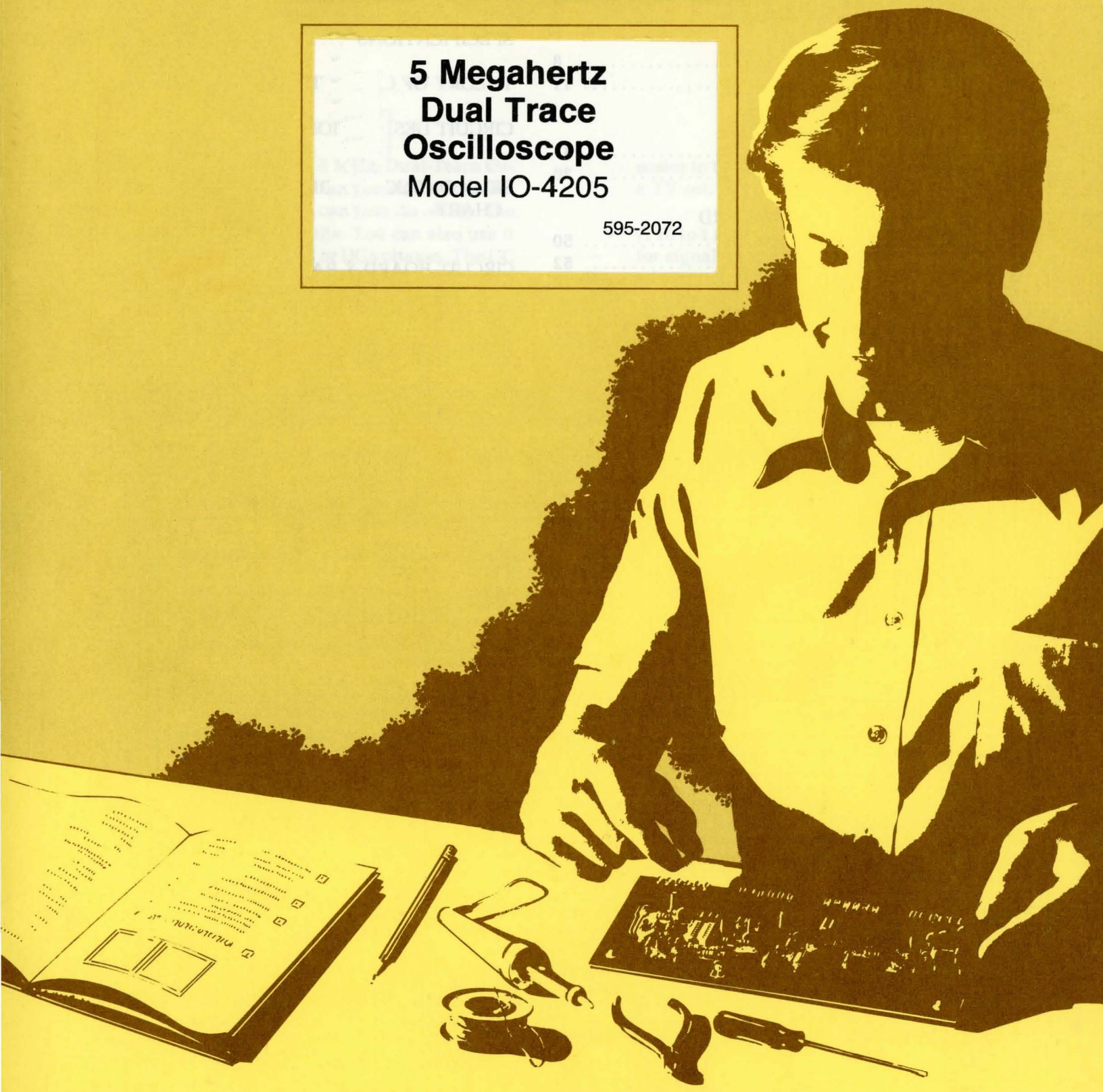
HEATHKIT®
MANUAL

5 Megahertz Dual Trace Oscilloscope

Model IO-4205

595-2072



HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATH COMPANY PHONE DIRECTORY

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

Kit orders and delivery information ..... (616) 982-3411
Credit ..... (616) 982-3561
Replacement Parts ..... (616) 982-3571

Technical Assistance Phone Numbers
8:00 A.M. to 12 P.M. and 1:00 P.M. to 4:30 P.M., EST, Weekdays Only

R/C, Audio, and Electronic Organs ..... (616) 982-3310
Amateur Radio ..... (616) 982-3296
Test Equipment, Weather Instruments and Home Clocks ..... (616) 982-3315
Television ..... (616) 982-3307
Aircraft, Marine, Security, Scanners, Automotive, Appliances and General Products ..... (616) 982-3496
Computers ..... (616) 982-3309

YOUR HEATHKIT 90 DAY LIMITED WARRANTY

If you are not satisfied with our service - warranty or otherwise - or with our products, write directly to our Director of Customer Services, Heath Company, Benton Harbor, Michigan 49022. He will make certain your problems receive immediate, personal attention.

Our attorney, who happens to be quite a kitbuilder himself, insists that we describe our warranty using all the necessary legal phrases in order to comply with the new warranty regulations. Fine. Here they are:

For a period of ninety (90) days after purchase, Heath Company will replace or repair free of charge any parts that are defective either in materials or workmanship. You can obtain parts directly from Heath Company by writing us at the address below or by telephoning us at (616) 982-3571. And we'll pay shipping charges to get those parts to you — anywhere in the world.

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

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

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

Our warranty does not cover and we are not responsible for damage caused by the use of corrosive solder, defective tools, incorrect assembly, misuse, fire, or by unauthorized modifications to or uses of our products for purposes other than as advertised. Our warranty does not include reimbursement for customer assembly or set-up time.

This warranty covers only Heathkit products and is not extended to allied equipment or components used in conjunction with our products. **We are not responsible for incidental or consequential damages.** Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

HEATH COMPANY
BENTON HARBOR, MI. 49022

Prices and specifications subject to change without notice.

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for the

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BENTON HARBOR, MICHIGAN 49022

TABLE OF CONTENTS

INTRODUCTION

The Heathkit Model IO-4205, 5 MHz, Dual-Trace Oscilloscope is a compact, versatile, easy-to-build, electronic instrument that you can use to study the waveforms in electronic circuits. You can also use it to measure frequency, and AC or DC voltages. The DC to 5 MHz bandwidth and the excellent input sensitivity of the vertical amplifiers allow you to use this Oscilloscope for nearly all types of waveform applications. The triggered horizontal sweep circuit and the many other outstanding features provide accuracy and capabilities that are usually found only in higher priced oscilloscopes.

Among the many other features this Oscilloscope offers are:

- A special TV position on the trigger selector. This allows low frequencies to pass while rejecting high frequencies, thus making it easier to trigger on the vertical frequency of a TV set.
- A 10 to 1 attenuation circuit that can be used for signals applied to the external, horizontal input jack.
- Accurately calibrated vertical attenuators with variable controls.
- A calibrated time base (seven time base selections, variable within each selection).

These features, along with the attractive styling, will make this Oscilloscope a welcome asset to the laboratory, service shop, or the ham shack.

UNPACKING

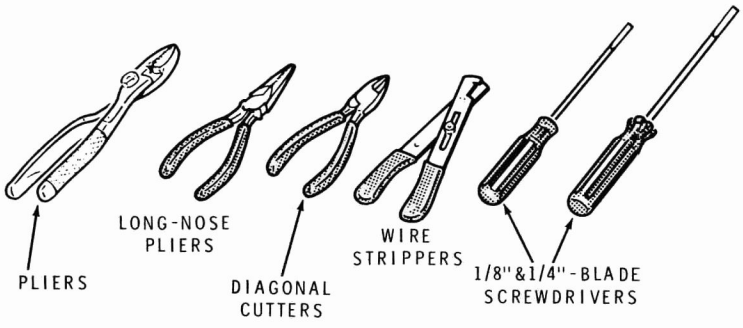
Inside the shipping carton was the box stamped PK1 which contained this Assembly Manual. With this box removed from the shipping carton, you will find bags stamped PACK 2 through PACK 4. The Manual will refer to these areas as "packs." You will be directed to open each of these "packs" as it is needed. All other parts in the shipping carton will be considered the "final pack." Caution: Do not remove any parts from their bags or the "final pack" until they are specifically called for in a Parts List in the Manual.

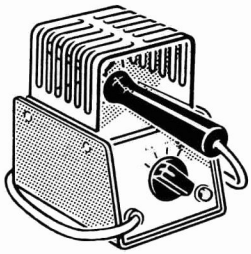
Each assembly section of the Manual contains its own "Parts List" and "Step-by-Step Assembly" instructions. At the beginning of each "Parts List," you will be instructed to open one of the packs. You will also be directed, in some Parts Lists, to remove certain parts from the final pack.

ASSEMBLY NOTES

TOOLS

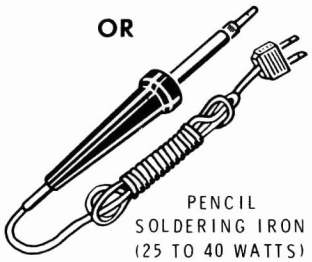
You will need these tools to assemble your kit.





HEATHKIT SOLDERING IRON

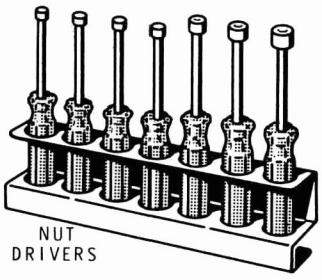
OR



PENCIL SOLDERING IRON (25 TO 40 WATTS)

OTHER HELPFUL TOOLS

DESOLDERING BULB*



NUT DRIVERS

NUT STARTER (MAY BE SUPPLIED WITH KIT)

DESOLDERING BRAID*

*TO REMOVE SOLDER FROM CIRCUIT CONNECTIONS.

ASSEMBLY

1. Follow the instructions carefully. Read the entire step before you perform each operation.

2. 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.

3. Most kits use a separate "Illustration Booklet" that contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. Keep the "Illustration Booklet" with the Assembly Manual. The illustrations in it are arranged in Pictorial number sequence.

4. Position all parts as shown in the Pictorials.

5. Solder a part or a group of parts only when you are instructed to do so.

6. Each circuit part in an electronic kit has its own component number (R2, C4, etc.). Use these numbers when you want to identify the same part in the various sections of the Manual. These numbers, which are especially useful if a part has to be replaced, appear:

   — In the Parts List,

   — At the beginning of each step where a component is installed,

   — In some illustrations,

   — In the Schematic,

   — In the section at the rear of the Manual.

7. 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.

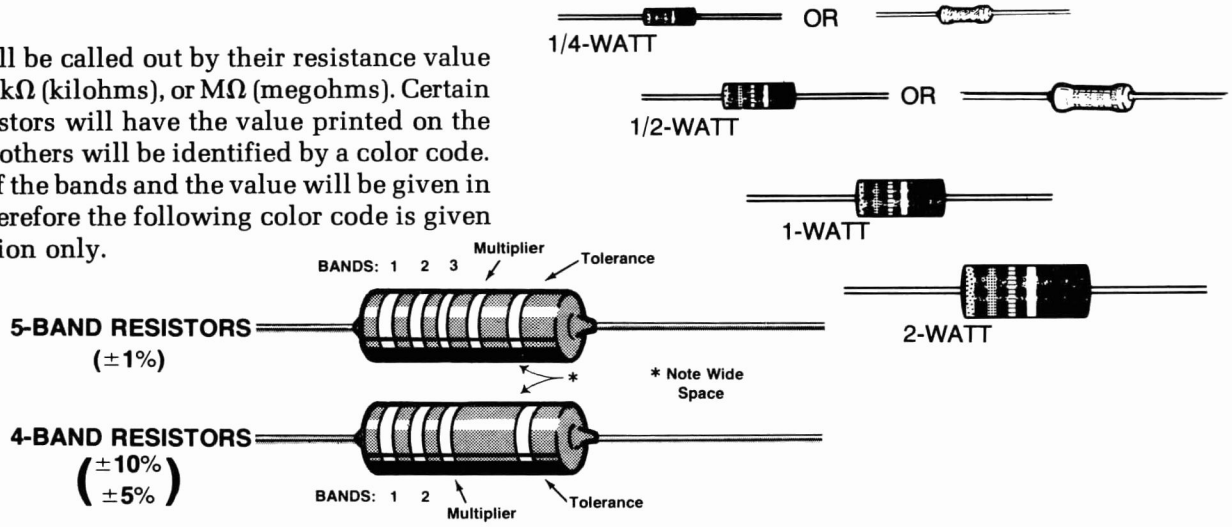
It is easy to make a good solder connection if you follow a few simple rules:

1. Use the right type of soldering iron. A 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.

PARTS

Resistors will be called out by their resistance value in Ω (ohms), kΩ (kilohms), or MΩ (megohms). Certain types of resistors will have the value printed on the body, while others will be identified by a color code. The colors of the bands and the value will be given in the steps, therefore the following color code is given for information only.



Band 1 1st Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

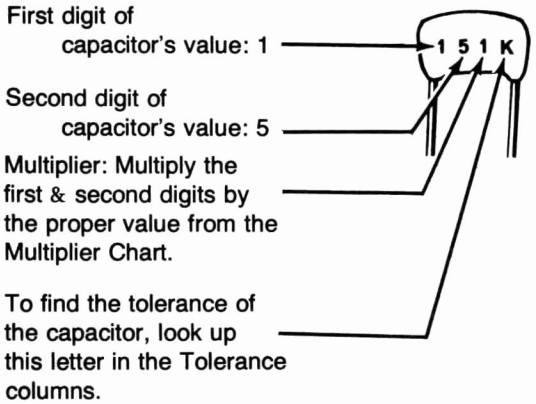
Band 2 2nd Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Band 3 (if used) 3rd Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Multiplier	
Color	Multiplier
Black	1
Brown	10
Red	100
Orange	1,000
Yellow	10,000
Green	100,000
Blue	1,000,000
Silver	0.01
Gold	0.1

Resistance Tolerance	
Color	Tolerance
Silver	±10%
Gold	± 5%
Brown	± 1%

Capacitors will be called out by their capacitance value in μF (microfarads) or pF (picofarads) and type: ceramic, Mylar*, electrolytic, etc. Some capacitors may have their value printed in the following manner:



EXAMPLES:

151K = 15 × 10 = 150 pF
759 = 75 ×0.1 = 7.5 pF

NOTE: The letter "R" may be used at times to signify a decimal point: as in: 2R2 = 2.2 (pF or μF).

MULTIPLIER		TOLERANCE OF CAPACITOR		
FOR THE NUMBER:	MULTIPLY BY:	10 pF OR LESS	LETTER	OVER 10 pF
0	1	±0.1 pF	B	
1	10	±0.25 pF	C	
2	100	±0.5 pF	D	
3	1000	±1.0 pF	F	±1%
4	10,000	±2.0 pF	G	±2%
5	100,000		H	±3%
			J	±5%
8	0.01		K	±10%
9	0.1		M	±20%

*DuPont Registered Trademark

VERTICAL CIRCUIT BOARD

PARTS LIST

Remove the parts from the pack marked #1. Check each part against the following list. The key numbers correspond to the numbers on the Vertical Circuit Board Parts Pictorial (Illustration Booklet, Pages 1 and 2). Any part that is in an individual envelope with the part number on it should be placed back into 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.

Some parts are marked with a "171-" or "172-" packaging number. These numbers are used for packaging purposes only and do not appear in the "Manual Parts List."

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. For prices, refer to the separate "Heath Parts Price List."

RESISTORS

All resistors are 5% (fourth band gold) unless designated 10% (fourth band silver).

NOTE: The resistors may be packed in more than one envelope (stamped RES). Open all the resistor envelopes in this pack before you check the resistors against the Parts List.

1/2-Watt

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	6-279	3	2.7 Ω (Red-Viol-Gold)	R179, R181, R182
A1	6-100	20	10 Ω (Brn-Blk-Blk)	R124A, R124B, R131A, R131B, R142A, R142B, R145A, R145B, R157A, R157B, R158A, R158B, R159A, R159B, R164A, R164B, R166, R168, R174, R175
A1	6-220	4	22 Ω (Red-Red-Blk)	R147A, R147B, R148A, R148B

Resistors (Cont'd.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	6-330	8	33 Ω (Org-Org-Blk)	R1A, R1B, R2A, R2B, R105A, R105B R106A, R106B
A1	6-390	2	39 Ω (Org-Wht-Blk)	R151A, R151B
A1	6-470	2	47 Ω (Yel-Viol-Blk)	R134A, R134B
A1	6-820	2	82 Ω (Gry-Red-Blk)	R144A, R144B
A1	6-101	6	100 Ω (Brn-Blk-Brn)	R161A, R161B R162A, R162B R171, R172
A1	6-201	2	200 Ω (Red-Blk-Brn)	R117A, R117B
A1	6-221	8	220 Ω (Red-Red-Brn)	R111A, R111B R113A, R113B R114A, R114B R183, R184
A1	6-271	2	270 Ω (Red-Viol-Brn)	R108A, R108B
A1	6-331	2	330 Ω (Org-Org-Brn)	R116A, R116B
A1	6-391	6	390 Ω (Org-Wht-Brn)	R135A, R135B R139A, R139B R153A, R153B
A1	6-471	2	470 Ω (Yel-Viol-Brn)	R136A, R136B
A1	6-511	2	510 Ω (Grn-Brn-Brn)	R115A, R115B
A1	6-751	2	750 Ω (Viol-Grn-Brn)	R163A, R163B

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
Resistors (Contd.)				
A1	6-102	20	1000 Ω (Brn-Blk-Red)	R104A, R104B, R133A, R133B, R141A, R141B, R146A, R146B, R149A, R149B, R156A, R156B, R165, R167, R185, R186, R187, R188, R191, R192
A1	6-122	2	1200 Ω (Brn-Red-Red)	R155A, R155B
A1	6-182	2	1800 Ω (Brn-Gry-Red)	R137A, R137B
A1	6-272	4	2700 Ω (Red-Viol-Red)	R118A, R118B, R122A, R122B
A1	6-332	4	3300 Ω (Org-Org-Red)	R119A, R119B, R121A, R121B
A1	6-912	2	9100 Ω (Wht-Brn-Red)	R103A, R103B
A1	6-103	4	10 kΩ (Brn-Blk-Org)	R109A, R109B, R154A, R154B
A1	6-153	2	15 kΩ (Brn-Grn-Org)	R132A, R132B
A1	6-223	1	22 kΩ (Red-Red-Org)	R169
A1	6-913	2	91 kΩ (Wht-Brn-Org)	R102A, R102B
A1	6-104	2	100 kΩ (Brn-Blk-Yel)	R107A, R017B
A1	6-914	2	910 kΩ (Wht-Brn-Yel)	R101A, R101B
Other Resistors				
A2	6-1801-11	4	1800 Ω (1.8 k) 1/8-watt, 1% (Brn-Gry-Blk-Brn)	R123A, R123B, R127A, R127B
A2	6-4320-11	4	432 Ω, 1/8-watt, 1% (Yel-Org-Red-Blk)	R125A, R125B, R126A, R126B
A3	1-19-1	1	220 Ω, 1-watt, 10% (Red-Red-Brn)	R173
A4	5-11-2	1	15 kΩ, 2-watt, 10% (Brn-Grn-Org)	R176
A5	3-55-5	2	2000 Ω (2 k), 5-watt	R177, R178
CAPACITORS				
Ceramic				
B1	21-7	2	33 pF	C117A, C117B
B1	21-121	4	56 pF	C112A, C112B, C116A, C116B
B1	21-75	1	100 pF	C121
B1	21-722	2	330 pF	C105A, C105B
B1	21-140	2	.001 μF	C128, C129
B1	21-36	2	.002 μF	C108A, C108B
Capacitors, Ceramic (Cont'd.)				
B1	21-141	1	.0033 μF	C131
B1	21-27	4	.005 μF	C107A, C107B, C135, C136
B1	21-47	3	.01 μF	C109A, C109B, C122
B1	21-31	1	.02 μF	C124
B1	21-199	2	.1 μF	C114A, C114B
Electrolytic				
B2	25-115	8	10 μF	C111A, C111B, C113A, C113B, C123, C132, C133, C134
B3	25-117	4	100 μF	C118A, C118B, C119A, C119B
B3	25-160	3	250 μF	C125, C126, C127
Trimmer				
B4	31-56	4	1.5 - 20 pF	C101A, C101B, C103A, C103B
B4	31-54	2	4-40 pF	C102A, C102B
B4	31-52	4	8-60 pF	C104A, C104B, C115A, C115B
B5	31-77	2	80-400 pF	C106A, C106B
Other Capacitors				
B6	27-28	2	.1 μF Mylar	C1, C2
DIODES				
C1	56-56	20	1N4149	D101A, D101B, D102A, D102B, D103A, D103B, D104A, D104B, D105A, D105B, D106A, D106B, D108A, D108B, D109A, D109B, D111A, D111B, D112A, D112B
C1	56-67	1	VR10A	D107
C1	56-89	4	GD510	D113, D114, D115, D116

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

TRANSISTORS-INTEGRATED CIRCUITS (IC's)

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

1. Part Number.
2. Type number. (On integrated circuits, this refers only to the numbers and letters listed. Any additional letters or numbers on an IC are not significant.)
3. Part number and type number.
4. Part number with a type number other than the one listed.

D1	417-235	8	2N4121 transistor	Q106A, Q106B, Q107A, Q107B, Q108A, Q108B, Q109A, Q109B
D1	417-237	2	SE6020 transistor	Q113, Q114
D1	417-260	4	2N4258A transistor	Q104A, Q104B, Q105A, Q105B
D1	417-293	4	2N5770 transistor	Q111A, Q111B, Q112A, Q112B
D1	417-801	4	MPSA20 transistor	Q103A, Q103B, Q117, Q118
D2	417-834	2	MPSU10 transistor	Q115, Q116
D3	417-902	4	5566 transistor	Q101A, Q101B, Q102A, Q102B
D4	443-1	1	7400 IC	U101
D4	443-4	1	7472 IC	U102

OTHER CIRCUIT COMPONENTS

E1	10-357	2	100 Ω control	R112A, R112B
E2	10-917	3	200 Ω control	R152A, R152B, R189
E2	10-918	2	500 Ω control	R143A, R143B
E2	10-936	2	1000 Ω (1K) control	R138A, R138B
E3	10-1118	2	1000 Ω (1K) control	R4A, R4B
E4	60-73	2	DP3T 3-position slide switch	SW1A, SW1B
E5	60-624	1	DP4T 4-position slide switch	SW3
E6	63-1316	2	Rotary switch with 5000 Ω (5K) control	SW2A-R3A, SW2B-R3B
E7	475-16	2	Ferrite bead	

HARDWARE

#4 Hardware

F1	250-428	1	4-40 × 1/4" flat head screw
F2	250-52	2	4-40 × 1/4" screw
F3	250-186	4	#4 × 3/8" screw
F4	252-15	3	4-40 nut
F5	254-9	3	#4 lockwasher

#6 Hardware

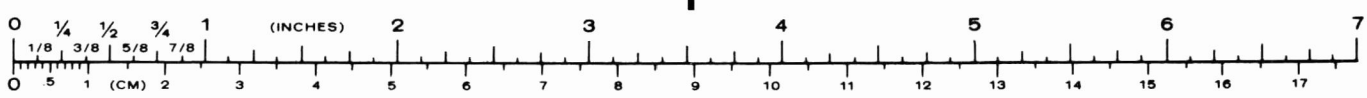
G1	250-1282	3	6-32 × 1/8" black setscrew
G2	250-33	4	6-32 × 1/8" setscrew
G3	250-416	4	6-32 × 1/4" flat head screw
G4	250-56	4	6-32 × 1/4" screw
G5	252-3	4	6-32 nut
G6	254-1	4	#6 lockwasher

Other Hardware

H1	253-50	2	1/4" plastic spacer
H2	252-7	4	3/8-32 nut
H3	255-145	2	3/8" spacer

MISCELLANEOUS

J1	75-769	1	Slide switch cover (1-7/16")	
J2	75-770	1	Slide switch cover (29/32")	
J3	266-1008	1	Slide switch cover (1-3/16")	
	85-2043-1	1	Vertical circuit board	
J4	204-2315	1	Switch bracket	
J5	204-2333	2	Control bracket	
J6	206-1273	1	Circuit board shield	
J7	215-95	2	Heat sink	
	343-15	4'	Shielded cable	
	344-51	3'	Brn wire	
	346-1	8-1/2"	Sleeving	
	347-55	1-1/2'	8-conductor flat cable	
	390-1436	1	Metal front panel	
J8	432-892	2	BNC connector	J1, J2
J9	434-230	4	8-pin IC socket	
J10	434-298	2	14-pin IC socket	
J11	453-66	2	5" extension shaft	
J12	455-44	2	Split plastic bushing	
J13	456-7	2	Shaft coupling	
J14	462-1049	1	Red knob	
J15	462-1050	2	Small black knob	
J16	462-1055	1	Large black knob	
L1	490-5	1	Plastic nut starter	
	134-237	1	Cable with connector	
L2	260-16	2	Alligator clip	
L3	73-34	2	Red alligator clip insulator	
	390-147	1	Danger label	
	390-1255	1	Fuse label	
	390-1483	1	Power consumption label	
	391-34	1	Blue and white label	
	597-260	1	Parts Order Form	
			Solder	
			Assembly Manual (See Page 1 for Part Number)	



STEP-BY-STEP ASSEMBLY

START

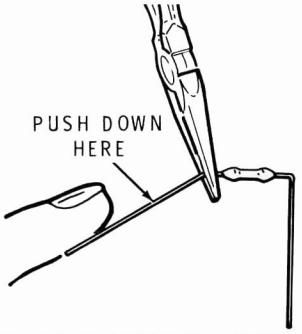
In the following steps, you will be given detailed instructions on how to install and solder the first part on the circuit board. Read and perform each step carefully. Then use the same procedure whenever you install parts on a circuit board.

NOTE: Only a portion of the circuit board is shown in some of the following Pictorials. The small "Identification Drawing" at the top of the page shows the area of the circuit board to be assembled.

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

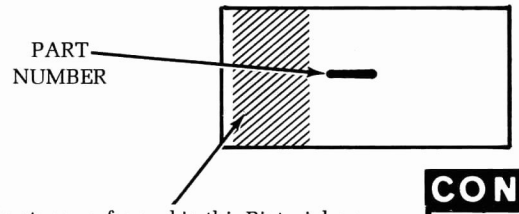
NOTE: When you install a component that has its value printed on it, position the value marking up, so it can be easily read. Diodes should be mounted with their type or part number up, if possible.

( ) Hold a 910 kΩ (Wht-Brn-Yel) resistor with long-nose pliers and bend the leads straight down to fit the hole spacing on the circuit board.



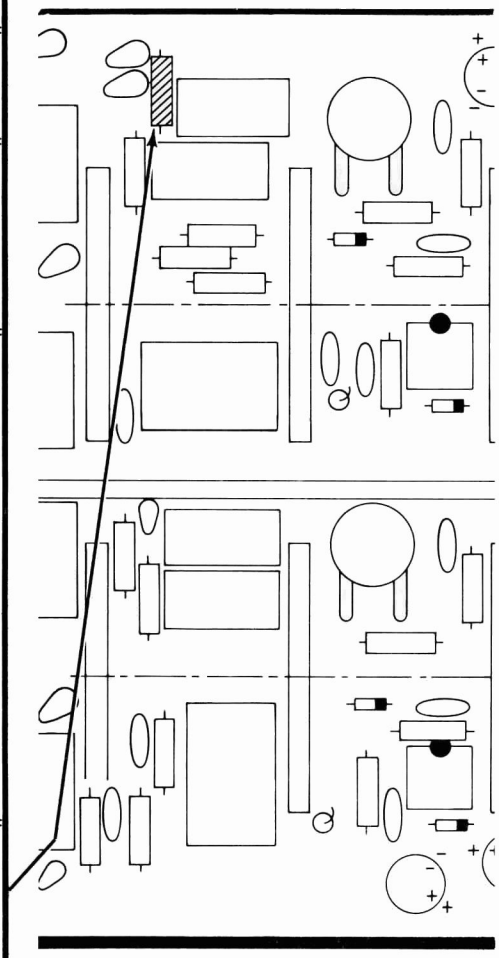
( ) R101B: Push the leads through the holes at the indicated location on the circuit board. The end with color bands may be positioned either way.

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



IDENTIFICATION
DRAWING

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

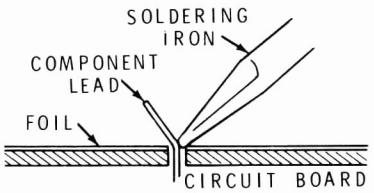


PICTORIAL 1-1

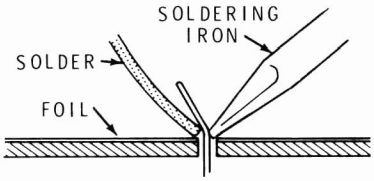
CONTINUE

( ) Turn the circuit board over and solder the resistor leads to the foil as follows:

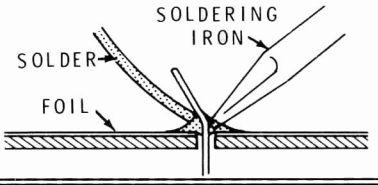
1. Push the soldering iron tip against both the lead and the circuit board foil. Heat **both** for two or three seconds.



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



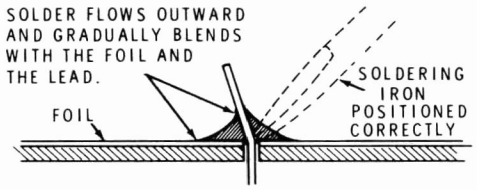
3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



( ) Cut off the excess lead lengths close to the connection. WARNING: Clip the leads so the ends will not fly toward your eyes.

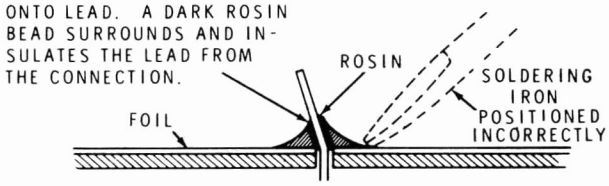
( ) Check each connection. Compare it to the illustrations on Page 12. After you have checked the solder connections, proceed with the assembly on Page 13. Use the same soldering procedure for each connection.

A GOOD SOLDER CONNECTION

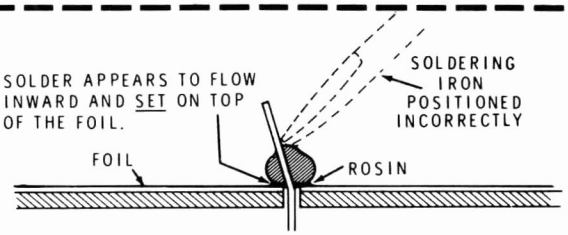


When you heat the lead and the circuit board foil at the same time, the solder will flow evenly onto the lead and the foil. The solder will make a good electrical connection between the lead and the foil.

POOR SOLDER CONNECTIONS



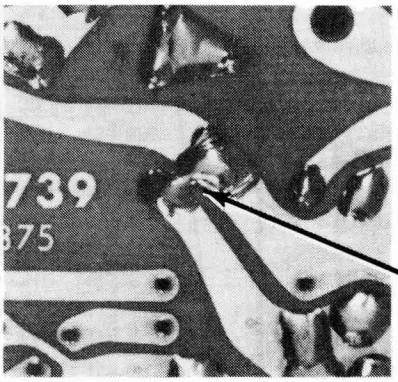
When the lead is not heated sufficiently, the solder will not flow onto the lead as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.



When the foil is not heated sufficiently the solder will blob on the circuit board as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

SOLDER BRIDGES

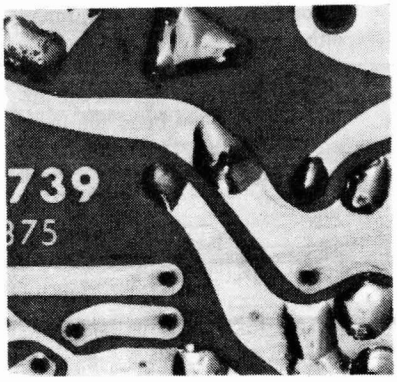
A solder bridge between two adjacent foils is shown in photograph **A**. Photograph **B** shows how the connection should appear. A solder bridge may occur if you accidentally touch an adjacent previously soldered connection, if you use too much solder, or if you "drag" the soldering iron across other 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.



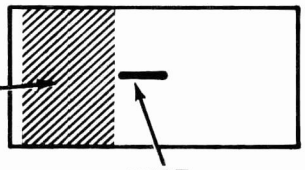
A

SOLDER BRIDGE

B



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 most circuit boards has a coating on it called "solder resist." This is a protective insulation to help prevent solder bridges.



IDENTIFICATION DRAWING

START

NOTE: Be sure you installed resistor R101B in Pictorial 1-1 (Page 11).

( ) R102B: 91 kΩ (Wht-Brn-Org).

( ) R105B: 1.5 Ω (Brn-Grn-Gold). NOTE: Your circuit board may be marked **33** at this location.

( ) R103B: 9100 Ω (Wht-Brn-Red).

( ) R104B: 1000 Ω (Brn-Blk-Red).

( ) R101A: 910 kΩ (Wht-Brn-Yel).

( ) R102A: 91 kΩ (Wht-Brn-Org).

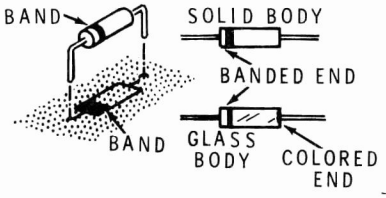
( ) R103A: 9100 Ω (Wht-Brn-Red).

( ) R104A: 1000 Ω (Brn-Blk-Red).

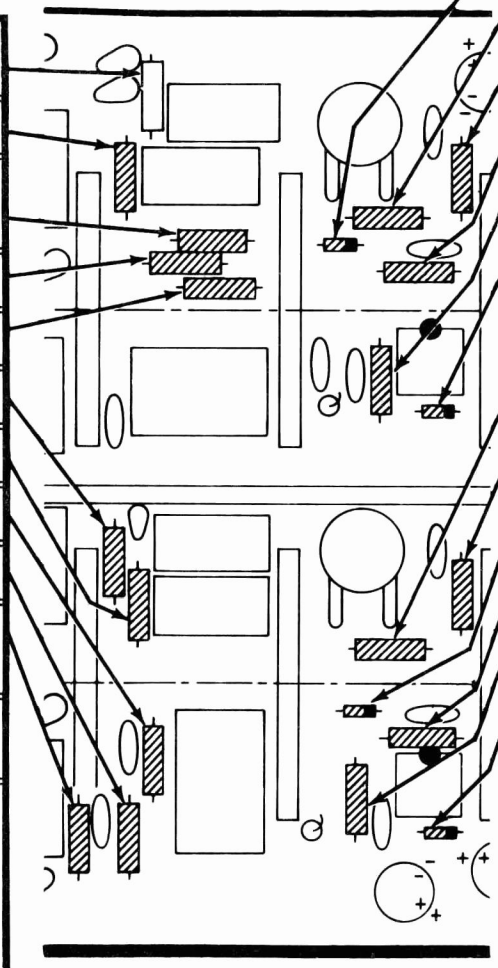
( ) R105A: 1.5 Ω (Brn-Grn-Gold). NOTE: Your circuit board may be marked **33** at this location.

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

NOTE: When you install a diode, always match the band on the diode with the band mark on the circuit board. A DIODE WILL NOT WORK PROPERLY IF IT IS INSTALLED BACKWARDS. See Detail 1-2A.



If your diode has a solid body, the band is clearly defined. If your diode has a glass body, do not mistake the colored end inside the diode for the banded end. Look for a band painted on the outside of the glass.



PICTORIAL 1-2

CONTINUE

( ) D102B: Selected transistor (#417-854). See Detail 1-2B.

( ) R111B: 220 Ω (Red-Red-Brn).

( ) R109B: 10 kΩ (Brn-Blk-Org).

( ) R108B: 270 Ω (Red-Viol-Brn).

( ) R107B: 100 kΩ (Brn-Blk-Yel).

( ) D101B: Selected transistor (#417-854). See Detail 1-2B.

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

( ) R111A: 220 Ω (Red-Red-Brn).

( ) R109A: 10 kΩ (Brn-Blk-Org).

( ) D102A: Selected transistor (#417-854). See Detail 1-2B.

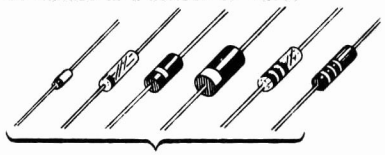
( ) R108A: 270 Ω (Red-Viol-Brn).

( ) R107A: 100 kΩ (Brn-Blk-Yel).

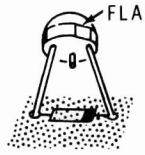
( ) D101A: Selected transistor (#417-854). See Detail 1-2B.

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

IMPORTANT: THE BANDED END OF DIODES CAN BE MARKED IN A NUMBER OF WAYS.



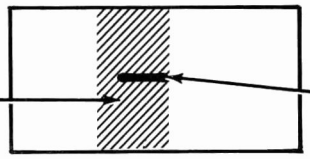
Detail 1-2A



Detail 1-2B

IDENTIFICATION DRAWING

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



PART NUMBER

START

( ) R113B: 220 Ω (Red-Red-Brn).

( ) R117B: 200 Ω (Red-Blk-Brn).

( ) R116B: 330 Ω (Org-Org-Brn).

( ) R123B: 1800 Ω (1.8 k), 1% (Brn-Gry-Blk-Brn).

( ) R131B: 10 Ω (Brn-Blk-Blk).

( ) R127B: 1800 Ω (1.8 k), 1% (Brn-Gry-Blk-Brn).

( ) R115B: 510 Ω (Grn-Brn-Brn).

( ) R114B: 220 Ω (Red-Red-Brn).

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

( ) R117A: 200 Ω (Red-Blk-Brn).

( ) R116A: 330 Ω (Org-Org-Brn).

NOTE: When a bare wire is called for in a step, remove all the insulation from the specified length of brown wire.

( ) 1" bare wire.

( ) R125A: 432 Ω, 1% (Yel-Org-Red-Blk).

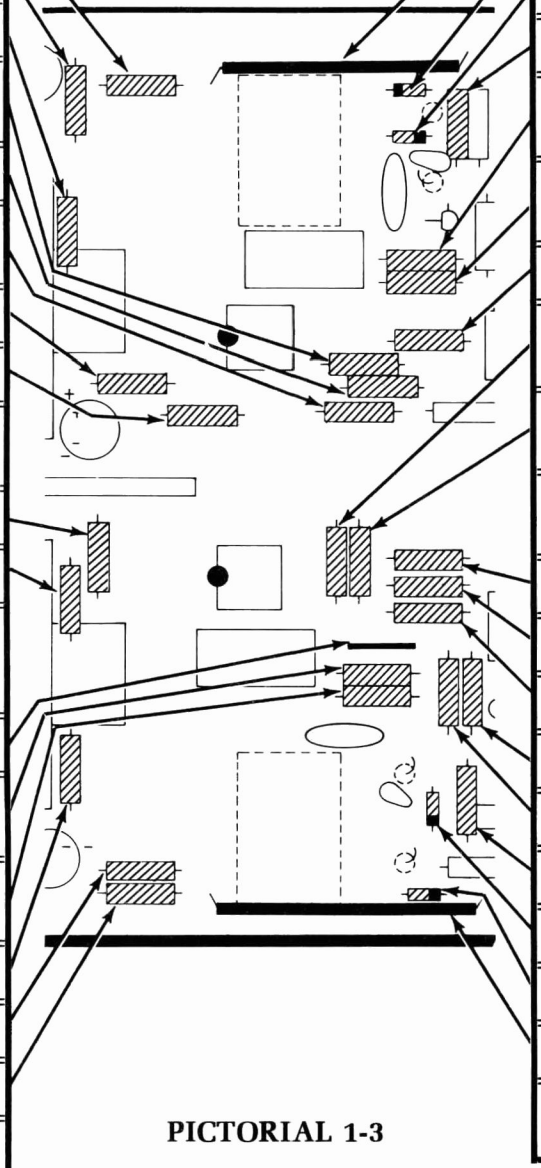
( ) R126A: 432 Ω, 1% (Yel-Org-Red-Blk).

( ) R115A: 510 Ω (Grn-Brn-Brn).

( ) R114A: 220 Ω (Red-Red-Brn).

( ) R113A: 220 Ω (Red-Red-Brn).

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



PICTORIAL 1-3

CONTINUE

NOTE: When a wire is called for in a step, cut the brown wire to the specified length. Then remove 1/4" of insulation from each end.

( ) 2-1/4" Brn wire.

( ) D104B: 1N4149 diode (#56-56).

( ) D103B: 1N4149 diode (#56-56).

( ) R118B: 2700 Ω (Red-Viol-Red).

( ) R126B: 432 Ω, 1% (Yel-Org-Red-Blk).

( ) R125B: 432 Ω, 1% (Yel-Org-Red-Blk).

( ) R124B: 10 Ω (Brn-Blk-Blk).

( ) R127A: 1800 Ω (1.8 k), 1% (Brn-Gry-Blk-Brn).

( ) R123A: 1800 Ω (1.8 k), 1% (Brn-Gry-Blk-Brn).

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

( ) R134A: 47 Ω (Yel-Viol-Blk).

( ) R131A: 10 Ω (Brn-Blk-Blk).

( ) R124A: 10 Ω (Brn-Blk-Blk).

( ) R132A: 15 kΩ (Brn-Grn-Org).

( ) R122A: 2700 Ω (Red-Viol-Red).

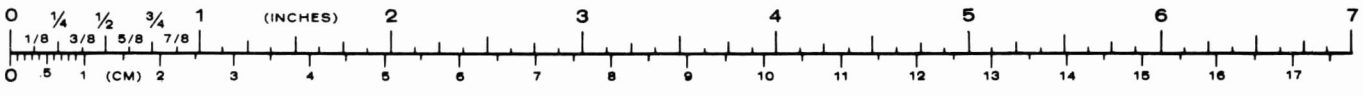
( ) R136A: 470 Ω (Yel-Viol-Brn).

( ) D104A: 1N4149 diode (#56-56).

( ) D103A: 1N4149 diode (#56-56).

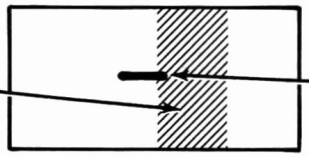
( ) 2-3/8" Brn wire.

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



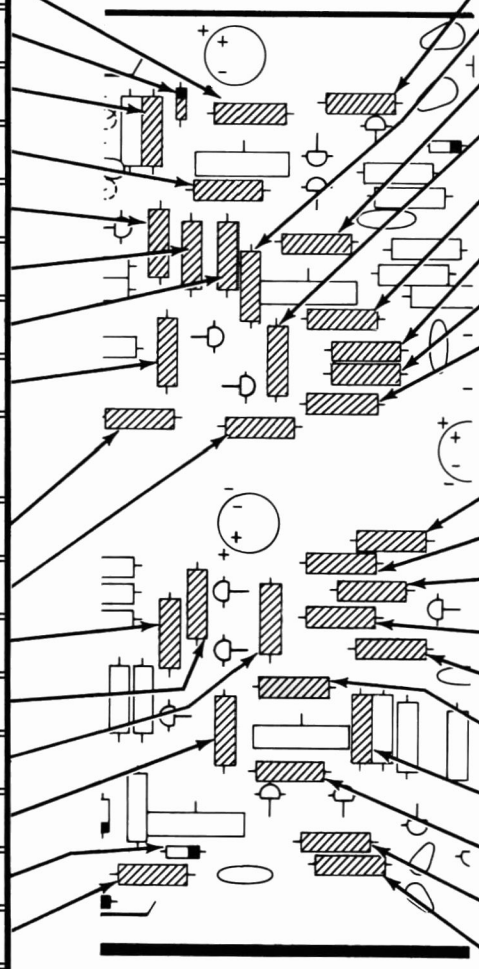
IDENTIFICATION DRAWING

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



START

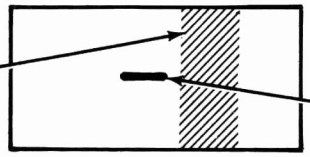
( ) R149B: 1000 Ω (Brn-Blk-Red).
( ) D105B: 1N4149 diode (#56-56).
( ) R136B: 470 Ω (Yel-Viol-Brn).
( ) R137B: 1800 Ω (Brn-Gry-Red).
( ) R122B: 2700 Ω (Red-Viol-Red).
( ) R132B: 15 kΩ (Brn-Grn-Org).
( ) R145B: 10 Ω (Brn-Blk-Blk).
( ) R139B: 390 Ω (Org-Wht-Brn).
( ) Solder the leads to the foil and cut off the excess lead lengths.
( ) R134B: 47 Ω (Yel-Viol-Blk).
( ) R135B: 390 Ω (Org-Wht-Brn).
( ) R139A: 390 Ω (Org-Wht-Brn).
( ) R135A: 390 Ω (Org-Wht-Brn).
( ) R156A: 1000 Ω (Brn-Blk-Red).
( ) R137A: 1800 Ω (Brn-Gry-Red).
( ) D105A: 1N4149 diode (#56-56).
( ) R118A: 2700 Ω (Red-Viol-Red).
( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

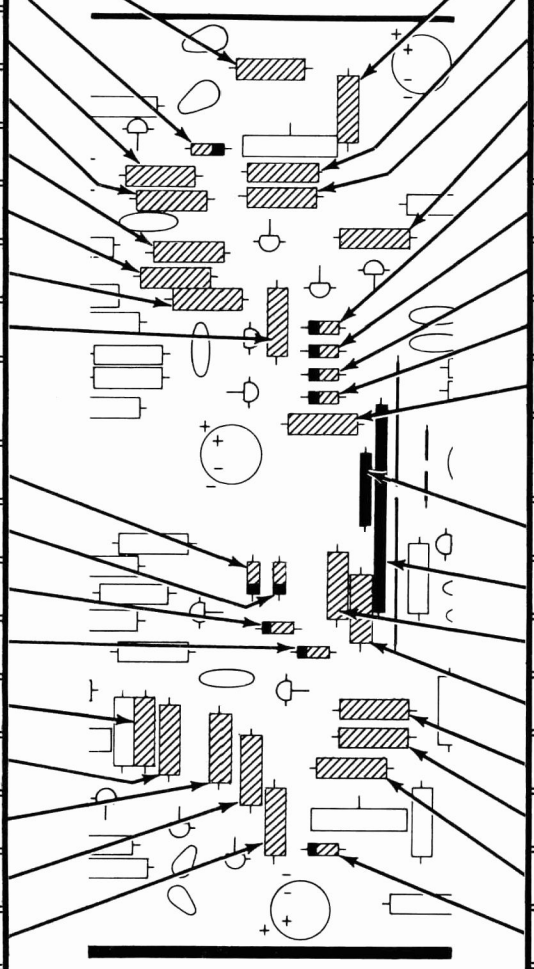
( ) R155B: 1200 Ω (Brn-Red-Red).
( ) R144B: 82 Ω (Gry-Red-Blk).
( ) R142B: 10 Ω (Brn-Blk-Blk).
( ) R156B: 1000 Ω (Brn-Blk-Red).
( ) R141B: 1000 Ω (Brn-Blk-Red).
( ) R158B: 10 Ω (Brn-Blk-Blk).
( ) R157B: 10 Ω (Brn-Blk-Blk).
( ) R133B: 1000 Ω (Brn-Blk-Red).
( ) Solder the leads to the foil and cut off the excess lead lengths.
( ) R159A: 10 Ω (Brn-Blk-Blk).
( ) R133A: 1000 Ω (Brn-Blk-Red).
( ) R157A: 10 Ω (Brn-Blk-Blk).
( ) R141A: 1000 Ω (Brn-Blk-Red).
( ) R158A: 10 Ω (Brn-Blk-Blk).
( ) R144A: 82 Ω (Gry-Red-Blk).
( ) R142A: 10 Ω (Brn-Blk-Blk).
( ) R154A: 10 Ω (Brn-Blk-Blk).
( ) R148A: 22 Ω (Red-Red-Blk).
( ) R147A: 22 Ω (Red-Red-Blk).
( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-4



START

- ( ) R164B: 10 Ω (Brn-Blk-Blk).
- ( ) D106B: 1N4149 diode (#56-56).
- ( ) R146B: 1000 Ω (Brn-Blk-Red).
- ( ) R148B: 22 Ω (Red-Red-Blk).
- ( ) R147B: 22 Ω (Red-Red-Blk).
- ( ) R151B: 39 Ω (Org-Wht-Blk).
- ( ) R162B: 100 Ω (Brn-Blk-Brn).
- ( ) R161B: 100 Ω (Brn-Blk-Brn).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) D109A: 1N4149 diode (#56-56).
- ( ) D111A: 1N4149 diode (#56-56).
- ( ) D108A: 1N4149 diode (#56-56).
- ( ) D112A: 1N4149 diode (#56-56).
- ( ) R146A: 1000 Ω (Brn-Blk-Red).
- ( ) R149A: 1000 Ω (Brn-Blk-Red).
- ( ) R155A: 1200 Ω (Brn-Red-Red).
- ( ) R151A: 39 Ω (Org-Wht-Blk).
- ( ) R154A: 10 kΩ (Brn-Blk-Org).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.



