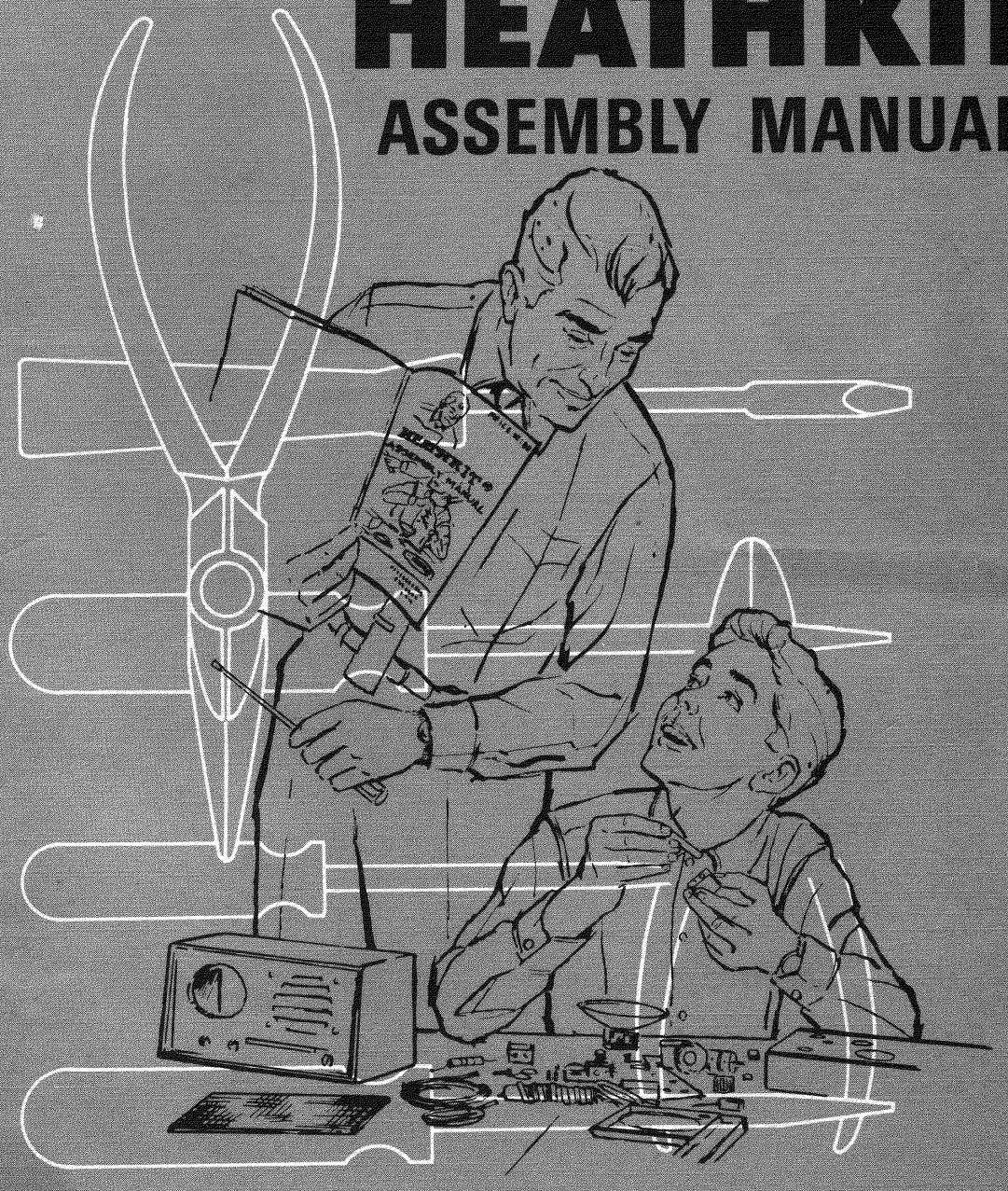
MODEL

IM-1202 Digital Multimeter

HEATHKIT®

ASSEMBLY MANUAL



HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATHKIT®

PRICE $2.00

I-595-1489-01

Dear Customer:

The Heathkit electronic product you have purchased is one of the best performing electronic products in the world.

Here's how we aim to keep it that way:

Your Heathkit Warranty

During your first 90 days of ownership, any parts which we find are defective, either in materials or workmanship, will be replaced or repaired free of charge. And we'll pay shipping charges to get those parts to you — anywhere in the world.

If we determine a defective part has caused your Heathkit electronic product to need other repair, through no fault of yours, we will service it free — at the factory, at any retail Heathkit Electronic Center, or through any of our authorized overseas distributors.

This protection is exclusively yours as the original purchaser. Naturally, it doesn't cover damage by use of acid-core solder, incorrect assembly, misuse, fire, flood or acts of God. But, it does insure the performance of your Heathkit electronic product anywhere in the world — for most any other reason.

After-Warranty Service

What happens after warranty? We won't let you down. If your Heathkit electronic product needs repairs or you need a part, just write or call the factory, your nearest retail Heathkit Electronic Center, or any Heath authorized overseas distributor. We maintain an inventory of replacement parts for each Heathkit model at most locations — even for many models that no longer appear in our current product line-up. Repair service and technical consultation are available through all locations.

We hope you'll never need our repair or replacement services, but it's nice to know you're protected anyway — and that cheerful help is nearby.

Sincerely,

HEATH COMPANY
Benton Harbor, Michigan 49022

Assembly

and

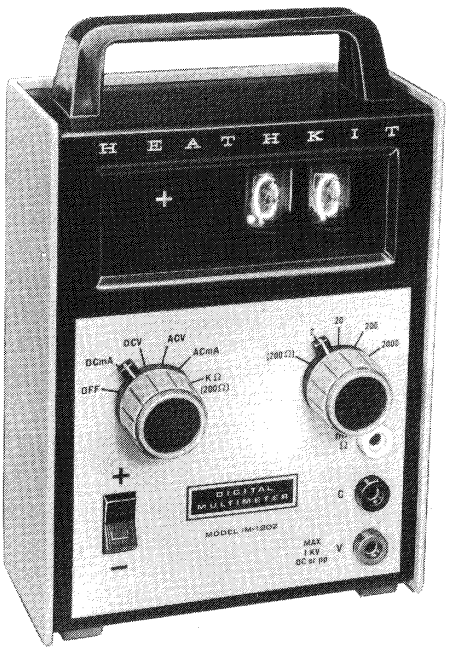
Operation

of the

HEATHKIT®

DIGITAL MULTIMETER

MODEL IM-1202



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

TABLE OF CONTENTS

INTRODUCTION

The Heathkit Model IM-1202 Digital Multimeter will accurately measure voltage, current, and resistance values and display them on cold-cathode tubes and indicator lamps. Solid-state circuitry is used throughout the instrument for reliability and compactness.

Four ranges are used for voltage and current, both AC and DC. The voltage ranges are 2, 20, 200, and 2 k (2000) volts, although the maximum input voltages are limited to 1000 volts DC and 700 volts rms AC. The current ranges for both AC and DC are 2, 20, 200, and 2 k (2000) mA (2 amperes). The five resistance ranges available are 200 ohms and 2, 20, 200, and 2 k (2000) kilohms (2 megohms).

All DC voltage ranges have a one megohm input impedance to avoid loading the circuit being measured. The voltage and current ranges provide an overrange indication by illuminating an indicator lamp. A front panel switch controls the polarity displayed and the decimal point is automatically located for each range by the setting of the Range switch.

Overload protection is provided by fuses on the current and resistance inputs, and the AC power line. A 3-wire polarized line cord is used, with the grounded wire connected directly to the chassis and cabinet for user protection. The input C (common) jack is not connected to the chassis. Dual transformer primary windings permit wiring the unit for either 120 or 240 volts AC, 50-60 Hz.

The meter is housed in a rust-free, aluminum cabinet with a convenient carrying handle. The convenience, versatility, and accuracy of this Digital Multimeter make it a most desirable instrument for the lab, service shop, or ham shack.

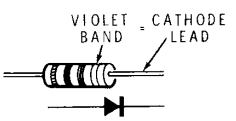
Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

January 10, 1973

Dear Customer:

The zener diode (part number 56-58) supplied with this kit may have either a solid body or a glass body. The "banded end" of the diode, referred to in your Manual, is clearly visible as a black band on the diode with the glass body.

If the diode in your kit has a solid body, disregard all but the violet band. The violet band is the identifier for the cathode end of the diode, referred to in your Manual as the banded end.



Thank you,

HEATH COMPANY

UNPACKING

The Digital Multimeter packaging consists of the shipping carton, which contains smaller packages and a number of loose parts. After the package stamped 1 and 2 is removed from the shipping carton, the remaining parts in the shipping carton make up pack #3.

Each of the assembly sections of the Manual contains its own parts list and step-by-step instructions. At the beginning of each parts list you will be instructed which numbered package to open. You will also need some parts from pack #3 to complete the assembly of the parts in packs #1 and #2. Take these parts out of pack #3 when they are called for; then set pack #3 aside until it is called for later.

To avoid intermixing parts, do not open any of the parts packages until instructed to do so.

LOGIC CIRCUIT BOARD

PARTS LIST

Unpack the section of package 1 and 2 marked #1 and check each part against the following list. The key numbers correspond to the numbers on the Logic Circuit Board Parts Pictorial (fold-out from Page 9). Any part that is packaged in an individual envelope with a part number on it should be placed back in its envelope after it is identified until it is called for in a step.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS				
1/4-Watt, 10%				
A1	1-14-12	1	12 kΩ (brown-red-orange)	.10
A1	1-10-12	1	15 kΩ (brown-green-orange)	.10
A1	1-12-12	2	82 kΩ (gray-red-orange)	.10
A1	1-33-12	2	120 kΩ (brown-red-yellow)	.10
A1	1-88-12	2	10 MΩ (brown-black-blue)	.10
1/4-Watt, 5%				
A1	1-64-12	5	390 Ω (orange-white-brown-gold)	.10
A1	1-69-12	3	1000 Ω (brown-black-red-gold)	.10
A1	1-74-12	2	3300 Ω (orange-orange-red-gold)	.10
Resistors, 1/4-Watt, (cont'd.)				
A1	1-80-12	1	10 kΩ (brown-black-orange-gold)	.10
A1	1-94-12	2	18 kΩ (brown-gray-orange-gold)	.10
A1	1-84-12	2	100 kΩ (brown-black-yellow-gold)	.10
CONTROL				
A2	10-904	1	5000 Ω (5 k)	.55
CAPACITORS				
B1	21-140	1	.001 μF disc	.10
B1	21-94	1	.05 μF disc	.15
B1	21-95	3	.1 μF disc	.15
B2	27-70	2	.0022 μF Mylar*	.40

*Registered Trademark, DuPont

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
DIODE-TRANSISTORS				
C1	~~56-84~~ 56-56	~~1~~ 1	~~1N4148 diode~~ 1N4149 diode	~~.15~~ .20
NOTE: Transistors are marked for identification in one of the following four ways:				
			1. Part number.	
			2. Type number.	
			3. Part number and type number.	
			4. Part number with a type number other than the one listed.	
C2	417-294	2	MPSA42 transistor	.60
C2	417-801	3	MPSA20 transistor	.20
INTEGRATED CIRCUITS				
NOTE: If either the part number or the "Description" number is on an integrated circuit, you have the correct part. Do not be concerned about any other numbers. On integrated circuits, the description number may have additional letters and numbers other than those given in the list. Example: SN(7490)N or MC(7490)P.				
C3	443-1	1	7400 integrated circuit (IC)	.45
C3	443-5	1	7473 integrated circuit (IC)	5.20
C3	443-7	2	7490 integrated circuit (IC)	1.95
C3	443-46	1	7402 integrated circuit (IC)	.55
C4	443-35	2	7441 integrated circuit (IC)	2.85
WIRE-SLEEVING				
	340-8	1	Small bare wire	.05/ft
	340-11	1	Large bare wire (for soldering iron tip)	.05/ft
	346-1	1	Sleeving	.05/ft

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
HARDWARE				
D1	250-325	1	6-32 x 5/8" screw	.05
D2	250-369	1	#6 x 1/4" sheet metal screw	.05
D3	252-10	1	Speed nut*	.05
D4	253-13	1	Fiber shoulder washer	.05
MISCELLANEOUS				
	85-1364-1	1	Logic circuit board	3.30
E1	214-131	1	Lamp housing	.60
E2	261-16	1	Round mounting foot	.05
E3	411-284	2	Display tube	5.00
E4	412-49	2	Large neon lamp	.40
E5	412-63	2	Small neon lamp	.75
E6	431-62	1	3-lug terminal strip	.10
E7	434-225	5	14-pin IC socket	.20
E8	434-226	2	16-pin IC socket	.20
E9	434-234	2	Tube socket	.80
E10	490-111	1	IC puller	.10
			Solder (Additional 6' rolls of solder, #331-13, can be purchased for 25 cents each.)	
PARTS NEEDED FROM PACK #3				
	391-34	1	Blue and white label	
	597-260	1	Parts Order Form	
	597-308	1	Kit Builders Guide	
		1	Manual (See front cover for part number.)	2.00

*Registered Trademark, Tinnerman Co.

NOTE: See Page 50 for "Replacement Parts and Price Information."

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.

Resistors are designated by the color code and the resistance value. The symbol "Ω" means ohms (K = 1,000; M = 1,000,000). Capacitors are designated by their value and type. The symbol "μF" means microfarad, and "pF" means picofarad. 1 μF is equal to 1,000,000 pF.

Due to the small foil area around the circuit board holes and the small areas between foils, it is necessary to use the utmost care to prevent solder bridges between adjacent foil areas. Use a minimum amount of solder and do not heat components excessively. Diodes, transistors, and IC's can be damaged if subjected to excessive amounts of heat. Use a soldering iron rated at 15 to 25 watts. Its tip should be no wider than 1/16" at the widest dimension; a pyramid or chisel shaped tip is best. This type of soldering iron will make a kit easier to assemble with less chance of solder bridges occurring. Solder a part, or group of parts, only when instructed to do so.

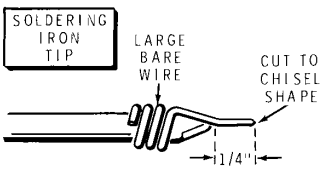


Figure 1

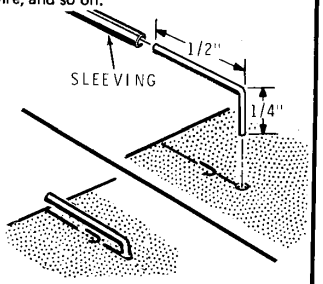
NOTE: If a small wattage, small-tip soldering iron is not available, proceed as follows: Be sure your soldering iron is cool. Then wrap the large bare wire, supplied with this kit, tightly around the soldering iron tip as shown in Figure 1. Allow approximately 1/4" of wire to extend beyond the end of the soldering iron. Cut the wire end to a chisel shape as shown. You may have to replace this arrangement occasionally as a wire wrap will loosen after it has been heated for some time.

Most parts will be installed on the top (the side with the component outlines) of the circuit board, and the leads will be soldered to the foil (other) side. Solder the leads only to the foil side of the board unless specifically instructed to do otherwise. Due to the nature of the board, solder may be drawn up through the circuit board plated-through holes to the top (component side) of the circuit board. This is normal.

START

NOTE: Position the logic circuit board screened side up as shown.

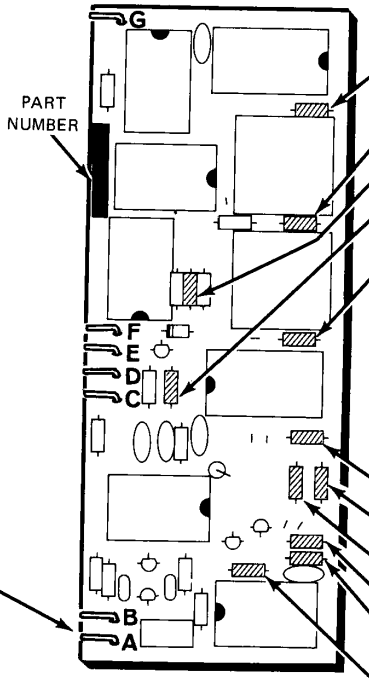
In the following steps, as you install short jumper wires, use a small piece of sleeving to space each wire slightly above the surface of the circuit board. Then remove the sleeving and use it to space the next wire, and so on.



( ) Cut seven 3/4" lengths of small bare wire. Bend each wire at a right angle as shown.

( ) Place a short length of sleeving over the 1/2" end of one of the wires. Install this wire in hole A on the circuit board. Make sure the wire is straight toward the edge of the board as shown in the Pictorial. Solder the wire to the foil and cut off any excess wire length on the foil side of the circuit board. Then remove the sleeving from the wire for use in the following steps.

( ) In the same manner, install 3/4" small bare wires at holes B, C, D, E, F, and G. Then discard the short piece of sleeving.



CONTINUE

( ) Cut each of the wires flush with the edge of the circuit board as shown in the Pictorial. NOTE: Be sure each wire is straight and slightly above the surface of the circuit board.

( ) 10 MΩ (brown-black-blue).

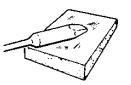
( ) 18 kΩ (brown-gray-orange).

( ) 390 Ω (orange-white-brown).

( ) 390 Ω (orange-white-brown).

( ) 18 kΩ (brown-gray-orange).

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN... WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



SAFETY WARNING: Avoid eye injury when you clip off excess wire ends. We suggest that you wear glasses, or at least clip the leads so the ends will not fly toward your eyes.

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) 82 kΩ (gray-red-orange).

( ) 120 kΩ (brown-red-yellow).

( ) 1000 Ω (brown-black-red).

( ) 120 kΩ (brown-red-yellow).

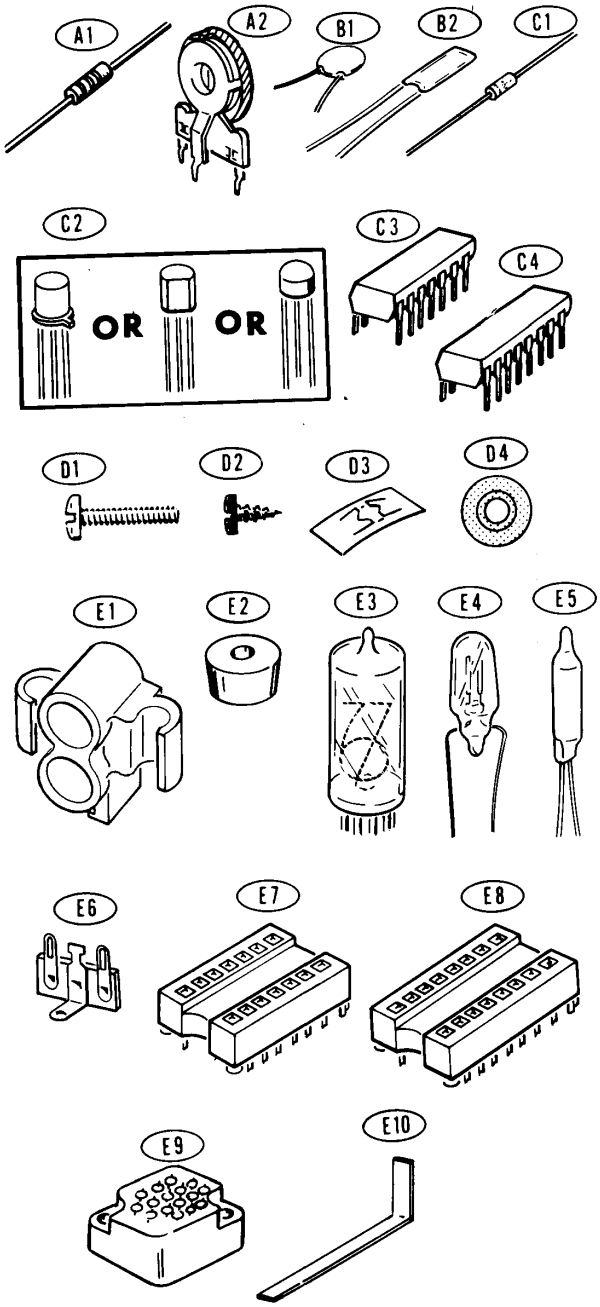
( ) 82 kΩ (gray-red-orange).

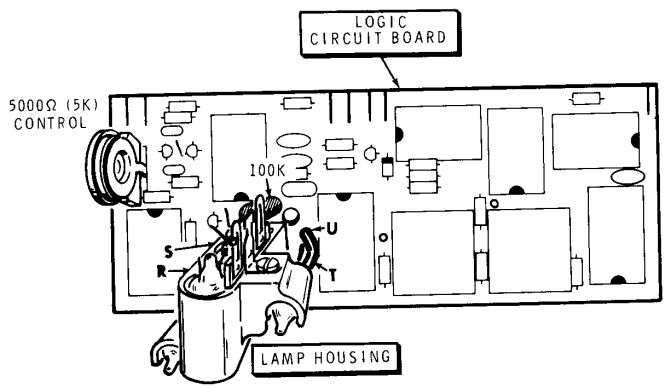
( ) 1000 Ω (brown-black-red).

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-1

LOGIC CIRCUIT BOARD PARTS PICTORIAL





PICTORIAL 1-5

HEATHKIT®

START

( ) 100 kΩ (brown-black-yellow).

( ) 10 MΩ (brown-black-blue).

( ) 390 Ω (orange-white-brown).

( ) 390 Ω (orange-white-brown).

( ) 390 Ω (orange-white-brown).

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) 10 kΩ (brown-black-orange).

( ) 1000 Ω (brown-black-red).

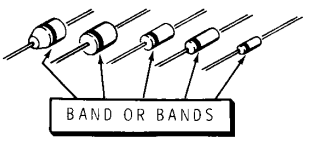
( ) 3300 Ω (orange-orange-red).

( ) 12 kΩ (brown-red-orange).

( ) 3300 Ω (orange-orange-red).

( ) 15 kΩ (brown-green-orange).

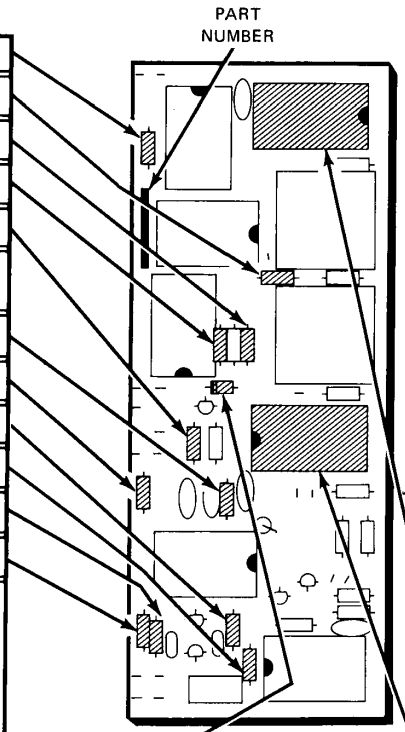
NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



( ) ~~1N4148~~ diode (#56-~~84~~) at D17.

( ) Solder the leads to the foil and cut off the excess lead lengths.

NOTE: The remaining 100 kΩ resistor will be installed later.



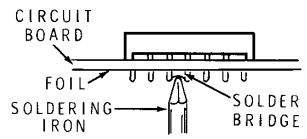
PICTORIAL 1-2

CONTINUE

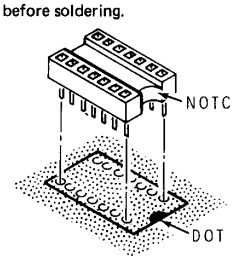
NOTE: Read this information carefully before you install the IC (integrated circuit) sockets in the following steps. First, be sure to position the socket as shown, with the cutout on one end above the dot on the circuit board. Solder the pins of each socket when you install it.

Use a small-tip soldering iron if possible. The IC socket pins are very close together. Therefore, be sure you do not bridge solder between pins on different foils. When removing the soldering iron, move the tip of the iron straight up from the pin to avoid bridging solder to another pin. Do not place the soldering iron tip between the socket pins when soldering, as this increases the possibility of a solder bridge.

If a solder bridge does occur, turn the circuit board foil side down as shown, and hold the soldering iron tip between the two points that are bridged. The solder will flow down the soldering iron tip.



NOTE: Both 14-pin and 16-pin dual-in-line IC's and sockets are used in this kit. Be very careful when you install the sockets, as it is possible to erroneously place a 14-pin socket in a 16-pin socket location. Make sure all pins are in their holes before soldering.

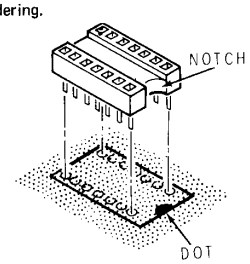


( ) 16-pin IC socket at IC4.

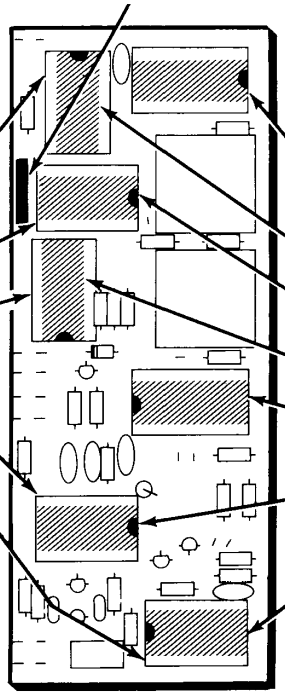
( ) 16-pin IC socket at IC3.

START

NOTE: Install 14-pin IC sockets in the same manner as you installed the 16-pin sockets. Be sure to position the socket as shown with the cutout on one end above the dot on the circuit board. Solder the pins of each socket as you install it. Make sure all pins are in their holes before soldering.

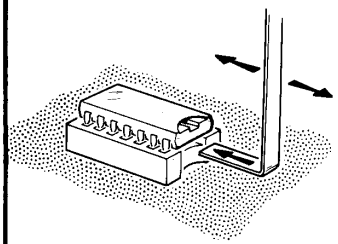


- ( ) 14-pin IC socket at IC7.
- ( ) 14-pin IC socket at IC6.
- ( ) 14-pin IC socket at IC2.
- ( ) 14-pin IC socket at IC8.
- ( ) 14-pin IC socket at IC5.



CONTINUE

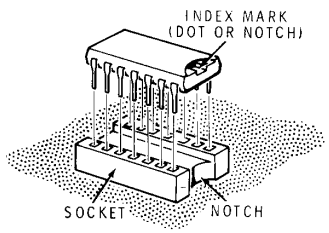
NOTE: An IC Lifter has been furnished to remove an IC from its socket if necessary.



Push the shorter end of the lifter in between the IC and the socket and rock the longer portion back and forth. Be very careful as the IC pins are very easily bent.

In the following steps, install IC's in the designated sockets. Be careful to match the index mark on each IC to the cutout in the end of its socket.

Before applying downward pressure to an IC, make sure each IC pin is centered in its proper socket aperture. Handle IC's with care as their pins are very easily bent.

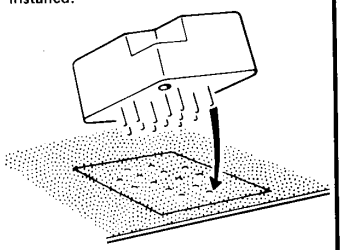


- ( ) 7441 IC (#443-35) at IC4.
- ( ) 7490 IC (#443-7) at IC7.
- ( ) 7490 IC (#443-7) at IC6.
- ( ) 7402 IC (#443-46) at IC2.
- ( ) 7441 IC (#443-35) at IC3.
- ( ) 7400 IC (#443-1) at IC8.
- ( ) 7473 IC (#443-5) at IC5.

PICTORIAL 1-3

START

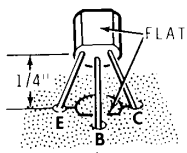
When you install the tube sockets in the following steps, turn the circuit board over and solder each socket to the foil as it is installed.



( ) Tube socket at V2.

( ) Tube socket at V1.

NOTE: Install each of the following transistors as shown. Solder each lead to the foil and cut off the excess lead lengths.



( ) MPSA20 transistor (#417-801) at Q12.

