PRICE $2.00

HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATHKIT®
ASSEMBLY MANUAL

HEATHKIT

5-INCH TRIGGERED SWEEP OSCILLOSCOPE
MODEL IO-103

595-1327-03

Dear Customer:

You have just purchased one of the best performing electronic products in the world — your Heathkit.

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

Your Heathkit Warranty

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

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

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

After-Warranty Service

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

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

Sincerely,

HEATH COMPANY
Benton Harbor, Michigan 49022

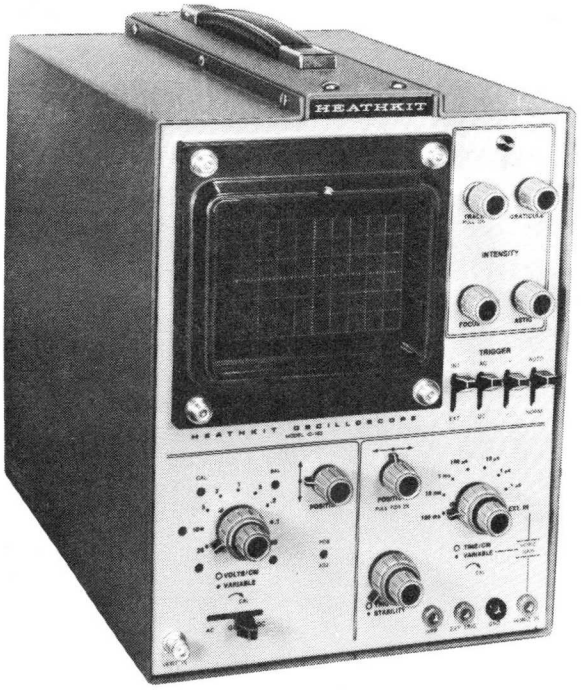
Assembly and Operation

of the

HEATHKIT®

5-INCH TRIGGERED SWEEP OSCILLOSCOPE

MODEL IO-103



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

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INTRODUCTION

The cathode ray oscilloscope is one of the most versatile instruments available. It can be used to measure ac and dc voltages, frequency, or phase, as well as to study the waveforms of complex signals. These capabilities make the oscilloscope valuable for waveform analysis, particularly in audio, television, and transmitter work.

The Heathkit Model IO-103 5" Triggered Sweep Oscilloscope is an accurate and dependable instrument which has a wide range of applications. When properly assembled and calibrated, this Oscilloscope can be used to observe or measure all types of electrical and electronic waveforms within its listed specifications, from relatively simple sine and square waves to complex pulse and composite signals. The basic uses of this instrument are similar to those of other oscilloscopes with comparable sensitivity and frequency response.

The following professional features make the IO-103 Oscilloscope outstanding: an accurately calibrated vertical attenuator switch with variable control; triggered horizontal sweep circuits; calibrated time base switch (seven decade steps, variable within each step); a display magnifier that will double any portion of a normal display; provisions for use of external triggering signals or a horizontal deflection signal.

The Oscilloscope uses four printed circuit boards which minimize point-to-point wiring and reduce construction time. The transformer operated, silicon rectifier power supply can be wired to operate from 110-130 volt, or 220-260 volt ac power lines. This Oscilloscope has good display stability because both amplifiers and the sweep circuit power supplies are zener regulated. The primary circuit of the power transformer is fused for protection from overload.

Other features include: an all solid-state circuit (except for the CRT), high input sensitivity, modern styling, moderate price, and versatility. Its rugged construction and ease of operation add to its usefulness and long life.

NOTE: The following test instruments will be required to perform the adjustments in the "Calibration" section of this Manual; a high impedance input voltmeter and an instrument (or instruments) capable of producing a sine wave of 10 kHz and square waves at 1000 Hz and 100 kHz.

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

'versatile - veelzydig, veranderlyk
provisions - voorsiening, voorsorgsmaatreël
'moderate - gematigd.

UNPACKING

The Oscilloscope packaging consists of the large shipping carton which contains smaller packages and a number of loose parts. Some of the smaller packages have numbers 1 through 4 stamped on them. After these four numbered packages have been removed from the large carton, the remaining parts in the carton will be package #5.

You will be directed to open each package as it is needed. Each of the assembly sections of the Manual contains its own parts list and step-by-step instructions. At the beginning of each parts list you will be instructed which numbered package to open. You will also be directed to remove some of the parts from package #5 to complete each assembly section.

To avoid intermixing parts do not open any of the parts packages until directed to do so at the beginning of one of the parts lists. Any part that is packaged in an individual envelope with a part number on it should be placed back in its envelope after it is identified, until that part is called for in a step.

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

To order replacement parts, refer to the price column in the Parts Lists and use the Parts Order Form furnished with this kit.

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

POWER SUPPLY CIRCUIT BOARD

PARTS LIST

Unpack the package marked 1 and check each part against the following list. The key numbers correspond to the numbers on the "Power Supply Circuit Board Parts Pictorial" (fold-out from Page 11).

