuit from severe accidental overloads. Q2 and Q3 are connected in a parallel circuit that performs like a 9-volt zener diode. That is, this circuit presents an infinite impedance to input voltages up to about 9 volts, but acts like a short circuit to higher voltages. Excess voltages would then be dropped across resistor R16.

OUTPUT CIRCUIT (Figure 10 fold-out from this page)

The heart of the Solid-State Voltmeter is the output circuit. The switching, attenuating, and rectifying that is done in the circuits shown on the left side of the Schematic provide the correct signal voltage to the output circuit. Whether AC or DC voltage, or resistance, is being measured, the meter pointer is driven by the voltage applied to the output circuit from transistor Q1.

The source (S) of FET Q1 is direct coupled to the base (B) of transistor Q5. Transistors Q5 and Q6 are used as emitter followers that provide the voltage and current required to drive the meter, which is connected between the emitters of these two transistors. Transistor Q6 operates with its base bias fixed by resistors R28 and R29. When the Bias Adjust and Zero Adjust controls are properly set, and no voltage applied to the gate of Q1 from the switching circuits, the emitter voltage of Q5 is equal to the emitter voltage of Q6. Since there is no voltage drop across the meter, no current flows through it, and the pointer remains at zero.

Since the source current of FET Q1 is constant, and transistor Q5 is a direct coupled emitter follower, voltage variations at the gate of Q1 are transferred to the meter circuit. A positive voltage from the input circuits to the gate of Q1 will cause the emitter of Q5 to become more positive than the emitter of Q6, resulting in a forward (upscale) indication on the meter. A negative input voltage would lower the voltage at the emitter of Q5 and cause the meter pointer to move backward. However, in the DC- position of the Function switch, the meter polarity is reversed so that negative input voltages cause forward (upscale) meter readings.

The AC Cal and DC Cal controls provide calibration of the AC and DC voltage measurement functions of the Voltmeter. In the DC position of the Function switch, for example, with the Volts range switch set to .5 and one-half volt applied to the probe tip, the voltage difference between the emitters of Q5 and Q6 would be too great for the meter. With DC Cal control R26 in series with the meter, the actual voltage applied across the meter can be adjusted so the pointer will indicate the voltage that is applied to the probe tip.

The ohmmeter circuit requires no calibration control. When the Function switch is turned to Ohms, the Ohms Zero control adjusts the base bias of transistor Q7 to supply the correct amount of voltage (from battery E2 to the gate of FET Q1) for full scale deflection of the meter.

POWER SUPPLY (Figure 11)

Either of two separate power sources can be selected with the Power switch. In the Line position, the power supply uses a dual-primary transformer for operation from either 120 volts or 240 volts, 50/60 Hz, depending on how the Voltmeter was wired during assembly. The two primary windings are connected in parallel for 120 volt operation, or in series for 240 volt operation. A neon pilot lamp (NE-2H), glows when the power cord is connected to an AC source and the Power switch turned to Line. A 3-wire line cord is used, with the ground lead connected to the cabinet of the Voltmeter.

Silicon diode D4 and capacitor C4 form a half-wave rectifier circuit in the transformer secondary. Zener diode D5 regulates the B+ voltage to approximately 6.8 volts. R31 is a dropping resistor which limits the current through zener diode D5.

In the Batt position of the Power switch, the 9-volt battery is connected, through resistor R32, to the B+ circuit. Zener diode D5 regulates the B+ voltage to approximately 6.8 volts to compensate for an aging or weakening battery and provides constant B+ when switching from line to battery.

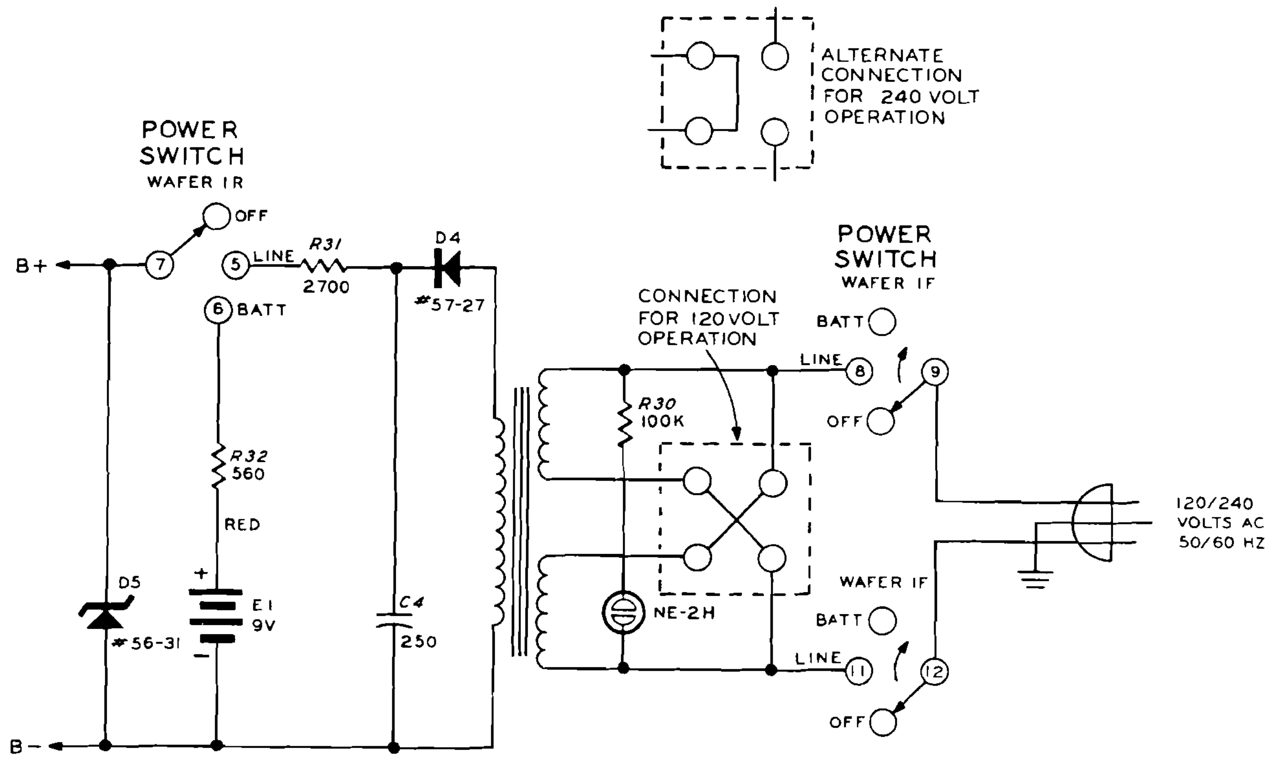
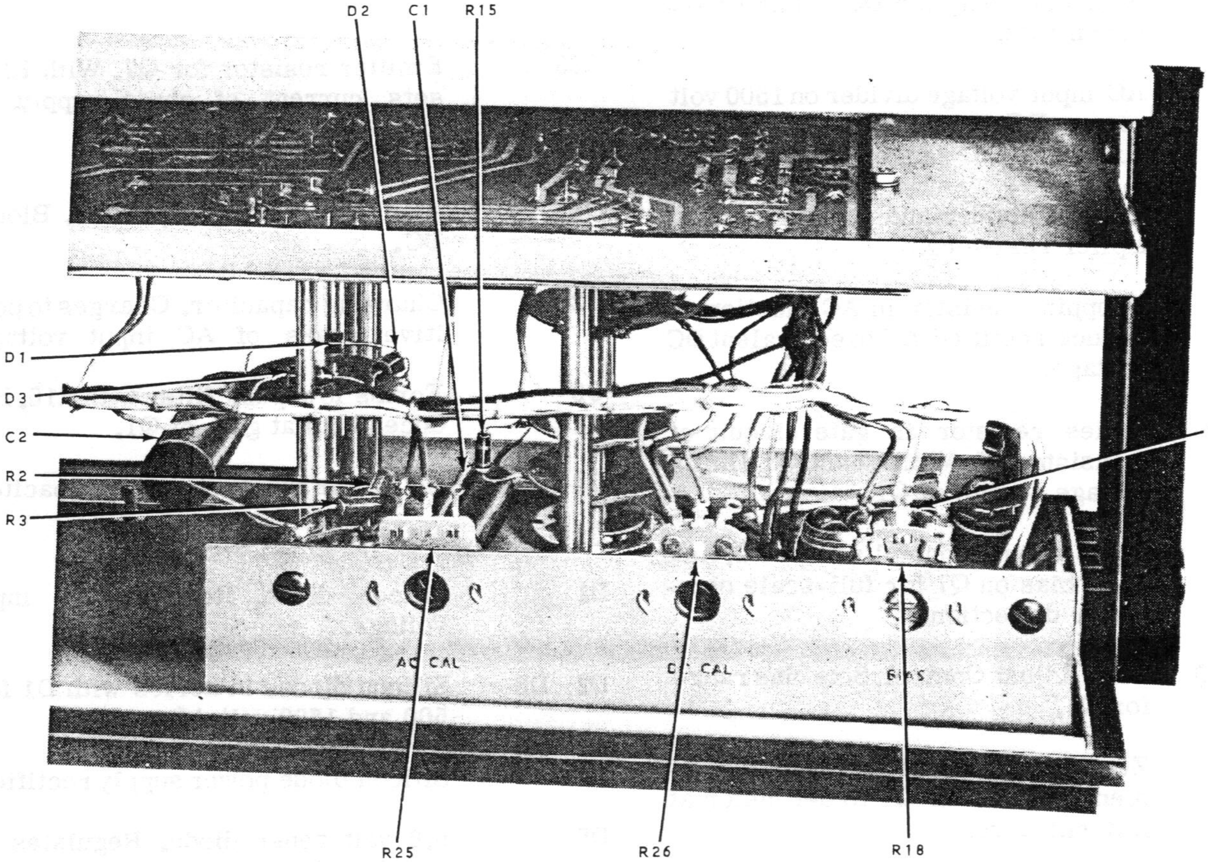