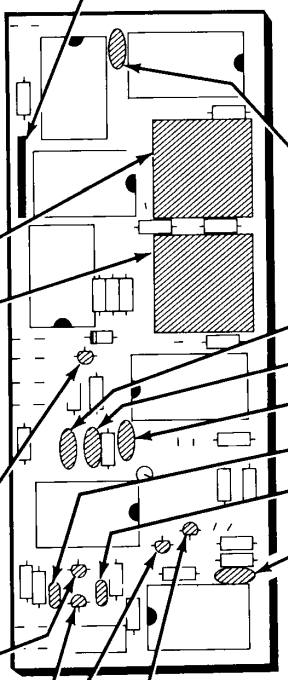
( ) MPSA20 transistor (#417-801) at Q16.

( ) MPSA20 transistor (#417-801) at Q15.

( ) MPSA42 transistor (#417-294) at Q14.

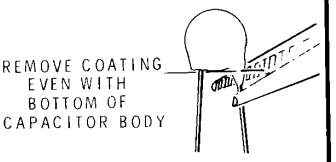
( ) MPSA42 transistor (#417-294) at Q13.

PART NUMBER



CONTINUE

NOTE: Before you install disc capacitors, use long-nose pliers to remove the excess insulation from the capacitor leads.



( ) .1 μF disc.

( ) .05 μF disc.

( ) .001 μF disc.

( ) .1 μF disc.

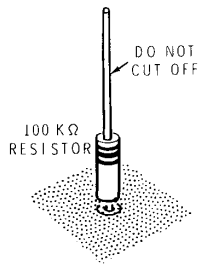
( ) .0022 μF Mylar.

( ) .0022 μF Mylar.

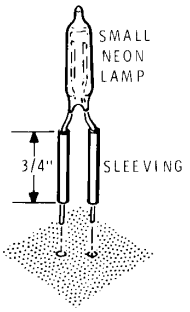
( ) .1 μF disc.

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-4



Detail 1-5A



Detail 1-5B

Refer to Pictorial 1-5 (fold-out from Page 10) for the following steps.

( ) Refer to Detail 1-5A and vertically mount a 100 kΩ (brown-black-yellow) resistor at the location shown. Solder the lead to the foil and cut off the excess lead length. The free end will be connected later.

( ) Refer to Detail 1-5B and cut two 3/4" lengths of sleeving. Place one length of sleeving on each lead of a small neon lamp as shown.

( ) Mount this lamp at U and T. Solder the leads to the foil and cut off the excess lead lengths.

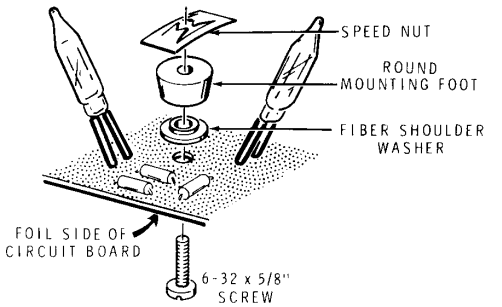
( ) In the same manner, place 3/4" lengths of sleeving on the leads of another small neon lamp. Mount this lamp at R and S. Solder the leads to the foil and cut off the excess lead lengths.

( ) Refer to Detail 1-5C and mount a 5000 Ω control (5 kΩ) at the location shown in the Pictorial. Push the control firmly down onto the circuit board; then solder the leads to the foil.

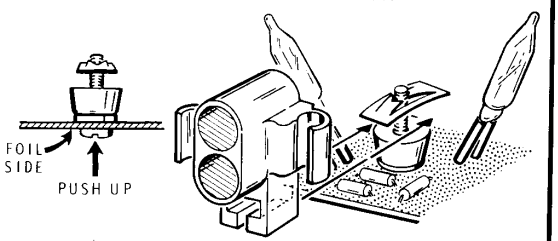
( ) Refer to Detail 1-5D and mount a 3-lug terminal strip on the lamp housing with a #6 x 1/4" sheet metal screw. Position the terminal strip as shown.

Refer to Detail 1-5E and mount the lamp housing onto the logic circuit board as instructed.

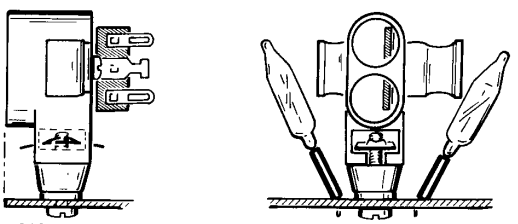
1 ( ) PUSH A 6-32 x 5/8" SCREW THROUGH THE LOGIC CIRCUIT BOARD FROM THE FOIL SIDE; THEN THROUGH A FIBER SHOULDER WASHER AND A ROUND MOUNTING FOOT. TURN A SPEED NUT ONTO THE TIP OF THE SCREW ABOUT 1-1/2 TURNS.



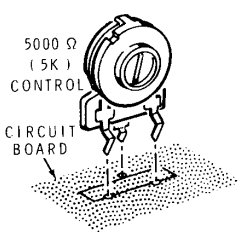
2 ( ) PUSH THE SCREW UP UNTIL IT IS AGAINST THE FOIL SIDE OF THE CIRCUIT BOARD. THEN SLIDE THE LOWER PORTION OF THE LAMP HOUSING ONTO THE SCREW SO THE SPEED NUT IS INSIDE THE LOWER SECTION OF THE HOUSING, AND THE HOUSING IS ON TOP OF THE ROUND MOUNTING FOOT.



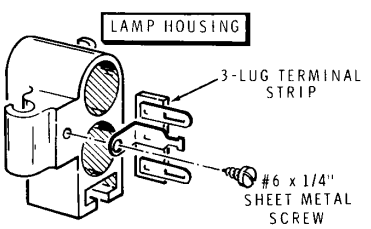
3 ( ) SLIDE THE HOUSING IN EITHER DIRECTION TO EVENLY SPACE THE SPEED NUT, FROM FRONT TO REAR IN THE BOTTOM OF THE HOUSING AS SHOWN. TIGHTEN THE 5/8" SCREW UNTIL IT IS SNUG. NOTE: THE FRONT OF THE HOUSING SHOULD BE EVEN WITH THE EDGE OF THE BOARD.



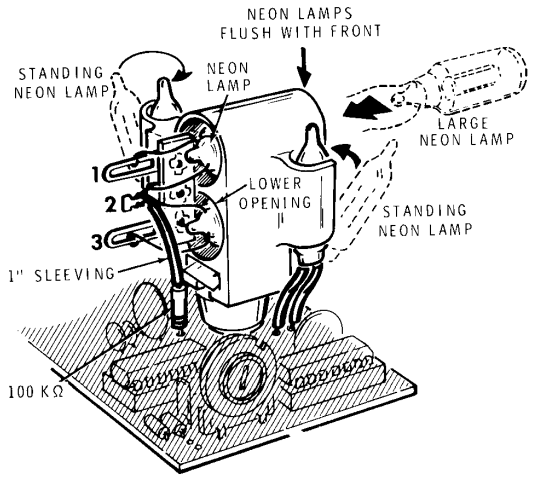
Detail 1-5E



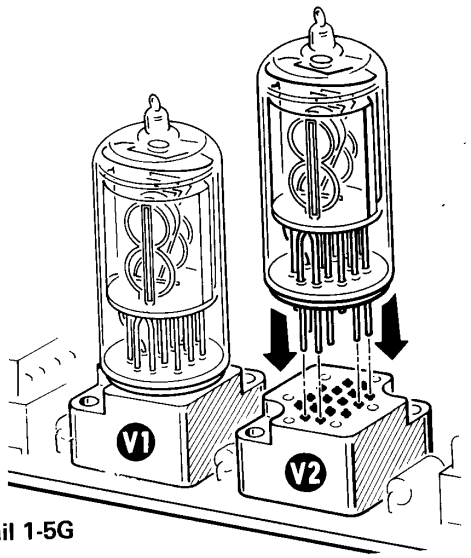
Detail 1-5C



Detail 1-5D



Detail 1-5F



Detail 1-5G

Refer to Detail 1-5F for the following steps.

( ) Push a large neon lamp into the lower opening of the lamp housing from the front, until the tip of this lamp is flush with the front of the opening.

( ) Connect the leads of this lamp to lugs 2 (NS) and 3 (NS) of the terminal strip as shown.

( ) Similarly, install the other large neon lamp in the upper opening of the lamp housing. Connect the leads of this lamp to lugs 1 (NS) and 2 (NS) of the terminal strip as shown.

( ) Place a 1" length of sleeving on the free lead of the vertically mounted 100 kΩ resistor and connect this lead to lug 2 of the terminal strip on the lamp housing (S-3).

( ) Slightly spread the two sides of the lamp housing with the small end of the nut driver before you install the lamps in the following step.

( ) Carefully press the standing neon lamps into each side of the lamp housing as shown. Be sure the lamp elements are lined up, from front to rear.

( ) Carefully align the pins of one of the display tubes with the openings in socket V1 as shown in Detail 1-5G. Push the tube firmly down into the socket.

( ) In the same manner, install a display tube at V2.

Circuit Board Checkout

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) "Cold" solder connections.

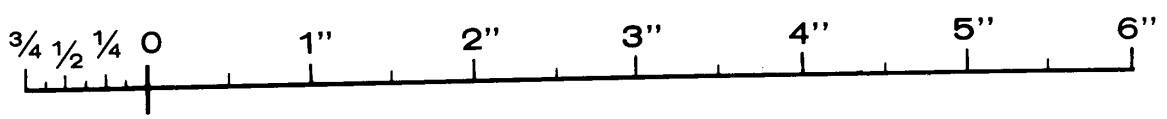
( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Transistors for the proper type and installation.

( ) Diode for the correct position of the banded end.

Set the logic circuit board aside temporarily.



MAIN CIRCUIT BOARD

PARTS LIST

Unpack the package marked #2 and check each part against the following list. The key numbers correspond to the numbers on the Main Circuit Board Parts Pictorial (fold-out from Page 17). Any part that is packaged in an individual envelope with a part number on it should be placed back in its envelope after it is identified until it is called for in a step.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS				
1/4-Watt, 10%				
A1	1-26-12	1	5600 Ω (green-blue-red)	.10
A1	1-14-12	2	12 kΩ (brown-red-orange)	.10
A1	1-10-12	1	15 kΩ (brown-green-orange)	.10
A1	1-48-12	1	680 kΩ (blue-gray-yellow)	.10
A1	1-88-12	1	10 MΩ (brown-black-blue)	.10
1/4-Watt, 5%				
A1	1-60-12	2	100 Ω (brown-black-brown-gold)	.10
A1	1-62-12	1	220 Ω (red-red-brown-gold)	.10
A1	1-69-12	2	1000 Ω (brown-black-red-gold)	.10
A1	1-72-12	2	2200 Ω (red-red-red-gold)	.10
A1	1-74-12	1	3300 Ω (orange-orange-red-gold)	.10
A1	1-76-12	3	4700 Ω (yellow-violet-red-gold)	.10
A1	1-79-12	1	8200 Ω (gray-red-red-gold)	.10
Resistors 1/4-Watt, 5% (cont'd.)				
A1	1-80-12	3	10 kΩ (brown-black-orange-gold)	.10
A1	1-81-12	1	27 kΩ (red-violet-orange-gold)	.10
A1	1-83-12	1	47 kΩ (yellow-violet-orange-gold)	.10
A1	1-84-12	1	100 kΩ (brown-black-yellow-gold)	.10
A1	1-95-12	1	180 kΩ (brown-gray-yellow-gold)	.10
A1	1-93-12	2	330 kΩ (orange-orange-yellow-gold)	.10
A1	1-87-12	5	1 MΩ (brown-black-green-gold)	.10
Precision				
A2	3-42-5	1	.9 Ω, 5-watt, 1/2%	.20
A2	2-47-1	1	10 Ω, 1-watt, 1/2%	.60
A2	2-83	1	200 Ω, 1/2-watt, 1%	.25
A2	2-17-12	1	9090 Ω (9.09 k), 1/4-watt, 1/10%	.70
A2	2-38	1	20 kΩ, 1/2-watt, 1%	.20
A2	2-54	1	200 kΩ, 1/2-watt, 1%	.20
A2	2-55	1	2 MΩ, 1/2-watt, 1%	.25
A2	2-4	1	100 Ω, 1/2-watt, 1/2%	.70
A2	2-6	1	1000 Ω (1 k), 1/2-watt, 1/2%	.60

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
Precision (Cont'd.)				
A2	2-670-12	1	1010 Ω (1.01 k), 1/4-watt, 1/2%	.75
A2	2-228	1	2000 Ω (2 k), 1/2-watt, 1%	.45
A2	2-294	1	90.9 kΩ, 1/2-watt, 1/2%	.55
A2	2-98-1	1	909 kΩ, 1-watt, 1/2%	1.60
Other Resistors				
A3	1-163	1	6.8 MΩ, 5% (blue-gray-green-gold)	.10
A4	1-19-1	1	220 Ω, 1-watt (red-red-brown)	.10
CAPACITORS				
B1	20-52	1	7.5 pF mica	.35
B2	21-70	1	.01 μF, 1400 V disc	.15
B2	21-16	1	.01 μF, 500 V disc	.10
B2	21-95	3	.1 μF disc	.15
B3	25-28	1	100 μF electrolytic	.60
B4	25-148	1	1000 μF electrolytic	.95
B5	25-220	3	10 μF tantalum	.45
B5	25-223	2	47 μF tantalum	1.50
B6	27-1	2	.1 μF Mylar	1.55
B6	27-86	2	.47 μF Mylar	.40
DIODES-TRANSISTORS				
C1	56-25	2	1N4166A diode	1.00
C1	56-845	7	1N4148 diode	.15
C1	57-27	3	1N2071 diode	.50
C1	57-65	3	1N4002 diode	.20

NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways:

1. Part number.
2. Type number.
3. Part number and type number.
4. Part number with a type number other than the one listed.

C2	417-234	3	2N3638A transistor	.60
C3	417-272	1	D40C1 transistor	1.05
C4	417-291	2	2N5458 transistor	.75
C4	417-801	5	MPSA20 transistor	.20

INTEGRATED CIRCUIT

NOTE: If either the part number or the "Description" number is on an integrated circuit, you have the correct part. Do not be concerned about any other numbers. On integrated circuits, the description number may have additional letters and numbers other than those given in the list. Example: SN(7490)N or MC(7490)P.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
C5	442-39	1	301A integrated circuit (IC)	1.55
CONTROLS-SWITCHES				
D1	10-382	3	2000 Ω (2 k) control	.55
D1	10-383	1	10 kΩ control	.35
D1	10-388	1	20 kΩ control	.30
D1	10-389	2	100 kΩ control	.30
D1	10-384	1	500 kΩ control	.30
D1	10-393	1	5 MΩ control	.55
D2	60-37	1	Rocker switch	1.15
D3	63-662	1	Four-wafer rotary switch	5.00
D4	63-663	1	Two-wafer rotary switch	3.70
HARDWARE				
E1	250-478	2	4-40 x 1-3/4" screw	.05
E2	255-2	2	3/16" spacer	.05
E3	255-172	2	1-3/8" spacer	.10
E4	259-6	1	#6 solder lug	.05
WIRE				
	344-21	1	Medium red wire	.05/ft
	344-50	1	Black wire	.05/ft
	344-52	1	Small red wire	.05/ft
	344-59	1	White wire	.05/ft
MISCELLANEOUS				
	85-1224-2	1	Main circuit board	2.60
F1	434-233	1	8-pin IC socket	.15
F2	432-134	9	Connector pin (2 extra)	.10
	100-1612	1	Calibration voltage envelope containing:	.65
A1		*1*	*10 kΩ, 1/4-watt, 5% resistor (brown-black-orange-gold)*	
A1		*1*	*22 kΩ, 1/4-watt, 5% resistor (red-red-orange-gold)*	
C1		*1*	*1N709A diode*	

NOTE: See Page 50 for "Replacement Parts and Price Information."

STEP-BY-STEP ASSEMBLY

The steps performed in this Pictorial are in this area of the circuit board.

PART NUMBER

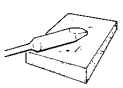
IDENTIFICATION DRAWING

START

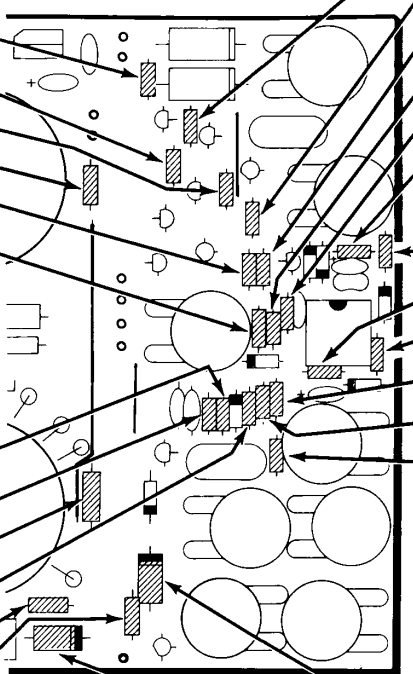
NOTE: Position the main circuit board as shown in the identification drawing. Then proceed with the following steps.

- ( ) 1 MΩ (brown-black-green).
- ( ) 100 Ω (brown-black-brown).
- ( ) 2200 Ω (red-red-red).
- ( ) 100 Ω (brown-black-brown).
- ( ) 10 kΩ (brown-black-orange).
- ( ) 10 MΩ (brown-black-blue).

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN... WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



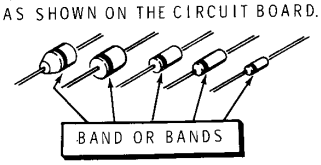
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) 330 kΩ (orange-orange-yellow).
- ( ) 10 kΩ (brown-black-orange).
- ( ) 1.01 kΩ precision resistor.
- ( ) 330 kΩ (orange-orange-yellow).
- ( ) 1 MΩ (brown-black-green).
- ( ) 8200 Ω (gray-red-red).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

- ( ) 10 kΩ (brown-black-orange).
- ( ) 2200 Ω (red-red-red).
- ( ) 4700 Ω (yellow-violet-red).
- ( ) 1 MΩ (brown-black-green).
- ( ) 15 kΩ (brown-green-orange).
- ( ) 4700 Ω (yellow-violet-red).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) 12 kΩ (brown-red-orange).
- ( ) 1 MΩ (brown-black-green).
- ( ) 12 kΩ (brown-red-orange).
- ( ) 1000 Ω (brown-black-red).
- ( ) 5600 Ω (green-blue-red).
- ( ) 100 kΩ (brown-black-yellow).

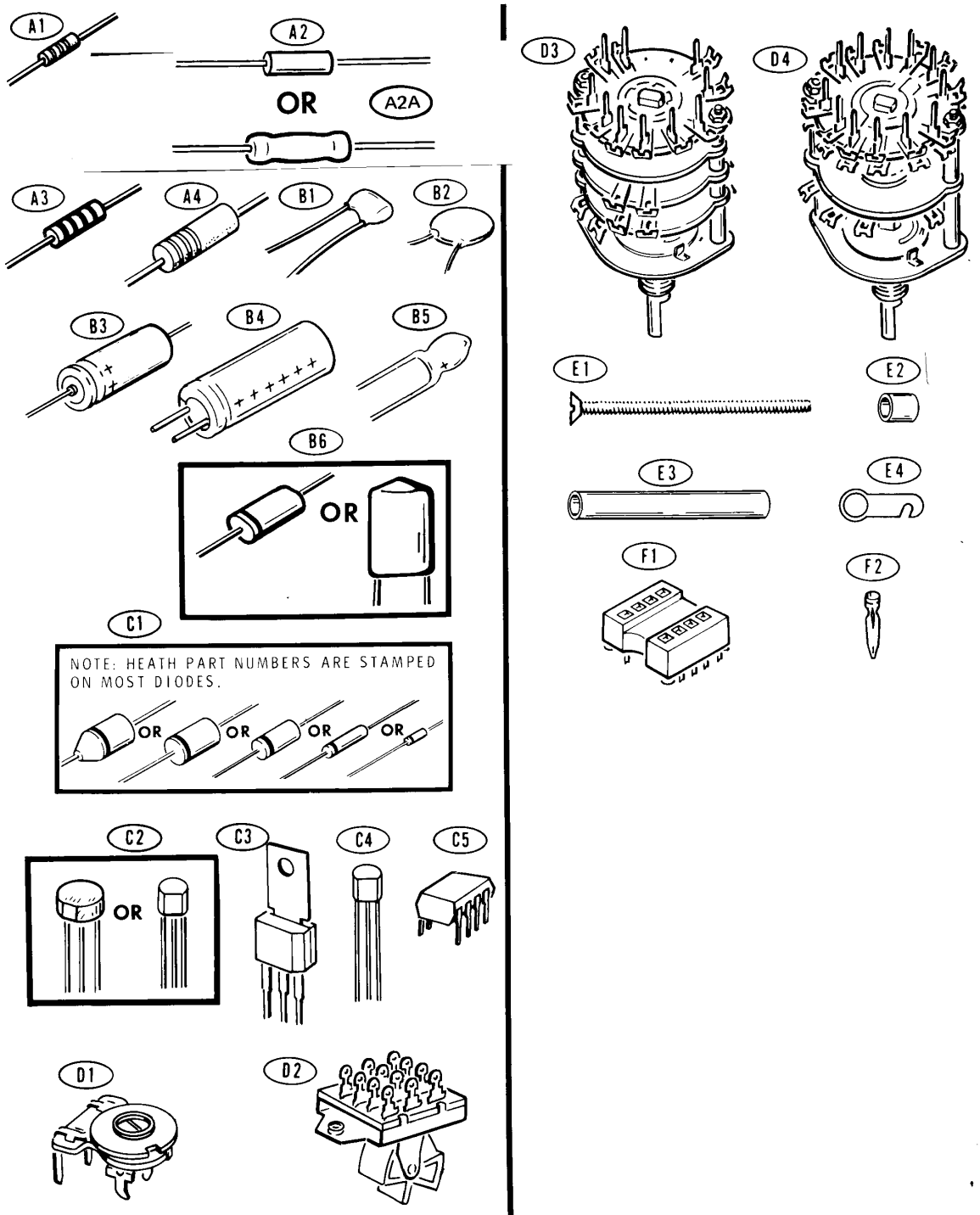
NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



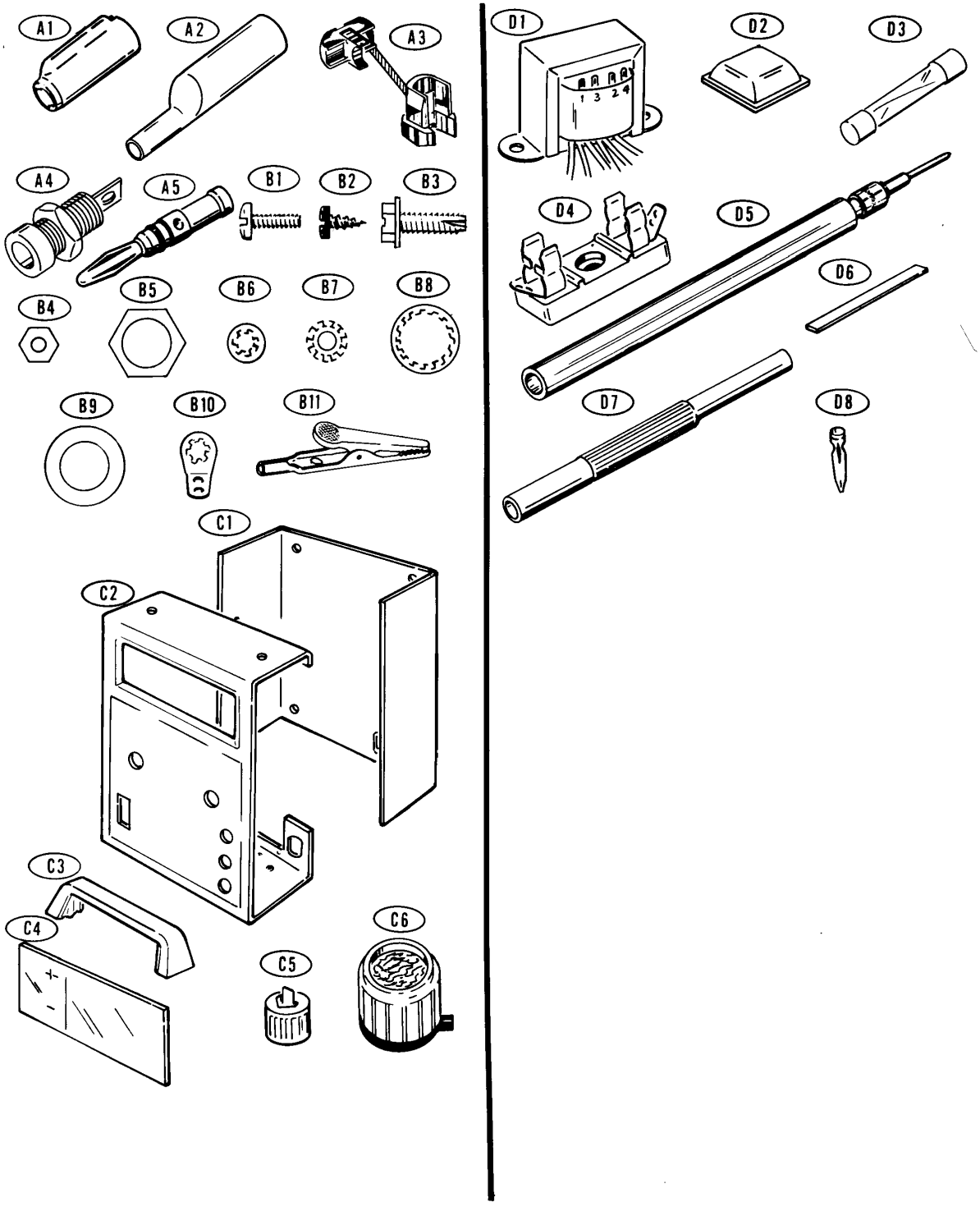
- ( ) 1N2071 diode (#57-27) at D2.
- ( ) 1N2071 diode (#57-27) at D1.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-1

MAIN CIRCUIT BOARD PARTS PICTORIAL



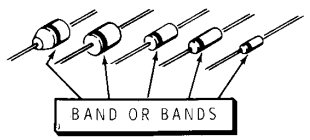
FRONT PANEL
PARTS PICTORIAL



HEATHKIT

START

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



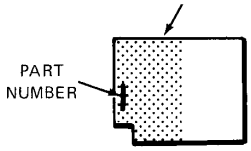
CAUTION: Some of the diodes installed in the following steps have similar numbers. Read the numbers carefully.

- ( ) 1N4002 diode (#57-65) at D11.
- ( ) 1N4002 diode (#57-65) at D12.
- ( ) 1N4002 diode (#57-65) at D13.
- ( ) 1N4166A diode (#56-25) at D15.
- ( ) 1N2071 diode (#57-27) at D16.
- ( ) 1N4166A diode (#56-25) at D14.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

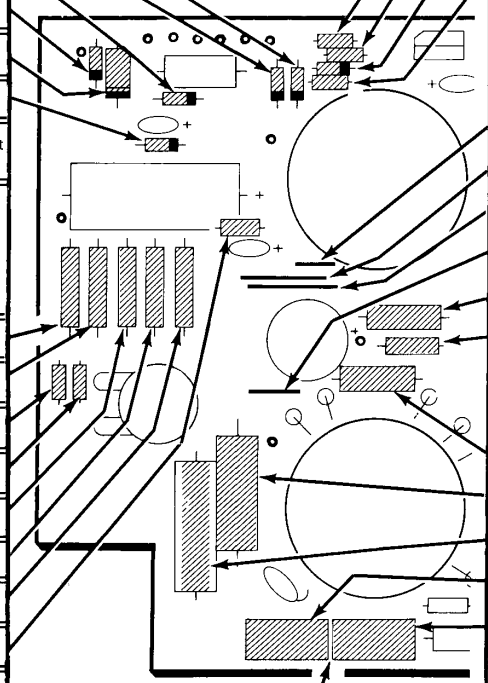
NOTE: When you install precision resistors in the following steps, be sure to use the holes indicated by the printed pattern on the circuit board. The inner row of holes will be used for another purpose.

