

# **ASSEMBLY**

Model IP-2718

## **TRI-POWER SUPPLY**

Part No. 595-1840

**HEATH COMPANY**  
BENTON HARBOR, MICHIGAN 49022

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# PARTS LIST

Check each part against the following list. Any part that is packed in an individual envelope with the part number on it should be placed back in the envelope after you identify it until it is called for in a step. Do not discard any packing materials until all parts are accounted for.

The key numbers correspond to the numbers on the "Parts Pictorial" in the separate "Illustration Booklet."

Each circuit part in this kit has its own "Circuit Component Number" (R1, C11, D21, etc.). This is a specific number for only that one part. The purpose of these numbers is to help you easily identify the same part in each section of the Manual.

These numbers will appear:

- In the Parts List.
- At the beginning of each step where a component is installed.
- In some illustrations.
- In the sections at the rear of the Manual.

To order a replacement part: Always include the PART NUMBER. Use the Parts Order Form furnished with the kit. If one is not available, see "Replacement Parts" inside the rear cover of the Manual. Your Warranty is located inside the front cover. For price information, refer to the separate "Heath Parts Price List."

KEY PART No.	PART No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
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## RESISTORS

### 1/2-Watt Resistors

Notes:

1. All resistors are 10% tolerance unless otherwise noted.
2. A fourth color band of silver indicates 10% tolerance; a fourth band of gold indicates 5% tolerance.
3. The resistors may be packed in more than one envelope. Open all the resistor envelopes in this pack before you check them against the Parts List.

A1	1-1	✓ 2	47Ω (yellow-violet-black)	R5, R6
A1	1-48	✓ 2	390Ω (orange-white-brown)	R115, R215
A1	1-157	✓ 4	470Ω, 5% (yellow-violet-brown)	R108, R117, R208, R217
A1	1-8	✓ 2	820Ω (gray-red-brown)	R104, R204

KEY PART No.	PART No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
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### Resistors (cont'd.)

A1	1-9	✓ 2	1000Ω (brown-black-red)	R106, R206
A1	1-90	✓ 4	2000Ω, 5% (red-black-red)	R111, R112, R211, R212
A1	1-89	✓ 2	2400Ω, 5% (red-yellow-red)	R119, R219
A1	1-46	✓ 2	3900Ω (orange-white-red)	R103, R203
A1	1-16	✓ 2	4700Ω (yellow-violet-red)	R102, R202
A1	1-20	✓ 2	10 kΩ (brown-black-orange)	R114, R214
A1	1-24	✓ 6	33 kΩ (orange-orange)	R101, R118, R121, R201, R218, R221
A1	1-25	✓ 1	47 kΩ (yellow-violet-orange)	R1
A1	1-128	✓ 2	62 kΩ, 5% (blue-red-orange)	R122, R222

### 1-Watt Resistors

A2	1-19-1	✓ 1	220Ω (red-red-brown)	R2
A2	1-56-1	✓ 2	1200Ω (brown-red-red)	R113, R213
A2	1-22-1	✓ 2	1500Ω (brown-green-red)	R105, R205



KEY PART No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
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### Precision Resistors

A3	2-94	✓ 1	0.1Ω, 1/2-watt, 1%	R4
A4	2-296	✓ 1	150Ω, 1/2-watt, 1%	R3
A4	2-24-12	✓ 2	555Ω, 1/4-watt, 1%	R107, R207
A4	2-247	✓ 2	5000 (5K)Ω, 1/2-watt, 1%	R124, R224
A4	2-181	✓ 1	5490 (5.49K)Ω, 1/2-watt, 1%	R12
A4	2-265	✓ 2	12.2 kΩ, 1/2-watt, 1%	R123, R223
A4	2-323	✓ 2	19.95 kΩ, 1/2-watt, 1%	R11, R13

### Other Resistor

A5	3-8-1	✓ 2	1.1 Ω, 1-watt, 3%, wire-wound	R109, R209
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### CONTROLS

B1	10-918	✓ 2	500Ω	R116, R216
B2	10-281	✓ 1	10 kΩ	R7
B3	12-156	✓ 1	Dual 10 kΩ control	R8, R9

### CAPACITORS

#### Disc Capacitors

C1	21-9	✓ 2	100 pF	C106, C206
C1	21-173	✓ 1	.0022 μF	C3
C1	21-72	✓ 1	.005 μF, 1.4 KV	C1
C1	21-16	✓ 3	.01 μF	C5, C6, C7
C1	21-48	✓ 2	.05 μF	C107, C207
C1	21-99	✓ 1	.2 μF	C4

#### Electrolytic Capacitors

C2	25-283	✓ 4	10 μF	C105, C109, C205, C209
C2	25-251	✓ 4	50 μF	C104, C108, C204, C208
C3	25-116	✓ 2	50 μF vertical electrolytic	C102, C202
C4	25-192	✓ 2	2000 μF	C103, C203
C5	25-822	✓ 1	12000 μF	C2

#### Mylar\* Capacitor

C6	27-47	✓ 2	.1 μF Mylar	C101, C201
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\*Registered Trademark, DuPont Corp.

KEY PART No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
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### DIODES-TRANSISTORS-INTEGRATED CIRCUIT

#### Diodes

D1	56-31	✓ 2	PS18775 zener diode	ZD109, ZD209
D1	56-50	✓ 2	DO-7 zener diode	ZD104, ZD204
D1	56-57	✓ 2	1N716A zener diode	ZD108, ZD208
D1	57-42	✓ 2	3A1 diode	D1, D2
D1	57-65	✓ 14	1N4002 diode	D101, D102, D103, D105, D106, D107, D110, D201, D202, D203, D205, D206, D207, D210

#### Transistors and Integrated Circuit

NOTE: Transistors and integrated circuits may be marked for identification in any of the following four ways:

1. Part number.
2. Type number (on integrated circuits, this refers only to the numbers; the letters may be different or missing).
3. Part number and type number.
4. Part number with a type number other than the one listed.

D2	417-201	✓ 4	X29A829 transistor	Q102, Q106, Q202, Q206
D2	417-258	✓ 4	TIS87 transistor	Q107, Q108, Q207, Q208
D2	417-294	✓ 2	MPSA42 transistor	Q103, Q203
D2	417-801	✓ 6	MPSA20 transistor	Q101, Q104, Q105, Q201, Q204, Q205
D3	417-282	✓ 2	MJ2841 transistor	Q1, Q2
D3	442-30	✓ 1	UA309K integrated circuit (IC)	IC1

#### SWITCHES-KNOBS-INSERTS

E1	60-2	✓ 2	Slide switch	SW1, SW3
E2	60-54	✓ 1	Line switch	SW2
E3	63-1257	✓ 1	Rotary switch	SW4
E4	462-363	✓ 1	Red knob	
E5	462-361	✓ 1	Round knob (with center hole)	
E6	462-920	✓ 2	Round knob	
E7	455-51	✓ 1	Short knob insert	
E8	455-52	✓ 1	Small-center knob insert	
E9	455-619	✓ 2	Large-center knob insert	

KEY PART QTY. DESCRIPTION CIRCUIT  
No. No. \_\_\_\_\_ Comp. No.

**PLASTIC PARTS-INSULATORS**

F1	75-17	✓	6	Black binding post base
F1	75-197	✓	6	Red binding post base
F1	75-198	✓	1	Green binding post base
F2	73-47	✓	1	1" × 1" foam pad
F3	75-52	✓	1	Switch insulator
F4	75-60	✓	3	Transistor insulator (between two pieces of cardboard)
F5	75-142	✓	3	Transistor cover
F6	75-734	✓	3	Circuit board mount
F7	75-736	✓	1	Strain relief
F8	100-16-2	✓	3	Black binding post cap
F8	100-16-18	✓	3	Red binding post cap
F8	100-699	✓	1	Green binding post cap
F9	261-34	✓	4	Foot
F10	354-7	✓	2	Capacitor tie
F11	413-10	✓	1	Red lens

**METAL PARTS**

G1	90-1168-1	✓	1	Cabinet top
G2	200-1257-1	✓	1	Chassis
G3	204-2162	✓	1	Meter bracket
G4	207-612	✓	1	Capacitor clamp
G5	215-84	✓	2	Heat sink
G6	427-3	✓	7	Binding post
G7	259-10	✓	1	Control solder lug

**HARDWARE**

NOTE: Hardware packets are marked to show the size of the hardware they contain (HDW #4, or, HDW #2 & #6, etc.). You may have to open more than one packet — in this pack — to locate all the hardware of any one size (#6, for example). (Hardware is shown actual size.)

**#6 Hardware**

H1	250-369	✓	6	#6 × 1/4" black sheet metal screw
H2	250-381	✓	9	6-32 × 3/8" black screw
H3	250-162	✓	14	6-32 × 1/2" screw
H4	252-3	✓	24	6-32 nut
H5	254-1	✓	17	#6 lockwasher
H6	254-6	✓	1	#6 external lockwasher
H7	259-1	✓	8	#6 solder lug
H8	254-27	✓	1	Binding post lockwasher

KEY PART QTY. DESCRIPTION CIRCUIT  
No. No. \_\_\_\_\_ Comp. No.

**Other Hardware**

J1	250-330	✓	4	10-32 × 3/8" screw
J2	252-5	✓	4	10-32 nut
J3	254-3	✓	4	#10 lockwasher
J4	252-7	✓	3	Control nut
J5	253-10	✓	3	Control flat washer
J6	254-4	✓	5	Control lockwasher
J7	252-32	✓	1	Push-on nut

**WIRE HARNESS-WIRE-SLEEVING**

134-951	✓	1	Wire harness
344-2	✓	36"	Black stranded wire
344-3	✓	6"	Red stranded wire
344-50	✓	30"	Solid black wire
344-52	✓	19"	Solid red wire
346-1	✓	8"	Sleeving
89-54	✓	1	Line cord

**MISCELLANEOUS**

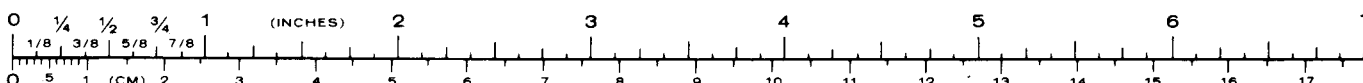
54-918	✓	1	Power transformer	T1	
85-1750-3	✓	1	Circuit board		
407-718	✓	1	Meter	M1	
K1	412-15	✓	1	Neon lamp	PL1
K2	421-1	✓	1	1-1/2-ampere fuse	F1
K3	352-13	✓	1	Silicone grease	
K4	422-1	✓	1	Fuseholder	
K5	431-5	✓	1	4-lug terminal strip	
K6	434-117	✓	3	Transistor socket	
K7	490-5	✓	1	Nut starter	
		✓		Solder	

**PRINTED MATERIAL**

K8	391-34	✓	1	Blue and white label
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NOTE: Be sure you refer to the numbers on the blue and white label in any communications you may have about this kit with Heath Company. You may want to write the model and series numbers in this sample for future convenience.

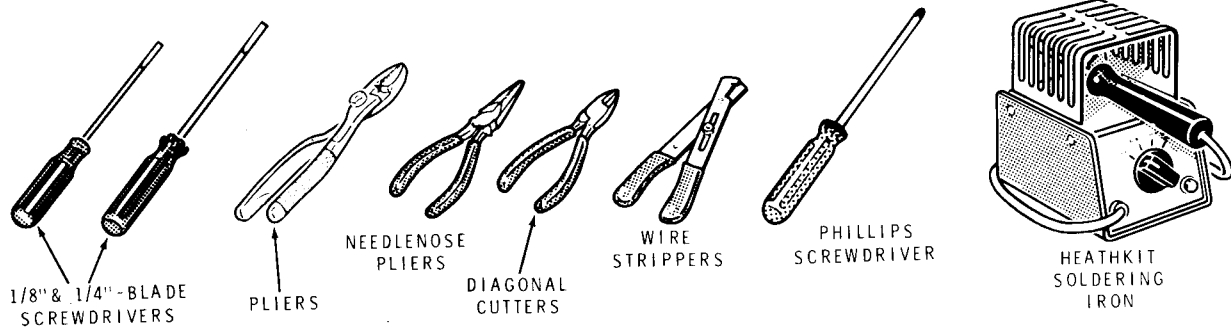
K9	390-1255	✓	1	Fuse label
	597-260	✓	1	Parts Order Form
		✓	1	Technical Correspondent letter
		✓	1	Assembly Manual (See front cover for part number.)



# ASSEMBLY NOTES

## TOOLS

You will need these tools to assemble your kit.



1/8" & 1/4" - BLADE  
SCREWDRIVERS

PLIERS

NEEDLENOSE  
PLIERS

DIAGONAL  
CUTTERS

WIRE  
STRIPPERS

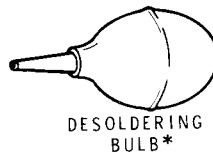
PHILLIPS  
SCREWDRIVER

HEATHKIT  
SOLDERING  
IRON

### OTHER HELPFUL TOOLS



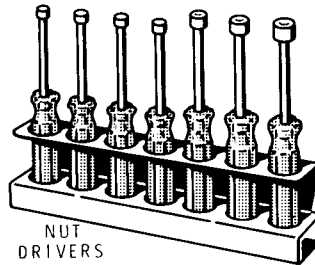
NUT STARTER  
(MAY BE SUPPLIED  
WITH KIT)



DESOLDERING  
BULB\*



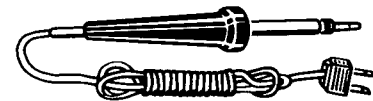
SOLDER  
BRAID\*



NUT  
DRIVERS

\*TO REMOVE SOLDER FROM CIRCUIT BOARDS.

OR



PENCIL SOLDERING IRON  
(25 TO 40 WATTS)

## ASSEMBLY

- Follow the instructions carefully, and read the entire step before you perform the operation.
- Position all parts as shown in the Pictorials.
- The illustrations in the Manual are called Pictorials and Details. Pictorials show the overall operation for a group of assembly steps; Details generally illustrate a single step. When you are directed to refer to a certain Pictorial "For the following steps", continue using that Pictorial until you are referred to another Pictorial for another group of steps.
- A separate "Illustration Booklet" contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. When the Manual says to refer to a certain Pictorial or Detail, refer to the "Illustration Booklet" if that illustration is not on the same page or the page across from it.  
  
Keep the "Illustration Booklet" with the Assembly Manual. The illustrations in it are arranged in Pictorial numbers sequence.
- Solder a part or a group of parts only when you are instructed to do so.

6. Resistors will be called out by their resistance value in  $\Omega$  (ohms),  $k\Omega$  (kilohms), or  $M\Omega$  (megohms), and color code. Use 1/2-watt resistors unless directed otherwise.
7. Capacitors will be called out by their capacitance value (in pF or  $\mu F$ ) and type (disc ceramic, Mylar, or electrolytic).
8. When you are instructed to cut something to a particular length, use the scales (rulers) provided at the bottom of the Manual pages.

**SAFETY WARNING: Avoid eye injury when you cut off excess lead lengths. Hold the leads so they cannot fly toward your eyes.**

## SOLDERING

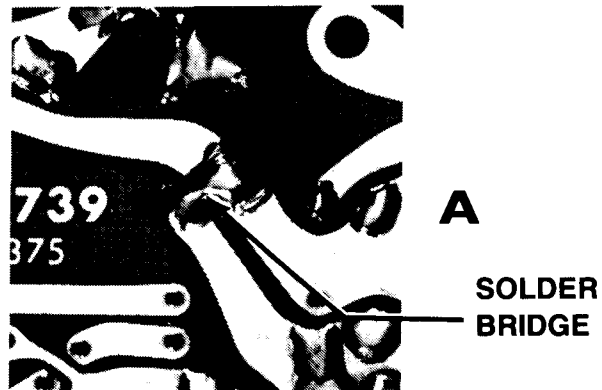
Soldering is one of the most important operations you will perform while assembling your kit. A good solder connection will form an electrical connection between two parts, such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well-assembled kit from operating properly.

It is easy to make a good solder connection if you follow a few simple rules:

1. Use the right type of soldering iron. A good quality, 25 to 40-watt, pencil soldering iron with a 1/8" or 3/16" chisel or pyramid tip works best.
2. Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned.
3. Due to the small foil area around the circuit board holes and the small areas between foils, you must use the utmost care to prevent solder bridges between adjacent foil areas.

A solder bridge between two adjacent foils is shown in photograph A below. Photograph B shows how the connection should appear. A solder bridge may occur if you accidentally touch an adjacent previously soldered connection, if you use too much solder, or if you "drag" the soldering iron across other foils as you remove it from the connection. A good rule to follow is: Always take a good look at the foil area around each lead before you solder it. Then, when you solder the connection, make sure the solder remains in this area, and does not bridge to another foil. This is especially important when the foils are small and close together. NOTE: It is alright for solder to bridge two connections on the same foil.

Use only enough solder to make a good connection, and lift the soldering iron straight up from the circuit board. If a solder bridge should develop, turn the circuit board foil-side-down and heat the solder between connections. The excess solder will run onto the tip of the soldering iron, and this will remove the solder bridge. NOTE: The foil side of each circuit board has a coating on it called "solder resist." This is a protective insulation to help prevent solder bridges.



## STEP-BY-STEP ASSEMBLY

**IMPORTANT:** In the following circuit board pictorials, only the **left** half of the circuit board is shown; the right half is identical to the left. Component callouts in the 200-series (R201, C201, Q201, etc.) are on the left half of the circuit board and the 100-series (R101, C101, Q101, etc.) are on the right half of the circuit board. All 100-series components are in the 20-volt A supply; 200-series components are in the 20-volt B supply.

In Pictorials 1-2 through 1-4 (Pages 11 through 13), you will install **two** components for each assembly instruction. When you install R201, for instance, check one of the two step brackets (✓) ( ). Then install R101 in its similar location on the other half of the board and check the remaining step bracket (✓) (✓).



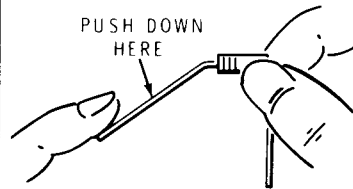
# CIRCUIT BOARD ASSEMBLY

## START

In the following steps you will be given detailed instructions on how to install and solder the first part on the circuit board. Read and perform each step carefully. Then use the same procedure whenever you install parts on a circuit board.

✓ Position the circuit board as shown with the printed side (not the foil side) up.

✓ Hold a 470 Ω (yellow-violet-brown) resistor by the body as shown and bend the leads straight down.

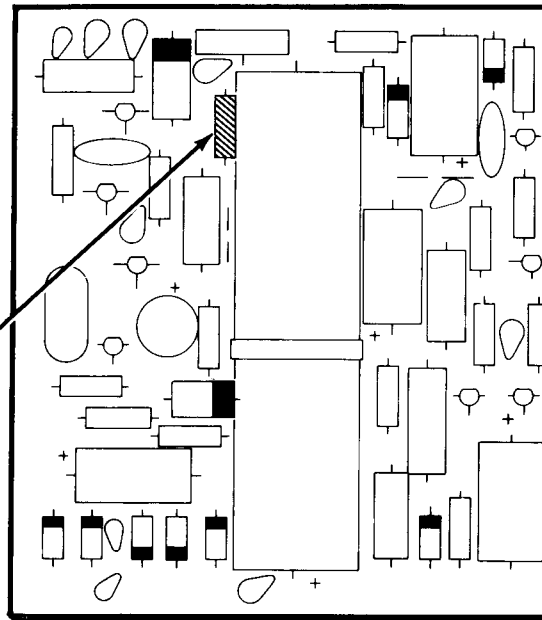
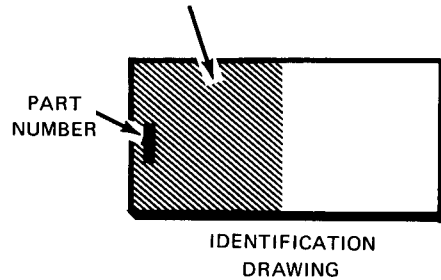


✓ R217: Push the leads through the holes at the proper location on the circuit board. The end with color bands may be positioned either way.

✓ Press the resistor against the circuit board. Then bend the leads outward slightly to hold the resistor in place.