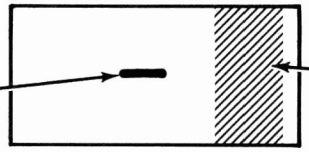
CONTINUE

- ( ) R163: 750 Ω (Viol-Grn-Brn).
- ( ) R153B: 390 Ω (Org-Wht-Brn).
- ( ) R154B: 10 kΩ (Brn-Blk-Org).
- ( ) R187: 1000 Ω (Brn-Blk-Red).
- ( ) D111B: 1N4149 diode (#56-56).
- ( ) D112B: 1N4149 diode (#56-56).
- ( ) D109B: 1N4149 diode (#56-56).
- ( ) D108B: 1N4149 diode (#56-56).
- ( ) R159B: 10 Ω (Brn-Blk-Blk).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) 1" Brn wire.
- ( ) 2" Brn wire.
- ( ) R165: 1000 Ω (Brn-Blk-Red).
- ( ) R167: 1000 Ω (Brn-Blk-Red).
- ( ) R162A: 100 Ω (Brn-Blk-Brn).
- ( ) R161A: 100 Ω (Brn-Blk-Brn).
- ( ) R153A: 390 Ω (Org-Wht-Brn).
- ( ) D106A: 1N4149 diode (#56-56).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-5

IDENTIFICATION DRAWING

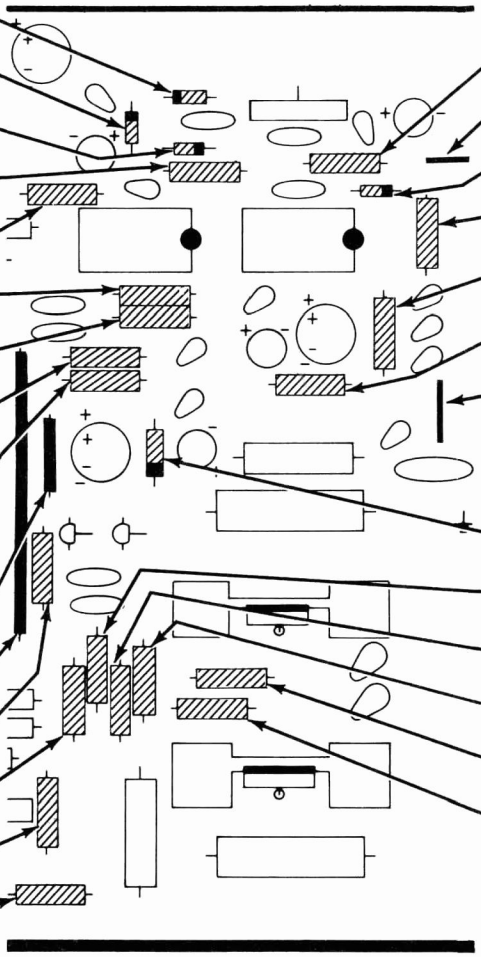
PART NUMBER



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

START

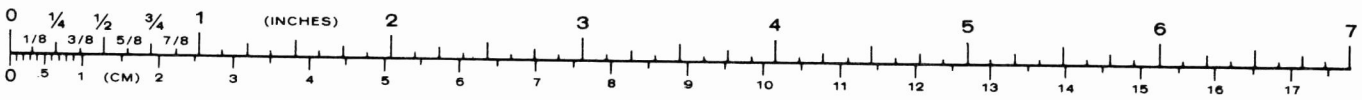
- ( ) D116: GD510 diode (#56-89).
- ( ) D114: GD510 diode (#56-89).
- ( ) D113: GD510 diode (#56-89).
- ( ) R192: 1000 Ω (Brn-Blk-Red).
- ( ) R186: 1000 Ω (Brn-Blk-Red).
- ( ) R188: 1000 Ω (Brn-Blk-Red).
- ( ) R185: 1000 Ω (Brn-Blk-Red).
- ( ) R184: 220 Ω (Red-Red-Brn).
- ( ) R183: 220 Ω (Red-Red-Brn).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) 1" Brn wire.
- ( ) 2-3/8" Brn wire.
- ( ) R166: 10 Ω (Brn-Blk-Blk).
- ( ) R171: 100 Ω (Brn-Blk-Brn).
- ( ) R163: 750 Ω (Viol-Grn-Brn).
- ( ) R164A: 10 Ω (Brn-Blk-Blk).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.



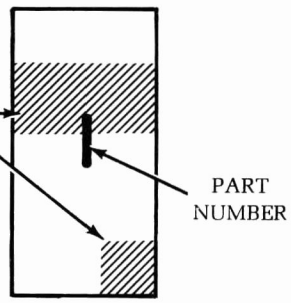
CONTINUE

- ( ) R191: 1000 Ω (Brn-Blk-Red).
- ( ) 1" bare wire.
- ( ) D115: GD510 diode (#56-89).
- ( ) R181: 2.7 Ω (Red-Viol-Gold).
- ( ) R182: 2.7 Ω (Red-Viol-Gold).
- ( ) R179: 2.7 Ω (Red-Viol-Gold).
- ( ) 1" bare wire.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) D107: VR10A diode (#56-67).
- ( ) R169: 22 kΩ (Red-Red-Org).
- ( ) R172: 100 Ω (Brn-Blk-Brn).
- ( ) R168: 10 Ω (Brn-Blk-Blk).
- ( ) R174: 10 Ω (Brn-Blk-Blk).
- ( ) R175: 10 Ω (Brn-Blk-Blk).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-6



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

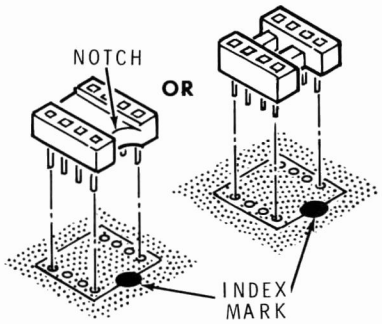


IDENTIFICATION DRAWING

START

( ) Reposition the circuit board as shown. Solder the pins to the foil as you install each part.

NOTE: When you install an IC socket, insert the pins into the circuit board holes. The index mark on the circuit board must still be visible after the socket is installed.



( ) 8-pin IC socket at Q101A.

( ) 8-pin IC socket at Q101B.

( ) 8-pin IC socket at Q102A.

( ) 8-pin IC socket at Q102B.

( ) 14-pin IC socket at U102.

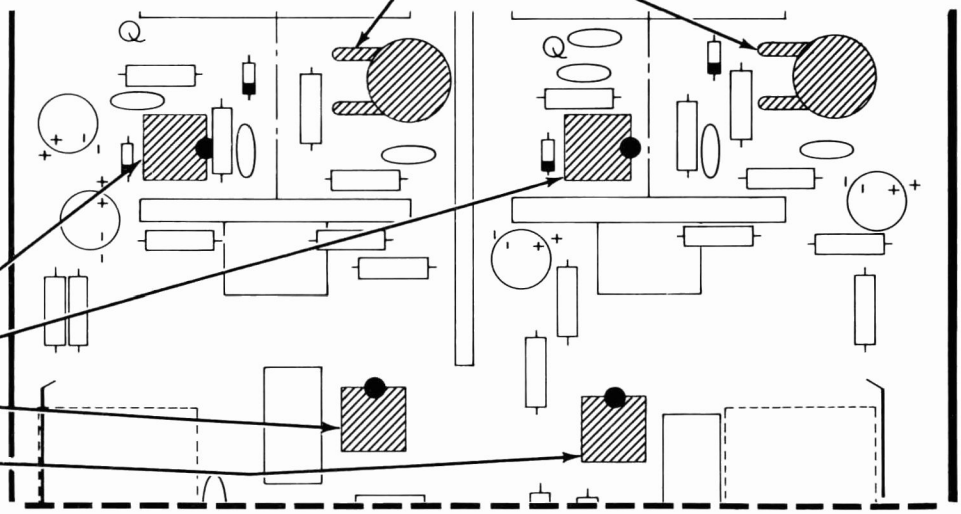
( ) 14-pin IC socket at U101.

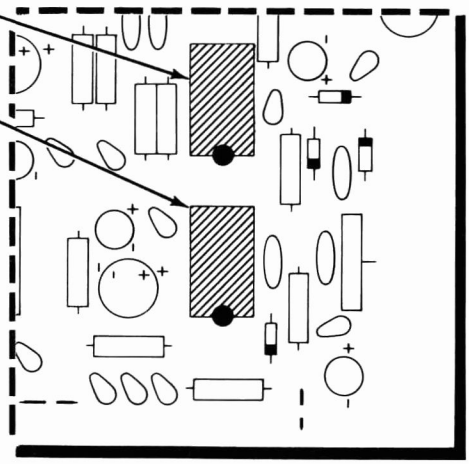
CONTINUE

NOTE: When you install a control, insert the pins into the circuit board holes and solder them to the foil.

( ) R112A: 100 Ω control (#10-357).

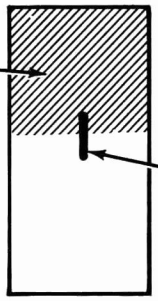
( ) R112B: 100 Ω control (#10-357).





PICTORIAL 1-7

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

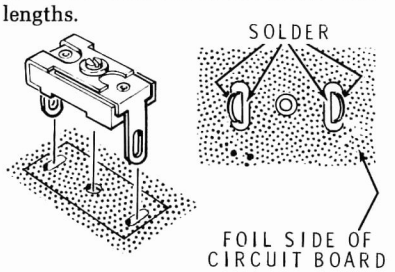


IDENTIFICATION DRAWING

PART NUMBER

START

NOTE: When you install a trimmer capacitor, insert its end leaves into the circuit board slots. Solder both sides of the end leaves to the foil as you install each trimmer. All the leaves must be soldered. Then cut off the excess leaf lengths.



( ) C102B: 4-40 pF trimmer (#31-54).

( ) C101B: 1.5-20 pF trimmer (#31-56).

( ) C102A: 4-40 pF trimmer (#31-54).

( ) C101A: 1.5-20 pF trimmer (#31-56).

( ) C104A: 8-60 pF trimmer (#31-52).

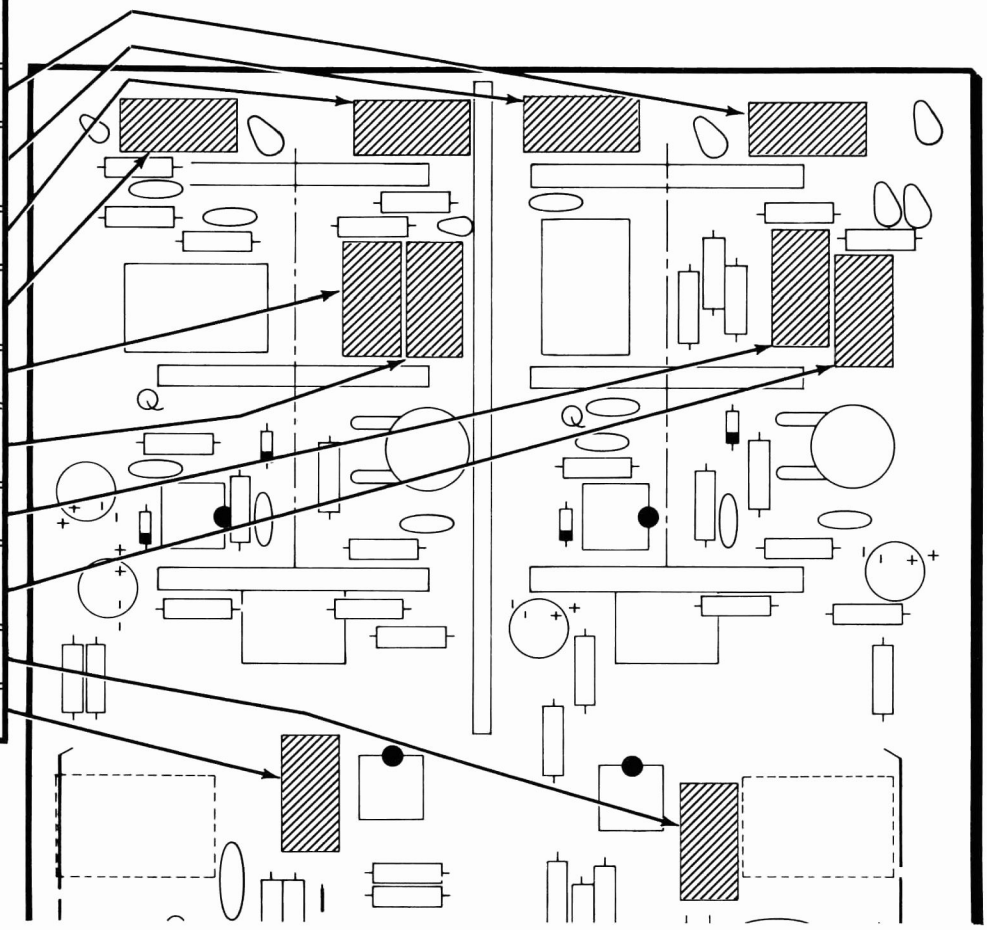
( ) C103A: 1.5-20 pF trimmer (#31-56).

( ) C104B: 8-60 pF trimmer (#31-52).

( ) C103B: 1.5-20 pF trimmer (#31-56).

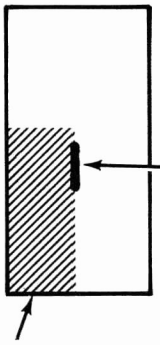
( ) C115A: 8-60 pF trimmer (#31-52).

( ) C115B: 8-60 pF trimmer (#31-52).



PICTORIAL 1-8

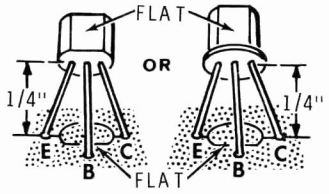
IDENTIFICATION DRAWING



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

START

NOTE: When you install a transistor in each of the following nine steps, align its flat with the flat on the board. Insert the leads into their correct E, B, and C holes. Position the transistor 1/4" above the board. Then solder the leads to the foil and cut off the excess lead lengths.



( ) Q103A: MPSA20 transistor (#417-801).

( ) Q107A: 2N4121 transistor (#417-235).

( ) Q106A: 2N4121 transistor (#417-235).

( ) Q109A: 2N4121 transistor (#417-235).

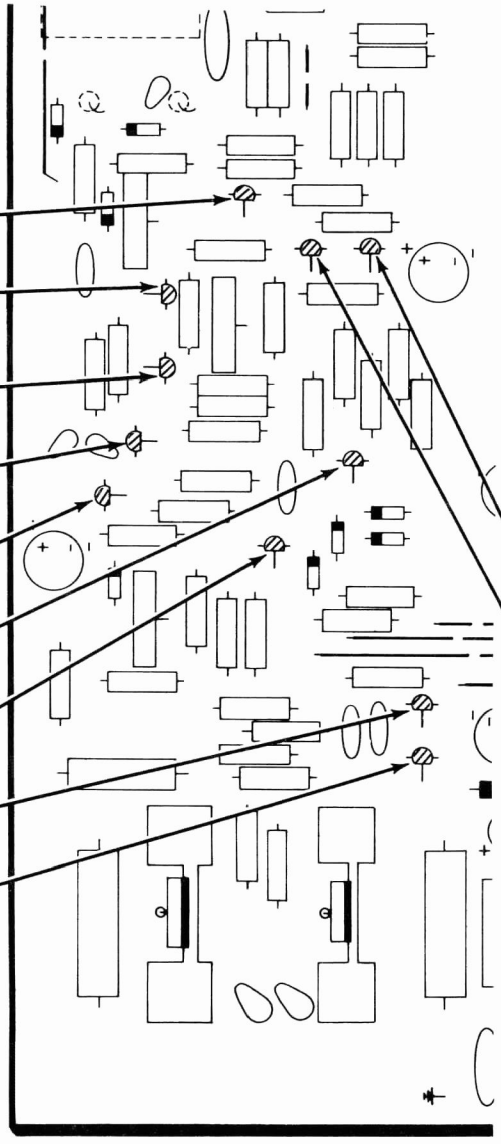
( ) Q108A: 2N4121 transistor (#417-235).

( ) Q111A: 2N5770 transistor (#417-293).

( ) Q112A: 2N5770 transistor (#417-293).

( ) Q113: SE6020 transistor (#417-237).

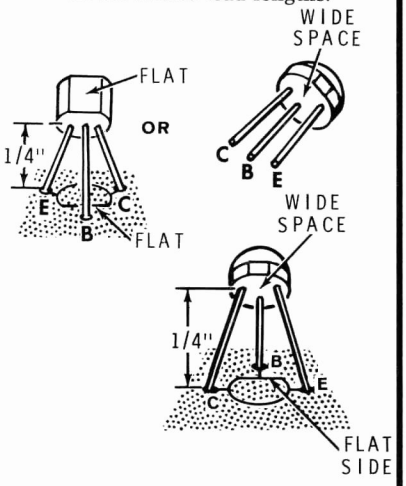
( ) Q114: SE6020 transistor (#417-237).



CONTINUE

NOTE: In the following four steps, install each of the transistors as follows:

1. Refer to the illustration example below and identify the E, B, and C leads of the transistor.
2. Insert the transistor leads into the corresponding E, B, and C holes in the circuit board.
3. Position the transistor approximately 1/4" above the circuit board.
4. Turn the circuit board over, solder the leads to the foil, and cut off the excess lead lengths.

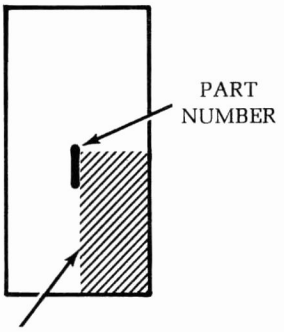


( ) Q104A: 2N4248 transistor (#417-260).

( ) Q105A: 2N4248 transistor (#417-260).

PICTORIAL 1-9

IDENTIFICATION DRAWING



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

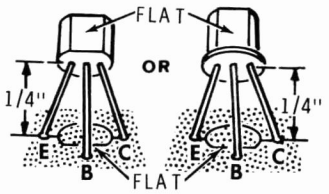
START

( ) Q104B: 2N4258 transistor (#417-260).

( ) Q105B: 2N4258 transistor (#417-260).

CONTINUE

NOTE: When you install a transistor in each of the following nine steps, align its flat with the flat on the board. Insert the leads into their correct E, B, and C holes. Position the transistor 1/4" above the board. Then solder the leads to the foil and cut off the excess lead lengths.



( ) Q103B: MPSA20 transistor (#417-801).

( ) Q106B: 2N4121 transistor (#417-235).

( ) Q107B: 2N4121 transistor (#417-235).

( ) Q109B: 2N4121 transistor (#417-235).

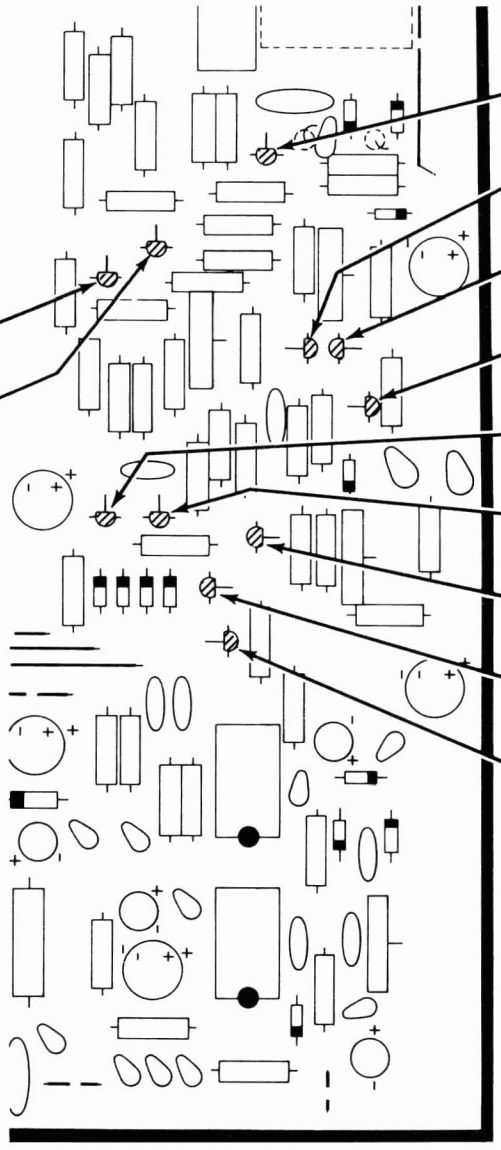
( ) Q111B: 2N5770 transistor (#417-293).

( ) Q112B: 2N5770 transistor (#417-293).

( ) Q108B: 2N4121 transistor (#417-235).

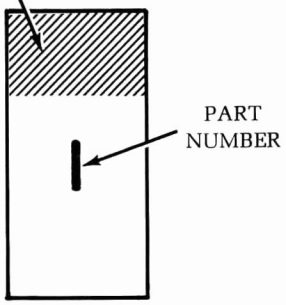
( ) Q117: MPSA20 transistor (#417-801).

( ) Q118: MPSA20 transistor (#417-801).



PICTORIAL 1-10

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



IDENTIFICATION
DRAWING

START

( ) C107B: .005 μF ceramic.

( ) C109B: .01 μF ceramic.

( ) C105B: 330 pF ceramic.

( ) C105A: 330 pF ceramic.

( ) C107A: .005 μF ceramic.

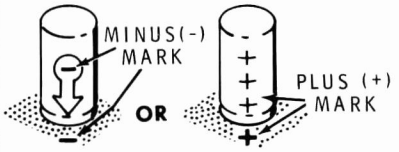
( ) C108B: .002 μF ceramic.

( ) C112B: 56 pF ceramic.

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

( ) C108A: .002 μF ceramic.

NOTE: When you install electrolytic capacitors, always match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board OR match the minus (−) mark on the capacitor with the minus (−) mark on the circuit board.



( ) C113A: 10 μF electrolytic.

( ) C111A: 10 μF electrolytic.

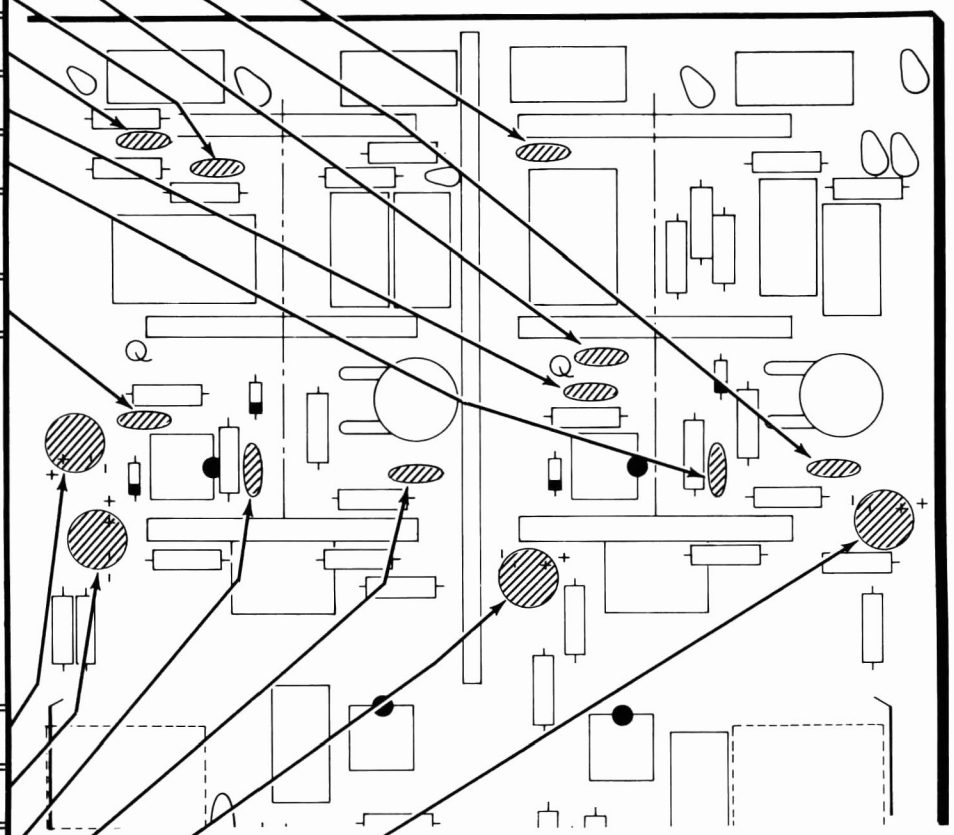
( ) C112A: 56 pF ceramic.

( ) C109A: .01 μF ceramic.

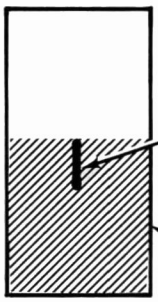
( ) C111B: 10 μF electrolytic.

( ) C113B: 10 μF electrolytic.

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



PICTORIAL 1-11



START

( ) C114A: .1 μF ceramic.

( ) C114B: .1 μF ceramic.

( ) C116A: 56 pF ceramic.

( ) C116B: 56 pF ceramic.

( ) C117B: 33 pF ceramic.

( ) C117A: 33 pF ceramic.

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

( ) C128: .001 μF ceramic.

( ) C129: .001 μF ceramic.

( ) C121: 100 pF ceramic.

( ) C122: .01 μF ceramic.

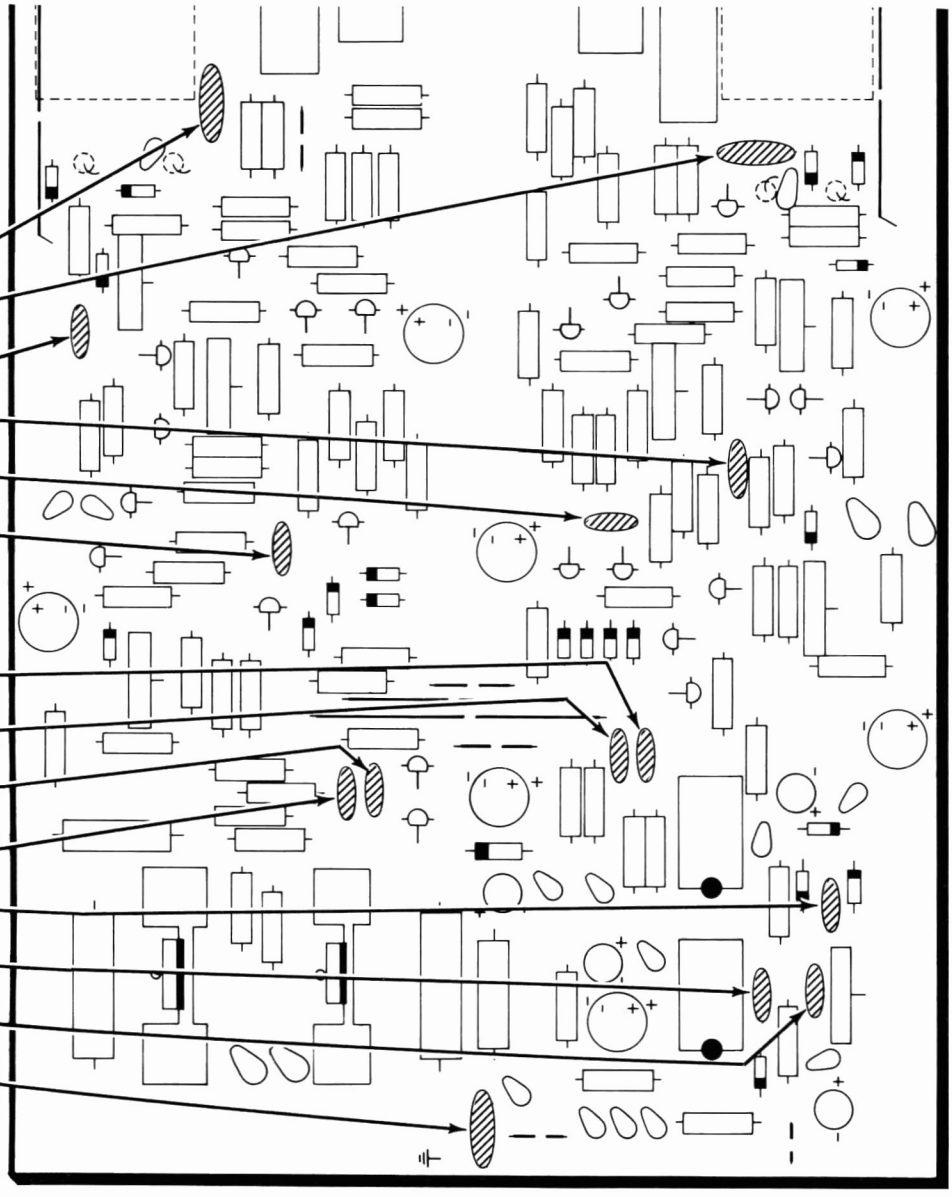
( ) C131: .0033 μF ceramic.

( ) C135: .005 μF ceramic.

( ) C136: .005 μF ceramic.

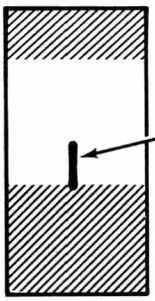
( ) C124: .02 μF ceramic.

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



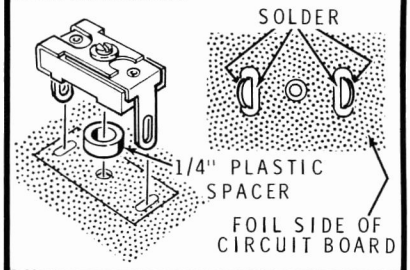
PICTORIAL 1-12

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



START

NOTE: When you install a trimmer capacitor, place a 1/4" plastic spacer over the screw and insert its end leaves into the circuit board slots. Solder both sides of the end leaves to the foil as you install each trimmer. All the leaves must be soldered.



( ) C106A: 80-400 pF trimmer (#31-77).

( ) C106B: 80-400 pF trimmer (#31-77).

( ) C118A: 100 μF electrolytic.

( ) C119B: 100 μF electrolytic.

( ) C118B: 100 μF electrolytic.

( ) C119A: 100 μF electrolytic.

( ) C126: 250 μF electrolytic.

( ) C133: 10 μF electrolytic.

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

( ) C125: 250 μF electrolytic.

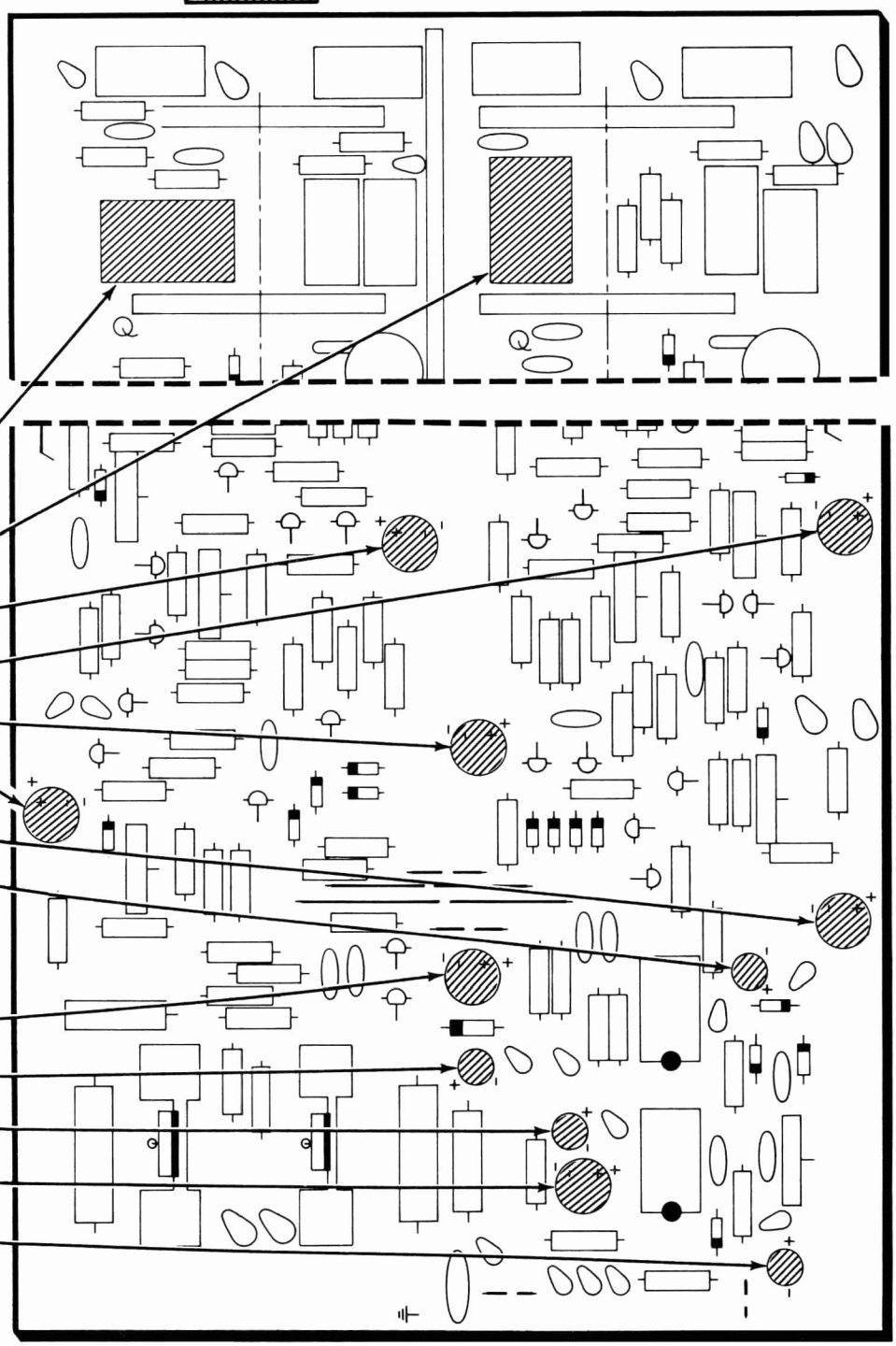
( ) C123: 10 μF electrolytic.

( ) C134: 10 μF electrolytic.

( ) C127: 250 μF electrolytic.

( ) C132: 10 μF electrolytic.

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



PICTORIAL 1-13

START

NOTE: Solder the leads or pins to the foil and cut off the excess lengths of each part as you install it.

When you install a control, be sure it is tight against and perpendicular to the circuit board. Do not cut off the pins.

( ) R138A: 1000 Ω (1 k) control (#10-936).

( ) R138B: 1000 Ω (1 k) control (#10-936).

( ) R143A: 500 Ω control (#10-918).

( ) R143B: 500 Ω control (#10-918).

( ) R152B: 200 Ω control (#10-917).

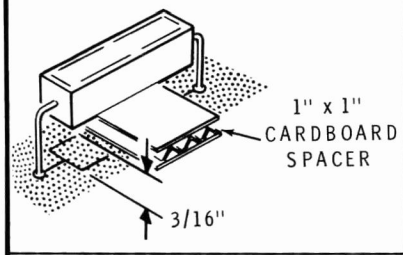
( ) R189: 200 Ω control (#10-917).

( ) R152A: 200 Ω control (#10-917).

( ) R176: 15 kΩ, 2-watt (Brn-Grn-Org).

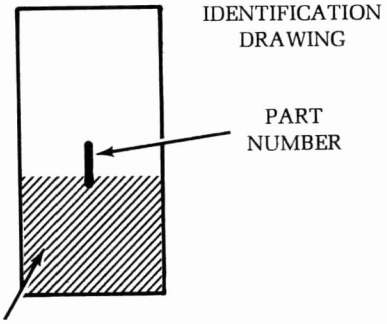
( ) R173: 220 Ω, 1-watt (Red-Red-Brn).

NOTE: When you are instructed to mount a resistor 3/16" above the circuit board as shown, use a 1" × 1" piece of 3/16" cardboard (from shipping carton) for a spacer. After the leads are soldered, remove the cardboard spacer.

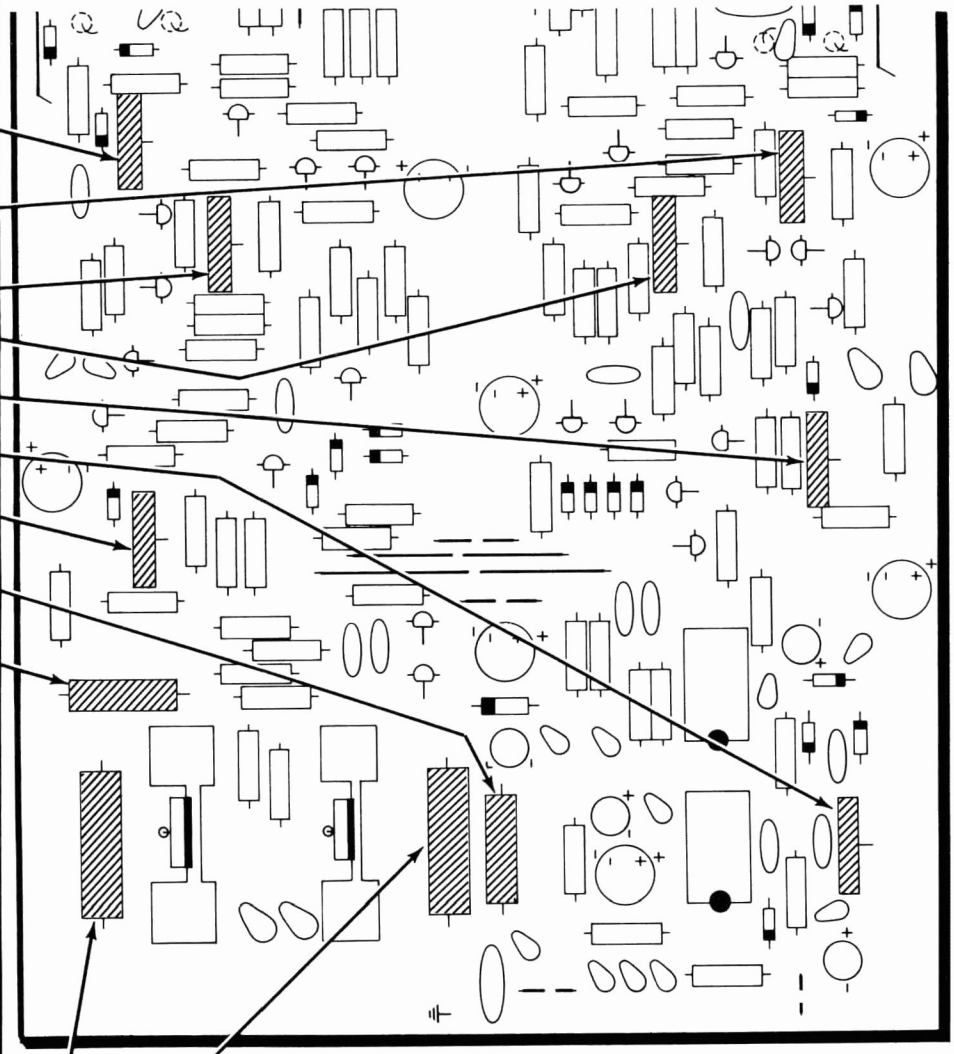


( ) R178: 2000 Ω, 5-watt (3/16" above board).

( ) R177: 2000 Ω, 5-watt (3/16" above board).



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



PICTORIAL 1-14

Refer to Pictorial 1-15 (Illustration Booklet, Page 3) for the following steps.

NOTE: When you install a transistor or integrated circuit (IC) in the following steps, be sure to match the pin 1 end of the transistor or IC to the index mark on the circuit board. See Detail 1-15A.

( ) Q101A: Install a 5566 transistor (#417-902) at location Q101A.

( ) Q101B: Install a 5566 transistor (#417-902) at location Q101B.

( ) Q102A: Install a 5566 transistor (#417-902) at location Q102A.

( ) Q102B: Install a 5566 transistor (#417-902) at location Q102B.

( ) U102: Install a 7472IC (#443-4) at location U102.

( ) U101: Install a 7400 IC (#443-1) at location U101.

( ) SW2B - R3B: Refer to Detail 1-5B and mount a rotary switch with 5000 Ω (5 k) control (#63-1316) at its location on the printed side of the circuit board as follows:

1. Carefully align the pins of the front wafer (A) with their holes in the circuit board.

2. Fit the pins of each switch wafer, one wafer at a time, into their board holes until all the switch and control pins are in place. Then push the switch down tight against the circuit board.

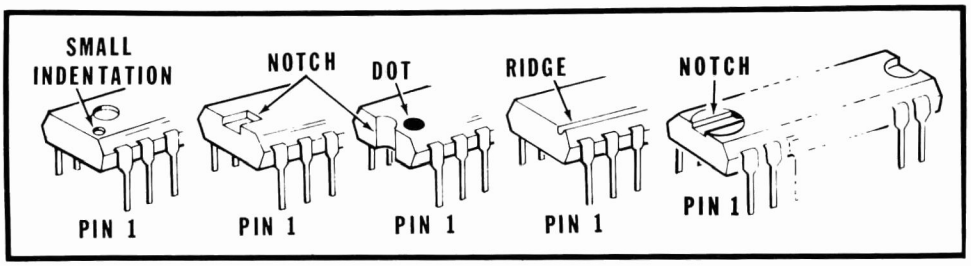
3. Carefully turn the circuit board over and solder **only** the end pins of each wafer to the foil. Inspect these switch pins to make sure all the pins are tight against the printed side of the circuit board. If they are not, reheat the connection and push the switch tight against the board. Then solder all the remaining switch and control pins to the foil.

( ) SW2A - R3A: In the same manner, install the other rotary switch with 5000 Ω (5 k) control (#63-1316) at its location on the circuit board.

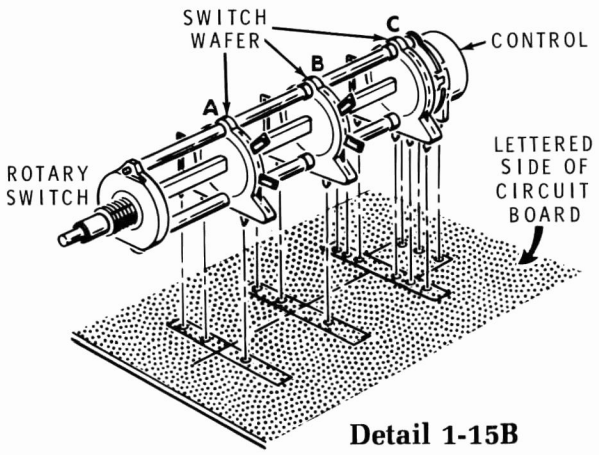
NOTE: When you are instructed to prepare wires, as in the next step, cut the specified color wire to the indicated length and remove 1/4" of insulation from each end.

( ) Prepare the following brown wires. The wires are listed in the order they will be used.

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



Detail 1-15A



Detail 1-15B

NOTES:

1. When you connect a wire to the circuit board, always cut off the excess lead length after the connection is soldered.

2. in the following steps, (NS) means not to solder because other wires will be added later. "S-" with a number, such as (S-3), means to solder the connection. The number following the "S" tells how many wires are at the connection.

3. When you wire to the rotary switches, be sure **no** wires or components are positioned directly above the screws in the trimmer capacitors, as these trimmers must be adjusted later.

( ) Connect a 3″ Brn wire from circuit board hole A (S-1) to switch SW2A wafer A lug 9 (NS). Position the wire between the shaft and indicated spacer on the switch.

( ) Connect a 2″ Brn wire from circuit board hole A2 (S-1) to switch SW2A wafer A lug 8 (S-1).

( ) Place a 1/2″ length of sleeving on each lead of a 33 Ω, 1/2-watt (Org-Org-Blk) 5% resistor.

( ) R2A: Connect this resistor to switch SW2A between wafer A lug 9 (NS) and wafer B lug 8 (S-1).

( ) R106A: Connect a 33 Ω, 1/2-watt (Org-Org-Blk) 5% resistor from the indicated resistor outline in the circuit board (S-1) to switch SW2A wafer B lug 9 (S-1).

( ) Connect a 3″ Brn wire from circuit board hole CC (S-1) to switch SW2B wafer A lug 9 (NS). Position the wire between the shaft and the indicated spacer on the switch.

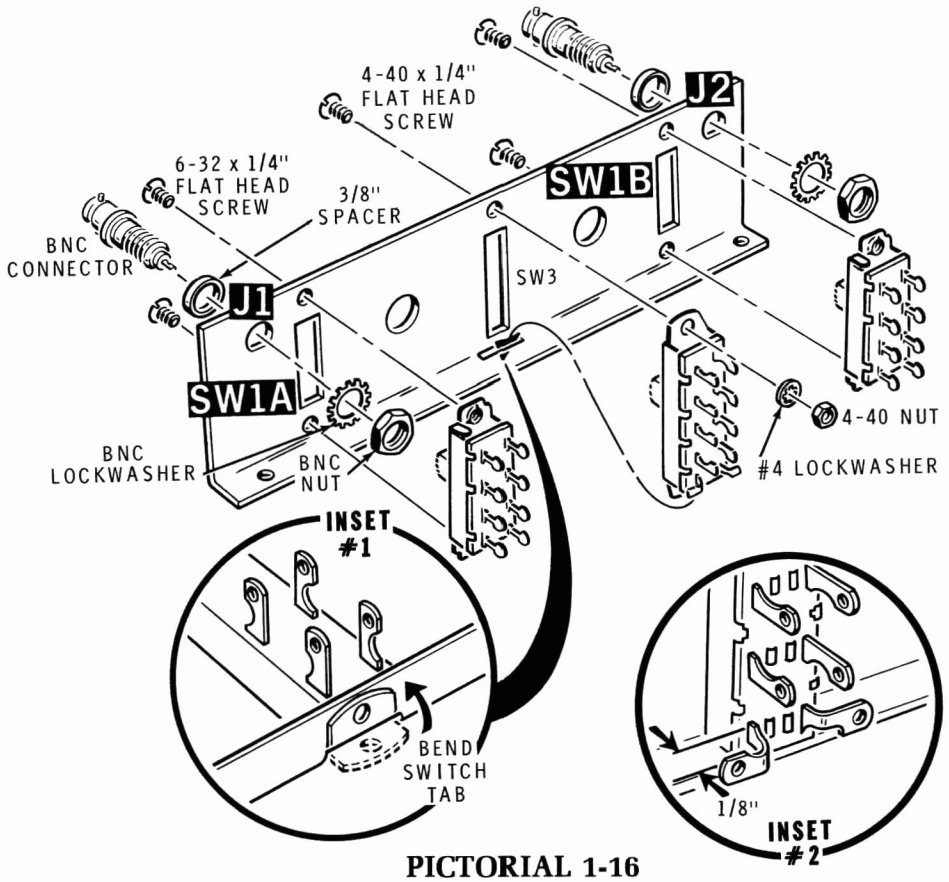
( ) Connect a 2-1/4″ Brn wire from circuit board hole B2 (S-1) to switch SW2B wafer A lug 8 (S-1). Position the wire between the shaft and the indicated spacer on the switch.

( ) Place a 1/2″ length of sleeving on each lead of a 33 Ω, 1/2-watt (Org-Org-Blk) 5% resistor.

( ) R2B: Connect this resistor to switch SW2B between wafer A lug 9 (S-2) and wafer B lug 8 (S-1).

( ) R106B: Connect a 33 Ω, 1/2-watt (Org-Org-Blk) 5% resistor from the indicated resistor outline on the circuit board (S-1) to switch SW2B wafer B lug 9 (S-1).

( ) Set the circuit board aside temporarily.



PICTORIAL 1-16

Refer to Pictorial 1-16 for the following steps.

( ) Locate the switch bracket and position it as shown.

( ) SW1A: Install a DP3T 3-position slide switch at location SW1A in the switch bracket. Use 6-32 × 1/4″ **flat head** screws. The switch can be installed either way.

( ) SW1B: In the same manner, install a DP3T 3-position slide switch at location SW1B in the switch bracket.

NOTE: The term "hardware" in the following steps refers to the screws, nuts, and lockwashers you will use to mount parts. The phrase "Use 4-40 × 1/4″ hardware," for example, means to use a 4-40 × 1/4″ screw, one or more #4 lockwashers and a 4-40 nut. Refer to the Detail called out in the step for the correct number of lockwashers to use and the correct way to install the hardware. Use the plastic nut starter furnished with the kit to pick up #4 and #6 nuts and start them on screws.