- ( ) 200 Ω precision resistor.
- ( ) 2000 Ω (2 k) precision resistor.
- ( ) 1 MΩ (brown-black-green).
- ( ) 180 kΩ (brown-gray-yellow).
- ( ) 20 kΩ precision resistor.
- ( ) 200 kΩ precision resistor.
- ( ) 2 MΩ precision resistor.
- ( ) 1000 Ω (brown-black-red).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.



IDENTIFICATION DRAWING



CAUTION: BE SURE THE RESISTOR LEADS IN THIS AREA DO NOT TOUCH

CONTINUE

NOTE: Locate the small envelope, part #100-1612. The parts in this envelope will be installed in the following three steps. It is important that you save the envelope; you will need the information on it to calibrate this instrument later.

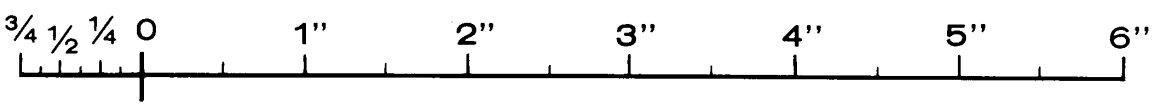
The calibration figures on the envelope should be permanently inked onto the foil side of the main circuit board, or on the inside of the cabinet (see Page 39).

- ( ) 10 kΩ (brown-black-orange).
- ( ) 22 kΩ (red-red-orange).
- ( ) 1N709A diode (#56-58) at D10. Be sure to position the banded end as shown.
- ( ) 3300 Ω (orange-orange-red).

NOTE: Cut bare wires to the indicated lengths, in the following steps. Then form the wires to the circuit board outline and install each wire in the circuit board holes.

- ( ) 3/4" bare wire.
- ( ) 1-1/4" bare wire.
- ( ) 1-1/4" bare wire.
- ( ) 3/4" bare wire.
- ( ) 90.9 kΩ precision resistor.
- ( ) 9090 Ω (9.09 k) precision resistor.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) 909 kΩ 1-watt precision resistor.
- ( ) .9 Ω wire-wound resistor.
- ( ) 10 Ω precision resistor.
- ( ) 100 Ω precision resistor.
- ( ) 1000 Ω (1 k) precision resistor.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-2



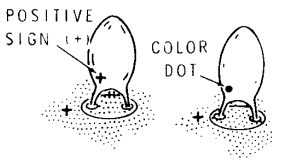
HEATHKIT®

START

( ) .1 μF disc.

NOTE: Tantalum capacitors may be marked two ways as shown. When you install the following capacitor, be sure to match the positive (+) sign or color dot with the positive (+) marking on the circuit board.

MAY BE MARKED WITH POSITIVE SIGN (+) OR COLOR DOT



( ) 47 μF tantalum.

( ) 1-1/4" bare wire.

( ) 2-3/4" white wire. Remove 1/4" of insulation from each wire end and form the wire to the outline on the circuit board.

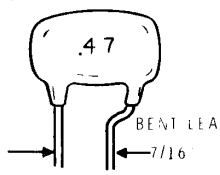
( ) 1" bare wire.

( ) .1 μF disc.

( ) 1N4149 diode (#56-56) at D3. Position the banded end as shown.

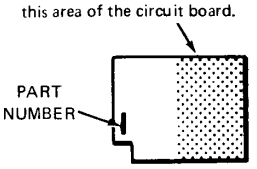
( ) .01 μF, 500 V disc.

( ) .47 μF Mylar. If necessary, form the leads as shown.

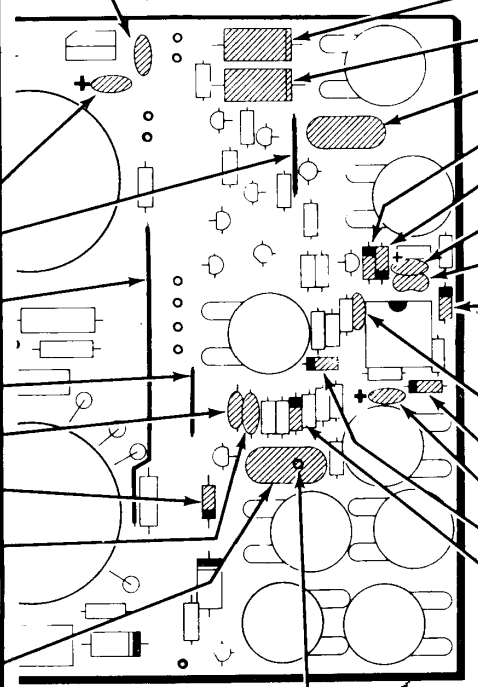


( ) Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.

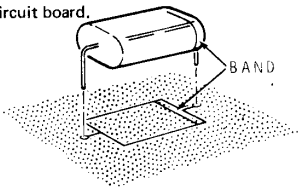


IDENTIFICATION DRAWING



CONTINUE

NOTE: When you install Mylar capacitors in the next two steps be sure to position the banded end of each capacitor at the same end as the banded outline on the circuit board.



( ) .1 μF Mylar.

( ) .1 μF Mylar.

( ) .47 μF Mylar. Form the leads as before.

( ) 1N4149 diode (#56-56) at D7.

( ) 1N4149 diode (#56-56) at D6.

( ) 10 μF tantalum. Be sure to position the positive (+) mark as shown.

( ) 7.5 pF mica.

( ) 1N4149 diode (#56-56) at D9.

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) .1 μF disc.

( ) 1N4149 diode (#56-56) at D8.

( ) 47 μF tantalum.

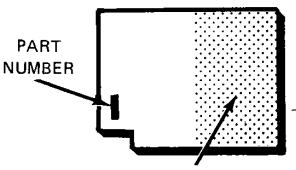
( ) 1N4149 diode (#56-56) at D4.

( ) 1N4149 diode (#56-56) at D5.

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-3

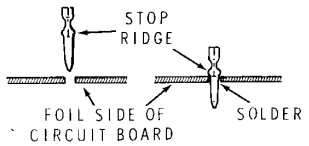
IDENTIFICATION DRAWING



The steps performed in this Pictorial are in this area of the circuit board.

START

( ) Install and solder wire connectors (#432-134) as shown.



( ) Wire connector at A.

( ) Wire connector at B.

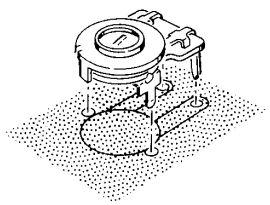
( ) Wire connector at C.

( ) Wire connector at D.

( ) Wire connector at E.

( ) Wire connector at F.

NOTE: When you install controls in the following steps, push each control down onto the surface of the circuit board. Then solder all the lugs to the foil.



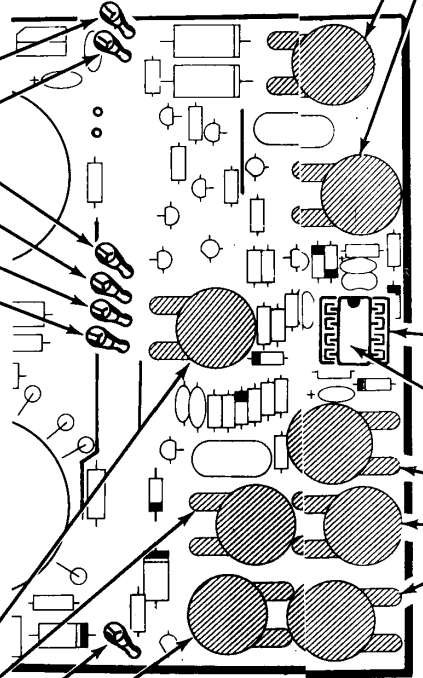
( ) 2000 Ω (2 k) control (#10-382).

( ) 500 kΩ control (#10-384).

( ) Wire connector at G.

( ) 2000 Ω (2 k) control (#10-382).

( ) Check all the wire connectors and be sure none have filled with solder. If necessary replace a solder-filled connector with an extra one provided. Do not discard any unused connector pins.

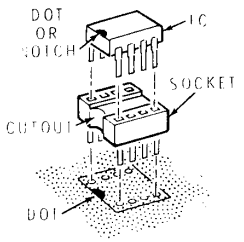


CONTINUE

( ) 20 kΩ control (#10-388).

( ) 2000 Ω (2 k) control (#10-382).

NOTE: When you install the 8-pin IC socket in the following step, be sure to match the cutout on the end of the socket to the similarly-shaped mark on the circuit board. Solder the pins when the socket is installed.



( ) 8-pin IC socket at IC1.

( ) 301A (#442-39) integrated circuit. Be sure to match the dot or notch on the IC with the cutout on the socket.

( ) 10 kΩ control (#10-383).

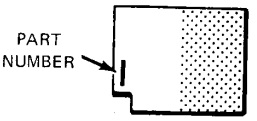
( ) 100 kΩ control (#10-389).

( ) 5 MΩ control (#10-393).

PICTORIAL 2-4

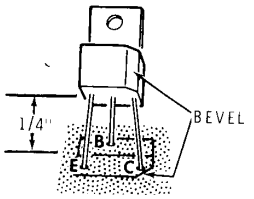
START

The steps performed in this Pictorial are in this area of the circuit board.



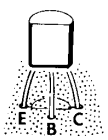
IDENTIFICATION DRAWING

NOTE: Bend the leads and install the following transistor as shown. Match the bevel on the transistor with the bevel outline on the circuit board. Solder the leads to the foil and cut off the excess lead lengths.



( ) D40C1 transistor (#417-272) at Q11.

NOTE: Installl the following transistors as shown. Be sure to match the E, B, and C leads on the transistor with the E, B, and C holes in the circuit board. Solder the leads to the foil as the transistor is installed and cut off the excess lead lengths.



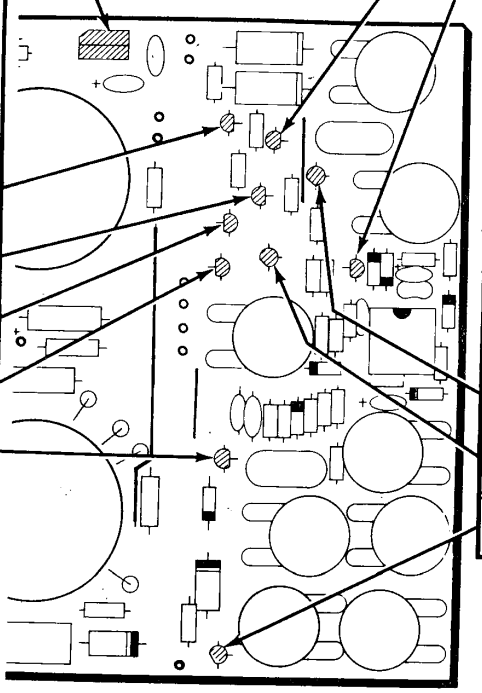
( ) MPSA20 transistor (#417-801) at Q1.

( ) MPSA20 transistor (#417-801) at Q2.

( ) MPSA20 transistor (#417-801) at Q5.

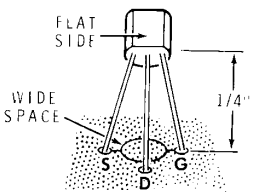
( ) MPSA20 transistor (#417-801) at Q3.

( ) MPSA20 transistor (#417-801) at Q9.



CONTINUE

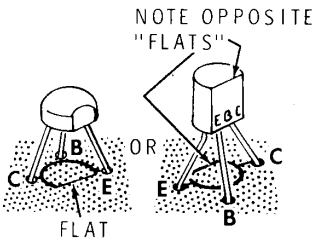
NOTE: Install the next two transistors as shown. Solder the leads to the foil and cut off the excess lead lengths



( ) 2N5458 transistor (#417-291) at Q7.

( ) 2N5458 transistor (#417-291) at Q8.

IMPORTANT NOTE: Study the illustration carefully then install the following transistors as shown. Be sure to match the C, B, and E leads on the transistor with the C, B, and E holes in the circuit board. Solder the leads to the foil and cut off the excess lead lengths.



( ) 2N3638A transistor (#417-234) at Q6.

( ) 2N3638A transistor (#417-234) at Q4.

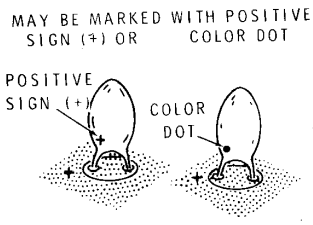
( ) 2N3638A transistor (#417-234) at Q10.

PICTORIAL 2-5

START

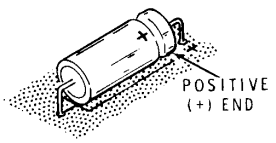
( ) 220 Ω, 1-watt (red-red-brown).

NOTE: Tantalum capacitors may be marked two ways as shown. When you install the following capacitor, be sure to match the positive (+) sign or color dot with the positive (+) marking on the circuit board.



(✓) 10 μF tantalum.

NOTE: Be sure to match the positive (+) marking on the following electrolytic capacitor with the positive (+) marking on the board.



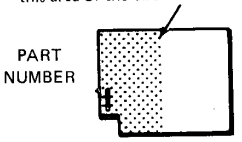
( ) 100 μF electrolytic.

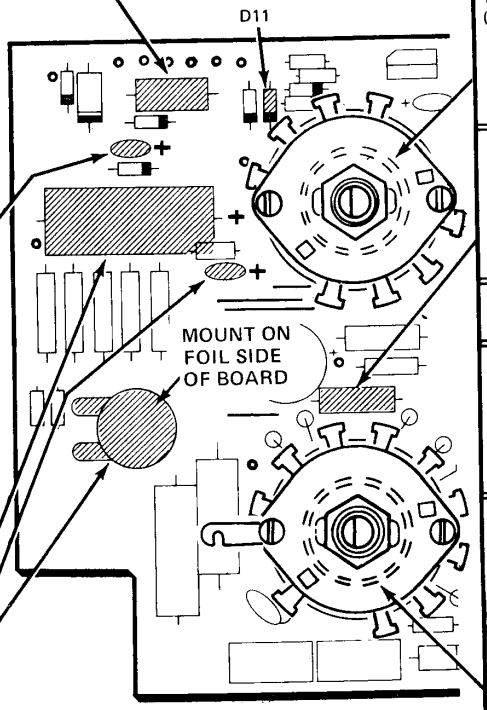
( ) 10 μF tantalum capacitor.

( ) 100 kΩ control (#10-389). Mount this control on the foil side of the circuit board. Be sure to mount it tightly against the foil.

( ) Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.





PICTORIAL 2-6

CONTINUE

NOTE: When you install rotary switches, be sure they are positioned as shown. Push the switch all the way down onto the circuit board. Then solder all the lugs to the foil.

(✓) 4-wafer rotary switch (#63-662) at SW-2. On the switch wafer nearest the circuit board, bend the terminal up away from D11 so there is no danger of a short circuit.

(✓) 909 kΩ, 1-watt precision resistor.

NOTE: If the resistor you received in your kit has a large body, it will be necessary to install it as directed in Detail 2-6A below.

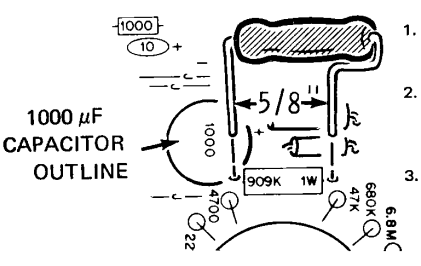
Refer to Detail 2-6B for the following steps.

(✓) Hold the switch shaft upward so the lugs on the top wafer are positioned as shown. Then remove the indicated long screw from the switch assembly. Discard the indicated lockwasher.

(✓) Place a #6 solder lug on the long screw; then replace the screw into the assembly. Be sure the two 3/4" spacers are properly positioned; then tighten the screw securely.

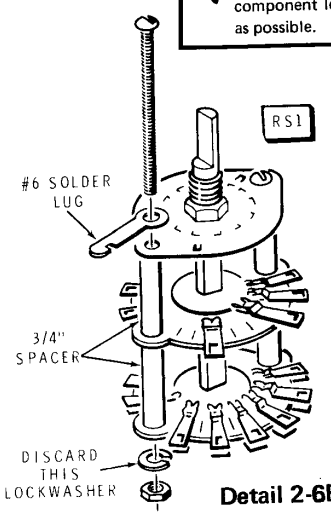
(✓) Mount the 2-wafer rotary switch at SW1. Be sure the solder lug on the top of the switch is positioned as shown. Solder the lugs to the foil.

(✓) Cut all excess switch lugs and component leads as close to the foil as possible.

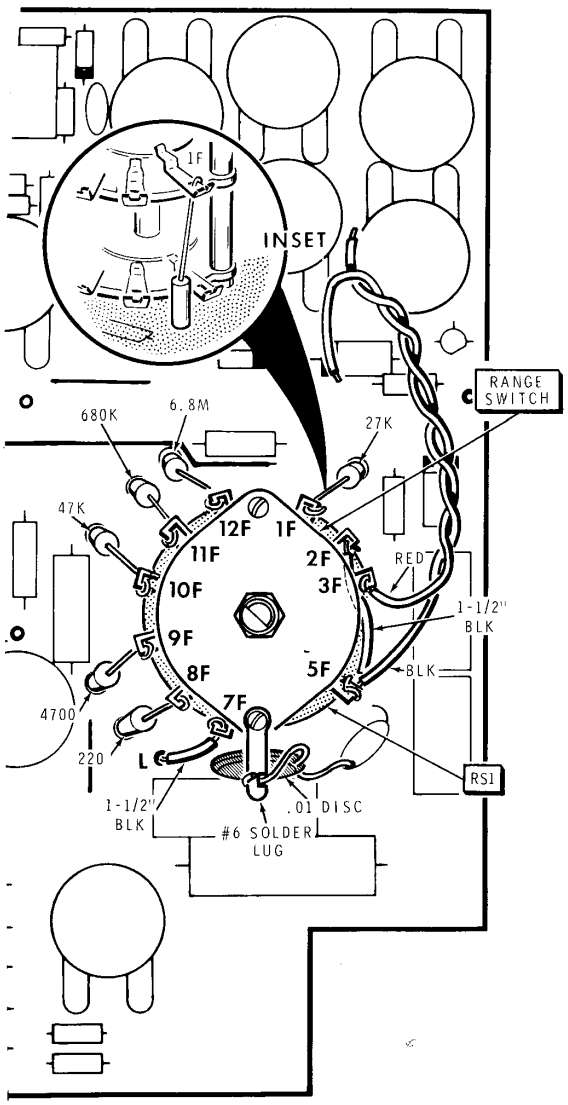


1. Bend resistor leads exactly as shown.
2. Position resistor with leads as shown.
3. Install resistor. Solder leads to foil and cut off excess lengths.

Detail 2-6A



Detail 2-6B



PICTORIAL 2-7

RANGE SWITCH WIRING

Refer to Pictorial 2-7 for the following steps and position the circuit board as shown.

NOTE: When you install components between the circuit board and a switch wafer, as in the following steps, insert one of the component leads into the proper circuit board location. Then insert the other lead through and around the designated lug of the switch wafer. Solder the lead to the underside of the circuit board; then solder the other lead to the wafer lug as directed by the solder steps. Cut off any excess lead lengths.

Switch wafers are called out from the end closest to the knob end of the switch shaft (such as "RS1, RS2," and so on). Lugs are numbered from 1 to 12, in clockwise rotation from the 1 o'clock position, and lettered either F or R for the front or the rear of the wafer. Therefore, "RS1-2F" would mean: range switch; wafer 1 (top wafer); lug 2 (at the 2 o'clock position); on the front of the wafer.

Position the main circuit board as shown in the Pictorial and proceed with the following steps.

( ) 27 kΩ resistor (red-violet-orange) from "27K" on the circuit board (S-1) to RS1-1F (S-1).

( ) .01 μF, 1400 V disc capacitor from ".01" on the circuit board (S-1) to the #6 solder lug on the top of switch 1 (S-1).

( ) 1-1/2" black wire from L on the circuit board (S-1) to RS1-7F (S-1).

( ) 220 Ω resistor (red-red-brown) from "220" on the circuit board (S-1) to RS1-8F (S-1).

( ) 4700 Ω resistor (yellow-violet-red) from "4700" on the circuit board (S-1) to RS1-9F (S-1).

( ) 47 kΩ resistor (yellow-violet-orange) from "47K" on the circuit board (S-1) to RS1-10F (S-1).

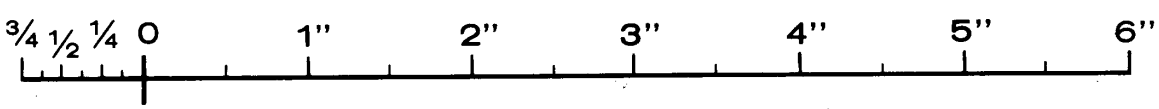
( ) 680 kΩ resistor (blue-gray-yellow) from "680K" on the circuit board (S-1) to RS1-11F (S-1).

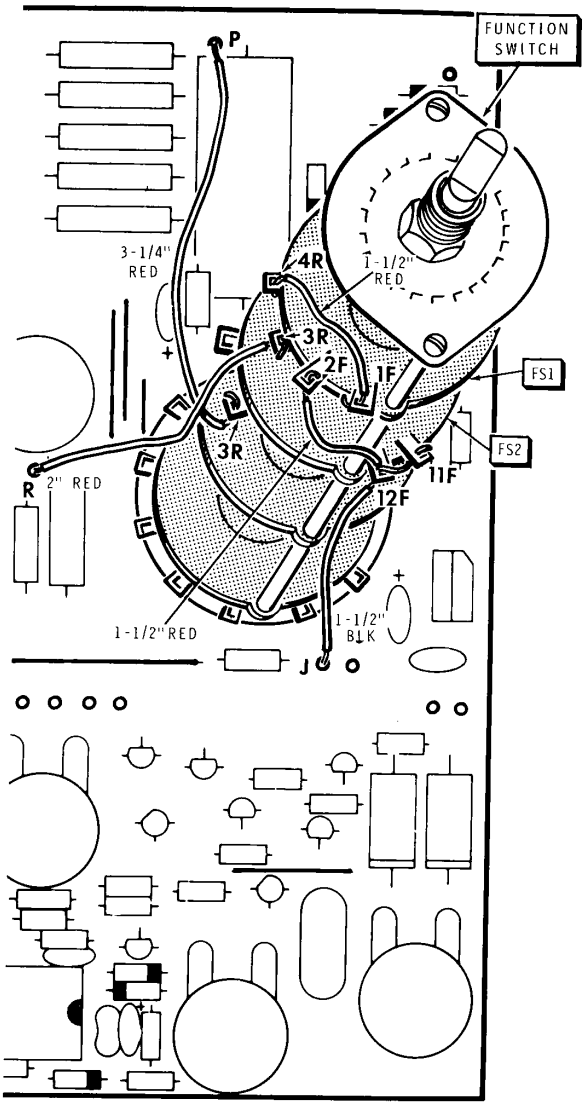
( ) 6.8 MΩ resistor (blue-gray-green-gold) from "6.8M" on the circuit board (S-1) to RS1-12F (S-1).

( ) Connect a 1-1/2" black wire from RS1-2F (S-1) to RS1-5F (NS). Position the wire as shown.

( ) Prepare a 5" small red wire and a 5" black wire. Twist these two wires together.

( ) At one end of the twisted pair, connect the black wire to RS1-5F (S-2) and the red wire to RS1-3F (S-1). The free ends of this twisted pair of wires will be connected later.





PICTORIAL 2-8

FUNCTION SWITCH WIRING

Refer to Pictorial 2-8 and position the circuit board as shown for the following steps.

( ) Prepare the following small red wires:

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

(✓) Connect a 1-1/2" red wire between lugs FS1-1F (S-1) and FS1-4R (NS).

(✓) Connect a 1-1/2" red wire from FS1-2F (S-1) to FS2-12F (NS).

(✓) Connect a 3-1/4" red wire from FS2-3R (S-1) to hole P on the main circuit board (S-1).

(✓) Connect a 2" red wire from FS1-3R (S-1) to hole R on the main circuit board (S-1).

(✓) Prepare a 1-1/2" black wire by removing 1/4" of insulation from one end and 1/2" of insulation from the other end.

NOTE: Where a wire passes through a connection and then goes to another point, as in the next step, it will count as two wires in the solder instructions, one entering and one leaving the connection.

(✓) Pass the 1/2" bare end of the 1-1/2" black wire through FS2-12F (S-3) to FS2-11F (S-1). Connect the other end of this wire to hole J in the main circuit board (S-1).

Refer to Pictorial 2-9 and position the circuit board as shown, for the following steps.

( ) Prepare the following wires:

1-1/2" black
1-1/4" black

(✓) Connect the 1-1/2" black wire from FS2-10F (S-1) to hole H on the main circuit board (S-1).

(✓) Connect the 1-1/4" black wire from FS2-7F (S-1) to hole K in the main circuit board (S-1).

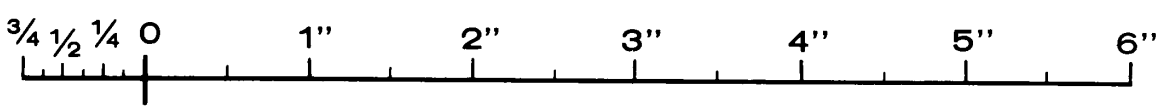
(✓) Prepare a 6" and a 7" medium red wire. Place one end of each of the two wires together to form the "beginning end," and form a twisted pair.

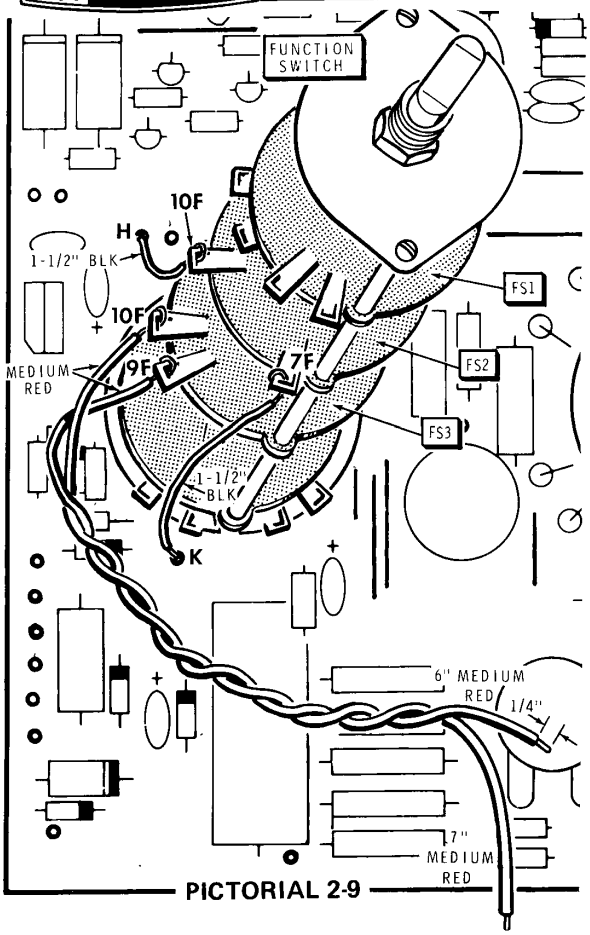
(✓) At the "beginning end" of the twisted pair, connect one wire to lug FS3-9F (S-1), and the other wire to lug FS3-10F (S-1). Wrap these wire ends tightly around the wafer lugs to make mechanically secure connections. The free ends will be connected later.

( ) Set the main circuit board aside temporarily.

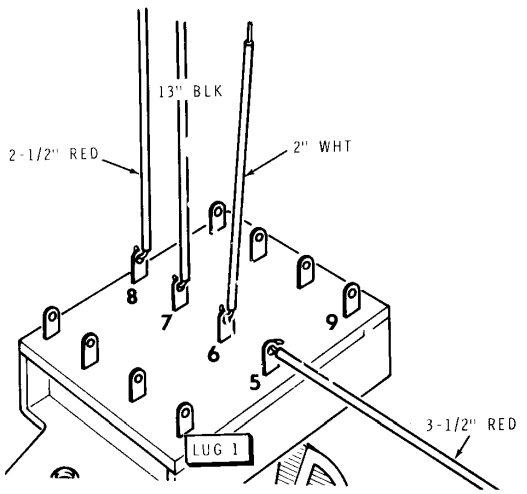
ROCKER SWITCH WIRING AND INSTALLATION

NOTE: After you have soldered a wire to a rocker switch terminal, push the wire insulation along the wire toward the switch terminal as far as possible. This is to avoid any bare wire which might cause a short circuit to another switch terminal after the free ends of the wires are connected.