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

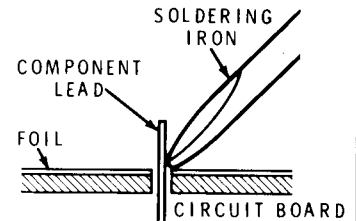


PICTORIAL 1-1

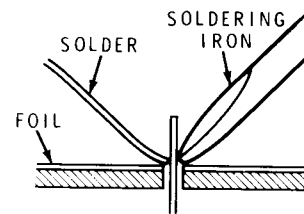
## CONTINUE

✓ Solder each of the resistor leads to the circuit board as follows:

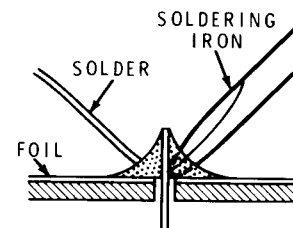
1. Place the soldering iron tip against both the lead and the circuit board foil. Heat both for 2 or 3 seconds.



2. Then apply solder to the other side of the connection. **IMPORTANT:** Let the heated lead and the circuit board foil melt the solder.



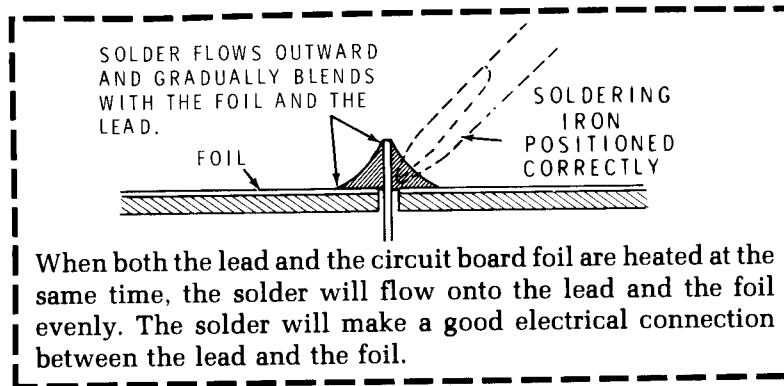
3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



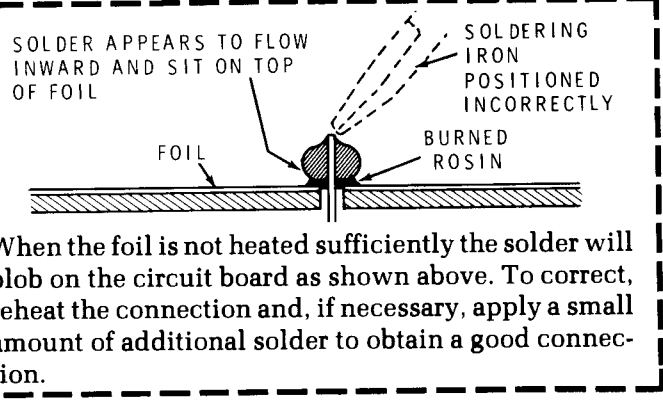
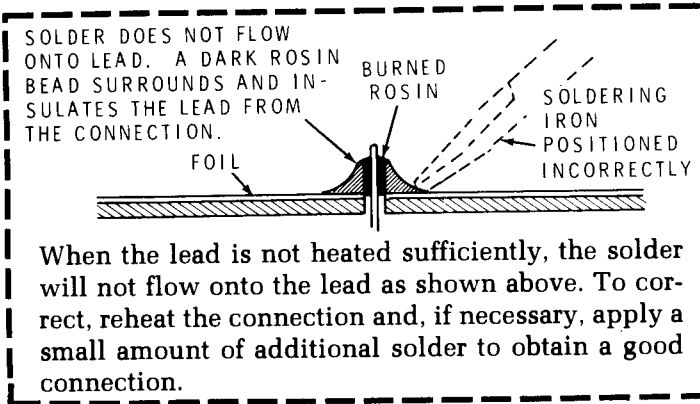
✓ Hold the lead with one hand while you cut off the excess lead length close to the connection. This will keep you from being hit in the eye by the flying lead.

✓ Check the connection. Compare it to the illustrations on the next page. After you have checked the solder connections, proceed with the assembly on Page 11. Use the same soldering procedure for each connection.

### A GOOD SOLDER CONNECTION

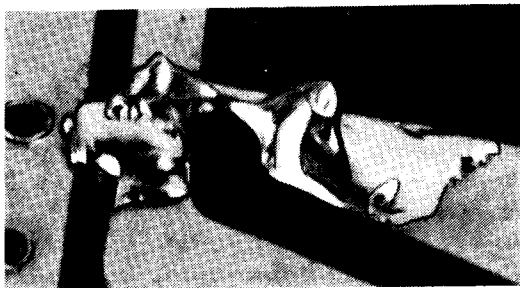


### POOR SOLDER CONNECTIONS



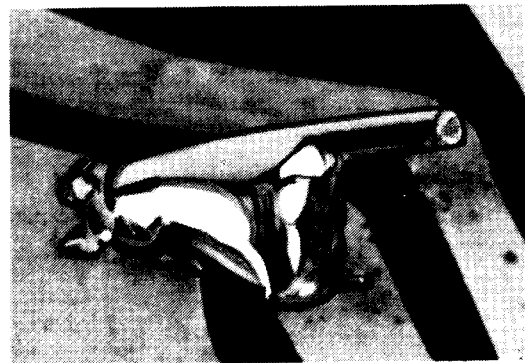
### SOLDER CONNECTIONS TO WATCH OUT FOR

The following photographs show examples of the types of bad solder connections that are the most common cause of trouble. If you locate any of these bad solder connections in your kit, correct them as instructed.

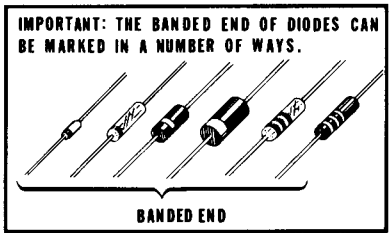


Here, hot solder has been dropped onto the foil and the solder connected or bridged (or crossed) three foils. To correct, hold the circuit board above the soldering iron and reheat the solder. As the solder melts, it will flow down the iron.

NOTE: Solder that bridges two connections on the SAME FOIL is alright and should not be corrected.



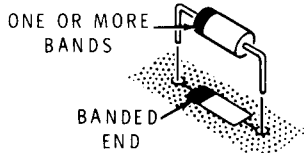
Here, solder has flowed along a lead and bridged to another foil. To correct, hold the circuit board above the soldering iron and reheat the solder. As the solder melts, it will flow down the iron. Then cut off the excess lead lengths. PROTECT YOUR EYES.



**Detail 1-2A**

**START**

**NOTE:** When you install diodes, as in the following steps, be sure you position the banded end of each diode as it is shown on the circuit board. See Detail 1-2A.



( ) ( ) ZD209, ZD109: PS18775 zener diode (#56-31).

( ) ( ) R117: 470 Ω (yellow-violet-brown).  
NOTE: R217, on the left side of the board, was installed on Pictorial 1-1.

( ) ( ) R208, R108: 470 Ω (yellow-violet-brown).

**NOTE:** To prepare jumper wires, use solid black wire. Cut the wire to the lengths indicated; then remove 1/4" of insulation from each wire end.

( ) ( ) 3/4" jumper wire.

( ) ( ) R201, R101: 33 kΩ (orange-orange-orange).

( ) ( ) R203, R103: 3900 Ω (orange-white-red).

( ) ( ) D201, D202, D207, D206, D203: D101, D102, D107, D106, D103: Mount five 1N4002 diodes (#57-65). Position the banded ends as shown.

**SAFETY WARNING:** Avoid eye injury when you cut off excess lead lengths. Hold the leads so they cannot fly toward your eyes.

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

( ) ( ) R202, R102: 4700 Ω (yellow-violet-red).

( ) ( ) ZD204, ZD104: DO-7 zener diode (#56-50). Position the banded end as shown.

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

**CONTINUE**

( ) ( ) R215, R115: 390 Ω (orange-white-brown).

( ) ( ) R206, R106: 1000 Ω (brown-black-red).

( ) ( ) ZD208, ZD108: 1N716A zener diode (#56-57). Position the banded end as shown.

( ) ( ) D205, D105: 1N4002 diode (#57-65). Position the banded end as shown.

( ) ( ) R212, R112: 2000 Ω (red-black-red).

( ) ( ) 1" jumper wire.

( ) ( ) R214, R114: 10 kΩ (brown-black-orange).

( ) ( ) R211, R111: 2000 Ω (red-black-red).

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

( ) ( ) R218, R118: 33 kΩ (orange-orange-orange).

( ) ( ) R221, R121: 33 kΩ (orange-orange-orange).

( ) ( ) R219, R119: 2400 Ω (red-yellow-red).

( ) ( ) R222, R122: 62 kΩ (blue-red-orange).

( ) ( ) D210, D110: 1N4002 diode (#57-65). Position the banded end as shown.

( ) ( ) R204, R104: 820 Ω (gray-red-brown).

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

**FOR GOOD SOLDER CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN.**

**WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.**



**PICTORIAL 1-2**



**START** ▾

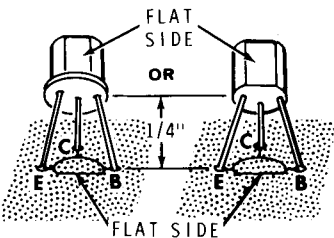
NOTE: When you install a precision resistor, bend the resistor leads so the value (in ohms or k ohms) is exposed when the resistor is installed.

(Q) (R) R209, R109: 1.1 Ω, 1-watt, wire-wound resistor.

(A) (R) R207, R107: 555 Ω, 1/4-watt, precision resistor.

NOTE: When you install transistors on this Pictorial, always be sure to match the flat on the transistor with the flat marked on the board.

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



(A) (Q) Q206, Q106: X29A829 transistor (#417-201).

(X) (A) Q202, Q102: X29A829 transistor (#417-201).

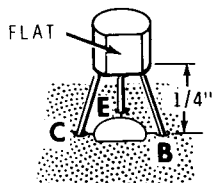
(A) (R) R223, R123: 12.2 kΩ, 1/2-watt, precision resistor.

(A) (R) R224, R124: 5000 (5K) Ω, 1/2-watt, precision resistor.

(A) (R) R213, R113: 1200 Ω (brown-red-red), 1-watt resistor.

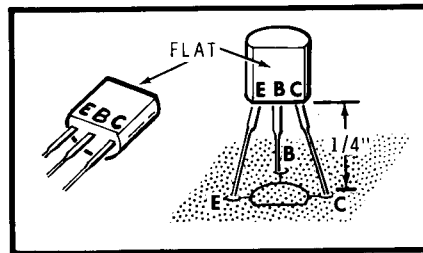
(A) Solder the leads to the foil and cut off the excess lead lengths.

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

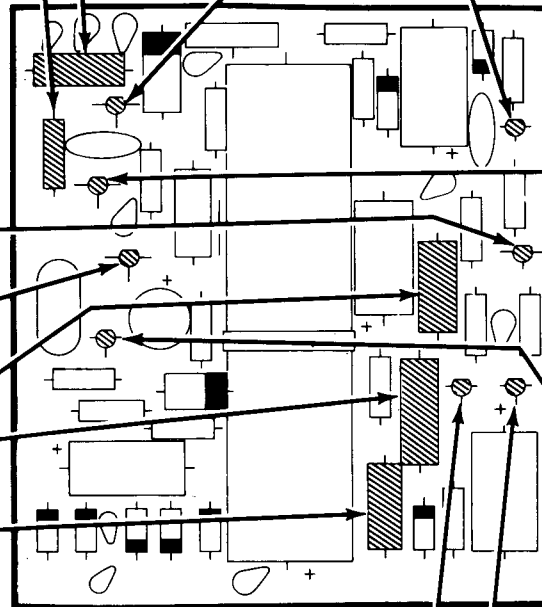


(Q) (R) Q207, Q107: TIS87 transistor (#417-258).

(A) (R) Q208, Q108: TIS87 transistor (#417-258).



**Detail 3-1A**



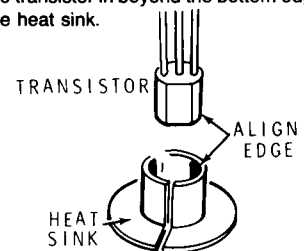
**CONTINUE** ▾

Install each of the following transistors as shown in Detail 3-1A. Solder each lead to the foil and cut off the excess lead lengths.

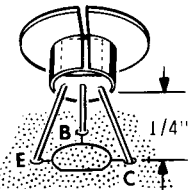
(Q) (A) Q204, Q104: MPSA20 transistor (#417-801).

(A) (R) Q205, Q105: MPSA20 transistor (#417-801).

NOTE: In the following step, install heat sinks on each transistor as shown. Place the heat sink on your work area as shown, and press the transistor into it. Do not press the transistor in beyond the bottom edge of the heat sink.



(A) (A) Q203, Q103: MPSA42 transistor (#417-294) with heat sink.



(A) (R) Q201, Q101: MPSA20 transistor (#417-801). See Detail 3-1A.

**PICTORIAL 1-3**

**START** ◀

⤵ ⤴) R205, R105: 1500 Ω, 1-watt (brown-green-red).

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

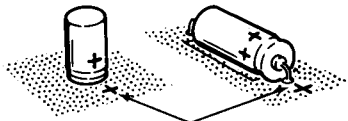


REMOVE COATING EVEN WITH BOTTOM OF CAPACITOR BODY

⤵ ⤴) C206, C106: 100 pF disc.

⤵ ⤴) C201, C101: .1 μF Mylar.

NOTE: When you install electrolytic capacitors, always position the positive (+) end as shown.



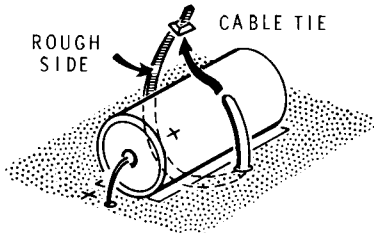
POSITIVE (+)  
END

⤵ ⤴) C202, C102: 50 μF vertical electrolytic (#25-116).

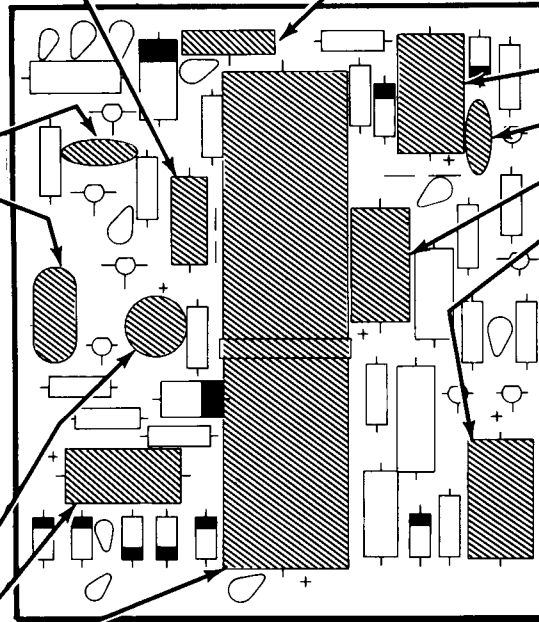
⤵ ⤴) C205, C105: 10 μF electrolytic.

⤵ ⤴) C203, C103: 2000 μF electrolytic.

⤵ ⤴) Pass a cable tie through the circuit board and around capacitors C203 and C103 as shown. Pull the tie tight and cut off the excess tie length.

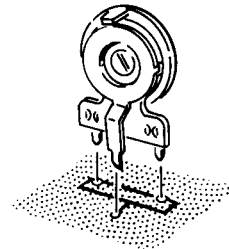


⤵ ⤴) Solder the leads to the foil and cut off the excess lead lengths.



**CONTINUE** ▶

⤵ ⤴) R216, R116: 500 Ω control. Solder the lugs to the foil.



⤵ ⤴) C204, C104: 50 μF electrolytic.

⤵ ⤴) C207, C107: .05 μF disc.

⤵ ⤴) C209, C109: 10 μF electrolytic.

⤵ ⤴) C208, C108: 50 μF electrolytic.

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

**CIRCUIT BOARD CHECKOUT**

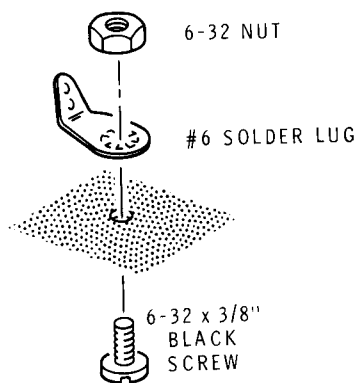
Carefully inspect the circuit board for the following conditions.

- ⤵ ⤴) Unsoldered connections.
- ⤵ ⤴) "Cold" solder connections.
- ⤵ ⤴) Solder bridges between foil patterns. See "Soldering" on Page 7.
- ⤵ ⤴) Protruding leads which could touch together.
- ⤵ ⤴) Transistors for the proper **type** and **installation**.
- ⤵ ⤴) Electrolytic capacitors for the correct position of the positive (+) end.
- ⤵ ⤴) Diodes for the correct position of the banded end.

Set the circuit board aside temporarily.

**PICTORIAL 1-4**

## CHASSIS ASSEMBLY



**Detail 2-1A**

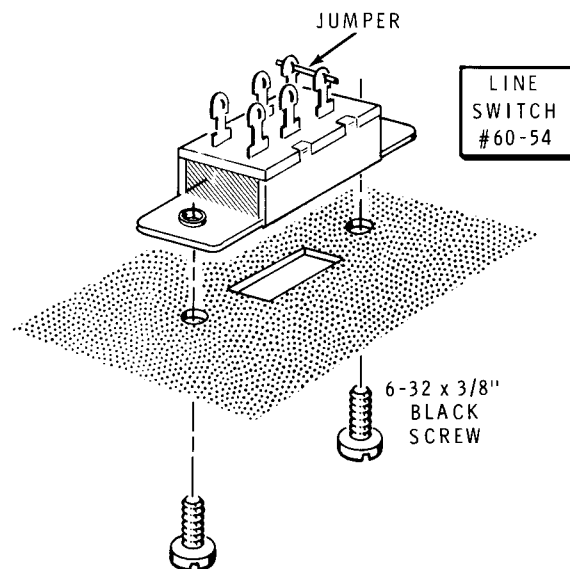
### PARTS MOUNTING

Refer to Pictorial 2-1 (in the "Illustration Booklet") for the following steps.

- (X) Temporarily turn the chassis bottom-side up. Refer to the inset drawing on the Pictorial and remove the backing paper from each of the four feet. Press the feet in place on each of the chassis corners as shown on the inset drawing.

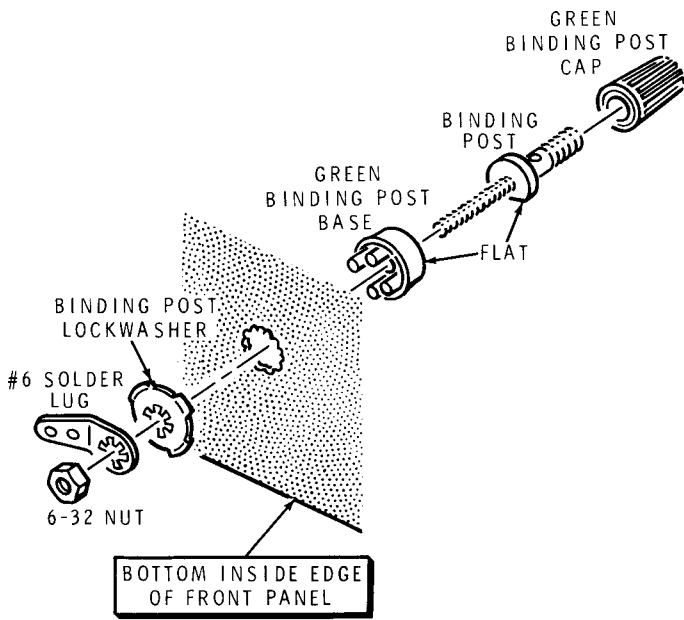
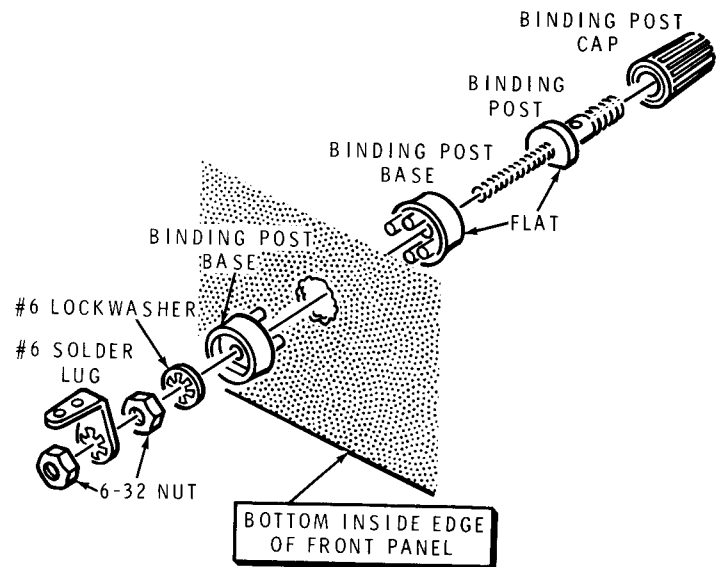
Position the chassis on your work area as shown in the Pictorial; then proceed with the following steps.