( ) SW3: Push either tab of a DP4T 4-position slide switch into the slot at location SW3 in the switch bracket. Secure the other tab of the switch with 4-40 × 1/4″ flat head hardware. Now bend the switch tab, that is in the slot, flat against the bend in the switch bracket. See inset drawing #1 on Pictorial 1-16.

( ) J1: Install a BNC connector at location J1 in the switch bracket. Use the lockwasher and nut furnished with the connector and a 3/8″ spacer.

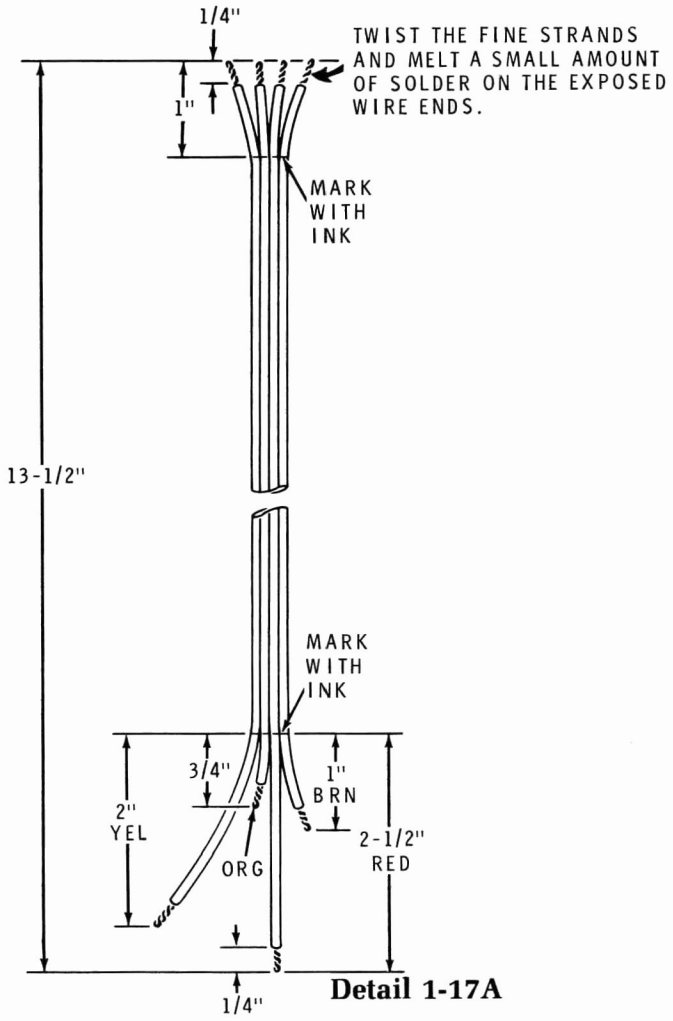
( ) J2: In the same manner, install a BNC connector at location J2 in the switch bracket.

( ) Refer to inset drawing #2 on Pictorial 1-16 and bend the indicated lugs on switch SW3 as shown.

Refer to Pictorial 1-17 (Illustration Booklet, Page 4) for the following steps.

( ) Prepare two 2″ brown wires.

( ) Remove an extra 1/2″ (total 3/4″) of insulation from one end of both 2″ brown wires.



Detail 1-17A

Connect these two wires to switch SW3 as follows:

( ) Pass the longer bared end of one 2" Brn wire through lug 9 (NS) to lug 4 (S-1). Connect the other end of this wire to lug 6 (S-1).

( ) Pass the longer bared end of the other 2" Brn wire through lug 8 (NS) to lug 7 (S-1). Connect the other end of this wire to lug 5 (S-1).

( ) Locate the 8-conductor flat cable. Separate this cable for its full length between the Yel and Grn conductors. Discard the 4-conductor section consisting of the Grn, Blu, Viol, and Gry conductors, as it will not be used.

( ) Refer to Detail 1-17A and prepare the ends of the 13-1/2" length of 4-conductor flat cable.

NOTE: Where a wire passes through a connection and goes to another point, it will count as two wires in the solder instructions (S-2), one entering and one leaving the connection. Be sure, when you solder these connections, to apply enough heat to solder these "through wires."

Connect the end of this 4-conductor flat cable, that has its ends even, to switch SW3 as follows:

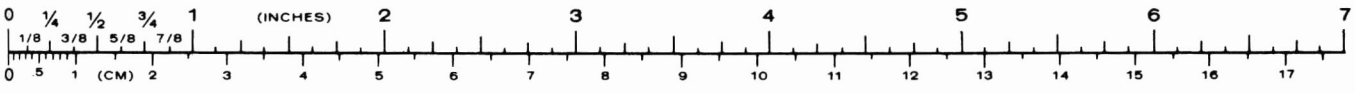
( ) Yel to lug 10 (S-1).

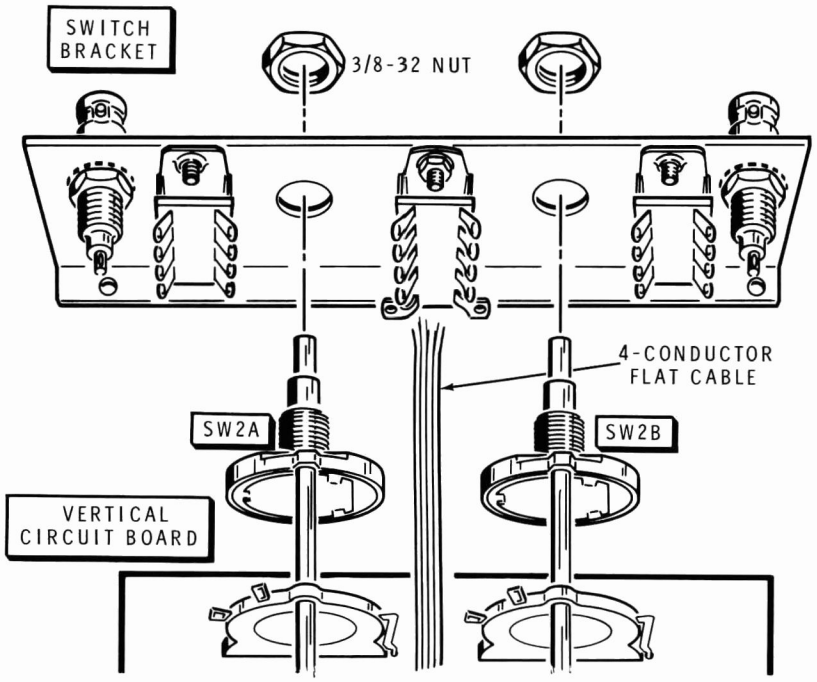
( ) Org to lug 9 (S-3).

( ) Red to lug 8 (S-3).

( ) Brn to lug 3 (S-1).

The free end of this cable will be connected later.





Detail 1-17B

( ) Refer to Detail 1-17B and mount the switch bracket onto switches SW2A and SW2B (mounted on the vertical circuit board) with 3/8-32 nuts. Be sure to position the flange of the switch bracket as shown and the 4-conductor cable above the board.

Connect the free end of the 4-conductor flat cable to the circuit board as follows:

( ) Org to hole T (S-1).

( ) Brn to hole P (S-1).

( ) Yel to hole S (S-1).

( ) Red to hole X (S-1).

( ) Prepare two 1-3/4″ brown wires.

( ) Connect a 1-3/4″ Brn wire from switch SW1A lug 7 (S-1) to circuit board hole B (S-1).

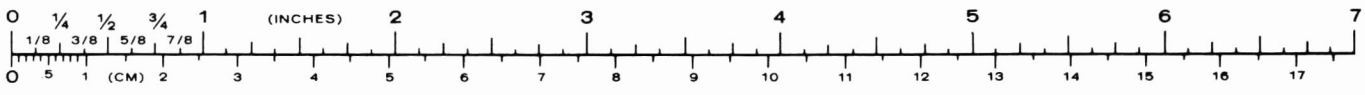
( ) Connect a 1-3/4″ Brn wire from switch SW1B lug 3 (S-1) to circuit board hole BB (S-1).

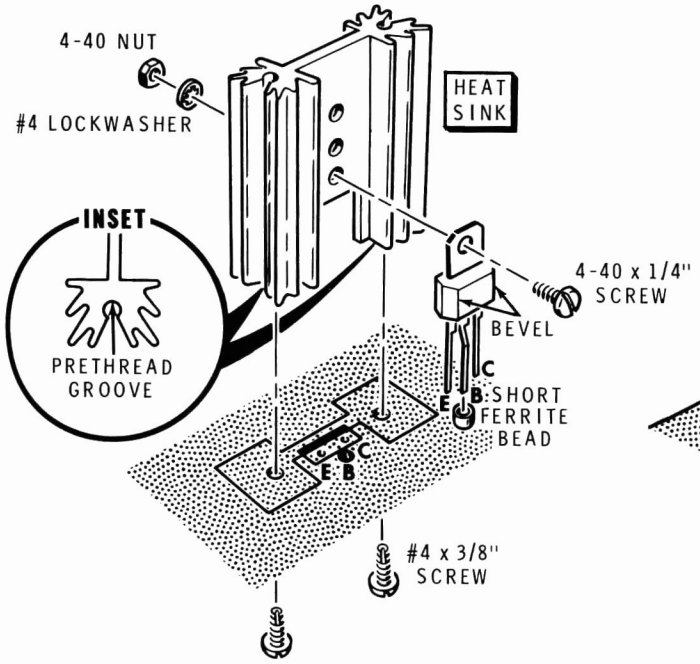
( ) Position these two wires down against the circuit board.

( ) Place a 3/8″ length of sleeving on each lead of two 33 Ω, 1/2-watt (Org-Org-Blk) 5% resistors.

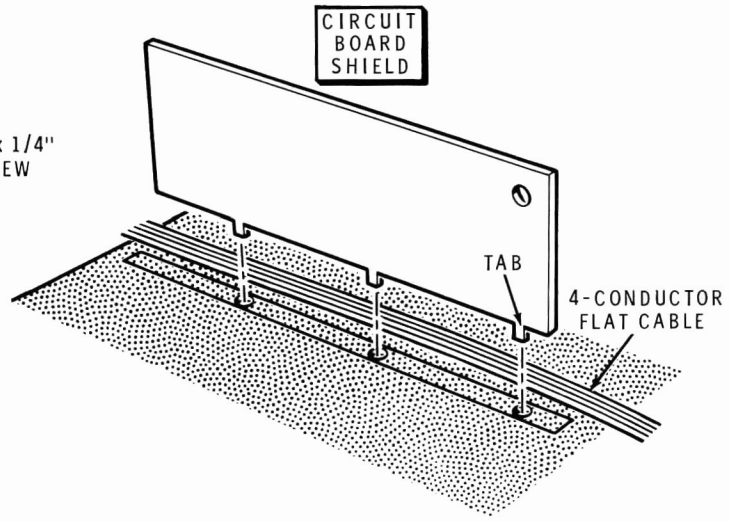
( ) R1A: Connect one lead of one of these resistors to switch SW1A through lug 3 (S-2) to lug 6 (S-1). Connect the other lead to switch SW2A lug 9 (S-3). Position the resistor as shown.

( ) R1B: Connect one lead of the other 33 Ω resistor to switch SW1B through lug 7 (S-2) to lug 2 (S-1). Connect the other lead to hole AA in the circuit board (S-1). Position the resistor as shown.





Detail 1-17C



Detail 1-17D

NOTE: Be sure to position the capacitors, installed in the next two steps, **exactly** as they are shown in Pictorial 1-17.

( ) C1: Connect one lead of .1 μF Mylar capacitor through connector J1 (S-2) to switch SW1A through lug 1 (S-2) to lug 5 (S-1). Connect the other lead to switch SW1A lug 4 (S-1). Disregard the band on the capacitor.

( ) C2: Connect one lead of a .1 μF Mylar capacitor through connector J2 (S-2) to switch SW1B through lug 5 (S-2) to lug 1 (S-1). Connect the other lead to switch SW1B lug 8 (S-1). Disregard the band on the capacitor.

( ) Refer to Detail 1-17C and prethread the two grooves in the bottom of both heat sinks. Use a #4 $\times$3/8" screw.

( ) Refer to Detail 1-17C and install an MPSU10 transistor (#417-834) on a heat sink with 4-40 $\times$ 1/4" hardware. Be sure the beveled edges of the transistor are positioned as shown.

( ) In the same manner, install another MPSU10 transistor (#417-834) on a heat sink.

( ) Q115: Place a short ferrite bead on the center lead of one of these transistors. Insert the E, B, and C leads of the transistor into their corresponding E, B, and C holes in the circuit board at location Q115. Secure the heat sink to the circuit board with two #4 $\times$ 3/8" screws. Then solder the transistor leads to the foil and cut off the excess lead lengths.

( ) Q116: In the same manner, install the other transistor and short ferrite bead at location Q116 on the circuit board.

( ) Refer to Detail 1-17D and insert the tabs on the circuit board shield into their circuit board holes and push the shield down tight against the printed side of the circuit board. Be sure the flat 4-conductor cable is positioned as shown. Then turn the circuit board over and solder the shield tabs to the foil.

Refer to Pictorial 1-18 (Illustration Booklet, Page 5) for the following steps.

( ) Turn the circuit board foil side up and position it as shown in Pictorial 1-18.

( ) Refer to Detail 1-18A and mount a control bracket at location R4B on the circuit board. Use 6-32 × 1/4" hardware.

( ) In the same manner, mount the other control bracket at location R4A on the circuit board.

( ) R4B: Refer to Detail 1-18A and mount a 1000 Ω (1 k) control (#10-1118) on the control bracket at location R4B with a 3/8-32 nut. Position the control so its lugs are up as shown.

( ) R4A: In the same manner, install a 1000 Ω (1 k) control (#10-1118) on the control bracket at location R4A.

NOTE: When you wire these two controls in the following steps, do not allow any of the resistor leads to touch the metal case of the controls.

( ) R12B: Connect a 3300 Ω, 1/2-watt (Org-Org-Red) 5% resistor from control R4B lug 1 (S-1) to the indicated hole in the circuit board (S-1).

( ) R119B: Connect a 3300 Ω, 1/2-watt (Org-Org-Red) 5% resistor from control R4B lug 3 (S-1) to the indicated hole in the circuit board (S-1).

( ) R121A: Connect a 3300 Ω, 1/2-watt (Org-Org-Red) 5% resistor from control R4A lug 1 (S-1) to the indicated hole in the circuit board (S-1).

( ) R119A: Connect a 3300 Ω, 1/2-watt (Org-Org-Red) 5% resistor from control R4A lug 3 (S-1) to the indicated hole in the circuit board (S-1).

( ) Prepare two 2" brown wires.

NOTE: When you connect a wire to the foil side of a circuit board, keep the insulation on the wire 1/8" above the foil to be sure you get a good solder connection to the wire and circuit board foil.

( ) Connect a 2" Brn wire from control R4B lug 2 (S-1) to the indicated hole in the circuit board (S-1).

( ) Connect a 2" Brn wire from control R4A lug 2 (S-1) to the indicated hole in the circuit board (S-1).

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) Poor solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Transistors for the proper type and installation.

( ) Electrolytic capacitors for the correct position of the positive (+) or negative (−) end.

( ) Diodes for the proper type and the correct position of the banded end.

( ) IC's for the proper type and installation.

There are a number of unused holes in the circuit board that will be used later. Set the circuit board aside temporarily.

Save the remaining parts for use later.

The following parts should be left over at this time. Save them for use later.

3	6-32 × 1/8" black setscrews
4	6-32 × 1/8" setscrews
3	Slide switch covers
1	Metal front panel
2	5" extension shafts
2	Split plastic bushings
2	Shaft couplings
1	Red knob
2	Small black knobs
1	Large black knob
1	Sleeving
1	Shielded cable
1	Label
1	Cable assembly with connector
2	Alligator clips
2	Alligator clip insulators

HORIZONTAL CIRCUIT BOARD

PARTS LIST

Remove the parts from the pack marked #2 and check each part against the following list. The key numbers correspond to the numbers on the Horizontal Circuit Board Parts Pictorial (Illustration Booklet, Page 6).

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. For prices, refer to the separate "Heath Parts Price List."

RESISTORS

All resistors are 5% (fourth band gold) unless designated 10% (fourth band silver).

NOTE: The resistors may be packed in more than one envelope (stamped RES). Open all the resistor envelopes in this pack before you check the resistors against the Parts List.

1/2-Watt

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	6-279	5	2.7 Ω (Red-Viol-Gold)	R241, R275, R276, R277, R281
A1	6-100	3	10 Ω (Brn-Blk-Blk)	R244, R269, R270
A1	6-470	2	47 Ω (Yel-Viol-Blk)	R214, R215
A1	6-221	8	220 Ω (Red-Red-Brn)	R230, R237, R238, R246, R253, R254, R259, R260
A1	6-271	2	270 Ω (Red-Viol-Brn)	R212, R255
A1	6-331	2	330 Ω (Org-Org-Brn)	R209, R228
A1	6-391	1	390 Ω (Org-Wht-Brn)	R229
A1	6-511	2	510 Ω (Grn-Brn-Brn)	R206, R207
A1	6-561	2	560 Ω (Grn-Blu-Brn)	R235, R258
A1	6-821	1	820 Ω (Gry-Red-Brn)	R217

Resistors (Cont'd.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	6-102	13	1000 Ω (Brn-Blk-Red)	R12, R202, R204, R218, R219, R221, R227, R245, R262, R268, R273, R278, R282
A1	6-152	1	1500 Ω (Brn-Grn-Red)	R248
A1	6-182	5	1800 Ω (Brn-Gry-Red)	R205, R208, R213, R216, R250
A1	6-222	1	2200 Ω (Red-Red-Red)	R272
A1	6-682	1	6800 Ω (Blu-Gry-Red)	R226
A1	6-103	1	10 kΩ (Brn-Blk-Org)	R256
A1	6-153	1	15 kΩ (Brn-Grn-Org)	R210
A1	6-473	2	47 kΩ (Yel-Viol-Org)	R220, R222
A1	6-683	1	68 kΩ (Blu-Gry-Org)	R225
A1	6-104	5	100 kΩ (Brn-Blk-Yel)	R201, R239, R243, R252, R274
A1	6-684	1	680 kΩ (Blu-Gry-Yel)	R224
A1	6-914	1	910 kΩ (Wht-Brn-Yel)	R242
A1	6-105	1	1 MΩ (Brn-Blk-Grn)	R280
A1	1-163	1	6.8 MΩ (Blu-Gry-Grn)	R223
A1	1-166	1	10 MΩ (Brn-Blk-Blu)	R240

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
Other Resistors				
A2	1-21-1	1	680 Ω, 1-watt, 10% (Blu-Gry-Brn)	R232
A3	1-23-2	2	5600 Ω, 2-watt (Grn-Blu-Red)	R263, R265
A4	5-2-2	2	22 kΩ, 2-watt	R233, R264
CAPACITORS				
Ceramic				
B1	21-157	1	5 pF	C219
B1	21-7	1	33 pF	C204
B1	21-32	2	47 pF	C220, C235
B1	21-121	2	56 pF	C205, C213
B1	21-75	1	100 pF	C212
B1	21-21	1	200 pF	C222
B1	21-56	1	470 pF	C214
B1	21-36	3	.002 μF	C211, C218, C229
B1	21-16	2	.01 μF	C202, C224
B1	21-82	1	.02 μF	C210
B1	21-199	3	.1 μF	C209, C228, C232
Tantalum — Electrolytic				
C1	25-221	1	2.2 μF tantalum	C208
C2	25-820	2	10 μF NP (non-polarized) electrolytic	C203, C221
C2	25-115	9	10 μF electrolytic	C206, C217, C223, C225, C226, C227, C230, C231, C234
C2	25-233	1	22 μF electrolytic	C207
Other Capacitors				
C3	29-5	1	1000 pF polystyrene	C216
C4	27-47	1	.1 μF Mylar	C201
C5	27-2	1	1 μF film	C215

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
DIODES				
D1	56-56	8	1N4149	D201, D204 D207, D208, D209, D210, D213, D214
D1	56-59	1	1N750A	D206
D1	56-67	2	VR10A	D205, D211

TRANSISTORS — INTEGRATED CIRCUITS (IC's)

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

1. Part number.
2. Type number. (On integrated circuits this refers only to the numbers and letters listed. Any additional letters or numbers on an IC are not significant.)
3. Part number and type number.
4. Part number with a type number other than the one listed.

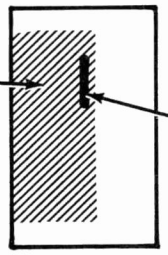
E1	417-134	5	MPS6520 transistor	Q209, Q210, Q212, Q213, Q217
E2	417-154	1	2N2369 transistor	Q216
E1	417-235	2	2N4121 transistor	Q203, Q204
E1	417-801	4	MPSA20 transistor	Q202, Q205, Q206, Q211
E3	417-834	2	MPSU10 transistor	Q214, Q215
E4	417-902	3	5566 transistor	Q201, Q207, Q208
E5	443-6	1	7474 IC	U201
E5	443-22	1	74121 IC	U205
E5	443-23	1	74122 IC	U203
E5	443-44	1	7413 IC	U204
E5	443-625	1	74132 IC	U202

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
CONTROLS				
F1	10-918	2	500 Ω control	R231, R247
F2	10-391	1	1000 Ω (1K) control	R236
F1	10-936	1	1000 Ω (1K) control	R257
F1	10-398	1	2000 Ω (2K) control	R251
F1	10-904	1	5000 Ω (5K) control	R211
HARDWARE				
G1	250-52	2	4-40 × 1/4" screw	
G2	250-186	4	#4 × 3/8" screw	
G3	252-15	2	4-40 nut	
G4	254-9	2	#4 lockwasher	
MISCELLANEOUS				
H1	434-230	3	8-pin IC socket	
H2	434-298	5	14-pin IC socket	
H3	475-16	2	Short ferrite bead	FB
H4	475-10	2	Long ferrite bead	FB

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
PARTS FROM FINAL PACK				
J1	63-1315	1	Rotary switch with 5 kΩ and 10 kΩ controls	SW5-R10-R11
	85-2044-2	1	Horizontal circuit board	
J2	215-95	2	Heat sink	
	344-51	6'-8"	Brn wire	
	344-163	2'	Blk wire	
	344-165	1'	Red wire	
	344-166	1'	Org wire	
	344-167	1'	Yel wire	
	344-168	1'	Grn wire	
	344-56	2'	Blu wire	
	344-170	1'	Viol wire	
	344-58	2'	Gry wire	
	344-172	1'	Wht wire	
	344-173	1'	Wht-Blk wire	
	344-174	1'	Wht-Brn wire	
	344-175	1'	Wht-Red wire	
	344-176	1'	Wht-Org wire	
	344-177	1'	Wht-Yel wire	
	344-178	1'	Wht-Grn wire	
	344-179	1'	Wht-Blu wire	
	344-180	1'	Wht-Viol wire	
	344-181	1'	Wht-Gry wire	

STEP-BY-STEP ASSEMBLY

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



START

Position the circuit board printed side up as shown.

NOTE: When you install a diode, always match the band on the diode with the band on the circuit board.

( ) D201: 1N4149 diode (#56-56).

( ) D214: 1N4149 diode (#56-56).

( ) 1" bare wire.

( ) 1" bare wire.

( ) 1" bare wire.

( ) 1-3/8" Brn wire.

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

( ) 1" bare wire.

( ) 1" bare wire.

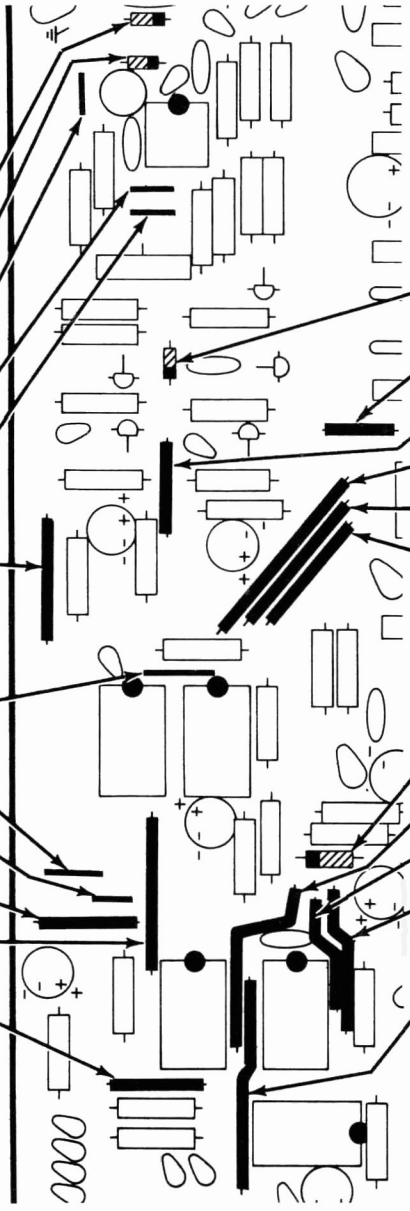
( ) 1" bare wire.

( ) 1-1/8" Brn wire.

( ) 1-5/8" Brn wire.

( ) 1-1/8" Brn wire.

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



CONTINUE

( ) D204: 1N4149 diode (#56-56).

( ) 1" Brn wire.

( ) 1-1/8" Brn wire.

( ) 1-3/4" Brn wire.

( ) 1-5/8" Brn wire.

( ) 1-3/8" Brn wire.

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

( ) D206: 1N750 diode (#56-59).

( ) 1-7/8" Brn wire.

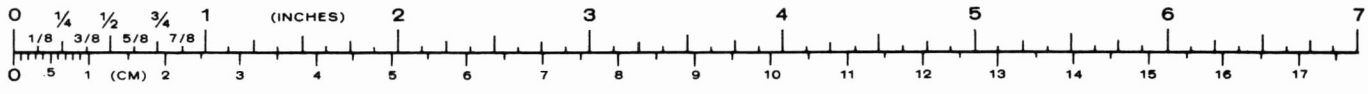
( ) 1-1/4" Brn wire.

( ) 1-1/2" Brn wire.

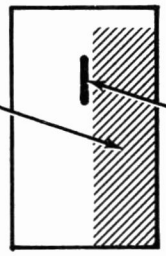
( ) 2" Brn wire.

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

PICTORIAL 2-1

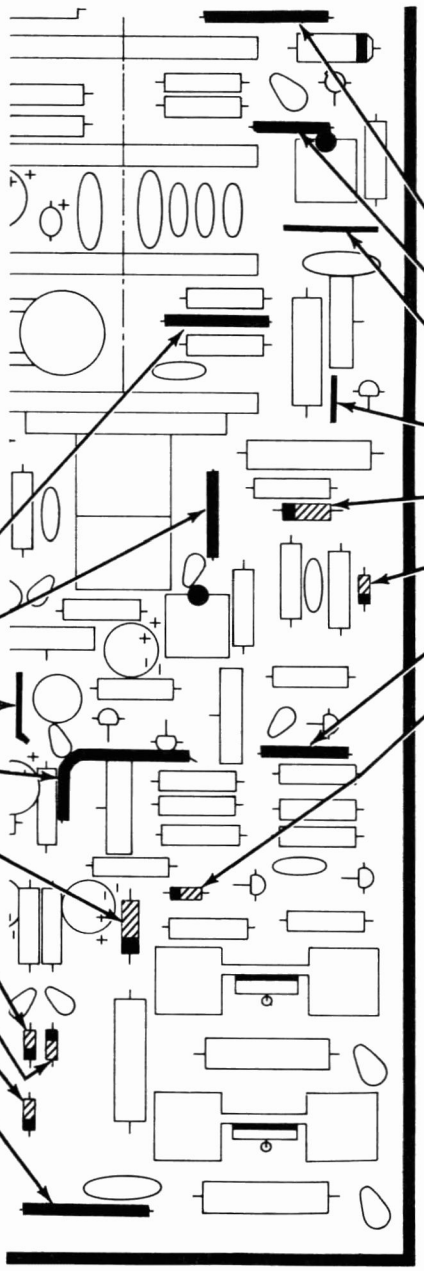


The steps performed in this Pictorial are in this area of the circuit board.



IDENTIFICATION DRAWING

PART NUMBER



START

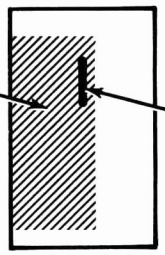
- ( ) 1-1/8" Brn wire.
- ( ) 1" Brn wire.
- ( ) 1" bare wire.
- ( ) 1-3/4" Brn wire.
- ( ) D211: VR10 diode (#56-67).
- ( ) D208: 1N4149 diode (#56-56).
- ( ) D207: 1N4149 diode (#56-56).
- ( ) D213: 1N4149 diode (#56-56).
- ( ) 1-3/8" Brn wire.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

- ( ) 1-3/8" Brn wire.
- ( ) 1" Brn wire.
- ( ) 1-1/8" bare wire.
- ( ) 1" bare wire.
- ( ) D205: VR10 diode (#56-67).
- ( ) D209: 1N4149 diode (#56-56).
- ( ) 1-1/8" Brn wire.
- ( ) D210: 1N4149 diode (#56-56).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-2

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



IDENTIFICATION DRAWING

PART NUMBER

START

( ) R201: 100 kΩ (Brn-Blk-Yel).

( ) R252: 100 kΩ (Brn-Blk-Yel).

( ) R207: 510 Ω (Grn-Brn-Brn).

( ) R208: 1800 Ω (Brn-Gry-Red).

( ) R206: 510 Ω (Grn-Brn-Brn).

( ) R212: 270 Ω (Red-Viol-Brn).

( ) R215: 47 Ω (Yel-Viol-Blk).

( ) R216: 1800 Ω (Brn-Gry-Red).

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

( ) R219: 1000 Ω (Brn-Blk-Red).

( ) R241: 2.7 Ω (Red-Viol-Gold).

( ) R281: 2.7 Ω (Red-Viol-Gold).

( ) R229: 390 Ω (Org-Wht-Brn).

( ) R228: 330 Ω (Org-Org-Brn).

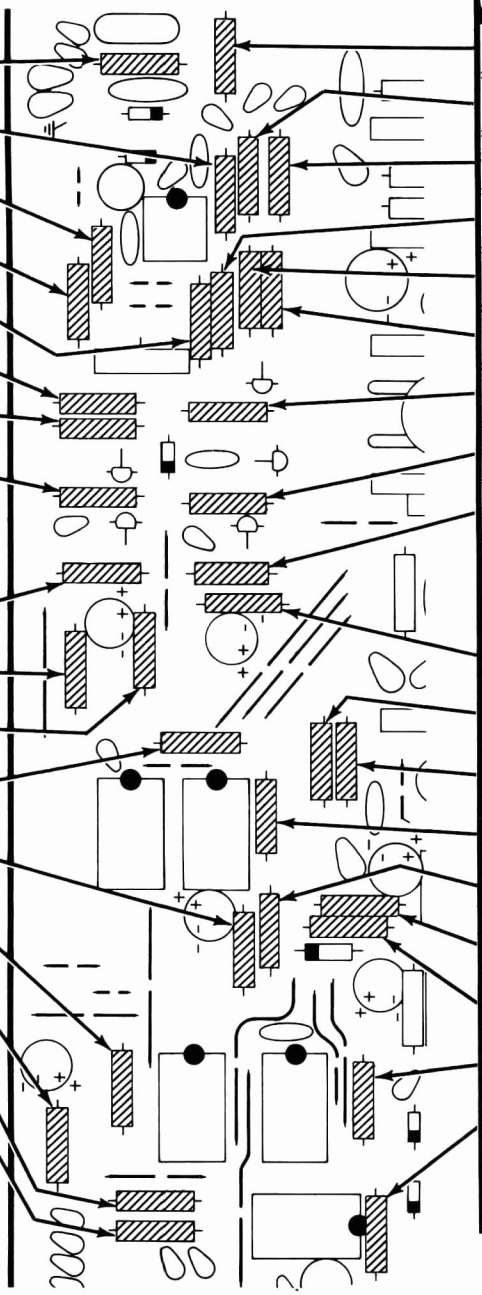
( ) R268: 1000 Ω (Brn-Blk-Red).

( ) R277: 2.7 Ω (Red-Viol-Gold).

( ) R278: 1000 Ω (Brn-Blk-Red).

( ) R227: 1000 Ω (Brn-Blk-Red).

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



CONTINUE

( ) R280: 1 MΩ (Brn-Blk-Grn).

( ) R204: 1000 Ω (Brn-Blk-Red).

( ) R202: 1000 Ω (Brn-Blk-Red).

( ) R205: 1800 Ω (Brn-Gry-Red).

( ) R210: 15 kΩ (Brn-Grn-Org).

( ) R209: 330 Ω (Org-Org-Brn).

( ) R214: 47 Ω (Yel-Viol-Blk).

( ) R213: 1800 Ω (Brn-Gry-Red).

( ) R218: 1000 Ω (Brn-Blk-Red).

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

( ) R217: 820 Ω (Gry-Red-Brn).

( ) R242: 910 kΩ (Wht-Brn-Yel).

( ) R244: 10 Ω (Brn-Blk-Blk).

( ) R237: 220 Ω (Red-Red-Brn).

( ) R238: 220 Ω (Red-Red-Brn).

( ) R276: 2.7 Ω (Red-Viol-Gold).

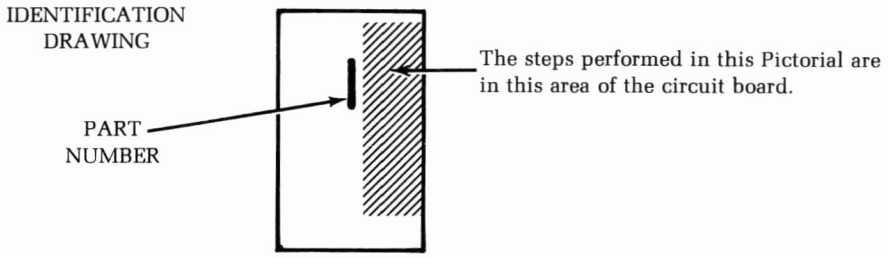
( ) R275: 2.7 Ω (Red-Viol-Gold).

( ) R222: 47 kΩ (Yel-Viol-Org).

( ) R220: 47 kΩ (Yel-Viol-Org).

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

PICTORIAL 2-3



START

( ) R221: 1000 Ω (Brn-Blk-Red).

( ) R223: 6.8 MΩ (Blu-Gry-Grn).

( ) R224: 680 kΩ (Blu-Gry-Yel).

( ) R243: 100 kΩ (Brn-Blk-Yel).

( ) R274: 100 kΩ (Brn-Blk-Yel).

( ) R254: 220 Ω (Red-Red-Brn).

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

( ) R262: 1000 Ω (Brn-Blk-Red).

( ) R256: 10 kΩ (Brn-Blk-Org).

( ) R260: 220 Ω (Red-Red-Brn).

( ) R255: 270 Ω (Red-Viol-Brn).

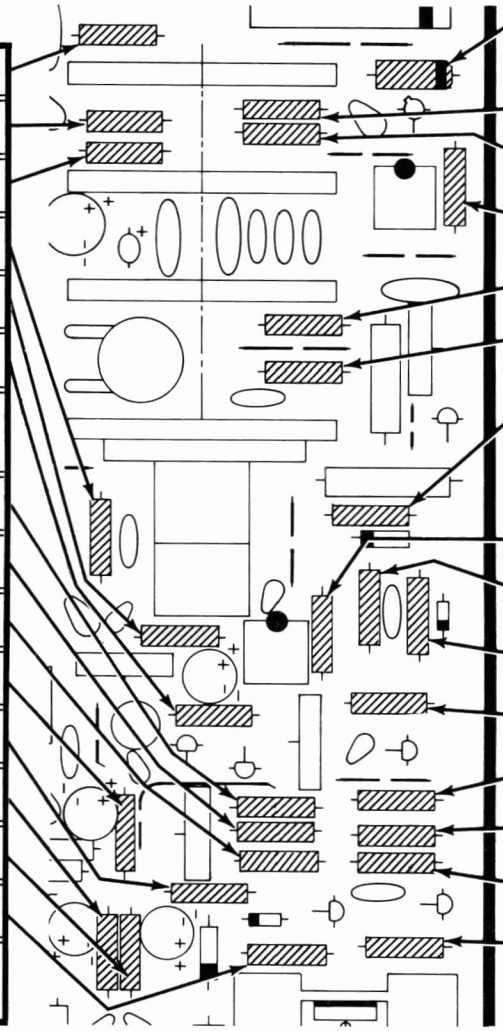
( ) R282: 1000 Ω (Brn-Blk-Red).

( ) R250: 1800 Ω (Brn-Gry-Red).

( ) R248: 1500 Ω (Brn-Grn-Red).

( ) R270: 10 Ω (Brn-Blk-Blk).

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



CONTINUE

( ) C216: 1000 pF polystyrene. Match the band (colored end) on the capacitor with the band on the circuit board.

( ) R225: 68 kΩ (Blu-Gry-Org).

( ) R226: 6800 Ω (Blu-Gry-Red).

( ) R230: 220 Ω (Red-Red-Brn).

( ) R273: 1000 Ω (Brn-Blk-Red).

( ) R272: 2200 Ω (Red-Red-Red).

( ) R235: 560 Ω (Grn-Blu-Brn).

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

( ) R246: 220 Ω (Red-Red-Brn).

( ) R240: 10 MΩ (Brn-Blk-Blu).

( ) R239: 100 kΩ (Brn-Blk-Yel).

( ) R253: 220 Ω (Red-Red-Brn).

( ) R245: 1000 Ω (Brn-Blk-Red).

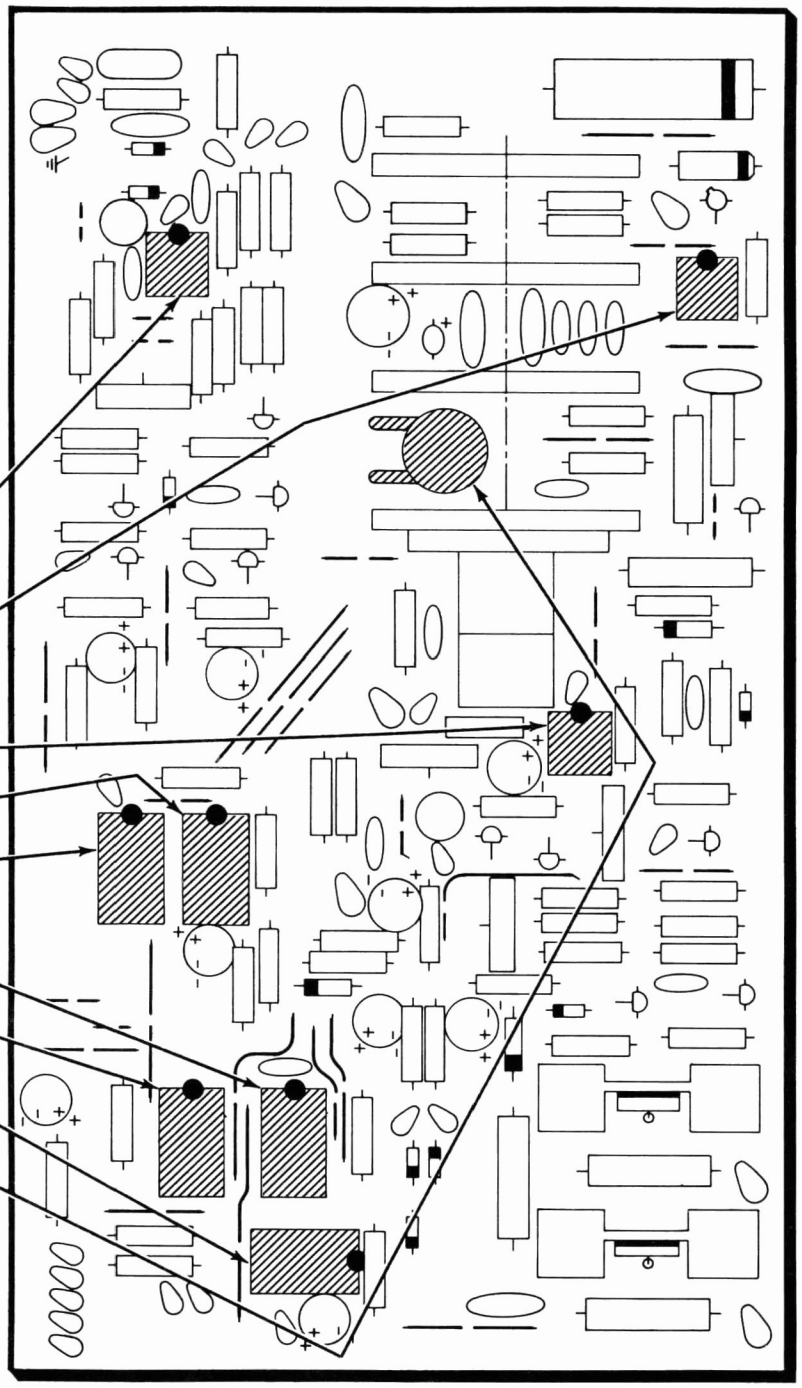
( ) R258: 560 Ω (Grn-Blu-Brn).

( ) R259: 220 Ω (Red-Red-Brn).

( ) R269: 10 Ω (Brn-Blk-Blk).

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

PICTORIAL 2-4



START

NOTE: When you install a part in this Pictorial, solder the pins of each part to the foil as each part is installed.

( ) 8-pin IC socket at Q201.

( ) 8-pin IC socket at Q207.

( ) 8-pin IC socket at Q208.

( ) 14-pin IC socket at U204.

( ) 14-pin IC socket at U202.

( ) 14-pin IC socket at U205.

( ) 14-pin IC socket at U201.

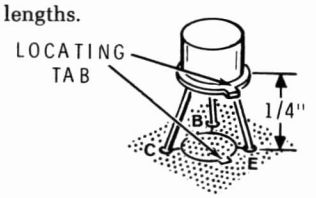
( ) 14-pin IC socket at U203.

( ) R236: 1000 Ω (1 k) control (#10-391).

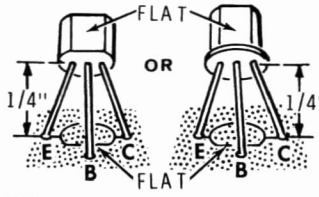
PICTORIAL 2-5

START

( ) Q216: 2N2369 transistor (#417-154). Align the tab on the transistor with the tab outline on the circuit board. Insert the C, B, and E leads into the corresponding holes of the circuit board. Position the transistor 1/4" above the circuit board. Solder the leads to the foil and cut off the excess lead lengths.



NOTE: When you install a transistor, align its flat with the flat on the board. Insert the leads into their correct E, B, and C holes. Position the transistor 1/4" above the board. Then solder the leads to the foil and cut off the excess lead lengths.



( ) Q202: MPSA20 transistor (#417-801).

( ) Q204: 2N4121 transistor (#417-235).

( ) Q203: 2N4121 transistor (#417-235).

( ) Q206: MPSA20 transistor (#417-801).

( ) Q205: MPSA20 transistor (#417-801).

( ) Q217: MPS6520 transistor (#417-134).

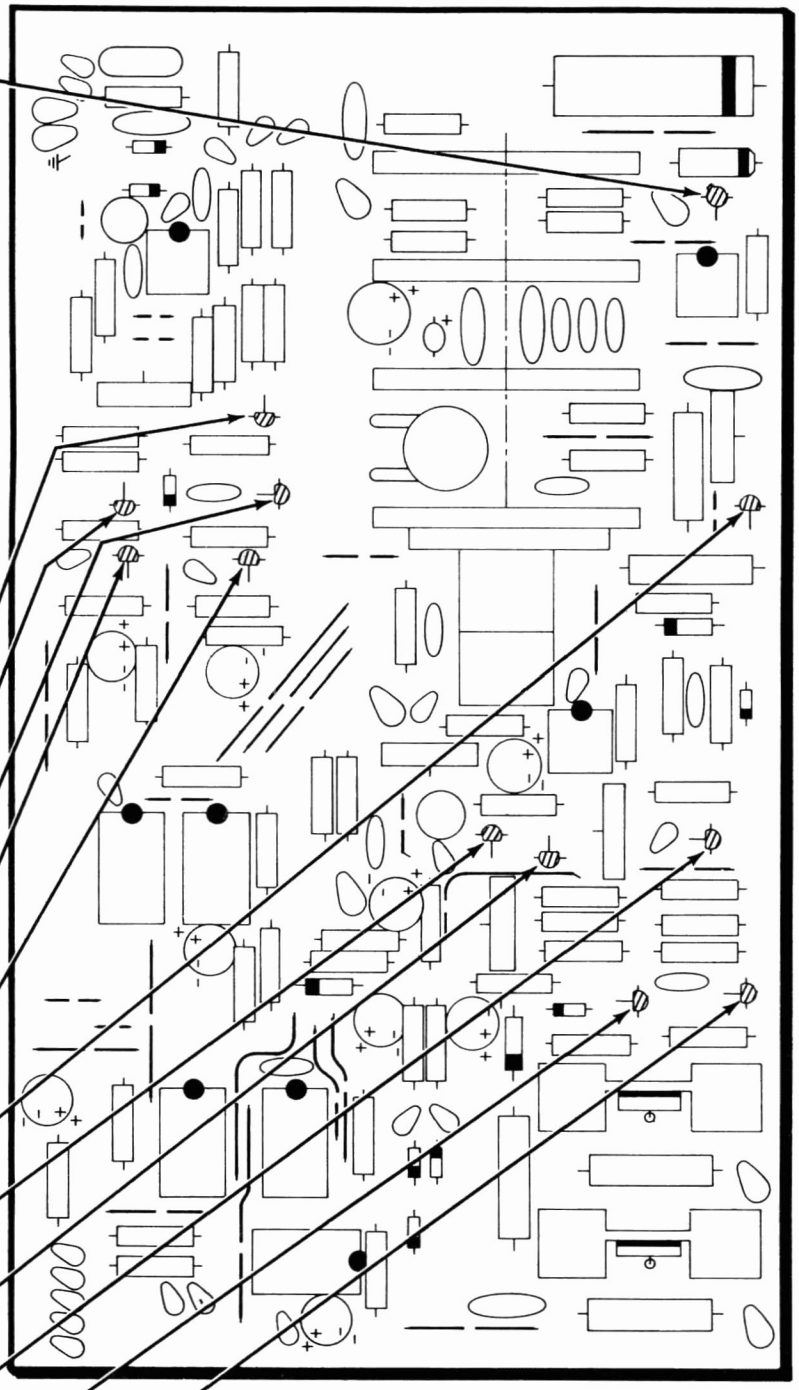
( ) Q211: MPSA20 transistor (#417-801).

( ) Q210: MPS6520 transistor (#417-134).

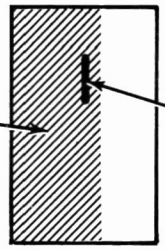
( ) Q209: MPS6520 transistor (#417-134).

( ) Q213: MPS6520 transistor (#417-134).

( ) Q212: MPS6520 transistor (#417-134).



PICTORIAL 2-6



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

IDENTIFICATION DRAWING

PART NUMBER

START

( ) C201: .1 μF Mylar.

( ) C202: .01 μF ceramic.

CAUTION: There are both nonpolarized and polarized electrolytic capacitors in this kit. Nonpolarized capacitors are marked NP, and polarized capacitors have a positive "+" or negative "−" marking. Be sure to use an NP capacitor when it is specified in a step. All other electrolytic capacitors will be the polarized type.

NOTE: NP capacitors can be installed with either lead in either hole.

( ) C203: 10 μF NP electrolytic.

( ) C204: 33 pF ceramic.

( ) C205: 56 pF ceramic.

NOTE: When you install a polarized electrolytic capacitor, always match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board OR match the minus (−) mark on the capacitor with the minus (−) mark on the circuit board.

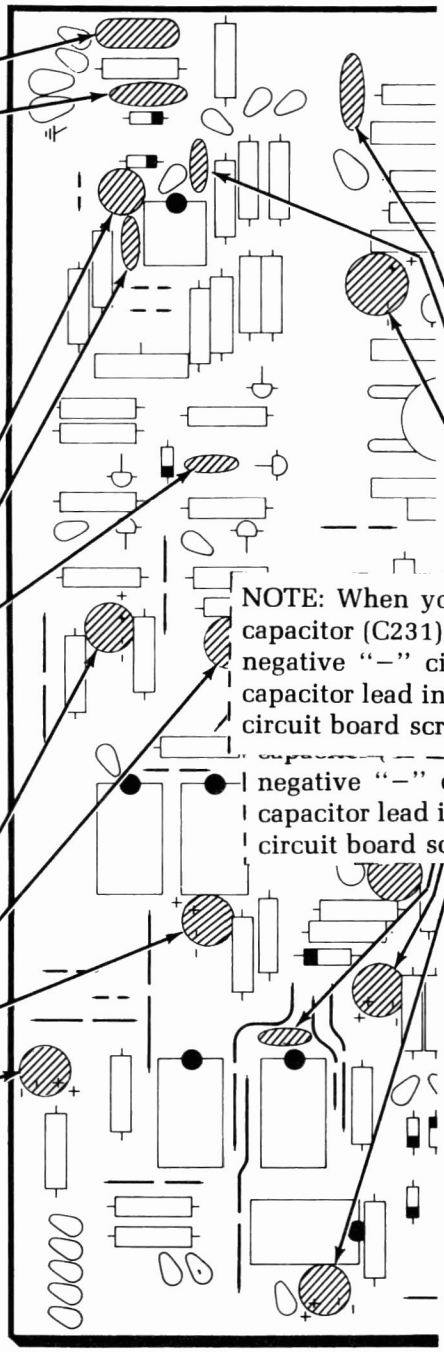
( ) C225: 10 μF electrolytic.