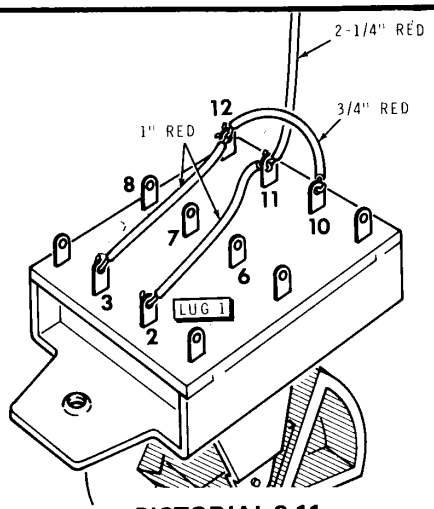




PICTORIAL 2-9



PICTORIAL 2-10



PICTORIAL 2-11

Refer to Pictorial 2-10 for the following steps:

( ) Prepare the following wires:

2" white	13" black
3-1/2" small red	2-1/2" small red

( ) Position the rocker switch as shown and mark the lug numbers on the end of the switch with a felt tip pen, or mark pin 1 with a dot of finger nail polish. Either end of the switch may be used.

In the following steps, connect the prepared wires to the indicated lugs of the rocker switch. Be sure none of the wires extend beyond the ends of the switch.

( ) Connect the 2" white wire to lug 6 (S-1).

( ) Connect the 3-1/2" red wire to lug 5 (S-1).

( ) Connect the 13" black wire to lug 7 (S-1).

( ) Connect the 2-1/2" red wire to lug 8 (S-1).

( ) Prepare the following small red wires:

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

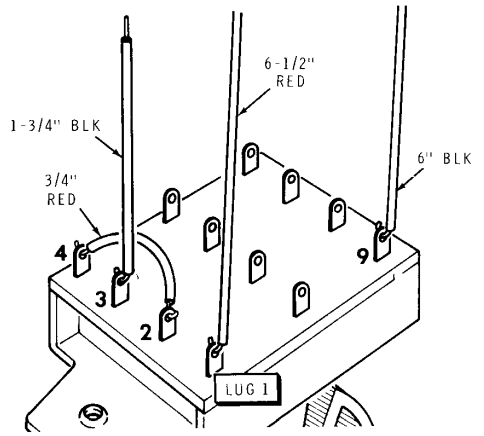
Refer to Pictorial 2-11 and continue to wire the rocker switch:

( ) Connect a 1" red wire from lug 11 (NS) to lug 2 (NS). Position the wire between lugs 6 and 7.

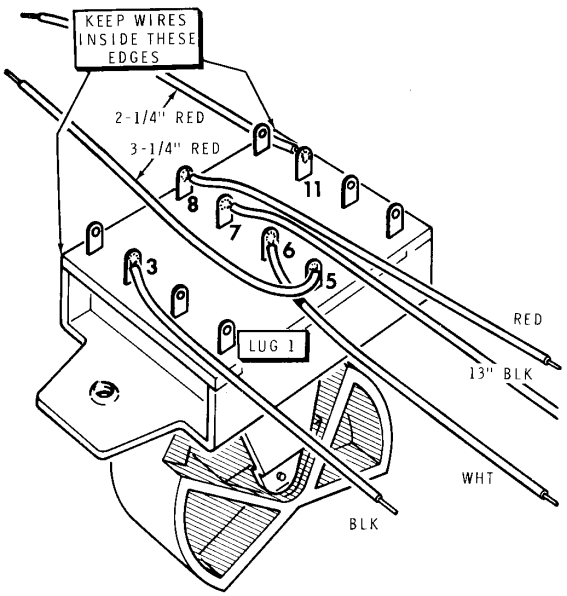
( ) Connect the 2-1/4" red wire to lug 11 (S-2).

( ) Connect a 1" red wire from lug 12 (NS) to lug 3 (NS). Position this wire between lugs 7 and 8.

( ) Connect a 3/4" red wire from lug 10 (S-1) to lug 12 (S-2).



PICTORIAL 2-12



PICTORIAL 2-13

Refer to Pictorial 2-12 for the following steps:

( ) Prepare the following wires:

1-3/4" black	6-1/2" small red
3/4" small red	6" black

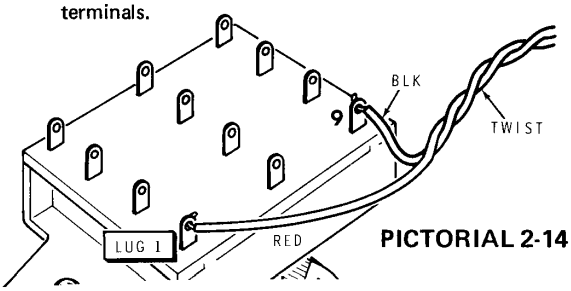
( ) Connect a 1-3/4" black wire to lug 3 (S-2).

( ) Connect a 3/4" red wire from lug 2 (S-2) to lug 4 (S-1).

( ) Connect a 6-1/2" red wire to lug 1 (S-1).

( ) Connect a 6" black wire to lug 9 (S-1).

( ) Refer to Pictorial 2-13 and, except for the wires in the two preceding steps, bend all wires to a horizontal position as shown in this top view of the switch terminals.

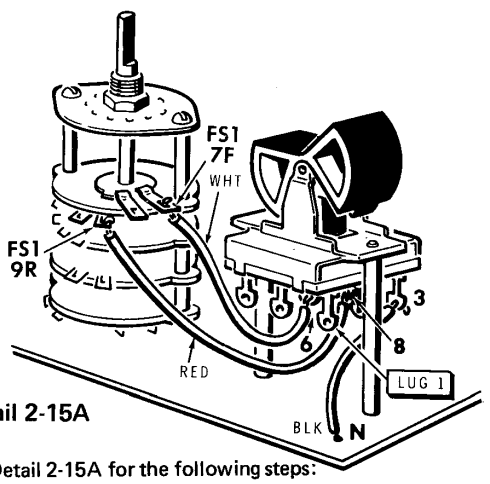


PICTORIAL 2-14

( ) Refer to Pictorial 2-14, position the red wire from lug 1 and the black wire from lug 9 as shown, and form a twisted pair from the two wires.

NOTE: Before you perform the following step, be sure none of the wires protrude beyond the ends of the rocker switch.

( ) Refer to Pictorial 2-15 and mount the rocker switch on the main circuit board with two 4-40 x 1-3/4" screws, two 3/16" spacers, and two 1-3/8" spacers as shown. First, slide a 3/16" spacer onto a screw. Push the screw through the circuit board from the foil side, slide a 1-3/8" spacer onto the screw, and turn the screw into the switch mounting hole. Then loosen each mounting screw one-half turn.

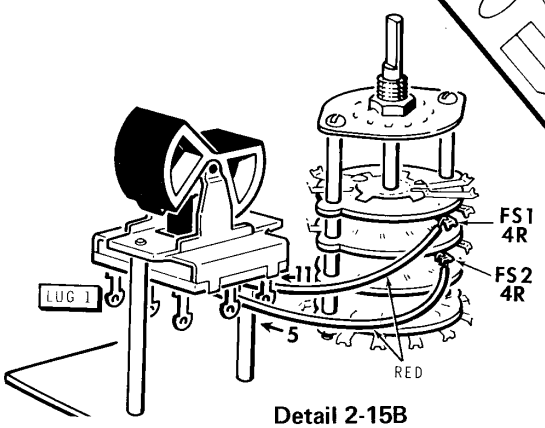


Detail 2-15A

Refer to Detail 2-15A for the following steps:

( ) Connect the red wire coming from lug 8 of the rocker switch to FSI-9R (S-1).

( ) Connect the white wire coming from lug 6 of the rocker switch to FSI-7F (S-1).



Detail 2-15B

✓ Connect the black wire coming from lug 3 of the rocker switch to hole N in the circuit board (S-1).

Refer to Detail 2-15B for the two following steps:

(✓ Connect the red wire coming from lug 11 of the rocker switch to FSI-4R (S-2).

✓ Connect the red wire coming from lug 5 of the rocker switch to FS2-4R (S-1).

Refer to Pictorial 2-15 for the following steps:

(✓ Prepare a 13" small red wire and a 13" white wire.

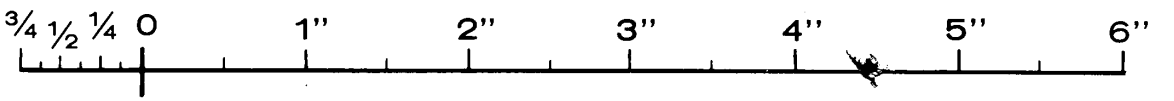
(✓ Connect the 13" white wire to FS1-8F (S-1).

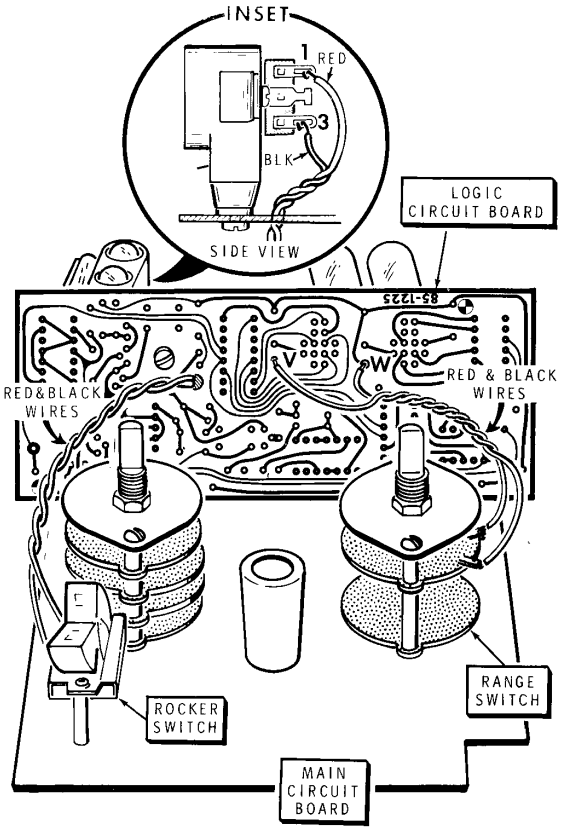
(✓ Connect the 13" small red wire to FS1-10R (S-1).

(✓ Position the 13" red and white wires from the function switch, and the 13" black wire from the rocker switch together and twist them to form a 3-wire twisted cable as shown. Do not put any strain on the function switch solder lugs while you form the cable.

(✓ Mount a 1000 μF electrolytic capacitor on the main circuit board between the two wafer switches as shown. Be sure to match the positive (+) mark on the capacitor with the + mark on the circuit board. Solder both leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-15





PICTORIAL 3-1

FINAL CIRCUIT BOARD ASSEMBLY

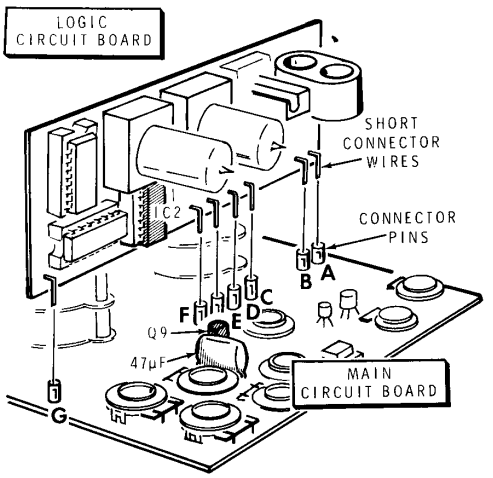
Refer to Pictorial 3-1 for the following steps.

NOTE: Before you perform the following steps, check both circuit boards and be sure all excess component leads, lugs, and wire ends are trimmed as close to the foil sides of the boards as possible.

( ) Place the logic circuit board near the main circuit board switches as shown in the Pictorial.

( ) Locate the twisted black and red wires coming from lugs 1 and 9 of the rocker switch. Push these wires through the logic circuit board from the foil side. Refer to the inset drawing on the Pictorial and connect the red wire to terminal strip lug 1 (S-2) and the black wire to lug 3 (S-2).

( ) Locate the twisted black and red wires coming from the Range switch. Connect the red wire to foil pad W (S-1) and the black wire to foil pad V (S-1) on the logic circuit board.



Detail 3-1A

( ) Refer to Detail 3-1A and carefully mount the logic circuit board onto the main circuit board as shown. Align the short connector wires on the edge of the logic board with connector pins A through G. Then carefully press the logic board straight down until the edge rests on the surface of the main circuit board. Make sure Q9 does not interfere with IC2 on the logic circuit board. Push the .47 µF capacitor toward the control, if necessary.

Set the circuit board assembly aside temporarily.

FRONT PANEL

PARTS LIST

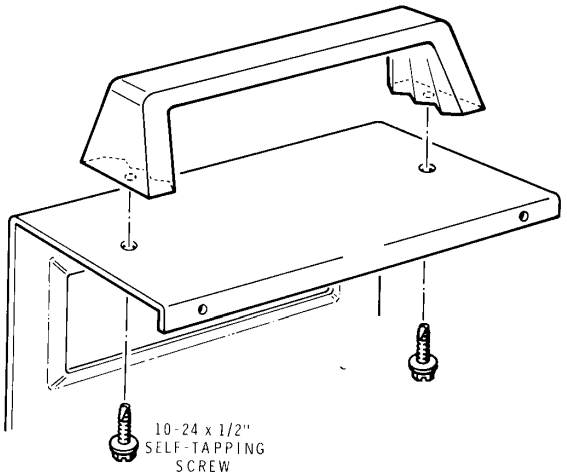
Unpack package #3, which is all the remaining parts, and check each part against the following list. The key numbers correspond to the numbers on the Front Panel Parts Pictorial (fold-out from Page 18). Any part that is packaged in an individual envelope or carton with a part number on it should be placed back in its envelope or carton after it is identified until it is called for in a step.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
INSULATORS-GASKET-JACKS-PLUGS				
A1	70-10	1	Black plug insulator	.10
A1	70-11	1	Red plug insulator	.10
A2	73-21	1	Alligator clip insulator	.10
	73-92	1	Foam gasket	.15
A3	75-71	1	Strain relief	.10
A4	436-11	1	Red jack	.15
A4	436-22	1	Black jack	.15
A4	436-24	1	White jack	.15
A5	438-47	2	Banana plug	.15
HARDWARE				
B1	250-89	5	6-32 x 3/8" screw	.05
B2	250-369	5	#6 x 1/4" sheet metal screw	.05
B3	250-255	2	10-24 x 1/2" self-tapping screw	.05
B4	252-3	5	6-32 nut	.05
B5	252-7	2	Control nut	.05
B6	254-1	4	#6 internal lockwasher	.05
B7	254-6	4	#6 external lockwasher	.05
B8	254-5	2	Control lockwasher	.05
B9	253-10	2	Control flat washer	.05
B10	259-1	1	#6 solder lug	.05
B11	260-1	1	Alligator clip	.10
CABINET AND KNOB PARTS				
C1	90-585-1	1	Cabinet	4.10
C2	203-1449-1	1	Front panel	2.60
C3	211-15	1	Handle	.20
C4	446-608	1	Front panel window	2.00

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
Cabinet and Knob Parts (cont'd.)				
C5	455-50	2	Knob bushing	.10
C6	462-245	2	Knob	.25
WIRE-CORD				
	341-1	1	Large black wire	.10
	341-2	1	Large red wire	.10
	89-23	1	Line cord	.75
MISCELLANEOUS				
D1	54-815	1	Power transformer	5.00
D2	261-29	5	Plastic foot	.05
	390-362	1	Fuse label	.10
	390-988	1	Front panel label	.45
D3	421-2	1	3-ampere fuse	.10
D3	421-19	1	1/4-ampere fuse	.15
D4	422-1	2	Fuseholder	.25
D5	439-1	1	Test probe	.45
D6	205-778	1	Alignment tool blade	.10
D7	490-5	1	Nut starter	.10
	171-7325	1	Consisting of:	
D8	*432-134*	*7*	*Connector pin*	*.10*
	344-51	*1*	*Brown wire*	*.05/ft*
	344-52	*1*	*Red wire*	*.05/ft*
	344-53	*1*	*Orange wire*	*.05/ft*
	344-54	*1*	*Yellow wire*	*.05/ft*
	344-55	*1*	*Green wire*	*.05/ft*
	344-56	*1*	*Blue wire*	*.05/ft*
	344-57	*1*	*Violet wire*	*.05/ft*

NOTE: See Page 50 for "Replacement Parts and Price Information."

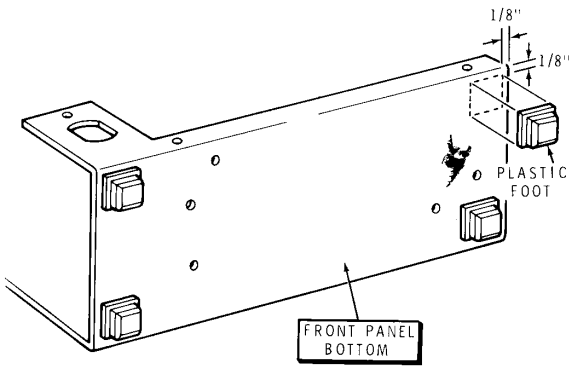
STEP-BY-STEP ASSEMBLY



Detail 4-1A

Refer to Pictorial 4-1 (fold-out from Page 31) for the following steps.

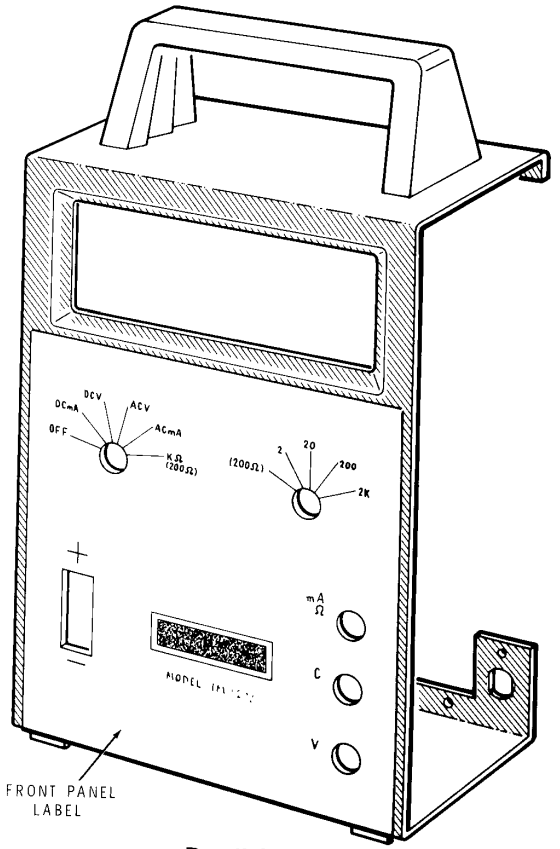
( ) Locate the front panel and the handle. Mount the handle with two 10-24 x 1/2" self-tapping screws as shown in Detail 4-1A.



Detail 4-1B

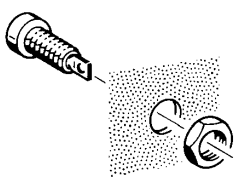
( ) Remove the protective backing from a plastic foot and mount it on the corner of the front panel bottom as shown in Detail 4-1B.

( ) In a similar manner, mount a plastic foot at each remaining corner.



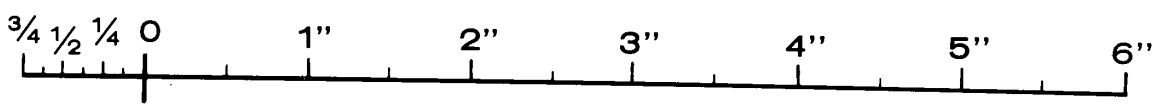
Detail 4-1C

( ) Carefully remove the protective backing from the front panel label and place it in the recessed area on the front panel. Be sure the label holes align with the panel holes before you press the label into place. See Detail 4-1C.



Detail 4-1D

( ) Refer to Detail 4-1D and mount a white jack at hole A with the attached nut.



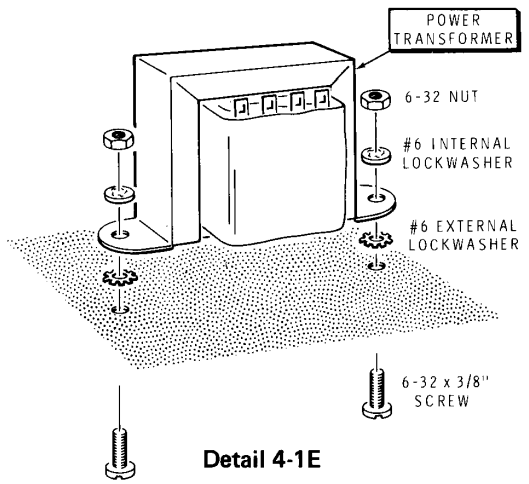
( ) In a similar manner, mount a black jack at hole B.

( ) Mount a red jack at hole C.

NOTES:

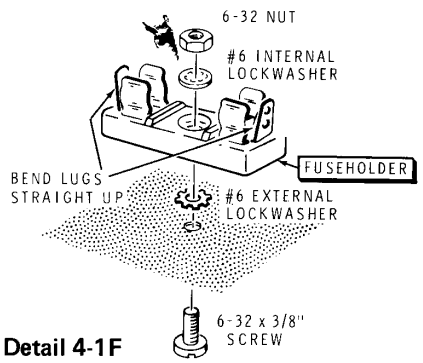
1. Use the plastic nut starter supplied with this kit to hold and start 6-32 nuts and lockwashers on screws.

2. In the next three steps place the external lockwasher next to the chassis.



Detail 4-1E

(✓) Mount the power transformer as shown in Detail 4-1E. Use two 6-32 x 3/8" screws, two #6 external lockwashers, two #6 internal lockwashers, and two 6-32 nuts.



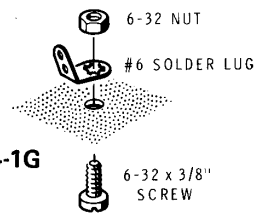
Detail 4-1F

NOTE: You will be unable to start the nuts on fuseholder screws with the nut starter in the following two steps.

( ) Refer to Detail 4-1F and mount a fuseholder at hole D with a 6-32 x 3/8" screw, a #6 external lockwasher, a #6 internal lockwasher, and a 6-32 nut. Bend both lugs of the fuseholder straight up as shown.

( ) In a similar manner, mount a fuseholder at hole E. Bend both lugs straight up as shown.

(✓) Mount a #6 solder lug at hole F with a 6-32 x 3/8" screw and a 6-32 nut as shown in Detail 4-1G.



Detail 4-1G

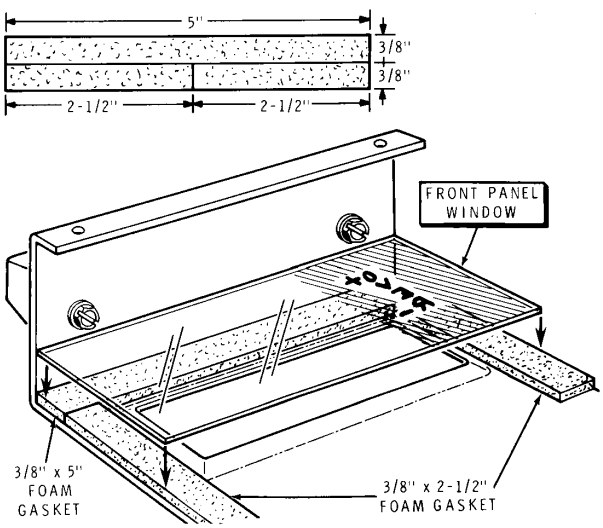
( ) Refer to Detail 4-1H and cut the foam gasket into two 3/8" x 5" strips. Then cut one of the strips into two 3/8" x 2-1/2" strips.

( ) Remove a protective covering from the long foam gasket strip and press the strip into place above the panel opening as shown.

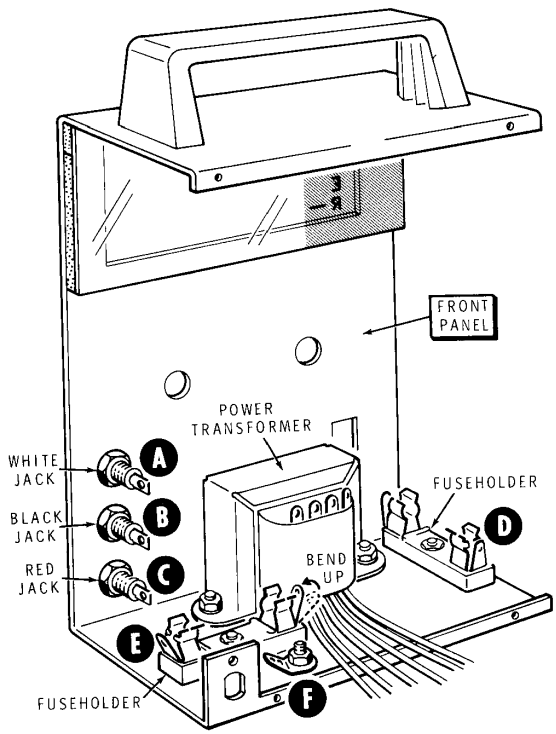
( ) In a similar manner, press the other two strips into place on both sides of the panel opening.

( ) Remove the protective covering from the top of the foam gasket strips and also from both sides of the front panel window. One side of the front panel will be shiny – not filmy; the other side is etched. If you can peel the coating with your finger nail, there is a coating that must be removed.

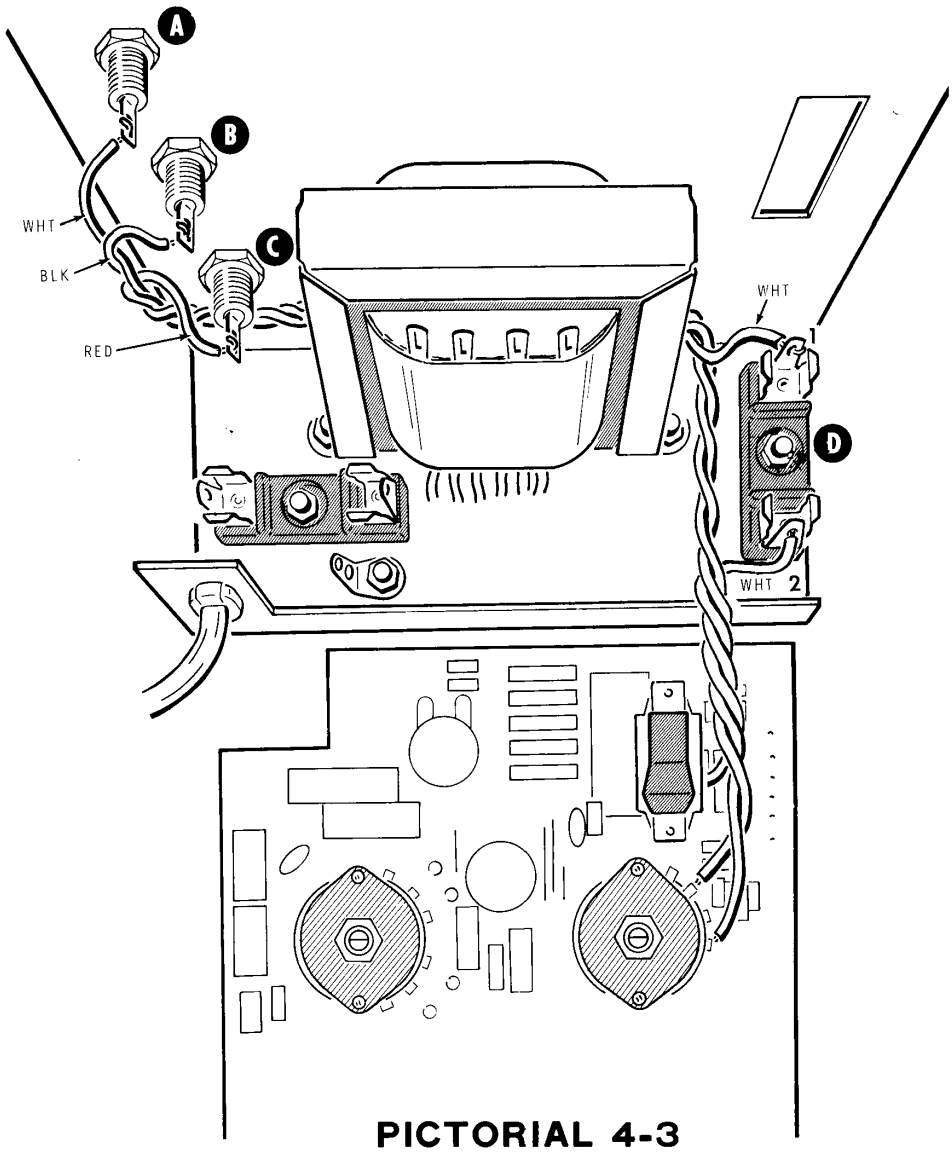
( ) Align the front panel window to the top of the front panel chassis, center it between the sides, and press it into place. Be sure the window lettering reads correctly from the front.