ALTERNATE CONNECTION FOR 240 VOLT OPERATION
POWER SWITCH
WAFER 1R
OFF
B+
7
5 LINE
R31
2700
6 BATT
D4
#57-27
POWER SWITCH
WAFER 1F
CONNECTION FOR 120 VOLT OPERATION
BATT
LINE 8
9
OFF
R30
100K
R32
560
RED
120/240 VOLTS AC 50/60 HZ
WAFER 1F
D5
#56-31
E1
9V
C4
250
NE-2H
BATT
LINE 11
12
OFF
B−

Figure 11

FUNCTIONAL PARTS LIST

R1	1-megohm resistor in probe. Reduces the loading of the circuit under test. Used only for DC voltage measurements.
R2, R3	AC input voltage divider on 1500 volt range. DC return for rectifier circuit on all AC ranges.
R4-R14	Voltage divider and resistance multiplier resistors.
R15	Dropping resistor in AC function, to reduce rectified AC to equivalent DC voltage.
R16	Series resistor in gate circuit of transistor Q1. With Q2 and Q3, limits voltage at gate of Q1.
R17	Ohms Adjust control across E2. Adjusts bias on Q7 for full-scale ohmmeter deflection.
R18, R20	Bias Adjust Control. Sets bias range for Q1.
R19	Zero Adjust Control. Finer adjustment of bias on Q1 to set meter at left-end zero.
R21, R22	Base bias voltage divider for Q4.
R23	Emitter resistor of constant current source Q4. Sets current through Q4 and Q1.
R24, R27	Emitter load resistors for output transistors Q5 and Q6.
R25	AC Calibration control.
R26	DC Calibration control.
R28, R29	Base bias voltage divider for Q6
R30	Series current limiter for neon pilot lamp.
R31	Series dropping resistor for line operation. Sets current through D5.
R32	Series dropping resistor for battery operation.
R33	Emitter resistor for Q7. With R17 - sets current of ohms supply E2 through R14.
C1	AC input coupling capacitor. Blocks DC.
C2	Charging capacitor. Charges to positive peaks of AC input voltage.
C3	Forms low-pass filter with R16. Reduces hum at gate of Q1.
C4	AC power supply charging capacitor.
C5	AC bypass for bias network.
D1	Silicon diode. Rectifies AC input voltage.
D2, D3	Silicon diodes in series with D1 for 500 and 1500 volt AC ranges.
D4	Silicon diode power supply rectifier.
D5	6.8 volt zener diode. Regulates B+ supply voltage.
Q1	Field effect transistor (FET). Used as a source follower to provide high impedance input and low impedance output to transistor Q5.
Q2, Q3	2N3393 transistors connected to act as 9-volt zener diodes. Protects Q1 and output circuit from severe overload.
Q4	Constant current source for Q1. Used as a source resistor.
Q5, Q6	Output transistors. Provide voltage and current to operate meter.
Q7	Constant current source for ohmmeter circuit.

CHASSIS PHOTOGRAPHS



REPLACEMENT PARTS PRICE LIST

RESISTORS

1/2 Watt

PART No.	PRICE Each	DESCRIPTION
1-103	.10	33 Ω
1-119	.10	560 Ω
1-13	.10	2700 Ω
1-20	.10	10 KΩ
1-22	.10	22 KΩ
1-25	.10	47 KΩ
1-26	.10	100 KΩ
1-30	.10	270 KΩ
1-35	.10	1 MΩ
1-38	.10	3.3 MΩ

Precision 1%, 1/2 Watt

PART No.	PRICE Each	DESCRIPTION
2-131	.20	10 Ω
2-24	.20	90 Ω
2-29	.20	900 Ω
2-31	.20	2162 Ω (2.162 KΩ)
2-33	.20	6838 Ω (6.838 KΩ)
2-39	.20	21.62 KΩ
2-40	.20	68.38 KΩ
2-42	.20	216.2 KΩ
2-45	.20	683.8 KΩ
2-146	.25	2.162 MΩ
2-147	.40	6.838 MΩ

Precision 1%, 1 Watt

PART No.	PRICE Each	DESCRIPTION
2-56-1	.25	632.4 KΩ
2-55-1	.25	1.3676 MΩ

CAPACITORS

PART No.	PRICE Each	DESCRIPTION
21-27	.10	.005 μfd disc
23-101	.95	.015 μfd tubular
25-131	.90	250 μfd electrolytic
25-54	.40	10 μfd electrolytic

CONTROLS

PART No.	PRICE Each	DESCRIPTION
10-219	1.05	2000 Ω
10-57	.35	10 KΩ tab mount
12-80	1.65	50 KΩ dual tandem, tab mount

SWITCHES

PART No.	PRICE Each	DESCRIPTION
63-433	2.45	3-position, 1-wafer (Power)
63-434	2.10	7-position, 1-wafer (Ohms)
63-463	4.30	4-position, 4-wafer (Function)
63-464	3.60	8-position, 3-wafer (Volts)

DIODES-TRANSISTORS-LAMP

PART No.	PRICE Each	DESCRIPTION
56-31	1.30	6.8 volt zener diode
57-27	.60	Silicon diode
417-118	.55	2N3393 transistor
417-140	1.50	Field effect transistor
412-15	.15	Neon pilot lamp

METAL PARTS

PART No.	PRICE Each	DESCRIPTION
90-346-1	1.35	Cabinet half shell
200-493	.95	Chassis
203-486-1	1.35	Front panel
203-487-1	.70	Subpanel
203-488-1	1.35	Rear panel
204-254	.15	Battery bracket (1-1/2 volt)
204-779	.30	Battery bracket (9 volt)
204-759-1	.15	End cap
204-760-1	.70	Side rail
210-34	4.35	Front panel bezel

PLASTIC PARTS

PART No.	PRICE Each	DESCRIPTION
73-27	.10	Grommet (8 halves)
75-30	.10	Line cord strain relief (for round cord)
75-71	.10	Line cord strain relief (for flat cord)
211-32	.30	Handle
261-16	.05	Cup insulator
261-28	.10	Foot
261-30	.10	Line cord retainer
413-10	.10	Pilot lamp lens
462-245	.25	Pointer knob
462-246	.25	Plain knob

WIRE

PART No.	PRICE Each	DESCRIPTION
89-23	.80	Line cord
134-160	1.60	Cable assembly
344-59	.05/ft	Hookup wire
341-1	.05/ft	Black test lead
343-11-1	.05/ft	Shielded test lead