( ) C234: 10 μF electrolytic.

( ) C217: 10 μF electrolytic.

( ) C227: 10 μF electrolytic.

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



CONTINUE

( ) C228: .1 μF ceramic.

( ) C229: .002 μF ceramic.

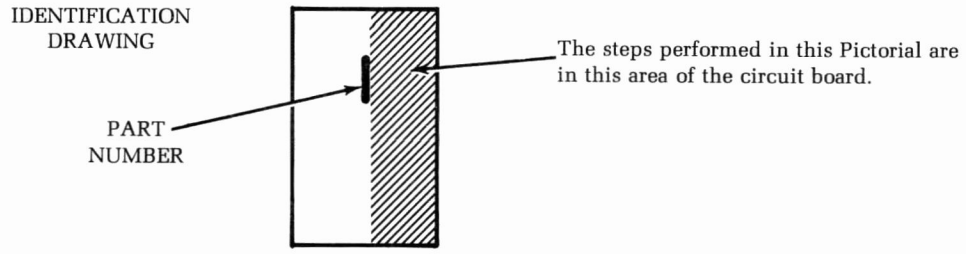
( ) C207: 22 μF electrolytic.

( ) C219: 5 pF ceramic.

NOTE: When you install the following electrolytic capacitor (C231), insert the positive "+" lead in the negative "−" circuit board hole and the negative capacitor lead in the positive circuit board hole. The circuit board screen is incorrect.

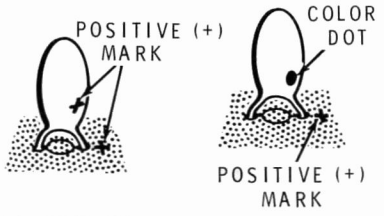
negative "−" circuit board hole and the negative capacitor lead in the positive circuit board hole. The circuit board screen is incorrect.

PICTORIAL 2-7



START

NOTE: When you install a tantalum capacitor, match the positive (+) mark, or color dot on the capacitor with the positive (+) mark on the board.



( ) C208: 2.2 μF tantalum.

( ) C209: .1 μF ceramic.

( ) C210: .02 μF ceramic.

( ) C235: 47 pF ceramic.

( ) C220: 47 pF ceramic.

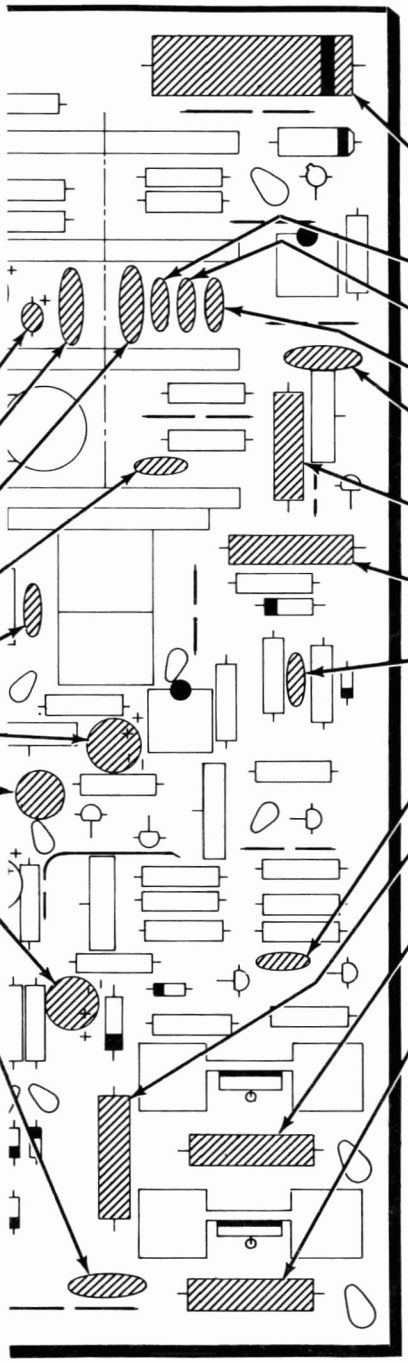
( ) C226: 10 μF electrolytic.

( ) C221: 10 μF NP electrolytic.

( ) C223: 10 μF electrolytic.

( ) C224: .01 μF ceramic.

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



CONTINUE

( ) C215: 1 μF film. Match the band on the capacitor with the band on the circuit board.

( ) C211: .002 μF ceramic.

( ) C212: 100 pF ceramic.

( ) C213: 56 pF ceramic.

( ) C232: .1 μF ceramic.

( ) R232: 680 Ω, 1-watt (Blu-Gry-Brn).

( ) R233: 22 kΩ, 2-watt.

( ) C218: .002 μF ceramic.

( ) C222: 200 pF ceramic.

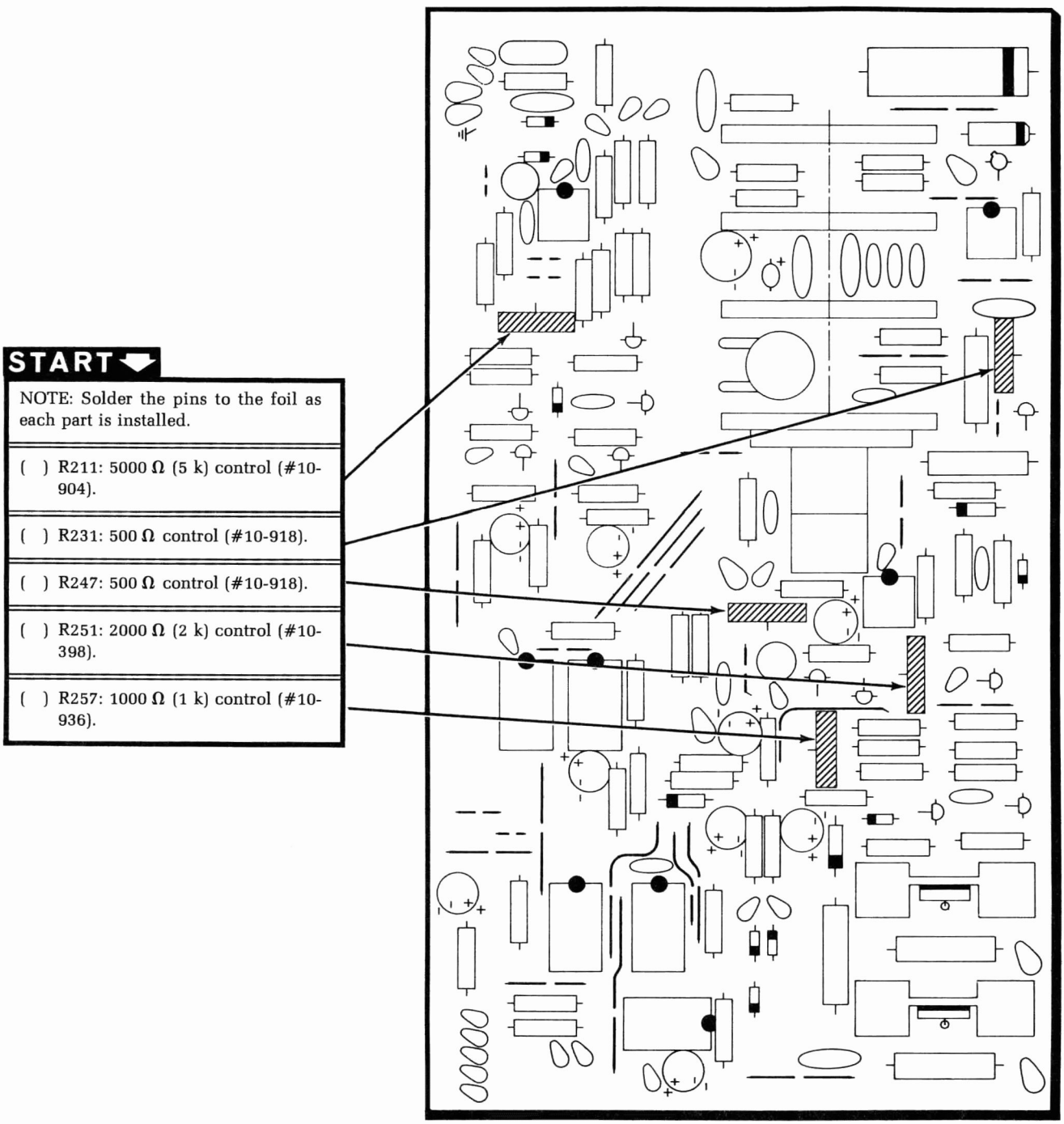
( ) R264: 22 kΩ, 2-watt.

( ) R215: 5600 Ω, 2-watt (Grn-Blu-Red).

( ) R263: 5600 Ω, 2-watt (Grn-Blu-Red).

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

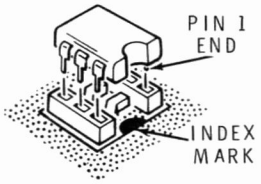
PICTORIAL 2-8

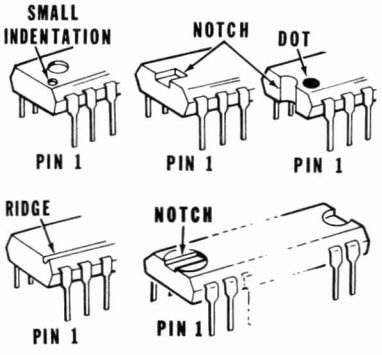


PICTORIAL 2-9

START

Align the pin 1 end of the IC with the index mark on the circuit board as you install each integrated circuit or transistor.





( ) Q201: 5566 transistor (#417-902).

( ) Q207: 5566 transistor (#417-902).

( ) Q208: 5566 transistor (#417-902).

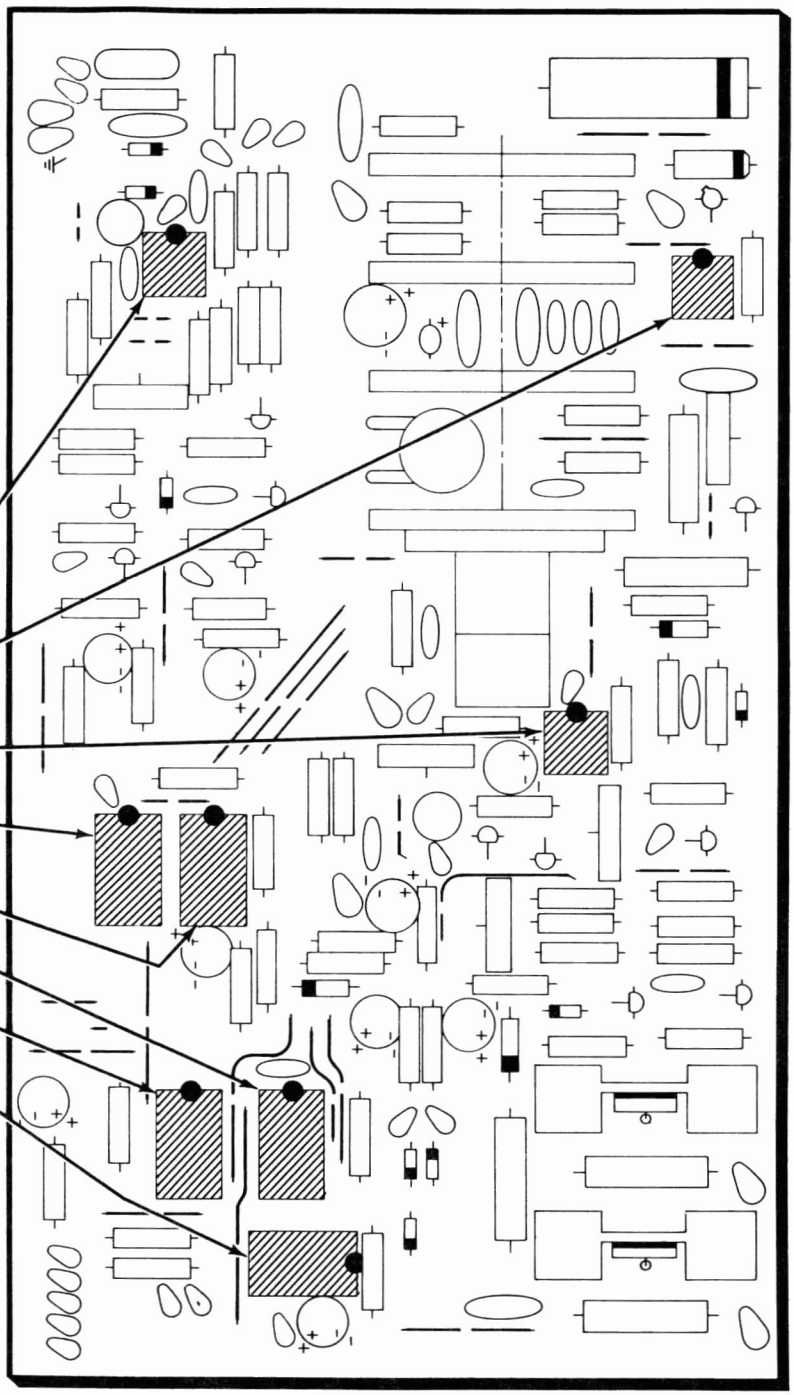
( ) U202: 74132 IC (#443-625).

( ) U204: 7413 IC (#443-44).

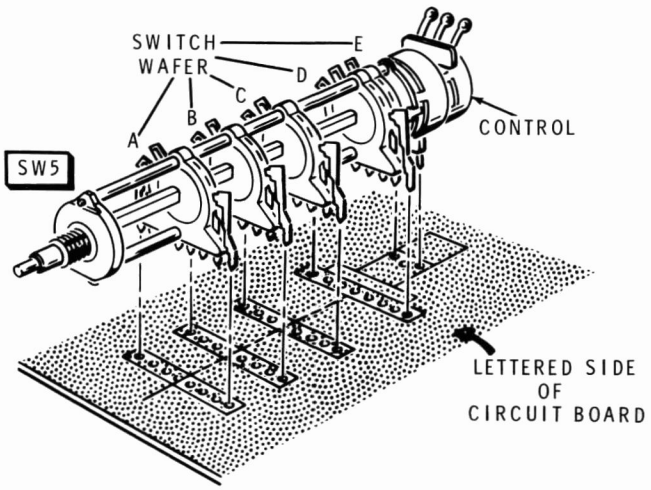
( ) U205: 74121 IC (#443-22).

( ) U201: 7474 IC (#443-6).

( ) U203: 74122 IC (#443-23).



PICTORIAL 2-10



Detail 2-11A

Refer to Pictorial 2-11 (Illustration Booklet, Page 7) for the following steps.

( ) SW5-R10-R11: Refer to Detail 2-11A and mount the rotary switch with 5000 Ω (5k) and 10k controls (#63-1315) at its location on the circuit board as follows:

1. Carefully align the pins of the front wafer (A) with their holes in the circuit board.

2. Fit the pins of each switch wafer, one wafer at a time, into their board holes until all the switch pins and the pins of control R11 are in place. Then push the switch down tight against the circuit board.

3. Carefully turn the circuit board over and solder **only** the end pins in each wafer to the foil. Inspect these switch pins to make sure all the pins are tight against the printed side of the circuit board. If they are not, reheat the connection and push the switch tight against the board. Then solder all the remaining switch and control pins to the foil.

( ) Prepare the following brown wires:

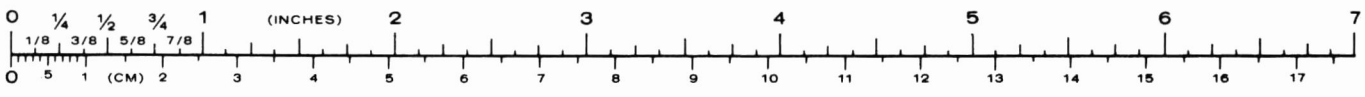
3-1/4″	3-1/4″
2″	3-1/4″
2-1/4″	4-1/4″
2″	

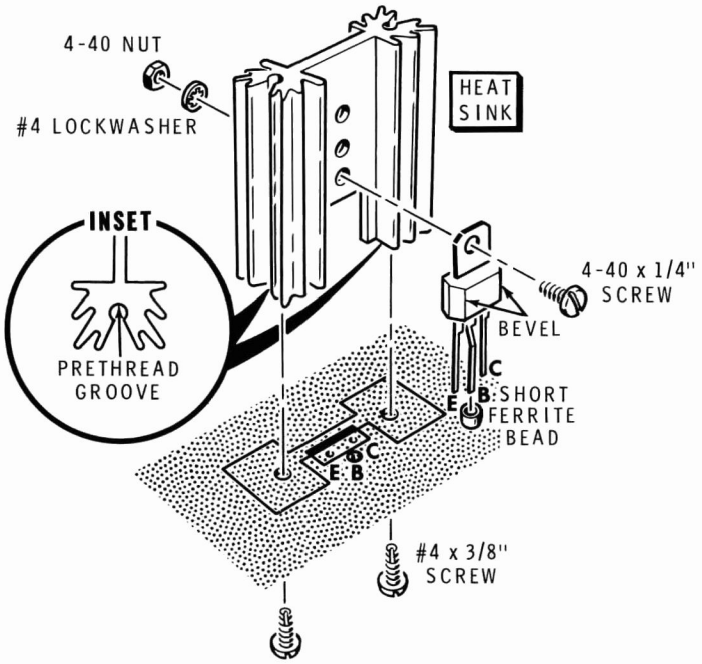
( ) Remove an extra 1/2″ of insulation (total 3/4″) from one end of a 3-1/4″ Brn wire.

( ) Connect the longer bared end of this wire to switch SW5 wafer A through lug 5 (S-2) to lug 4 (S-1). Connect the other end of this wire in circuit board hole B9 (S-1).

( ) Remove an extra 1/2″ of insulation (total 3/4″) from one end of a 2″ Brn wire.

( ) Connect the longer bared end of this wire to switch SW5 wafer B through lug 4 (S-2) to lug 5 (S-1). Connect the other end of this wire in circuit board hole A9 (S-1).





Detail 2-11B

( ) Connect a 2-1/4" Brn wire from switch SW5 wafer E lug 9 (S-1) to control R11 lug 3 (NS).

( ) Connect a 2" Brn wire from switch SW5 wafer E lug 8 (S-1) to control R11 lug 2 (NS).

( ) Connect a 3-1/4" Brn wire from circuit board hole D9 (S-1) to switch SW5 wafer D lug 5 (S-1).

( ) Connect a 3-1/4" Brn wire from circuit board hole M (S-1) to switch SW5 wafer E lug 4 (S-1).

( ) Connect a 4-1/4" Brn wire from circuit board hole D8 (S-1) to switch SW5 wafer D lug 4 (S-1).

Refer to the inset drawing on Pictorial 2-11 for the following steps.

( ) Prepare a 3" and a 2" Brn wire.

( ) Connect a 3" Brn wire from circuit board hole J (S-1) to control R11 lug 2 (S-2).

( ) Connect a 2" Brn wire from circuit board hole I (S-1) to control R11 lug 3 (S-2).

( ) R12: Connect a 1000 Ω, 1/2-watt (Brn-Blk-Red) resistor from switch SW5 wafer E lug 5 (S-1) to control R11 lug 1 (S-1). Use a 5/8" length of sleeving on each lead.

( ) Refer to Detail 2-11B and prethread the two grooves in the bottom of both heat sinks. Use a #4 × 3/8" screw.

( ) Refer to Detail 2-11B and install an MPSU10 transistor (#417-834) on a heat sink with 4-40 × 1/4" hardware. Be sure the beveled edges of the transistor are positioned as shown.

( ) In the same manner, install another MPSU10 transistor (#417-834) on a heat sink.

( ) Q215: Place a **short** ferrite bead on the center lead of one of these transistors. Insert the E, B, and C leads of the transistor into their corresponding holes in the circuit board at location Q215. Secure the heat sink to the circuit board with two #4 × 3/8" screws. Then solder the transistor leads to the foil and cut off the excess lead lengths.

( ) Q214: In the same manner, install the other transistor and a **short** ferrite bead at location Q214 on the circuit board.

Refer to Pictorial 2-12 for the following steps.

( ) Prepare the following wires:

8″ Org	8″ Red
6-1/2″ Wht-Blk	7-1/2″ Wht-Viol
6-1/2″ Viol	9-1/2″ Wht-Yel
6-1/2″ Wht-Blu	9-1/2″ Wht-Gry
4-1/2″ Blk	

Connect only one end of each of the following wires to the horizontal circuit board. Their free ends will be connected later.

( ) 8″ Org wire to hole K (S-1).

( ) 6-1/2″ Wht-Blk wire to hole L (S-1).

( ) 6-1/2″ Viol wire to hole AA (S-1).

( ) 6-1/2″ Wht-Blu wire to hole BB (S-1).

( ) 4-1/2″ Blk wire to hole (⏚) ground (S-1).

( ) 8″ Red wire to hole B (S-1).

( ) 7-1/2″ Wht-Viol wire to hole N (S-1).

( ) 9-1/2″ Wht-Yel wire to hole C (S-1).

( ) 9-1/2″ Wht-Gry wire to hole A (S-1).

( ) Prepare the following wires:

7″ Wht-Brn	12″ Wht-Org
8″ Wht-Grn	12″ Wht-Red
9″ Brn	12″ Wht
8-1/2″ Yel	10″ Blu
12″ Grn	9-1/2″ Gry

Connect only one end of each of the following wires to the horizontal circuit board. Their free ends will be connected later.

( ) 8″ Wht-Grn wire to hole P (S-1).

( ) 7″ Wht-Brn wire to hole Q (S-1).

( ) 9″ Brn wire to hole EXT (S-1).

( ) 8-1/2″ Yel wire to hole R (S-1).

( ) 12″ Grn wire to hole E (S-1).

( ) 12″ Wht-Org wire to hole F (S-1).

( ) 12″ Wht-Red wire to hole D (S-1).

( ) 12″ Wht wire to hole G (S-1).

( ) Remove an extra 1/2″ of insulation from only one end (total 3/4″) of the remaining blue and gray prepared wires. Pass the longer bared end of each wire through the ferrite bead in the next two steps.

Connect only one end of the two following wires to the **foil** side of the horizontal circuit board. Their free ends will be connected later.

( ) 10″ Blu wire with a long ferrite bead to hole X2 (S-1).

( ) 9-1/2″ Gry wire with a long ferrite bead to hole X1 (S-1).

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) Poor solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Transistors for the proper type and installation.

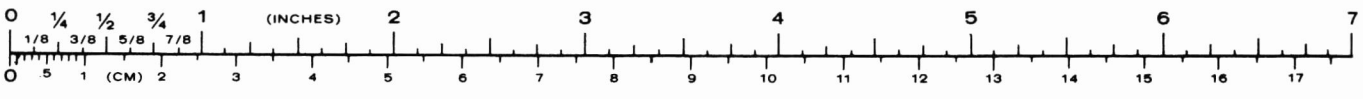
( ) Electrolytic capacitors for the correct position of the positive (+) end.

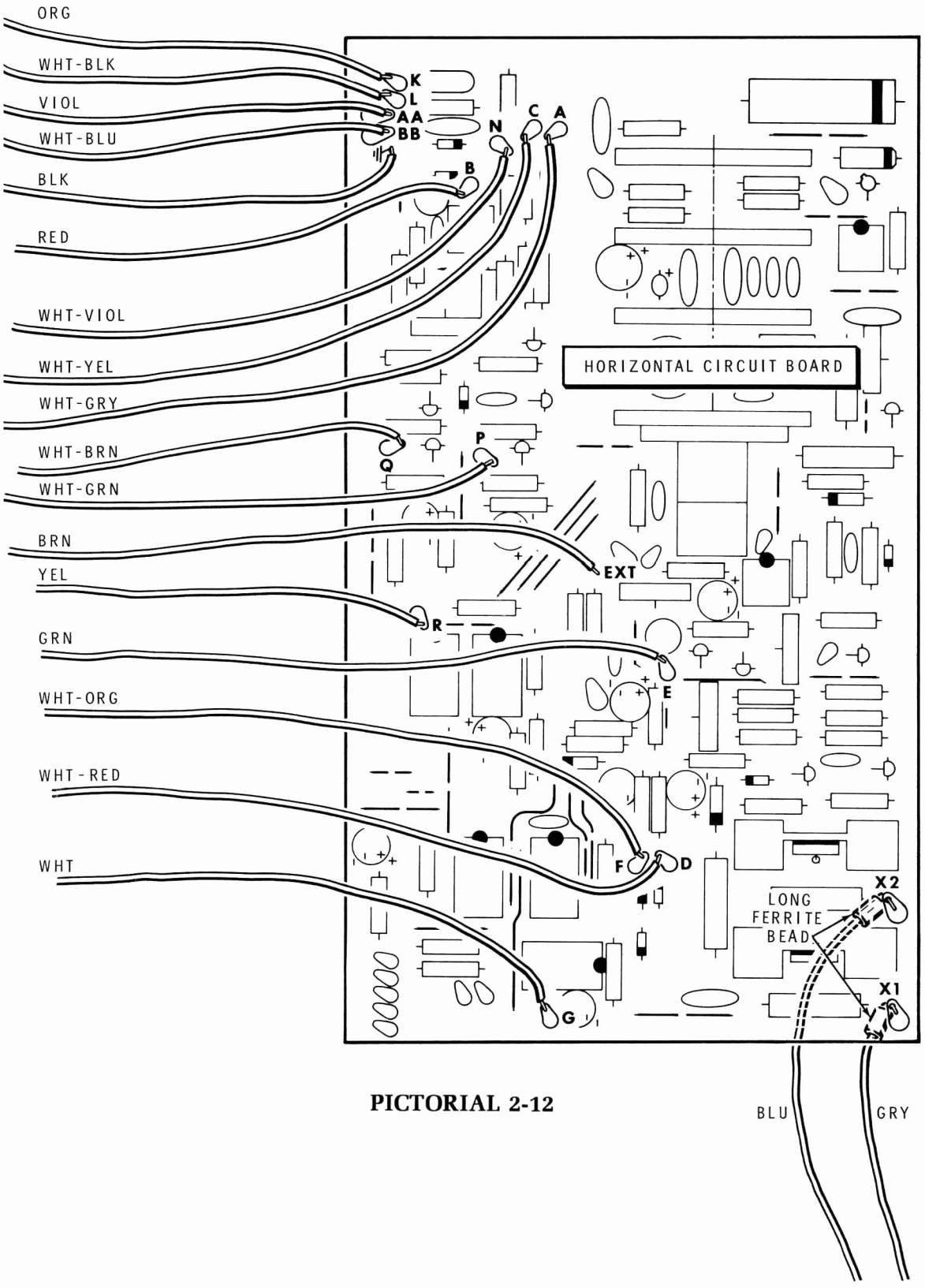
( ) Diodes for the proper type and the correct position of the banded end.

( ) IC's for the proper type and installation.

There are a number of unused holes in the circuit board that will be used later. Set the circuit board aside temporarily.

Save the remaining parts for use later.





PICTORIAL 2-12

POWER SUPPLY CIRCUIT BOARD

PARTS LIST

Open the pack marked #3 and check each part against the following list. The key numbers correspond to the numbers on the Power Supply Circuit Board Parts Pictorial (Illustration Booklet, Page 8).

To order a replacement part, see "Replacement Parts" inside the rear cover. For prices, refer to the separate "Heath Parts Price List."

RESISTORS

All resistors are 5% (fourth band gold) unless designated 10% (fourth band silver).

NOTE: The resistors may be packed in more than one envelope (stamped RES). Open all the resistor envelopes in this pack before you check the resistors against the Parts List.

1/2-Watt

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	6-510	1	51 Ω (Grn-Brn-Blk)	R322
A1	6-471	1	470 Ω (Yel-Viol-Brn)	R332
A1	6-511	1	510 Ω (Grn-Brn-Brn)	R325
A1	6-561	1	560 Ω (Grn-Blu-Brn)	R307
A1	6-102	3	1000 Ω (Brn-Blk-Red)	R311, R314, R320
A1	6-152	1	1500 Ω (Brn-Grn-Red)	R341
A1	6-182	3	1800 Ω (Brn-Gry-Red)	R312, R313, R342
A1	6-222	1	2200 Ω (Red-Red-Red)	R317
A1	6-432	1	4300 Ω (Yel-Org-Red)	R334
A1	6-472	1	4700 Ω (Yel-Viol-Red)	R315
A1	6-562	1	5600 Ω (Grn-Blu-Red)	R316
A1	6-682	2	6800 Ω (Blu-Gry-Red)	R335, R336
A1	6-103	1	10 kΩ (Brn-Blk-Org)	R331
A1	6-123	1	12 kΩ (Brn-Red-Org)	R326
A1	6-153	2	15 kΩ (Brn-Grn-Org)	R328, R329
A1	6-183	1	18 kΩ (Brn-Gry-Org)	R321
A1	6-273	1	27 kΩ (Red-Viol-Org)	R327
A1	6-473	2	47 kΩ (Yel-Viol-Org)	R318, R338

Resistors (Cont'd.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	6-104	3	100 kΩ (Brn-Blk-Yel)	R319, R333, R339
A1	6-474	1	470 kΩ (Yel-Viol-Yel)	R324
A1	6-105	1	1 MΩ (Brn-Blk-Grn)	R323

Other Resistors

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A2	1-30-1	1	220 kΩ, 1-watt, 10% (Red-Red-Yel)	R308
A2	1-32-1	3	470 kΩ, 1-watt, 10% (Yel-Viol-Yel)	R301, R309, R310
A2	3-5-2	1	2.2 Ω, 2-watt, 10% (Red-Red-Gold)	R302
A2	3-11-2	1	3.9 Ω, 2-watt, 10% (Org-Wht-Gold)	R303
A3	5-1-3	1	2700 Ω (2.7 kΩ), 3-watt, 10%	R306

CAPACITORS

Ceramic

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	21-33	1	3.3 pF	C317
B1	21-120	2	500 pF	C314, C315
B1	21-141	1	.0033 μF	C319
B1	21-16	1	.01 μF	C318

HEATHKIT®

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
Other Capacitors				
B2	28-2	1	1 pF phenolic (Brn-Blk-Wht)	C312
B3	27-47	1	.1 μF Mylar	C316
B4	23-115	3	.1 μF paper	C301, C302, C303
B5	25-837	3	1.5 μF Tantalum	C309, C310, C311
B6	25-288	1	25 μF electrolylic	C320
B7	25-241	4	1200 μF electrolytic	C304, C305, C306, C307
DIODES				
C1	56-26	1	1N191 (Brn-Wht-Brn)	D314
C1	56-56	7	1N4149	D312, D315, D316, D318 D319, D320, D321
C1	56-89	1	GD510	D313
C1	56-634	2	2EZ82D5	D311, D317
C1	57-27	8	IN2071	D303, D304, D305, D306 D307, D308, D309, D310
C1	57-52	2	D07	D301, D302

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
TRANSISTORS—INTEGRATED CIRCUITS (IC's)				
D1	417-237	2	SE6020 transistor	Q301, Q302
D1	417-295	1	MPSL51 transistor	Q305
D1	417-811	4	MPSL01 transistor	Q303, Q304, Q306, Q307
D2	442-617	2	UA78	U301, U302
D2	442-618	1	UA79	U303
MISCELLANEOUS				
E1	10-312	1	10 kΩ control	R340
E1	10-941	1	100 kΩ control	R330
E2	215-629	3	Heat sink	
E3	250-49	6	3-48 × 1/4" screw	
E4	252-1	6	3-48 nut	
E5	254-7	6	#3 lockwasher	
PART FROM FINAL PACK				
	85-2045-1	1	Power supply circuit board	
E6	354-7	6	Cable tie	

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

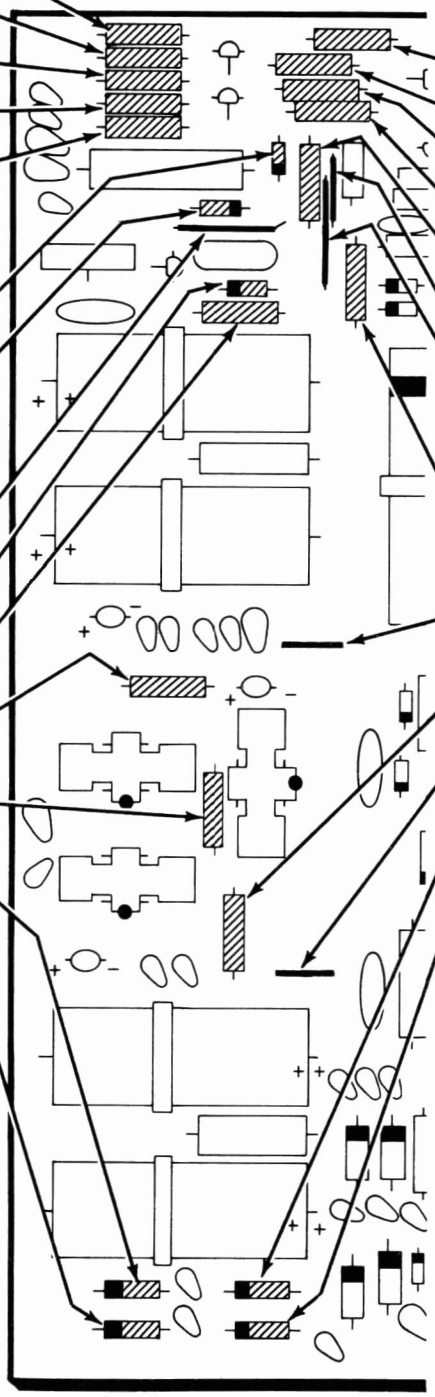
1. Part number.
2. Type number. (On integrated circuits this refers only to the numbers and letters listed. Any additional letters or numbers on an IC are not significant.)
3. Part number and type number.
4. Part number with a type number other than the one listed.

STEP-BY-STEP ASSEMBLY

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

START

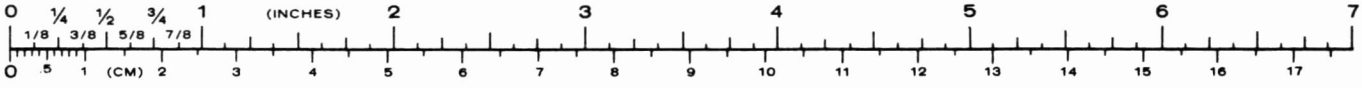
- ( ) R311: 1000 Ω (Brn-Blk-Red).
- ( ) R314: 1000 Ω (Brn-Blk-Red).
- ( ) R313: 1800 Ω (Brn-Gry-Red).
- ( ) R312: 1800 Ω (Brn-Gry-Red).
- ( ) R315: 4700 Ω (Yel-Viol-Red).
- NOTE: When you install a diode, always match the band on the diode with the band on the circuit board.
- ( ) D315: 1N4149 diode (#56-56).
- ( ) D314: 1N191 diode (Brn-Wht-Brn, #56-26).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) 1-1/4" Brn wire.
- ( ) D311: 2EZ82D5 zener diode (#56-634).
- ( ) R339: 100 kΩ (Brn-Blk-Yel).
- ( ) R336: 6800 Ω (Blu-Gry-Red).
- ( ) R335: 6800 Ω (Blu-Gry-Red).
- ( ) D304: 1N2071 diode (#57-27).
- ( ) D303: 1N2071 diode (#57-27).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.



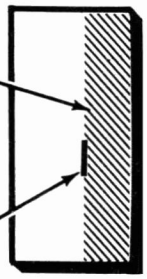
CONTINUE

- ( ) R320: 1000 Ω (Brn-Blk-Red).
- ( ) R319: 100 kΩ (Brn-Blk-Yel).
- ( ) R316: 5600 Ω (Grn-Blu-Red).
- ( ) R317: 2200 Ω (Red-Red-Red).
- ( ) R318: 47 kΩ (Yel-Viol-Org).
- ( ) 1" Brn wire.
- ( ) 1-1/4" Brn wire.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) R328: 15 kΩ (Brn-Grn-Org).
- ( ) 1" bare wire.
- ( ) R334: 4300 Ω (Yel-Org-Red).
- ( ) 1" bare wire.
- ( ) D306: 1N2071 diode (#57-27).
- ( ) D305: 1N2071 diode (#57-27).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 3-1



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

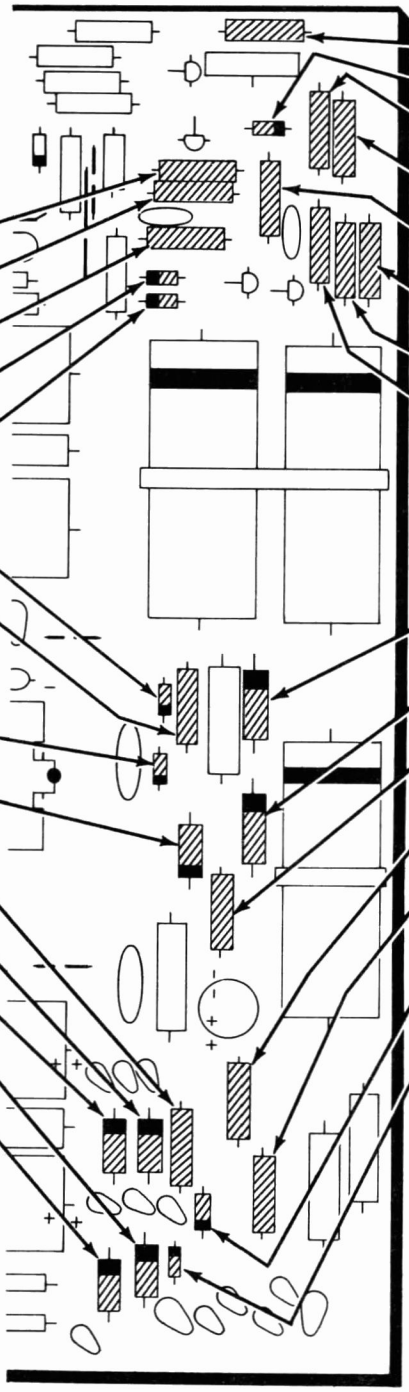


IDENTIFICATION DRAWING

PART NUMBER

START

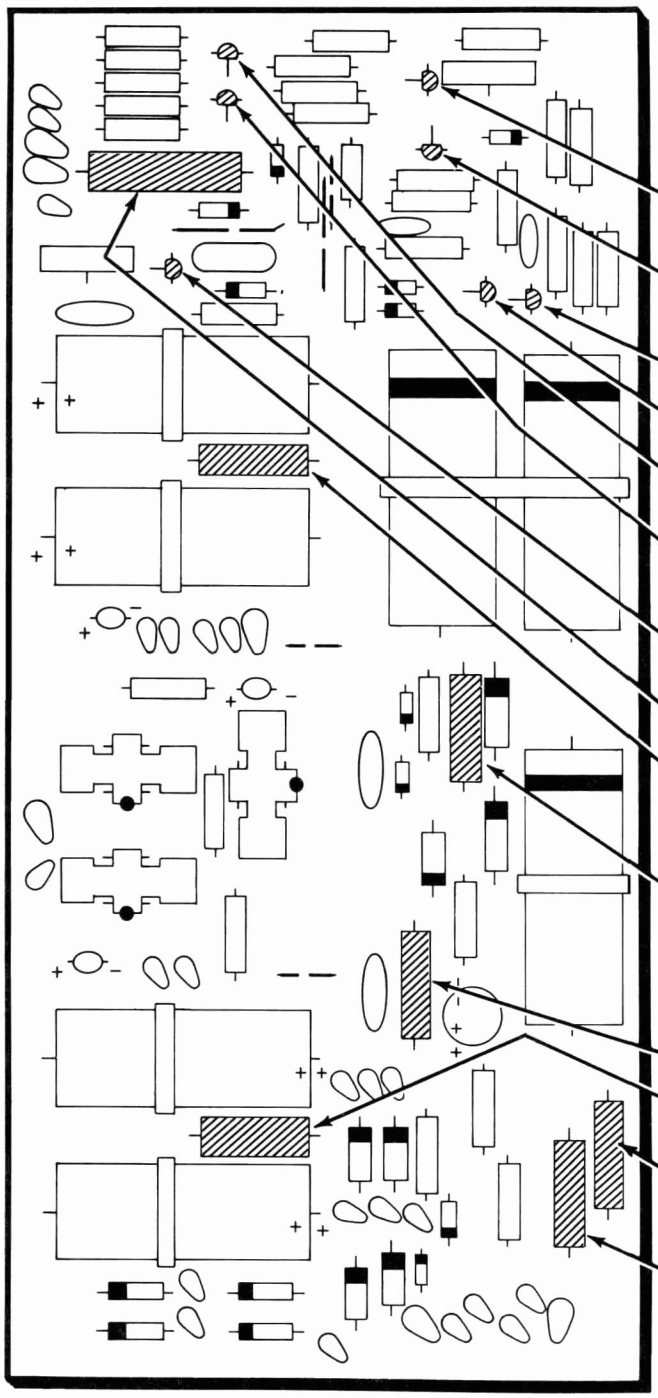
- ( ) R321: 18 kΩ (Brn-Gry-Org).
- ( ) R326: 12 kΩ (Brn-Red-Org).
- ( ) R327: 27 kΩ (Red-Viol-Org).
- ( ) D318: 1N4149 diode (#56-56).
- ( ) D319: 1N4149 diode (#56-56).
- ( ) D316: 1N4149 diode (#56-56).
- ( ) R323: 1 MΩ (Brn-Blk-Grn).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) D320: 1N4149 diode (#56-56).
- ( ) D317: 2EZ82D5 zener diode (#56-634).
- ( ) R307: 560 Ω (Grn-Blu-Brn).
- ( ) D310: 1N2071 diode (#57-27).
- ( ) D309: 1N2071 diode (#57-27).
- ( ) D308: 1N2071 diode (#57-27).
- ( ) D307: 1N2071 diode (#57-27).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

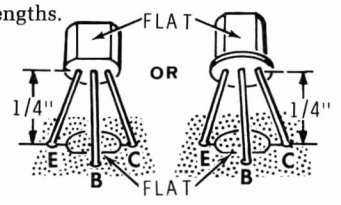
- ( ) R322: 51 Ω (Grn-Brn-Blk).
- ( ) D321: 1N4149 diode (#56-56).
- ( ) R341: 1500 Ω (Brn-Grn-Red).
- ( ) R342: 1800 Ω (Brn-Gry-Red).
- ( ) R329: 15 kΩ (Brn-Grn-Org).
- ( ) R332: 470 Ω (Yel-Viol-Brn).
- ( ) R331: 10 kΩ (Brn-Blk-Org).
- ( ) R333: 100 kΩ (Brn-Blk-Yel).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) D301: DO7 diode (#57-52).
- ( ) D302: DO7 diode (#57-52).
- ( ) R338: 47 kΩ (Yel-Viol-Org).
- ( ) R324: 470 kΩ (Yel-Viol-Yel).
- ( ) R325: 510 Ω (Grn-Brn-Brn).
- ( ) D313: GD510 diode (#56-89).
- ( ) D312: 1N4149 diode (#56-56).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 3-2



START

NOTE: When you install a transistor, align its flat with the flat on the board. Insert the leads into their correct E, B, and C holes. Position the transistor 1/4" above the board. Then solder the leads to the foil and cut off the excess lead lengths.



( ) Q303: MPSL01 transistor (#417-811).

( ) Q306: MPSL01 transistor (#417-811).

( ) Q305: MPSL51 transistor (#417-295).

( ) Q304: MPSL01 transistor (#417-811).

( ) Q302: SE6020 transistor (#417-237).

( ) Q301: SE6020 transistor (#417-237).

( ) Q307: MPSL01 transistor (#417-811).

( ) R306: 2700 Ω (2.7 k) 3-watt.

( ) R303: 3.9 Ω, 2-watt (Org-Wht-Gold).

( ) R301: 470 kΩ, 1-watt (Yel-Viol-Yel).

( ) R308: 220 kΩ, 1-watt (Red-Red-Yel).

( ) R302: 2.2 Ω, 2-watt (Red-Red-Gold).

( ) R310: 470 kΩ, 1-watt (Yel-Viol-Yel).

( ) R309: 470 kΩ, 1-watt (Yel-Viol-Yel).

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

PICTORIAL 3-3

START

NOTE: Solder the pins of a control to the foil as it is installed.

( ) R340: 10 kΩ control (#10-312).

( ) R330: 100 kΩ control (#10-941).

( ) C318: .01 μF ceramic.

( ) C316: .1 μF Mylar.

( ) C312: 1 pF phenolic (Brn-Blk-Wht).

( ) C317: 3.3 pF ceramic.

( ) C319: .0033 μF ceramic.

NOTE: When you install a tantalum capacitor, match the positive (+) mark or color dot on the capacitor with the positive (+) mark on the circuit board.

( ) C311: 1.5 μF tantalum.

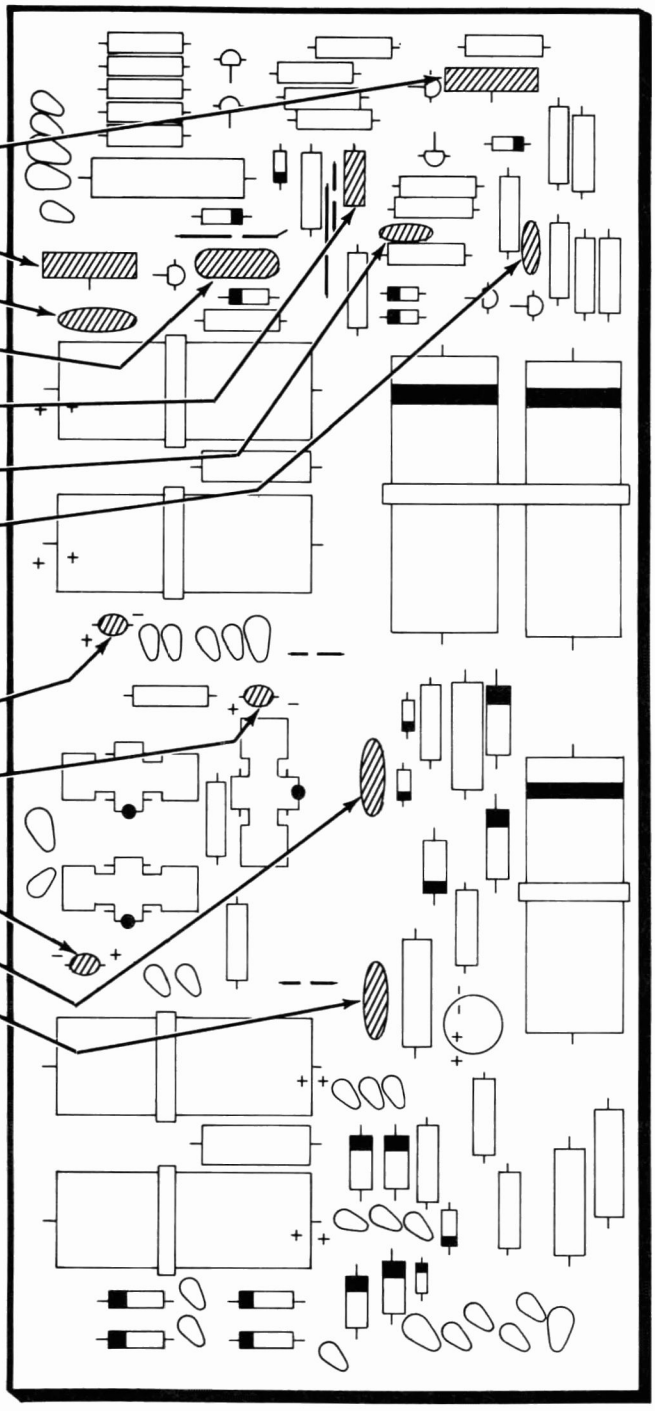
( ) C309: 1.5 μF tantalum.

( ) C310: 1.5 μF tantalum.

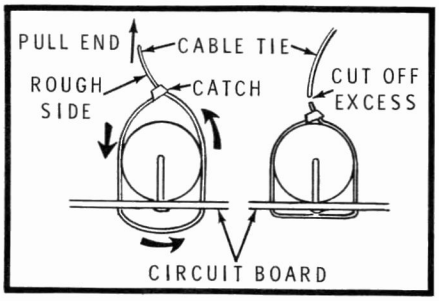
( ) C314: 500 pF ceramic.

( ) C315: 500 pF ceramic.