Detail 4-1H

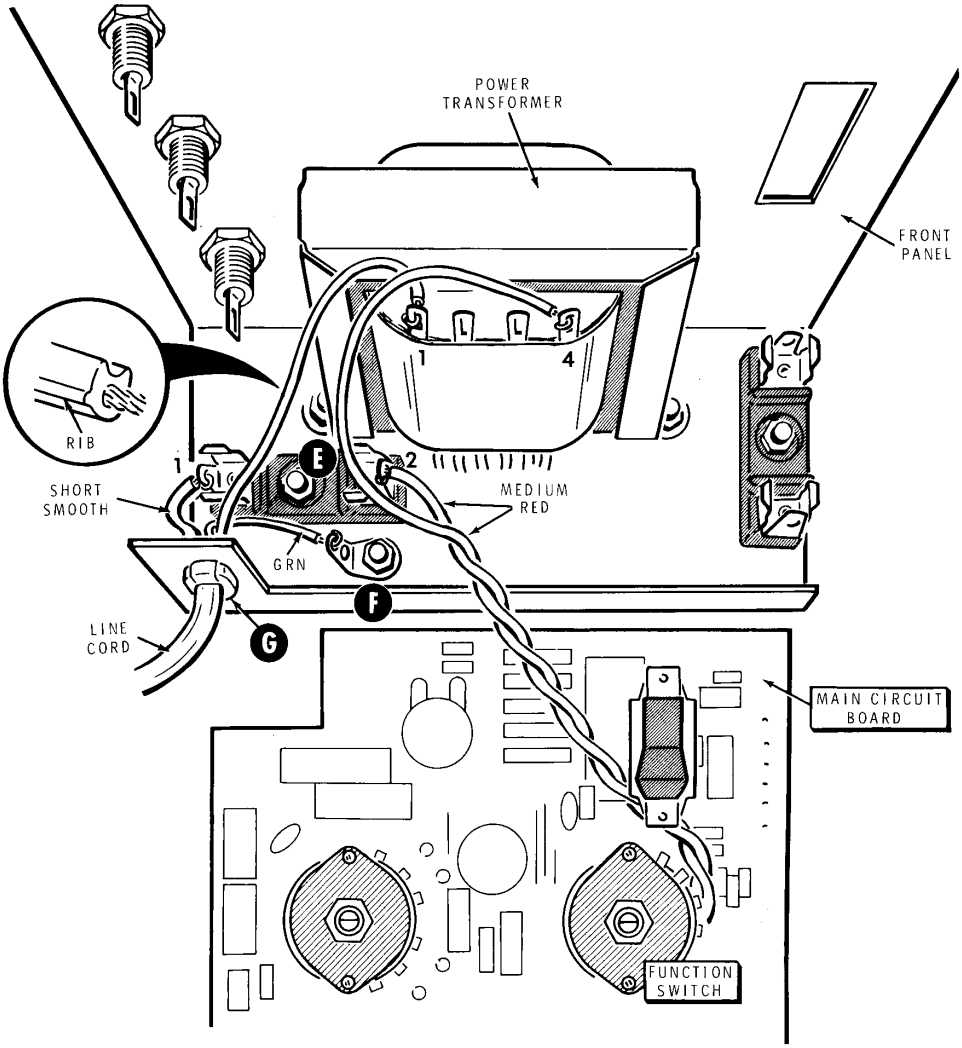


PICTORIAL 4-1



PICTORIAL 4-3

Refer

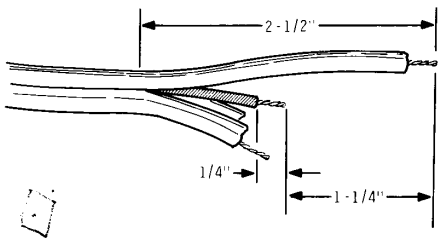


PICTORIAL 4-2

Refer to Pictorial 4-2 for the following steps.

(J) Refer to Detail 4-2A and prepare the line cord as follows: Separate the wires 2-1/2" at the free end of the line cord and cut 1-1/4" from both the green wire and the wire without the ribs (the smooth wire). Remove 1/4" of insulation from these two ends. Add a small amount of solder to the wire ends to hold the fine strands together.

(J) Insert these wires through hole G in the rear of the front panel.



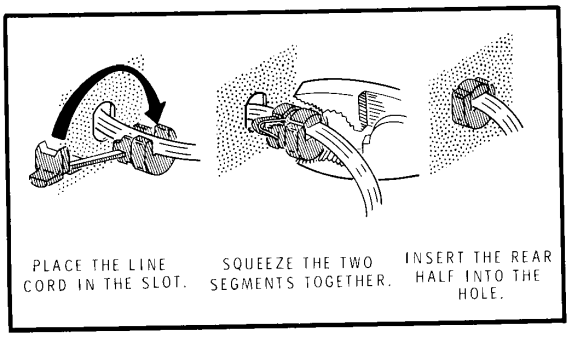
Detail 4-2A

NOTE: Be sure to make the connections in the following steps mechanically secure by wrapping each wire end tightly around the indicated lug.

( ) Connect the green wire to solder lug F (S-1).

( ) Connect the short smooth wire to fuseholder E lug 1 (S-1).

( ) Connect the ribbed wire to lug 1 of the transformer (NS).



Detail 4-2B

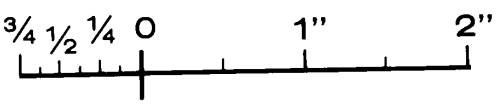
( ) Install the strain relief on the line cord as shown in Detail 4-2B.

( ) Position the main circuit board and front panel as shown.

( ) Connect the short wire of the medium red twisted pair from the function switch to lug 2 of fuseholder E (S-1) as shown. Make a secure mechanical connection.

( ) Connect the long wire at the free end of the medium red twisted pair coming from the Function switch to lug 4 of the transformer (NS). Position this wire as shown.

NOTE: The following steps give two different sets of wiring instructions. One set of instructions is for 120 VAC line voltage and the other is for 240 VAC line voltage. In the United States, 120 VAC is most often used, while in many other countries 240 VAC is more common. Use only the instructions that agree with the line voltage in your area.

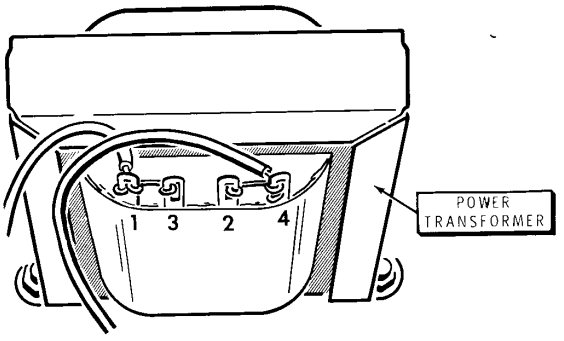


FOR 120 VAC ONLY

Refer to Detail 4-2C for the following steps. Make each connection mechanically secure before soldering.

( ) Cut a 3/4" bare wire and connect this bare wire between lugs 1 (S-2) and 3 (S-1) of the power transformer.

( ) Cut 3/4" bare wire and connect this bare wire between lugs 2 (S-1) and 4 (S-2) of the power transformer.



120 VOLT WIRING

Detail 4-2C

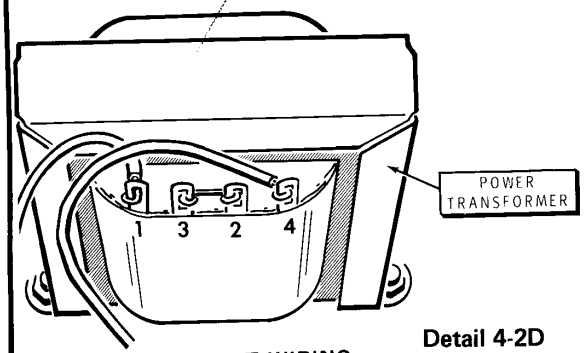
FOR 240 VAC ONLY

Refer to Detail 4-2D for the following steps. Make each connection mechanically secure before soldering.

( ) Solder the connection at lug 4 (S-1) of the power transformer.

( ) Solder the connection at lug 1 (S-1) of the power transformer.

( ) Cut a 3/4" bare wire and connect this bare wire between lugs 2 (S-1) and 3 (S-1) of the power transformer.



240 VOLT WIRING

Detail 4-2D

Refer to Pictorial 4-3 (fold-out from Page 32) for the following steps.

( ) Route the red, black, and white twisted wires under and behind the transformer to the input jacks as shown.

( ) Connect the red wire to the red banana plug at C (S-1).

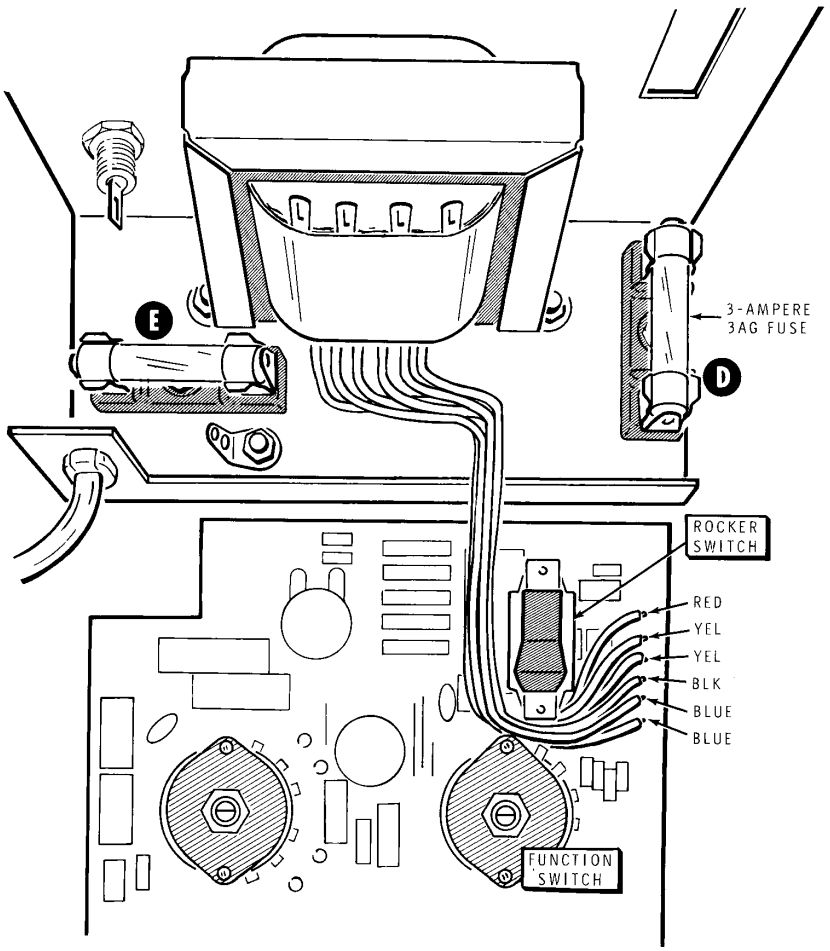
( ) Connect the black wire to the black banana plug at B (S-1).

( ) Connect the white wire to the white banana plug at A (S-1).

( ) At fuseholder D, cut through the white wire of the 3-wire twisted cable and remove 1/4" of insulation from each of the two ends.

( ) Connect the end of the white wire coming from the Function switch to lug 2 of fuseholder D (S-1).

( ) Connect the end of the white wire coming from the white banana plug to lug 1 of fuseholder D (S-1).



PICTORIAL 4-4

Refer to Pictorial 4-4 and connect the transformer leads to the indicated circuit board holes as follows:

( ) Position the six transformer leads between the Function switch and the rocker switch, under the existing wires, and as near the circuit board as possible.

( ) Connect the red lead in the "RED" hole (S-1).

( ) Connect either yellow lead in either "YEL" hole (S-1).

( ) Connect the other yellow lead in the other "YEL" hole (S-1).

( ) Connect the black lead in the "BLK" hole (S-1).

( ) Connect either blue lead in either "BLUE" hole (S-1).

( ) Connect the other blue lead in the other "BLUE" hole (S-1).

( ) Cut the excess lead lengths of the newly installed leads as close to the foil as possible.

( ) Insert the 3-ampere fuse into fuseholder D.

( ) Insert the 1/4-ampere fuse in fuseholder E. NOTE: If your unit is wired for 240 VAC use a 1/8-ampere fuse (not supplied) in fuseholder E.

Refer to Pictorial 4-5 (fold-out from this page) for the following steps.

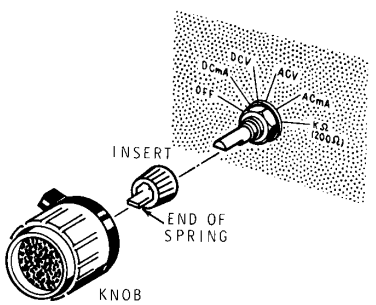
( ) Mount the circuit board to the front panel as shown with two control lockwashers, two control flat washers, and two control nuts. Be sure the display tubes are straight in their sockets. Take care, and see that no wires or leads are pinched between the switches and the front panel. Before you tighten the control nuts, make sure the logic circuit board is perpendicular to the front panel.

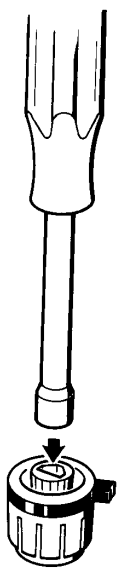
( ) Position the rocker switch so it works freely; then tighten the two rocker switch mounting screws.

( ) Place a knob insert on the function switch shaft.

( ) Turn the switch shaft fully counterclockwise.

( ) Position a knob pointer to the "off" position and place the knob over the insert. Press it part way onto the insert.





Detail 4-5A

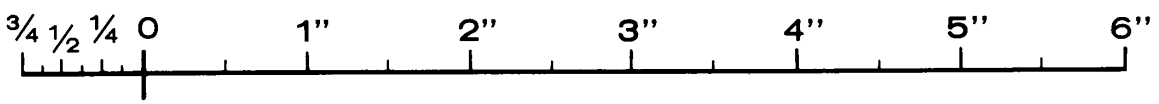
( ) Carefully remove the knob and insert together and firmly press the insert into the knob as shown in Detail 4-5A. Tap on the tool until the insert fully enters the knob.

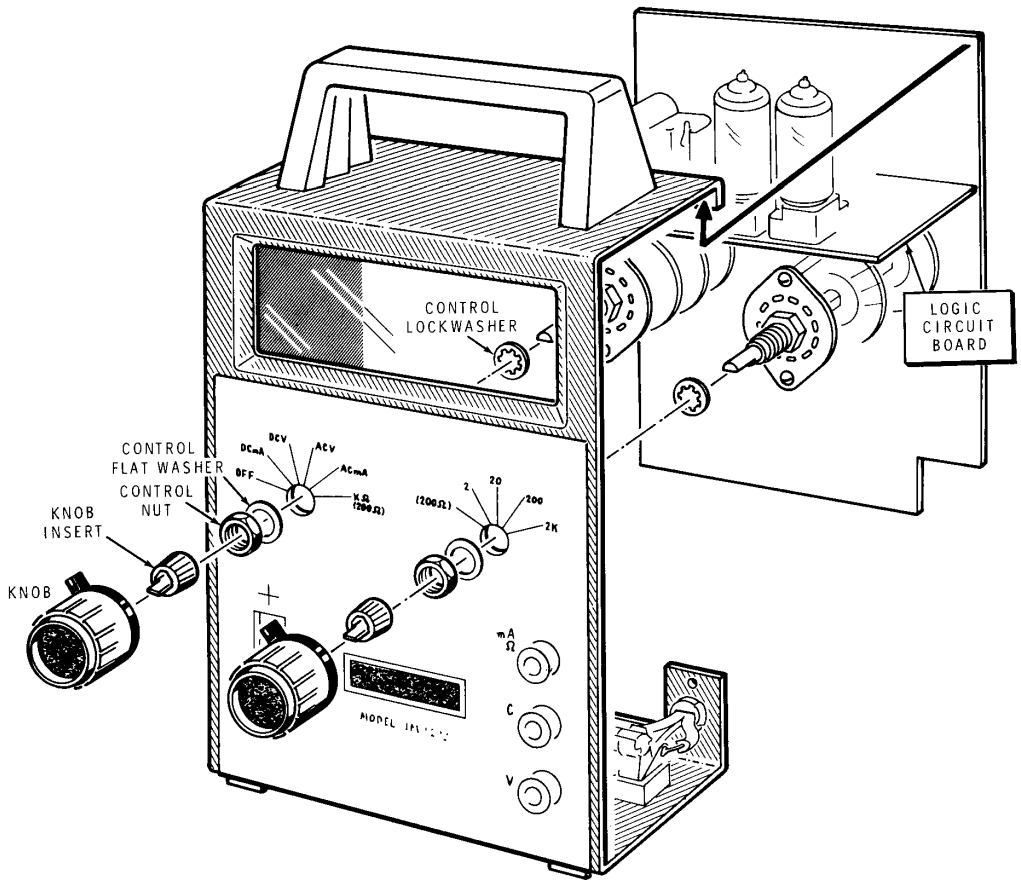
( ) Place the knob back on the function switch shaft.

( ) Place a knob insert on the Range switch.

( ) Turn the range switch shaft fully counterclockwise.

( ) As before, place a knob on the insert on the Range switch. Use the "200 Ω" position to align the pointer.





PICTORIAL 4-5

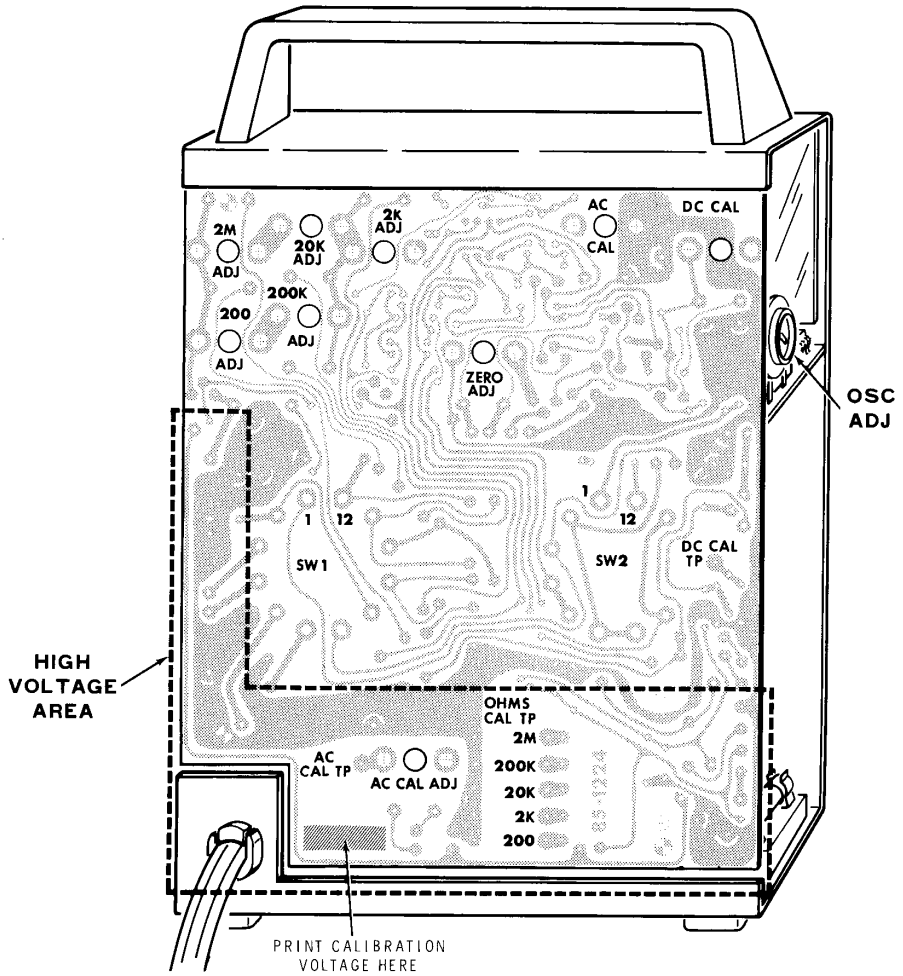

2M
ADJ
20K
ADJ
2K
ADJ
AC
CAL
DC CAL
200K
ADJ
200
ADJ
ZERO
ADJ
OSC
ADJ
1
12
SW1
1
12
SW2
DC CAL
TP
HIGH
VOLTAGE
AREA
OHMS
CAL TP
2M
200K
20K
2K
200
AC
CAL TP
AC CAL ADJ
PRINT CALIBRATION
VOLTAGE HERE

Figure 3

Refer to Pictorial 4-6 and prepare the meter test leads.

( ) Remove 1/2" of insulation from one end of the large red wire.

( ) Install a test probe on this end of the large red wire as follows:

1. Unscrew the insulator and the cap nut from the probe tip and insert the wire through the smaller hole in the insulator.

2. Twist the fine wires together and insert them through the hole in the probe. Then form the wires around the probe and screw the cap nut over them. Screw the insulator back on the probe.

( ) Remove 3/4" of insulation from the free end of the large red wire.

( ) Insert this end of the large red wire into a banana plug as shown. Then bend the wire flat against the plug body.

( ) Place the banana plug on a small phillips screwdriver (or similar tool) and push a red plug insulator onto the plug and wire until the insulator snaps into place.

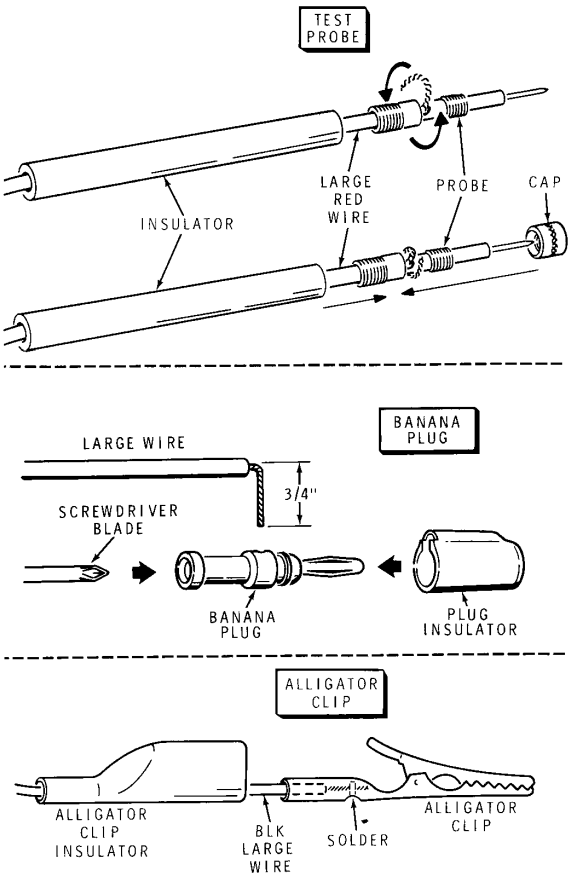
( ) Remove 3/4" insulation from one end of the large black wire.

( ) Install a banana plug and black plug insulator on this end of the large black wire.

( ) Remove 1/2" insulation from the free end of the large black wire.

( ) Install an alligator clip on this end of the large black wire. Insert the end of the black wire through the smaller end of the alligator clip insulator. Twist the fine wires together and insert them into the alligator clip (S-1). Slip the alligator clip insulator down over the alligator clip after the clip has cooled.

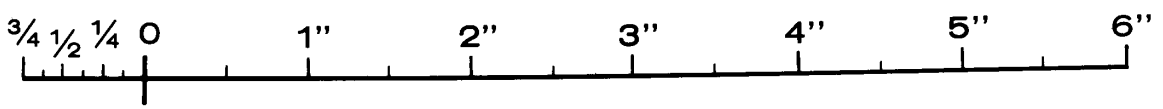
This completes the "Step-by-Step Assembly" section of the Manual. The cabinet will be installed later. Carefully inspect the Multimeter and all circuit boards for loose or unsoldered wires, and cold solder connections. Remove any wire clippings or solder splashes that may be lodged in the wiring.



PICTORIAL 4-6

Securely hold the Multimeter and shake it to be sure all clippings are removed. Then proceed with the "Tests and Calibration" section of the Manual.

NOTE: Save any parts remaining; they may be used later.



TESTS AND CALIBRATION

In this section of the Manual you will test and calibrate your IM-1202 Digital Multimeter. If at any time you do not obtain the results indicated, refer to the "In Case of Difficulty" section on Page 45. Locate and repair any problem before you continue with the calibration.

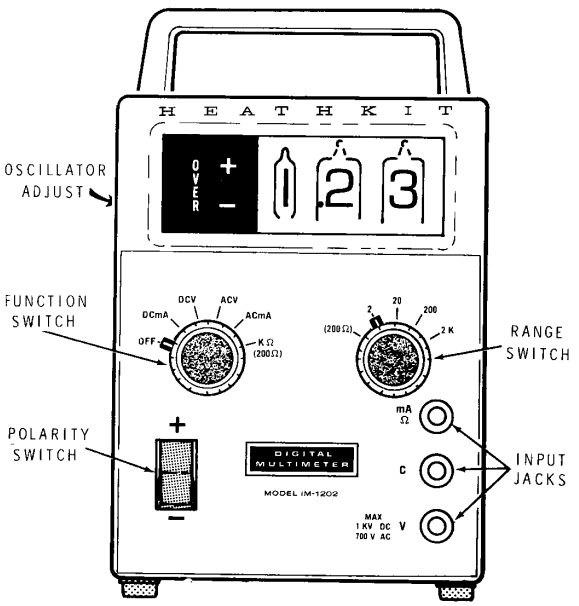


Figure 2

Figure 2 shows the front switches and input jacks of your Multimeter. Figure 3 (fold-out from Page 36) shows the remaining controls and test points. Carefully study Figures 2 and 3 and identify the function of each switch, control, and input.

( ) Refer to Figure 4 and insert all except approximately 3/8" of the alignment tool blade into the small end of the nut starter.

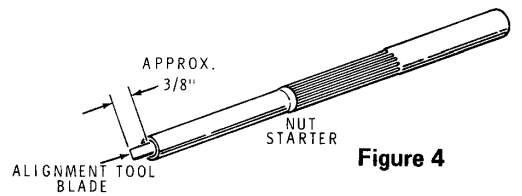


Figure 4

( ) Use this alignment tool to set all nine rear controls and the OSC ADJ control to their centers of rotation (slots vertical).

( ) Set the front panel switches to the following positions.

Function switch:	OFF.
Range switch:	2.
Polarity switch:	+.

WARNING: When the line cord is connected to an AC outlet, AC voltage will be present at several places. These areas are shown in boxed-in area in the "Circuit Board Voltage Charts" (on Page 61), and in Figure 3 (fold-out from Page 36).