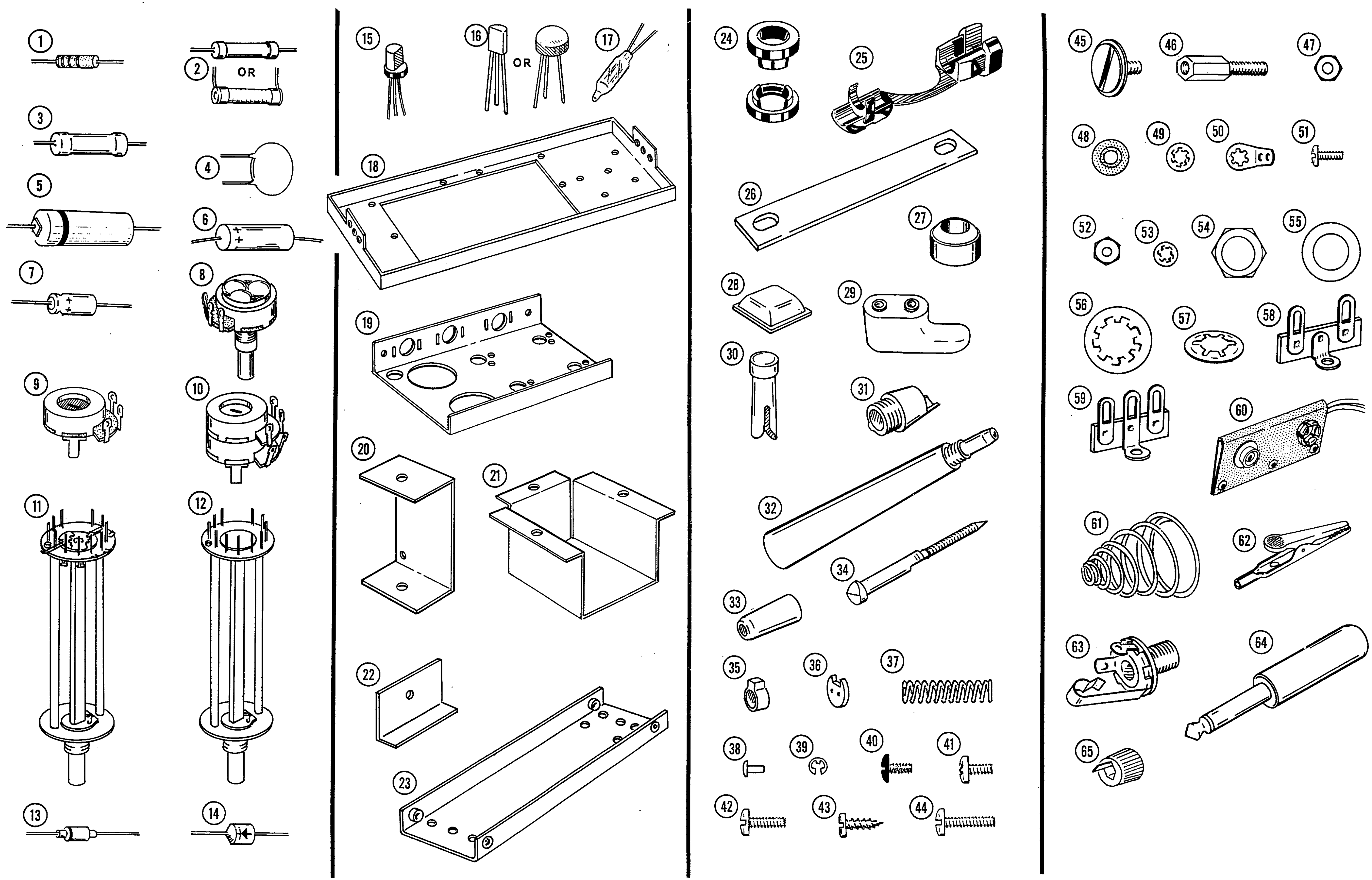
PART No.	PRICE Each	DESCRIPTION
PROBE PARTS		
476-13	.25	Front body
476-14	.20	Center body
476-15	.20	Rear body
477-7	.55	Probe tip
459-6	.25	Switch lever
459-7	.25	Insert insulator
258-53	.05	Contact spring
256-15	.05	Rivet
253-51	.05	E washer
#6 HARDWARE		
250-116	.05	6-32 x 1/4" black screw
250-229	.05	6-32 x 1/4" phillips head screw
250-89	.05	6-32 x 3/8" screw
250-8	.05	#6 x 3/8" sheet metal screw
250-162	.05	6-32 x 1/2" screw
250-303	.20	6-32 decorative screw
250-304	.15	6-32 x 7/16" spacer stud
252-3	.05	6-32 nut
253-2	.05	#6 fiber shoulder washer
254-1	.05	#6 lockwasher
259-1	.05	#6 solder lug
OTHER HARDWARE		
250-52	.05	4-40 x 1/4" screw
252-2	.05	4-40 nut
254-9	.05	#4 lockwasher
252-7	.05	Control nut
253-10	.05	Control flat washer
254-4	.05	Control lockwasher
252-73	.05	Speednut

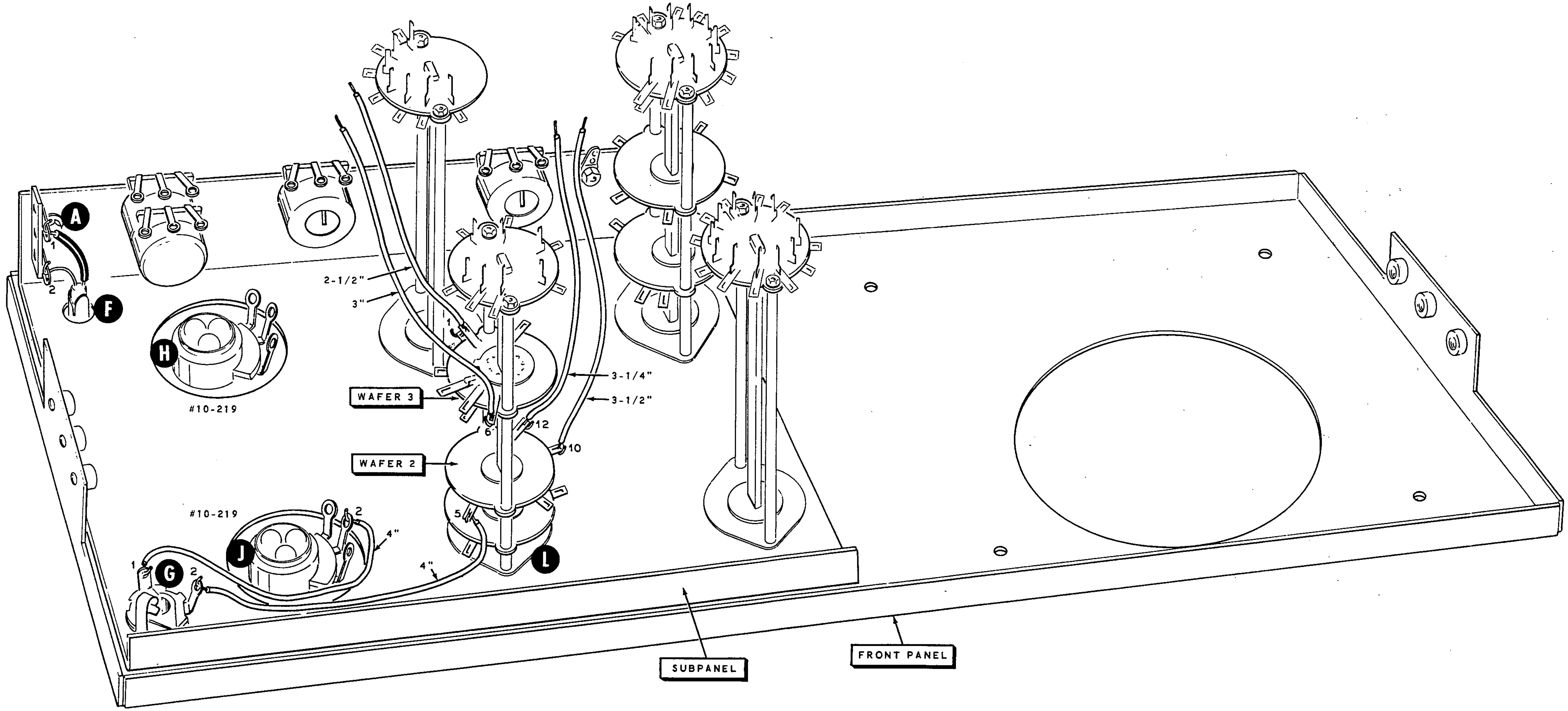
PART No.	PRICE Each	DESCRIPTION
MISCELLANEOUS		
54-177	2.55	Power transformer
407-125	10.50	100 microampere meter
85-178-1	2.60	Circuit board
431-2	.10	2-lug terminal strip
431-10	.10	3-lug terminal strip
432-33	.25	Battery connector
258-7	.10	Battery holder spring
260-1	.15	Alligator clip
260-51	.20	Alligator clip with threaded insert
436-20	.45	Phone jack
438-28	.65	Phone plug
455-50	.10	Knob bushing
432-27	.40	Line cord plug adapter
331-6	.15	Solder
490-5	.10	Nut starter
595-889	2.00	Manual