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



PICTORIAL 3-4



Detail 3-5A

START

NOTE: When you install an electrolytic capacitor, match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board.

( ) C305: 1200 μF electrolytic.

( ) C307: 1200 μF electrolytic.

NOTE: When you install a paper capacitor, match the band on the capacitor with the band on the circuit board.

( ) C303: .1 μF paper.

( ) C302: .1 μF paper.

( ) C301: .1 μF paper.

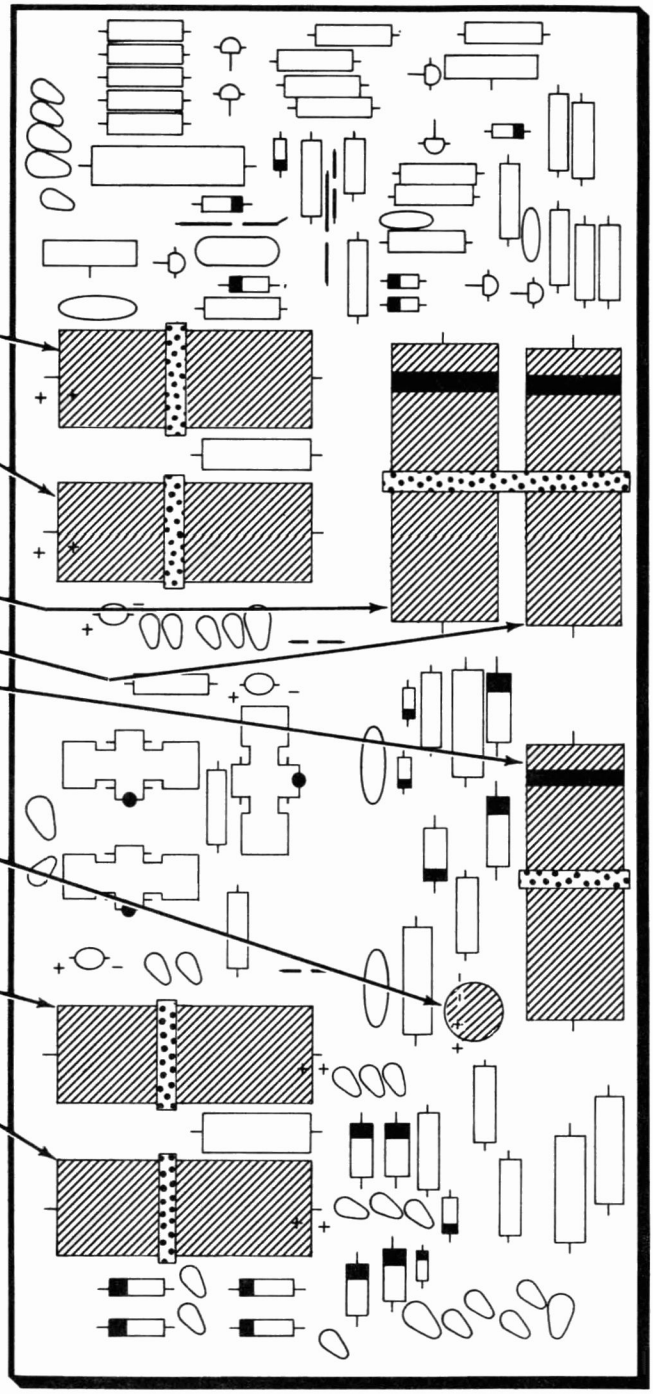
( ) C320: 25 μF electrolytic. Match the positive (+) mark on the capacitor with the positive (+) mark on the board **or** match the negative (−) mark on the capacitor with the negative (−) mark on the board.

( ) C306: 1200 μF electrolytic.

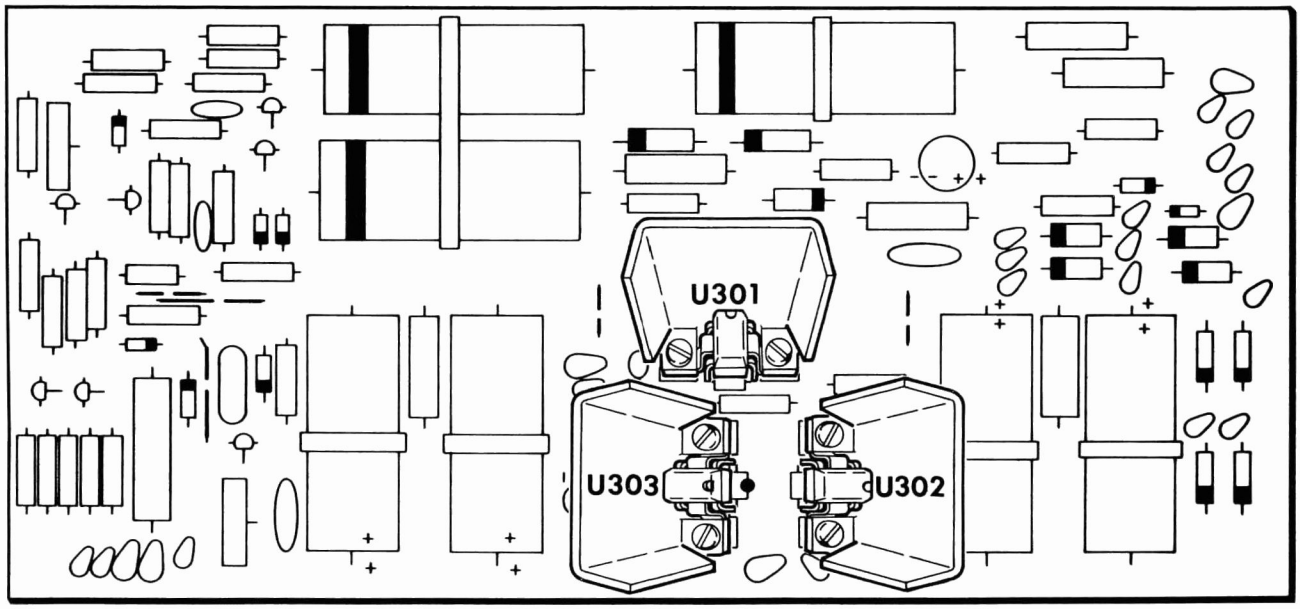
( ) C304: 1200 μF electrolytic.

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

( ) Refer to Detail 3-5A and install the six cable ties through the circuit board holes and around the paper and tubular electrolytic capacitors. Be sure the rough side of the cable tie is toward the capacitor. Fit the cable tie end through the catch and pull the cable tie tight. Then cut off the excess cable tie.



PICTORIAL 3-5



POWER SUPPLY CIRCUIT BOARD

PICTORIAL 3-6

Refer to Pictorial 3-6 for the following steps.

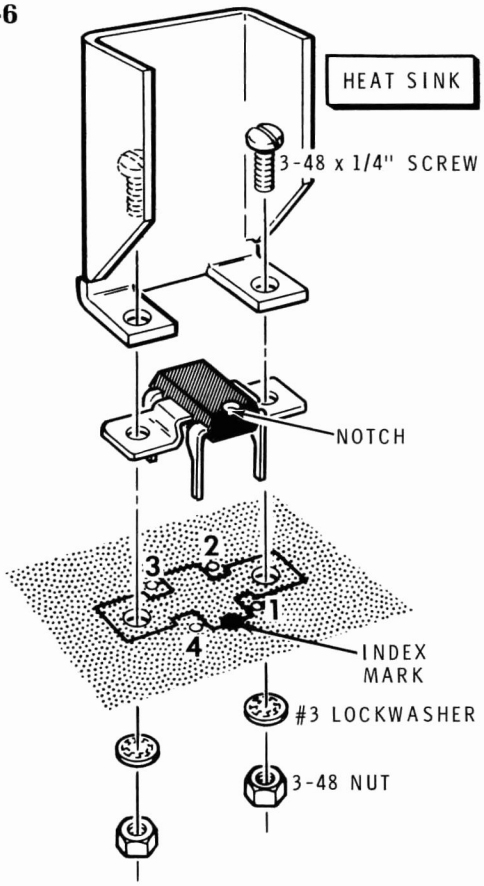
( ) U303: Refer to Detail 3-6A and install a UA79 IC (#442-618) at location U303 on the circuit board. Match the notch in the IC with the index mark on the circuit board and insert the IC pins in their holes in the circuit board. Then press the IC tight against the board but do not solder its pins at this time.

( ) Refer to Detail 3-6A and mount a heat sink at location U303 with 3-48 × 1/4" hardware. Be sure to position the heat sink as shown in Pictorial 3-6.

( ) Now solder the pins of the IC to the foil and cut off the excess pin lengths.

( ) U301: In the same manner, install a UA78 IC (#442-617) and a heat sink at location U301. Position the heat sink as shown.

( ) U302: In the same manner, install a U78 IC (#442-617) and a heat sink at location U302. Position the heat sink as shown.



Detail 3-6A

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) Poor solder connections.

( ) Solder bridges between the foil patterns.

( ) Protruding leads which could touch together.

( ) Transistors for proper type and installation.

( ) Electrolytic capacitors for the correct position of the positive (+) end.

( ) Diodes for the proper type and the correct position of the banded end.

( ) IC's for proper type and installation.

There are a number of unused holes in the circuit board which will be used later. Set the circuit board aside temporarily.

CHASSIS

PARTS LIST

Open the pack marked #4 and check these and the remaining parts in the final pack against the following list. The key numbers corresponding to the numbers on the Chassis and Final Pack Parts Pictorial (Illustration Booklet, Pages 9 and 10).

To order a replacement part, see "Replacement Parts" inside the rear cover. For prices, refer to the separate "Heath Parts Price List."

CIRCUIT COMPONENTS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	6-473	1	47 kΩ, 1/2-watt (Yel-Viol-Org) resistor	R13
A1	6-104	1	100 kΩ,1/2-watt (Brn-Blk-Yel) resistor	R16
A2	1-31-1	1	330 kΩ,1-watt,10% (Org-Org-Yel) resistor	R17
A3	5-2-3	1	270 Ω, 3-watt,10% resistor	R15
A4	3-12-10	1	500 Ω, 10-watt, 10% resistor	R14
A5	10-1118	3	1000 Ω (1k) control	R5, R7, R8
A5	10-1119	1	1 MΩ control	R6
A6	25-228	1	100-100-300 μF electrolytic capacitor	C3 A, B ,C,
A7	54-953	1	Power transformer	T1
A8	60-2	1	DPDT 2-position slide switch	SW9
A9	60-4	2	SPDT 2-position slide switch	SW7, SW8
A10	60-54	1	DPDT 120V-240V slide switch	SW10
A11	60-73	1	DP3T 3-position slide switch	SW6
A12	60-624	1	DP4T 4-position slide switch	SW4
	411-815	1	5DEP31F cathode ray tube (CRT)	V1

Circuit Components (Cont'd.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A13	412-15	1	NE2H pilot lamp	PL1
A14	421-20	1	1/2-ampere, 3AG, slow-blow fuse	F1

HARDWARE

NOTE: The hardware may be packed in more than one envelope (stamped HDW). Open all the hardware envelopes according to size before you check the hardware against the Parts List.

#4 Hardware

B1	250-375	2	4-40 × 5/16" flat head screw
B2	252-15	2	4-40 nut
B3	254-9	2	#4 lockwasher

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
#6 Hardware				
C1	250-1282	9	6-32 × 1/8″ black setscrew	
C2	250-1164	6	6-32 × 3/16″ flat head screw	
C3	250-138	17	6-32 × 3/16″ screw	
C4	250-365	2	#6 × 1/4″ hex washer head screw	
C5	250-1157	12	6-32 × 1/4″ hex stud	
C6	250-32	2	6-32 × 3/8″ flat head screw	
C7	250-89	12	6-32 × 3/8″ screw	
C8	250-1101	1	6-32 × 3/8″ T-bolt	
C9	250-591	5	#6 × 1/2″ screw	
C10	250-1203	1	#6 × 9/16″ screw	
C11	250-29	2	6-32 × 3/4″ screw	
C12	252-3	25	6-32 nut	
C13	252-22	2	6-32 push-on nut	
C14	254-1	26	#6 lockwasher	
C15	255-63	3	6-32 × 2″ threaded spacer	
C16	259-1	3	#6 solder lug	
#8 Hardware				
D1	250-1138	8	#8 × 5/8″ hex washer head screw	
D2	254-4	4	8-32 nut	
D3	252-68	8	8-32 push-on nut	
D4	254-2	4	#8 lockwasher	
Other Hardware				
E1	252-5	2	10-32 nut	
E2	254-37	2	#10 lockwasher	
E3	252-73	1	5/16″ push-on nut	
E4	252-7	5	3/8″ nut	
E5	253-10	7	3/8″ flat washer	
E6	254-4	4	3/8″ lockwasher	
LINE CORD — HARNESS — CABLE				
	89-54	1	Line cord	
	134-237	1	Cable with connector	
	134-1021	1	Harness	

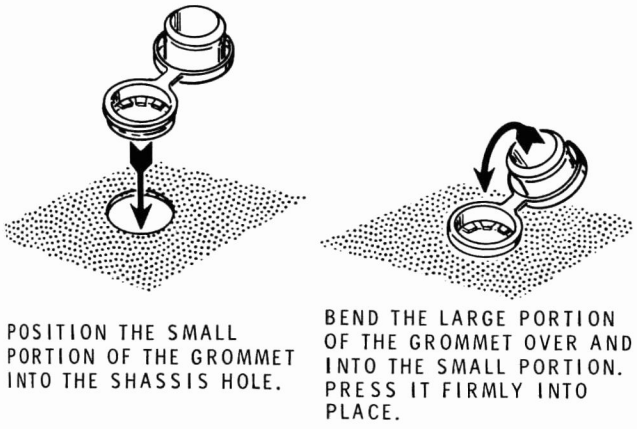
KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
METAL PARTS				
F1	200-1348	1	Chassis	
F2	204-2141	1	Front panel bracket	
F3	204-2313	2	CRT bracket	
F4	204-2314	1	Circuit board bracket	
F5	206-1216	1	CRT shield	
F6	206-1274	1	Input shield	
F7	207-1	2	CRT clamp	
MISCELLANEOUS				
G1	73-5	1	3/4″ × 5″ rubber strip	
G2	73-34	2	Red alligator clip insulator	
G3	73-45	7	Plastic grommet	
G4	75-52	1	Slide switch insulator	
G5	75-754	1	Line cord strain relief	
G6	75-771	4	Slide switch cover (2-1/2″)	
	92-609	1	Cabinet shell	
G7	92-679	1	Cabinet front	
	211-49	1	Handle	
G8	260-16	2	Alligator clip	
G9	261-1	3	Foot	
G10	266-991	4	Plastic spacer	
	300-18	1	Felt strip	
	351-9	1	Epoxy glue packet	
G11	354-5	2	Cable tie	
G12	413-10	1	Red lens	
G13	414-36	1	Graticule	
G14	422-1	1	Fuse block	
G15	431-82	1	Terminal collar	
G16	434-41	1	CRT socket	
G17	436-11	3	Red socket	J3, J4, J6
G17	436-22	1	Black socket	J5
G18	462-1049	2	Red knob	
G19	462-1055	2	Large black knob	
G20	462-1059	4	Small black knob with skirt	
G21	490-14	1	Allen wrench	
G22	205-778	1	Alignment tool blade	

STEP-BY-STEP ASSEMBLY

Refer to Pictorial 4-1 (Illustration Booklet, Page 11) for the following steps.

( ) Position the chassis as shown. This is the top side of the chassis. The front of the chassis is to your left.

( ) Refer to Detail 4-1A and install a plastic grommet in hole BA from the top of the chassis.

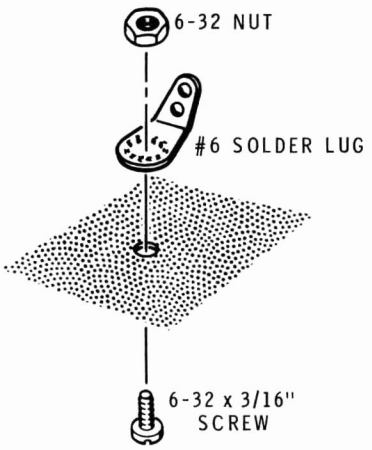


Detail 4-1A

In the same manner, install plastic grommets in the following chassis holes.

( ) BB
( ) BC
( ) BD
( ) BE
( ) BF
( ) BG

NOTE: Use the **flat head** screws only when **flat head** hardware is specifically called for in a step.

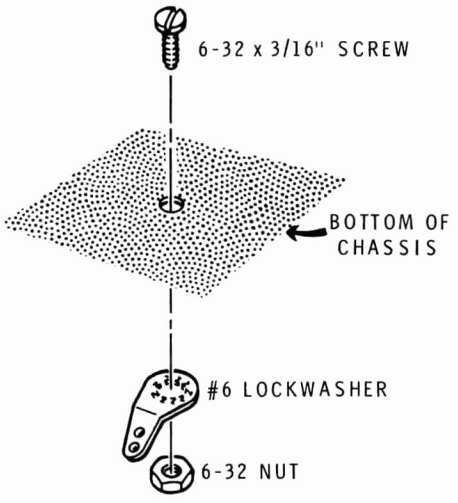


Detail 4-1B

( ) Refer to Detail 4-1B and mount a #6 solder lug on top of the chassis at location K with a 6-32 × 3/16″ screw and a 6-32 nut. Position the solder lug as shown.

( ) Refer to Detail 4-1C and mount a #6 solder lug on the bottom of the chassis at location N with a 6-32 × 3/16″ screw and a 6-32 nut. Position the solder lug as shown.

( ) In the same manner, install a #6 solder lug at location P.

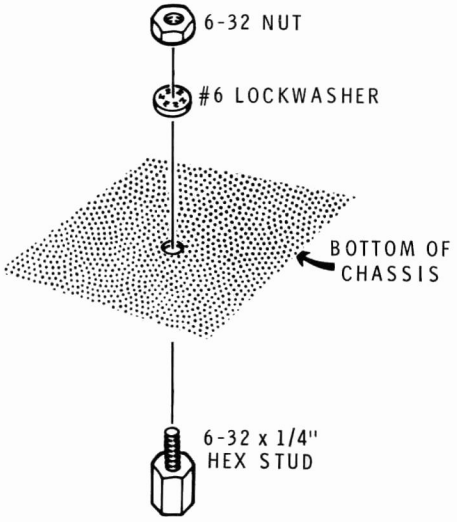


Detail 4-1C

( ) Refer to Detail 4-1D and **loosely** mount a 6-32 × 1/4" hex stud on the bottom of the chassis at location CA with a #6 lockwasher and a 6-32 nut. This stud will be tightened later.

In the same manner, **loosely** mount 6-32 × 1/4" hex studs at the following chassis holes.

( ) CB
( ) CC
( ) CD
( ) CE
( ) CF
( ) CG
( ) CH
( ) CJ
( ) CK
( ) CL
( ) CM



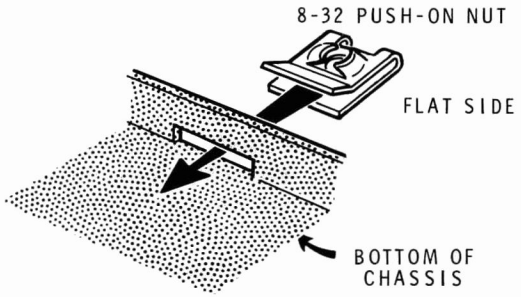
Detail 4-1D

( ) Refer to Detail 4-1E and install an 8-32 push-on nut in the slot at location H. Be sure the flat side of the nut is on the bottom of the chassis. Do not use the two 6-32 push-on nuts at this time.

( ) In the same manner, install 8-32 push-on nuts at locations J, L, and M.

( ) Install an 8-32 push-on nut at location T with the flat side of the nut on the rear (outside) of the chassis.

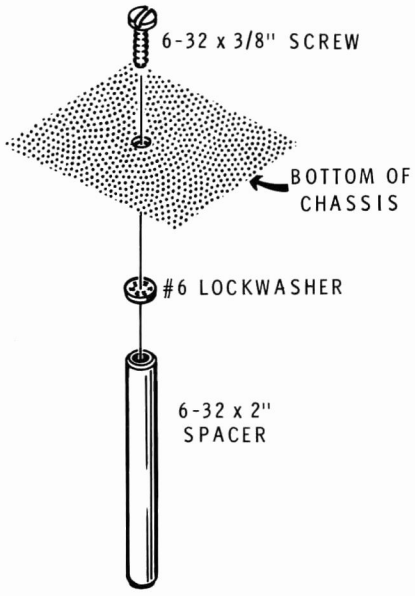
( ) In the same manner, install 8-32 push-on nuts at locations U, X, and Y on the rear of the chassis.



Detail 4-1E

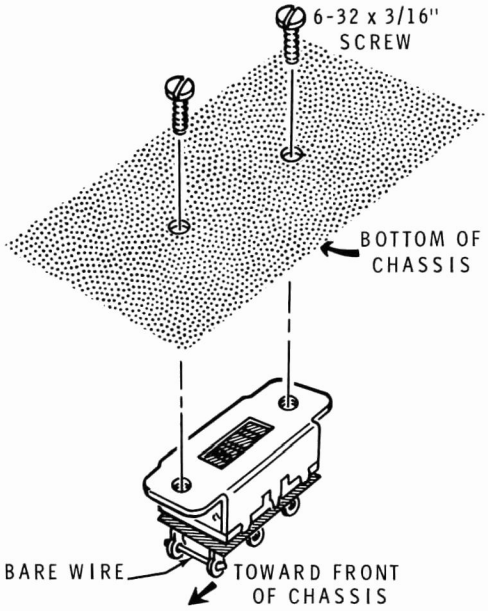
( ) Refer to Detail 4-1F and install a 6-32 × 2" threaded spacer on the bottom of the chassis at location Q. Use a 6-32 × 3/8" screw and a #6 lockwasher.

( ) In the same manner, install 6-32 × 2" threaded spacers at locations R and S.



Detail 4-1F

( ) SW10: Refer to Detail 4-1G and mount the DPDT 120V-240V slide switch on the bottom of the chassis at location SW10 with 6-32 × 3/16″ screws. Be sure the switch is positioned so the lugs with the bare wire between them is toward the front of the chassis.



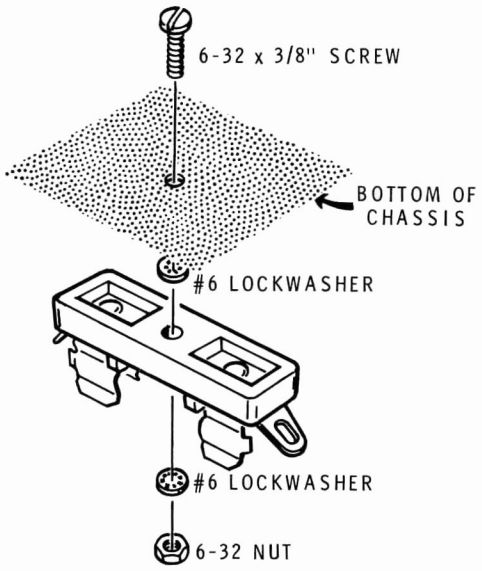
Detail 4-1G

( ) Refer to Detail 4-1H and mount the fuse block on the bottom of the chassis at location F1 with 6-32 × 3/8″ hardware.

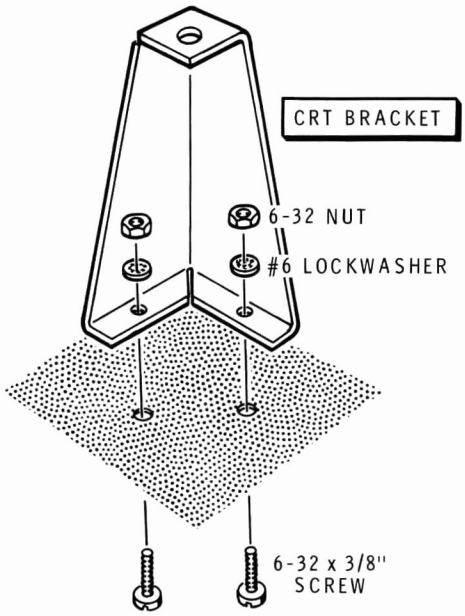
( ) Refer to Detail 4-1J and mount a CRT (cathode ray tube) bracket on the top of the chassis at either of the V1 locations. Use 6-32 × 3/8″ hardware.

( ) In the same manner, install the other CRT bracket at the remaining V1 location.

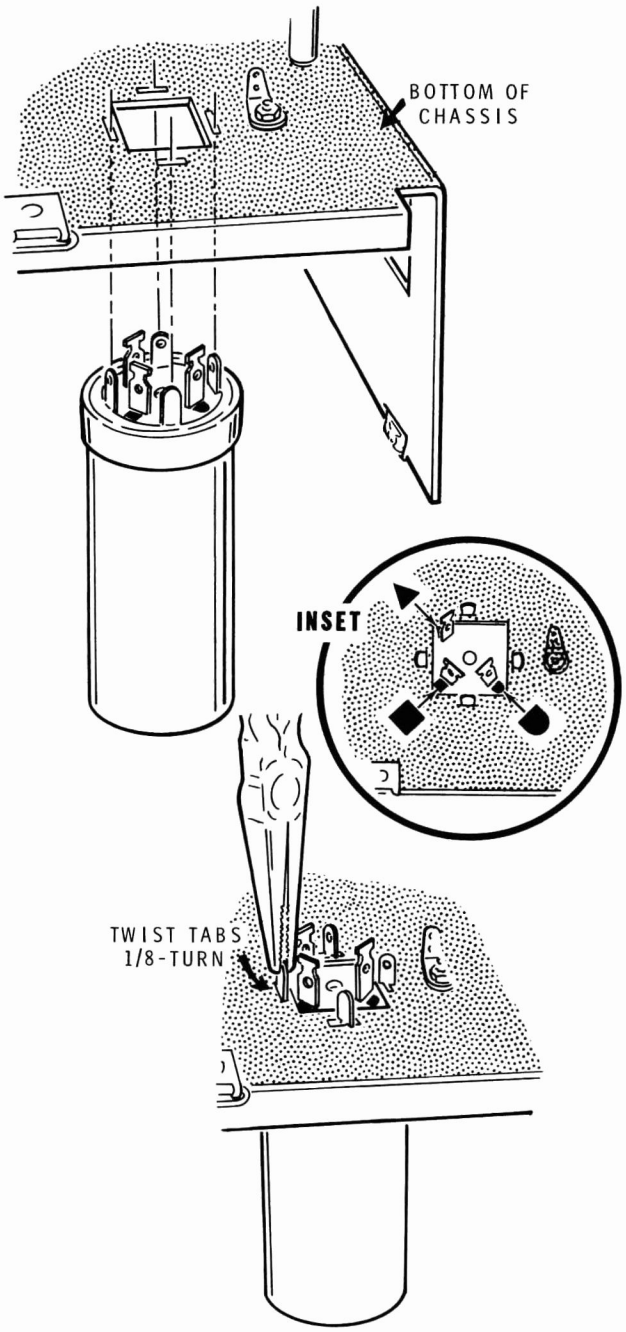
( ) Install a 6-32 push-on nut on the top of each CRT bracket. Be sure that the flat side of each nut is up and that each nut is positioned as shown on Pictorial 4-1.



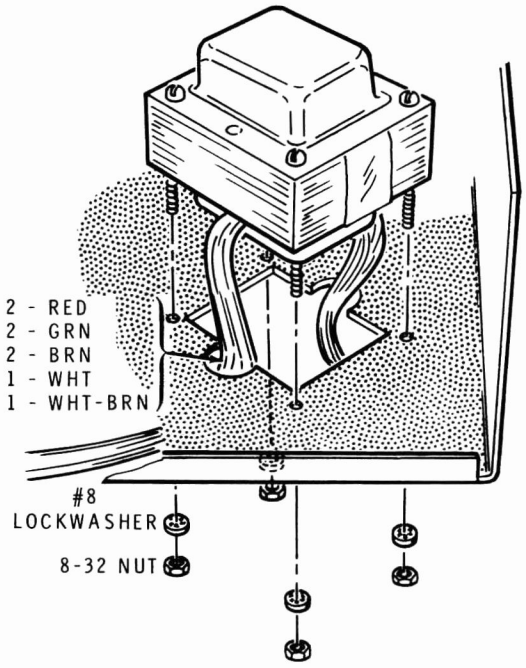
Detail 4-1H



Detail 4-1J



Detail 4-1K



Detail 4-1L

( ) C3: Refer to Detail 4-1K and mount the 100-100-300 μF electrolytic capacitor (#25-228) on the top of the chassis at location C3. Refer to the inset drawing which shows the capacitor lug positions from the bottom of the chassis.

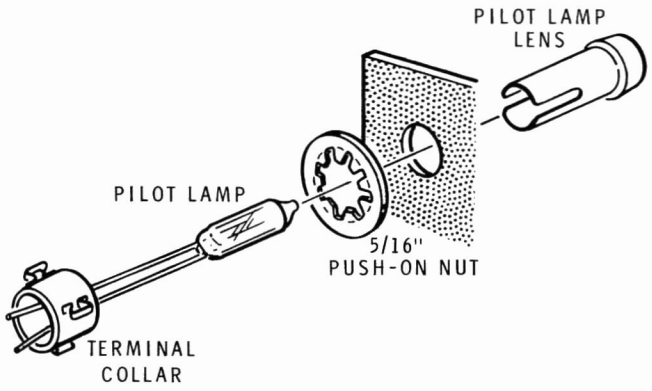
( ) T1: Refer to Detail 4-1L and mount the power transformer (#54-953) at location T1 with #8 lockwashers and 8-32 nuts. Be sure to position the transformer so the proper color wires are located as shown.

Refer to Pictorial 4-2 (Illustration Booklet, Page 12) for the following steps.

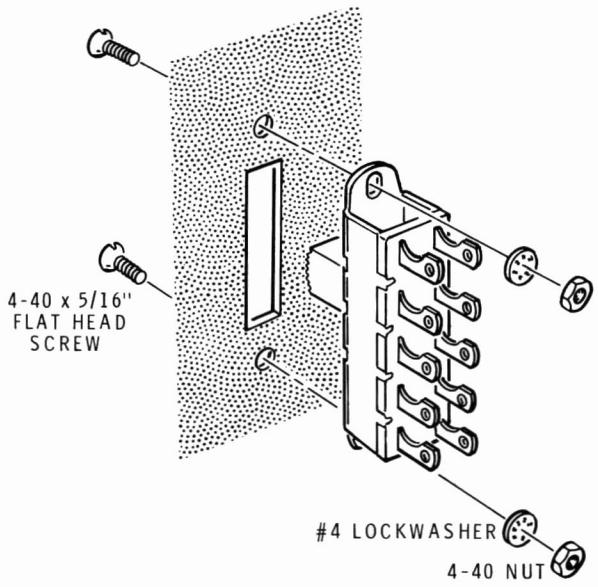
( ) Refer to Detail 4-2A and install the pilot lamp lens in hole PL1 in the chassis with a 5/16" push-on nut. Be sure the slot in the lens is positioned as shown before you push the nut tight against the chassis.

( ) PL1: Push the pilot lamp all the way into the pilot lamp lens.

( ) Refer to Detail 4-2A and push the terminal collar onto the pilot lamp lens until the collar is even with the end of the lens. Position the terminal collar so its lugs are located as shown.



Detail 4-2A



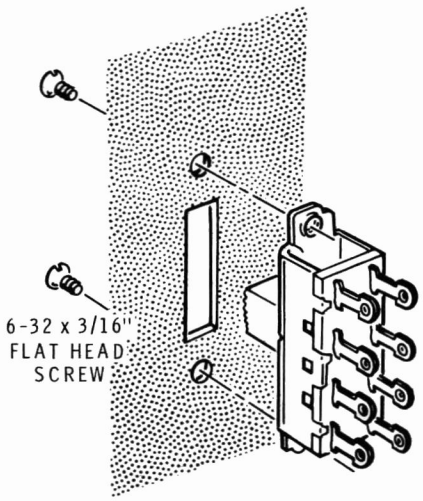
Detail 4-2B

( ) SW4: Refer to Detail 4-2B and mount the DP4T 4-position slide switch at location SW4 with 4-40 × 5/16" **flat head** hardware. The switch can be mounted either way.

( ) SW6: Refer to Detail 4-2C and install a DP3T 3-position slide switch at location SW6 with 6-32× 3/16" **flat head** screws.

( ) SW7: In the same manner, install an SPDT 2-position slide switch at location SW7. Position the switch so its lugs are located as shown.

( ) SW8: In the same manner, install another SPDT 2-position slide switch at location SW8.



Detail 4-2C

( ) Refer to the inset drawing on Pictorial 4-2 and install a split bearing (furnished with the vertical circuit board parts) in hole R4A. The wide side of the bearing must be on the inside of the chassis.

( ) In the same manner, install a split bearing in hole R4B.

Refer to Pictorial 4-3 (Illustration Booklet, Page 13) for the following steps.

( ) Turn the chassis over and position it as shown.

( ) Locate the harness and position it on the chassis with the wires from the various breakouts (BO) as shown.

( ) Pass the wires from BO#1 through grommet BA for connection later.

( ) Pass the wires from BO#8 through grommet BF for connection later.

( ) Pass the large Brn, large Red, large Org, and the small Gry-Wht wires from BO#9 through grommet BE for connection later.

( ) Twist together the two green leads coming from transformer T1. Pass these leads under the harness and through grommet BE for connection later.

Refer to Pictorial 4-4 (Illustration Booklet, Page 14) for the following steps.

Connect the leads from transformer T1 to switch SW10 as follows. Make mechanically secure connections. (See the inset drawing on Pictorial 4-4.

( ) Blk-Grn lead to lug 5 (S-1).

( ) Blk lead to lug 6 (NS).

( ) Blk-Yel lead to lug 2 (S-1).

( ) Blk-Red lead to lug 3 (NS).

Connect the wires coming from BO#7 in the harness as follows. Make mechanically secure connections.

( ) Either large Brn wire to fuse block F1 lug 2 (S-1).

( ) Other large Brn wire to switch SW10 lug 3 (S-2).

( ) Connect a 1" bare wire (remove all the insulation from a 1" length of brown wire) from capacitor C3 lug 4 (S-1) to solder lug N (NS).

Connect the wires coming from BO#9 in the harness as follows:

( ) All five Blk wires to solder lug N (S-6). Be sure all wires, especially the lower ones, get soldered.

( ) Both Viol wires to capacitor C3 lug 1 (NS).

( ) Both Wht-Red wires to capacitor C3 lug 2 (NS).

( ) Red wire to capacitor C3 lug 3 (NS).

( ) Place a 1" length of sleeving on each lead of a 500 Ω, 10-watt resistor.

( ) R14: Connect this resistor to capacitor C3 between lugs 1 (S-3) and 2 (NS). Position this resistor directly above the capacitor lugs.

( ) Place a 5/8" length of sleeving on each lead of a 270 Ω, 3-watt resistor.

( ) R15: Connect this resistor to capacitor C3 between lugs 2 (S-4) and 3 (S-2). Position this resistor 1/2" above the chassis.

Refer to Pictorial 4-5 (Illustration Booklet, Page 14) for the following steps.

( ) Locate the power supply circuit board and position it as shown.

Connect the wires coming from BO#3 of the harness to the power supply circuit board as follows:

( ) Wht-Grn wire to hole S (S-1).

( ) Wht wire to hole R (S-1).

( ) Grn wire to hole AA (S-1).

( ) Viol wire to hole AD (S-1).

( ) Wht-Gry to hole Y (S-1).

Connect the wires coming from BO#4 of the harness to the power supply circuit board as follows:

( ) Either Gry wire to hole Q (S-1).

( ) Other Gry wire to hole V (S-1).

( ) Any of the three Yel wires to hole N (S-1).

( ) Either of the remaining Yel wires to hole T (S-1).

( ) Remaining Yel wire to hole AH (S-1).

Connect the wires coming from BO#5 of the harness to the power supply circuit board as follows:

( ) Blk wire to hole D (S-1).

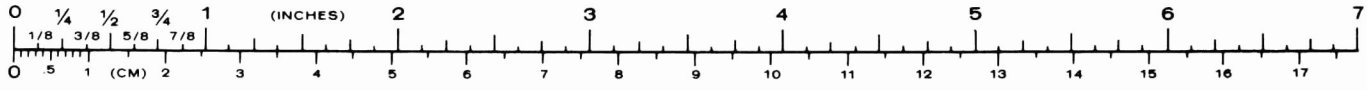
( ) Either Org wire to hole P (S-1).

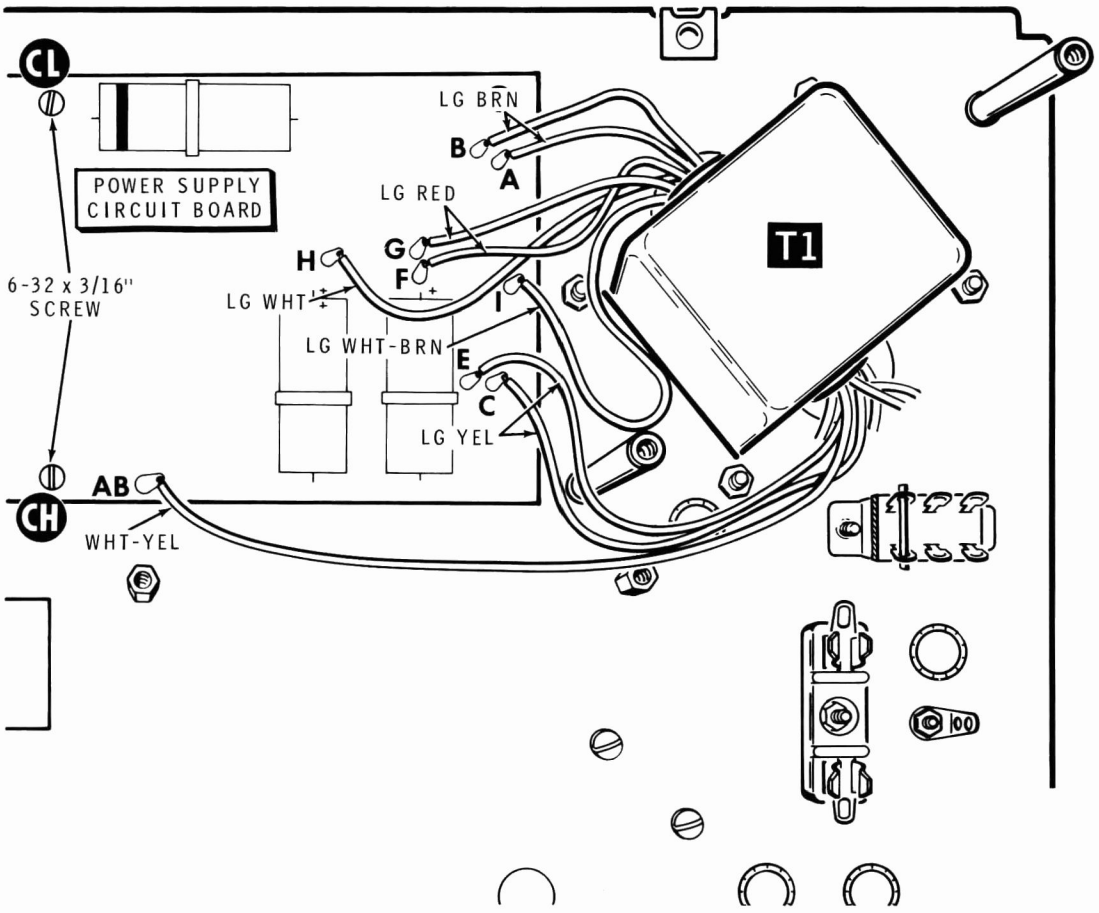
( ) Other Org wire to hole U (S-1).

( ) Wht-Red wire to hole J (S-1).

( ) Wht-Yel wire to hole L (S-1).

( ) Wht-Brn wire to hole K (S-1).





PICTORIAL 4-6

Connect the wires coming from BO#6 of the harness to the power supply circuit board as follows:

( ) Large Blk wire to hole AE (S-1).

( ) Large Org wire to hole X (S-1).

( ) Large Red wire to hole W (S-1).

( ) Large Yel wire to hole AF (S-1).

Refer to Pictorial 4-6 for the following steps.

Connect the leads coming from the transformer T1 to the power supply circuit board as follows:

( ) Large Wht-Yel lead to hole AB (S-1).

( ) Either large Yel lead to hole E (S-1).

( ) Other large Yel lead to hole C (S-1).

( ) Large Wht-Brn lead to hole I (S-1).

( ) Large Wht lead to hole H (S-1).

( ) Either large Red lead to hole F (S-1).

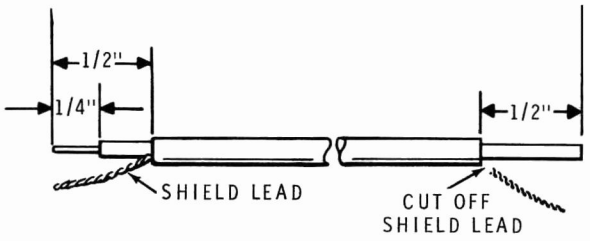
( ) Other large Red lead to hole G (S-1).

( ) Either large Brn lead to hole A (S-1).

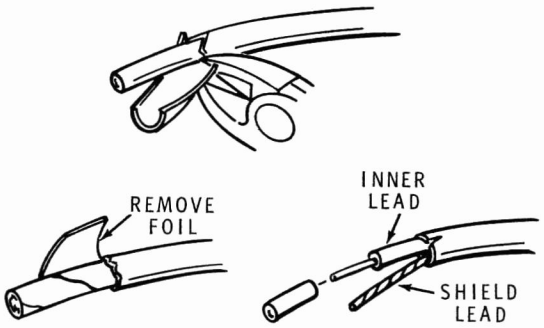
( ) Other large Brn lead to hole B (S-1).

This completes the wiring to the power supply circuit board. Be sure all connections are soldered, and cut off all excess lead lengths as close to the foil as possible.

( ) Temporarily mount the power supply circuit board at hex studs CL and CH with 6-32 × 3/16″ screws.



TAKING CARE NOT TO CUT THE SHIELD LEAD, REMOVE THE OUTER INSULATION.



REMOVE THE FOIL AND REMOVE 1/4" OF INSULATION FROM THE END OF THE INNER LEAD. **Detail 4-7A**

Refer to Pictorial 4-7 (Illustration Booklet, Page 15) for the following steps.

( ) Refer to Detail 4-7A and prepare both ends of a 20" length of shielded cable (furnished with the vertical circuit board parts).

Connect the end of this cable with the bared inner lead to the vertical circuit board as follows:

( ) Inner lead to hole HH (S-1).

( ) Shield lead to hole KK (S-1).

( ) At the other end of this cable, remove 1/4" of insulation from the inner lead. This will be used to identify this cable when it is connected later.

( ) Refer to Detail 4-7A and prepare both ends of a 26" length of shielded cable.

Connect the end of this cable with the bared inner lead to the vertical circuit board as follows:

( ) Inner lead in hole H (S-1).

( ) Shield lead in hole K (S-1).

DO NOT remove any insulation from the free end of this cable; it will be connected later.

( ) Prepare the ends of an 8" Gry wire and an 8" Blu wire.

( ) Connect one end of an 8" Gry wire in hole Y2 in the vertical circuit board (S-1). The other end will be connected later.

( ) Connect one end of an 8" Blu wire in hole Y1 in the vertical circuit board (S-1). The other end will be connected later.

( ) Position the vertical circuit board on the chassis as shown in Pictorial 4-7.

Connect the wires coming from BO#10 of the harness to the vertical circuit board as follows:

( ) Blk wire to hole (⏚) ground (S-1).

( ) Viol wire to hole N (S-1).

( ) Yel wire to hole W (S-1).

( ) Org wire to hole U (S-1).

( ) Gry wire to hole V (S-1).

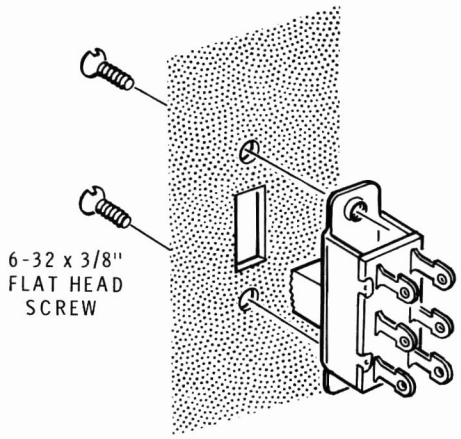
( ) Wht-Grn wire to hole C (S-1).

( ) Grn wire to hole D (S-1).

This completes the wiring of the vertical circuit board. Check to see that all connections are soldered, and cut off all excess lead lengths as close to the foil as possible.

Refer to Pictorial 4-8 (Illustration Booklet, Page 16) for the following steps.

( ) Secure the vertical circuit board to the chassis with two #6 × 1/4" hex washer head screws through the switch bracket and into chassis holes B and C and 6-32 × 3/16" screws through the circuit board and into hex studs CA, CB, CC, CD, CE, and CF. Then tighten the nuts on the hex studs.



Detail 4-9A

( ) Position the free ends of the two shielded cables coming from the vertical circuit board under the harness and then through grommet BF for connection later.

( ) Pass the free end of the Blu wire coming from the vertical circuit board through grommet BC for connection later.

( ) Pass the free end of the Gry wire coming from the vertical circuit board through grommet BD for connection later.

NOTE: Position the harness away from these blue and gray wires.

( ) Position the indicated leads coming from power transformer T1 on top of the harness near the corner of the vertical circuit board and install a cable tie around all these wires. See the inset drawing on Pictorial 4-8. Pull the cable tie tight and cut off its excess.

( ) Remove the protective backing from the DANGER label and press the label in place on the chassis at the location shown near the power supply circuit board.

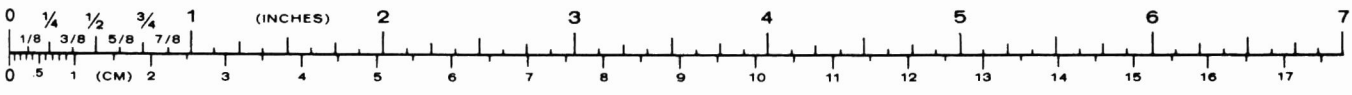
Set the chassis aside temporarily.

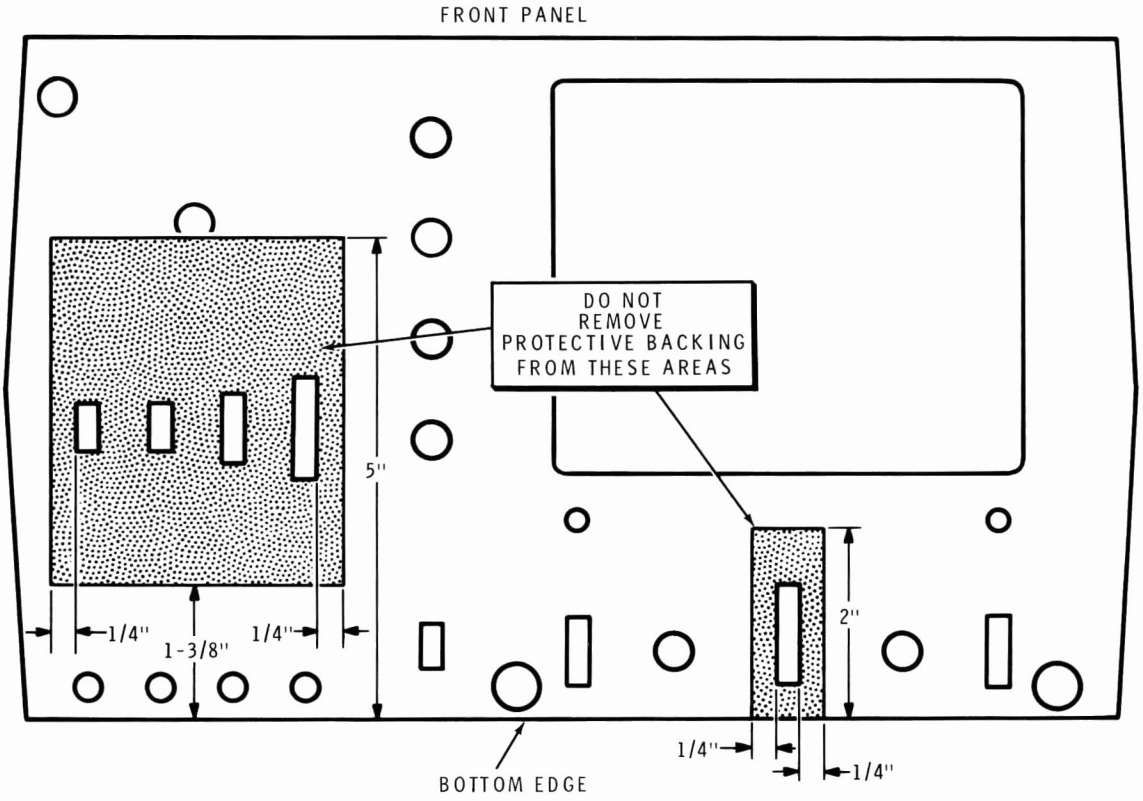
Refer to Pictorial 4-9 (Illustration Booklet, Page 17) for the following steps.