**NOTE:** When hardware is called for in a step, only the screw size will be given. For instance, if 6-32 x 3/8" hardware is called for, it means that you should use a 6-32 x 3/8" screw, one or more #6 lockwashers, and a 6-32 nut. The Pictorial or a Detail will show the proper number of lockwashers used. The Pictorial or a Detail will show the proper number of lockwashers used. The plastic nut starter can be used to pick up and start 6-32 and 4-40 nuts on screws.



**Detail 2-1B**

- ( ) Refer to Detail 2-1A and mount a #6 solder lug at A on the chassis. Use 6-32 x 3/8" black hardware; do **not** use a #6 lockwasher.
- ( ) SW2. Refer to Detail 2-1B and mount the line switch (#60-54) on the bottom of the chassis. Be sure to position wired switch lugs 3 and 6 as shown in the Pictorial. Use two 6-32 x 3/8" black screws.
- ( ) SW1, SW3. Similarly, mount slide switches (#60-2) at SW1 and SW3 on the front panel. Use two 6-32 x 3/8" black screws to secure each switch.


**Detail 2-1C**

**Detail 2-1D**

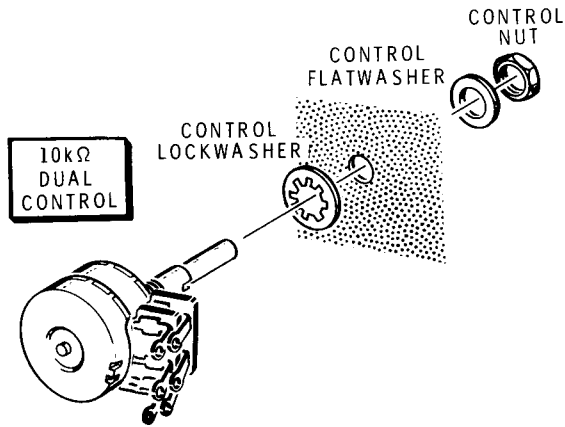
Refer to Detail 2-1C and mount a green binding post assembly at J1 on the front panel in the following four steps:

- (✓) 1. Place a green binding post base on the binding post in the manner shown. Be sure to match the flat on the base with the flat on the post.
- (✓) 2. Position the binding post and base into J1 on the front panel. Be sure the hole in the binding post is vertical.
- (✓) 3. Place the binding post lockwasher and a #6 solder lug on the binding post stud on the inside of the front panel; then secure the binding post with a 6-32 nut. Position the #6 solder lug as shown in the Pictorial.
- (✓) 4. Place a green binding post cap onto the front end of the binding post.

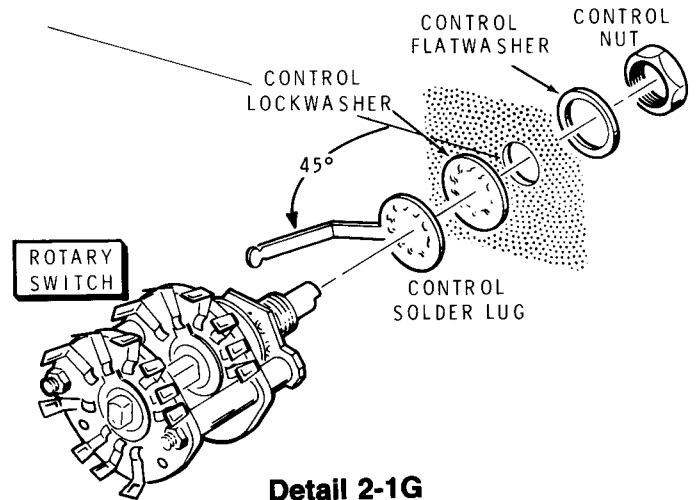
Refer to Detail 2-1D and mount a black binding post assembly on the front panel at J2 in the following six steps:

- (✓) 1. Place a black binding post base on a binding post as shown.

- (✓) 2. Position the binding post base into the front panel at J2. Be sure the hole in the binding post is vertical.
  - (✓) 3. Place a second black binding post base on the binding post stud inside the front panel. Turn the inner base back and forth slightly until the small bosses on the inner base are mated with the bosses on the outer base. The inner base must also be flush with the inside of the panel.
  - (✓) 4. Secure the binding post with a #6 lockwasher and a 6-32 nut.
  - (✓) 5. Place a #6 solder lug on the binding post stud and secure it with a 6-32 nut. Position the solder lug as shown in the Pictorial.
  - (✓) 6. Place a black cap on the binding post.
- (✓) In the same manner, mount **black** binding post assemblies at J4 and J6.
- (✓) In the same manner, mount three **red** binding post assemblies at J3, J5, and J7.



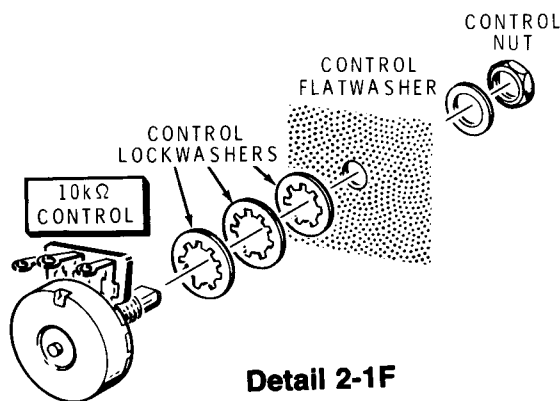
**Detail 2-1E**



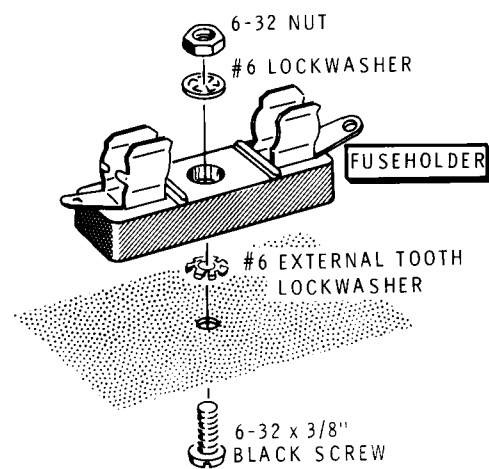
**Detail 2-1G**

- ⤴) R8/R9. Refer to Detail 2-1E and mount a dual 10 kΩ control (#12-156) at R8/R9 on the front panel with a control lockwasher, a control flat washer, and a control nut. Position the control lugs as shown in Pictorial 2-1.
- ⤴) R7 Refer to Detail 2-1F and mount a 10 kΩ control (#10-281) at R7 on the front panel. Use **three** control lockwashers, a control flat washer, and a control nut as shown. Position the control lugs as shown in the Pictorial.
- ⤴) SW4: Refer to Detail 2-1G and temporarily mount the rotary switch (#63-1257) at SW4 on the front panel. Use a control solder lug, a control lockwasher, a control flat washer, and a control nut. Position the switch and the solder lug on the inside of the panel as shown in the Pictorial. The control solder lug should be approximately 45 degrees down from a horizontal position, as shown.

- ⤴) F1: Refer to Detail 2-1H and mount the fuseholder at F-1 in the bottom of the chassis with 6-32 × 3/8" black hardware as shown. Position the fuseholder as shown in the Pictorial.
- ⤴) Locate the fuse label. In the blank spaces provided on this label write the fuse value, "1-1/2 A., 3 AG."
- ⤴) Remove the paper backing from the fuse label and press the label in place next to the fuseholder. **NOTE:** Do not cover any of the holes in the bottom of the chassis.

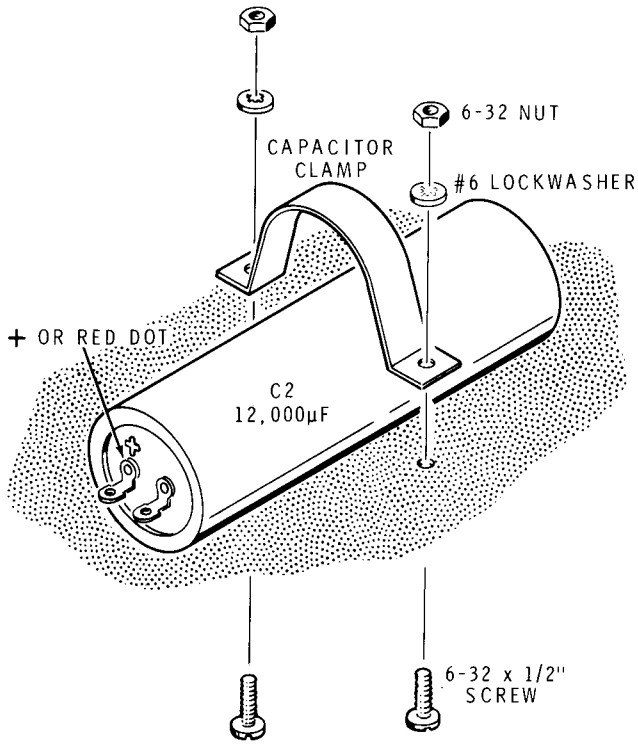


**Detail 2-1F**

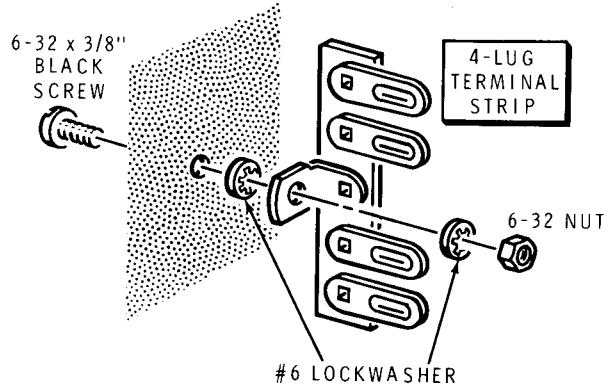


**Detail 2-1H**





**Detail 2-1J**



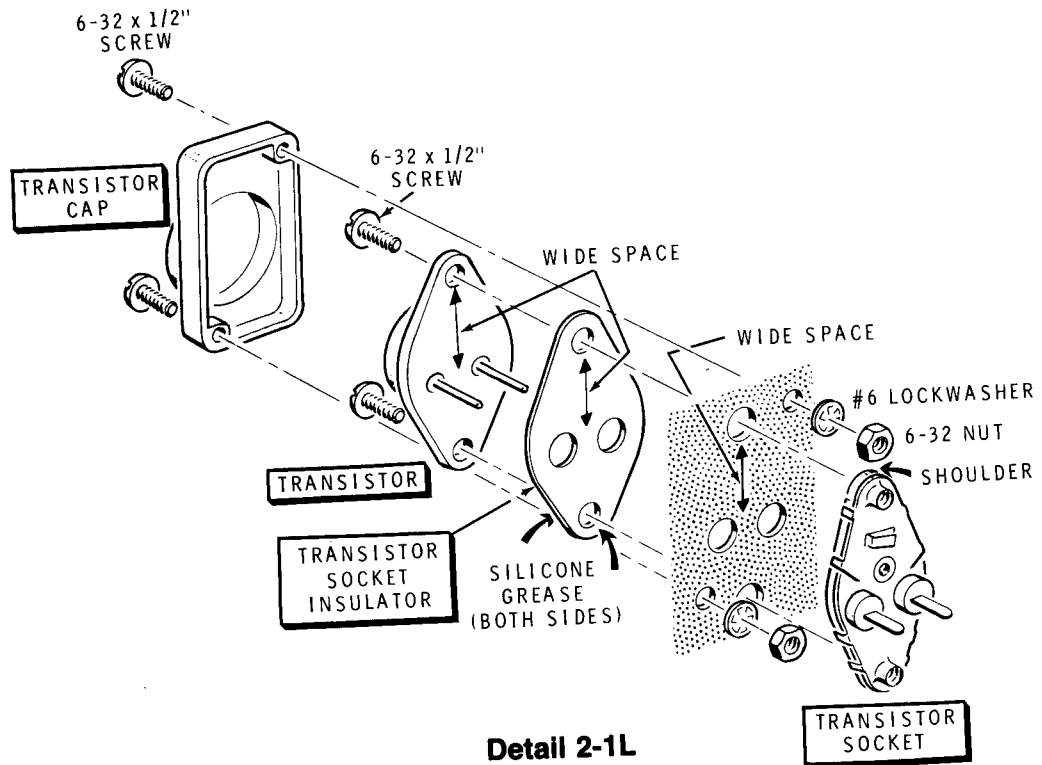
**Detail 2-1K**

Refer to Detail 2-1J and mount the 12,000  $\mu$ F electrolytic capacitor in the following four steps.

1. Locate the capacitor clamp. Form the clamp around the 12,000  $\mu$ F electrolytic capacitor as shown in the Detail.
2. Position the capacitor clamp in the chassis and loosely secure one end of the clamp at hole B with a 6-32  $\times$  1/2" screw, a #6 lockwasher, and a 6-32 nut.
3. C2: Position the 12,000  $\mu$ F electrolytic capacitor into the chassis bottom as shown in the Pictorial. Then secure the other end of the capacitor clamp at hole C with 6-32  $\times$  1/2" hardware as shown in the Detail.

NOTE: The positive lug of capacitor C2 may be marked with a plus ("+") mark or with a red dot.

4. Position the positive-marked lug (+ or dot) of capacitor C2 as shown in the Pictorial. Then slide the capacitor rearward so you have enough space between the front chassis panel and the body of the capacitor to work on the front panel mounted components. Tighten the clamp screws until you can just slide the capacitor with some difficulty.
- Refer to Detail 2-1K and mount a 4-lug terminal strip at TS1 on the rear panel. Use 6-32  $\times$  3/8" black hardware. Position the terminal strip as shown in the Pictorial.



Refer to Detail 2-1L for the next six steps.

1. Open the small container of silicone grease. Apply a small amount of this grease to both sides of a transistor insulator. Place this insulator on the rear of an MJ2841 transistor (#417-282). **IMPORTANT:** Be sure the wide space between the insulator holes matches the wide space on the transistor as shown in the Detail.
  2. Place a transistor socket against the inside of the rear panel at Q1. Be sure the socket hole spacing matches the holes in the rear panel, and that the shoulders on the socket are centered in the top and bottom holes of the panel. Then, position the prepared transistor and insulator against the outside of the rear panel and push the transistor pins into the pin-holes in the socket. Be sure that all holes and pins are correctly aligned.
  3. Q1. Secure the transistor to the rear panel with two 6-32 x 1/2" screws.
  4. Secure a transistor cap to the rear panel, over transistor Q1, with two sets of 6-32 x 1/2" hardware as shown in the Detail.
  5. Q2. In the same manner, prepare and install the remaining MJ2841 transistor (#417-282) and cap at Q2 in the rear panel.
  6. IC1. In the same manner as in the transistor installation steps, mount a UA309K integrated circuit (#442-30) and cap at IC1 on the rear panel.
- Make a mark 1" from the top of the chassis on the inside right front corner. Make another mark 1" down in the right rear corner of the chassis. Make a third mark 2-1/2" toward the rear from the front panel, close to the right side bottom flange.
- NOTE:** Be sure the circuit board mounts are as close as possible to the side flanges of the chassis as you position them in the following steps; once the mounts are pressed in place, they will be difficult to reposition.
- Remove the paper backing from a circuit board mount. Press the mount in place at F against the inside of the front panel, starting downward from the 1" mark you made in the previous step.
  - In the same manner, press a circuit board mount 1" down at D inside the right rear chassis corner.
  - Press a circuit board mount in the bottom of the chassis at E, from the 2-1/2" mark rearward.



## FRONT PANEL PREWIRING

Refer to Pictorial 2-2 in the "Illustration Booklet" for the following steps.

**NOTE:** To prepare a wire, as in the following step, cut the wire to the indicated length and remove 1/4" of insulation from each wire end. To further prepare stranded wire, tightly twist the bare wire ends and apply a small amount of solder to hold the strands together.

Prepare the following lengths of **solid** wire:

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

**NOTE:** In the following steps, (NS) means not to solder because other wires will be added later. "S-" with a number, such as (S-2), means to solder the connection. The number following the "S" tells how many wires are at the connection.

- (✓) Connect a 3-1/2" black wire from control R9 lug 4 (S-1) to J6 (NS). Route the wire around switch SW3 as shown.
- (✓) Connect a 1-1/2" black wire from control R8 lug 1 (S-1) to control R7 lug 1 (NS).
- (✓) Connect a 4-1/2" black wire from control R7 lug 1 (S-2) to J4 (NS). Route this wire against the front panel as shown.
- (✓) Connect a 4" black wire from binding post J1 (NS) to the control solder lug at switch SW4 (NS).

**NOTE:** When you are instructed to connect wires or component leads to rotary switch SW4, as in the following step, "lug 2F" means lug 2 on the top of the switch **front** wafer. "Lug 2R" would designate the same position on the **rear** switch wafer. Lugs are numbered counterclockwise starting at the right wafer stud as viewed from the rear. All lug positions are counted, from 1 to 12, even though there are open spaces on the wafer. Note that on the front wafer, lugs 8F through 12F are missing, and that lug 7F is just under the left wafer stud.

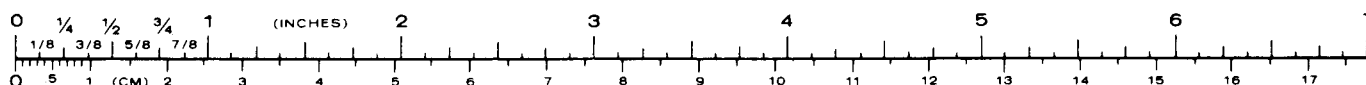
- (✓) Connect a 3" black wire from binding post J2 (NS) to switch SW4 lug 2F (S-1). Route the wire as shown.
- (✓) Connect a 2-1/4" red wire from control R7 lug 2 (S-1) to switch SW3 lug 3 (S-1).

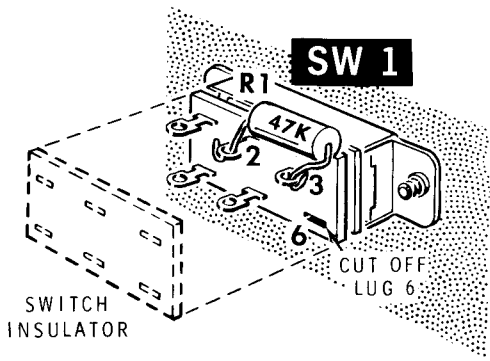
(✓) Connect a 2-1/2" red wire from control R7 lug 3 (S-1) to switch SW3 lug 6 (S-1).

Prepare the following lengths of **solid** wire:

2" red            6-1/2" black  
 2" red            5-1/4" red  
 2-1/2" red

- (✓) Connect a 2" red wire from control R8 lug 2 (S-1) to switch SW3 lug 1 (S-1).
- (✓) Connect a 2" red wire from control R8 lug 3 (S-1) to switch SW3 lug 4 (S-1).
- (✓) Connect a 2-1/2" red wire from binding post J3 (NS) to switch SW4 lug 11R (NS).
- (✓) Connect one end of a 6-1/2" black wire to switch SW4 lug 7F (S-1). The free end will be connected later.
- (✓) Connect one end of a 5-1/4" red wire to switch SW4 lug 7R (S-1). The free end will be connected later.
- (✓) Cut the leads of a .01  $\mu$ F disc capacitor to 3/4".
- (✓) C5. Connect this prepared .01  $\mu$ F disc capacitor from binding post J2 (NS) to binding post J1 (S-2). Use enough heat and solder to assure a good connection.
- (✓) Cut the leads of another .01  $\mu$ F disc capacitor to 1".
- (✓) Cut one 3/4" length and two 1" lengths of small sleeving.
- (✓) C6. Place a 3/4" length of sleeving on one lead of the prepared .01  $\mu$ F disc capacitor. Connect this lead to binding post J4 (NS). Connect the other capacitor lead to the control solder lug at SW4 (NS). Position this capacitor against the inside of the front panel.
- (✓) C7. Place 1" lengths of sleeving on the leads of a .01  $\mu$ F disc capacitor. Connect the capacitor leads to binding post J6 (NS) and to the control solder lug at SW4 (S-3). Position this capacitor against the inside of the front panel.
- (✓) Cut the leads of a .2  $\mu$ F disc capacitor to 1/2".
- (✓) C4. Connect the prepared .2  $\mu$ F disc capacitor from binding post J2 (NS) to binding post J3 (NS). Position the capacitor as shown in the Pictorial.