A factory-wired and tested replacement probe assembly, Model PKW-4, is available from Heath Company at $4.50 plus postage. Due to the cost of handling, the replacement probe assembly is not available in kit form.

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 an authorized Service Center or 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.

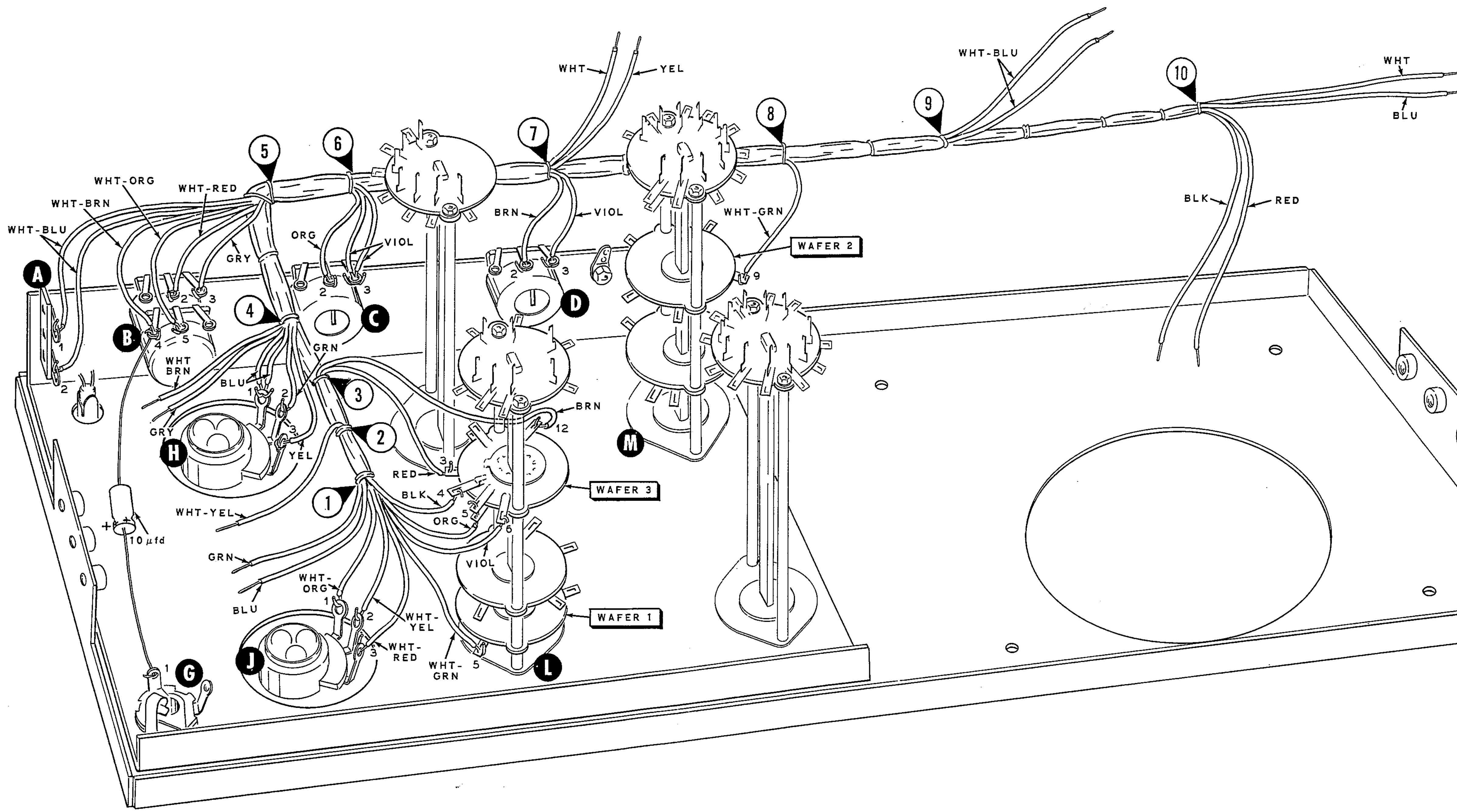
PARTS PICTORIAL





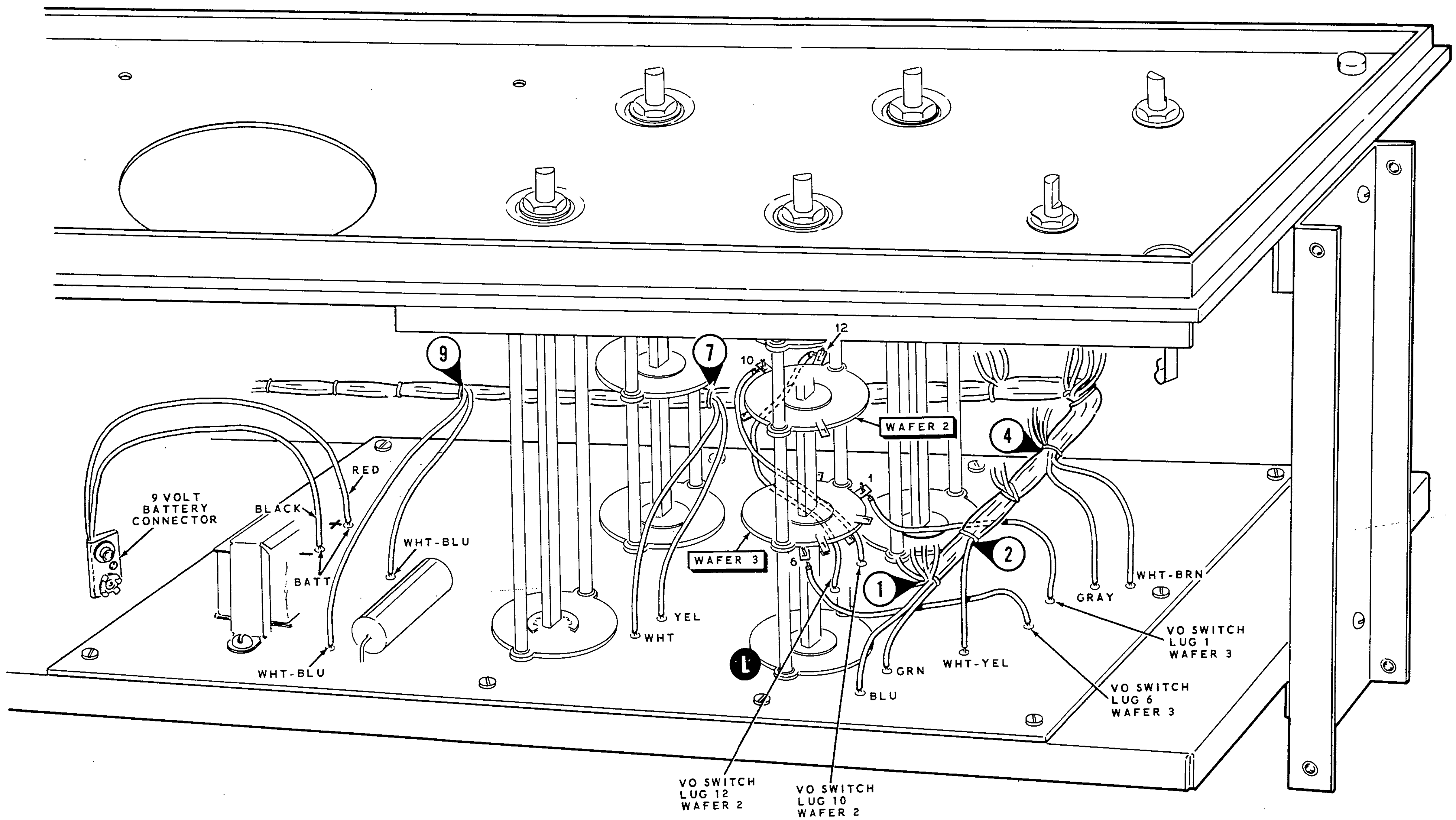
A
1
2
F
H
#10-219
2-1/2"
3"
1
WAFER 3
3-1/4"
3-1/2"
6
12
10
WAFER 2
#10-219
2
4"
5
J
4"
1
G
2
L
SUBPANEL
FRONT PANEL