CAUTION: Place a large soft cloth on your work area to protect the cabinet front from being scratched as you work with the Oscilloscope.

( ) SW9: Refer to Detail 4-9A and mount the DPDT 2-position slide switch at location SW9 on the cabinet front. Use 6-32 × 3/8" **flat head** screws.

Set the cabinet front aside temporarily.





Detail 4-9B

NOTE: In the next step, you will be instructed to remove the protective backing from the back (unprinted) side of the front panel. The protective backing **must not** be removed from the two shaded areas; otherwise, the switch covers, positioned in the five recessed areas of the cabinet front, will stick to the adhesive back of the front panel, and prevent these five switches from operating. Cut through the protective backing around these two shaded areas with a sharp knife. Then, when you remove the protective backing, be sure these shaded areas remain in place on the front panel.

( ) Refer to Detail 4-9B and remove the protective backing from the back of the front panel except for the two shaded areas mentioned in the previous note.

( ) Temporarily lay the front panel **adhesive side up** on your work area.

( ) Position the cabinet front as shown in Pictorial 4-9.

( ) Fit the 6-32 × 3/8″ T-bolt into the indicated square recess in the cabinet front.

( ) Place a 2-1/2″ slide switch cover in each of the recessed areas at switch locations SW4, SW6, SW7, and SW8 in the cabinet front.

Locate the three slide switch covers (two fiber and one metal) supplied with the vertical circuit board parts. Install these covers in the recessed area at switch location SW3 in the following order.

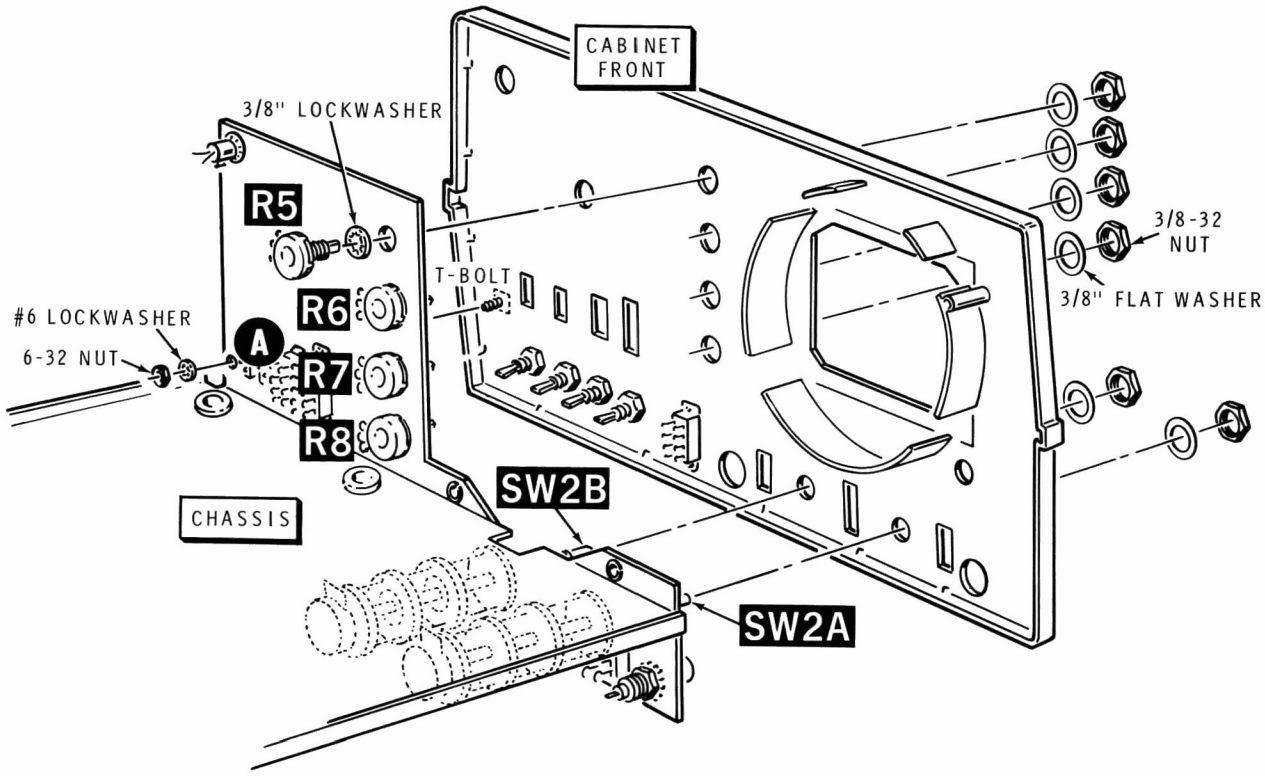
( ) 1. 1-7/16″ switch cover.

( ) 2. 1-3/16″ metal switch cover. Be sure its tabs fit down into the cutout in the 1-7/16″ cover.

( ) 3. 29/32″ switch cover.

NOTE: Be sure the switch covers and T-bolt remain in their recessed areas when you perform the next step.

( ) Carefully fit the front panel (adhesive side down) into the recessed area of the cabinet front. Press the front panel down into place.



PICTORIAL 4-10

( ) J3: Install a red socket at location J3 in the front panel. Use the nut furnished with the socket.

( ) J4: In the same manner, install a red socket at location J4.

( ) J5: Install a **black** socket at location J5.

( ) J6: Install the remaining red socket at location J6.

Refer to Pictorial 4-10 for the following steps.

( ) Temporarily remove the 3/8-32 nuts from rotary switches SW2A and SW2B.

NOTE: If necessary, slide the switch covers so they line up with the slide switches when you mount the cabinet front in the following steps.

( ) Fit the cabinet front onto the front of the chassis. Be sure all the switches and the T-bolt fit properly into their slots and holes.

( ) Install 3/8" flat washers and 3/8-32 nuts on rotary switches SW2A and SW2B.

( ) Install a #6 lockwasher and a 6-32 nut on the T-bolt at hole A in the chassis front.

( ) R8: Mount a 1000 Ω(1k) control (#10-1118) at location R8 with a 3/8" lockwasher, 3/8" flat washer, and a 3/8"-32 nut. Position the control so its lugs are located as shown.

( ) R7: In the same manner, install a 1000 Ω (1k) control (#10-1118) at location R7.

( ) R6: Install a 1 MΩ control (#10-1119) at location R6. Cut the control locating tab off the control so it does not touch the inside of the chassis.

( ) R5: Install a 1000 Ω (1k) control (#10-1118) at location R5.

Refer to Pictorial 4-11 (Illustration Booklet, Page 17) for the following steps.

( ) Position the chassis upside down as shown.

( ) Push the slide switch insulator onto the rear of switch SW9.

Connect the wires coming from BO#2 of the harness as follows:

( ) Either large Brn wire to switch SW9 lug 6 (S-1). Make a mechanically secure connection.

( ) Other large Brn wire to switch SW9 lug 5 (S-1). Make a mechanically secure connection.

( ) Wht-Brn wire to socket J3 (S-1).

( ) Blk wire to socket J5 (NS).

( ) Pass the Wht-Red wire coming from BO#2 through grommet BB for connection later.

( ) Prepare a 5-1/2" Wht-Blu wire and a 3" Blk wire.

( ) Connect one end of a 5-1/2" Wht-Blu wire to socket J4 (S-1). Pass the other end of this wire through grommet BA for connection later.

( ) Connect one end of a 3" Blk wire to socket J5 (S-2). Pass the other end of this wire through grommet BB for connection later.

Refer to Pictorial 4-12 for the following steps.

( ) Refer to Detail 4-12A and prepare the end of the line cord.

( ) Refer to Detail 4-12B and pass the prepared end of the line cord through hole W in the rear of the chassis.

( ) Refer to Detail 4-12B and install the line cord in the line cord strain relief. Install the line cord strain relief at location W with a #6 × 9/16" screw.

Pass the end of the line cord through grommet BG and connect its leads as follows. All three connections must be mechanically secure.

( ) Grn to solder lug P (S-1).

( ) Blk lead to fuse block F1 lug 1 (S-1).

( ) Wht lead to switch SW10 lug 6 (S-2).

ALTERNATE LINE VOLTAGE OPERATION

This Oscilloscope can be operated on either 120 VAC or 240 VAC line voltage. In the United States 120 VAC is most often used, while in other countries 240 VAC is more common. USE ONLY THE INSTRUCTIONS THAT AGREE WITH THE LINE VOLTAGE IN YOUR AREA.

120 VAC LINE VOLTAGE

( ) Move slide switch SW10, if necessary, so the **120** is visible on the top of the switch. Use a screwdriver blade to move the switch slider.

( ) F1: Install the 1/2-ampere, 3AG, slow-blow fuse in the fuse block at location F1.

( ) Remove the protective backing from the fuse label and press the label onto the bottom of the chassis at the indicated location.

( ) Write "1/2-ampere, 3AG, Slow-blow" on the line on the fuse label.

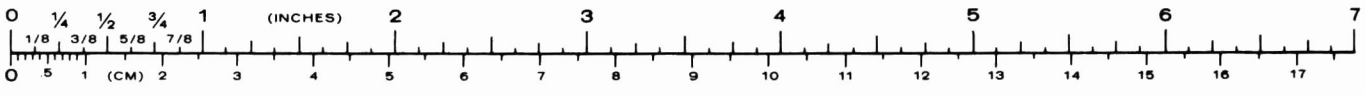
240 VAC LINE VOLTAGE

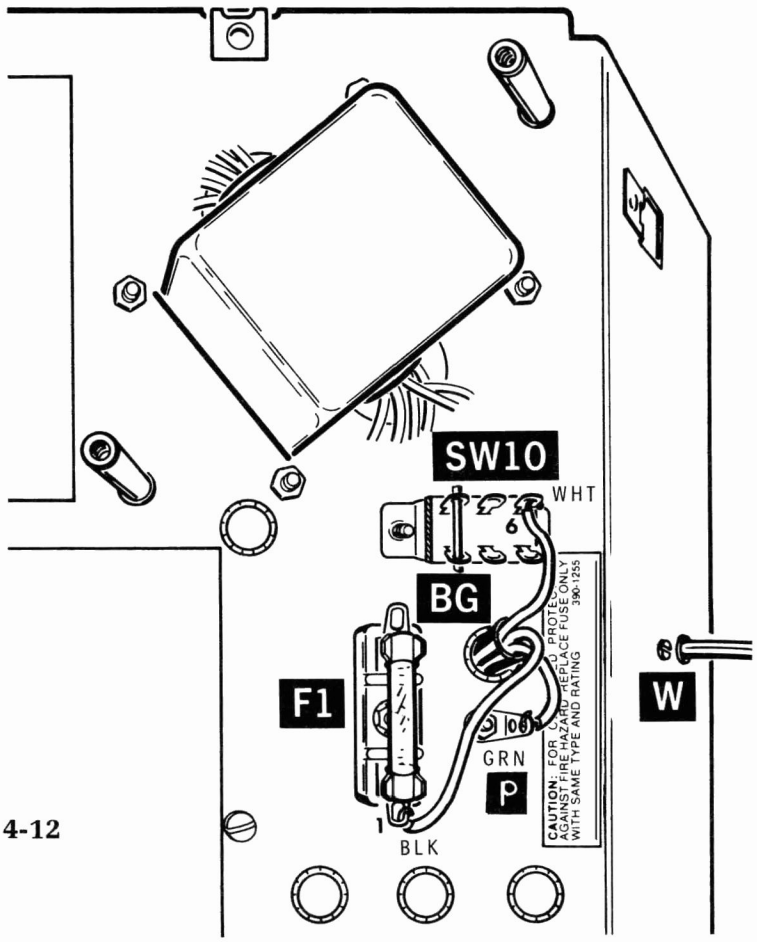
( ) **Move slide switch SW10, if necessary, so the 240** is visible on the top of the switch. Use a screwdriver blade to move the switch slider.

( ) F1: Install a 1/4-ampere, 3 AG, slow blow fuse (not supplied) in the fuse block at location F1.

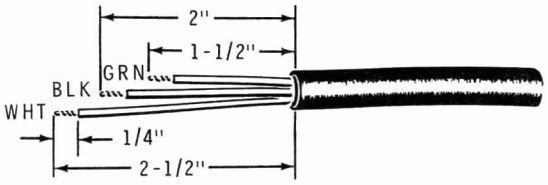
( ) Remove the protective backing from the fuse label and press the label onto the bottom of the chassis at the indicated location.

( ) Write "1/4-ampere, 3AG, Slow-blow" on the line on the fuse label.

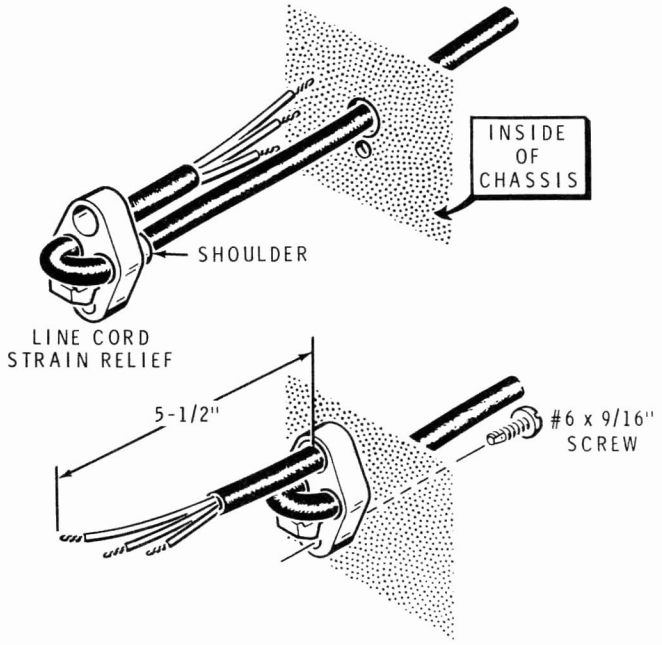




PICTORIAL 4-12



Detail 4-12A



Detail 4-12B

Refer to Pictorial 4-13 (Illustration Booklet, Page 18) for the following steps.

( ) Position the chassis top side up as shown.

Connect the wires from BO#1 of the harness as follows:

( ) **Large** Yel wire to control R6 lug 3 (NS).

( ) **Large** Brn wire to control R6 lug 2 (S-1).

( ) **Large** Blk wire to control R6 lug 1 (NS).

( ) Yel wire to control R5 lug 3 (S-1).

( ) Grn wire to control R5 lug 2 (S-1).

( ) Blk wire to control R5 lug 1 (S-1).

( ) Wht-Yel wire to switch SW4 lug 5 (S-1).

( ) R17: Connect a 330kΩ, 1-watt (Org-Org-Yel) resistor to control R6 between lugs 1 (S-2) and 3 (S-2).

( ) Place a 1/2" length of sleeving on a 1" bare wire. Connect this wire to switch SW4 between lugs 4 (NS) and 7 (S-1).

( ) Connect the free end of the Wht-Blu wire coming from grommet BA to switch SW4 lug 3 (S-1).

( ) Locate the shielded cable coming from grommet BF with the insulation removed from its inner lead. Connect the inner lead to switch SW4 lug 8 (S-1). There is no shield lead connection at this end of the cable.

( ) Remove 1/4" of insulation from the inner lead of the other shielded cable coming from grommet BF.

( ) Connect the inner lead of this cable to switch SW4 lug 6 (S-1). There is no shield lead connection at this end of the cable.

( ) Connect the free end of the Blk wire coming from grommet BB to solder lug K (NS).

( ) Connect the free end of the Wht-Red wire coming from grommet BB to pilot lamp PL1 lug 3 (NS).

( ) Prepare a 2-1/2" black wire and a 6-1/2" black wire.

( ) Connect a 2-1/2" Blk wire from switch SW8 lug 3 (S-1) to solder lug K (NS).

( ) Connect a 6-1/2" Blk wire from pilot lamp PL1 lug 1 (NS) to solder lug K (NS).

( ) Connect one lead of the pilot lamp to PL1 lug 1 (S-2).

( ) Connect the other lead of the pilot lamp to PL1 lug 2 (NS).

Be sure the pilot lamp leads do not touch each other.

( ) R13: Connect a 47 kΩ (Yel-Viol-Org) resistor to PL1 between lugs 2 (S-2) and 3 (S-2).

Refer to Pictorial 4-14 (Illustration Booklet, Page 19) for the following steps.

CAUTION: When you connect the wires in the following steps, **do not** burn the insulation on the wires that were connected earlier.

Connect the free ends of the wires coming from the horizontal circuit board to the chassis as follows. Position the following six wires under the shielded cables connected to switch SW4.

( ) Wht-Org wire to control R8 lug 3 (S-1).

( ) Grn wire to control R8 lug 2 (S-1).

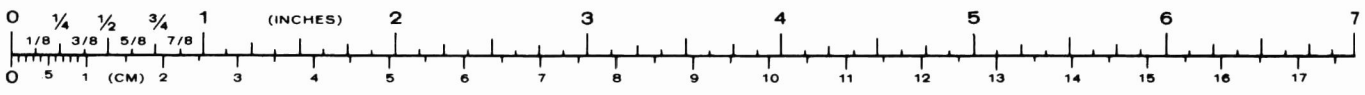
( ) Wht-Red to control R8 lug 1 (S-1).

( ) Wht-Gry to control R7 lug 3 (S-1).

( ) Red wire to control R7 lug 2 (S-1).

( ) Wht-Yel to control R7 lug 1 (S-1).

( ) Remove an additional 3/4" of insulation (total 1") from the free end of the Org wire. Pass the end of this wire through switch SW4 lug 4 (S-3) to switch SW6 lug 6 (S-1).



( ) Wht-Blu wire to switch SW6 lug 8 (S-1).

( ) Remove an additional 1/2" of insulation (total 3/4") from the free end of the Wht-Viol wire. Connect the free end of this wire to switch SW6 through lug 7 (S-2) to lug 1 (S-1).

Refer to Pictorial 4-15 (Illustration Booklet, Page 20) for the following steps.

Connect the free ends of the wires coming from the horizontal circuit board to the chassis as follows:

( ) Viol wire to switch SW6 lug 4 (S-1).

( ) Remove an additional 1/4" of insulation (total 1/2") from the free end of the Wht-Blk wire. Connect this wire to switch SW6 through lug 3 (S-2) to lug 2 (S-1).

( ) Wht-Grn wire to switch SW7 lug 3 (S-1).

( ) Yel wire to switch SW7 lug 2 (S-1).

( ) Wht-Brn wire to switch SW7 lug 1 (S-1).

( ) Wht wire to switch SW8 lug 2 (S-1).

Refer to Pictorial 4-16 (Illustration Booklet, Page 21) for the following steps.

Connect the wires from BO#8 coming from grommet BF to the horizontal circuit board as follows:

( ) Yel wire to hole W (S-1).

( ) Gry wire to hole V (S-1).

( ) Org wire to hole U (S-1).

( ) Red wire to hole X (S-1).

( ) Blk wire to hole H (S-1).

( ) Wht wire to hole S (S-1).

( ) Grn wire to hole T (S-1).

Connect the following wires from the horizontal circuit board to the chassis as follows:

( ) Blk wire to solder lug K (S-4).

( ) Brn wire through grommet BB to socket J6 (S-1).

This completes the wiring to the horizontal circuit board. Check to see that all connections are soldered and then cut off all the excess wire lengths close to the foil. The remaining Blu and Gry wires connected to the circuit board will be connected later.

( ) Carefully position all the wires and harness connected to the horizontal circuit board as shown.

( ) Pass the shaft of the rotary switch through the chassis at location SW5. Secure the switch with a 3/8" flat washer and a 3/8-32 nut.

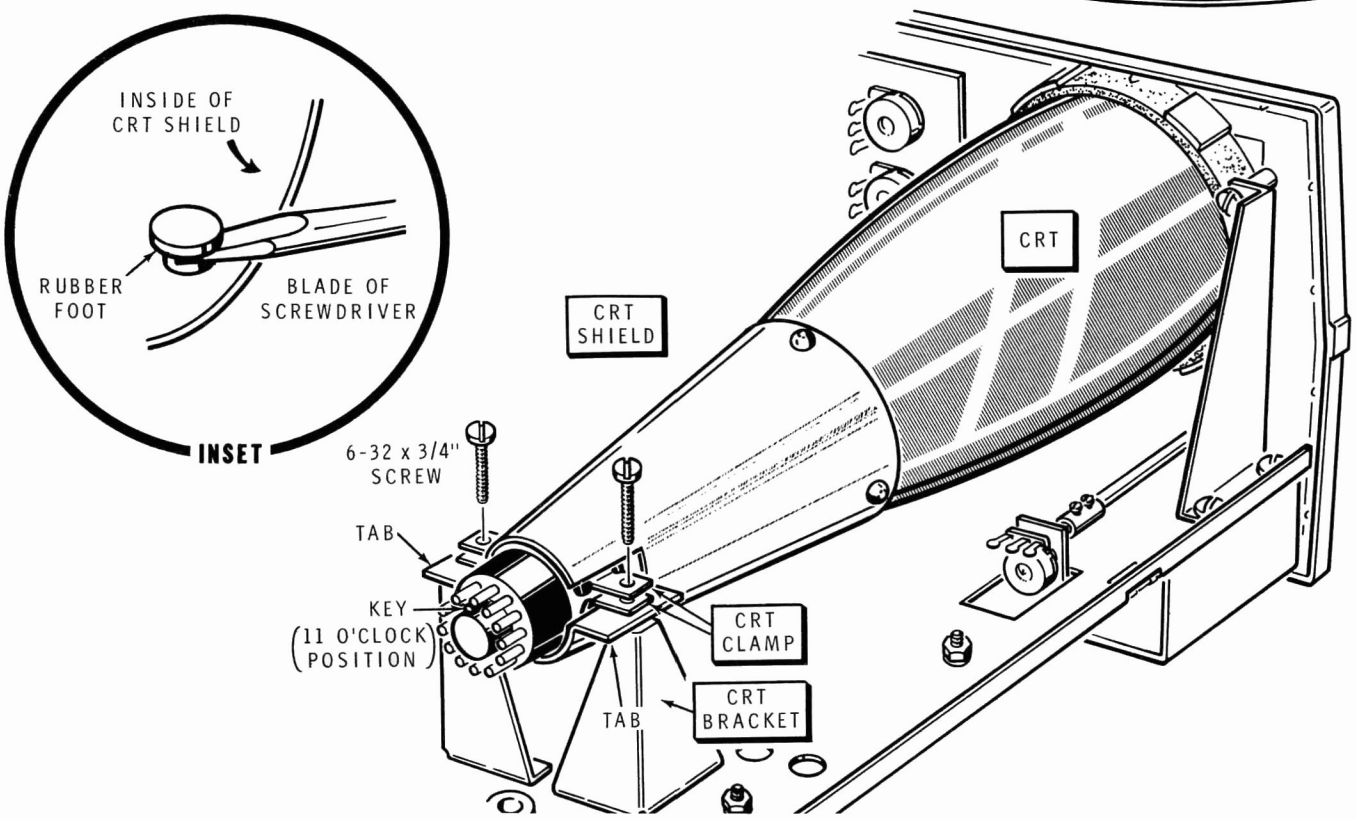
( ) Refer to Detail 4-16A and remove the power supply circuit board screws from holes CL and CH.

( ) Refer to the inset drawing on Pictorial 4-16 and mount the circuit board bracket at location Z on the chassis with 6-32 × 3/8" hardware.

( ) Remount the power supply circuit board with 6-32 × 3/16" screws at hex studs CG, CH, CJ, CK, CL, and CM. Then tighten the nuts on the hex studs.

( ) Secure the other end of the horizontal circuit board to the circuit board bracket with 6-32 × 3/8" hardware.

( ) Position all the wires connected between the horizontal circuit board and the chassis as shown. Then install a cable tie through the two indicated chassis holes and around these wires. Pull the cable tie tight and cut off its excess end.



PICTORIAL 4-18

Refer to Pictorial 4-17 (Illustration Booklet, Page 22) for the following steps.

Reposition the chassis as shown.

( ) Locate the two shaft couplings, two 5″ extension shafts, and four #6 × 1/8″ setscrews furnished with the vertical circuit board parts.

( ) Start two 6-32 × 1/8″ setscrews in each shaft coupling.

( ) Install a shaft coupling 5/16″ onto the shaft of control R4B. Tighten the proper setscrew.

( ) In the same manner, install the other shaft coupling on the shaft of control R4A.

NOTE: It may be necessary to temporarily loosen the control bracket mounting hardware (when you perform the next two steps) to get proper extension shaft alignment with the front panel holes.

( ) Pass a 5″ extension shaft through the appropriate hole in the front panel and into the shaft coupling on control R4B so the shaft extends 5/16″ outside the front panel. Tighten the setscrew in the shaft coupling.

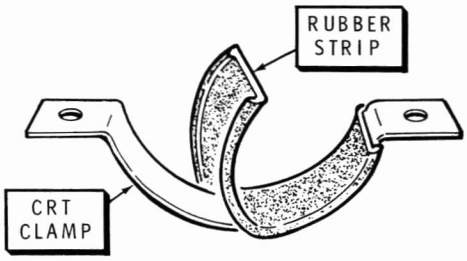
( ) In the same manner, install a 5″ extension shaft through the proper hole in the front panel and into the shaft coupling on control R4A.

( ) Locate the graticule and remove the protective backing. (There may also be a protective film on the face of the graticule which must be removed at this time.)

( ) Place the graticule in the large rectangular opening in the cabinet front from the inside. Position the printed side of the graticule to the outside.

NOTE: When you install the felt strip in the next step, its edge must be against the graticule to hold the graticule in place in its opening in the cabinet front.

( ) Remove the protective backing from the felt strip. Then press the felt strip inside the CRT ring, starting on the side nearest the edge of the cabinet front. The adhesive side must be "out" against the plastic cabinet front. DO NOT allow the ends to overlap. Cut off any excess.



Detail 4-18A

CAUTION: When you install the input shield in the next step, be sure the shield is up tight against the bottom of the chassis between the circuit boards before you tighten the screws, or you may break one of the circuit boards.

( ) Install the input shield with #6 × 1/2" screws in chassis holes F and G. Be sure not to pinch any wires between the shield and the chassis.

( ) Install the front panel bracket with #6 × 1/2" screws into chassis holes D and E and into the input shield. Do not tighten the screws.

( ) Install another #6 × 1/2" screw through the top slot in the front panel bracket and into the cabinet front.

( ) If necesary, reposition the front panel bracket so the front panel is perpendicular to the top of the chassis. Then tighten the screws at holes D and E.

Refer to Pictorial 4-18 for the following steps.

( ) Refer to the inset drawing on Pictorial 4-18 and install a rubber foot in each of the three indicated holes in the CRT shield. Use a small screwdriver to force the feet into the holes.

( ) Cut the 3/4" × 5" rubber strip into two equal lengths.

( ) Refer to Detail 4-18A and place a length of rubber strip onto each CRT clamp.

WARNING: Handle the CRT very carefully. Because of its high vacuum, do not strike, scratch, or subject the CRT to more than moderate pressure at any time. A fracture of the glass could result in an implosion of considerable violence capable of causing personal injury.

( ) Carefully unpack the CRT.

( ) Slide the CRT shield over the neck of the CRT. Note the position of the tabs on the CRT shield with reference to the key on the CRT plug.

( ) Push the face of the CRT into the ring in the cabinet front. Note the position of the key on the CRT plug.

( ) Install the two CRT clamps around the neck of the CRT but inside the CRT shield.

( ) Secure the CRT clamps and the CRT shield to the tops of the CRT brackets with two 6-32 × 3/4" screws. Tighten these screws only enough to hold the CRT in place. The CRT may have to be repositioned later.

Refer to Pictorial 4-19 (Illustration Booklet, Page 22) for the following steps.

( ) Align the keyway of the CRT socket with the key on the CRT plug and push the socket onto the CRT plug.

( ) Connect the Blu wire coming from grommet BC to the CRT socket lug 6 (S-1).

( ) Connect the Gry wire coming from grommet BD to the CRT socket lug 7 (S-1).

Connect the wires coming from grommet BE to the CRT socket as follows:

( ) Wht-Gry wire to lug 8 (S-1).

( ) Large Brn wire to lug 4 (S-1).

( ) Large Red wire to lug 3 (NS).

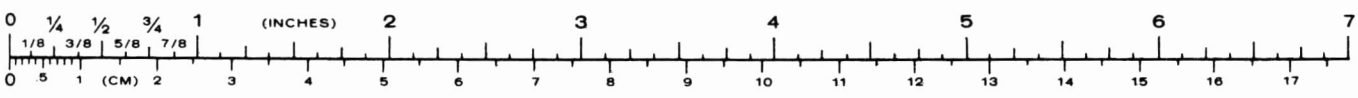
( ) Large Org wire to lug 2 (S-1).

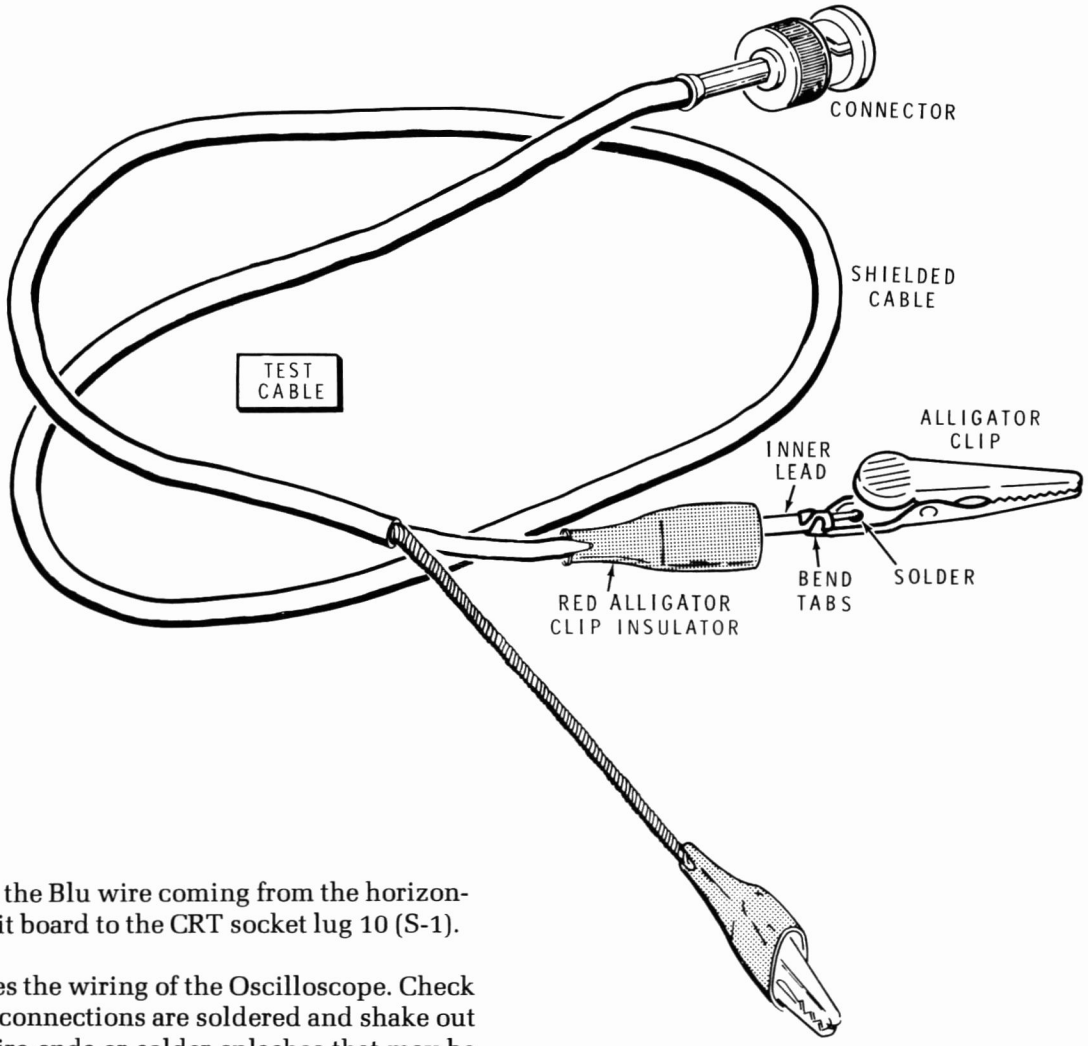
( ) Either large Grn wire to lug 1 (NS).

( ) Other large Grn wire to lug 12 (S-1).

( ) R16: Connect a 100 kΩ (Brn-Blk-Yel) resistor to the CRT socket between lugs 1 (S-2) and 3 (S-2).

( ) Connect the Gry wire coming from the horizontal circuit board to the CRT socket lug 9 (S-1).





PICTORIAL 4-21

( ) Connect the Blu wire coming from the horizontal circuit board to the CRT socket lug 10 (S-1).

This completes the wiring of the Oscilloscope. Check to see that all connections are soldered and shake out any cut-off wire ends or solder splashes that may be lodged in the wiring or on the circuit boards.

Refer to Pictorial 4-20 (Illustration Booklet, Page 22) for the following steps.

( ) Start a 6-32 × 1/8" black setscrew in each of the 12 knobs. Use the allen wrench furnished with the kit. NOTE: Four of the knobs and three of the setscrews were packed with the vertical circuit board parts.

( ) Turn the Y1 POS and Y2 POS control shafts fully counterclockwise. Then install a small black knob on each of these shafts with each knob pointer positioned as shown.

( ) Install a small black knob with skirt on each of the INTENSITY, FOCUS, TRIG LEVEL, and HORIZ POS control shafts.

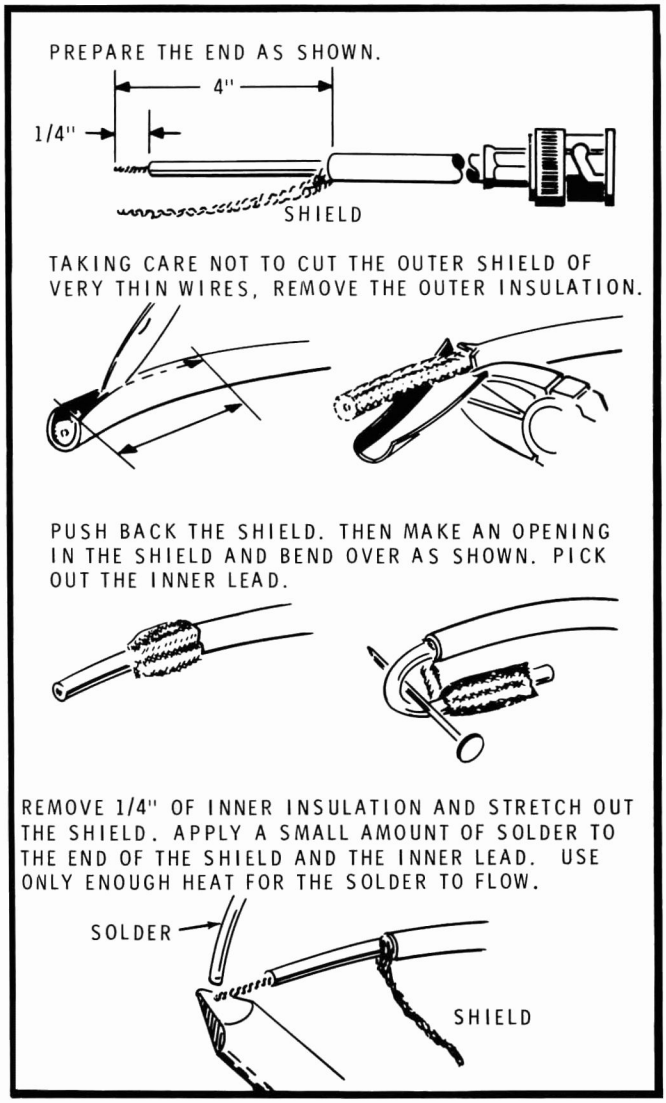
( ) Turn the three rotary switches (large outer shafts) fully counterclockwise.

( ) Install a large black knob on the two VOLTS/CM switch shafts with their pointers at the "20" positions.

( ) Install a large black knob on the TIME/CM switch shaft with its pointer at the "200" position.

( ) Turn the remaining three small inner control shafts to their fully **clockwise** positions.

( ) Install a red knob on each of these control shafts with each knob pointer at the CAL position.

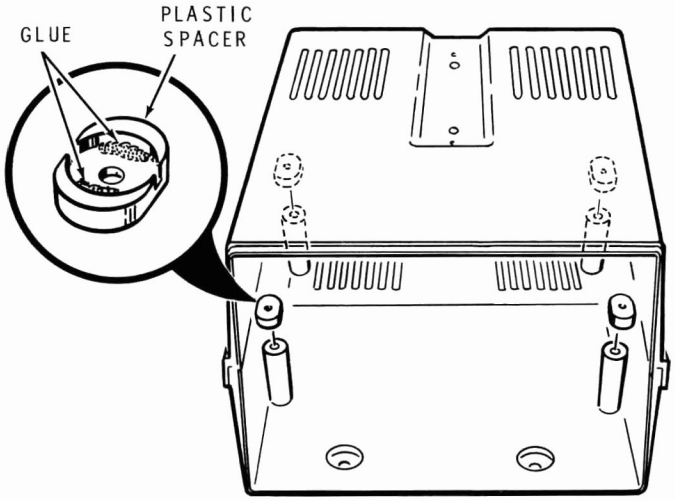


Detail 4-21A

Refer to Pictorial 4-21 for the following steps.

( ) Locate one of the shielded cables with a connector on one end. Refer to Detail 4-21A and prepare the free end of this cable.

( ) Slide a red alligator clip insulator over the end of the inner lead.



PICTORIAL 4-22

( ) Solder an alligator clip to the end of the inner lead. After the connection has cooled, push the insulator over the alligator clip.

( ) In the same manner, install an alligator clip and insulator on the end of the shield lead.

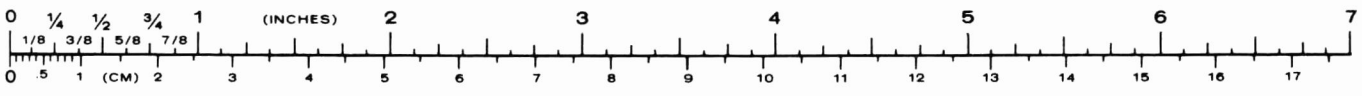
( ) Repeat the four previous steps and prepare the other shielded cable with connector.

Refer to Pictorial 4-22 for the following steps.

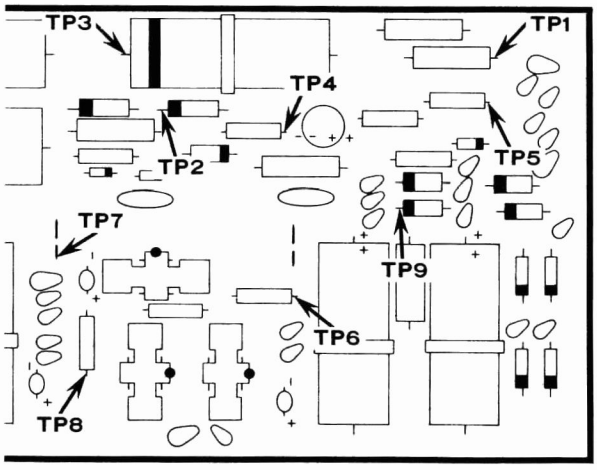
CAUTION: When you install the plastic spacers in the next step, carefully follow the instructions and observe the cautions on the epoxy glue packet. Also, be sure you do not get epoxy in the holes in plastic spacers or bosses in the cabinet.

( ) Glue a plastic spacer on each of the four bosses in the cabinet. DO NOT attempt to install any screws in these holes for at least 30 minutes after the spacers are installed.

This completes the assembly of your Oscilloscope. Proceed to the "Initial Tests" section of this Manual.



INITIAL TESTS



PICTORIAL 5-1

RESISTANCE MEASUREMENTS

( ) If an ohmmeter is available, measure the resistance between each flat plug prong and the round prong on the line cord. In both measurements you should obtain an infinite indication. Be sure the test probe is not touching the chassis or any connection.

If you do not obtain infinite indications, recheck all primary wiring and make sure no fine wire strands at any connection are touching another connection.

Use an ohmmeter to make the following resistance measurements before you apply power to the Oscilloscope. This will insure that the power supply will not be damaged due to a wiring error or some incorrectly installed or faulty part. If you do not get the proper indication in a step, check the wiring and installation of the parts listed in the "Possible Cause" column for that step. You may also refer to the "In Case of Difficulty" section of the Manual (Page 97). Be sure you obtain the correct resistance reading before proceeding.

Refer to Pictorial 5-1 for the following steps.

( ) Position the Oscilloscope bottom side up.

( ) Connect the negative ohmmeter lead to the chassis of the Oscilloscope. Then touch the positive meter lead to the points indicated in the following chart.

NOTE: Not all ohmmeters are polarized the same. Therefore, if you do not get the correct meter reading the first time, connect the positive meter lead to the chassis and touch the negative meter lead to the point indicated in the chart. If this produces the correct indication, cross out the word "positive" in the heading of the first column and write in "negative."

NOTE: The ohmmeter that was used to make the following measurements was powered by a 1.5 volt battery and set on the RX1000 range.

Make all of the following measurements on the power supply circuit board.

POSITIVE METER LEAD TO:	APPROXIMATE METER READING	POSSIBLE CAUSE
( ) TP1.	600 kΩ-1 MΩ	1. Resistors R310, R309. 2. Focus control R2 and resistor R3. 3. Diodes D317, D302, and D301. 4. Capacitors C301, C302, and C303. 5. Power Transformer.
( ) TP2. ( ) TP3.	600 kΩ-1 MΩ	1. Power transformer. 2. Diodes D301 and D302. 3. Capacitors C301, C302, and C303.
( ) TP4.	900 kΩ-1.5 MΩ	1. Power transformer. 2. Diodes D301 and D302. 3. Capacitors C301, C302, and C303.
( ) TP5.	600 kΩ-1.5 MΩ	1. Power transformer. 2. Diodes D301 and D302. 3. Capacitors C301, C302, C303,C314, and C315.
( ) TP6.	400 Ω-1000 Ω	1. Capacitor C310. 2. IC U302. 3. Resistors R334, R335, and R336.
( ) TP7.	300 Ω-800 Ω	1. Capacitor C309. 2. IC U301. 3. Connections to other circuit boards.
( ) TP8.	400 Ω-1000 Ω	1. Capacitor at C311. 2. IC U303. 3. Resistors R334, R335, and R336. 4. Connections to other circuit boards.
( ) TP9.	9000 Ω-20 kΩ	1. Diodes D307, D308, D309, and D310. 2. All sections of capacitor C308. 3. Connections to other circuit boards.

This completes the Initial Tests. Proceed to "Calibration."

CALIBRATION

In this section, you will set the circuit board and front panel controls of your Oscilloscope for proper operation. To do this, you will need a high input impedance voltmeter and a sine-square wave generator. Perform the adjustments exactly as instructed and DO NOT connect the line cord to an AC outlet until you are instructed to do so.

Refer to Pictorial 6-1 (Illustration Booklet, Page 23) for the following steps.

Set the front panel controls as follows:

( ) Y1 POS: Center of rotation.

( ) Both AC-GND-DC: GND.

( ) Both VOLTS/CM: 0.02.

( ) Both VARIABLE: Full clockwise.

( ) Y1-Y2-CHOP-ALT: Y1.

( ) Y2 POS: Center of rotation.

( ) POWER: OFF.

( ) INTENSITY: Full clockwise.

( ) FOCUS: Center of rotation.

( ) TRIG LEVEL: Center of rotation.

( ) HORIZ POS: Center of rotation.

( ) TIME/CM: 200 μS.

( ) SWEEP VAR/HORIZ GAIN: Full clockwise.

( ) Y1-Y2-EXT-LINE: Y1.

( ) AC-DC-TV: AC.

( ) +/−: +.

( ) AUTO-NORMAL: AUTO.

( ) Refer to Detail 6-1A and push the alignment tool blade into the end of the plastic nut starter. Always use this tool to adjust the trimmer capacitors and controls in the following steps.

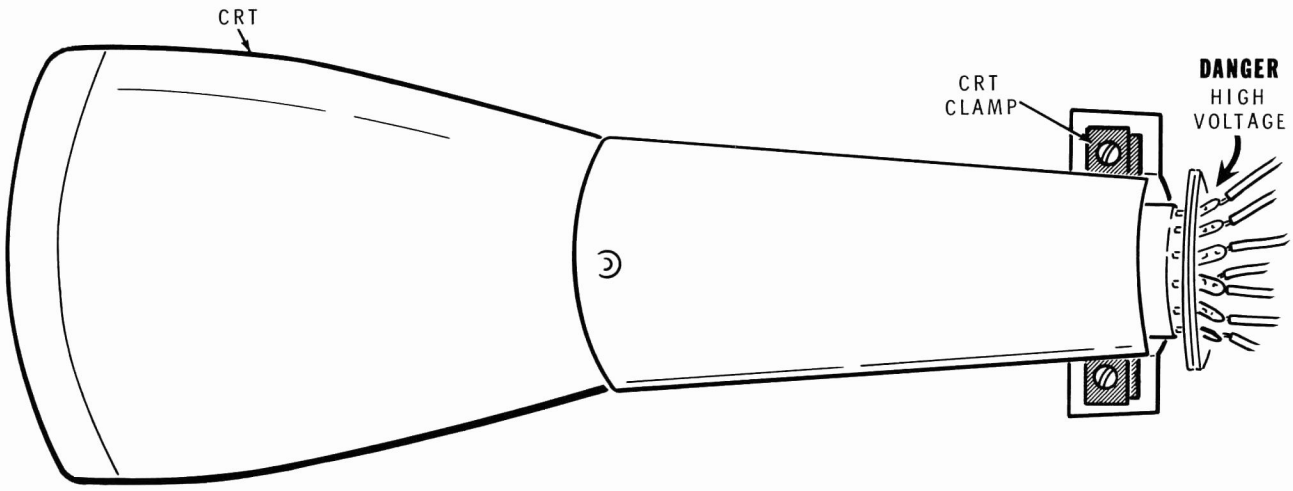
( ) Set all the circuit board controls to their centers of rotation.

( ) On the vertical circuit board, turn all the trimmer capacitors clockwise until they are snug. Then turn them counterclockwise 1/2 turn.

CAUTION: AC and DC voltages in some areas of the Oscilloscope may exceed 1300 volts. Be very careful when you make the following adjustments. Make sure the Oscilloscope is setting on a nonmetallic surface and is not within reach of a water pipe or other ground conductor. The "Dangerous Voltage Areas" are shown on Page 26 in the Illustration Booklet.

( ) Connect the Oscilloscope line cord to an AC outlet.

NOTE: If you do not get the proper results in the following steps, recheck the steps to make sure you have adjusted the correct controls. If you still do not get the indicated results, turn the Oscilloscope off and refer to the "In Case of Difficulty" section on Page 97.



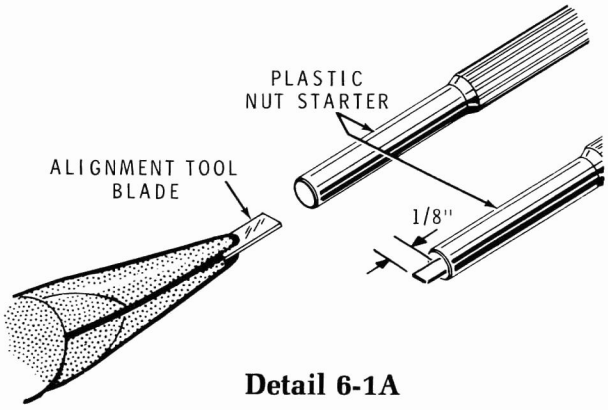
PICTORIAL 6-2

( ) Set the ON-OFF switch on the Oscilloscope to the ON position. The red Power Lamp should light. Allow the Oscilloscope at least one minute to warm up.

NOTE: You may have to adjust the vertical (Y1 POS or Y2 POS) and HORIZ POS controls to get the trace on the CRT in the next step.

( ) Check to see if the CRT trace is parallel with the horizontal graticule lines. If it is not parallel, perform the following numbered steps.

1. Note the position of the trace and turn off the power.
2. Refer to Pictorial 6-2 and loosen the CRT clamp.
3. Rotate the CRT to align the trace.
4. Turn the power on and check the position of the trace.



Detail 6-1A

5. Repeat steps 1, 3, and 4 as necessary to align the trace to the horizontal graticule lines.
6. After the correct results have been obtained, turn the power off and tighten the CRT clamp.

DC CALIBRATION

POWER SUPPLY CIRCUIT BOARD

( ) Place the POWER switch in the ON position.