**Detail 2-2A**

Refer to Detail 2-2A and prepare slide switch SW1 in the following four steps.

- ( ) 1. Place a switch insulator onto the lugs of slide switch SW1.
- ( ) 2. With diagonal cutters, cut lug 6 from slide switch SW1.
- ( ) 3. Cut the leads of a 47 kΩ resistor (yellow-violet-orange) to 1/2".
- ( ) 4. R1. Connect the leads of the prepared resistor between switch SW1 lugs 2 (S-1) and 3 (NS) as shown in the Detail.
- ( ) Cut two 1-1/2" lengths of small sleeving.
- ( ) Refer to Detail 2-2B and mount a red lens on the front panel at PL1. Use a push-on nut and press the nut firmly against the inside of the front panel with a screwdriver blade.

( ) PL1. Place the prepared sleeving on the leads of the neon lamp. Then push the body of the lamp all the way into the red lens at PL1. Connect either of the lamp leads to switch SW1 lug 3 (S-2) and the other lead to SW1 lug 5 (NS). NOTE: Be careful not to cross the lamp leads.

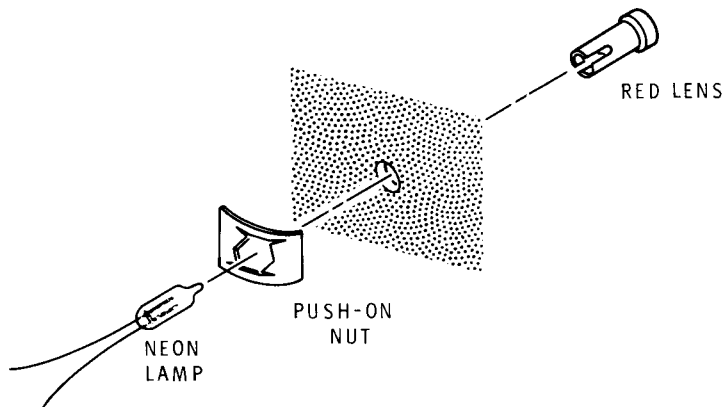
( ) Prepare the following lengths of stranded wire:

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

Refer to Pictorial 2-3 (in the "Illustration Booklet") for the following three steps.

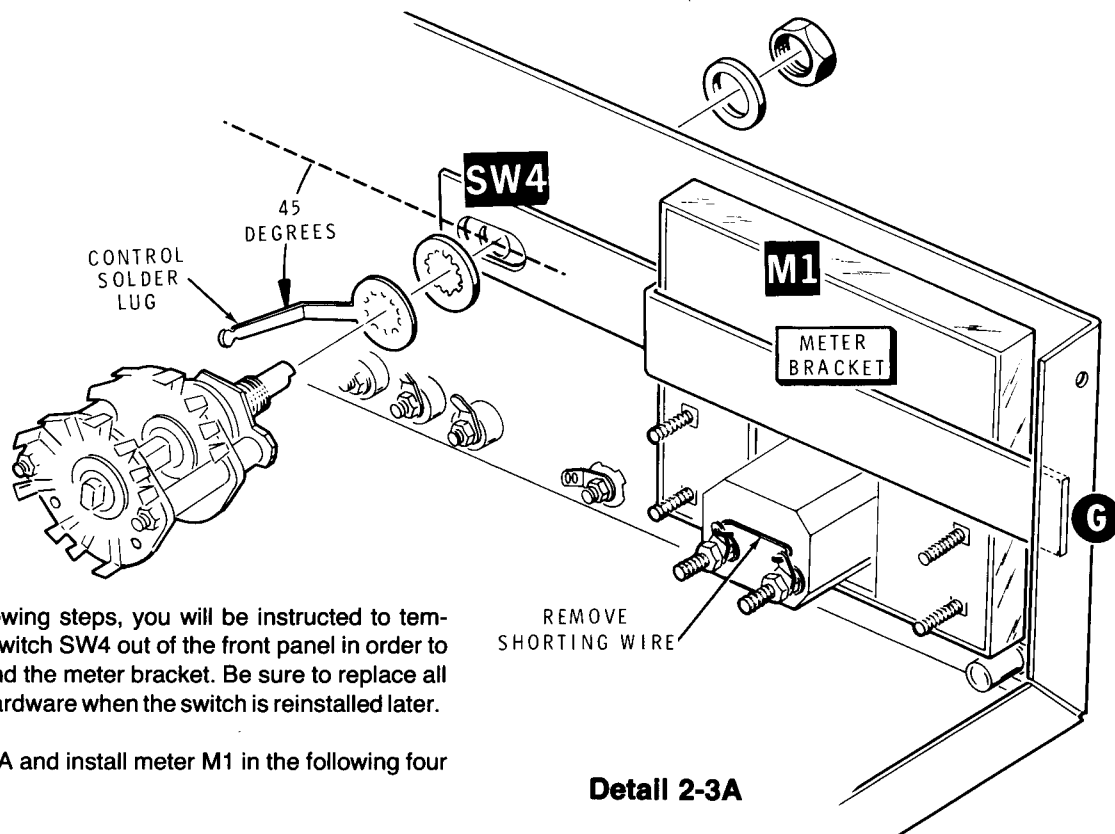
**IMPORTANT:** When you connect the stranded wires in the following steps, be sure to wrap each wire end securely around the designated lug to assure a good mechanical connection. **DO NOT ALLOW ANY LOOSE STRANDS TO TOUCH THE CHASSIS OR ANY OTHER SWITCH LUGS.**

- ( ) 1. Connect one end of a 5" black stranded wire to switch SW1 lug 5 (S-2). The free end will be connected later.
- ( ) 2. Connect a 6-1/2" black stranded wire from switch SW1 lug 4 (S-1) to fuseholder F1 lug 1 (S-1). Route the wire as shown in Pictorial 2-3.
- ( ) 3. Connect one end of a 5" black stranded wire to switch SW1 lug 1 (S-1). The free end will be connected later.



**Detail 2-2B**





NOTE: In the following steps, you will be instructed to temporarily lift rotary switch SW4 out of the front panel in order to install meter M1 and the meter bracket. Be sure to replace all the meter switch hardware when the switch is reinstalled later.

Refer to Detail 2-3A and install meter M1 in the following four steps.

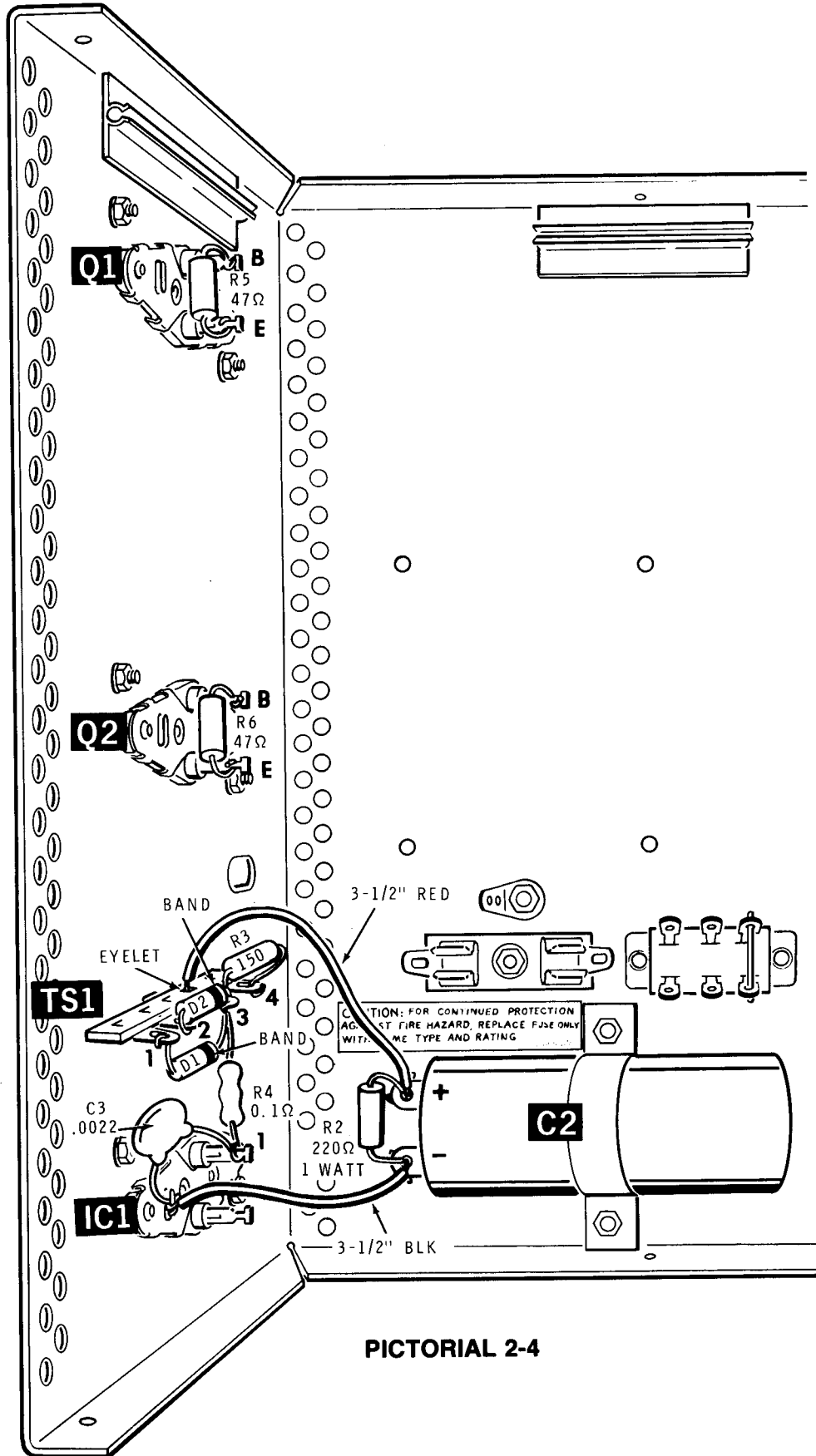
- (1) 1. Temporarily remove the hardware holding rotary switch SW4 out of the front panel. Carefully move the switch down and away from its mounting hole.

NOTE: As you mount meter M1 in the following step, it may be necessary to reposition large capacitor C2 and the 47 kΩ resistor on switch SW1.

- (2) 2. M1. Mount the meter into the meter opening in the front panel. Be sure the meter is pushed all the way into the cutout space. Fit the tip of the meter bracket as far as possible into slot G in the side flange of the chassis.
  - (3) 3. Secure the other end of the meter bracket with the shaft of rotary switch SW4. Be sure both the control lockwasher and the control solder lug are on the switch shaft. Position SW4 as shown and secure the switch to the front panel with the hardware previously removed. Be sure to position the control solder lug downward at 45 degrees as shown.
  - (4) 4. If there is a shorting wire between the meter lugs, remove and discard the wire.
- (5) Check to be sure the meter lug hardware is tight.
- (6) Connect the free end of the red wire coming from switch SW4 lug 7R to the positive (+) meter lug as shown in the Pictorial (S-1). Position the wire as shown.

**Detail 2-3A**

- (7) Connect the free end of the black wire coming from SW4 lug 7F to the negative (-) meter lug (S-1). Position the wire as shown.
- (8) Cut two 1" lengths of solid red wire; then remove all the insulation from both wires. These bare wires will be used in the next two steps.
- (9) Connect a 1" bare wire between switch SW4 lugs 6F (NS) and 5R (S-1).
- (10) Connect a 1" bare wire between switch SW4 lugs 4F (NS) and 3R (S-1).
- (11) Cut the leads of a 5490Ω (5.49K) precision resistor to 1/2".
- (12) R12. Connect the leads of the 5490Ω resistor to switch SW4 lugs 11R (S-2) and 2R (S-1).
- (13) Cut the leads of a 19.95 kΩ precision resistor to 3/4".
- (14) R11. Connect the leads of the resistor to switch SW4 lugs 10R (NS) and 4R (S-1).
- (15) Cut the leads of another 19.95 kΩ precision resistor to 1/2".
- (16) R13: Connect the leads of this resistor to switch SW4 lugs 9R (NS) and 6R (S-1). NOTE: Be sure the connection to switch lug 6R does not come in contact with the nearby switch wafer stud.



PICTORIAL 2-4

## REAR PANEL PREWIRING

Refer to Pictorial 2-4 for the following steps.

- ( ) Cut the leads of a .0022  $\mu$ F disc capacitor to 1/2".

NOTE: When you connect wires or component leads to the transistor and IC socket lugs in the following steps, crimp the wires and leads as near the ends of the lugs as possible. When you solder, use the solder sparingly to avoid bonding the transistor pins to the socket lugs.

- (✓) C3. Connect the leads of the .0022  $\mu$ F disc capacitor between IC1 lugs 1 (NS) and C (case) (NS).

- ( ) Cut the leads of a 150 $\Omega$  precision resistor to 1/2".

- (✓) R3. Connect the resistor between terminal strip TS1 lugs 3 (NS) and 4 (NS).

- (✓) Cut the leads of a 0.1  $\Omega$ , 1/2-watt, wire-wound resistor to 1/2".

- ( ) R4. Connect the leads of the resistor to terminal strip TS1 lug 3 (NS) and to IC1 lug 1 (NS).

- (✓) Cut the leads of a 3A1 diode (#57-42) to 3/4".

- (✓) D2. Connect the lead on the banded end of the prepared diode to terminal strip TS1 lug 3 (NS). Connect the other diode lead to TS1 lug 2 (S-1).

- (✓) Cut the leads of another 3A1 diode to 1".

- (✓) D1. Connect the lead on the banded end of the diode to terminal strip TS1 lug 3 (S-4). Connect the other diode lead to TS1 lug 1 (S-1).

- ( ) Cut the leads of two 47 $\Omega$  resistors (yellow-violet-black) to 3/4".

- (✓) R5. Connect one of the prepared resistors between transistor Q1 base (B) (NS) and emitter (E) (NS) lugs.

- (✓) R6. Connect the other prepared 47  $\Omega$  resistor between transistor Q2 base (B) (NS) and emitter (E) (NS) lugs.

- (✓) Cut both leads of a 220  $\Omega$  (red-red-brown), 1-watt resistor to 3/4".

- (✓) R2. Connect the leads of the prepared resistor between the positive (+) lug (NS) and the negative (-) lug (NS) of capacitor C2 as shown.

- ( ) Prepare the following lengths of stranded wire:

3-1/2" black

3-1/2" red

- (✓) Connect a 3-1/2" stranded black wire from the negative (-) lug of capacitor C2 (NS) to the case (C) (NS) connector on IC1.

NOTE: In the following steps, you will be instructed to connect wires to the terminal strip "eyelets." To do this, pass the free end of the wire through the open hole in the lower part of the terminal strip lug. Then solder the wire to the eyelet and cut off the excess wire end.

- (✓) Connect the 3-1/2" red stranded wire from capacitor C2 positive (+) lug (S-2) to terminal strip TS1 lug 3 eyelet (S-1).

## WIRE HARNESS INSTALLATION

Refer to Pictorial 3-1 (in the "Illustration Booklet") for the following steps.

- (✓) Refer to Detail 3-1A (in the "Illustration Booklet") and form the wire harness on your work area as shown.

NOTE: Each group of wires that emerges from the wire harness is called a "breakout" and each has a number as shown in Detail 3-1A. During the assembly steps the harness breakouts will be called out as BO#1, BO#2, and so on, through BO#7.

- ( ) Position the wire harness into the chassis as shown in the Pictorial with BO#1 near the left rear corner. Form the harness toward the right, across the right side, and then across the front of the chassis. Position the harness down against the bottom of the chassis wherever possible.

NOTE: In the following steps, use solder sparingly to avoid soldering transistor and IC pins to their socket lugs.

Connect the wires coming from BO#1 in the following steps.

- (✓) Blue wire to IC1 lug 1 (S-3).

- (✓) Black wire to the case (C) lug of IC1 (S-3).

- (✓) Red wire to IC1 lug 2 (S-1).

- ( ) Violet wire to terminal strip TS1 lug 4 (S-2).

Connect the wires coming from BO#2 in the following steps.

- (✓) Yellow wire to the base (B) lug of transistor Q2 (S-2).

- (✓) Orange wire to the emitter (E) lug of transistor Q2 (S-2).

- (✓) Blue wire to the collector (C) lug of transistor Q2 (S-1).

- ( ) Violet wire to the base (B) lug of transistor Q1 (S-2).

- (✓) Red wire to the emitter (E) lug of transistor Q1 (S-2).

- ( ) Gray wire to the collector (C) lug of transistor Q1 (S-1).



NOTE: The wires from harness breakouts BO#3 and BO#4 will be connected later.

Connect the wires coming from BO#5 in the following steps.

- (↘) Three orange wires to binding post J7 (S-3).
- (↘) Two brown wires to binding post J6 (S-4).
- (↘) Blue wire to SW3 lug 5 (S-1).
- (↘) Green wire to SW3 lug 2 (S-1).

NOTE: Route the following two wires around switch SW3 as shown in the Pictorial.

- (↘) Violet wire to control R9 lug 6 (S-1).
- (↘) Red wire to control R9 lug 5 (S-1).

Connect the wires coming from BO#6 in the following steps.

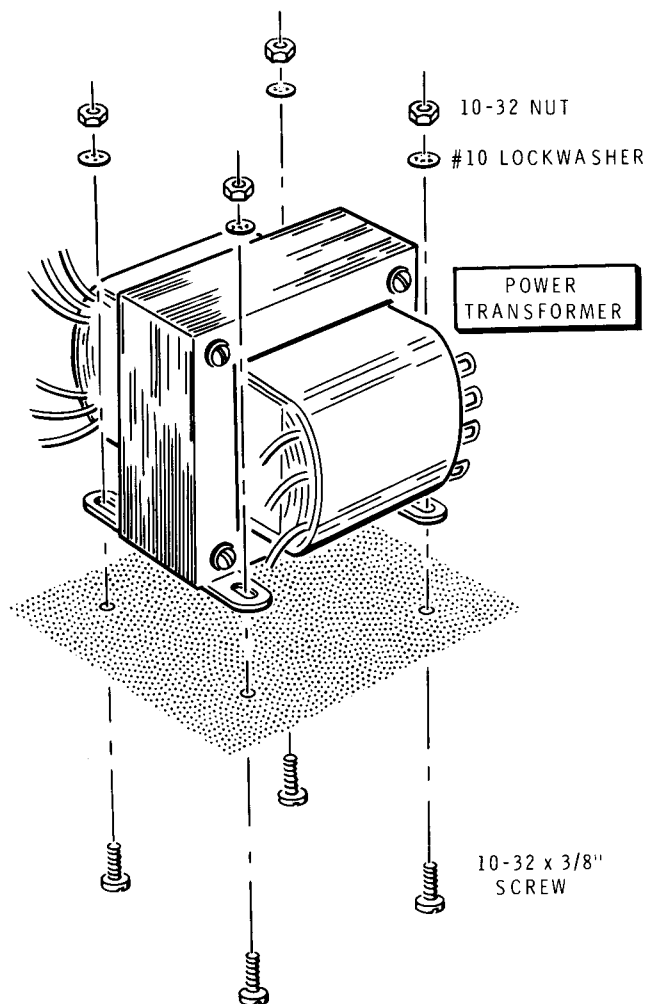
- (↘) Three red wires to binding post J5 (S-3).
- (↘) Two black wires to binding post J4 (S-4).

Connect the wires coming from BO#7 in the following steps.

- (↘) Heavy red wire to binding post J3 (S-3).
- (↘) Heavy black wire to binding post J2 (S-4).
- (↘) Recheck the wiring to all seven front panel binding posts. Grasp each wire with pliers and try to move it. If necessary, reheat the post solder lug and add more solder to assure a good connection.

Connect the remaining wires coming from BO#7 to the indicated lugs of rotary switch SW4 in the following steps.