PICTORIAL 6

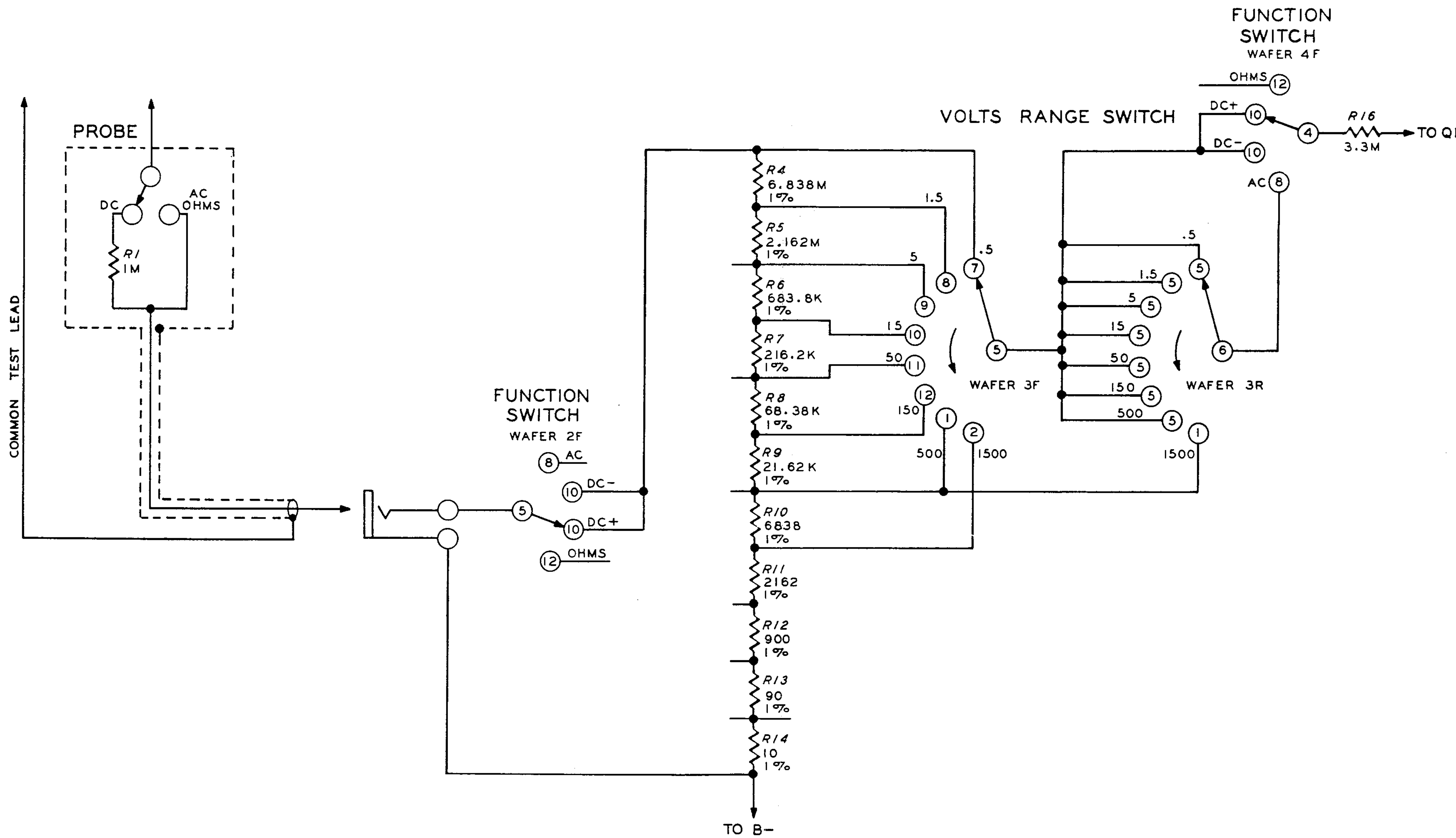


WHT
YEL
WHT-BLU
WHT
BLU
WHT-ORG
WHT-RED
WHT-BRN
WHT-BLU
GRY
ORG
VIOL
BRN
VIOL
WHT-GRN
WAFER 2
BLK
RED
GRN
BLU
WHT BRN
GRY
YEL
BRN
RED
BLK
ORG
VIOL
WAFER 3
WHT-YEL
10 μfd
GRN
BLU
WHT-ORG
WHT-YEL
WHT-RED
WHT-GRN
WAFER 1

PICTORIAL 7


9
7
12
10
WAFER 2
4
1
RED
9 VOLT
BATTERY
CONNECTOR
BLACK
BATT
WHT-BLU
WAFER 3
6
2
WHT-BRN
GRAY
YEL
WHT
L
GRN
WHT-YEL
BLU
VO SWITCH
LUG 1
WAFER 3
VO SWITCH
LUG 6
WAFER 3
WHT-BLU
VO SWITCH
LUG 12
WAFER 2
VO SWITCH
LUG 10
WAFER 2

PICTORIAL 9



PROBE
DC
AC OHMS
R1 1M
COMMON TEST LEAD
FUNCTION SWITCH WAFER 2F
AC
DC-
DC+
OHMS
R4 6.838M 1%
R5 2.162M 1%
R6 683.8K 1%
R7 216.2K 1%
R8 68.38K 1%
R9 21.62K 1%
R10 6838 1%
R11 2162 1%
R12 900 1%
R13 90 1%
R14 10 1%
TO B-
VOLTS RANGE SWITCH
WAFER 3F
WAFER 3R
FUNCTION SWITCH WAFER 4F
OHMS
DC+
DC-
AC
R16 3.3M
TO Q1