( ) Turn the front panel INTENSITY control fully counterclockwise.

Refer to Pictorial 6-3 (Illustration Booklet, Page 24) for the following steps.

( ) Adjust the INTEN BIAS control clockwise (as viewed from the front panel) until the trace is visible (the trace may already be visible). Then adjust the control back counterclockwise until the trace disappears.

( ) Adjust the ASTIG control:

— Turn the INTENSITY control clockwise until the trace appears.

— Turn the TIME/CM switch to the EXT IN ×10 position.

— Center the spot with the HORIZ POS control.

— Adjust the ASTIG control and front panel FOCUS control until the dot is small, round, and as clear as possible.

HORIZONTAL CIRCUIT BOARD

( ) Use the front panel HORIZ POS control and center the spot on the screen.

( ) Connect the negative voltmeter lead to the chassis of the Oscilloscope.

( ) Set the voltmeter to measure 1.5 volts DC.

Refer to Pictorial 6-4 (Illustration Booklet, Page 24) for the following steps.

NOTE: In the following steps, when a step calls for an adjustment of zero volts, make the adjustment to zero volts ±50 millivolts.

( ) Touch the voltmeter probe to TP1 and adjust the ZERO ADJ control for zero volts.

( ) Measure the voltage at TP2 and adjust the INPUT ZERO control for zero volts.

( ) Set the voltmeter to measure 5 volts DC.

( ) Measure the voltage at TP3 and record the reading beside this step. It should be approximately 5 volts (4.8 to 5.2).

( ) Measure the voltages at TP4 and TP5. Adjust the front panel HORIZ POS control until both test points are equal. Then adjust the BIAS ADJ control until the test point voltages equal the meter reading you recorded in the previous step.

VERTICAL CIRCUIT BOARD

( ) Set the voltmeter to measure 1.5 volts DC.

Refer to Pictorial 6-5 (Illustration Booklet, Page 24) for the following steps.

( ) Measure the voltage at TP6. Then adjust the Y2 DC BAL control for zero volts.

( ) Measure the voltage at TP7 and adjust the Y1 DC BAL control for zero volts.

( ) Place the front panel Y1, Y2, CHOP, ALT switch in the ALT position. Two traces should be on the screen. If necessary, use the Y1, or Y2 POS controls to position the traces near one another.

( ) Rotate the Y1 VARIABLE control fully counterclockwise. Place your finger on the CRT to mark the new location of the Y1 trace line if it moved. Return the Y1 VARIABLE control to its CAL position. Then adjust the Y1 DC BAL control to move the Y1 trace to the location marked by your finger. Repeat this procedure as many times as necessary until the trace no longer moves when you rotate the Y1 VARIABLE control. If the trace did not move initially, no adjustment of the DC BAL control is needed.

( ) In the same manner, check the Y2 trace line and adjust the Y2 DC BAL control.

NOTE: Because of the normal aging of your Oscilloscope, you may have to repeat the previous adjustment periodically.

( ) Place the front panel Y1-Y2-CHOP-ALT switch in the Y1 position.

( ) Set the voltmeter to measure 5 volts DC.

( ) Measure the voltages at TP8 and TP9. Adjust the front panel Y1 POS control until both readings are the same. Then adjust the Y1 BIAS ADJ control until the reading is the same as the one you recorded earlier in the Manual (4.8 to 5.2 volts).

( ) Measure the voltage at TP10 and adjust the Y1 TRIG ZERO control for zero volts.

( ) Place the front panel Y1-Y2-CHOP-ALT switch in the Y2 position.

( ) Measure the voltages at TP11 and TP12. Adjust the front panel Y2 POS control until both readings are the same. Then adjust the Y2 BIAS ADJ control until the reading is the same as the one you recorded earlier (4.8 to 5.2 volts).

( ) Measure the voltage at TP13 and adjust the Y2 TRIG ZERO control for zero volts.

AC CALIBRATION

Set the front panel controls as follows:

( ) Both VOLTS/CM: 0.05

( ) Both VARIABLE: Full clockwise.

( ) Y1-Y2-CHOP-ALT: Y1

( ) Y1-Y2-EXT-LINE: Y1

( ) TIME/CM: 200 μs

( ) Use the Y1 pos and HORIZ POS controls and center the trace on the screen.

( ) Place the Y1 AC-GND-DC switch in the AC position.

( ) Refer to Pictorial 6-6 (Illustration Booklet, Page 24) and connect a 1 kHz square wave signal to the Y1 INPUT connector. Adjust the generator output to produce a display that is 4 or 5 cm high. Adjust the TRIG LEVEL as required.

VERTICAL CALIBRATION AND ATTENUATOR COMPENSATION

Refer to Pictorial 6-5 (Illustration Booklet, Page 24) for the following steps.

NOTE: In the following steps, use the channel Y1 switches and trimmer capacitors.

1. ( ) Set the VOLTS/CM switch to the 0.1 position. Use a nonmetallic screwdriver to adjust the ×100 trimmer capacitor for a proper display like the one labeled RIGHT in Pictorial 6-7. If it will not adjust, then adjust the ×10 trimmer capacitor.

2. ( ) Set the VOLTS/CM switch to the 1 position, readjust the generator output as necessary, and adjust the ×1000 trimmer capacitor for a proper display. If it will not adjust, then adjust the ×100 trimmer capacitor.

3. ( ) Set the VOLTS/CM switch to the 10 position, readjust the generator output as necessary, and adjust the ×10 trimmer capacitor for a proper display.

4. ( ) Repeat the above three steps until the compensation is correct.

( ) Set the Y1-Y2-CHOP-ALT switch to Y2, the Y2 AC-GND-DC switch to AC, the Y1-Y2-EXT-LINE switch to Y2, connect the square wave signal to the Y2 INPUT connector, and repeat the previous four steps for channel Y2.

NOTE: If you do not have a calibrated voltage source, disregard the next three steps and use the 1 V (P-P) 60 Hz signal that is available at the front panel. Connect the signal to the Y2 INPUT connector, set the TIME/C switch to 2 mS, set the VOLTS/CM switch to 0.2, and adjust the Y2 CAL control for a display that is 4.5 cm high. The Y2 VARIABLE control must be set fully clockwise.

1. ( ) Set the generator output to .1 V.

2. ( ) Set the Y2 VOLTS/CM switch to .02.

3. ( ) Adjust the Y2 CAL control for a display 5 cm high.

( ) Set the TIME/CM switch to 0.2 μs.

( ) Set the generator frequency to 1 MHz and adjust its output to produce a display that is four or five cm high.

( ) Adjust the Y2 H.F. COMP trimmer capacitor for a square wave with a smooth leading edge as shown in Pictorial 6-8 (Illustration Booklet, Page 24).

( ) Connect the 1 MHz square wave signal to the Y1 INPUT connector.

( ) Set the Y1 VOLTS/CM switch to 0.1 (be sure the VARIABLE control is fully clockwise), the Y1-Y2-CHOP-ALT switch to Y1, and the Y1-Y2-EXT-LINE switch to Y1. Adjust the square wave generator until the display is 4 or 5 cm high.

( ) Adjust the Y1 H.F. COMP trimmer capacitor for a square wave with a smooth leading edge as shown in Pictorial 6-7.

NOTE: If you do not have a calibrated voltage source, disregard the next three steps and use the 1 V (P-P) 60 Hz signal that is available at the front panel. Connect the signal to the Y1 INPUT connector, set the TIME/CM switch to 2 ms, set the VOLTS/CM switch to 0.2, and adjust the Y1 CAL control for a display that is 4.5 cm high. The Y1 VARIABLE control must be set fully clockwise.

1. ( ) Set the Y1 VOLTS/CM switch to .02.

2. ( ) Set the generator output to 0.1 V.

3. ( ) Set the TIME/CM switch to 200 μs.

4. ( ) Adjust the Y1 CAL control for a display 5 cm high.

HORIZONTAL AMPLIFIER ADJUSTMENTS

( ) Set the Y1 AC-GND-DC switch to GND.

Refer to Pictorial 6-4 for the following steps.

( ) Adjust the SWEEP LENGTH control for a trace that is 10 cm long (just fills the screen).

( ) Set the Y1 AC-GND-DC switch to AC.

( ) Set the generator frequency to 5 kHz.

( ) Adjust the horizontal circuit board CAL control and the HORIZ POS control so there are ten complete waveforms in 10 cm as shown in Pictorial 6-9 (Illustration Booklet, Page 24).

NOTE: If a calibrated signal source is not available, use the 1 V (P-P) 60 Hz output. Set the TIME/CM switch to 2 mS and adjust the HORIZ CAL control for a waveform that is 8.6 cm long. The 1 V (P-P) 60 Hz output can be used for the remaining Horizontal Amplifier Adjustments.

( ) Set the Y1 AC-GND-DC switch to GND.

( ) Readjust the SWEEP LENGTH control for a trace that is 10 cm long (just fills the screen).

( ) Move the trace one division to the left with the HORIZ POS control and again adjust the SWEEP LENGTH control until the trace again fills the screen. The trace is now 11 cm long.

( ) Set the generator frequency to produce a sine wave approximately 500 Hz.

( ) Set the Y1 AC-GND-DC switch to AC.

( ) Set the TIME/CM switch to 2 ms.

( ) Adjust the Y1 POS control to center the trace vertically on the screen.

( ) Adjust the HORIZ POS control so the left end of the trace is on the screen.

( ) Adjust the TRIG LEVEL control so the trace starts on the zero base line (center of the graticule). Then move the +/− switch to the "−" position. Adjust the TRIG BAL control so the trace starts on the zero base line. Move the +/− switch back and forth to make this final adjustment.

( ) Move the TRIGGER COUPLING switch to DC. If the trace starting point moves, adjust the Y1 TRIG ZERO control (on the vertical board) until there is no movement when you switch the coupling switch back and forth between the AC and DC positions. Use the TRIG LEVEL control to keep the trace starting on the zero base line.

( ) Move the signal cable from the Y1 INPUT to the Y2 INPUT. Change the Y-Y2-CHOP-ALT switch

from Y1 to Y2 and the Y1-Y2 EXT-LINE switch from Y1 to Y2.

( ) Now repeat the trigger zero adjustment for the Y2 channel.

LOW-CAPACITY PROBE

NOTE: If you do not have a low capacity probe, disregard the following steps and proceed to "Final Assembly."

( ) Set the Y1-Y2-CHOP-ALT switch to Y1 and the TRIGGERING switches to Y1, AC, +, and AUTO.

( ) Set the TIME/CM switch to 200 μs.

( ) Set the Y1 VOLTS/CM switch to 0.05 and the VARIABLE control fully clockwise.

( ) Connect a low-capacity probe to the Y1 INPUT connector.

( ) Connect the probe to a 1 kHz square wave signal.

( ) Adjust the output of the generator to produce a display that is 4 cm high.

( ) Adjust the compensation capacitor on the probe for a proper square wave with no overshoot as shown in Pictorial 6-7.

( ) Set the VOLTS/CM switch to 0.5.

( ) Readjust the generator output for a 4 cm display.

( ) Adjust Y1 trimmer capacitor #1 for a proper square wave. If you cannot make this adjustment, readjust the probe capacitor and capacitor #1 until the correct waveform is displayed.

( ) Set the VOLTS/CM to 0.05 and readjust the generator output for a 4 cm display again.

( ) Adjust trimmer capacitor #2 for a proper square wave.

NOTE: If necessary, repeat the previous steps until a proper square wave is displayed.

( ) Repeat the previous steps under "Low-Capacity Probe" for the Y2 channel. However, whenever Y1 is called for, insert Y2. If may be possible to adjust channel Y2 without changing the probe compensation capacitor. If this happens, then you will be able to use the same probe on either channel and will not need to make any adjustments when using the probe.

( ) Disconnect the Low-Capacity Probe.

PHASE ADJUSTMENT

( ) Change the Y1-Y2-CHOP-ALT switch to the CHOP position.

( ) Change the TIME/CM switch to the 2 μs position.

( ) Set the four TRIGGERING switches to the EXT, DC, +, and AUTO positions.

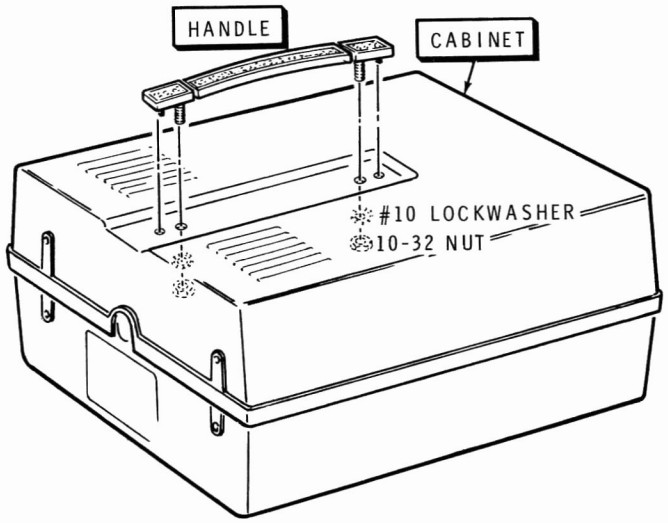
( ) Adjust the SWEEP VAR Y1 POS and Y2 POS controls for a pattern similar to that shown in Pictorial 6-10.

( ) Adjust the PHASE ADJ control (see Pictorial 6-5) so there is no vertical trace information at the beginning, between, or after any of the horizontal trace lines.

( ) Turn off the Oscilloscope POWER switch and unplug the line cord.

This completes the Calibration of the Oscilloscope. Proceed to the "Final Assembly" section of the Manual.

FINAL ASSEMBLY



Detail 7-1A

Refer to Pictorial 7-1 (Illustration Booklet, Page 25) for the following steps.

( ) Refer to Detail 7-1A and mount the handle in the holes provided in the cabinet. Use #10 lockwashers and 10-32 nuts.

( ) Place a soft cloth on your work surface. Then position the Oscilloscope face down on the cloth.

( ) Remove the protective backing from the blue and white label and press the label in place on the rear of the chassis. Always mention the numbers on this label in any communications you have with the Heath Company about this kit.

( ) Carefully slide the cabinet down over the chassis. Be sure the front edge of the cabinet is inside the lip around the outer edge of the cabinet front.

( ) Secure the cabinet to the chassis with eight #8 × 5/8" hex washer head screws. Tighten the four rear screws first.

( ) Remove the protective backing from the power consumption label and press the label in place on the rear of the cabinet.

This completes the "Final Assembly." Proceed to the "Operation" section of the Manual.

OPERATION

This section of the Manual explains the function of each control, switch, and connector; describes how to correlate between time/cm and frequency; and provides operational examples.

NORMAL OPERATING CHARACTERISTICS

The following information is provided to help answer possible questions you may have about the operation of your Oscilloscope.

- Several minutes may be required for the trace to stabilize when the Oscilloscope is first turned on, especially on the more sensitive voltage ranges.
- Random noise on the input signal may cause false triggering, especially on the most sensitive voltage ranges.
- A baseline will automatically appear after a short pause when the TRIGGERING AUTO/NORMAL switch is placed in the AUTO position or when the input signal is disconnected when automatic triggering is used.

USING A 10-MILLIVOLT OSCILLOSCOPE

When you use an Oscilloscope as sensitive as this, you must use special care to make reliable measurements. Keep the following points in mind when you measure very low level signals.

- Placement of the ground clip may be critical if the signal source ground carries an appreciable current. Voltage differences of several millivolts from one side of a chassis or ground foil to the other are common. Place the ground clip at the point that gives the least error. This is usually nearest the signal source. You may have to move the ground clip when you measure different points.
- Stray 60 Hz pickup may be hard to eliminate, especially in high impedance circuits. Be sure to use shielded test cables. Shield the signal source if necessary.
- Wideband measurements in the millivolt region are more difficult because of the inherent noise (shot noise and thermal noise) generated by electronic components. This may appear as a widening of the baseline or the baseline appearing out of focus. Noise on the baseline that appears as "hash" or "spikes" may be caused by the electromagnetic pickup of man-made noise such as ignition noise, appliance noise, etc. Noise of any kind may cause erratic triggering.

ALTERNATE PRIMARY VOLTAGES

In the United States 120 VAC line voltage is most often used, while in other countries 240 VAC line voltage is more common. If you intend to operate the Oscilloscope on 240 volts, perform the following steps. Otherwise, proceed to "Operation and Applications." NOTE: Electrical regulations in some areas require a special line cord and/or plug for 240-volt operation. Replace them if necessary.

( ) Make sure the line cord is unplugged.

( ) Remove the cabinet from the Oscilloscope.

( ) Shift the 120/240 slide switch to the 240 position. This switch is located near the rear of the chassis, between the CRT and power transformer.

( ) Remove the 1/2-ampere slow-blow fuse and install a 1/4-ampere slow-blow fuse (not furnished). The fuse block is located on the bottom side of the chassis.

( ) Reinstall the cabinet.

OPERATION AND APPLICATIONS

Refer to Pictorial 6-1 (Illustration Booklet, Page 23) for the location and explanation of the front panel controls and switches.

OPERATIONAL EXAMPLE

The following example will help you become more familiar with the control functions, especially the sweep and trigger controls.

Connect a 1 kHz sine wave source to the Y1 vertical INPUT connector. Set the TRIGGERING switches to Y1, AC, (+), and NORMAL. Set the Y1 INPUT switch to AC and the VERTICAL MODE switch to Y1.

Turn the TRIG LEVEL control to its center of rotation. Adjust the VOLTS/CM switch to obtain a trace 3 or 4 centimeters high. Adjust the HORIZ POS control so the left edge of the trace is just inside the left margin of the graticule. Set the TIME/CM switch to display a few cycles of the waveform. Adjust the Y1 POS control to center the trace vertically.

Now carefully readjust the TRIG LEVEL control and observe how the left edge (starting point) of the sweep moves upward as the control is turned clockwise, and downward as the control is turned counterclockwise. See A on Pictorial 8-1 (Illustration Booklet, Page 25).

Switch the TRIGGERING +/− switch to the "−" position, and note that the TRIG LEVEL control has the same effect except that the sweep start point is on the negative slope of the waveform.

There is no fixed rule for setting the TRIG LEVEL control, as no two waveforms are alike. For example, assume that you want to examine the "spike" on waveform B of Pictorial 8-1. By adjusting the TRIG LEVEL control so the sweep starts just before the spike, as in C in Pictorial 8-1, and decreasing the time required for one complete sweep by changing the position of the TIME/CM switch, the spike can be spread out across a large area of the screen for closer observation, as shown in D of Pictorial 8-1.

By reading the TIME/CM switch, you can determine the duration of the spike. This feature is also useful to observe distortion in circuits using square wave signals.

The TIME/CM switch should be set to display the desired waveform or portion of a waveform. Occasionally it may also be necessary to use the VARIABLE. However, the sweep time is not calibrated when the VARIABLE is used. Refer to the formula or the "TIME/CM FREQUENCY Correlation Chart" on Page 96 to determine unknown frequencies or sweep times when you use the calibrated positions of the TIME/CM switch.

The TRIGGERING Y1/Y2/EXT/LINE switch permits you to choose between internal or external triggering signals. The internal trigger is derived from the Y1 or Y2 vertical input signal, or the power line signal. The EXT (external) trigger position allows the sweep to be triggered from external sources, such as TV horizontal or vertical sync pulses, that are not necessarily related to the vertical input signal.

When the TRIGGERING AUTO/NORMAL switch is in the AUTO position, a sweep appears on the screen even in the absence of a signal. The AUTO position is useful for simple waveforms with frequencies from about 40 cycles and upward. This switch position is also useful for signals that are too weak to trigger the sweep circuits in the normal position.

The TRIGGERING AC/DC/TV switch will normally be on the AC position except when you use very low frequency or DC signals as a trigger source, or when you use the TV setting to filter out the horizontal sync signal when you view a composite waveform.

Dual-Trace Operation

Signal source: Sine wave — square wave generator capable of in-phase, simultaneous, sine wave and square wave output, 1kHz, 1volt.

Connect the sine wave signal to the Y1 INPUT and the square wave signal to the Y2 INPUT.

Set both the Y1 and Y2 VOLTS/CM switches at 1 V and both INPUT switches at AC; then set the following switches as indicated:

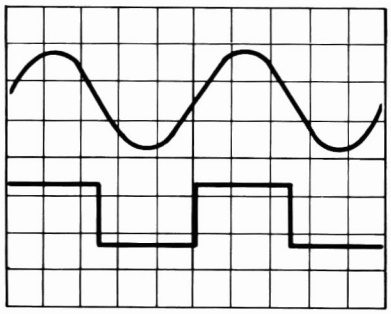
Y1, Y2, CHOP, ALT	ALT
TRIGGERING	Y1, AC, plus (+), AUTO
LEVEL	Center of rotation
TIME/CM	200 μS

Adjust the Y1 and Y2 POSITION controls so the two waveforms are separated on the CRT. The display will be similar to that shown in Pictorial 8-2.

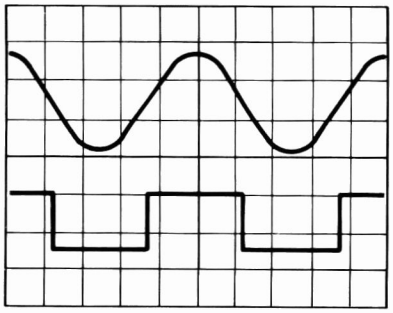
NOTE: In dual trace operation, use the ALT mode when operating at sweep speeds greater than 200 μS, and use the CHOP mode at the slower sweep speeds.

Turn the LEVEL control so triggering occurs at the peak of the sine wave as in Pictorial 8-3. Note that this is at the midpoint of the positive portion of the square wave.

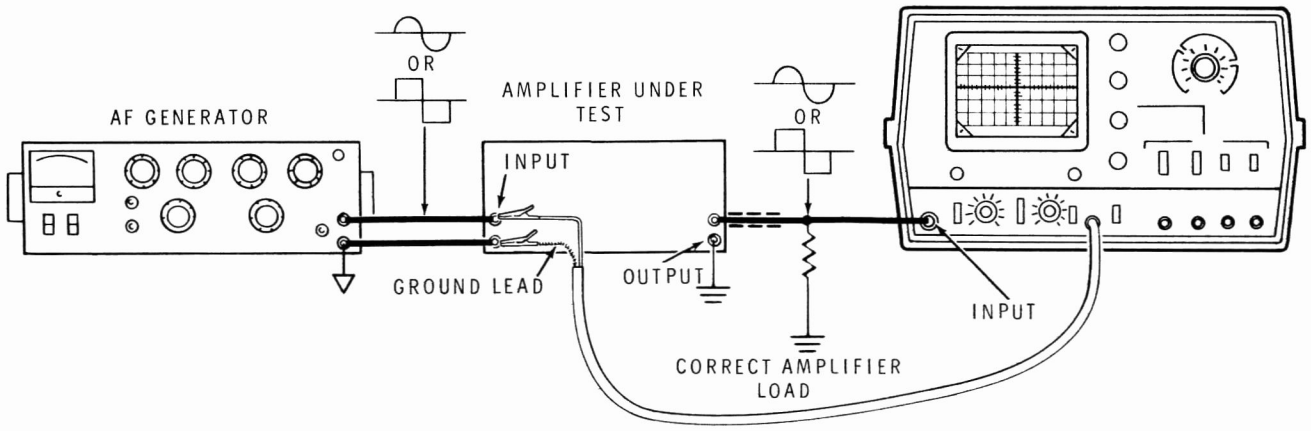
Return the LEVEL control to the center of rotation and the waveforms will again appear in their generated phase relationship.



PICTORIAL 8-2



PICTORIAL 8-3



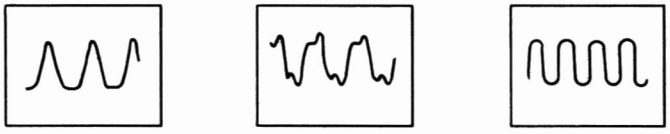
PICTORIAL 8-4

AUDIO AMPLIFIER CIRCUITS

You can observe frequency response, distortion, and gain in an audio amplifier by observing its output waveform when a sine wave or a square wave is applied to either amplifier input.

Pictorial 8-4 shows a typical setup for checking an audio amplifier. The audio generator injects either a low distortion sine wave or square wave signal into the input of the amplifier. The amplifier's output terminates in the proper load for the amplifier, and the oscilloscope is connected across the load and the output of the generator. Use the Y2 TRIGGERING position (if necessary) to synchronize the display.

The waveform produced by the audio generator will not be changed as it passes through properly operating circuits of a high-fidelity amplifier. However, if any circuit is not operating properly, the output waveform will be distorted. The two traces can be compared directly.



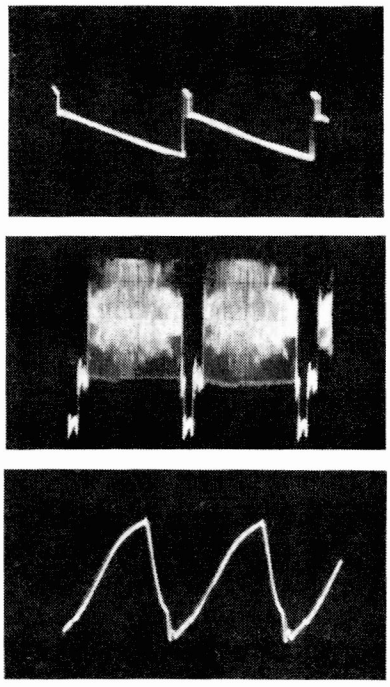
PICTORIAL 8-5

Pictorial 8-5, Part A, shows a sine wave with a serious flattening of one peak. This represents about 10% harmonic distortion, which could be caused by an improperly biased stage or a defective tube or transistor, and is a particularly objectionable amplifier fault. Pictorial 8-5, Part C, shows a flattening of both peaks, which usually indicates an overdriven stage somewhere in the amplifier.

While a sine wave signal will tell a lot about an amplifier, a square wave gives an additional indication of amplifier performance with respect to frequency response, amplitude distortion, and phase shift. The square wave generator must produce a clean waveform with straight sides, sharp corners, and flat horizontal lines, as shown in Pictorial 8-6, (Illustration Booklet, Page 25) Part A.

When a low frequency square wave signal is fed into the input of an amplifier, its output waveform will be a faithfully reproduced square wave if its frequency response is good and if little amplitude or phase distortion occurs in its circuits. The shape of the leading edge of an output waveform, as shown in Pictorial 8-6, Part B, indicates poor high frequency response. This may be caused by amplitude distortion (clipping), or phase shift, or both.

The slope of the flat portion of the waveform, as shown in Pictorial 8-6, Part C, indicates poor low frequency response.



PICTORIAL 8-7

TELEVISION RECEIVER CIRCUITS

An oscilloscope can also be used to service television receivers. There are two methods of using the oscilloscope in TV service work. One is the point-to-point probing to study components of a transmitted television signal and their effect on receiver circuits. The other method uses the signal from a sweep generator and is used primarily for the alignment of a receiver. These two methods will be treated separately in the following paragraphs.

Point-to-Point Signal Tracing

Most television maufacturers supply service information that shows correct oscilloscope patterns at various points in the receiver. These patterns are generally of the composite video signal or synchronizing signals that are received from a television transmitter, or generated within the receiver. Some of these patterns are shown in Pictorial 8-7, with the signal frequency indicated for each pattern. No special equipment is required for observing these patterns on your Oscilloscope, except a demodulator probe to detect modulation envelopes in the IF or RF amplifier sections.

Pictorial 8-8 is a simplified block diagram of a typical television receiver. It shows various stages and points for connecting the Oscilloscope probe. The letters at each test point indicate the type of probe to use, and the setting of the Oscilloscope's sweep speed. These letters are defined in the following chart.

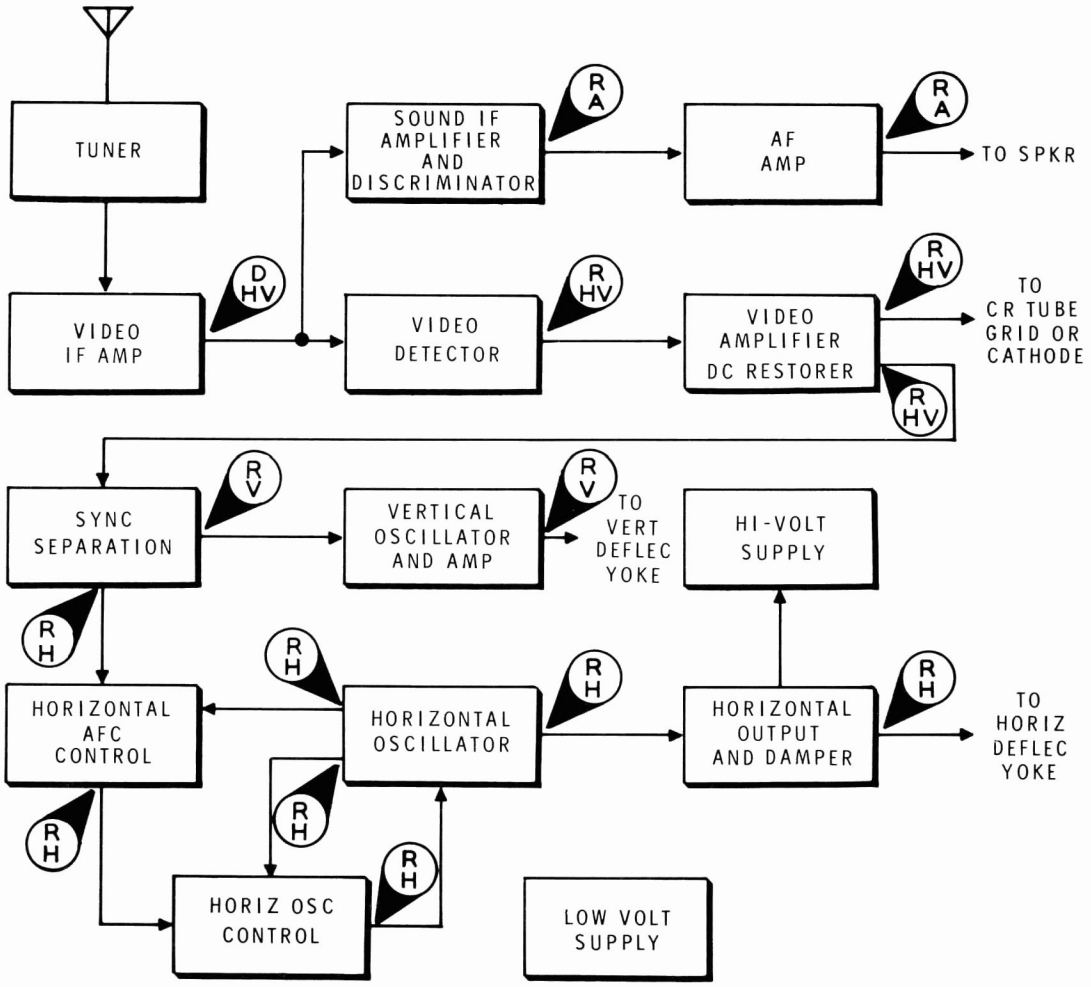
PROBE	SWEEP SPEED
R Direct	H 20 μs/cm
D Demodulator	V 2 ms/cm (use TV trigger)
A Audio	Test frequency

NOTE: For simplicity, all amplifier stages are shown within one block of the diagram in Pictorial 8-8. Tests may be made at the input or output of individual amplifier stages using the indicated probe and sweep frequency.

At any point up to the video detector, the voltages will be quite small and considerable vertical gain will be required. Within the sync circuits and deflection circuits, however, these voltages are larger and very little amplification is required.

In checking the waveforms, remember that two basic frequencies are involved in the television signal. The vertical or field frequency is 60 Hz. Any investigation of the circuit except within the horizontal oscillator, its differentiator network, and the horizontal amplifier stages, can generally be made using a sweep speed of 2 ms/cm. In order to study the horizontal pulse shape or the operation of the horizontal deflection system, it is generally necessary to operate the sweep generator at 20 μs/cm. This sweep rate will show the waveform of about three lines of the signal.

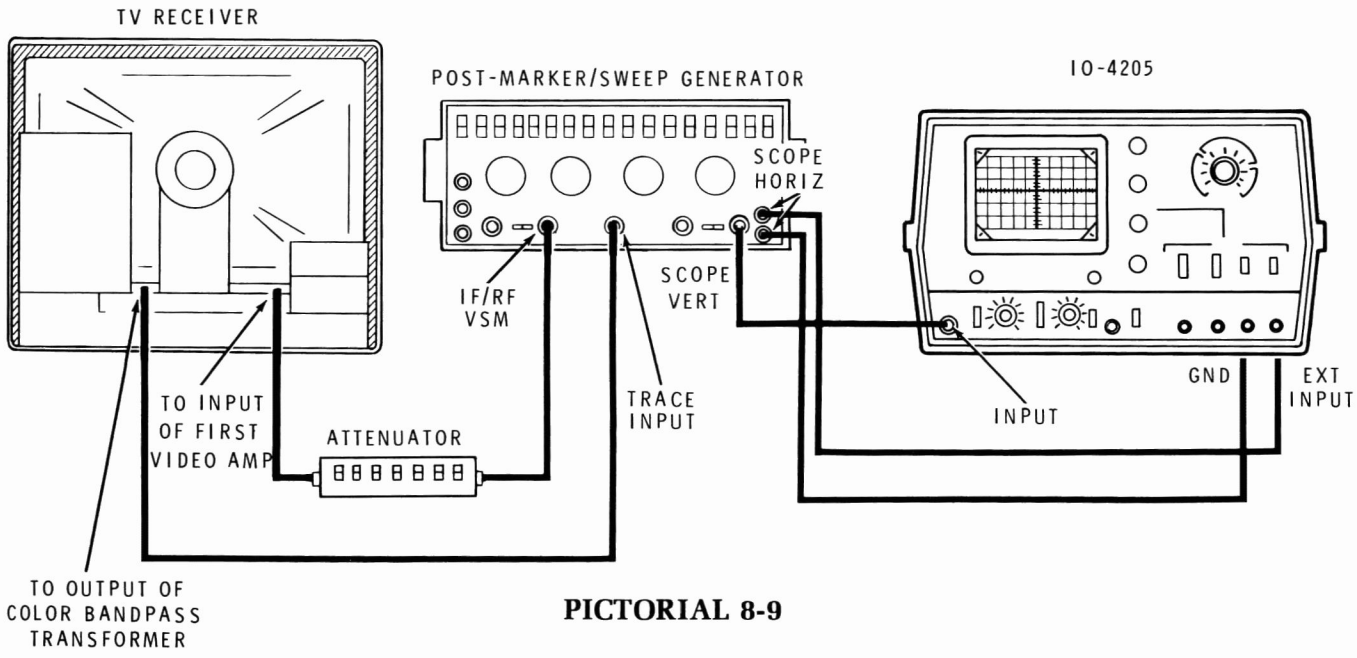
The point-to-point signal tracing method of analysis is most helpful in going through a receiver, since faulty receiver operation is generally caused by the loss of all or a significant portion of the picture information and pulses at some stage within the receiver. With a basic understanding of the function of each part of the signal and with a knowledge of what the signal actually looks like at any part of the receiver, it is a comparatively simple matter to isolate the defective portion and the particular component causing the failure.



PICTORIAL 8-8

Bear in mind that a phase shift of 180 degrees takes place in some circuits of a receiver. Therefore, the pattern displayed on the Oscilloscope screen may be inverted in some cases. The pattern or form of the wave should not be changed however.

Video amplifier response can be measured in exactly the same manner described for testing an audio amplifier, and again a square wave signal is the most efficient method to use. Because a video amplifier must pass signals as low as 20 Hz and as high as 4 or 5 MHz, a more comprehensive test is required. Usually a 60 Hz check is made to cover low and medium frequency characteristics. A second check at 25 kHz covers the high frequency portion of the response curve. Again, such tests require accuracy on the part of the Oscilloscope. The signal tracing technique can be used in these tests also. The square wave generator is fed directly into the first video amplifier stage. Very low signal input will be required. Then the Oscilloscope is connected to various stages, starting near the output end and working back until any distortion is isolated. Patterns such as Pictorial 8-6, Part B, (Illustration Booklet, Page 25) are responsible for poor picture detail or fuzziness, while the distortion of the waveform shown in Pictorial 8-6, Part C, can cause shading of the picture from top to bottom.

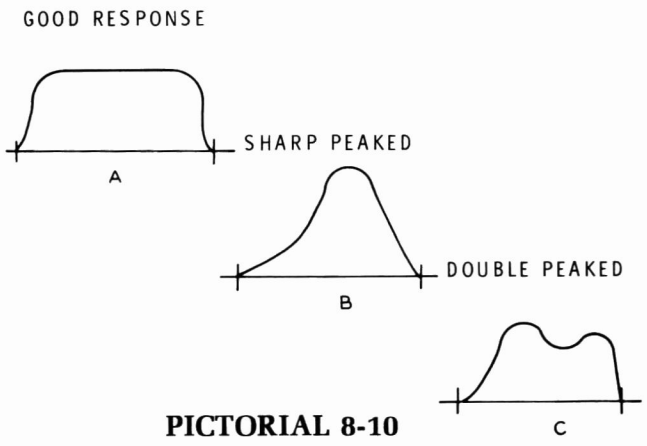


PICTORIAL 8-9

Receiver Alignment

Alignment of television RF and IF circuits requires the use of an alignment sweep generator as well as the Oscilloscope. This sweep generator supplies an RF signal that sweeps across all the frequencies of a television channel or IF amplifier 60 times a second. The sweep generator also supplies 60 Hz sweep voltage to the Horizontal input of the Oscilloscope. Pictorial 8-9 shows a typical setup for the alignment of a television receiver.

The exact procedure for alignment differs with various receivers and with different sweep generators. Maufacturer's service data usually includes alignment procedures and correct response waveforms.



PICTORIAL 8-10

Pictorial 8-10, Part A, shows a typical response curve for a properly aligned receiver. Notice that the top part of the waveform is essentially flat, and tapers sharply at both ends. The waveform shown in Part B of Pictorial 8-10 might result if the IF stages of the receiver were aligned too sharply or all at the same frequency. This would produce a narrow bandwidth and seriously affect picture quality. A misalignment of one or more IF stages would produce a waveform like that shown in Pictorial 8-10, Part C, which would also reduce picture quality.

AC VOLTAGE MEASUREMENTS

Because of its characteristics, the oscilloscope is particularly suited to the measurement of AC voltages. In some television circuits, it is imperative that such measurements be made accurately with respect to wave shape, so that the conventional rms-indicating AC voltmeter is no longer adequate. Most television service bulletins specify peak-to-peak voltages which appear at various points of the circuit.

The following relationships exist for sine wave AC voltages:

rms × 1.414 = Peak Voltage
rms × 2.828 = Peak-to-Peak Voltage
Peak Voltage × .707 = rms Voltage
Peak-to-Peak Voltage × 0.3535 = rms Voltage

TIME/CM-FREQUENCY CORRELATION

You can determine the frequency of a constant signal with your Oscilloscope by using the following formula.

$$\text{Frequency} = \frac{1}{\text{TIME/CM switch setting multiplied by the number of centimeters on the CRT covered by one cycle of the unknown frequency.}}$$

NOTE: The long vertical and horizontal lines on the graticule are spaced 1 cm (centimeter) apart. The short lines on the center vertical and horizontal lines are 2 mm (millimeters) apart. The usable graticule area is 8 cm high and 10 cm wide.

For example: Assume that one cycle of the unknown frequency covers five centimeters on the CRT (with the VARIABLE control full clockwise). The TIME/CM switch is set at 2 μs (2×10^{-6}). Using the previous formula.

$$\text{Frequency} = \frac{1}{\frac{2 \times 10^{-6}\ \text{sec} \times 5\ \text{cm}}{\text{cm}}}$$

Frequency = 100 kHz.

NOTE: The VARIABLE control cannot be used when you are computing with this equation, since there are no calibrated values associated with it. This control must be kept in the CAL (full clockwise) position when you are determining an unknown frequency.

TIME/CM-FREQUENCY CORRELATION CHART

TIME/CM SWITCH	TIME FOR 1 CM SWEEP	FREQUENCY (Hz) FOR 1 CYCLE/10-CM (full screen width)	FREQUENCY (Hz) FOR 5 CYCLES/10 CM (full screen width)
.2 μs	.2 μ sec	500,000	2500,000
.2 μs	2 μ sec	50,000	250,000
20 μs	20 μ sec	5,000	25,000
200 μs	200 μ sec	500	2500
2 ms	2 m sec	50	250
20 ms	20 m sec	5	25
200 ms	200 m sec	.5	2.5

NOTE: When the trigger selector is in the "line" position, a trace may not be visible on the CRT at sweep speeds above 20 μsec. The Oscilloscope will still be triggered, but the refresh rate is so low that the trace is dim.

IN CASE OF DIFFICULTY

This section of the Manual is divided into four parts. The first part, "General Troubleshooting Information," outlines possible causes that are the most often sources of trouble in newly assembled kits. Go through this part very carefully and apply these checks to your kit.

The second part "Troubleshooting Precautions and Notes," outlines precautions you should take when troubleshooting your Oscilloscope. Read this part carefully so you do not damage your oscilloscope while searching for the difficulty.

The third part, the "Troubleshooting Charts," is really two parts. The first part of this section consists of various tests to localize the trouble. You will then be directed to the second part, where you will pinpoint the trouble within the local area or circuit board.

If the "Troubleshooting Chart" does not help you locate the problem, read the "Circuit Description" and refer to the Schematic Diagram (fold-in) to help you determine where the trouble is.

The fourth part, "Checking Components," shows you how to use an ohmmeter to determine if a suspected component is faulty.

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

GENERAL TROUBLESHOOTING INFORMATION

The following paragraphs deal with the types of difficulties that may show up right after a kit is assembled. These difficulties are most likely to be caused by assembly errors or poor soldering.

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

2. About 90% of the kits that are returned for repair do not work properly due to poor solder connections. Therefore, you can eliminate many troubles by reheating all connections to make sure that they are soldered as described in the "Soldering Instructions," at the front of this Manual.

3. Check to make sure that all transistors are in their proper locations. Make sure that each transistor lead is connected to the proper point and that the transistor flats are properly positioned.

4. Check the values of the parts. Be sure that the proper part has been wired into the circuit as shown in the Pictorials and called out in the wiring instructions. For example, it would be easy to install a 200 Ω (red-black-brown) resistor for a 1000 Ω (brown-black-red) resistor.

5. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring. Check for solder bridges between circuit board foils. Compare your foil pattern against the "Circuit Board X-Ray Views" (Illustration Booklet, Pages 36, 37, and 38).

TROUBLESHOOTING PRECAUTION AND NOTES

WARNING: The full AC line voltage and high DC voltage is present at several places in the Oscilloscope. See Pictorials 9-1 and 9-2 (Illustration Booklet, Page 26). Be careful to avoid electrical shock when you work on the Oscilloscope.

1. Be cautious when you test transistors and integrated circuits. Although they have almost unlimited life when used properly, they are easily damaged by excessive voltage and current.

2. 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.

3. DO NOT remove any components while the Oscilloscope is turned on.

4. When you make repairs to the Oscilloscope, 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 Oscilloscope is turned on again.

5. Refer to the "Circuit Board X-Ray Views," and the "Schematic Diagram," to locate various components.

6. When the oscilloscope Trigger Selector is in the "LINE" position, a trace may not be visible on the CRT above 20 μsec. The oscilloscope will still be triggered, but the writing speed will be too fast to light the CRT.

TROUBLESHOOTING CHARTS

The "Troubleshooting Charts" are designed to pinpoint a trouble through a series of tests. The following symbols and procedures are used in the charts.

Follow the "YES" arrow when you obtain the correct measurement or condition.

Follow the "NO" arrow when you do not obtain the correct measurement or condition.

Components are listed in the order in which failure or a problem is most likely to occur.

All voltage measurements were made with a high impedance voltmeter, a nominal line voltage of 120 volts AC, and can vary ±20%.

Set the front panel controls and switches as follows:

INTENSITY: Center of rotation.

FOCUS: Center of rotation.

TRIG LEVEL: Center of rotation.

HORIZ POS: Center of rotation.

TIME/CM: X10 (full clockwise).

SWEEP VAR/HORIZ GAIN: CAL (fully clockwise).

Y1-Y2-EXT-LINE (trigger source switch): Y1.

AC-DC-TV (trigger coupling switch): AC.

POSITIVE (+)-NEGATIVE (−) (slope switch): Positive (+).

AUTO-NORMAL (trigger mode switch): NORMAL.

Y1-Y2-AC-GND-DC: GND.

Y1-Y2-VOLTS/CM: 0.05.

Y1 VARIABLE: CAL (fully clockwise).

Y2 VARIABLE: CAL (fully clockwise).

Y1 POS: Center of rotation.

Y2 POS: Center of rotation.

Y1-Y2-CHOP-ALT: Y1. (vertical mode switch).

OFF-ON: OFF.

Do not change the position of any control or switch unless you are instructed in a step to do so.

Connect the line cord to an AC outlet and turn the Oscilloscope on.

Perform the ±9 and +5 volt power supply test (Test #1) on Page 28 in the Illustration Booklet to verify the operation of the power supplies before you proceed. These power supplies must operate properly before you attempt any further troubleshooting. After you have completed Test #1, proceed to the "Trouble Locator Chart " on Page 100.

Trouble Locator Chart

Set the Y1-Y2-CHOP-ALT switch to Y1. Then alternately measure the collector voltages of Q115 and Q116. Adjust the Y1 POS control (on the front panel) until these voltages are 95 volts DC.

Set the Y1-Y2-CHOP-ALT switch to Y2. Then alternately measure the collector voltages of Q115 and Q116. Adjust the Y2 POS control (on the front panel) until these voltages are 95 volts DC.

NO → A problem exists in the vertical deflection circuits. Proceed to Test #2.

YES

Alternately measure the collector voltages of Q214 and Q215. Adjust the HORIZ POS control until these voltages are equal at 110 volts DC.

NO → A problem exists in the horizontal amplifier circuits. Proceed to Test #3.

YES

Turn the INTENSITY control fully clockwise and counterclockwise. A spot of light should be visible on the CRT and the intensity of the spot should vary as you turn the control.

NO → A problem exists in the blanking and/or CRT circuits. Proceed to Tests #4 and #5.

YES

Set the Y1-Y2-EXT-LINE switch to LINE. Then turn the TIME/CM selector through all of its positions. A trace should appear on all positions except X1 and X10. Then turn the selector to the 200 μS position. NOTE: The trace may not be possible on the CRT at the higher sweep speed settings. If this is the case, set the Y1-Y2-EXT-LINE switch to Y1 or Y2.

NO → A problem exists in the trigger or sweep circuits. Proceed to Tests #6 and #7.

YES

The major Oscilloscope circuits are operating properly. If a problem still exists, proceed to the test that most closely associates with the particular problem.

NOTE: Dual trace operation will only occur in the CHOP mode when the TIME/CM selector is set to the EXT IN position. If the Y1-Y2-CHOP-ALT switch is set to the ALT position, however, only one of the two channels will be displayed. This selection will be random.

CHECKING COMPONENTS

INTRODUCTION

To check a transistor accurately, you should use a transistor checker. However, if one is not available, you can use an ohmmeter to determine the general condition of any of the bipolar transistors (or diodes) in this kit. The ohmmeter used must have at least 1 volt DC at the probe tip to exeed the threshold of the diode junctions in the transistor being tested.

Set your ohmmeter to its low range for the following tests.

HOW TO CHECK TRANSISTORS AND DIODES

A. Unsolder and remove the component.

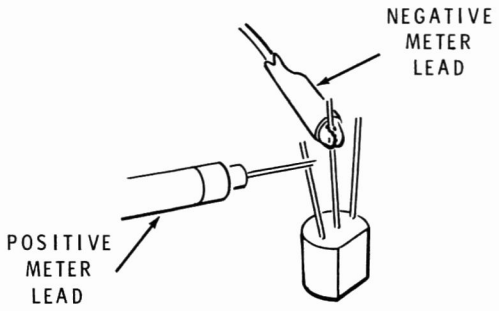
B. Connect the ohmmeter leads to the component as shown in the example illustration for transistors and diodes.

Example:

TRANSISTORS

Connect the positive meter lead to one lead as directed in the chart.

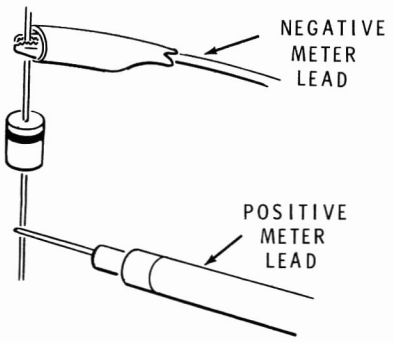
Connect the negative meter lead to another lead, as directed in the chart.