- (↘) Black wire to lug 6F (S-2).
- (↘) Yellow wire to lug 5F (S-1).
- (↘) Brown wire to lug 4F (S-2).
- (↘) Green wire to lug 3F (S-1).
- (↘) Blue wire to lug 1F (S-1).
- (↘) Red wire to lug 9R (S-2).
- (↘) Orange wire to lug 10R (S-2).
- (↘) Violet wire to lug 1R (S-1).



Detail 4-1A

## POWER TRANSFORMER INSTALLATION

Refer to Pictorial 4-1 (in the "Illustration Booklet") for the following steps.

- (↘) T1. Refer to Detail 4-1A and mount the power transformer into the chassis as shown. Use 10-32 x 3/8" hardware. Tighten the mounting hardware very securely. Be sure not to pinch any wires under the transformer.

Connect the wires coming from transformer T1 in the following steps.

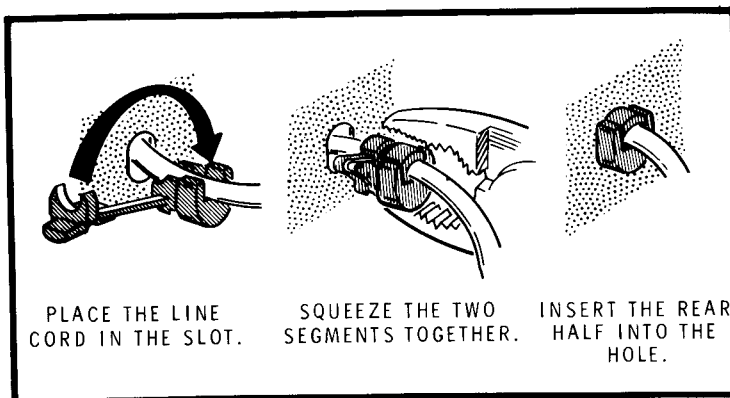
- (↘) Green-yellow wire to the negative (-) lug of capacitor C2 (S-3).
- (↘) Either green wire to terminal strip TS1 lug 2 eyelet (S-1).
- (↘) The other green lead to terminal strip TS1 lug 1 eyelet (S-1).



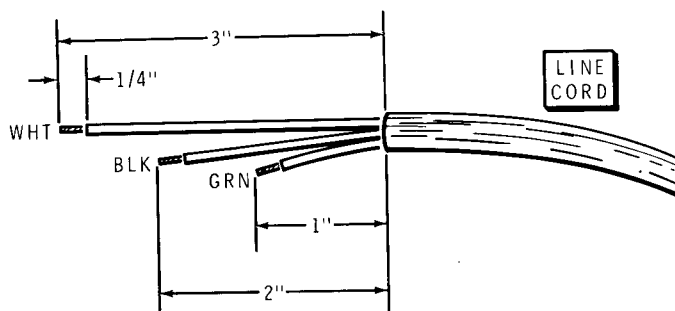


NOTE: The remaining power transformer wires will be connected later. As you connect all of the remaining wires in this Pictorial, securely wrap each wire end around its designated connection to assure a good mechanical connection.

- (✓) Connect the black stranded wire coming from power switch SW1 lug 5 to transformer T1 lug 1 (NS).
- (✓) Connect the black stranded wire coming from switch SW1 lug 1 to transformer T1 lug 2 (NS).
- ( ) Locate the 1-1/2 ampere fuse. Push it into the clips of fuseholder F1.



Detail 4-1C



Detail 4-1B

Refer to Detail 4-1B and prepare the end of the line cord in the following four steps:

- (✓) 1. Separate the ends of the line cord 3".
- ( ) 2. Cut 1" from the end of the black line cord lead.
- (✓) 3. Cut 2" from the end of the green line cord lead.
- ( ) 4. Remove 1/4" of insulation from the ends of the cut leads. Then tightly twist the ends of all three leads, and add solder to each lead end to hold the small strands together.

- ( ) Pass the prepared end of the line cord through rear panel opening G. Connect the ends of the line cord leads as shown in the Pictorial and as follows:

Green lead to solder lug A (S-1).

Black lead to fuseholder F1 lug 2 (NS).

White lead to transformer T1 lug 4 (NS).

- (✓) Refer to Detail 4-1C and place a line cord strain relief on the line cord close to the rear panel. Hold the strain relief tightly squeezed together with pliers for a few seconds; then push the strain relief into opening G.
- (✓) Cut two 3/4" lengths of sleeving.
- (✓) Cut the leads of a .005  $\mu$ F disc capacitor to 1". Place a 3/4" length of sleeving on each lead of this capacitor.
- (✓) C1. Connect one lead of the prepared .005  $\mu$ F disc capacitor to fuseholder F1 lug 2 (S-2). Connect the other capacitor lead to transformer T1 lug 4 (NS).

- (✓) Prepare the following lengths of black stranded wire:

2-1/2"     3"

4-1/2"     4"

- (✓) Connect a 2-1/2" black stranded wire from switch SW2 lug 4 (S-1) to transformer T1 lug 4 (S-3). NOTE: Be sure all three leads on lug 4 of the transformer are securely soldered. If necessary, reheat the connection and add more solder to it.
- (✓) Connect a 4-1/2" black stranded wire from switch SW2 lug 2 (S-1) to T1 lug 3 (S-1).
- (✓) Connect a 3" black stranded wire from SW2 lug 5 (S-1) to T1 lug 2 (S-2).
- (✓) Connect a 4" black stranded wire from SW2 lug 1 (S-1) to T1 lug 1 (S-2).



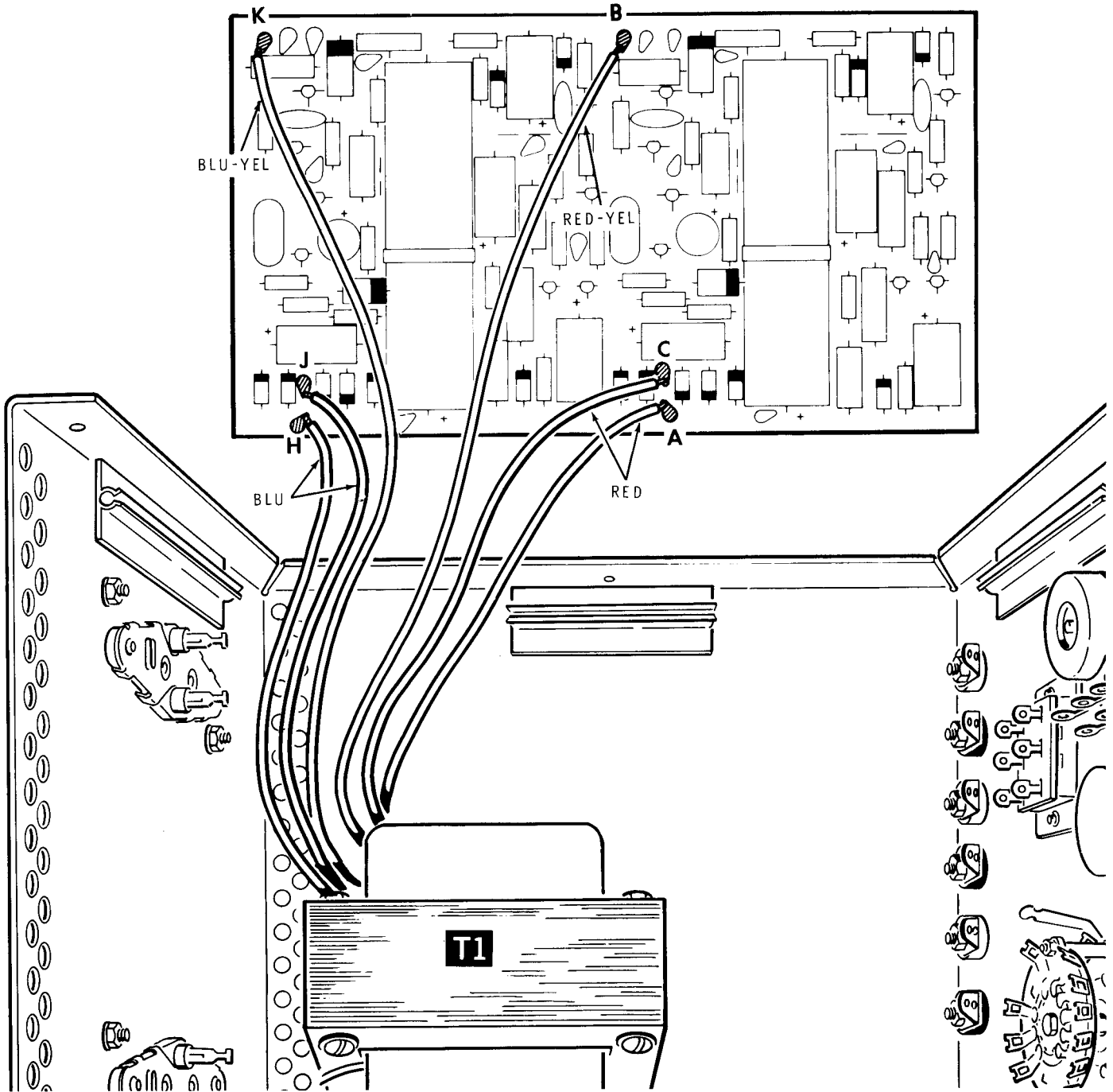
### CIRCUIT BOARD FINAL WIRING

Refer to Pictorial 5-1 for the following steps.

NOTE: In the following steps, connect the transformer leads to the circuit board. Solder each lead to the foil as you connect it and cut off the excess lead length.

- (2) Position the circuit board just to the end of the chassis as shown in the Pictorial.

- (3) Either blue lead to H.
- (4) Other blue lead to J.



PICTORIAL 5-1

- ( ) Either red lead to A.
- ( ) Other red lead to C.
- ( ) Blue-yellow lead to K.
- ( ) Red-yellow lead to B.

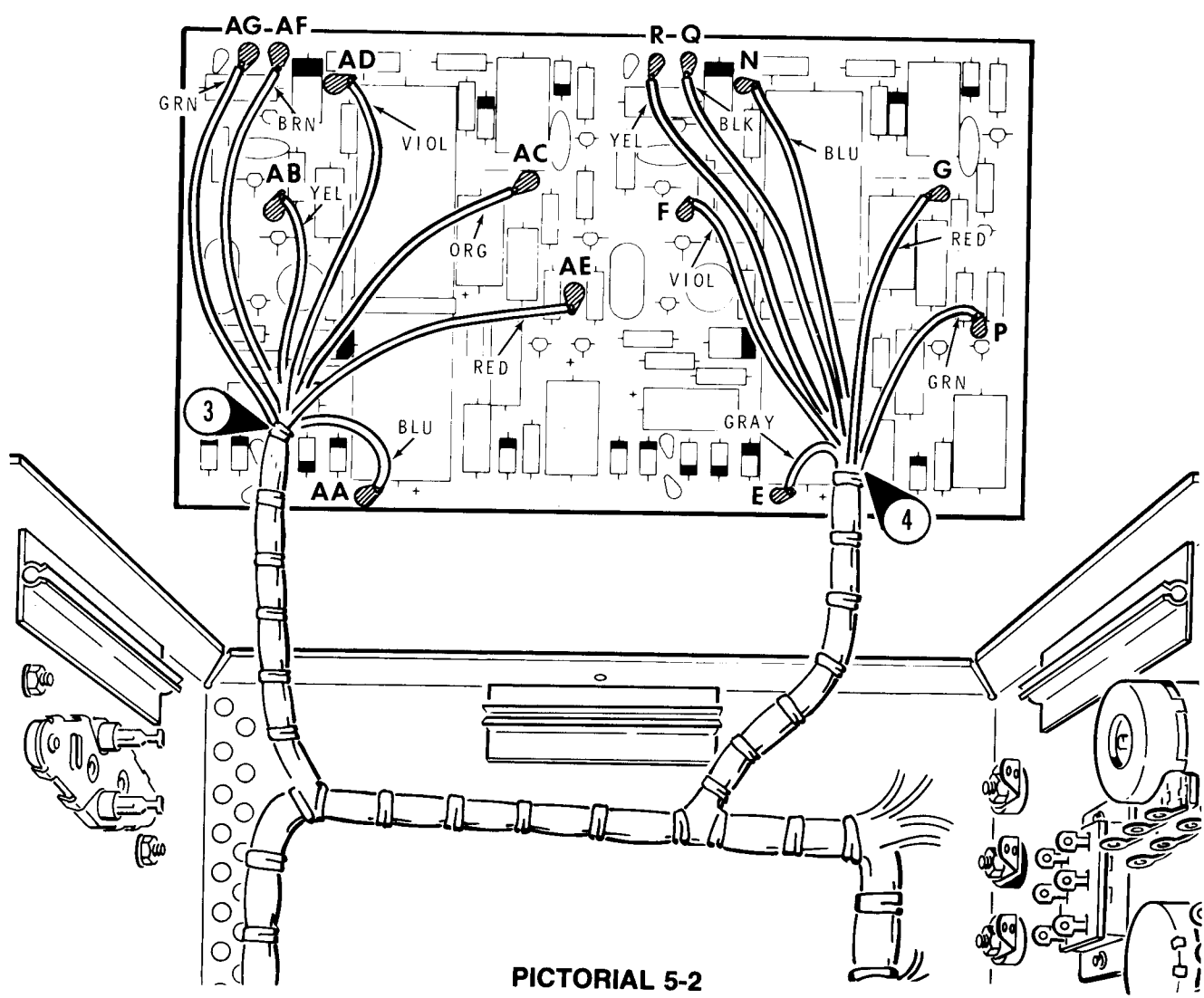
- (✓) Red wire to AE.
- (✓) Orange wire to AC.

Connect the wires coming from harness BO#4 to the circuit board in the following steps.

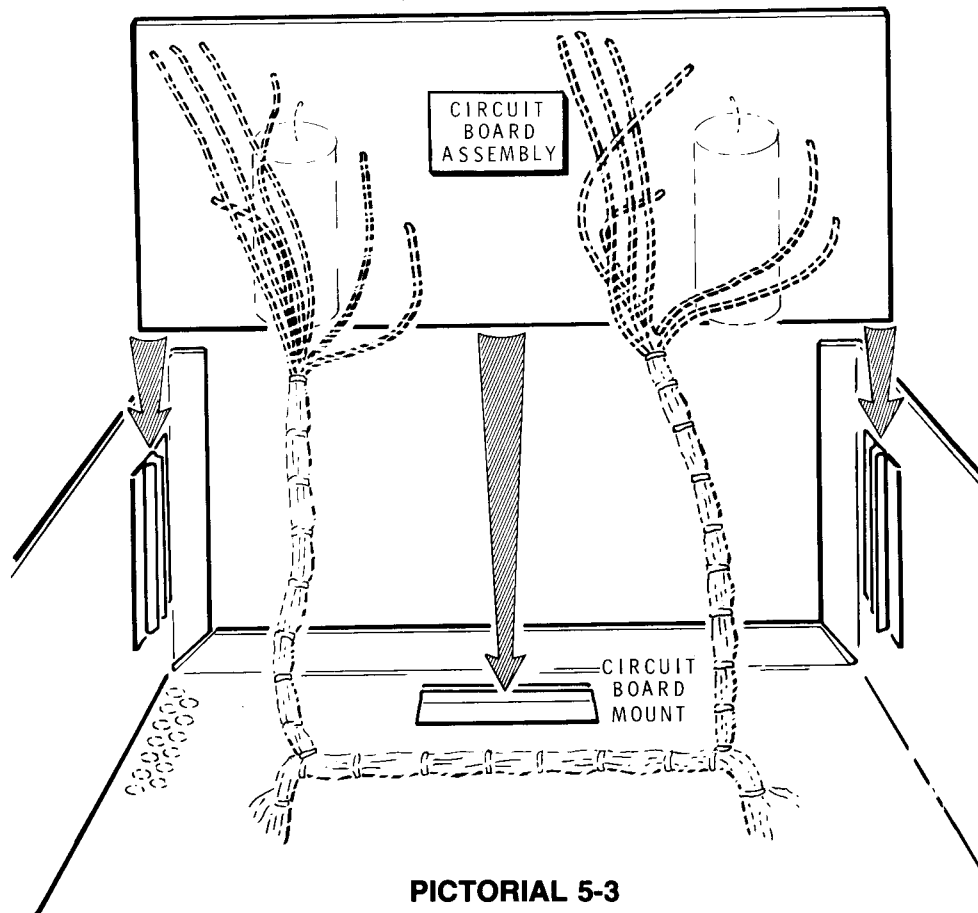
Refer to Pictorial 5-2 and connect the wires coming from harness BO#3 to the circuit board in the following steps.

- ( ) Blue wire to AA.
- ( ) Yellow wire to AB.
- ( ) Green wire to AG.
- (✓) Brown wire to AF.
- (✓) Violet wire to AD.

- (✓) Gray wire to E.
- (✓) Yellow wire to R.
- (✓) Black wire to Q.
- (✓) Blue wire to N.
- (✓) Red wire to G.
- (✓) Violet wire to F.
- (✓) Green wire to P.



PICTORIAL 5-2



PICTORIAL 5-3

- ( ) Refer to Pictorial 5-3 and lift the circuit board assembly and position it vertically downward into the front and rear circuit board mounts as shown. Be sure all wires and cables are out from under the bottom edge of the board; then press the bottom edge firmly into the bottom circuit board mount.

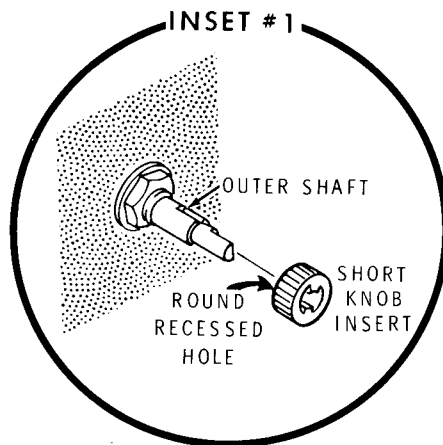
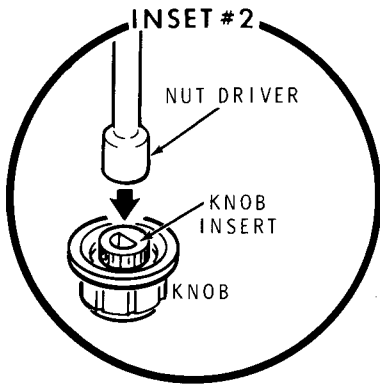
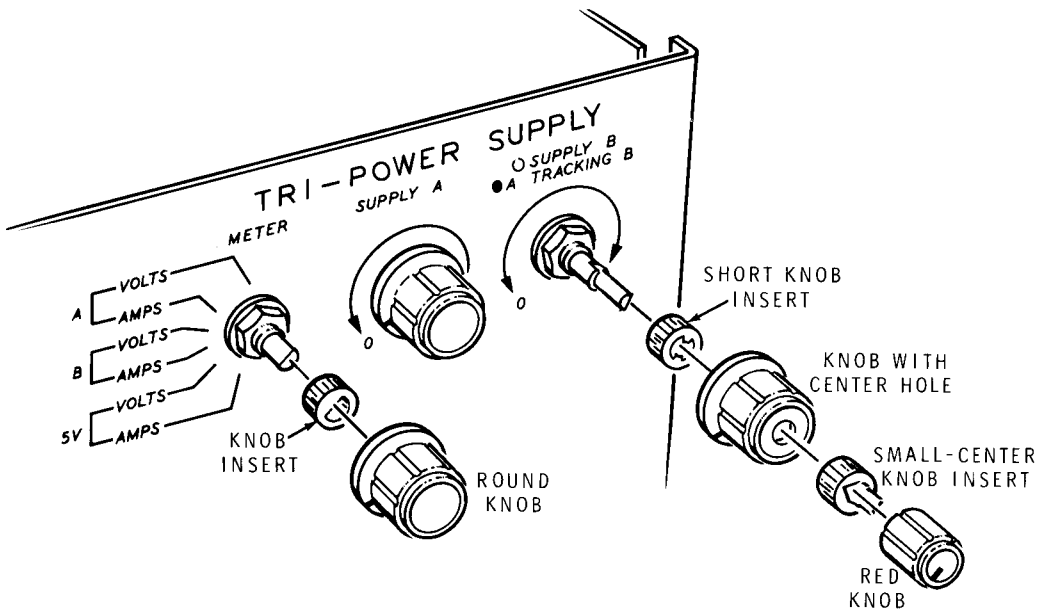
### KNOB INSTALLATION

Refer to Pictorial 6-1 for the following steps.