FIGURE 7

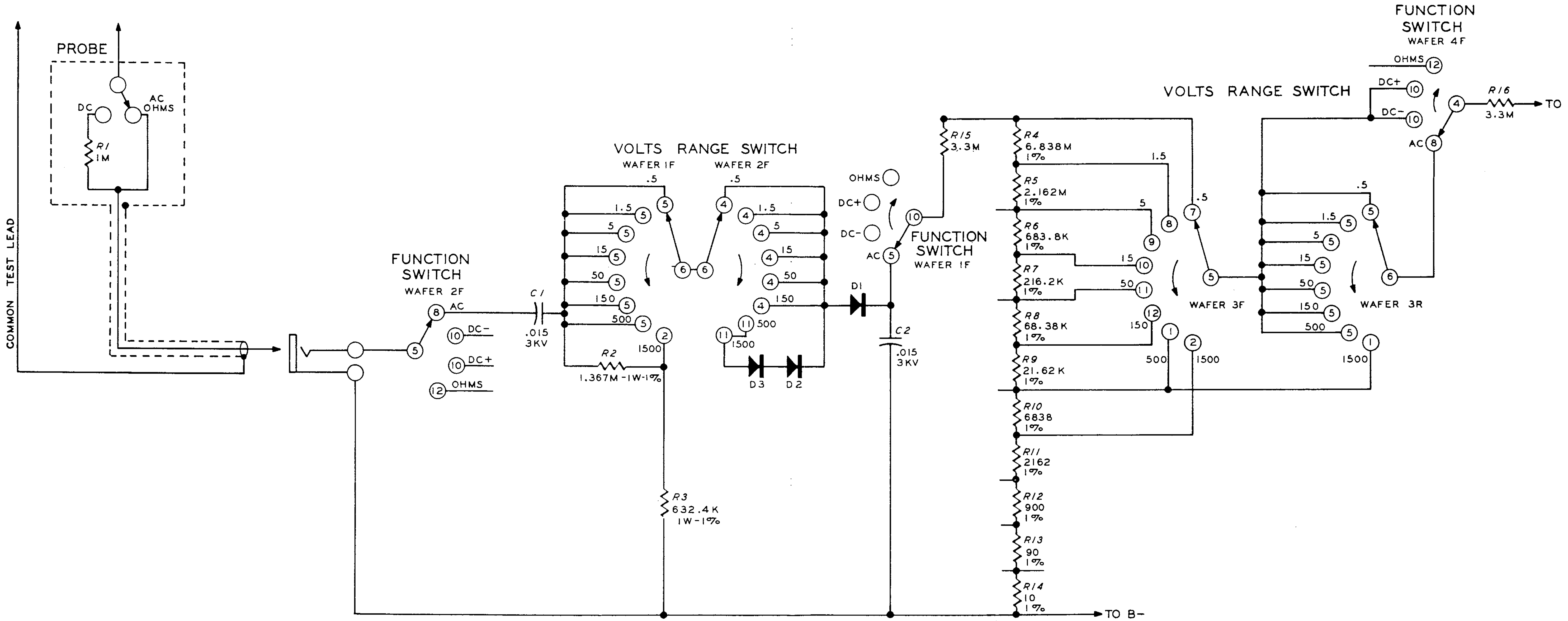
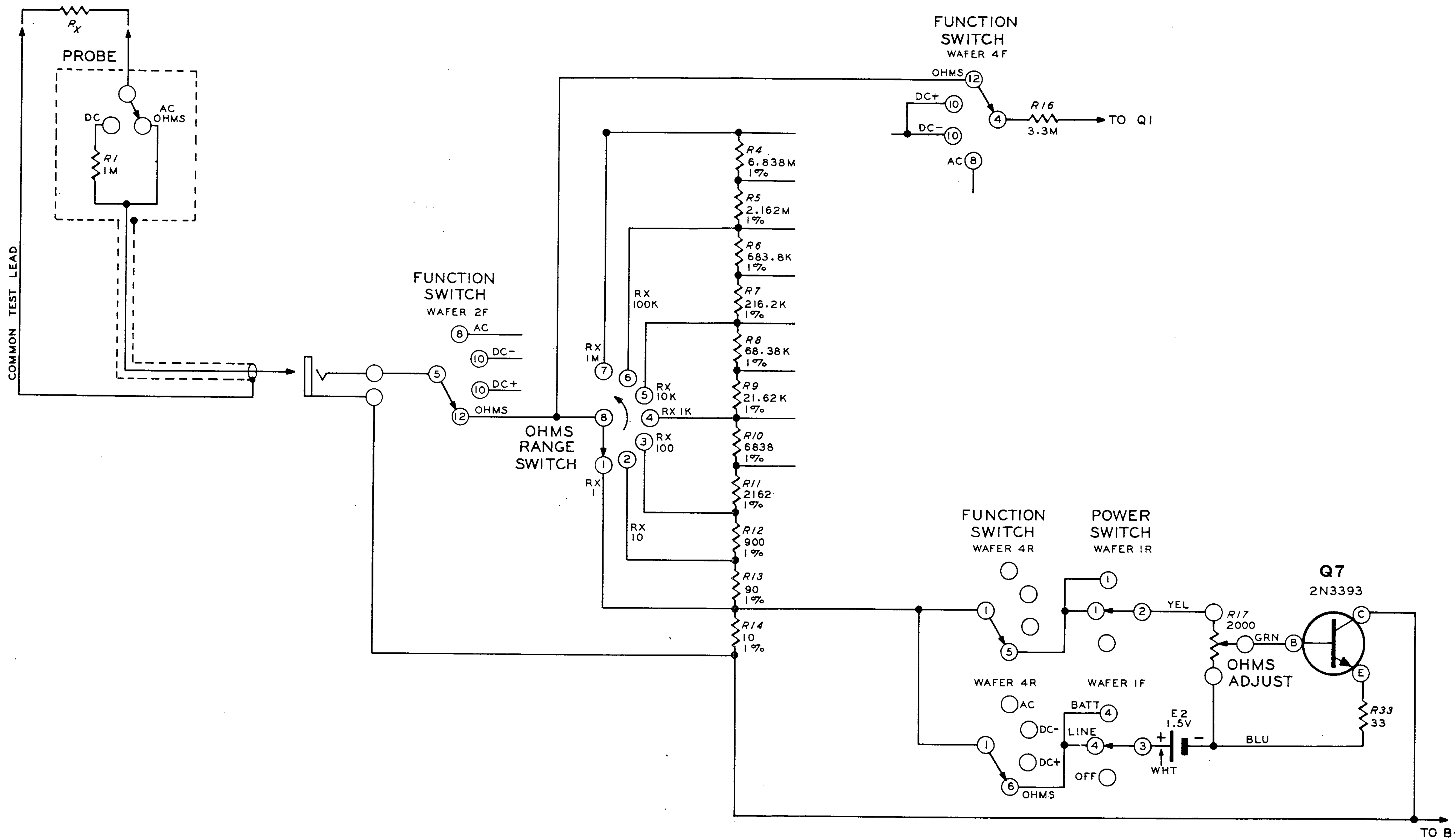

PROBE
DC
AC OHMS
R1 1M
COMMON TEST LEAD
FUNCTION SWITCH
WAFER 2F
AC
DC−
DC+
OHMS
C1
.015 3KV
VOLTS RANGE SWITCH
WAFER 1F
WAFER 2F
R2
1.367M - 1W - 1%
R3
632.4 K
1W - 1%
D1
D2
D3
C2
.015 3KV
R15
3.3M
FUNCTION SWITCH
WAFER 1F
R4 6.838M 1%
R5 2.162M 1%
R6 683.8K 1%
R7 216.2K 1%
R8 68.38K 1%
R9 21.62K 1%
R10 6838 1%
R11 2162 1%
R12 900 1%
R13 90 1%
R14 10 1%
TO B−
VOLTS RANGE SWITCH
WAFER 3F
WAFER 3R
FUNCTION SWITCH
WAFER 4F
R16
3.3M
TO Q1

FIGURE 8



R_X
PROBE
DC
AC OHMS
R1 1M
COMMON TEST LEAD
FUNCTION SWITCH WAFER 2F
AC
DC-
DC+
OHMS
OHMS RANGE SWITCH
RX 1M
RX 100K
RX 10K
RX 1K
RX 100
RX 10
RX 1
R4 6.838M 1%
R5 2.162M 1%
R6 683.8K 1%
R7 216.2K 1%
R8 68.38K 1%
R9 21.62K 1%
R10 6838 1%
R11 2162 1%
R12 900 1%
R13 90 1%
R14 10 1%
FUNCTION SWITCH WAFER 4F
OHMS
DC+
DC-
AC
R16 3.3M
TO Q1
FUNCTION SWITCH WAFER 4R
POWER SWITCH WAFER 1R
YEL
R17 2000
GRN
OHMS ADJUST
Q7 2N3393
WAFER 4R
WAFER 1F
AC
DC-
DC+
OHMS
BATT
LINE
OFF
E2 1.5V
WHT
BLU
R33 33
TO B-