( ) Plug the line cord into an AC outlet.

( ) Turn the Function switch to the DCV position and allow the unit to stabilize for at least 30 minutes. NOTE: The "+" polarity lamp, and the two right-hand digits (displaying any number) and the decimal point to the left of the left digit should all be lit. No other lamp should be lit.

( ) Use the alignment tool and turn the ZERO ADJ control until the readout is .01. Then slowly turn the control until the readout just changes to .00. Nothing should be plugged into the input jacks at this time. The threshold should rock between .01 and .00.

( ) Plug the red test lead into the red V input jack.

IMPORTANT: The value recorded on the calibration voltage envelope should be written on the margin of this page as it must be used for any future recalibration. If possible, you should also ink this information onto the foil side of the main circuit board and on the inside of the cabinet.

( ) Touch the red test lead probe tip to DC CAL TP and adjust the DC CAL control until the readout matches the value given on the calibration voltage envelope (#100-1612), whose contents were installed in Pictorial 2-5. NOTE: Observe that the number on the envelope has four digits, whereas the Multimeter can display only three digits. Convert the number to three digits by dropping the fourth digit if it is 4 or less, or by increasing the third digit by one if the fourth digit is 5 or more:

1.943 = 1.94
1.946 = 1.95

If the value on the envelope is 2 or higher, the Multimeter OVER lamp will be lit, but the 2 will not be displayed:

2.112 = OVER .11

( ) Disconnect the probe from the DC test point.

( ) Turn the Function switch to the kΩ position and adjust the Oscillator Adjust control for a readout of "OVER" .85, ±15 digits.

NOTE: If you are unable to obtain a reading of exactly "OVER .85," obtain the nearest possible reading with the Oscillator Adjust control. Then leave the control set at this point. This reading must fall within 15 digits (that is, no less than "OVER .70" or no more than "OVER 1.00"). If you are unable to calibrate within these limits, refer to the "In Case of Difficulty" section (Pages 45-49).

( ) Turn the Function switch to the DCV position and repeat the two previous steps until the correct readouts are obtained in both switch positions.

( ) Set the front panel switches in the following positions:

Function switch: DCV.
Polarity switch: +.
Range switch: 20.

( ) Touch the probe tip to AC CAL TP and adjust the AC CAL ADJ control (next to the AC TP) for a readout of 16.3.

NOTE: The readout may vary between 16.2, 16.3, and 16.4. A proper adjustment will readout 16.3 most of the time.

( ) Remove the probe from the AC CAL TP and turn the Function switch to the ACV position. Place the probe back on the AC CAL TP, allow the display to stabilize, and adjust the AC CAL control (at the top of the circuit board) for a meter reading of "OVER 0.0."

NOTE: The readout may vary between 19.9, "OVER" 0.0, and "OVER" 0.1. A proper adjustment will readout "OVER" 0.0 most of the time.

( ) Repeat the previous two steps until the correct readouts are obtained in both switch positions.

( ) Turn the Function switch to kΩ (200 Ω).

( ) Remove the red test lead from the V input jack and plug it into the white mA–Ω jack.

You will calibrate the five ohm ranges in the following steps. Touch the red test probe tip to the indicated OHMS CAL TP (test point) for each range and adjust the indicated control for an "OVER" 00 readout. The decimal point should be at the indicated position.

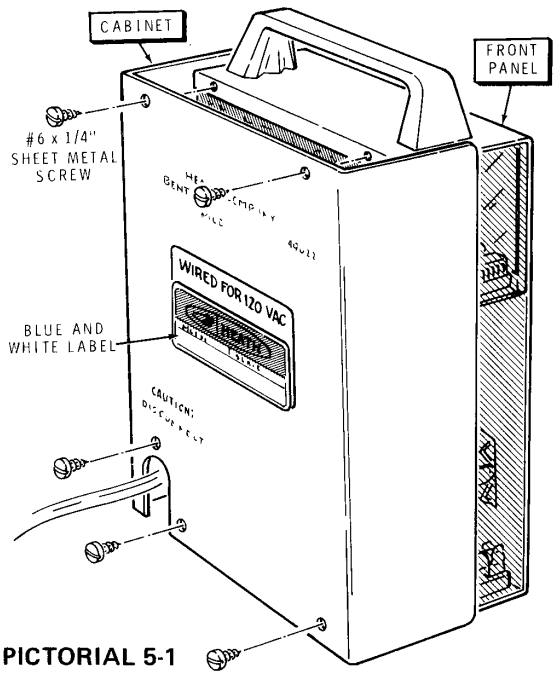
Range Switch	OHMS CAL TP (Test Point)	Control	Meter Reading
( ) (200 Ω)	200	200 ADJ	"OVER" 00
( ) 2	2 k	2 k ADJ	"OVER" .00
( ) 20	20 k	20 k ADJ	"OVER" 0.0
( ) 200	200 k	200 k ADJ	"OVER" 00
( ) 2 k	2 M	2 M ADJ	"OVER" .00

( ) Repeat the previous five steps as many times as necessary until you obtain a stable reading for each switch position.

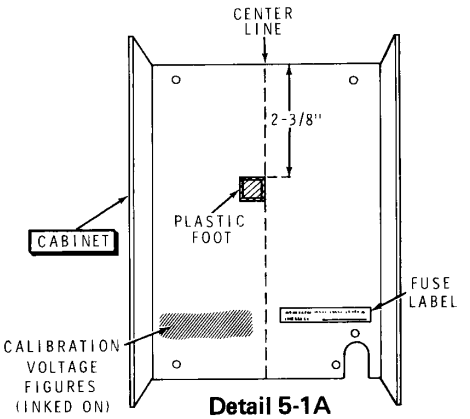
NOTE: If your Multimeter is operating from a 60 Hz power line during calibration, the infinity display will be "OVER" and approximately 85. In the unusual case when a 50 Hz AC power line is used during calibration and the Multimeter is then used on 60 Hz AC, the infinity reading will be "OVER" and approximately 35. This is due to the count period being approximately 2 ms shorter in the latter case.

This completes the "Initial Tests and Calibration" section of the Manual. Disconnect the AC line cord from the power source and proceed to the "Final Assembly" section.

FINAL ASSEMBLY



PICTORIAL 5-1



Detail 5-1A

Refer to Pictorial 5-1 for the following steps.

( ) Locate the cabinet and mark a vertical center line inside on the back surface. Then indicate a point 2-3/8" down from the top of the cabinet on the centerline. Remove the protective backing from a plastic foot and press it into place along the center line on the side opposite the cutout as shown.

( ) Write "1/4A, 3AG" in the blanks on the fuse label ("1/8A, 3AG" if your unit is wired for 240 VAC).

(✓) Remove the backing from the fuse label, and mount it at the location shown in Detail 5-1A.

(✓) Mount the cabinet to the front panel with five #6 x 1/4" screws. Position all wires inward so they are not pinched when the cabinet is installed.

NOTE: The blue and white label shows the model number and production series number of your kit. Refer to these numbers in any communications with Heath Company; this assures you that you will receive 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 rear panel as shown. Be sure to position the label so the appropriate line voltage lettering is exposed.

Proceed to the "Operation" section.

NOTE: IT IS NORMAL FOR THE CABINET TO PRESS AGAINST THE 100 KΩ CONTROL ON THE FOIL SIDE OF CIRCUIT BD

OPERATION

DUTY CYCLE

The power consumption of the Digital Multimeter is very low, and there is no objection to leaving the instrument on continuously during the daily work period. Allow a 15 minute warmup period, from a cold start, to insure best accuracy.

SAFETY PRECAUTIONS

CAUTION: Always observe basic safety rules any time voltage measurements are made. Always handle the test leads by their insulated portions and do not touch the exposed tips.

When high voltage measurements are made, remove the power from the unit under test and then connect the test leads. If this is not possible, be careful to avoid accidental contact with nearby objects which could provide a ground return path. Keep one hand behind you to minimize accidental shock hazard and be sure to stand on a properly insulated floor or floor covering. Do not switch meter ranges when high voltages and high currents are at the Meter inputs; to do so will cause switch contact arcing.

MEASUREMENTS

Refer to Figure 5 (fold-out from Page 43) while you read the following information.

CONNECTING THE MULTIMETER

Place the Function switch in the OFF position.

Plug the line cord into an AC outlet.

Plug the black test lead into the C (black) jack and the red lead into the other appropriate jack.

Follow the instructions (current, voltage, resistance, etc.) according to the type of measurement to be made.

When the Multimeter is turned on, the display tubes should light. When the meter leads are connected together the tubes should display "00."

DC CURRENT MEASUREMENTS

CAUTION: 3 amperes is the maximum DC current allowable on the 2 k mA range.

1. Set the RANGE switch to 2 k or the desired lower range if known.

2. Set the FUNCTION switch to DCmA.

3. Plug the red test lead into the mA–Ω jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on DCmA	25% on all ranges.
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	01 – 199	Over 50 (250)
2 k	.01 – 1.99	Over .50 (2.50)

DC VOLTAGE MEASUREMENTS

CAUTION: Do not connect the C input to a potential greater than 500 volts above power line ground; this can result in damage to the instrument.

1. Set the RANGE switch to 2 k or the desired lower range.

2. Set the FUNCTION switch to DCV.

3. Plug the red test lead into the V jack and observe the readings. If the OVER lamp comes on, switch to a higher range immediately as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on DCV	25% on all ranges except the 2 k range.
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	01 – 199	Over 50 (250)
2 k	.01 – 100 (1000)	None

AC VOLTAGE MEASUREMENTS

NOTE: When measuring AC voltage, any input other than a pure sine wave can cause an error because the AC converter is average-sensing and rms calibrated.

CAUTION: 700 volts rms is the maximum AC voltage allowable in the 2 k range; 140 volts rms on the 2 (volt) range.

1. Set the RANGE switch to 2 k or the desired lower range.

2. Set the FUNCTION switch to ACV.

3. Plug the red test lead into the V jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on ACV	25% on all ranges except the 2 k range.
2	.01 – 1.999	Over .50 (250)
20	0.1 – 19.99	Over 5.0 (25.0)
200	01 – 199.9	Over 50 (250)
2 k	.01 – 70 (700)*	None

*Approximate rms value of 1000V peak

AC CURRENT MEASUREMENTS

CAUTION: 3 amperes is the maximum AC current allowable on the 2 k range.

1. Set the RANGE switch to 2 k or the desired lower range if known.
2. Set the FUNCTION switch to ACmA.
3. Plug the red test lead into the mA–Ω jack and observe the reading. If the OVER lamp comes on switch to a higher range immediately as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on ACmA.	25% on all ranges.
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	01 – 199	Over 50 (250)
2 k	.01 – 1.99	Over .50 (2.50)

RESISTANCE MEASUREMENTS

CAUTION: The resistance circuits of the Multimeter are protected against the application of AC and DC voltages up to a level which would cause a current of 3 amperes.

1. Set the RANGE switch to the desired range.
2. Set the FUNCTION switch to kΩ (200 Ω).
3. Plug the red test lead into the mA–Ω jack.
4. Connect the load to the test leads and observe the reading. Raise or lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)		25% on all ranges.
	01 – 199	Over 50 (250)
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	01 – 199	Over 59 (250)
2 k	.01 – 1.99	Over .50 (2.50)

eter are
tages up

ɛrve the
RANGE
llowing
ɛ.

BLE
NGE

anges.

0)
.50)
5.0)
0)
.50)

+ AND – POL/ INDICATO

Indicates + or – dependir POLARITY switch. Not TION switch is in ACV or Indicates polarity of the respect to the black j (resistance) mode.

OVERRANGE INDICATOR

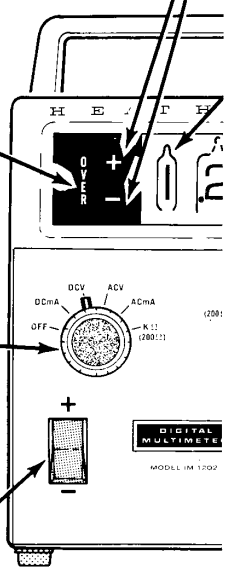
Lights when input is equal to or higher than setting of range switch (overrange).

FUNCTION SWITCH

Turns instrument on or off. Selects the proper circuits to measure ac or dc voltage, ac or dc current, or resistance.

POLARITY SWITCH

Reverses polarity without having to disconnect test leads.



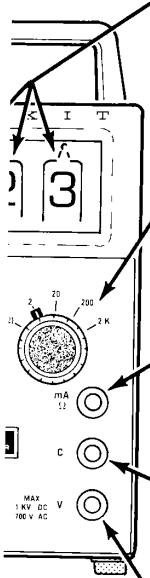
Figure

ARITY
RS

ıg on position of
lit when FUNC-
ACmA position.
white jack with
ack in the kΩ

DISPLAY INDICATORS

Displays value of whatever is being measured. Proper decimal point is automatically determined by the range switch setting.



RANGE SWITCH

Selects desired range of operation.

CURRENT-OHMS INPUT

Connect red test lead here when measuring current or resistance.

COMMON INPUT

Connect black test lead here for all measurements.

VOLTAGE INPUT

Connect the red test lead here when measuring voltage.

DC V(

CAUTI
greater
result ir

1. S
ra

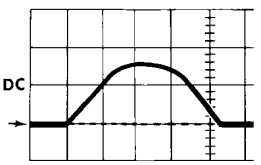
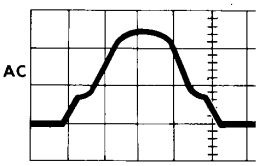
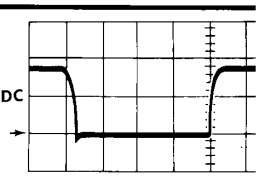
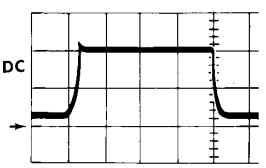
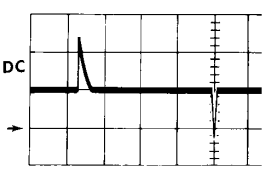
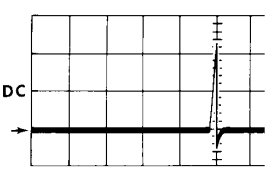
2. S

3. P
re
hi
e
sv
ta

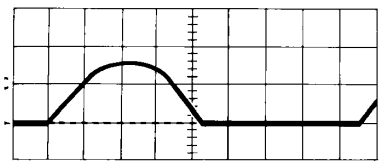
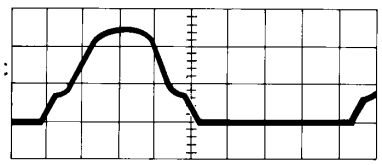
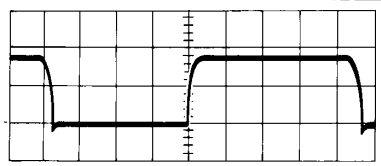
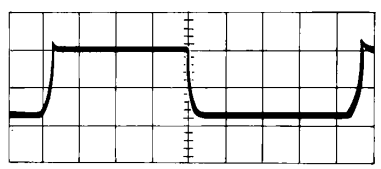
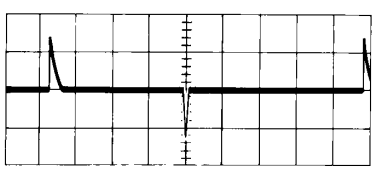
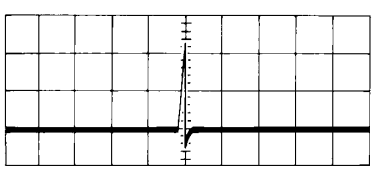
RANG
(200 S
2
20
200
2 k

WAVEFOI

Waveforms as displayed on Tektronix Model 547 with type 1A4 4-Channel Amplifier. Line sync.

	TEST POINT	OSCILLOSCOPE Vertical: Volts/cm	OSCILLOSCOPE Horizontal: m sec	INPUT COUPLING	Waveforms (DC zero-volt reference point ind
1	D16, Anode	200	2	DC	
2	IC8, pin 5 (2 VDC input)	1	2	AC	
3	IC8, pins 6 and 9	2	2	DC	
4	IC8, pin 8	2	2	DC	
5	IC8, pin 1	2	2	DC	
6	IC8, pins 3 and 12	2	2	DC	

WAVEFORMS

Waveforms (ero-volt reference point indicated by arrowhead)	POSSIBLE CAUSE OF IMPROPER WAVEFORM
	1. Diode D16. 2. No voltage from transformer.
	1. Resistor R219. 2. IC8. 3. Solder bridge.
	1. Pin 4 not held high (+5 VDC). 2. IC8. 3. Solder bridge.
	1. Pin 10 not held high (+5 VDC). 2. Pin 8 of IC2 grounded. 3. IC8. 4. Solder bridge.
	1. Capacitor C205 or C206. 2. Resistor R217. 3. Solder bridge.
	1. Pin 2 not held high (+5 VDC). 2. IC8.

WIRING HARNESS ASSEMBLY

If you decide to assemble the wiring harness for troubleshooting circuit boards as described on Page 46, remove the parts from the envelope marked 171-7325 and follow the instructions in Figure 6 below. If you do not use these parts, save them for possible future use.

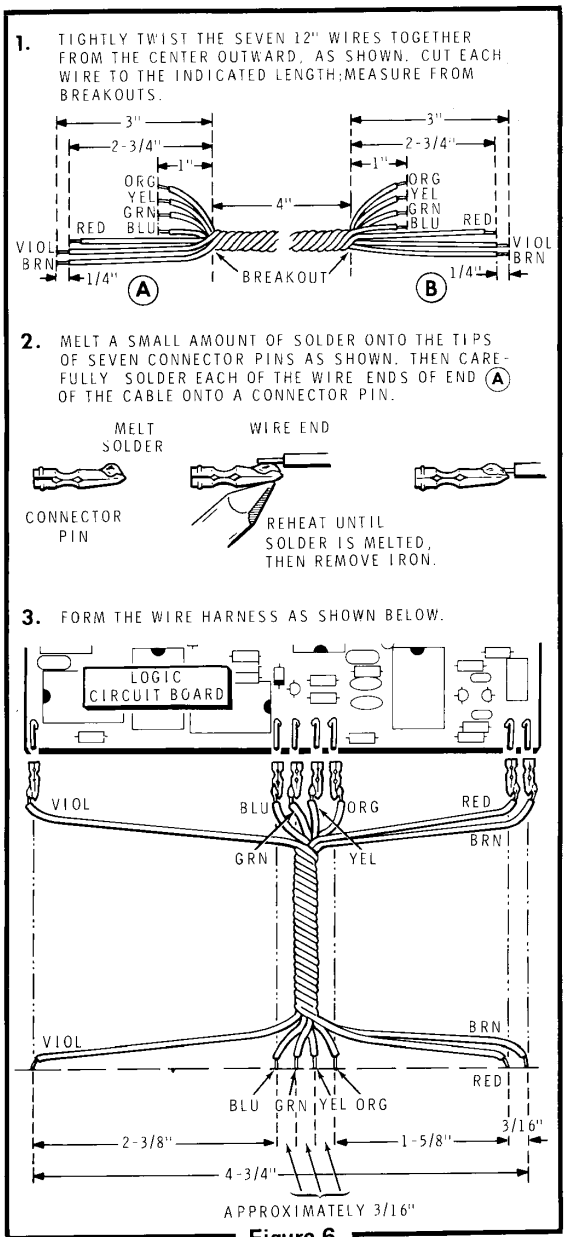
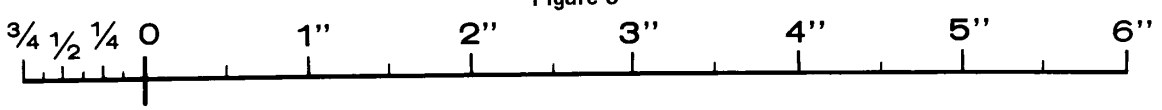


Figure 6



IN CASE OF DIFFICULTY

WARNING: When the line cord is connected to an AC outlet, AC voltage will be present at several places. These areas are shown in boxed-in area in the "Voltage Chart" (on Page 61).

Begin your search for any trouble that occurs after assembly by carefully following the steps listed in the "Visual Tests" secton. After visual tests are completed, refer to the "Troubleshooting Chart."

NOTE: Refer to the circuit board "X-Ray Views" on Pages 57, 58, and 59 for the phyical location of parts on the circuit boards.

VISUAL TEST

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering. 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 to be sure that all transistors are in their proper locations. Make sure each lead is connected to the proper point.

4. Check that each of the IC's are properly installed in their sockets, and that the pins are not bent out or under the IC. Also be sure the IC's are installed in their correct positions.

5. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial diagrams. It would be easy, for example, to install a 680 Ω (blue-gray-brown) resistor where a 6800 Ω (blue-gray-red) resistor should have been installed.

6. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

7. A review of the "Circuit Description" may help you determine where the trouble is.

If the trouble is still not located after the visual tests are completed, and a voltmeter is available, check voltrages against those shown on the Voltage Chart on Page 61. Read the "Precautions for Troubleshooting" (Page 46) before making any measurements. NOTE: All voltage readings were taken with a high impedance voltmeter. Voltages may vary ±20%.

WAVEFORMS

As a service aid, fold-outs from Pages 44 and 49 are drawings of oscilloscope patterns to be expected at the designated points in the Multimeter circuit. A high impedance, low capacitance probe is required in addition to an oscilloscope which can be set up for the time and voltage requirements designated.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Service" section of the "Kit Builders Guide" and to the "Factory Repair Service" information on Page 49 of this Manual. Your Warranty is located inside the front cover of the Manual.

PRECAUTIONS FOR TROUBLESHOOTING

1. Be cautious when testing IC and transistor circuits. Although they have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than most other components.

2. Be sure you do not short any terminals to ground when making voltage measurements. If the probe should slip, for example, and short out a bias or supply point, it is very likely to cause damage to one or more IC's, transistors, or diodes.

TROUBLESHOOTING

Because the Digital Multimeter is fundamentally a DC voltmeter, the basic circuitry is used when the Function switch is in the DCV position, and conditioning circuits are added for other functions. Consequently, if a malfunction occurs, first check the circuitry used for the DC voltmeter function. If that is operating satisfactorily, then check the circuitry added for other functions.

The following charts list the malfunctions that might arise and the same possible causes. Look at the problem column and try to locate your difficutly. Then try to correct the difficulty by checking the possible cause column.

Use charts #1 or #2 if any malfunction should arise in the DCV position. Use chart #3 if any malfunction should arise in any of the remaining positions. If a particular part or parts are mentioned (transistor Q2 for example, or resistor R6) as a possible cause, check these parts to see if they are incorrectly installed or wired. Check to see if an improper part was installed at that location. It is also possible for a part to be faulty, although this is rare.

The logic circuit board has foil patterns on both sides. Several "plated-through" holes carry the circuit from one side of the board to the other. When troubleshooting, be sure to check circuit continuity through the holes.

If it becomes necessary to troubleshoot your Multimeter, the task will be made easier if you assemble a wiring harness (as described on Page 44) so that the two circuit boards may be separated to provide better access to each. To use the wiring harness, proceed as follows:

1. Disconnect the logic circuit board from the main circuit board pins.

2. Push the bare wire ends into the main circuit board connector pins: brown to A, red to B, orange to C, yellow to D, green to E, blue to F, and violet to G.

3. Push the connectors on the wire ends onto the logic circuit board, in exactly the same order as noted in Step #2: brown wire connector to A, red wire connector to B, orange wire connector to C, yellow wire connector to D, green wire connector to E, blue wire connector to F, and violet to G.

4. For convenience during troubleshooting, you may temporarily install the knobs on their shafts; then rest the foil side of the logic board on these knobs.

Refer to the pages associated with the Schematic Diagram for IC basing diagrams and a cross reference table of Heath and manufacturers' numbers.

NOTE: Some of the circuits use IC's of the same type. An IC thought to be faulty can often be interchanged with one known to be good.

Troubleshooting Charts

The following two charts are for the DCV position. Chart #1 deals with the possibility of a malfunction that prevents the neon lamps or readout tubes from lighting or stabilizing. In chart #2, you will make measurements to check out the DCV position of the Function switch.

CHART #1

PROBLEM	POSSIBLE CAUSE
Neon lamps and readout tubes do not light.	1. Power line fuse blown. 2. Diode D16. 3. Function switch in OFF position. 4. Function switch miswired.
"1" or "OVER" lamp and readout tubes do not light.	1. Connector wire G on logic circuit board not making good contact with connector pin G on main circuit board.
Readout tubes light but are dim and all ten digits come on.	1. Connector wire A on logic circuit board not making good contact with connector pin A on main circuit board. 2. Connector wire B on logic circuit board not making good contact with connector pin B on main circuit board. 3. Transistor Q11 and its associated resistors, capacitors, and diodes.
A particular digit lights. However, all numerals appear dimly lit. (For example, a "3" condition always faintly lights 0 through 9.)	1. Open tube socket pin. 2. Open decoder driver pin(s).
Readout does not read 00 with inputs shorted.	1. ZERO ADJUST control not set properly. 2. Integrated circuit IC8 not producing reset pulse.
Readout counts up continuously.	1. Transistor Q12. 2. Integrated circuit IC8 not producing reset pulse.
Readout does not stabilize after warmup time.	1. Diode D17; transistors Q12, Q15, Q16; or an associated resistor or capacitor.
"1" or "OVER" lamps come on when inputs are shorted.	1. Transistor Q13 or Q14. 2. Integrated circuit IC5.
Two or more digits in a read-out tube on at the same time.	1. Solder bridge at readout tube socket. 2. Solder bridge at IC3 or IC4 sockets. 3. Interchange readout tubes. 4. Interchange IC3 or IC4.
Oscillator does not adjust to "OVER .85," ±15 digits.	1. Resistors R206 and R208. 2. Control R207. 3. Capacitors C201 and C203.

CHART #2

RED LEAD (V INPUT) TO:	FUNCTION SWITCH	RANGE SWITCH	"+", "–" SWITCH	PROBLEM	POSSIBLE CAUSE
Black lead (C input)	DCV position	2 position	"+" position	Readout does not read +.00.	1. Integrated circuit IC8 not producing reset pulse. 2. Transistor Q11 and its associated resistors, capacitors, and diodes. 3. Diode D16. 4. Integrated circuit IC6 or IC7. 5. Integrated circuit IC3 or IC4.
DC CAL TP	DCV position	2 position	"+" position	Readout does not read the value stamped on the voltage reference source package.	1. Transistors Q1 through Q7. 2. Integrated circuit IC2. 3. Transistor Q12, Q15, or Q16. 4. Transistor Q11 and its associated resistors, capacitors, and diodes. 5. Diode D16. 6. Integrated circuit IC6 or IC7. 7. Integrated circuit IC3 or IC4. 8. Instrument not calibrated.

CHART #3

FUNCTION SWITCH POSITION	PROBLEM	POSSIBLE CAUSE
DC mA	Readout does not seem to read correctly.	1. Resistors R101 through R109.
ACV		1. Transistor Q8 or integrated circuit IC1.
AC mA		1. Resistors R101 through R109. 2. Transistor Q8 or integrated circuit IC1.
KΩ (200 Ω)		1. Controls R111, R113, R115, R117, or R119 not adjusted properly. 2. Resistors R111 through R119, or R121 wrong value. 3. Transistor Q9 or Q10, or diode D1, D2, or D3.

OSCILLOSCOPE WAVEFORM PATTERNS

To check for the presence of waveforms shown in the charts (fold-out from this page and from Page 44), use an oscilloscope capable of the settings given. Set up the oscilloscope for line triggered sync and use a high impedance, low capacitance probe.

1. Set the Multimeter as follows:

   A. Set the POLARITY switch at +.

   B. Set the FUNCTION switch at DCV.

   C. Set the RANGE switch at 2.

2. Connect the common lead of the oscilloscope to the C input jack on the Multimeter.

3. Adjust the oscilloscope for the designated vertical and horizontal settings for the waveform to be observed.

4. Connect or touch the oscilloscope probe tip to the test point and compare the pattern to the one in the chart. If you do not obtain the proper waveform, look at the "Possible Cause of Improper Waveform" column to determine the problem.