- ( ) Place large-center knob inserts on the METER switch and the SUPPLY A control shafts. Place a short knob insert on the outer knob shaft at ○ SUPPLY B as shown on Inset #1 on the Pictorial.
- ( ) Turn each of the front panel control and switch shafts fully counterclockwise. NOTE: The control at R8/R9 labeled "○ SUPPLY B" and "● A TRACKING B" has an inner shaft and an outer shaft. Be sure both are fully counterclockwise. NOTE: If necessary, turn the inner shaft with pliers.

NOTE: In the following steps, make sure the knob pointers are correctly positioned before you push the knobs firmly onto the inserts.

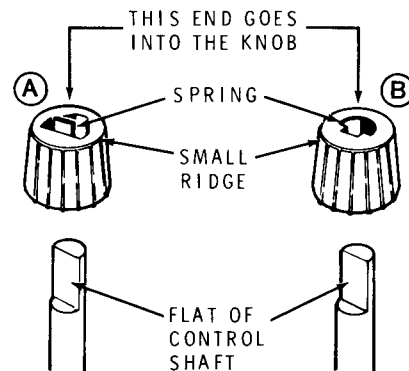
- ( ) Position a round knob (without the center hole) onto the shaft of the Meter switch. Position the knob pointer so it is in line with the "5V AMPS" indicator at approximately the 7 o'clock position.
- ( ) After you are sure the knob pointer is correctly positioned, push the knob further onto the insert. Then, remove both the knob and its insert from the shaft and tap the insert fully into the knob as shown in Inset #2 on the Pictorial. Replace the knob onto the Meter switch shaft.
- ( ) In the same manner, mount the other round knob (without a hole) onto the "Supply A" control shaft. Align the pointer with the "0" near the 7 o'clock position.
- ( ) Similarly, position a round knob (with center hole) onto the outer shaft knob insert at the "○ Supply B" control. Align the pointer on the knob with the "0" at the 7 o'clock position and press the knob onto the insert. As before, remove the knob and insert, tap the insert into the knob, and then replace the knob on the shaft. NOTE: This knob may be placed on the shaft 180 degrees from its proper position; be sure the pointer is correctly placed at the 7 o'clock "0" location.



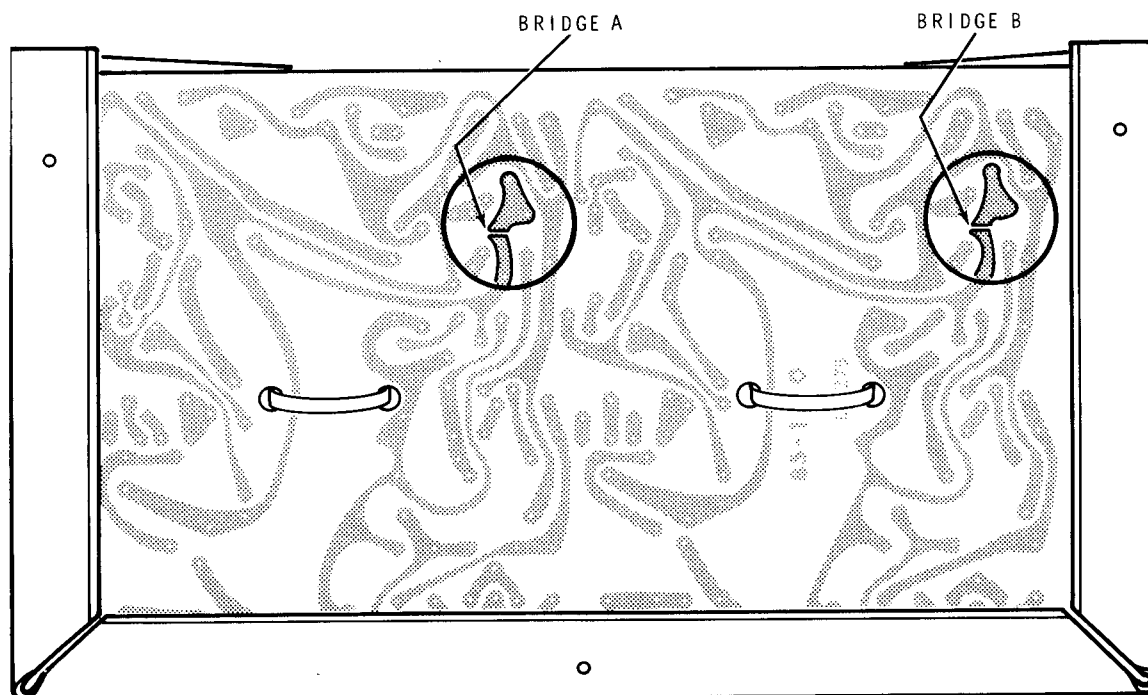
PICTORIAL 6-1

- ( ) Refer to Detail 6-1A and notice the the knob insert is tapered. When you place one of these inserts on a shaft, be sure the smaller (tapered) end faces out or the knob will not slide onto the insert. If you are not sure which end is smaller, roll the insert across a flat surface; the insert will gradually turn toward the smaller end.
- ( ) Place a small-center knob insert on the inner "• A Tracking B" control shaft. Align the pointer on the small red knob with the pointer on the black knob previously installed. As before, remove the knob, tap the insert into the knob, and then replace the knob on its shaft.

NOTE: KNOB #455-52 MAY LOOK LIKE A OR B BELOW. MUST GO ON SHAFT AS SHOWN.



Detail 6-1A



**PICTORIAL 6-2**

Refer to Pictorial 6-2 for the following steps.

- (1) Set the Power Supply on its left side so the foil side of the circuit board is up.
- (2) Refer to the inset drawing on the Pictorial and locate Bridge A on the circuit board. Melt sufficient solder onto the circuit board to form a **solid bridge** across the indicated foils.
- (3) In the same manner, form a **solid bridge** of solder across Bridge B on the circuit board foil.

Note: Solder Bridges A and B may be unsoldered during certain troubleshooting steps if necessary. For normal operation, both bridges **must** be soldered.

This completes the step-by-step assembly of your Power Supply. Carefully check all wires and components and make sure all connections are well soldered. Be sure there are no bits of wire ends lodged in the wires or inside the chassis where they might become a problem later. Be sure all excess wires and leads are cut from soldered connections, and that no wire or lead ends from separate connections touch one another.

# TESTS AND ADJUSTMENTS

Refer to Figure 1 (In the "Illustration Booklet") and study the descriptions and functions of the front panel controls.

## NOTES:

1. Do not apply power to the Tri-Power Supply until you are instructed to do so.
2. Power leads or cables are not supplied with your kit; you may wish to assemble several short jumper leads with banana plugs on both ends, as well as longer leads, to apply the output power from the Supply to other equipment.
3. A volt-ohmmeter is required for the following tests and adjustments.
4. If, during the following resistance and voltage tests, you do not obtain the desired results, refer to the "In Case of Difficulty" section of the Manual, starting on Page 40.

## RESISTANCE TESTS

- (✓) Connect the ohmmeter common lead to the front panel green binding post (chassis gnd).
- (✓) Using the positive ohmmeter lead, check each of the six red and black front panel binding posts. Each of these measurements must be 1 megohm or greater.
- ( ) Refer to Figure 2 (in the "Illustration Booklet"). Using the positive meter lead, check the collector (C) of transistors Q1 and Q2 and the case (C) of IC1. Each of these measurements must exceed 1 megohm.
- (✓) Using the positive meter lead, check both **flat** prongs on the line cord plug. Each reading must exceed 10 megohms with the POWER switch ON and with the switch OFF.
- (✓) In the same manner, check the large, round prong on the line cord plug. The reading must indicate 0 (zero) on the ohmmeter.
- ( ) Disconnect the common ohmmeter lead from the chassis ground post.
- (✓) One at a time, connect the ohmmeter common lead to each of the front panel black binding posts. Check each of the remaining two black binding posts with the positive meter lead. In each case, the ohmmeter reading should exceed 1 megohm.
- (✓) In the same manner, connect the ohmmeter common lead to each of the front panel red binding posts. Check the two remaining red binding posts with the ohmmeter positive lead. In each case, the ohmmeter readings must exceed 1 megohm.



# VOLTAGE TESTS

Refer to Figure 2 and turn controls R116 and R216 (on the top of the circuit board) to the centers of their rotation.

Refer to the inset drawing on Figure 1. On the underside of the chassis, using the tip of a screwdriver, set Line switch SW2 so the exposed numbers agree with the voltage in your area; either "120" or "240."

Refer to Figure 1 and preset the front panel controls as follows:

1. METER switch to A VOLTS.
2. SUPPLY A control fully counterclockwise.
3. Both inner and outer controls, ○ SUPPLY B and ● A TRACKING B, fully counterclockwise.
4. MODE SWITCH to INDEPENDENT.
5. POWER switch OFF.

NOTE: When you apply power to the Tri-Power Supply in the following step, carefully watch for any symptoms of trouble. These may be indicated by an erratic movement of the meter, some unusual noise, or indications of excessive heat. Should any of these occur, immediately turn the POWER switch OFF, remove the line cord from the AC outlet, and then refer to the "In Case of Difficulty" portion of the Manual on Page 40.

- ( ) Plug the line cord into an AC outlet.
- ( ) Turn the POWER switch ON. At this time, the meter pointer should indicate zero and the pilot light should glow.

**WARNING:** Avoid touching any components or leads in the "High Voltage" areas as shown in Figure 10 on Page 41.

- ( ) Turn the METER switch counterclockwise to each of the following positions; note the meter reading at each position:

<u>Set METER Switch To:</u>	<u>Meter Reading</u>
A AMPS	0 (Zero)
B VOLTS	0 (Zero)
B AMPS	0 (Zero)
5V VOLTS	5 (plus or minus 1/4 volt)
5V AMPS	0 (Zero)

- ( ) Set the METER switch to A VOLTS.

- ( ) Slowly turn the SUPPLY A control clockwise as you observe the meter. The meter pointer should move upscale.
- ( ) Turn the SUPPLY A control fully counterclockwise.
- ( ) Set the METER switch to B VOLTS.
- ( ) Slowly turn the dual ○ SUPPLY B / ● A TRACKING B dual controls clockwise as you observe the meter. The meter pointer should move upscale.
- ( ) Turn the dual controls fully counterclockwise.
- ( ) Set the METER switch to A VOLTS.
- ( ) Set the MODE switch to TRACKING.
- ( ) Slowly turn the dual control knobs clockwise as you observe the meter. The meter pointer should move upscale.
- ( ) Turn the dual controls fully counterclockwise.
- ( ) Turn the dual control knobs to obtain a 1-volt indication on the meter 0-20 volt scale.
- ( ) Set the METER switch to A AMPS.
- ( ) Briefly short the OUTPUT A negative (-) black binding post to the positive (+) red binding post as you observe the meter. The pointer should move upscale to indicate greater than 5 on the lower meter scale.
- ( ) Set the METER switch to B AMPS.
- ( ) Briefly short the OUTPUT B negative (-) and positive (+) binding posts together as you observe the meter. The pointer should move upscale to indicate greater than 5 on the lower meter scale.
- ( ) Set the METER switch to 5V AMPS.
- ( ) Briefly short the 5 VOLT SUPPLY negative (-) and positive (+) binding posts together as you observe the meter. The meter pointer should indicate a lower scale reading of more than 1.5 amperes, and the pointer may even go to its upper limit. NOTE: If this short between the binding posts is held for a short period of time, the pointer will begin to drift downward.
- ( ) Set the POWER switch to OFF.



## CALIBRATION

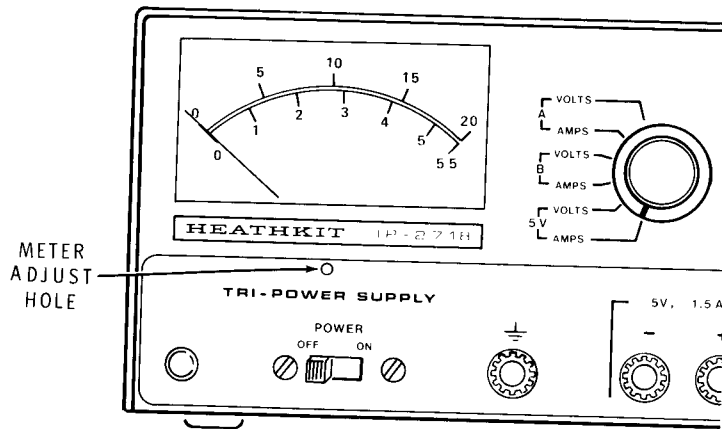


Figure 3

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

METER switch: B VOLTS.

SUPPLY A control: Fully clockwise.

SUPPLY B and A TRACKING B controls:  
Fully clockwise.

MODE switch: TRACKING.

NOTE: Refer to Figure 3 and perform the following step only if the meter pointer is **not** directly over the "0" (zero) on the meter scale.

( ) Locate the small hole in the front panel, directly under the center of the meter. Using a small screwdriver, carefully and slowly turn the small meter adjust screw through the small hole until the pointer is positioned directly over the "0" at the left side of the meter scale.

( ) Set the POWER switch to ON.

( ) Refer to Figure 2 and adjust circuit board control R216 until the pointer is directly over "20" on the upper meter scale.

( ) Turn the METER switch to A VOLTS.

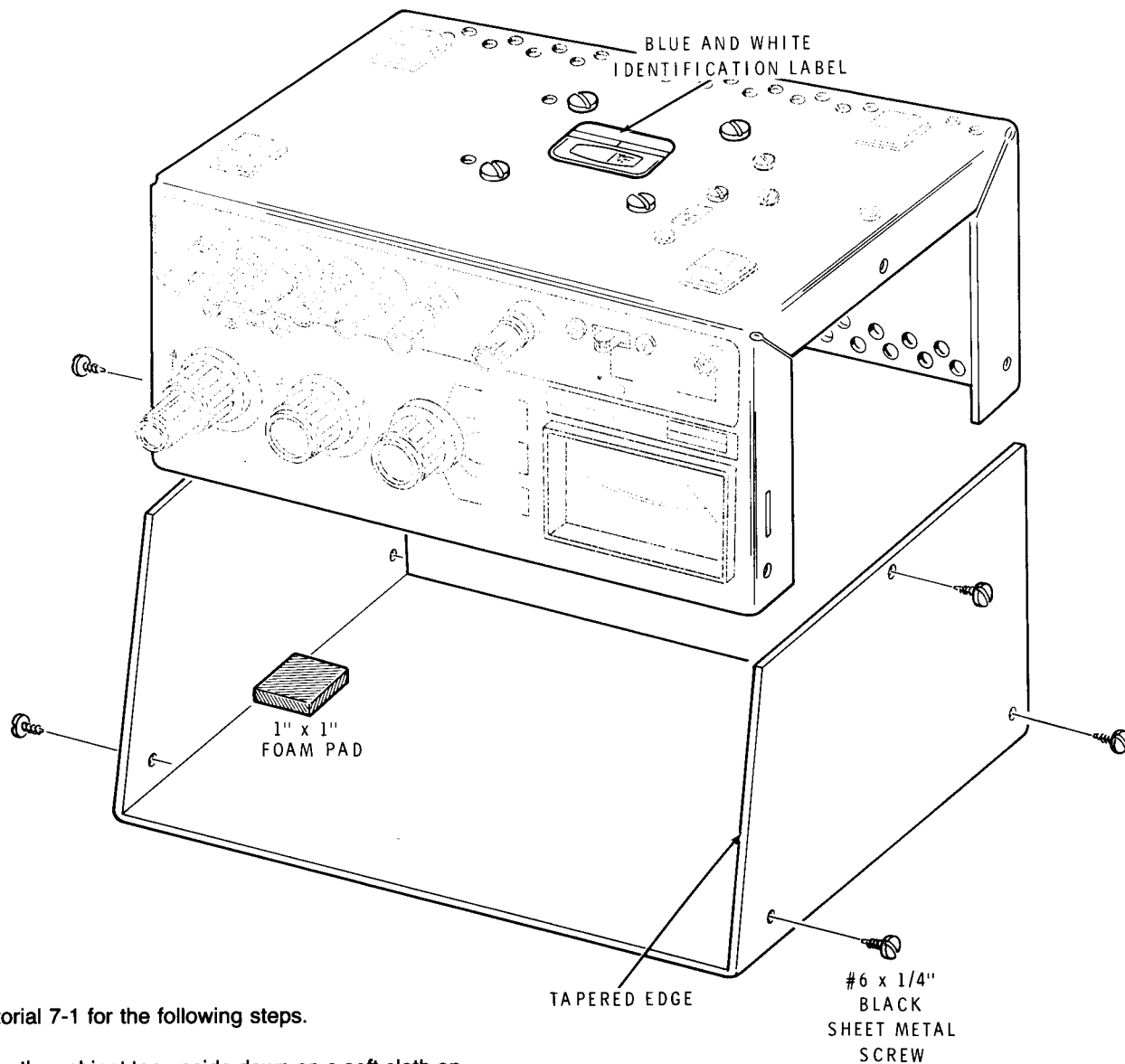
( ) On the circuit board, adjust control R116 until the pointer is directly over "20" on the upper meter scale.

( ) Set the Mode switch to INDEPENDENT. The pointer should now indicate between 19 and 21 on the upper scale.

( ) Turn the POWER switch OFF and remove the line cord plug from its socket.

This completes the "Calibration" of your Power Supply.

# FINAL ASSEMBLY



Refer to Pictorial 7-1 for the following steps.

- ( ) Position the cabinet top upside down on a soft cloth on your work area so the tapered front edges are toward you.
- ( ) Remove the paper backing from the 1" × 1" foam pad and press the pad in place on the underside of the cabinet top. Center the pad from front to rear, close to the left side as shown in the Pictorial.
- ( ) Turn the chassis assembly upside down and position it downward into the inverted cabinet top. Then secure the top to the chassis with six #6 × 1/4" black sheet metal screws.
- ( ) Remove the paper backing from the blue and white label and press the label in place on the underside of the chassis as shown. NOTE: Refer to the model and series numbers on the blue and white label in any correspondence you have with the Heath Company about this kit.

## PICTORIAL 7-1

This completes the assembly of your Tri-Power Supply.

# OPERATION

Refer to Figure 1 in the "Illustration Booklet."

Before you use your Tri-Power Supply, you should become entirely familiar with its capabilities, characteristics, and its features. Study Figure 1 to learn each control and switch function as you read this portion of the Manual.

## CONTROL AND SWITCH FUNCTIONS

### LINE AND POWER SWITCHES (SW2 and SW1)

Line switch SW2 is located on the underside of the chassis. If the line voltage in your area is 100-135 volts AC, use a screwdriver tip to push the switch slide to expose the "120" on the slide. If the line voltage in your area is 200-270 volts AC, push the switch slide to expose the "240."

The POWER switch on the front panel is a simple slide switch that applies the line voltage to the primary circuit of the power transformer when you push the switch to the ON position. At the same time, power is applied to the pilot light to indicate that power has been applied to the unit.

### METER SWITCH (SW4)

It is important that you know that METER switch (SW4) does **not** switch any output voltage or current. The switch permits you to observe any of the Power Supply outputs on the meter, whether voltage or current. The METER switch thus allows you to monitor any of the variable outputs and to set them accurately to any desired levels.

### METER

Note that the meter scales are printed in two colors. The lower scale, in red, corresponds to each of the METER switch functions that also are lettered in red: "A-AMPS" (current flowing to a load from the output of the A supply); "B-AMPS" (current flowing to a load from the output of the B supply); and, "5V-VOLTS" (the voltage available at the output of the 5-volt supply).

The upper meter scale, in black, corresponds to the following METER switch functions, also printed in black: "A-VOLTS" (the voltage at the output of the A supply); "B-VOLTS" (the voltage at the output of the B supply); and, "5V-AMPS" (current flowing to a load from the output of the 5-volt supply).

### SUPPLY A CONTROL (R7)

When you turn this control clockwise from its "0" position, the output of front panel jacks J4 and J5 (OUTPUT A) will increase from zero to any level up to 20 volts and a load current up to 500 milliamperes. Read these levels on the meter when the METER switch is either at "A-VOLTS" or at "A-AMPS." NOTE: In the TRACKING mode of operation, Supply A control R7 is disabled; control of the 20-volt A-supply is transferred to ● A TRACKING B control R8 (the small red knob at the right side of the front panel, which operates as a clutched control with ○ SUPPLY B control R9).