FIGURE 9

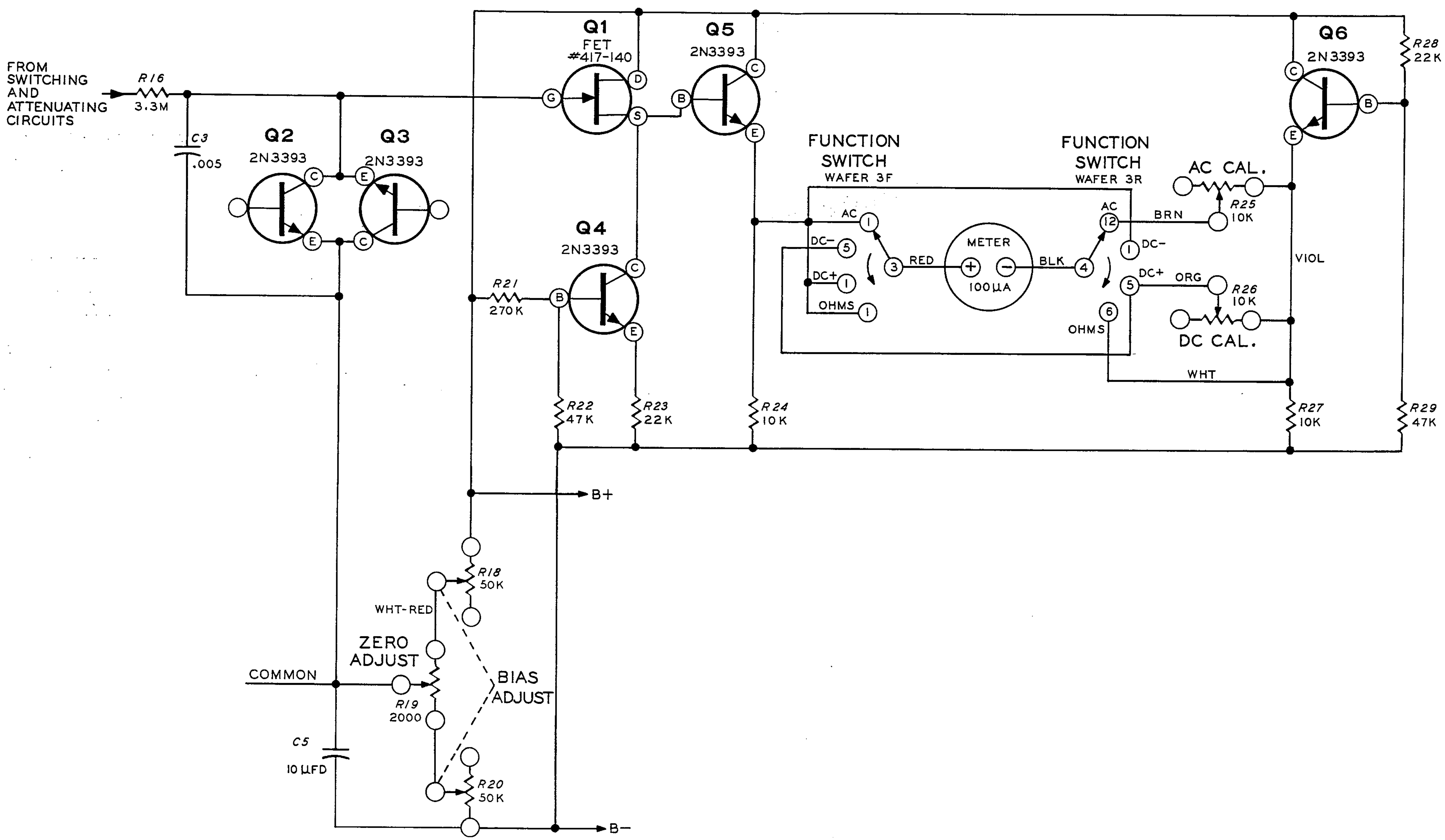
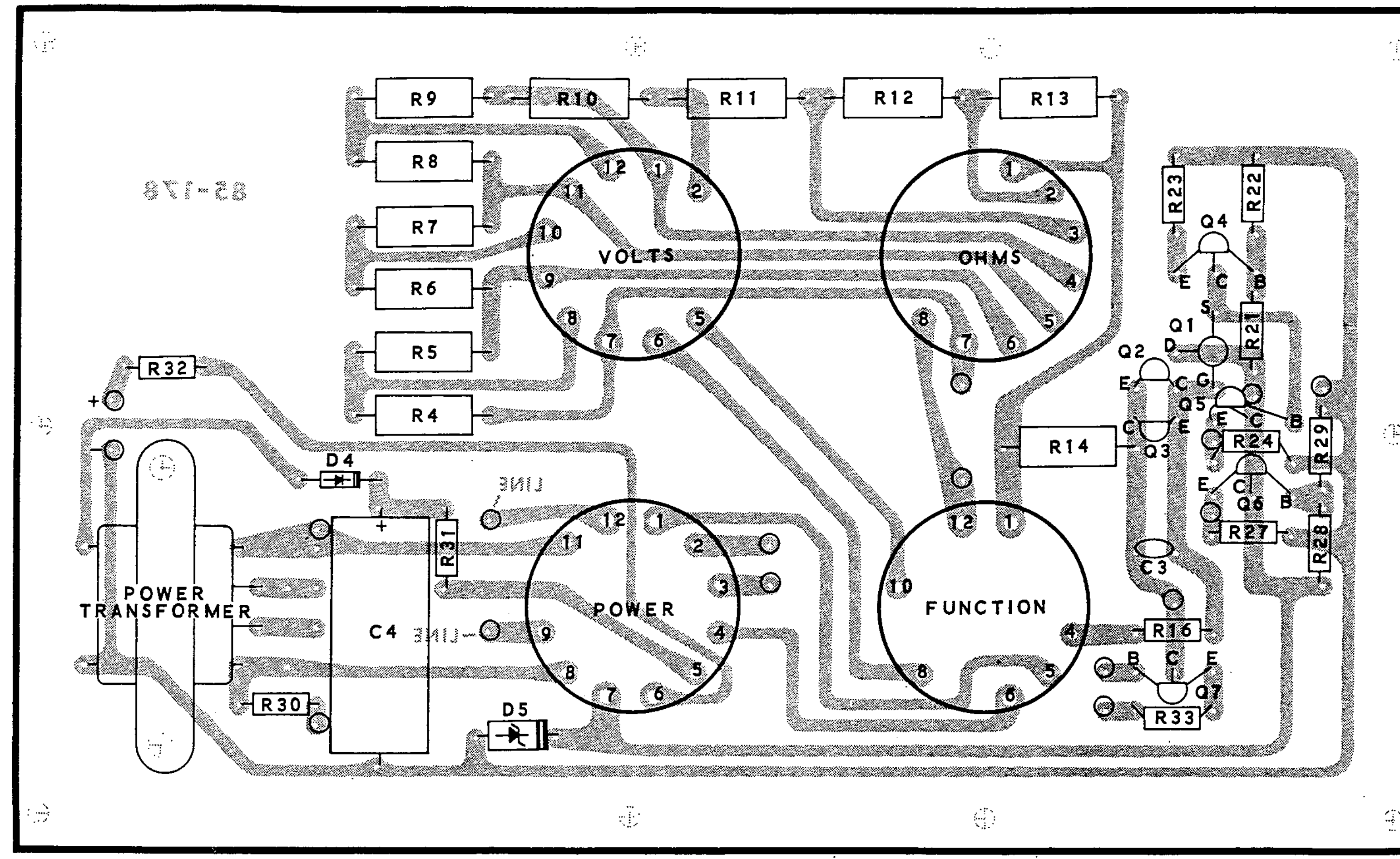

FROM SWITCHING AND ATTENUATING CIRCUITS
R16 3.3M
C3 .005
Q2 2N3393
Q3 2N3393
Q1 FET #417-140
Q5 2N3393
Q4 2N3393
Q6 2N3393
R21 270K
R22 47K
R23 22K
R24 10K
R27 10K
R28 22K
R29 47K
FUNCTION SWITCH WAFER 3F
FUNCTION SWITCH WAFER 3R
METER 100µA
RED
BLK
BRN
ORG
VIOL
WHT
AC CAL.
R25 10K
R26 10K
DC CAL.
AC
DC−
DC+
OHMS
B+
B−
R18 50K
WHT-RED
ZERO ADJUST
COMMON
R19 2000
BIAS ADJUST
R20 50K
C5 10 µFD