5. If you do not see the proper waveform display at the first test point tried, check lower numbered steps until you do observe the desired display. The difficulty will then be covered by the following step.

FACTORY REPAIR SERVICE

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

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

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

Prepare a letter in duplicate, containing the following information:

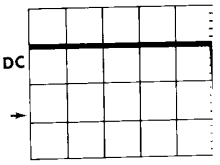
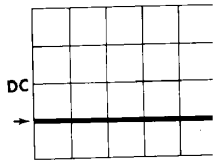
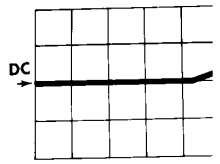
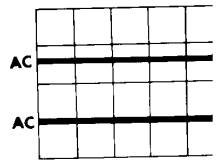
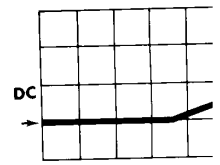
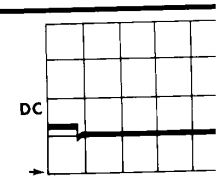
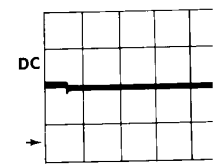
- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan 49022.

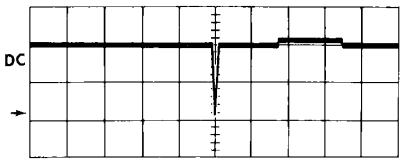
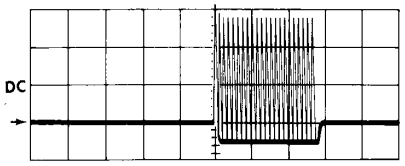
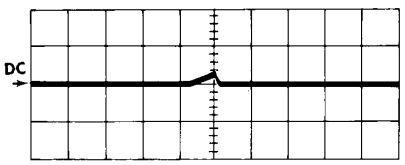
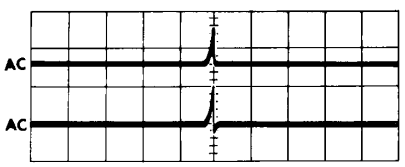
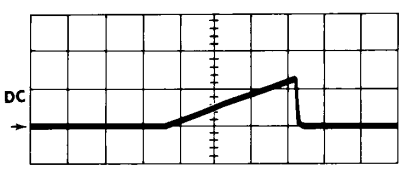
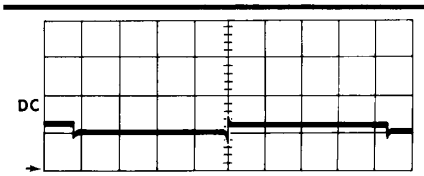
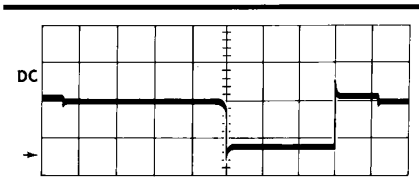
Check the equipment to see that all parts and screws are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

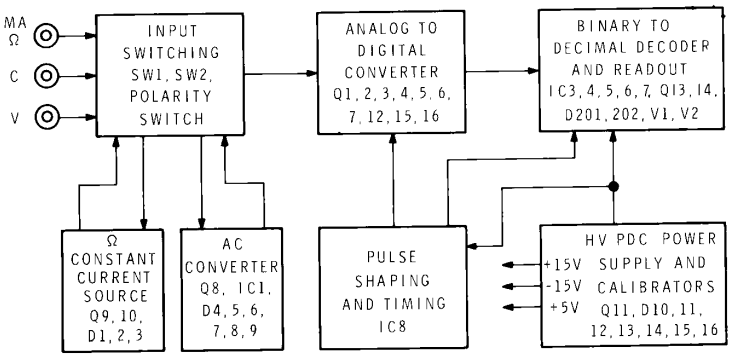
Heath Company
Service Department
Benton Harbor, Michigan 49022

WAVEFORMS (

	TEST POINT	OSCILLOSCOPE Vertical: Volts/cm	OSCILLOSCOPE Horizontal: m sec	INPUT COUPLING	Waveform (DC zero-volt reference poi
7	IC8, pin 11	2	2	DC	
8	IC7, pin 14 (2 VDC input)	2	2	DC	
9	Q1, base (input shorted)	2	2	DC	
10	IC2: (input shorted) Pin 6 Pin 12	.5 .5	1 1	AC AC	
11	Q1 base (2 VDC input)	2	2	DC	
12	D17 anode (input shorted)	1	2	DC	
13	D17 anode (2 VDC input)	1	2	DC	

\VEFORMS (Continued)

Waveforms DC zero-volt reference point indicated by arrowhead)	POSSIBLE CAUSE OF IMPROPER WAVEFORM
	1. Pin 13 not held high (+5 VDC). 2. IC8. 3. Solder bridge.
	1. No signal from transistor Q15. 2. Solder bridge.
	1. Capacitor C106. 2. Transistor Q5 "on" (emitter negative to base and collector). 3. Transistor Q7.
	1. Pin 6: A. Transistor Q1 or Q4 (check voltages). B. Control R152 misadjusted. Pin 12: A. Transistor Q2, Q3, or Q6 (check voltages). B. Control R152 misadjusted.
	1. Transistor Q1. 2. Check for input to Q1 base. 3. Check meter switch positions. 4. Should be 1 MΩ from V panel jack to Q1 emitter.
	1. Diode D17. 2. Control R204 or R210. 3. IC2.
	1. Refer to step 12.



BLOCK DIAGRAM

IV. DC AT A to D CONVERTER (EMITTER OF Q1)

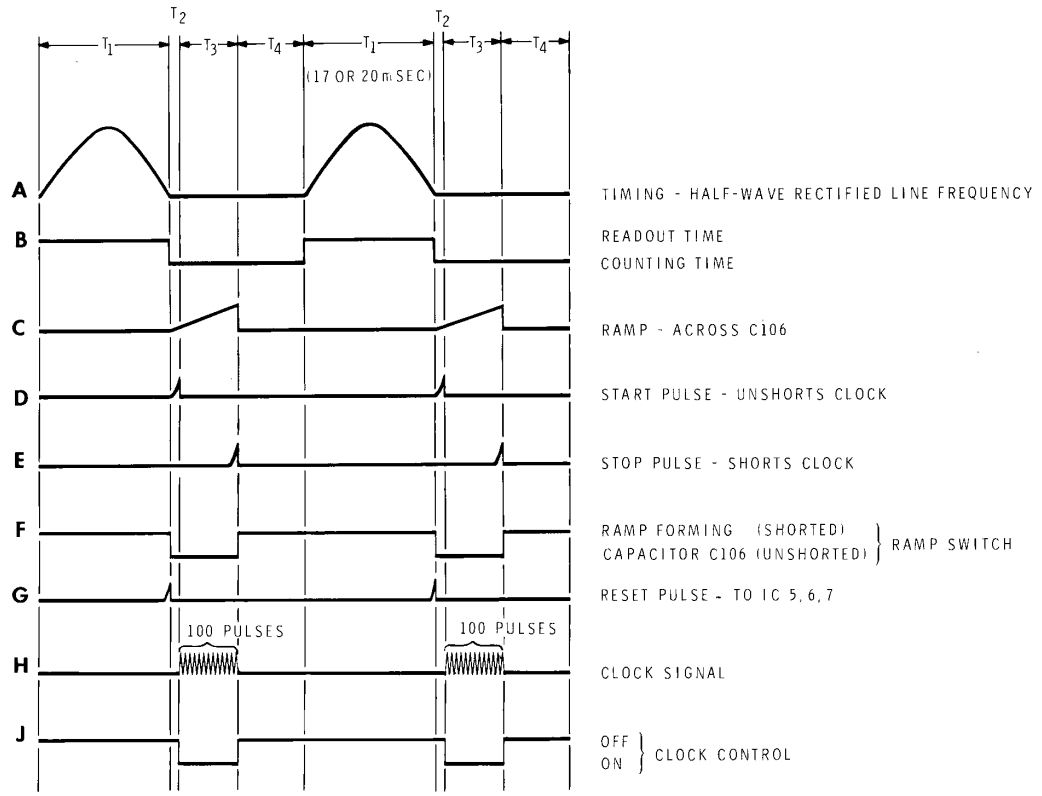


Figure 7

REPLACEMENT PARTS AND PRICE INFORMATION

To order Replacement Parts: Use the Parts Order Form furnished with this kit. If one is not available, see "Replacement Parts" in the "Kit Builders Guide."

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

SPECIFICATIONS

Functions	DC volts, DC current, AC volts, AC current, ohms.
Ranges (Full Scale)	DC volts: 0-2, 20, 200, 1,000 V. DC current: 0-2, 20, 200, 2,000 mA. AC volts: 0-2, 20, 200, 700 V rms (25 Hz to 10 kHz). AC current: 0-2, 20, 200, 2,000 mA rms (25 Hz to 10 kHz). Ohms: 0-200, 2K, 20K, 200K, 2,000K ohms.
Overrange	25% on all functions, within maximum input limits.
Maximum Input Without Damage	3 amperes into AC or DC mA, and Ohms (fuse protected). 700 VAC rms into Volts (except 2 V range: 140 VAC rms). 1000 VDC into Volts (except 2 V range: 200 VDC).
Resolution (low range)	Volts: 10 mV. Current: 10 μA. Ohms: 1 ohm.
Display	2-1/2 digit numeric.
Accuracy (Full Scale ±1 digit)	DC volts ±1%. DC current ±1.5%. AC volts ±1.5%. AC current ±1.5%. Ohms ±2%.
Input Impedance	1 megohm on all voltage ranges. 2 V drop maximum on current ranges.
Sample Rate	Line frequency.
Power Requirements	110-130 VAC/220-260 VAC, 50/60 Hz, 8 watts.
Dimensions (overall)	7-3/4" high, 5-3/16" wide, 3-1/8" deep.
Weight	2-1/2 pounds (1.2 kg).

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

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 63) and the Block Diagram (fold-out from Page 50) while you read the following description.

To help you locate parts in the Meter or on the Schematic, the resistors, capacitors, and other components are numbered in the following groups. NOTE: Transistors, diodes, integrated circuits, and tubes are numbered without regard to specific grouping.

0-99	Chassis mounted parts.
100-199	Parts mounted on the main circuit board.
200-299	Parts mounted on the logic circuit board.

Selected inputs of resistance, current, or voltage to be measured are directed through the contacts of the Polarity switch, the Function switch, and through the scaling networks of the Range switch to the input of the A to D (analog-to-digital) converter. Inputs other than DC volts are directed through conversion circuits. The result of switching, scaling, and conversion is that all inputs are converted to a proportional DC voltage level acceptable by the A to D converter.

The analog-to-digital converter converts the input DC voltage to a pulse count during a time period. This time period allows a clock oscillator to generate a number of pulses which are directly proportional to the DC input level. After passing through the decade divider and the decoder driver circuits, the number of gated pulses from the clock oscillator are displayed by the digital readout tubes.

BASIC MEASURING CIRCUIT

The basic measuring circuit is a monopolar analog-to-digital converter using a single ramp technique along with a stable oscillator for long-term accuracy. All inputs are converted to +DC volts before being applied to the A to D converter. Negative DC voltage or current is first inverted by the Polarity switch. Full scale input voltage to the A to D converter is +2 volts DC, regardless of the selected function or range.

If the input exceeds 2 volts DC, it is scaled down to 2 volts or less by the range switch before it enters the converter. AC voltages are converted to +DC by an average-sensing, rms calibrated operational rectifier circuit. When DC current is measured, a precision resistor is placed in shunt with the input to the A to D converter. For AC current, the shunt resistor is placed across the input to the AC converter. The voltage developed across the shunt resistor is thus measured, rectified if AC, and applied to the input of the A to D converter.

Resistance is measured by routing a calibrated constant current through the unknown resistance. The voltage drop developed across the unknown resistance is applied to the input to the A to D converter.

Timing for the conversion and readout circuits is controlled by the cyclic rate of the AC line frequency. The display tubes are illuminated only during the positive portions of the half-wave rectified high voltage pulses, and the A to D converter is cut off and no oscillator pulses are generated during this time. During the zero-level portion of the rectified high-voltage pulses, the readout is extinguished and a pulse is generated to reset the decade dividers to zero. Then the clock oscillator output is counted. The pulses are routed to the decoder network and applied to the readout tubes before the next half-wave voltage disables the oscillator and turns on the display tubes. The counting and readout time is equally divided, and both occur in slightly less than 17 milliseconds for the 60 Hz line frequency, and in 20 milliseconds for a 50 Hz line frequency. Normal persistence of vision does not permit the eye to detect the on-off operation of the readout tubes. Thus the display appears to be constant to the observer and provides a pseudo type of memory for the count.

INPUT SWITCHING

DC Current

DC Current is applied to the meter through the mA-Ω jack and the C jack on the front of the Meter. After passing through contacts on wafer 1 of the Function switch (FS1) and contacts of the Polarity switch, the current is routed to lugs 2 and 7 of FS4. As the current passes through lug 7 of FS4, and through a shunt resistor (R106 through R109 selected by range switch wafer RS2R), a voltage is developed across this shunt. This DC voltage is then applied to lug 2 of FS4 and through lug 1 of FS4 to the input of the A to D converter (the emitter of transistor Q1).

DC Voltage

When a DC voltage is being measured it is routed through the V input jack to lug 10 on FS1, through the switch contacts to lug 9 of FS1, and then to the Polarity switch. Voltage from the Polarity switch is routed through lugs 4 and 3 of FS1. The voltage is then applied to a voltage divider network on the range switch (RS2) consisting of precision resistors R101 through R104. A DC voltage developed across this divider, proportional to the input voltage, is routed through FS4 contacts and to the A to D converter input circuit.

AC Voltage

AC voltage is routed in the same manner as DC voltage through the input switching, until it passes through the voltage divider network, R101 through R104, on the Range switch where a proportionate voltage is developed. This scaled AC voltage is then applied to the AC converter through FS2, lugs 10 and 7. The DC output of the AC converter is routed through lugs 4 and 5 of FS4, to lug 1 of FS4, and then to the input of the A to D converter.

AC Current

AC current is directed through Function switch contact and into the shunt resistors of the Range switch, where a proportional voltage is developed, as in the case of the DC current. This AC voltage developed across a shunt resistor is applied through the AC converter, in the same manner as the AC voltage previously described. The resultant DC voltage is routed to the Function switch wafer 4 contacts, and then to the input of the A to D converter.

Resistance

When a resistance is being measured, the mA–Ω input lead is connected through lugs 7 and 8 of FS1, through contacts 7 and 11 of the Polarity switch (in the + position), and through lugs 1 and 2 of FS1 to lugs 7 and 12 of FS4. From this point, the unknown resistance is connected to the collector of constant current source transistor Q10, through diode D2 and resistor R132. Depending on the ohms range selected by the Range switch, a selected, calibrated resistance is placed in the emitter circuit of transistor Q10 and controls the level of the constant current through the circuit. Calibration resistances are composed of resistors R111 and R112 in the 2M circuit, R113 and R114 in the 200K circuit, R115 and R116 in the 20K circuit, R117 and R118 in the 2K circuit, and R119 and R121 in the 200 Ω circuit. A constant current passed through the unknown resistance will develop a voltage that is proportional to the value of that resistance. This voltage is then applied through lugs 6 and 1 of FS4 to the input of the A to D converter.

Ohms Constant Current Source

Transistors Q9 and Q10; diode D3; and resistors R111 through R119, R121, and R137 are the main components

for the OHMS constant current source. Diodes D1 and D2 are protection devices to prevent destruction of this circuit if the input leads are inadvertently connected across a voltage source. Transistor Q9 is connected as a zener diode. Transistor Q9, diode D3, and resistor R137 will maintain a constant bias for Q10, which is determined by the current through the Q10 emitter resistors (R111 through R119 and R121). The variable resistors are adjusted to allow the correct amount of current to flow through Q10 and each of the standard calibration resistors to provide a +2-volt DC level to be applied to the A to D converter for each range selected.

A 200 ohm resistor will require 10 milliamperes of current to develop a 2-volt drop across it. Therefore, resistor R119 is adjusted for a constant current of 10 mA when the Function switch is in the kΩ position, the Range switch is in the 200 Ω position, and a 200 Ω resistor is across the Ω and C input jacks of the Multimeter. Each of the remaining ohm ranges will divide the amount of constant current by ten so that as the range is decaded up, the current is decaded down to maintain a 2-volt DC level for full-scale readings on all five ranges.

AC Converter

The AC converter consists of transistor Q8, IC1, and the associated components to function as an operational rectifier having a gain such that the average rectified voltage of a sine wave will produce a DC voltage equal to the rms value of the applied input AC voltage. Capacitor C103 will prevent DC from entering the converter and diodes D4 and D5 are protection diodes to limit the input voltage for safe operation of Q8. Q8 is a source follower (a buffer stage) that provides a high input impedance at its input and a low output impedance to the operational amplifier, IC1. R153 is for DC stability, D8 and R154 provide negative feedback during negative inputs, and D9 and R155 provide negative feedback during positive inputs. R156 and R167 adjust the gain of IC1 to provide a DC voltage to the input of the A to D converter which is equal to the rms value of the AC voltage input to Q8. R129, R128, and C104 filter the half-wave voltage before it is applied to the A to D converter. C101, R133, and C105 give additional filtering for all inputs regardless of the function.

ANALOG-TO-DIGITAL CONVERTER

Refer to the waveshapes in Figure 7 (fold-out from Page 50) while you read the following information.

When a DC voltage is applied to the emitter of transistor Q1, the A to D converter will function as follows:

During time T1 (waveform A), the display is illuminated and the A to D converter is disabled. At the start of T2, the display is extinguished and the base of transistor Q5 goes low (waveform F). This removes the short across capacitor C106 and allows C106 to take on a charge by the current from transistor Q7, a constant current source. This charge is in the form of a ramp (waveform C). The termination of time T1 also produces a reset pulse (waveform G) to clear the counting circuit (IC's 5, 6, and 7) to zero for the start of another count. At the end of time T2, the voltage across capacitor C106 is at a level that permits transistor Q2 to conduct, lowering the voltage at its collector. This lower voltage at Q2's collector is inverted and amplified by transistor Q6 and applied at the input to IC2, which is wired as an R-S (Set-Reset) flip-flop (see Figure 8). The "high" at the reset input, pin 12, produces a "low" at the $\overline{Q}$ output, pin 13; this in turn turns off transistor Q3 and then transistor Q2. This forms a short start pulse (waveform D) and produces a "low" at the base of transistor Q12 (waveform J) which removes the short from clock oscillator transistors Q16 and Q15 and allows the oscillator to produce a series of pulses until a stop pulse is generated to disable the oscillator.

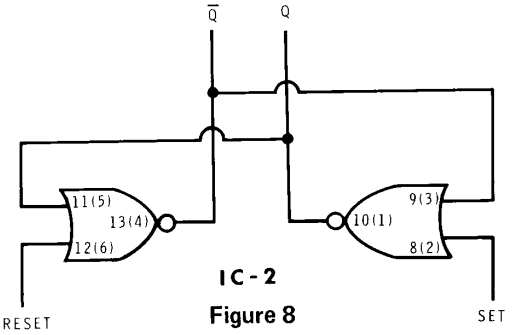


Figure 8

As an example, assume a 1-VDC input to the emitter of transistor Q1. This will cause a display of 100 on the readout tubes. When the ramp amplitude reaches the Q1 emitter voltage, plus the .6 to .8 volt forward base-to-emitter drop, Q1 will conduct and quickly lower the Q1 collector voltage. This negative going pulse is inverted by transistor Q4 which places a "high" on the input to the Stop R-S flip-flop, pins 1 through 6 (see Figure 8). The output (pin 1 of IC2) of the Stop R-S flip-flop will go high and allow transistor Q5 to conduct and discharge capacitor C106. This cuts off transistor Q1 to form the stop pulse (waveform E). The start and stop R-S flip-flops form a latching circuit to control the switching operation of transistor Q12 (waveform J), which controls the on/off period of the clock oscillator (waveform H). The clock frequency is adjusted with R207 so that one volt of DC applied to the emitter of Q1 will produce 100 pulses at the input to the counter circuits.

BINARY TO DECIMAL READOUT

The output string of clock oscillator pulses from the collector of oscillator transistor Q15 is applied to pin 14 of decade counter IC7. In IC7 the pulses are counted, and every tenth pulse (carry pulse) is connected from output pin 11 to input pin 14 of IC6. Once again, each tenth pulse is applied from output pin 11 of IC6 to input pin 1 of IC5. IC5 is a dual J-K flip-flop, each of which divides its input by two. This first carry pulse from pin 11 of IC6 will produce a "high" at pin 12, the Q output of FF1, and allows Q14 to conduct and illuminate DS202, the "ONE" lamp. The second pulse from IC6 will produce a low at FF1's Q output and extinguish the "ONE" lamp. The Q output of FF1 is connected to the CP input of FF2. The second pulse from the Q output of IC6 will produce a "high" at the base of transistor Q13 and complete the circuit for DS201 and illuminate the "OVER" lamp. The reset pulse to clear IC5 requires a pulse opposite that of the two decade counters, IC6 and IC7. Therefore the IC6 and IC7 reset pulse is inverted by IC8B before it is applied to IC5. In this manner, pulses are counted in units, tens, and hundreds in the decade counter IC's. Decoder drivers, IC3 and IC4, convert the binary count to decimal and drive the corresponding numerals in the readout tubes.

During the period in which the pulses are being coupled into the counter circuits, readout illumination is disabled by the absence of line frequency rectified pulses. When the binary information has been stored in the decoder drivers and the oscillator input is complete, the anode voltage to the readout tubes is raised to a high level and the appropriate numerals are illuminated. The repetition rate is such that the output display appears to be continuous to the observer.

POWER SUPPLY

The blue-leads winding of the power transformer, diodes D11 and D12, capacitor C114, zener diode D10, and transistor Q11 make up the regulated +5-volt DC power supply. The black lead of the transformer is the center tap for this full-wave winding and is connected to the Multimeter circuit ground. Transistor Q11 is a zener-controlled, Darlington, pass transistor stage. The output voltage at the emitter of Q11 remains constant over a wide range of input voltage and output load and current. Diode D10 and resistors R148 and R149 are factory selected components which provide an accurate, near full-scale voltage reference for DC calibration.

The yellow-leads winding of the power transformer; diode D13; capacitors C117, C115, and C116; resistor R158; and zener diodes D14 and D15 are the components of the +15-volt and −15-volt regulated supply. Because of the uniformity of the the current demand, a pass transistor is unnecessary. Resistor R151 limits the current to zener diode D10. The junction between zener diodes D14 and D15 center taps the supply voltage, and references both the positive and negative voltages to ground.

The red power transformer winding creates a secondary step-up voltage. This voltage is the supply that enables the readout tubes to be fired at the proper time, and also supplies the power for the four neon lamps used to illuminate the "+", "−", "1", and "OVER" symbols. The rectified AC pulses that control the oscillator and readout timing are derived from this circuit. The black transformer lead also connects this transformer circuit to the circuit and chassis grounds.

Resistors R161 and R163, plus AC TP ADJ control R162, provide the Meter with a transfer method for the calibration of the AC converter.

Resistors R218 and R219 in the pulse shaping network of IC8 form a voltage divider to attenuate the half-wave voltage to a level suitable to drive IC8.

The primary winding of power transformer T1 may be wired for a source voltage of either 120-volts or 240-volts AC, 50 to 60 Hz. Capacitor C118 connects the power line ground to circuit ground to eliminate shock hazard and to minimize A to D converter "hunt" while measuring any power line voltage or current.

Separate resistor standards on the main circuit board; R123, R124, R125, R126, and R127, permit full-scale calibration of the Meter ohms ranges.

CIRCUIT BOARD X-RAY VIEWS

NOTE: To identify a part shown in one of these Views, so you can order a replacement, proceed in either of the following ways:

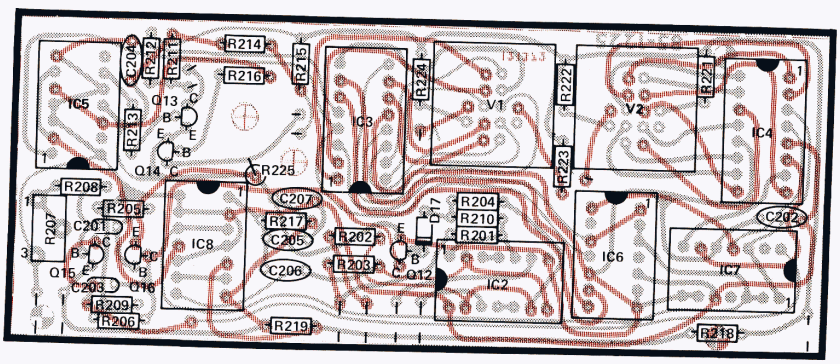
1. A. Refer to the place where the part is installed in the Step-by-Step instructions and note the "Description" of the part (for example: 22 kΩ, .05 μF, or 2N3638A).

   B. Look up this Description in the "Parts List."

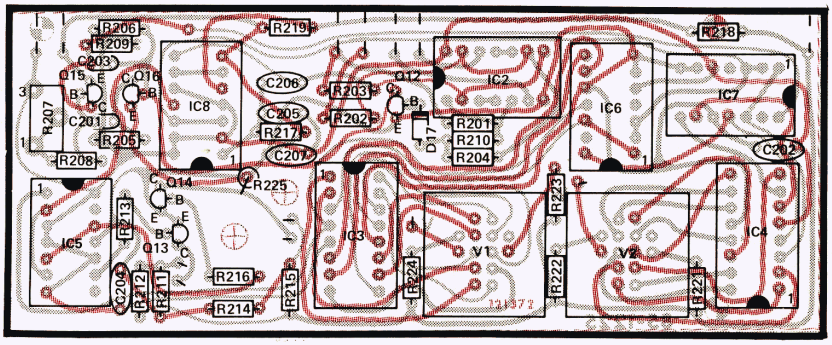
2. A. Note the identification number of the part (R-number, C-number, etc.).

   B. Locate the same identification number (next to the part) on the Schematic. The "Description" of the part will also appear near the part.

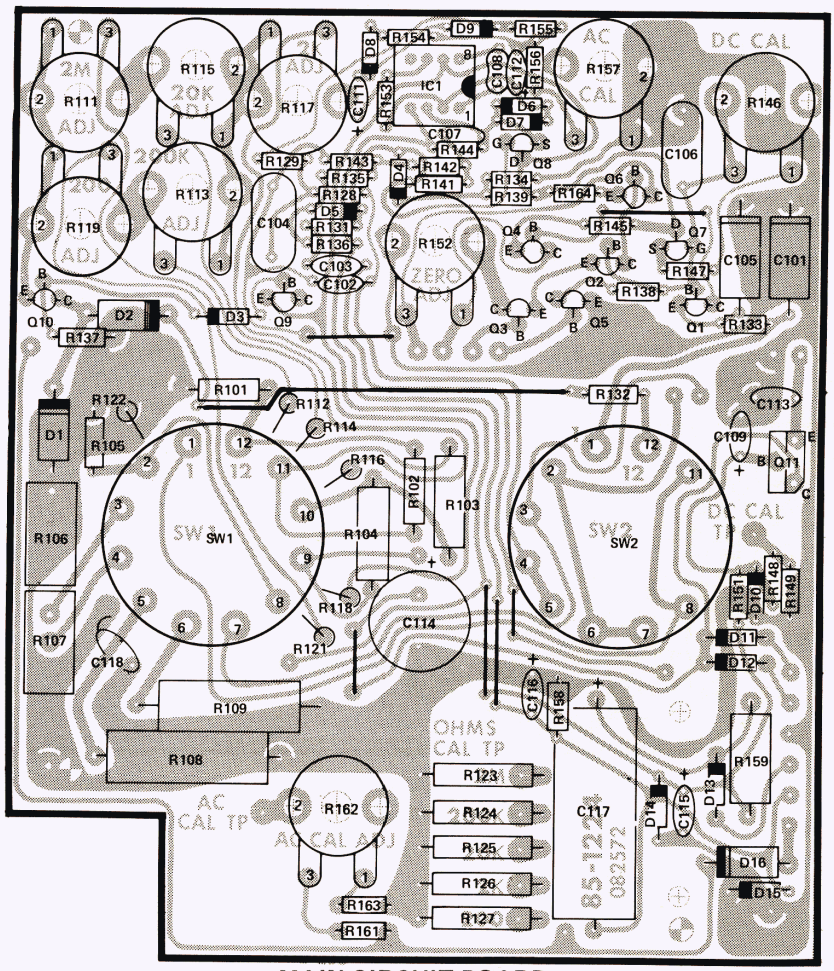
   C. Look up this Description in the "Parts List."