### ○ SUPPLY B CONTROL (R9)

Control R9 is half of the dual control at the right side of the front panel. The other half of this control is turned with the small red knob and is labeled "● A TRACKING B" in red lettering above the two control knobs. The two controls are "clutched" together so that both controls will turn when either knob is turned. Note that black knob R9 corresponds to the black letters ("○ SUPPLY B") on the panel just above the control.

Control R9 adjusts the voltage at OUTPUT B jacks J6 and J7. This control will vary the B supply voltage from zero to 20 volts DC and a load current up to 500 milliamperes. Read the output levels on the meter when the METER switch is turned to B-VOLTS and to B-AMPS.

### ● A TRACKING B CONTROL (R8)

Control R8 is "clutched" to "O SUPPLY B" control R9. At any time either control is turned, the other will turn with it. Since it is a friction action, either control may be operated independently of the other, providing the other control is grasped and held in place. Control R8 is enabled only when MODE switch SW3 is in the TRACKING position. In this manner, the A 20-volt supply is disabled at SUPPLY A control R7, and is controlled by the small red knob at R8. At no time are the electrical and electronic circuits of the A and B 20-volt power supplies connected together internally.

### MODE SWITCH (SW3)

In the INDEPENDENT mode of operation, the 20-volt A supply is connected to SUPPLY A control R7 through the contacts of the Mode switch. In this mode, control R9 (small red knob) is disconnected from the circuit. When MODE switch SW3 is in

the TRACKING mode, control R7 is removed from the circuit, and control R9 is enabled and the A-supply will track with the B-supply through the clutch action of the dual control knobs.

### OUTPUT JACKS (J1-J7)

Output jack J1 is a chassis ground connection. If, at any time, you wish to reference any of the three supplies to ground, external connections from the appropriate supply jacks may be connected to J1.

Jacks J2 and J3 are the connections for the fixed 5-volt, 1.5-ampere power supply.

Jacks J4 and J5 are the connections for the variable 20-volt, 500 milliampere A power supply.

Jacks J6 and J7 are the connections for the variable 20-volt, 500 milliampere B power supply.

## OPERATING PROCEDURES

Two modes of operation are provided at the output jacks on the front panel. These are the "Independent" and the "Tracking" modes. Each will be discussed under separate headings.

### INDEPENDENT MODE

Each of the three power supplies in the Tri-Power supply may be operated independently from one another, either floating or referenced to another AC or DC source, or referenced to the Tri-Power Supply ground connection at J1. In addition, any of the separate supplies may be connected in series with external jumpers to provide up to 45 volts DC, referenced to any external or internal level. NOTE: External references may not exceed 200 volts.

### TRACKING MODE

In the TRACKING mode of operation, the 20-volt A and B supplies are clutched together at the front panel dual control

R8/R9. As either of the controls is turned, the other will turn in the same manner. To adjust the controls, the voltage output must be observed on the meter for each 20-volt supply, and the level of each set by controls R8 and R9. For example, if you wish to have the A-supply referenced 5 volts greater than the variable B-supply, you should proceed as follows: Turn dual controls R8 and R9 fully counterclockwise. Grasp the black knob at R9 and turn it until some voltage is read on the meter. Then, as you hold the black knob, turn the small red knob on R8 until A-VOLTS on the meter indicates +5 volts more than shown for the B supply. Release the red knob. As you turn the black knob, the A supply voltage will track the B supply voltage, always at a potential of 5 volts ( $\pm 5\%$ ) higher than produced by the B supply.

In the TRACKING mode, the A and B supplies may be operated as a tracking pair of output voltages, referenced to a voltage not exceeding 200 volts. As in the INDEPENDENT mode, the three supplies may be connected as any combination in series, to supply up to 45 volts total, at any desired reference.

# APPLICATIONS

The following sections of the Manual will show you a number of examples of how you can use your Power Supply. The variety of uses is extensive, however, so only a few examples are given.

NOTE: Since 5 volts is used extensively in TTL logic applications, it is incorporated into the Tri-Power Supply as a fixed output. This 5 volts DC may be referenced to any other voltage up to 200 volts, or to the Power Supply front panel GND jack at J1.

## INDEPENDENT MODE APPLICATIONS

### INDEPENDENT FLOATING SUPPLIES

Refer to Figure 4 as you read the following information.

Figure 4 illustrates each of the three Power Supply outputs connected to separate loads. Each of the supplies may be floated at a level up to 200 volts from ground, or from each other. In this example; the MODE switch is at INDEPENDENT, SUPPLY A control R7 controls the output level of one 0-20 volt circuit, and SUPPLY B (black) control R9 controls the output of the other 0-20 volt circuit.

Each of the supplies has fixed current limiting in all modes of operation at slightly above the rated current output. This provides short-circuit protection to the Power Supply.

NOTE: Each circuit output has a .01  $\mu\text{F}$  capacitor connected from its negative terminal to chassis ground. This must be taken into consideration with many applications; such as where earth (power line) ground loops might be a problem, or where the Power Supply is used for floating operation in high-impedance circuits.

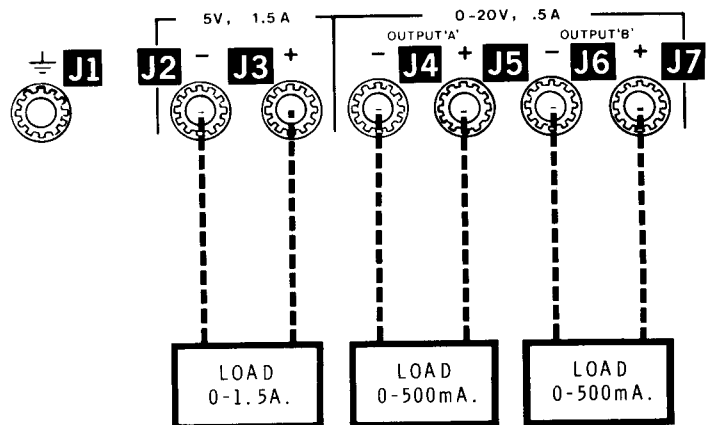


Figure 4

### INDEPENDENT GROUND-REFERENCED SUPPLIES

Any of the output terminals, whether + or - may be connected to ground, and in any combination. The following chart lists many of the possible voltage combinations using chassis ground as a reference.

5-Volt Supply	A-Supply	B-Supply
+5 volts, fixed	0 to +20 volts	0 to +20 volts
+5 volts, fixed	0 to +20 volts	0 to -20 volts
+5 volts, fixed	0 to -20 volts	0 to +20 volts
+5 volts, fixed	0 to -20 volts	0 to -20 volts
-5 volts, fixed	0 to +20 volts	0 to +20 volts
-5 volts, fixed	0 to +20 volts	0 to -20 volts
-5 volts, fixed	0 to -20 volts	0 to +20 volts
-5 volts, fixed	0 to -20 volts	0 to -20 volts

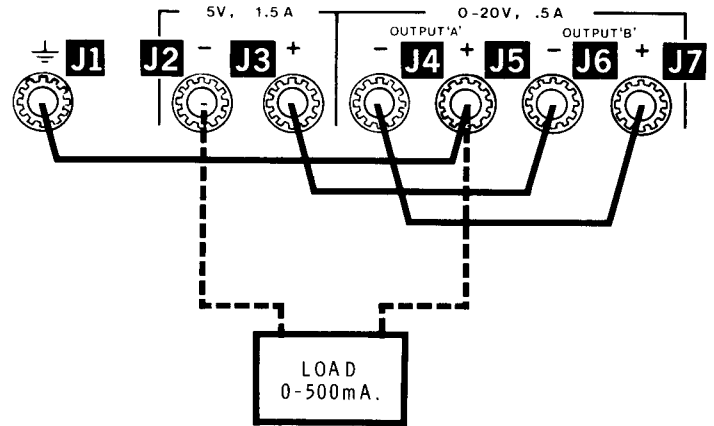


Figure 6

Figure 6 is an example of a circuit in which the three outputs of the circuit are connected in series, with a ground reference at the high end of the circuit. Thus the output to the load is variable from -5 to -45 volts. Load current is limited to 500 mA by the A and B-supply limiters.

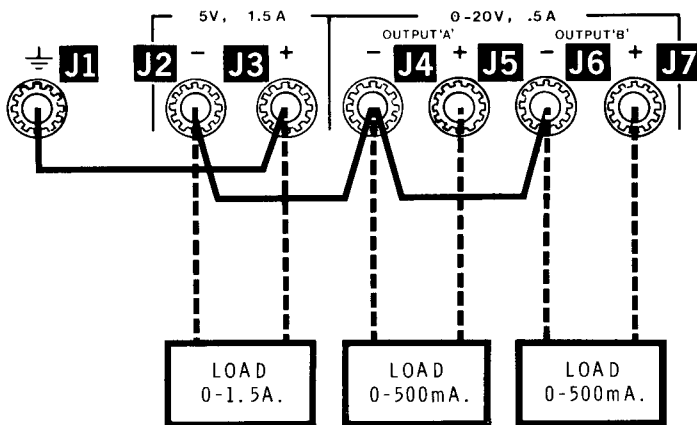


Figure 5

Figure 5 illustrates an example of a circuit in which the +5 volt terminal is referenced to ground, and both the 0 to +20-volt A and B supplies are referenced to -5 volts. Thus, each of the positive-going 20-volt supplies can be varied from -5 to +15 volts (+20 volts, overall).

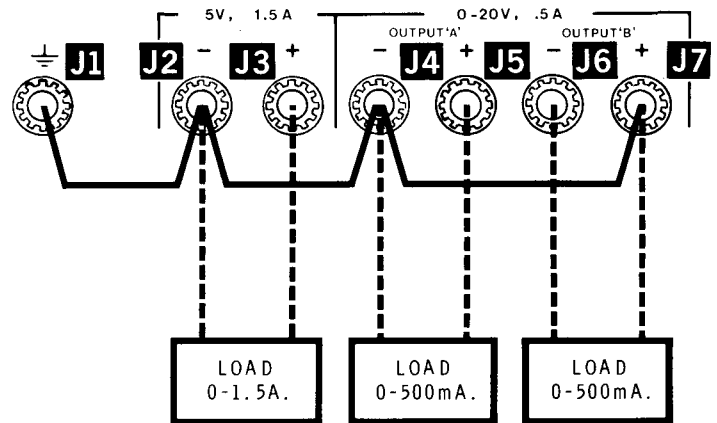


Figure 7

Figure 7 illustrates the Tri-Power Supply connected to produce separate outputs of +5 volts, fixed, the A-supply variable from 0 to +20 volts, and the B-supply variable from 0 to -20 volts.

## TRACKING MODE APPLICATIONS

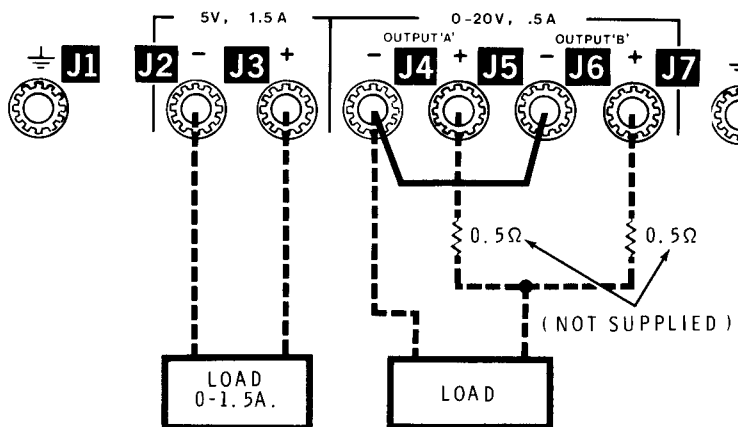


Figure 8

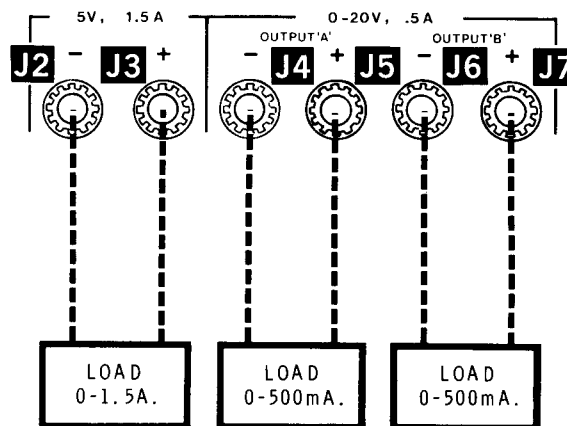


Figure 9

NOTE: In the Tracking Mode of operation, as previously described, A-supply control is clutched to the B-supply control at R8/R9.

### PARALLEL OPERATION

The purpose of connecting the two 20-volt power supplies in parallel is to provide higher current through the load. Figure 8 shows a typical Power Supply-to-load connection in which up to 1 ampere of current is available to the load. Note that 0.5 ohm current-sharing resistors (not supplied) are used in the output connections. The output voltage of the circuit is reduced by the IR voltage drop across these equalizing resistors. Each supply is short-circuit and overload protected; either 20-volt supply may current-limit slightly before the other.

### TRACKING-FLOATING CIRCUITS

NOTE: Each of the three power supplies is connected to a separate load as shown in Figure 9. Each supply is floating, and independent of reference levels. In this configuration, the MODE switch must be in TRACKING to produce the following outputs: 5 volts, fixed and floating, B-supply 0 to +20 volts floating with the A-supply output floating, and tracking the B supply at any predetermined voltage differential. To create a tracking  $\pm$  supply, the A+ terminal may be connected to the B- terminal, for example. The Power Supply may be wired in any manner of series connections of A, B, and 5-volt outputs in the Tracking Mode.

# IN CASE OF DIFFICULTY

This part of the Manual will help you locate and correct any difficulty which might occur in your Power Supply. The information is divided into three sections. The first section "General," contains suggestions of a general nature in the following areas:

- A. Visual checks and inspection.
- B. Bench-testing precautions.
- C. Repair techniques.

The second section consists of a "Troubleshooting Chart." It calls out specific problems that may occur and lists one or more conditions or components that could cause each difficulty. Capacitor C-numbers, transistor Q-numbers, etc., are identified in this chart by the same numbers that are used on the Schematic diagram. A "Circuit Board X-Ray View" (on Page 48) is also provided to help you locate the components. Refer to the "Chassis Assembly" steps to locate chassis-mounted parts.

**NOTE:** In an extreme case where you are unable to resolve a difficulty, refer to "Customer Service" information inside the rear cover of the Manual. Your Warranty is located inside the front cover.

## GENERAL

### VISUAL CHECKS

1. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, you can eliminate many difficulties by a careful inspection of connections to make sure they are soldered as described in the "Soldering" section of the "Assembly Notes" on Page 6 of this Manual. Reheat any doubtful connections and be sure all the wires are connected.
2. Check the circuit board to be sure there are no solder bridges between adjacent connections. Remove any solder bridges that may exist. Compare the circuit board foil pattern with the "Circuit Board X-Ray View" on Page 48.
3. Be sure each transistor and integrated circuit is in the proper location (correct part number and type number). Be sure that each transistor lead is positioned properly and has a good solder connection to the foil. Check the integrated circuit for proper positioning and good connections.
4. Check capacitor values carefully. Be sure the proper part is wired into the circuit at each capacitor location. For example, it would be easy to mistake a .001  $\mu\text{F}$  capacitor for a 100 pF capacitor. Always check the polarity of electrolytic and tantalum capacitors to be sure the "+" lead is installed at the correct location. Where required, insure that the banded end of a Mylar capacitor is at the correct location.
5. Check each resistor carefully. It would be easy, for example, to install a 1200  $\Omega$  (brown-red-red) resistor where a 220  $\Omega$  (red-red-brown) resistor is called for. A resistor that is discolored, cracked, or shows any sign of bulging would indicate that it is faulty and should be replaced.
6. Be sure the correct diode is installed at each diode location, and that the banded end is positioned correctly.
7. 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 you have consistently overlooked.
8. Check all component leads connected to the circuit board. Make sure the leads do not extend through the circuit board and make contact with other connections or parts.



## BENCH TESTING

**WARNING:** The full AC line voltage and high voltage DC is present at several points in the Power Supply. Be careful to avoid personal shock when you work on the Power Supply. Refer to Figure 10.

- Be cautious when you test the transistors and integrated circuits. Although they have almost unlimited life when used properly, they are more susceptible to damage from excessive voltage and current than are other circuit components.
- Be careful so you do not short any terminals to ground when you make voltage measurements. If the probe should slip, for example, and short out a bias or voltage supply point, it may damage one or more components.
- Do not remove any components while the Power Supply line cord is connected to the AC outlet.
- When you make repairs to the Power Supply, make sure you eliminate the cause as well as the effect of the trouble. If, for example, you should find a damaged resistor, be sure you find out what caused the resistor to become damaged. If the cause is not eliminated, the replacement resistor may also become damaged when the Power Supply is put back into operation.
- Refer to the X-Ray View, on Page 48 and the fold-in "Schematic" to locate the various components.
- Use a high impedance-input voltmeter to make any voltage measurements.

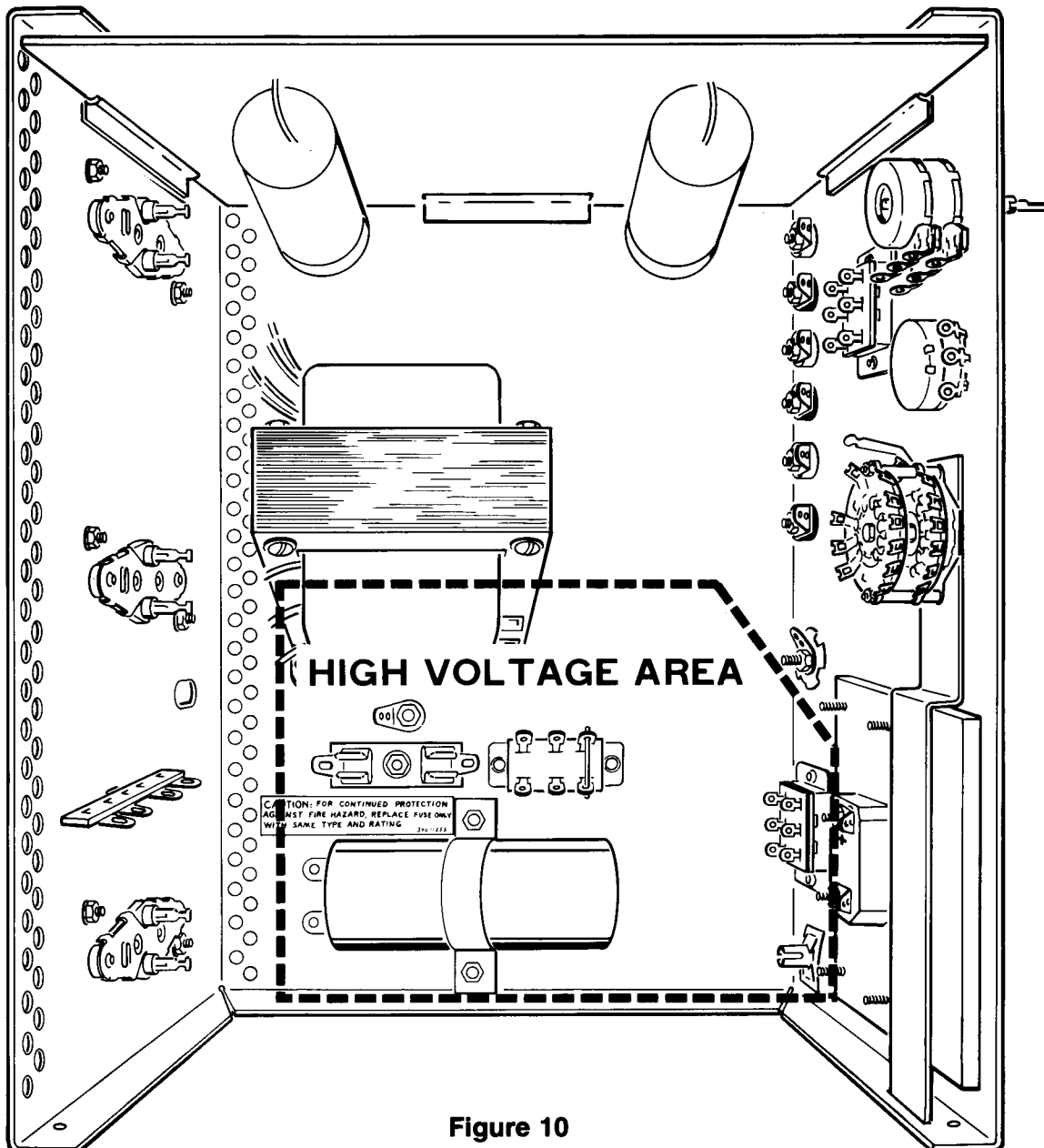


Figure 10

## REPAIR TECHNIQUES

### Components

Faulty resistors or capacitors should first be clipped from their leads to the circuit board. Heat the solder on the foil-side and allow the clipped lead to fall out of the hole. Preshape the leads of the replacement part and insert them into the holes in the circuit board. Solder the leads to the foil and cut off the excess lead lengths.