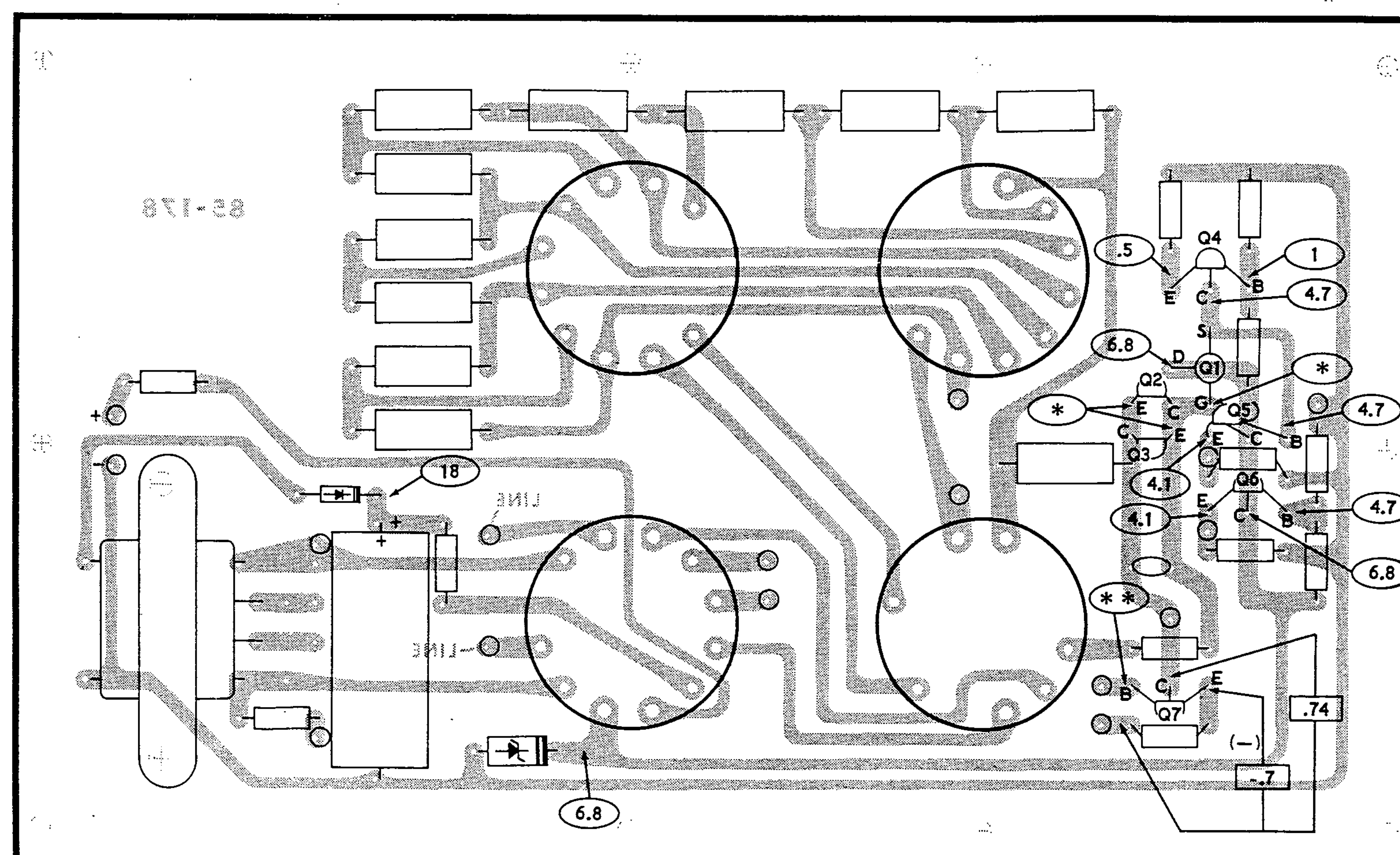
FIGURE 10

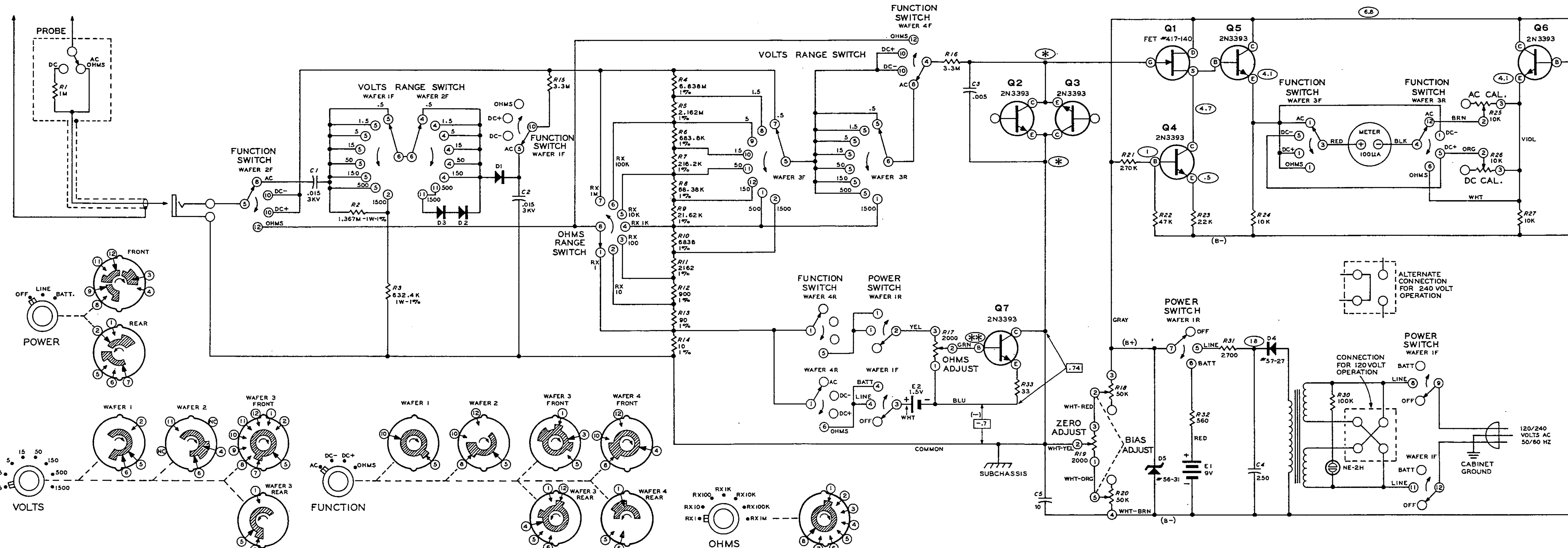
CIRCUIT BOARD X-RAY VIEW
(VIEWED FROM COMPONENT SIDE)



VOLTAGE CHART

1. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE MEASUREMENT, MADE WITH AN 11 MEGOHM INPUT VTVM, BETWEEN THE INDICATED POINT AND B-. (FUNCTION SWITCH IN AC POSITION, POWER SWITCH IN LINE POSITION).
2. ▭ THIS SYMBOL INDICATES A DC VOLTAGE MEASUREMENT BETWEEN TWO POINTS.
3. * VOLTAGE DEPENDS ON SETTINGS OF R18, R19, R20.
4. ** VOLTAGE DEPENDS ON SETTING OF R17.





SCHEMATIC OF THE HEATHKIT® SOLID-STATE VOLTMETER MODEL IM-16

NOTES:

1. ALL RESISTORS ARE 1/2 WATT, 10% UNLESS OTHERWISE INDICATED.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS (µfd).
3. ALL SWITCHES ARE SHOWN IN THE FULLY COUNTERCLOCKWISE POSITION, VIEWED FROM THE KNOB END OF THE SHAFT.
4. SWITCHES ARE IDENTIFIED BY THEIR USE, WAFER, AND WHETHER FRONT (F) OR REAR (R) OF THE WAFER. REAR SECTIONS OF WAFERS ARE VIEWED FROM THE REAR OF THE SWITCH.
5. THIS SYMBOL INDICATES A DC VOLTAGE MEASUREMENT, MADE WITH AN 11 MEGOHM INPUT VTVM, BETWEEN THE INDICATED POINT AND B-. (FUNCTION SWITCH IN AC POSITION, POWER SWITCH IN LINE POSITION).
6. THIS SYMBOL INDICATES A DC VOLTAGE MEASUREMENT BETWEEN TWO POINTS.
7. * VOLTAGE DEPENDS ON SETTINGS OF R18, R19, R20.
8. * * VOLTAGE DEPENDS ON SETTING OF R17.

SEE VOLTAGE CHART FOR LOCATION OF MEASUREMENT POINTS.