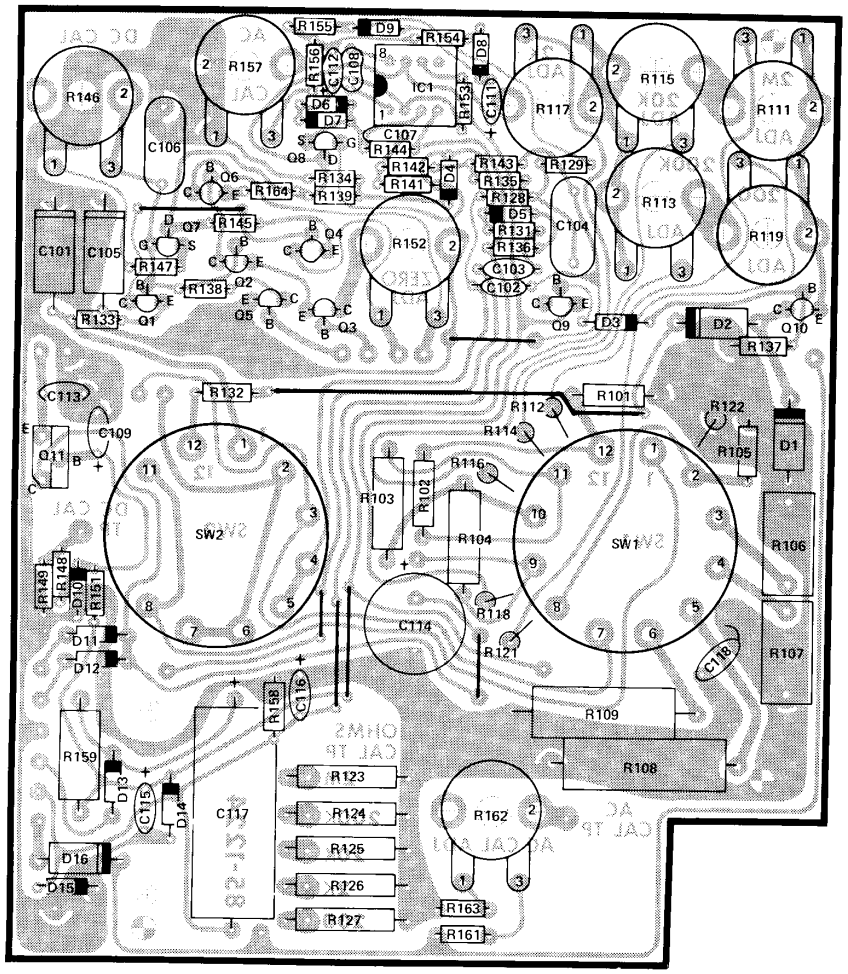
LOGIC CIRCUIT BOARD
(Viewed from foil side)



LOGIC CIRCUIT BOARD
(Viewed from component side)

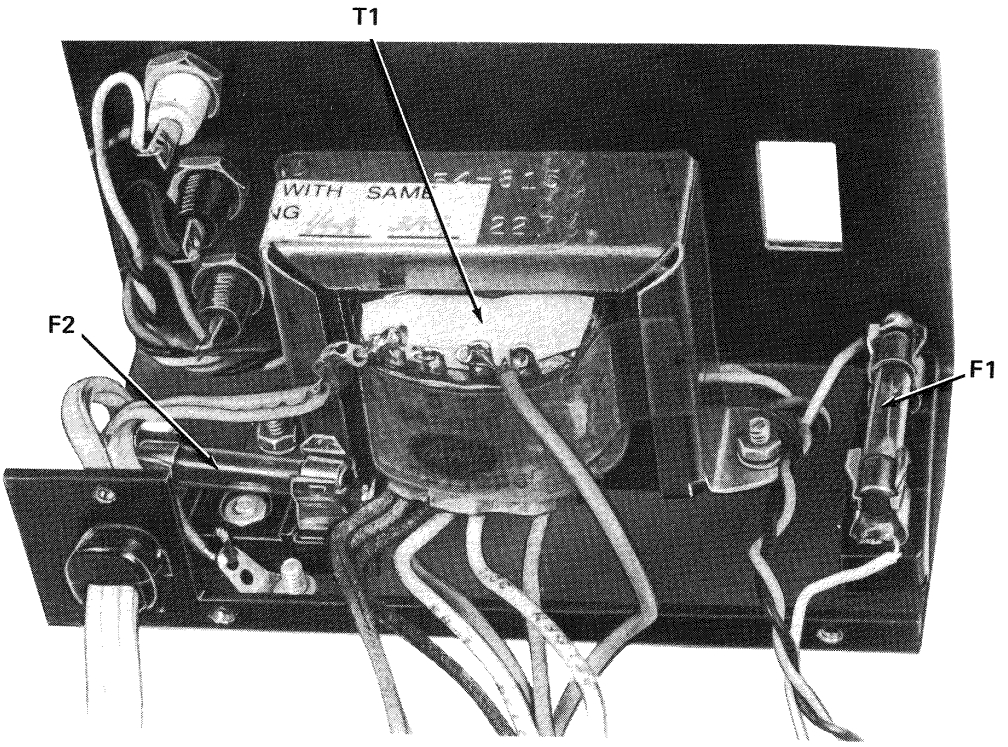


MAIN CIRCUIT BOARD
(Viewed from foil side)

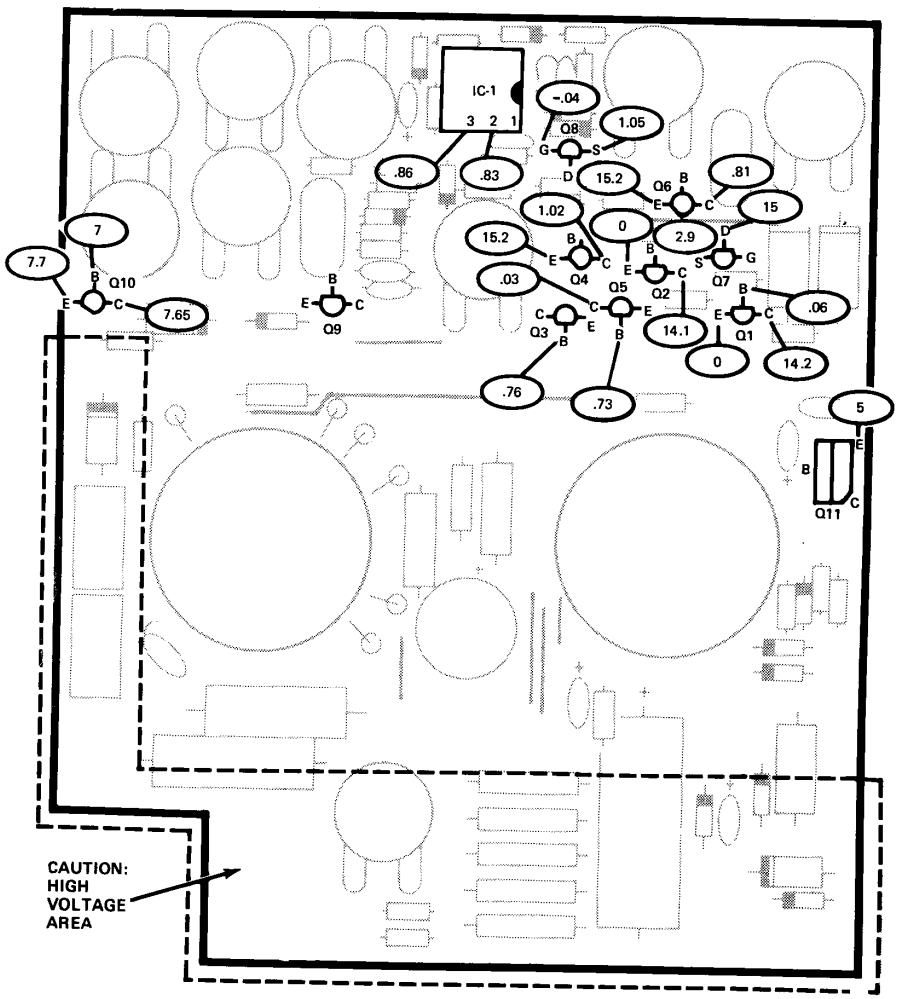


MAIN CIRCUIT BOARD
(Viewed from component side)

CHASSIS PHOTOGRAPH



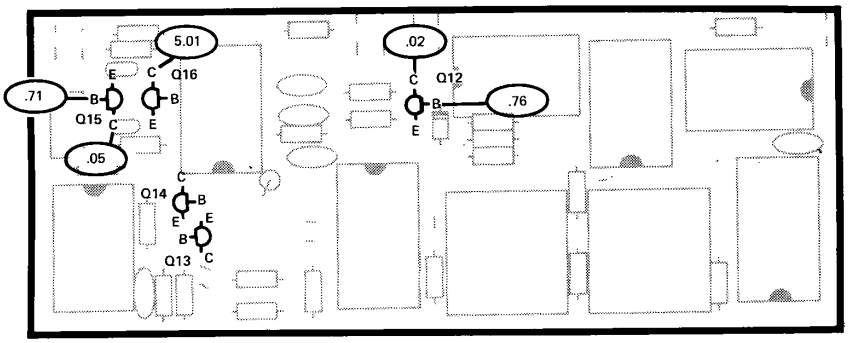
CIRCUIT BOARD VOLTAGE CHARTS



NOTE: VOLTAGES SHOWN ARE TAKEN UNDER THE FOLLOWING CONDITIONS:

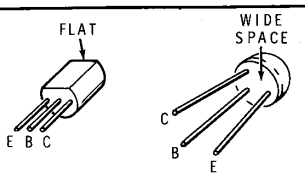
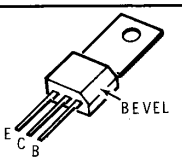
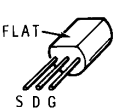
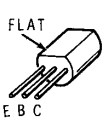
FUNCTION SWITCH: DC.
RANGE SWITCH: 2 VOLTS.
INPUT: V LEAD SHORTED TO C LEAD.

MAIN CIRCUIT BOARD
(Viewed from foil side)



LOGIC CIRCUIT BOARD
(Viewed from component side)

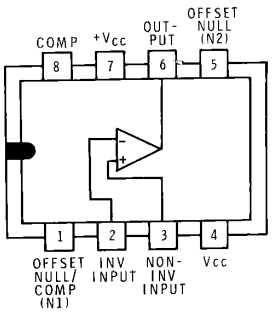
TRANSISTOR BASING DIAGRAMS

COMPONENT	HEATH PART NUMBER	TYPE	CASE DIAGRAM
Q4, Q6, Q10	417-234	2N3638A	
Q11	417-272	D40C1	
Q7, Q8	417-291	2N5458	
Q1, Q2, Q3, Q5, Q9, Q12, Q15, Q16	417-801	MPSA20	
Q13, Q14	417-294	MPSA42	

INTEGRATED CIRCUIT PIN-OUT DIAGRAMS

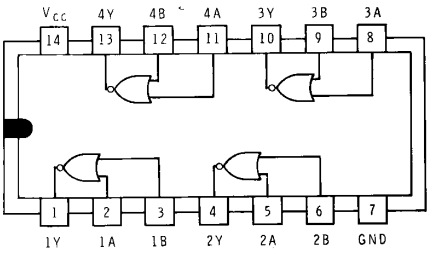
(ALL DIAGRAMS SHOWN FROM TOP)

IC1



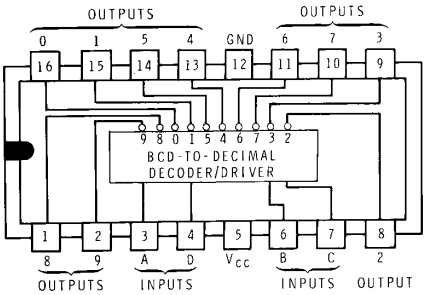
301A LINEAR OPERATIONAL AMPLIFIER
#442–39

IC2



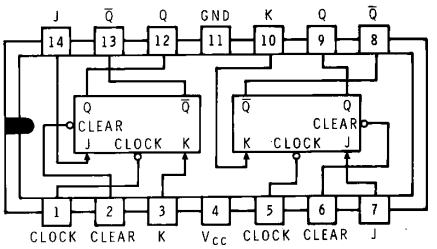
7402 QUADRUPLE–2 INPUT POSITIVE NOR GATE
#443–46

IC3
IC4



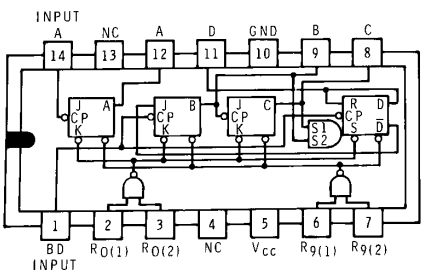
7441 BCD–TO–DECIMAL DECODER/DRIVER
#443–35

IC5



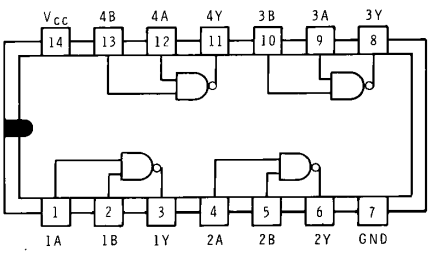
7473 DUAL J–K MASTER SLAVE FLIP–FLOP
#443–5

IC6
IC7



7490 DECADE COUNTER
#443–7

IC8

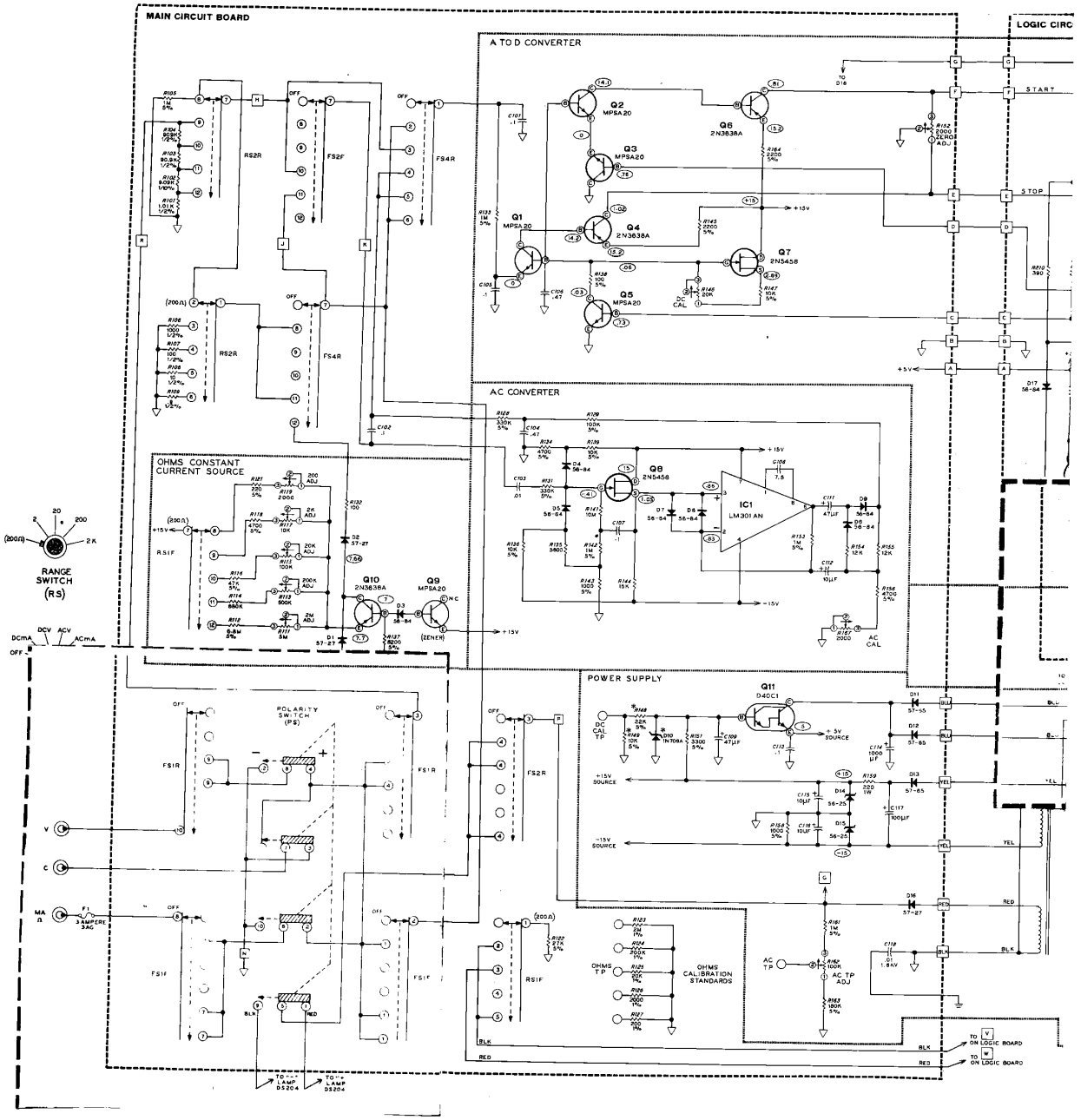


7400 QUADRUPLE 2–INPUT POSITIVE NAND GATE
#443–1

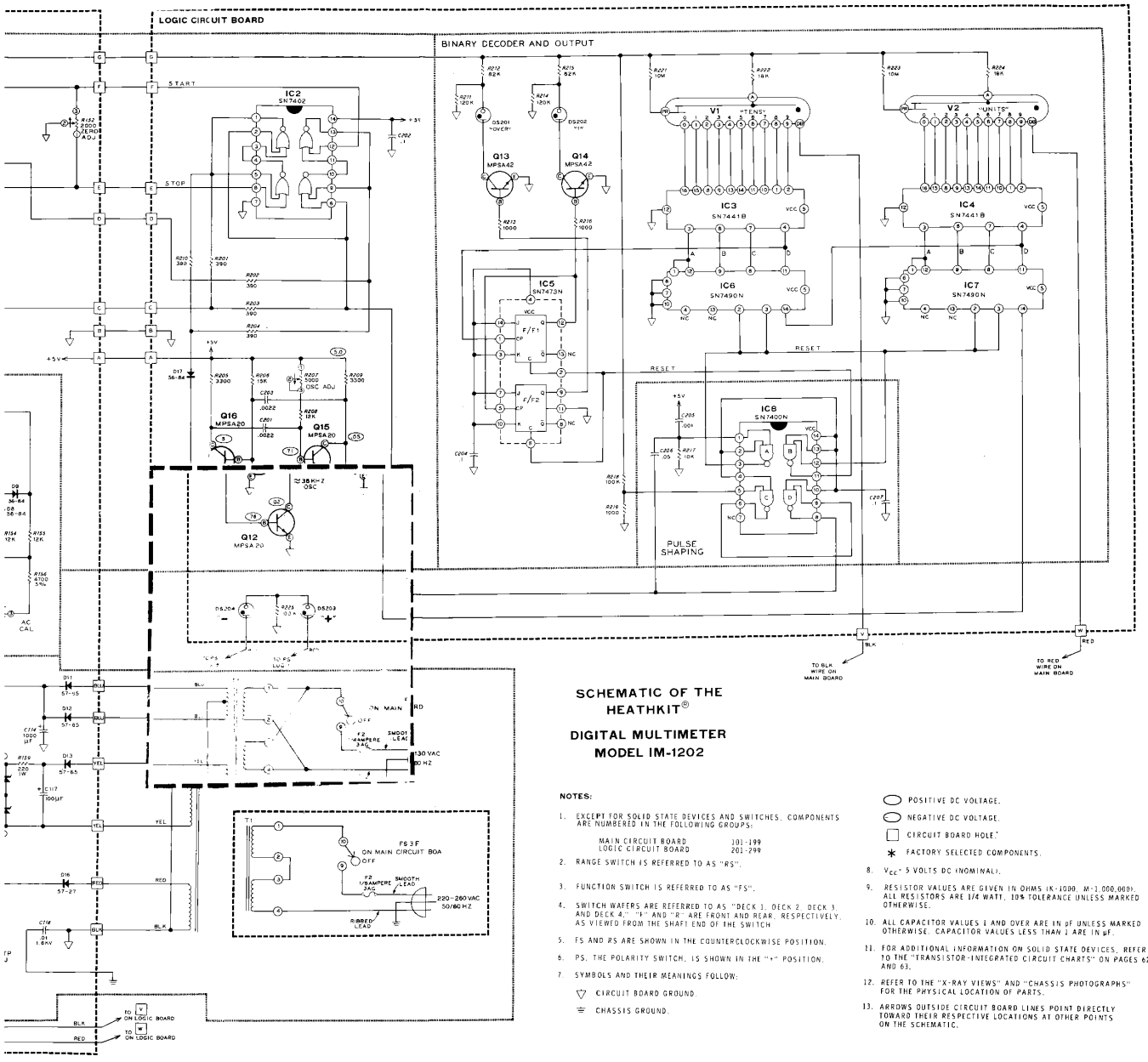
ALL DIODES MARKED 56-84 ARE NOW 56-56

DIODE

D3
D4, D5
D7, D6
D8, D9
D17



DIODE	LOCATED NEAR
D3	Q9
D4, D5	Gate of Q8
D7, D6	Input of IC1
D8, D9	Output of IC1
D17	Collector of Q16



SCHEMATIC OF THE HEATHKIT®

DIGITAL MULTIMETER MODEL IM-1202

NOTES:

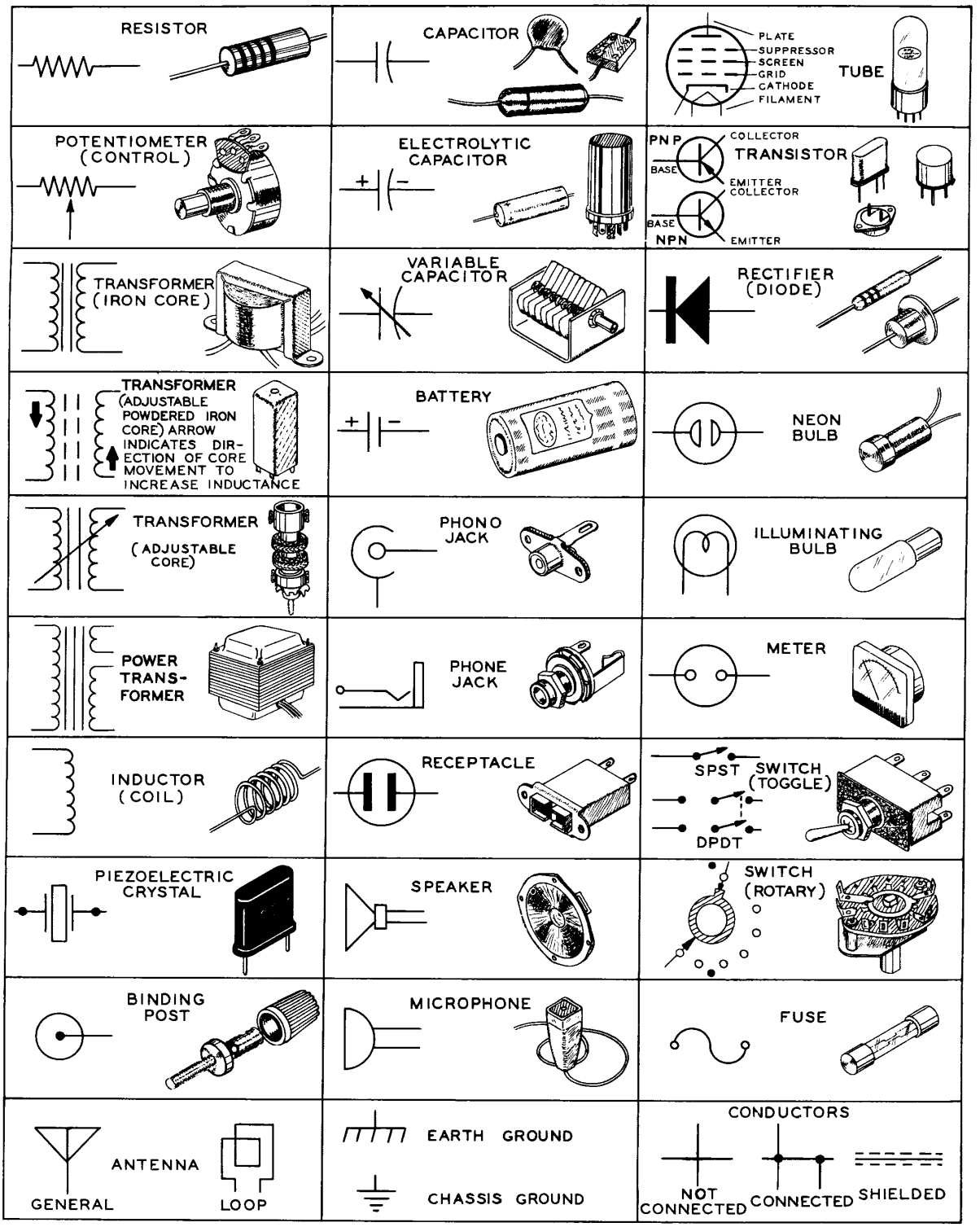
1. EXCEPT FOR SOLID STATE DEVICES AND SWITCHES, COMPONENTS ARE NUMBERED IN THE FOLLOWING GROUPS:

MAIN CIRCUIT BOARD	101-199
LOGIC CIRCUIT BOARD	201-299

2. RANGE SWITCH IS REFERRED TO AS "RS".
3. FUNCTION SWITCH IS REFERRED TO AS "FS".
4. SWITCH WAFERS ARE REFERRED TO AS "DECK 1, DECK 2, DECK 3, AND DECK 4." "F" AND "R" ARE FRONT AND REAR, RESPECTIVELY, AS VIEWED FROM THE SHAFT END OF THE SWITCH.
5. FS AND RS ARE SHOWN IN THE COUNTERCLOCKWISE POSITION.
6. PS, THE POLARITY SWITCH, IS SHOWN IN THE "+" POSITION.
7. SYMBOLS AND THEIR MEANINGS FOLLOW:
   - ▽ CIRCUIT BOARD GROUND.
   - ⏚ CHASSIS GROUND.
   - ⬭ POSITIVE DC VOLTAGE.
   - ⬭ NEGATIVE DC VOLTAGE.
   - □ CIRCUIT BOARD HOLE.
   - ✱ FACTORY SELECTED COMPONENTS.
8. V_{CC} = 5 VOLTS DC (NOMINAL).
9. RESISTOR VALUES ARE GIVEN IN OHMS (K=1000, M=1,000,000). ALL RESISTORS ARE 1/4 WATT, 10% TOLERANCE UNLESS MARKED OTHERWISE.
10. ALL CAPACITOR VALUES 1 AND OVER ARE IN pF UNLESS MARKED OTHERWISE. CAPACITOR VALUES LESS THAN 1 ARE IN µF.
11. FOR ADDITIONAL INFORMATION ON SOLID STATE DEVICES, REFER TO THE "TRANSISTOR-INTEGRATED CIRCUIT CHARTS" ON PAGES 62 AND 63.
12. REFER TO THE "X-RAY VIEWS" AND "CHASSIS PHOTOGRAPHS" FOR THE PHYSICAL LOCATION OF PARTS.
13. ARROWS OUTSIDE CIRCUIT BOARD LINES POINT DIRECTLY TOWARD THEIR RESPECTIVE LOCATIONS AT OTHER POINTS ON THE SCHEMATIC.

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.



HEATH

Schlumberger

HEATH COMPANY • BENTON HARBOR, MICHIGAN

THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

LITHO IN U.S.A.