Transistors can be removed in the same manner as previously described. The replacement transistor must be installed with its leads in the proper holes. Then quickly solder the leads to avoid heat damage. Cut off the excess lead lengths.

**CAUTION:** On several areas of the circuit board, the foil patterns are quite narrow. When you unsolder a part for checking or replacement, avoid excessive heat while removing the part. A suction-type desoldering tool will make part removal easier.

### Foil Repair

A break in a circuit board foil can be bridged by soldering across the break. Large gaps in the foil should be bridged with a length of bare wire. Lay the wire across the gap and solder each end to the foil.

## Troubleshooting Chart

### GENERAL

CONDITION	POSSIBLE CAUSE
Power Supply dead.	<ol style="list-style-type: none"> <li>1. Fuse blown.</li> <li>2. Bad solder connection, power transformer primary wiring.</li> <li>3. Power switch SW1.</li> <li>4. Line switch SW2.</li> </ol>
Fuse blows.	<ol style="list-style-type: none"> <li>1. Power or Line switches incorrectly wired.</li> <li>2. Power transformer secondary incorrectly wired.</li> <li>3. Integrated circuit IC1.</li> <li>4. Capacitors C2, C103, C203, C108, or C208 incorrectly installed or faulty.</li> </ol>

### 5-VOLT SUPPLY

CONDITION	POSSIBLE CAUSE
No Output.	<ol style="list-style-type: none"> <li>1. Diodes D1 or D2.</li> <li>2. Resistor R4.</li> <li>3. Integrated circuit IC1.</li> </ol>
Output greater than 5.25 volts DC.	<ol style="list-style-type: none"> <li>1. Integrated circuit IC1.</li> </ol>
Unable to get 1.5 amperes of current from supply.	<ol style="list-style-type: none"> <li>1. Integrated circuit IC1 loosely installed or defective.</li> <li>2. Resistor R4 wrong value.</li> </ol>
Excessive ripple at output jacks.	<ol style="list-style-type: none"> <li>1. Integrated circuit IC1.</li> <li>2. Diodes D1 or D2.</li> <li>3. Capacitor C2.</li> </ol>
5-Volt supply not floating. Resistance from either output jack to chassis is less than 1 MΩ.	<ol style="list-style-type: none"> <li>1. Wiring error.</li> <li>2. Integrated circuit IC1 case contacting chassis.</li> <li>3. Capacitor C5.</li> </ol>

## 20-VOLT A OR B SUPPLIES

NOTE: Since both of the 20-volt supplies are identical, troubleshooting for both supplies is the same. If one of the 20-volt supplies operates correctly, you may be able to compare in-circuit voltages to identify a problem. All 100-series components are in the A-supply; all 200-series components are in the B-supply.

CONDITION	POSSIBLE CAUSE
No output from 20-volt supply.	<ol style="list-style-type: none"> <li>1. Diodes D101, D102, D103, or diodes D201, D202, D203 open.</li> <li>2. Resistors R101, R103, R109, or resistors R201, R203, R209 open.</li> <li>3. Transistors Q101, Q102, Q103, Q107, or transistors Q201, Q202, Q203, or Q207 open.</li> <li>4. Capacitors C102, C109, or capacitors C202, C209, shorted or reversed.</li> <li>5. Zener diodes ZD104, ZD108, ZD109, or zener diodes ZD204, ZD208, ZD209 shorted or reversed.</li> <li>6. Transistors Q104, Q105, Q106, Q108, or transistors Q204, Q205, Q206, Q208 shorted or incorrectly installed.*</li> </ol>
Output too high, cannot be adjusted.	<ol style="list-style-type: none"> <li>1. Transistors Q102, Q103, Q1, Q107, or transistors Q202, Q203, Q2, Q207 shorted.</li> <li>2. Diodes D105, D110, or diodes D205, D210 open.</li> <li>3. Zener diodes ZD108, ZD109, or zener diodes ZD208, ZD209 open.</li> <li>4. Transistors Q106, Q108, or transistors Q206, Q208 open.</li> </ol>
Output current too low.	<ol style="list-style-type: none"> <li>1. Resistor R109 or resistor R209 open or incorrect value.</li> <li>2. Transistor Q104 or transistor Q204 faulty.*</li> </ol>
Output current does not limit.	<ol style="list-style-type: none"> <li>1. Solder bridge A or solder bridge B open.</li> <li>2. Transistor Q104 or transistor Q204 faulty.</li> <li>3. Resistor R108, R109 or resistor R208, R209 wrong value.</li> </ol>

CONDITION	POSSIBLE CAUSE
Excessive ripple in output voltages.	<ol style="list-style-type: none"> <li>1. Diodes D101, D102 or diodes D201, D202 open or faulty.</li> <li>2. Capacitors C101, C103, C104, C105, C108 or capacitors C201, C203, C204, C205, C208 open or faulty.</li> </ol>
Supply not floating. Resistance from either output jack to chassis is less than 1 M $\Omega$ .	<ol style="list-style-type: none"> <li>1. Transistor Q1 or transistor Q2 case shorted to chassis.</li> <li>2. Capacitor C6 or capacitor C7 faulty.</li> </ol>

\* NOTE: To check transistors Q104, Q105, Q204, and Q205, proceed as follows:

1. Disconnect the Power Supply from the AC outlet.
2. Unsolder Bridge A if the problem is in the A supply, and Bridge B if the problem is in the B supply. (See Pictorial 6-2 on Page 30.)

**CAUTION:** Current limiting protection will be disabled in the following steps; do not short together the terminals of either 20-volt supply as you perform these steps.

3. Turn on the Power Supply. Turn the voltage control fully clockwise. Observe the meter, and if the meter indicates a full-scale reading, transistor Q104 (or transistor Q204) is shorted.
4. Refer to Page 11, Pictorial 1-2, right column, 6th step. Temporarily unsolder the indicated jumper wire.
5. Turn on the Power Supply. Observe the meter. If it indicates a full-scale reading (pegged at upper limit), transistors Q105 (or Q205), Q106 (Q206), or Q108 (Q208) are shorted.
6. If necessary, replace the faulty component(s). Then resolder the Bridges and the jumper wires previously opened.



# SPECIFICATIONS

## Outputs

5-Volt Supply .....	5 volts DC $\pm 5\%$ at 1.5 amperes.
'A' -Supply .....	0-20 volts DC at 0.5 ampere, continuously adjustable.
'B' -Supply .....	0-20 volts DC at 0.5 ampere, continuously adjustable.

## Regulation

Load .....	Less than 0.1% (20 mv) variation from no load to full load on 20-volt supplies.
	Less than 2% (100 mv) variation from no load to full load on 5-volt supply.

Line .....	20-Volt Supplies: Less than 0.2% (40 mv) for a line voltage change of 10 volts.
------------	---

5-Volt Supply: Less than  
0.2% (10 mv) for a line  
voltage change of 10 volts.

Ripple and Noise .....	Less than 5 mv RMS.
------------------------	---------------------

Current Limiting .....	Limiting for each supply fixed slightly above rated current to provide short-circuit protection.
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Tracking Range .....	2 to 18 volts.
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Tracking Error .....	Less than 1 volt.
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Series Operation .....	All three supplies may be connected in series.
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Parallel Operation .....	20-volt supplies may be operated in parallel by adding 0.5 $\Omega$ current- equalizing resistors (not supplied).
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Voltage-Current Monitor Accuracy .....	5% of full scale.
Meter Ranges .....	Voltages, 0-20 and 0-5.5. Current, 0-550 mA and 0-2A.
Power Requirements .....	100-135 VAC or 200-270 VAC, 50/60 Hz, 100 watts at full load.
Power Switching Overshoot (On-Off) .....	None.
Voltage Control, 20-Volt Supplies 'A' and 'B'.....	Continuously variable, 0-20 volts.
Dimensions .....	4-1/2" high × 10-3/4" wide × 9" deep (11.43 cm × 27.3 cm × 22.86 cm).
Weight.....	10 lbs (3.73 kg).

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

## CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (in the "Illustration Booklet") while you read this "Circuit Description." The part numbers on the Schematic are arranged in the following groups to help you locate specific parts on the Schematic, chassis, and circuit boards:

- 1- 99 Parts mounted on the chassis.
- 101-199 Parts mounted on the circuit board, and in the 20-volt 'A' Supply.
- 201-299 Parts mounted on the circuit board, and in the 20-volt 'B' Supply.

The five principle sections of the Tri-Power Supply are the power primary circuit, the 5-volt supply, the 20-volt 'A' Supply, the 20-volt 'B' Supply, and the metering circuit.

### PRIMARY CIRCUIT

The primary circuit of the Tri-Power Supply includes; hash-filter capacitor C1 across the line cord input, fuse F1, Power switch SW1, pilot lamp PL1 and dropping resistor R1, Line switch SW2, and transformer T1. The purpose of the Line switch is to allow you to switch from 120-VAC operation to 240-VAC operation without rewiring the primary circuit of power transformer T1. To change from 120-VAC operation to

240-VAC operation, for example, you need only to push the slide of switch SW2 to indicate the voltage that agrees with the local AC service. CAUTION: Be sure never to have switch SW2 at "120" during 240-volt operation; this could damage the Power Supply. Three transformer secondary windings provide separate voltage sources for the three voltage regulators of the 5-volt supply and the two 20-volt supplies.

### 5-VOLT SUPPLY

One secondary winding on transformer T1 provides a voltage to rectifier diodes D1 and D2. The rectified DC voltage is filtered by capacitor C2. Resistor R4 is a current shunt for the metering circuit. Resistor R2 is a bleeder resistor.

Regulation in the 5-volt circuit is accomplished in integrated circuit IC1. The output voltage is fixed at 5 volts. The IC

provides internal overload, short-circuit, and high temperature protection. Capacitor C3 stabilizes the IC-regulator, and capacitor C4 lowers the high-frequency output impedance. Capacitor C5 provides an AC path to chassis ground for voltages induced when the 5-volt supply is used in the floating mode of operation.



## 20-VOLT 'A' AND 'B' SUPPLIES

NOTE: In the description of the 20-volt supplies, the "A" and "B" circuits are identical. One circuit will be described in this text which applies to either supply. Component callouts (R101, C111, Q103, etc.) in the 100-series are in the A-supply; component callouts in the 200-series are in the B-supply.

### RECTIFIER-FILTER CIRCUIT

One transformer secondary winding provides an AC voltage to full-wave rectifier diodes D101 and D102. The rectified voltage is routed through blocking diode D103 and is filtered by capacitor C103. Resistor R105 is a bleeder resistor to discharge C103 when the Power Supply is turned off.

A negative voltage is derived through rectifier diodes D106 and D107. This voltage is filtered by capacitor C105, and is then routed to the voltage regulator.

### CURRENT SOURCE

Current flows through zener diode ZD104, through resistor R103, to transistor Q101. The voltage drop across R104 is fixed at a constant value by ZD104 and the constant base-to-emitter voltage of transistor Q102. Thus, the current through R104 is constant. Since the collector current of Q102 is very nearly equal to its emitter current, the collector current will also be constant.

Transistor Q101 acts as a switch, to turn on quickly when the power supply is turned on. However, Q101's turn-off is delayed by the action of capacitor C101 to eliminate transients on the output of the supply when power is switched off.

### OUTPUT AMPLIFIER

The output amplifier of the 20-volt supply consists of power transistor Q1, which is driven by transistor Q103 in a Darlington connection. Resistor R5 stabilizes the output amplifier at higher operating temperatures.

### VOLTAGE REGULATOR

The reference voltage for the regulator circuit is derived from zener diode ZD109. Constant current for ZD109 is provided by resistor R115 and zener diode ZD108. ZD108 and resistor R106 are a pre-regulator for the reference source.

Differential transistors Q107 and Q108 compare a portion of the reference voltage as set by control R7 with a portion of the output voltage sampled between resistors R123 and R124.

An example of the action of this regulator circuit is as follows: If the output voltage rises due to a reduction in the load, the base voltage of transistor Q108 will increase. The collector voltage of Q108 will drop, causing an increase in the base current of transistor Q106. This causes an increase in the base current of transistor Q105 and its collector current will also increase. Since transistor Q102 provides a constant output current which is present both at Q103 and Q105, any increase in Q105 collector current will cause a reduction in Q103 base current. As Q103 base current decreases, its emitter current and that of transistor Q1, will also decrease. This decrease in the current from Q1 decreases the current from the Supply and will lower the output voltage to the correct level. The regulator circuit is designed to hold the output constant within a few millivolts for a full range of loads at the output terminals.

Diode D105, capacitors C102 and C104, with diode D110 and capacitor C108 eliminate overshoot during turn-on and turn-off of the Supply. Resistor R113 sets a negative bias current through current-metering resistor R109 equal to the positive current drawn by the regulator. This allows the meter to indicate the true supply output current when the Meter switch is correctly positioned.

### CURRENT LIMITER

Transistor Q104 senses the voltage drop across resistor R109. This resistor carries the output current. As the voltage across R109 reaches approximately .55 volts, Q104 starts to conduct taking some of the current from the output of driver transistor Q103. As the voltage across R109 increases further, Q104 will conduct fully, taking all of the current from source transistor Q102. This causes transistors Q103 and Q1 to turn off. In this manner, output current limiting can be maintained indefinitely.

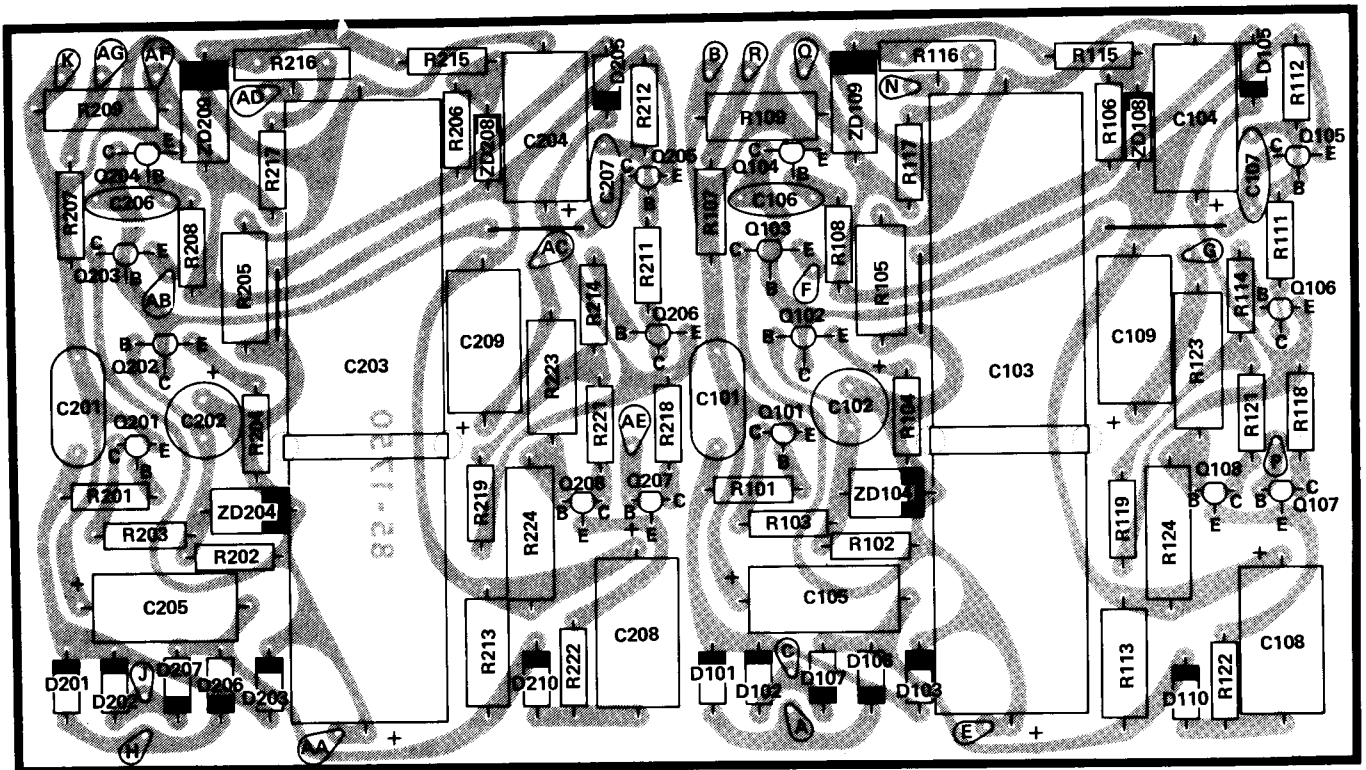
## METERING CIRCUIT

Switch SW4 selects any of the six output functions to be monitored by the meter. NOTE: This switch function does **not** select or affect any of the outputs at the front terminals of the Tri-Power Supply.

# CIRCUIT BOARD X-RAY VIEW

NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

- A. Find the circuit component number (R5, C3, etc.) on the X-Ray View or "Chassis Photograph."
- B. Locate this same number in the "Circuit Component Number" column of the "Parts List" in the front of this Manual.
- C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.

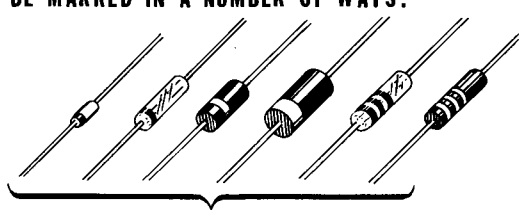


(Shown from component side)



# SEMICONDUCTOR IDENTIFICATION CHARTS

## DIODES

COMPONENT	HEATH PART NO.	MAY BE REPLACED WITH	IDENTIFICATION
ZD109, ZD209	56-31	PS18775	<p><b>IMPORTANT: THE BANDED END OF DIODES CAN BE MARKED IN A NUMBER OF WAYS.</b></p>  <p><b>BANDED END</b></p>
ZD104, ZD204	56-50	DO-7	
ZD108, ZD208	56-57	1N716A	
D1, D2	57-42	3A1	
D101, D102, D103, D105, D106, D107, D110, D201, D202, D203, D205, D206, D207, D210	57-65	1N4002	

### TRANSISTORS

COMPONENT	HEATH PART NO.	MAY BE REPLACED WITH	IDENTIFICATION
Q1, Q2	417-282	MJ2841	
Q107, Q108 Q207, Q208	417-258	T1S87	
Q102, Q106, Q202, Q206	417-201	X29A829	
Q103, Q203	417-294	MPSA42	
Q101, Q104, Q105, Q201, Q204, Q205,	417-801	MPSA20	

### INTEGRATED CIRCUIT

COMPONENT	HEATH PART NO.	MAY BE REPLACED WITH	IDENTIFICATION
IC1	442-30	UA309K	

**FOR PARTS REQUESTS ONLY**

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

**DO NOT WRITE IN THIS SPACE**

**INSTRUCTIONS**

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, \$3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax. Total enclosed \$\_\_\_\_\_
- If you prefer COD shipment, check the COD box and mail this form. COD

NAME \_\_\_\_\_  
 ADDRESS \_\_\_\_\_  
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 STATE \_\_\_\_\_ ZIP \_\_\_\_\_

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # \_\_\_\_\_ Invoice # \_\_\_\_\_  
 Date \_\_\_\_\_ Location \_\_\_\_\_  
 Purchased \_\_\_\_\_ Purchased \_\_\_\_\_

LIST HEATH PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE
TOTAL FOR PARTS			
HANDLING AND SHIPPING			
MICHIGAN RESIDENTS ADD 4% TAX			
<b>TOTAL AMOUNT OF ORDER</b>			

SEND TO: **HEATH COMPANY**  
 BENTON HARBOR  
 MICHIGAN 49022  
**ATTN: PARTS REPLACEMENT**

Phone (Replacement parts only): 616 982-3571

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**FOR PARTS REQUESTS ONLY**

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 CITY \_\_\_\_\_  
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