DIODES

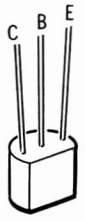
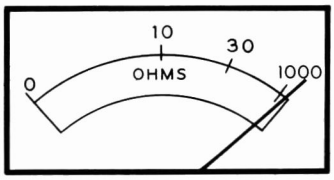
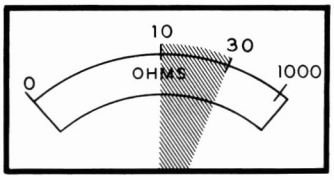
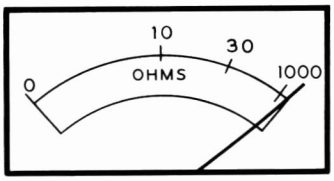
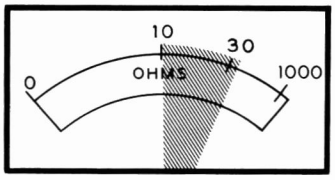
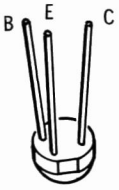
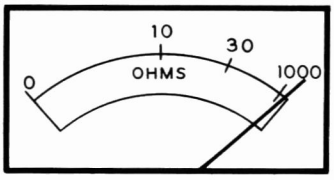
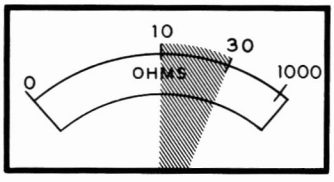
Connect the negative meter lead to one lead as directed in the chart.

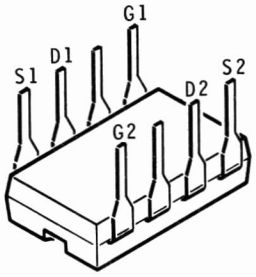
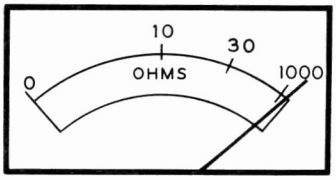
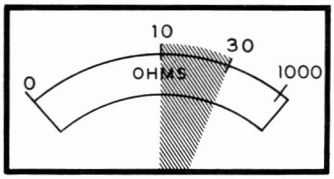
Connect the positive meter lead to the other lead, as directed in the chart.

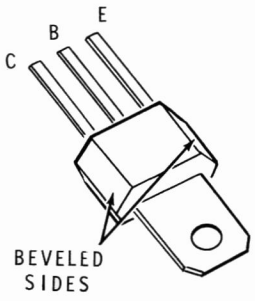
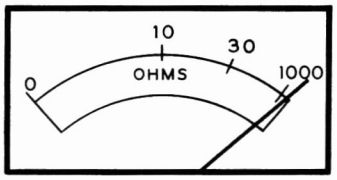
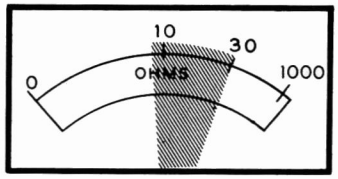
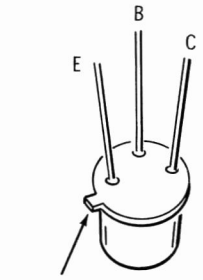
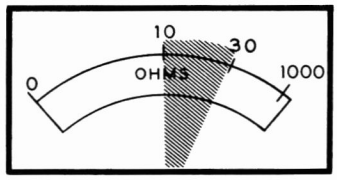
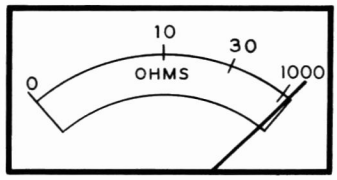
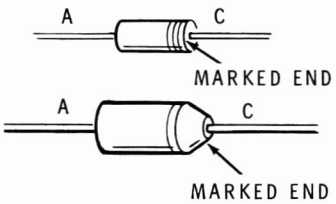
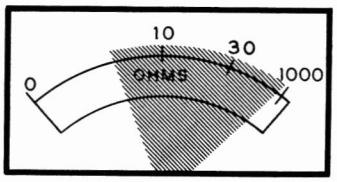
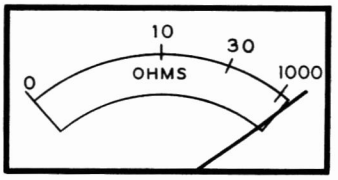


Proceed to the following chart and connect the ohmmeter leads to the component as indicated in the columns titled "Connect Positive Lead To," and "Connect Negative Lead To." The indicated meter reading in the last column is only a nominal reading. Your meter may read slightly different.

NOTE: The polarity of all ohmmeters is not the same. Therefore, if you do not get the indicated results, reverse your meter leads and try again. If you do get the correct results now, cross out the word "negative" in the heading in the second column and write in "positive." Also cross out the word "positive" in the heading in the third column and write in "negative."

TRANSISTOR	CONNECT NEGATIVE LEAD TO	CONNECT POSITIVE LEAD TO	METER READING
MPS6520 (417-134) SE6020 (417-237) 2N5770 (417-293) MPSA20 (417-801) MPSL01 (417-811) 	B B E	C E C	
	C E	B B	
2N4121 (417-235) MPSL51 (417-295) 	C E C	B B E	
	B B	C E	
2N4258A (417-260)  FLAT	C E C	B B E	
	B B	C E	

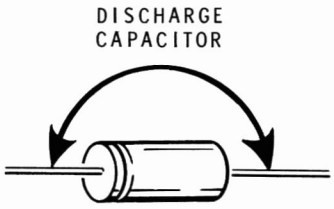
TRANSISTOR	CONNECT NEGATIVE LEAD TO:	CONNECT POSITIVE LEAD TO:	METER READING
NOTE: YOU MAY HAVE TO SET YOUR OHMMETER TO A HIGHER RANGE TO MEASURE THIS DUAL TRANSISTOR (417-902) NDP5565N  	G1 G1 G2 G2	D1 S1 D2 S2	
	D1 S1 D1 S1 D2 S2 D2 S2	G1 G1 S1 D1 G2 G2 S2 D2	

TRANSISTOR	CONNECT NEGATIVE LEAD TO	CONNECT POSITIVE LEAD TO	METER READING
MPSU10 (417-834)  	B	E	
	B	C	
	E	C	
	C	B	
	E	B	
2N2369 (417-154)  	C	B	
	E	B	
	B	E	
	B	C	
	C	E	
DIODES 56-26, 56-56 56-59, 56-67 56-89, 56-634 57-27, 57-52  	C	A	
	A	C	

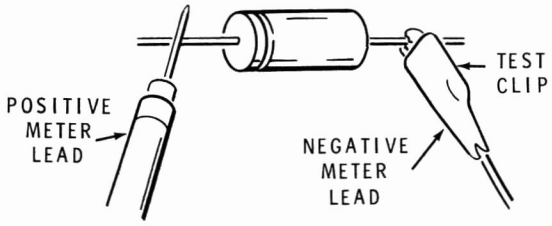
HOW TO CHECK CAPACITORS

A. Unsolder and remove the capacitor.

B. Discharge the capacitor by touching the leads together.



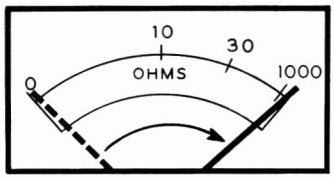
C. Connect the negative meter lead to one lead. Then, while watching the meter, touch the positive meter lead to the other capacitor lead. (Note the special instructions for the electrolytic capacitors.)



How to Connect Electrolytic Capacitors to the Meter and Chassis

Each electrolytic capacitor has a positive (+) mark at one end. When checking one of these capacitors, connect the positive (+) lead to the positive meter lead and the other lead to the negative lead.

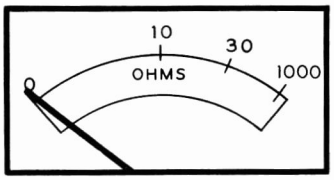
1. If the meter pointer deflects to the low ohms side quickly, and then gradually returns to the high ohms side, the capacitor is not faulty. NOTE: The time it takes for the pointer to return to the high ohms side depends upon the value of the capacitor. A 50 μF capacitor for example, will cause the pointer to return more rapidly than a 500 μF capacitor.



CAPACITY OK
#4

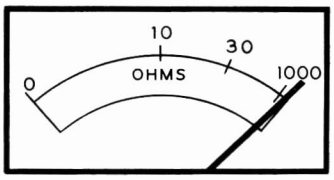
2. If the meter pointer deflects to the low ohms side and stays there, the capacitor is faulty (shorted).

CAPACITOR FAULTY (Short)



3. If the meter pointer does not deflect at all, but stays at the high ohms side, the capacitor is faulty (open).

CAPACITOR FAULTY (Open)



4. Recheck the capacitor, BUT FIRST DISCHARGE IT BY TOUCHING THE LEADS TOGETHER.

Because of the small capacitance of capacitors below the value of 50 μF, it is very difficult to determine if the capacitor is faulty (open). If your meter needle does not move at all when you are checking a small value capacitor, it does not mean that the capacitor is open.

SPECIFICATIONS

VERTICAL

Bandwidth	DC to 5 MHz, ±3 dB.
Attenuator	1, 2, 5 sequence, calibrated and variable.
Rise Time	70 ns.
Overshoot	≤5%.
Impedance	1 MΩ/38 pF.
Sensitivity	10 mv/cm.

SWEEP

Type	Triggered.
Range	200 ms to .2 μs in 7 steps, plus variable.
Trigger Source	Y1/Y2/Ext/Line.
Trigger Modes	AC/DC/TV; +/− Slope; Auto/Norm.

HORIZONTAL

Sensitivity	.1 V/cm.
Bandwidth	DC to 1 MHz.
Impedance	1 MΩ/50 pF.
Ext Horiz Input	X1 and X10 attenuator and variable.

GENERAL

CRT	5DEP31F. 8 × 10 centimeter viewing area. Blue-green, medium-persistence phosphor. 5″ round, flat face tube.
Accelerating Potential	Approximately 1.6 kV.
Graticule	Screened, 8 × 10 centimeters.
Power requirements	110-130 VAC or 220-260 VAC, 50/60 Hz, 50 watts.
Overall Dimensions	13″ wide, 8″ high, 17″ deep.
Net Weight	15 lbs.

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.

THEORY OF OPERATION

Refer to the Block Diagram (Illustration Booklet, Page 27) as you read the following material.

The dual-trace capability of this Oscilloscope allows two different signals to be displayed on a conventional CRT (cathode ray tube) that has only one set of vertical deflection plates. Two identical vertical preamplifier circuits, a switching circuit, and a vertical deflection amplifier make this possible. Each vertical preamplifier circuit attenuates its input signal by a known factor, amplifies it to a usable level, and provides the necessary positioning bias. The switching circuit (a diode-type switch), which is automatically controlled by the display control circuit, alternately allows the output signals from the two preamplifier circuits to pass to the vertical deflection amplifier. The vertical signal, a composite of both input signals, is amplified further by the vertical deflection amplifier before it is applied to the vertical deflection plates of the CRT. The signal at the vertical deflection plates, which produces the display on the CRT screen, thus represents both input signals as one "time-shared" signal.

The horizontal portion of the trace displayed on the CRT screen is produced by the sweep and trigger circuits in conjunction with the horizontal deflection amplifier. The sweep circuit produces the linear signal (ramp) used to sweep the electron beam across the CRT screen from left to right at a constant rate. This circuit is switch controlled (by the TIME/CM switch) to provide seven sweep rates needed to view and measure almost all input signals. This circuit must be triggered either by a portion of one of the vertical input signals, by an external signal, or by a portion of the line frequency signal.

In the absence of a trigger signal, an automatic baseline circuit causes the sweep circuits to operate while in the automatic mode. This ensures that, even though no signal is applied, a reference baseline (trace) will appear on the CRT screen. The sweep signal is coupled to the horizontal deflection amplifier where it is amplified before being applied to the horizontal deflection plates of the CRT. Other circuits within the horizontal amplifier also provide the necessary positioning bias.

At the end of each horizontal sweep, the blanking circuits (which are triggered by the sweep circuits) turn the trace off (blank it). This prevents a line (retrace) from being displayed as the electron beam returns to the left side of the CRT screen to start a new trace.

CIRCUIT DESCRIPTION

Refer to the Block Diagram (Illustration Booklet, Page 27) and the Schematic (fold-in) while you read this "Circuit Description." The part numbers are arranged in the following groups to help you locate specific parts on the Schematic, circuit boards, and chassis.

1-99	Parts on the chassis.
100-199	Parts on the vertical circuit board.
200-299	Parts on the horizontal circuit board.
300-399	Parts on the power supply circuit board.

VERTICAL CHANNELS

The vertical preamplifier consists of two identical circuits; one for channel Y1 and the other for channel Y2. The board-mounted components in the Channel Y1 vertical preamplifier circuit are designated by an A suffix, while those in the Channel Y2 vertical preamplifier are designated by a B suffix. (Example: A Channel Y1 divider resistor is R101A, while the corresponding divider resistor in Channel Y2 is R101B). Components without a suffix do not pertain to a specific channel. Since both channels are identical, only Channel Y1 is described in this "Circuit Description."

INPUT CIRCUITS

When Y1 input switch SW1A (AC-GND-DC) is in the DC position, a signal applied to the Y1 input connector is coupled to the input attenuator. When the Y1 input switch is in the AC position, the signal is coupled through capacitor C1, which passes only AC signals. This permits an AC signal superimposed on a DC potential to be seen without the DC component being displayed.

The GND position of this switch disconnects the input signal and grounds the attenuator input. This allows the trace to be adjusted to a zero reference without disconnecting the test leads from the circuit under test.

Because the first, second, third, and vertical deflection amplifiers operate at a fixed gain, any signal applied to them must be within a usable range (approximately 7 mV/cm). Therefore, the primary function of the vertical input circuits is to reduce the input signal by a known factor to this usable level.

The vertical input circuit basically consists of a high impedance attenuator, an input follower, and a low impedance attenuator. These circuits function together, through VOLTS/CM switch (SW2), to provide the total desired attenuation. The attenuator obtains its four attenuation factors (1, 10, 100, and 1000) from four divider networks (resistors R101A through R104A, and capacitors C103A through C107A). At DC and low AC frequencies, the resistive dividers reduce the input signal level. At higher frequencies, however, attenuation is determined by the resistor-capacitor (RC) networks.

Trimmer capacitors C103A, C104A, and C106A are used to adjust the capacitor division ratio to match the resistor ratio. Trimmer capacitors C101A and C102A

are adjusted during calibration to make the input capacitance of the Oscilloscope equal in all positions of the VOLTS/CM switch. This is essential when an attenuation probe (usually ×10) is used. Resistors R1A, R2A, and R106A are used to suppress oscillations in the attenuator circuit.

The input follower circuit consists of an FET (field-effect-transistor) source follower and DC current source. The attenuated input signal is coupled through resistors R106A and R107A and capacitor C108A to the gate of FET source follower Q101A-1. Capacitor C108A forms a high frequency path around R107A for improved frequency response. Input protection is provided by the two diodes D101A and D102A. The diodes are connected to the plus (+) and minus (−) 8-volt supplies. Thus, if the signal at the junction of the two diodes exceeds 8 volts, the diodes become forward biased and clamp the signal to a level that is within a diode drop of 8 volts. This prevents damage to Q101A if the VOLTS/CM switch is in a low range, and a high potential is applied to the input.

Transistor Q101A-1 provides a match between the high impedance of the input attenuator and the low impedance of the second attenuator. Transistor Q101A-2 is used as a constant current source. DC Balance control R112A sets the current through Q101A-2 so the voltage at the drain is 0 volt when no signal is present at input J1. Capacitor C112A forms a high frequency path around resistor R107A for improved high frequency response.

The output from Q101A-1 is coupled to the low impedance attenuator through variable attenuator control R3. The low impedance attenuator attenuates in a 1, 2, 5 sequence from the three divider resistors (R115A, R116A, and R117A).

The output from the second attenuator is coupled to the gate of transistor Q102A-1. Q102A-1 and Q102A-2 form the first gain stage with a gain factor of about 3. Vertical Position control R4A is connected to the gate of transistor Q102A-2. Transistor Q103A, a constant current source for the stage, and Bias Adjust control R138A sets the current through the stage. This in turn sets the bias voltage at the drain of transistors Q102A-1 and Q102A-2.

The output of the first gain stage is direct-coupled to the second gain stage through resistors R124A and R131A. The second stage is made up of transistors Q104A and Q105A. The gain factor of this stage is about 10. Vertical Calibration control R143A sets the gain of this stage and also of the vertical amplifier.

The output of the second stage is coupled to the third gain stage through resistors R157A and R158A. The gain of the third stage is about 10. The signal at the emitter of the second gain stage is coupled to the trigger amplifier through resistors R142A and R145A. The trigger amplifier will be described later.

DIODE SWITCH

Both preamplifier circuits (channels Y1 and Y2) share the vertical deflection amplifier. This is accomplished with two high-speed diode switch networks (D108A through D112A and D108B through D112B) that are actuated by the display control circuit. When one diode switch is turned on, the other is turned off, so only one signal can be coupled to the vertical deflection amplifier. Two-channel operation is accomplished by turning each diode switch network on and off at a rapid rate or on alternate display sweeps. Control of the diode switch will be described in a later section.

VERTICAL DEFLECTION

From the diode switch, the input signal is direct-coupled to the vertical deflection amplifier through resistors R166 and R168. This amplifier (made up of transistors Q113, Q114, Q115, and Q116) is wired in a differential cascode configuration, with a gain of about 20. Capacitor C121 between the emitters of Q113 and Q114 provides high-frequency square wave compensation. Ferrite beads on the base leads of common-base amplifier Q115/Q116 prevent oscillations in the amplifier. Circuit loading is provided by resistors R177 and R178. The output of this amplifier is coupled to the vertical deflection plates of the CRT for beam control. Vertical beam deflection requires between 9 and 12 voltsc/cm, depending on individual CRT characters.

TRIGGER AMPLIFIER

A differential amplifier and follower make up the trigger amplifier circuit. Its output is used to supply a trigger signal to the trigger circuit.

A portion of the input signal is coupled from the emitters of Q104A/Q105A to the input of differential amplifier Q106/Q107 in the trigger amplifier circuit. Emitter follower Q109A couples the trigger signal from the inverting leg (collector of Q108A) of the differential amplifier to the trigger circuit. Transistor Q108A is a temperature-compensated constant current source for this circuit. Trigger Zero control R152A in the emitter leg adjusts the current so the output of the follower will be zero with no signal to the trigger amplifier. Thus, the circuit performs as a differential to single-ended converter.

CONTROL CIRCUIT

The control circuit consists of the two switch driver transistors Q117 and Q118, the control integrated circuit U102, sections A and B of integrated circuit U101 making up the chopper oscillator, and Vertical Mode switch SW4. Section C of U101 acts as an inverter/buffer and supplies the chopper blanking signal.

When single trace operation is desired, switch SW3 is placed either in the Y1 or Y2 position. In these positions, integrated circuit U102 selects the proper switch driver transistor to allow the selected channel to operate. When the chop mode of the dual trace operation is desired, switch SW3 is placed in the Chop position. The chopper oscillator is activated and it applies a 200 kHz toggle pulse to pin 12 of U102. U102 drives the switch driver transistors at a 100 kHz rate. Thus, the two channels are switched on and off at this rate. Pictorial 10-1 (Page 112) shows a typical, 2-trace, chopped display that has been magnified for clarity. The oscillator signal is also applied to the blanking amplifier ("S" on the power supply circuit board) by section C of U101. This signal blanks the CRT during each on/off transition of the two channels. It is also desirable to switch the oscillator off during the retrace time. Therefore, a pulse is coupled from sweep control integrated circuit U201B to chopper oscillator U101A/U101B and control integrated circuit U102 to inhibit any switching during this time.

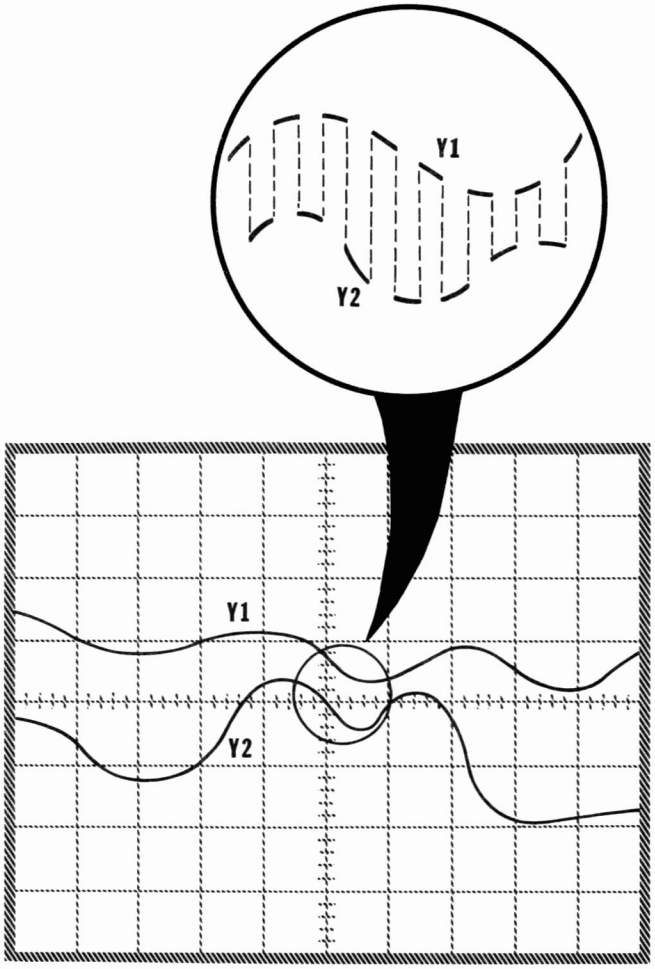
In the alternate channel mode of dual trace operation, the oscillator is disabled and the control pulse from the horizontal circuits controls the channel switching. Each time the sweep circuits sweep, the control pulse causes U102 to toggle. This turns on one channel while the other is turned off. Each successive sweep cycle will toggle U201B and alternate the channel being coupled through the diode switch to the vertical deflection circuits.

TRIGGER AND SWEEP CIRCUITS

On command from a trigger pulse, the horizontal time base circuits generate a linear ramp signal (sweep) to drive the CRT horizontal deflection plates and move the dot across the screen at a constant rate. In the automatic triggering mode, if no trigger is present, the time base circuits free-run and generate an auto baseline.

When a trigger signal of sufficient amplitude is present, the trigger amplifier amplifies the signal and presents it to the trigger comparator through the slope switch. The output of the comparator changes state and turns on the sweep control and allows the timing capacitor to be charged through the "bootstrap" constant current source. The charging of the capacitor produces a linear ramp signal that is coupled through the voltage followers to the horizontal deflection circuits.

The ramp signal is also coupled to the sweep end circuit. When the ramp reaches a preset voltage level, set by the Sweep Length control, the sweep end circuit triggers the blanking flip-flop and ramp hold-off monostable.



PICTORIAL 10-1

TRIGGER

In the automatic triggering mode, the trigger circuit examines the trigger signal for a proper trigger point. If the signal is large enough, the sweep circuit is activated by the trigger. If the signal is insufficient or absent, the circuits are allowed to free run.

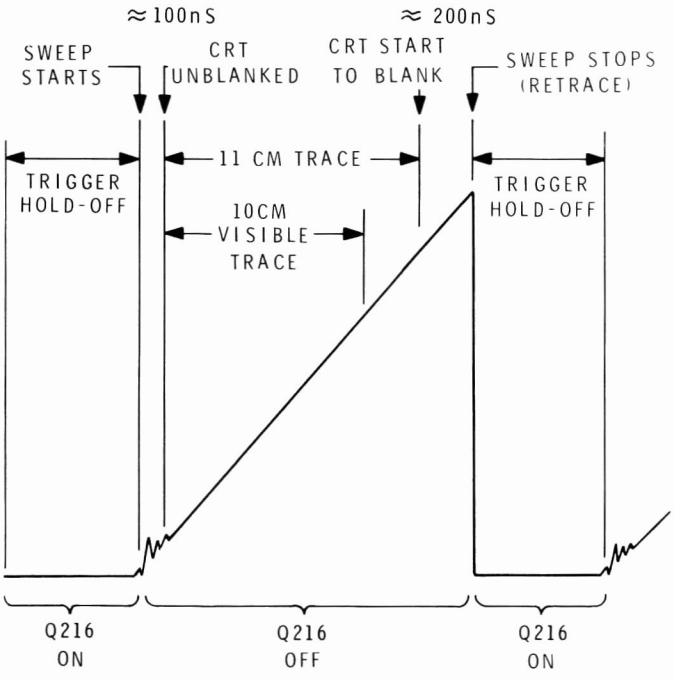
Depending on the desired trigger mode, one of four sources can be selected by the Trigger switch: Channel Y1 Trigger, Channel Y2 Trigger, External Trigger, or Line Sync. The Channels Y1 and Y2 trigger signals are provided by the vertical preamplifier trigger circuits, while the line sync signal is tapped directly off the 1-volt transformer winding. The external trigger input signal is coupled directly to trigger switch SW4. The signal is then coupled to switch SW6. SW6 selects the type of coupling (AC, DC, or TV) that will be used to couple the signal to the trigger circuits. In the AC position, the signal is coupled through capacitor C201 to the trigger circuits. In the DC position, the signal is coupled direct, and in the TV position, the signal is coupled through capacitors C201, C202, resistor R201, and diode D201. The circuit composed of capacitor C202, resistor R201, and diode D201 forms a low-pass filter and DC restorer. This circuit allows the trigger circuits to be synchronized to the vertical frame rate of a complex video TV signal.

The trigger signal is coupled to the first gain stage through resistor R252 and capacitor C229. C229 forms a high frequency path around R252 for high frequency response. Resistor R280 sets the input impedance of the amplifier. Diode D214 and the gate-drain junction of Q201A provide input protection.

The first gain stage is made up of transistors Q201A and Q201B. Transistor Q202 is a constant current source for the stage. Trigger Balance control R211 adjusts the current through the stage and the bias voltage at the output of the trigger amplifier. Trigger Level control R7 is connected to the gate of transistor Q201B.

The second gain stage is formed by transistors Q203 and Q204 and has a gain of about 30. The output of this stage is coupled to emitter followers Q205 and Q206. The output of the emitter followers is connected to Slope switch SW7.

The amplified signal, with either positive or negative slope as selected by SW7, is coupled to pin 1 of integrated circuit U202A. U202 contains four Schmitt input gates. A trailing edge or low-going pulse applied to pin 1 of U202A causes the output to go high. This high is coupled to pin 11 of U201B and to pin 3 and 4 of U203. U201B controls the sweep circuits and U203 controls the auto baseline portion of the sweep circuits.



PICTORIAL 10-2

SWEEP

The negative edge of the trigger pulse activates U201B and turns transistor Q216 off. This lets the timing capacitor charge through the bootstrap current source, and generates a linear voltage ramp. The ramp (sweep signal) is coupled to the horizontal deflection circuit, and the remaining sweep circuits. When the ramp reaches a pre-determined level, the CRT is blanked, U201B is reset, and Q216 is turned on to provide a discharge path for the timing capacitor (ramp returns to the zero level).

Refer to Pictorial 10-2 for the following discussion.

When transistor Q216 turns off, the timing capacitor begins to charge. After about 100 nS, the CRT unblanks and the trace becomes visible. This short delay hides any switching transients. At a preset ramp level, the CRT is again blanked before the trace is stopped (to give the CRT time to fully blank). After the short delay, transistor Q216 is turned on and the timing capacitor is discharged.

Initially, sweep control U201B is in a reset condition (Q is low and $\overline{Q}$ is high) and transistor Q216 is turned on. A trigger pulse from U202A will toggle U201B and switch Q high and $\overline{Q}$ low. The low from $\overline{Q}$ turns transistor Q216 off and toggles blanking control U201A. As Q216 turns off, the timing capacitor begins to charge through the "bootstrap" current source. At the same time, U201A switches the CRT blanking circuit and unblanks the CRT.

The bootstrap current source is part of the sweep generator. Field effect transistors Q207A and Q207B, and transistor Q217 form a voltage follower with a gain of approximately 1. It has a very high input impedance to prevent circuit loading, which could cause a non-linear voltage ramp (sweep). The junction of resistors R233 and R10 is held to a level 10 volts above the output of the emitter follower by zener diode D205. Since the follower input voltage equals the output voltage, the voltage across the selected timing resistor (R223, R224, R225, or R226) will always be constant. This will produce a constant current to charge the selected timing capacitor (C215, or C216). When variable control R10 is turned from its CAL position, the voltage differential is lowered. Thus, the charging current will be reduced and as a result, the sweep speed is reduced. The Variable control is used to provide continuous sweep speeds between the calibrated ranges. Zero ADJ control R231 adjusts the follower for the proper voltage offset.

The output of the sweep generator is coupled through resistor divider R272 and R273 to the horizontal deflection amplifier. It is also coupled through Sweep Length control R236 to Schmitt gate U204B. Control R236 is adjusted so the output of the Schmitt trigger-type gate will go low when the ramp voltage exceeds approximately 1.8 volts. (This represents a horizontal sweep of about 11 centimeters.) The low from U204B resets (clears) blanking control U201A, which blanks the CRT. Zener diode D206 protects the Schmitt trigger from misalignment or malfunction of the sweep generator. The function U204A will be described later.

The low from sweep end gate U204B is coupled to hold-off monostable U205. This signal is coupled via resistor R228 and capacitor C214. This RC combination causes a small delay that insures that the retrace will not occur until after the CRT is blanked. The hold-off monostable toggles ($\overline{Q}$ goes low) and remains in this condition until it "times out." The hold-off time is determined by TIME/CM switch SW5C and is of sufficient duration to insure complete retrace. With pin 13 of U202D high (from U204A), the low from $\overline{Q}$ of U205 will force pin 11 of U202D high. Pins 9 and 10 of U202C will go high and pin 8 of U202C is forced low resetting sweep control U201B. This forces the $\overline{Q}$ output high and turns on Q216 which quickly discharges

the sweep timing capacitor (retrace). The low from pin 8 of U202C does not affect gate U202B because pin 5 of U202B is already low (auto-baseline monostable U203 toggled by trigger signal). The low from hold-off monostable U205 "locks up" sweep control U201B, so that it cannot toggle on a trigger signal until after hold-off. After U205 "times out," U201B can toggle on the next trigger signal and start a new cycle.

If, for any reason the sweep control circuitry should "hang up," such as at initial turn-on, the ramp voltage would continue to increase. A voltage level would be reached where anti-lockup control U204A would activate and (through U202D and U202C) reset (clear) U201B, and discharge the sweep timing capacitor to initiate a new sweep cycle.

Normally, reoccurring trigger pulses hold monostable U203 on. The low at the $\overline{Q}$ output is coupled through U202B and holds the output of U202B high for normal sweeps to take place. However, with no input trigger pulses, U203 times out and its $\overline{Q}$ output goes high. This allows the set and clear inputs of U201B to be in opposite states by U202B, causing U201B to "free run" and produce sweeps for a base line. In "normal" mode operation, the automatic base line will never appear, as this feature is overridden by switch SW8.

HORIZONTAL AMPLIFIER

The sweep signal is coupled to the gate of Q208A by resistor R239 and capacitor C218. C218 forms a high frequency path around R239 for high frequency improvement. Resistor R240 sets the input impedance to the amplifier. Input protection is provided by diode D209 and the gate-drain junction of Q208A, connected to the ±9-volt sources; thus, clamping the input signal to these potentials. Transistor Q208A is connected as a source follower. Transistor Q208B is connected as current source for Q208A. Control R247 sets the current through this stage. The signal is connected from the drain of Q208B to the base of Q209. When the horizontal amplifier is used in the external/horizontal mode of operation, the input of the amplifier is connected to the X1 and the X10 attenuator. The attenuator is formed by resistors R242 and R243. Capacitors C219 and C220 provide frequency compensation. External horizontal variable control R11 and resistor R286 are also switched in at this time.

A reference voltage from the horizontal position control provides offset adjustment at the differential amplifier (base of Q210). Amplifier gain is about 10. Control R251 adjusts the gain of this amplifier, and therefore, the overall gain of the horizontal deflection circuit. This is to compensate for the individual deflection characteristics of the CRT. Transistor Q211 is the constant current source for this amplifier section. Control R257 adjusts the current through this stage and thus the bias voltage at the collectors of Q209 and Q210.

Final amplification occurs in the third deflection amplifier. It is a cascode differential amplifier with a gain of about 25. The output is coupled to the horizontal deflection plates of the CRT for beam control. Horizontal beam deflection requires between 14 and 20 volts/cm, depending on individual CRT characteristics.

POWER SUPPLIES AND BLANKING

+130 AND +160 VOLTS

Full-wave bridge rectifier diodes D307, D308, D309, and D310 produce 170 volts which is reduced to provide the +160-volt supply used in the horizontal deflection amplifier. A second filter divides the 160-volt source down to +130 volts for the vertical deflection amplifier, the blanking amplifier, and the astigmatism control.

±9 AND +5 VOLTS

Diodes D303, D304, D305, and D306 comprise two full-wave rectifiers that produce positive and negative 15 volts DC from the power transformer. These voltages are filtered and then coupled to voltage regulators U301, U302, and U303. Regulators U303 (−9 V) and U302 (+9 V) are connected in a tracking con-

figuration by resistors R334, R335, and R336. If one regulator shuts down, the other one is also shut down. U301 provides the regulated +5 volts supply.

HIGH VOLTAGE

Diodes D301, D302 and capacitors C301, C302 make up a voltage doubler that produces approximately −2000 VDC at nominal line voltage. Resistor R301 and capacitor C303 filter and reduce the voltage to approximately −1650 VDC. Divider string D311, R308, R17, R6, R309, and R310 supply the CRT cathode bias and a reduced voltage for focus control R6. Capacitor C320 bypasses diode D311 and resistor R338. Resistor R338 limits the CRT cathode current. Astigmatism adjust control R330 and emitter follower Q307 control the astigmatism anode voltage.

CRT BLANKING

Free-running oscillator Q305 and Q304 controls the trace brightness. The high frequency oscillator signal is capacitor-coupled to a bridge rectifier that produces a DC voltage on the cathode to turn on the CRT. The amplitude of the oscillator signal (controlled by the blanking circuit) can be increased or decreased by changing DC levels, or decreased by pulses. An oscillator signal of larger amplitude (as adjusted by the Intensity or Bias Adjust controls) will produce a larger DC voltage on the CRT cathode, which will make the trace brighter. A retrace pulse will reduce the amplitude of the oscillator signal, and the resulting reduced DC voltage will turn off the CRT during "retrace" or "hold-off."

To fully understand the blanking circuits, keep the following three ideas in mind.

1. The CRT is blanked when the control grid is 82 volts **more negative** than the cathode.

2. As the 82-volt difference between the grid and the cathode is reduced, the CRT is unblanked and the beam intensity is increased.

3. The CRT must be blanked and unblanked when the sweep circuits are operating, and there must be spot control when the Oscilloscope is used in the external horizontal mode. Therefore, there must be two paths of control: an AC path and a DC path.

The blanking amplifier provides the necessary gain to amplify the input blanking pulses and the voltage from the Intensity control. The Intensity control controls the output DC level of the amplifier (emitter of Q306), and the input blanking pulses reduce this DC level for the duration of each pulse. The leading and trailing edges of the amplified blanking pulses are capacitor-coupled to the grid of the CRT by C315 and R325.

At slow sweep speeds, the CRT is blanked for a very long period of time, or not at all in the EXT Horizontal position. Because of this, a "DC restoration" scheme is needed to translate the DC level at the output of the blanking amplifier to the control grid of the CRT. This is done by amplitude modulating an oscillator (Q305 and Q304) that is capacitor coupled by C314 to demodulator diodes D316 and D320. The demodulator is referenced to the −1650 volt supply and the output is coupled to the CRT control grid by R324 and R325.

The amplitude of the oscillator output follows the DC output of the blanking amplifier on a 1:1 basis. Then the output of the demodulator follows the peak value of the oscillator waveform. This means, then, that the DC output of the blanking amplifier is translated to the CRT grid on a 1:1 basis.

The blanking amplifier has a common base input stage, Q301. Here, the input blanking pulses and the Intensity control voltage are summed in its emitter. Transistors Q302, Q303, and Q306 are current and voltage amplifiers whose gain is determined by the ratio of feedback resistor R318 and the appropriate input resistance. Capacitor C312 is for high frequency compensation.

The blanking amplifier is coupled to the emitter of Q304 by R329. Q304, and Q305 form an emitter-coupled oscillator. Capacitor C319 and emitter resistor R333 determine the frequency of oscillation, which is approximately 200 kHz. Diode D319 protects Q304 from negative spikes during turn-on when C314 charges. D318 is referenced to a maximum voltage that the oscillator is limited to and clamps the output of the oscillator if it tries to exceed this voltage. The reference voltage is set by resistors R326 and R327, and C317 filters this voltage.

CALIBRATOR

The calibrator section consists of resistor R307 and diodes D312 and D313. The resistor and the diodes clamp the voltage to jack J3 to approximately .94 volt peak to peak.

SEMICONDUCTOR IDENTIFICATION CHARTS

This section is divided into two parts: "Component Number Index" and "Part Number Index." The Component Number Index provides a cross-reference between Circuit Component Numbers and their respective Heath Part Numbers. The component numbers are listed in numerical order. The Part Number Index provides a lead configuration detail (basing diagram) for each semiconductor part number. The Heath Part Numbers in this section are also listed in numerical order.

COMPONENT NUMBER INDEX

This index shows the Heath Part Number for each semiconductor in the IO-4205 Oscilloscope.

DIODES

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER
D101A, B-D106A,B	56-56
D107	56-67
D108A, B;D109A,B	56-56
D111A,B; D112A,B	56-56
D113-D116	56-89
D201	56-56
D204	56-56
D205	56-67
D206	56-59
D207-D210	56-56
D211	56-67

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER
D213,D214	56-56
D301, D302	57-52
D303, D310	57-27
D311	56-634
D312	56-56
D313	56-89
D314	56-26
D315, D316	56-56
D317	56-634
D318, D321	56-56

TRANSISTORS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER
Q101A,B; Q102A,B	471-902
Q103A,B	417-801
Q104A,B; Q105A,B	417-260
Q106A,B; Q109A,B	417-235
Q111A,B; Q112A,B	417-293
Q113, Q114	417-237
Q115, Q116	417-834
Q117, Q118	417-801
Q201	417-902
Q202	417-801
Q203, Q204	417-235
Q205, Q206	417-801
Q207, Q208	417-902
Q209, Q210	417-134
Q211	417-801
Q212, Q213	417-134
Q214, Q215	417-834
Q216	417-154
Q217	417-134
Q301, Q302	417-237
Q303, Q304	417-811
Q305	417-295
Q306, Q307	417-811

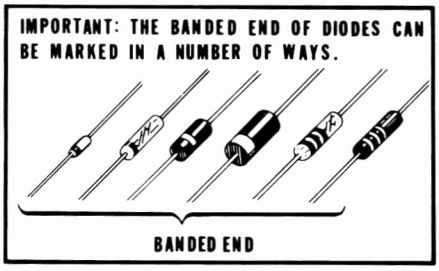
INTEGRATED CIRCUITS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER
U101	443-1
U102	443-4
U201	443-6
U202	443-625
U203	443-23
U204	443-44
U205	443-22
U301, U302	442-617
U303	442-618

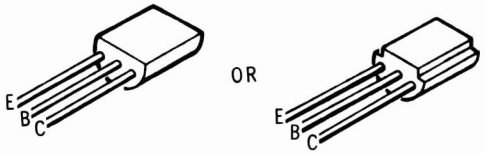
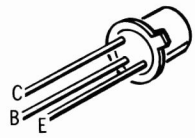
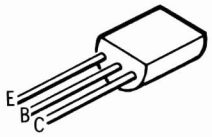
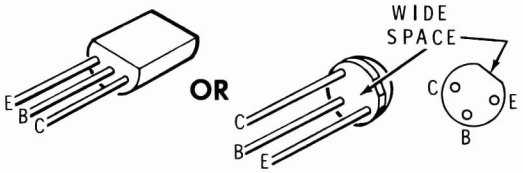
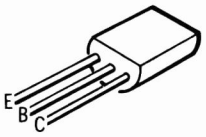
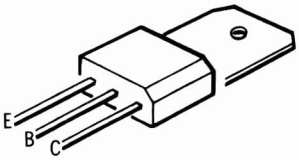
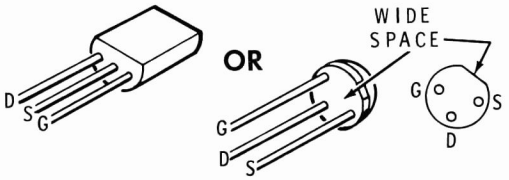
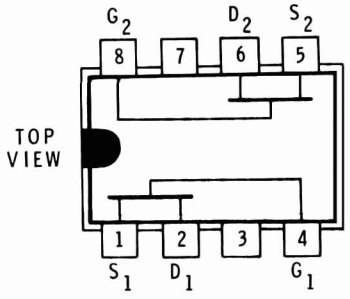
PART NUMBER INDEX

This index shows a lead configuration detail (basing diagram) for each semiconductor part number.

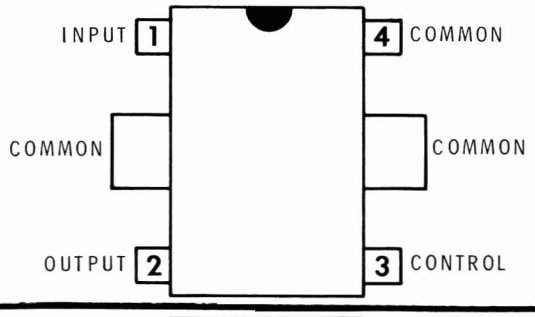
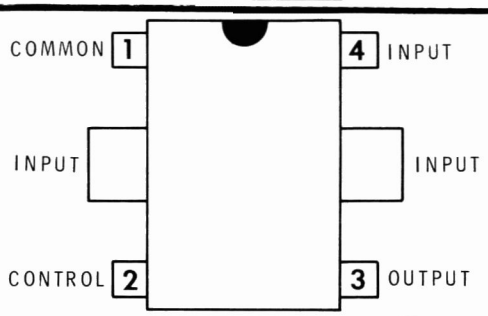
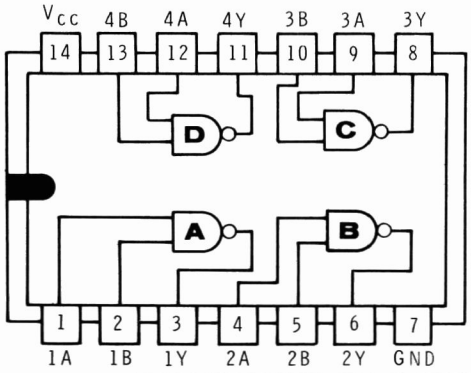
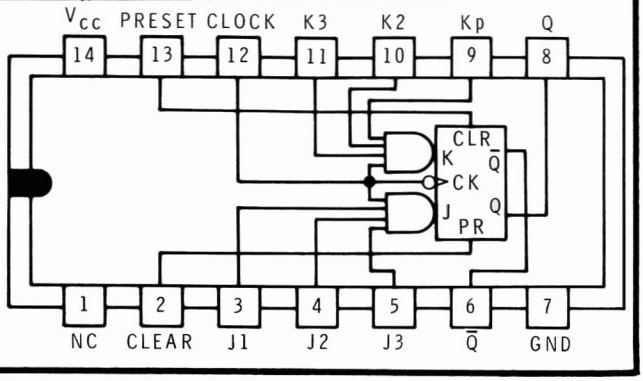
DIODES

HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
56-26	1N191	
56-56	1N4149	
56-59	1N750A	
56-67	VR10A	
56-89	GD510	
56-634	2EZ82D5	
57-27	1N2071	
57-52	DO-7	

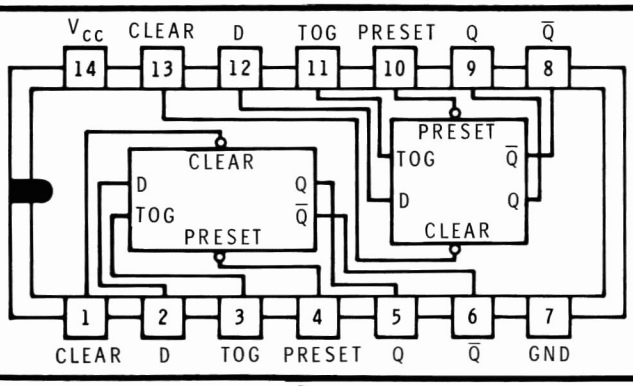
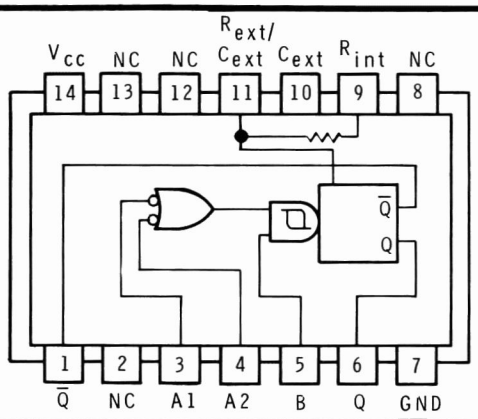
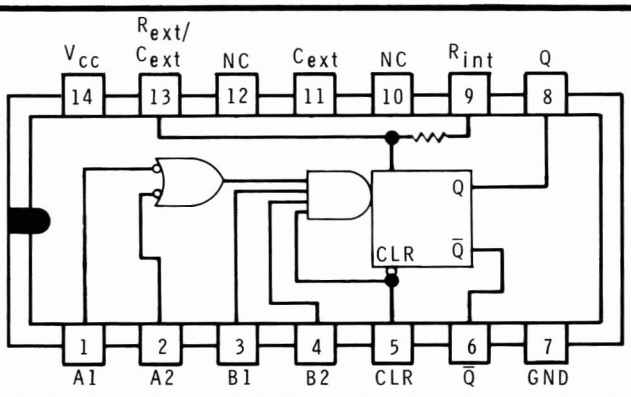
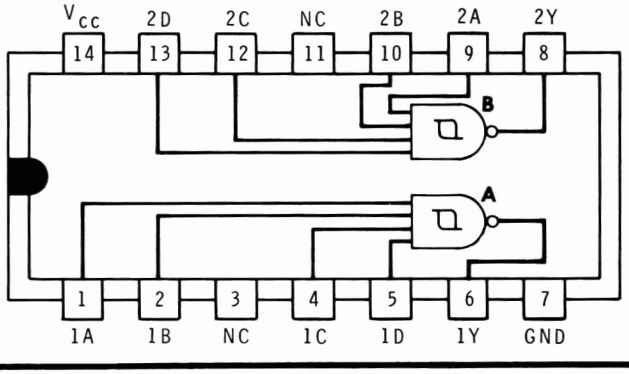
TRANSISTORS

HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
417-134	MPS6520	
417-154	2N2369	
417-235 417-237	2N4121 SE6020	
417-260	2N4258A	
417-293 417-295 417-801 417-811	2N5770 MPSL51 MPSA20 MPSL01	
417-834	MPSU10	
417-854	SELECTED	
417-902	NPD5566N	

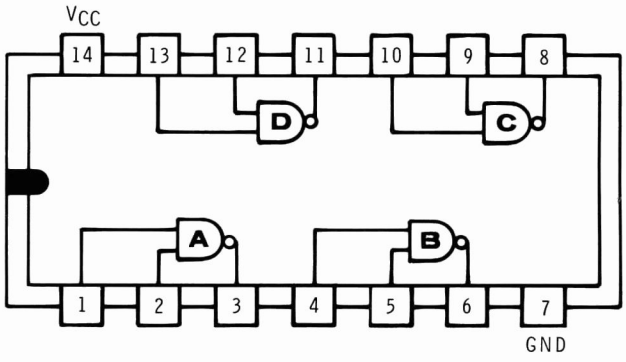
INTEGRATED CIRCUITS

HEATH PART NUMBER	MAY BE REPLACED WITH	BASING DIAGRAM (TOP VIEW)
442-617	μA78MGT2	
442-618	μA79MGT2	
443-1	SN7400N	
443-4	SN7472N	

Integrated Circuits (Cont'd).

HEATH PART NUMBER	MAY BE REPLACED WITH	BASING DIAGRAM (TOB VIEW)
443-6	SN7474N	
443-22	SN74121N	
443-23	SN74122N	
443-44	SN7413N	

Integrated Circuits (Cont'd.)

HEATH PART NUMBER	MAY BE REPLACED WITH	BASING DIAGRAM (TOP VIEW)
443-625	SN74132N	

CUSTOMER SERVICE

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

TECHNICAL CONSULTATION

Need help with your kit? — Self-Service? — Construction? — Operation? — Call or write for assistance. you'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment. Do not include the kit Manual.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

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