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS				
1/2-Watt, 10%				
A1	1-6	1	470 Ω (yellow-violet-brown)	.10
A1	1-35	1	1 MΩ (brown-black-green)	.10
1-Watt, 10%				
A2	1-55-1	1	180 Ω (brown-gray-brown)	.10
A2	1-19-1	1	220 Ω (red-red-brown)	.10
A2	1-54-1	1	270 Ω (red-violet-brown)	.10
A2	1-20-1	1	330 Ω (orange-orange-brown)	.10
A2	1-32-1	1	470 kΩ (yellow-violet-yellow)	.10
A2	1-37-1	1	3.3 MΩ (orange-orange-green)	.10
Other Resistors				
A3	1-13-2	1	220 Ω, 2-watt (red-red brown)	.15
A3	1-23-2	1	5600 Ω, 2-watt (green-blue-red)	.30
A3	1-17-2	1	6800 Ω, 2-watt (blue-gray-red)	.15
A4	3-41-5	1	140 Ω, 5-watt	.15
A4	3-5-5	1	210 Ω, 5-watt	.25
A4	3-9-7	1	100 Ω, 7-watt	.15
A4	3-12-7	1	700 Ω, 7-watt	.15
CAPACITORS				
Electrolytic				
B1	25-43	1	70 μF	1.15
B2	25-121	1	500 μF	1.30
Other Capacitors				
B3	21-44	1	.005 μF disc	.15
B4	23-62	3	.1 μF, tubular	.75
CONTROL				
C1	10-384	1	500 kΩ control	.30
DIODES-TRANSISTORS				
D1	56-48	2	BZT110A diode	3.15
D1	56-55	1	VR-36A diode	1.00
D1	56-66	1	1N3035 diode	.90
D1	56-68	1	ZVR-68 diode	1.50
D1	56-79	10	R4507-5 diode	1.60
D1	57-27	8	1N2071 diode	.25
D1	57-52	2	5D20 diode	1.20

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

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

D2	417-175	1	2N5294 transistor	1.45
D3	417-245	2	D40N1 transistor	.95

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
HARDWARE				
E1	250-213	3	4-40 x 5/16" screw	.05
E2	252-2	3	4-40 nut	.05
E3	250-229	4	6-32 x 1/4" screw	.05
E4	254-9	3	#4 lockwasher	.05
E5	255-152	2	Plastic spacer	.15
MISCELLANEOUS				
F1	215-57-1	2	Large heat sink	.15
F2	215-44	1	Small heat sink	.65
F3	490-5	1	Nut starter	.10
			Solder (Additional 3' rolls of solder #331-6, can be ordered for 15 cents each.)	

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
PARTS FROM PACK #5				
	85-470-2	1	Power supply circuit board	2.05
	597-260	1	Parts Order Form	
	597-308	1	Kit Builders Guide	
		1	Manual (See front cover for part number.)	2.00

NOTE: See Page 103 for "Replacement Parts and Price Information."

STEP-BY-STEP ASSEMBLY

Before starting to assemble this kit, read the "Kit Builders Guide" for complete information on wiring, soldering, and step-by-step assembly procedures. NOTE: Install 1/2-watt resistors on the power supply circuit board unless otherwise specified.

NOTE: When you install transistors in the following Pictorials, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type.

TRANSISTOR INSTALLATION

Transistors, because they are small and use very little power, permit high-performance, compact designs that were not feasible with electron tubes. Along with their virtues, however, many transistors do present a problem to the kit builder. Since most transistors are small, the leads must be grouped closely, making them difficult to identify correctly.

feasibility - doordyk. uitvoerbaar.

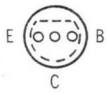
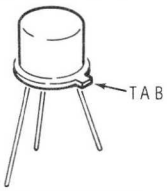
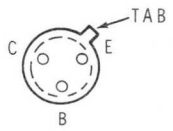
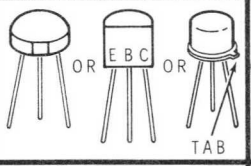
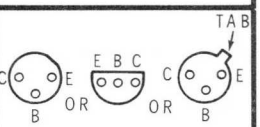
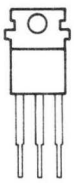
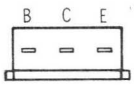
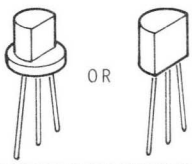
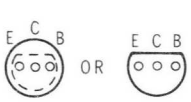
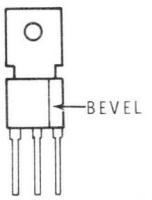
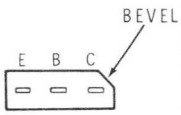
To help you avoid any problem in identifying transistor leads, we have provided the drawings below to show the lead arrangements for a variety of transistor types. Refer to these drawings, as directed in the Manual, when you install transistors.

Install each transistor by:

1. Comparing it with the ones shown on this chart. Be sure to correctly identify the transistor and its E, B, and C leads.

2. Placing the E, B, and C leads into the corresponding E, B, and C holes at the proper location on the circuit board.

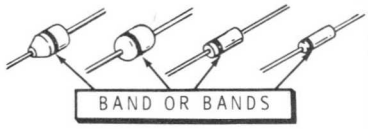
3. Positioning the transistor 1/4" above the circuit board. Then solder the leads to the foil and cut off the excess lead lengths.

HEATH PART NUMBER	CASE	BASING
417-83		
417-154		
417-169 417-241		
417-173		
417-175		
417-118 417-201		
417-245		

START

Position the power supply circuit board as shown in this Pictorial. Then proceed with the following steps.

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. THE CATHODE END OF THE DIODE IS MARKED WITH A BAND OR BANDS. ALWAYS POSITION THIS END AS SHOWN IN THE PICTORIAL.



( ) Install five R4507-5 diodes (#56-79) at ZD409. Be sure to position the banded ends as shown.

( ) 5D20 diode (#57-52) at D402.

( ) 5D20 diode (#57-52) at D401.

( ) 330 Ω, 1-watt (orange-orange-brown).

( ) 220 Ω, 1-watt (red-red-brown).

( ) 470 Ω, 1/2-watt (yellow-violet-brown).

( ) VR-36A diode (#56-55) at ZD404.

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

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

( ) Locate eight 1N2071 diodes (#57-27). They will be installed in the following steps.

( ) 1N2071 diode at D406. #57-27

( ) 1N2071 diode at D405.

( ) 1N2071 diode at D408.

( ) 1N2071 diode at D407.

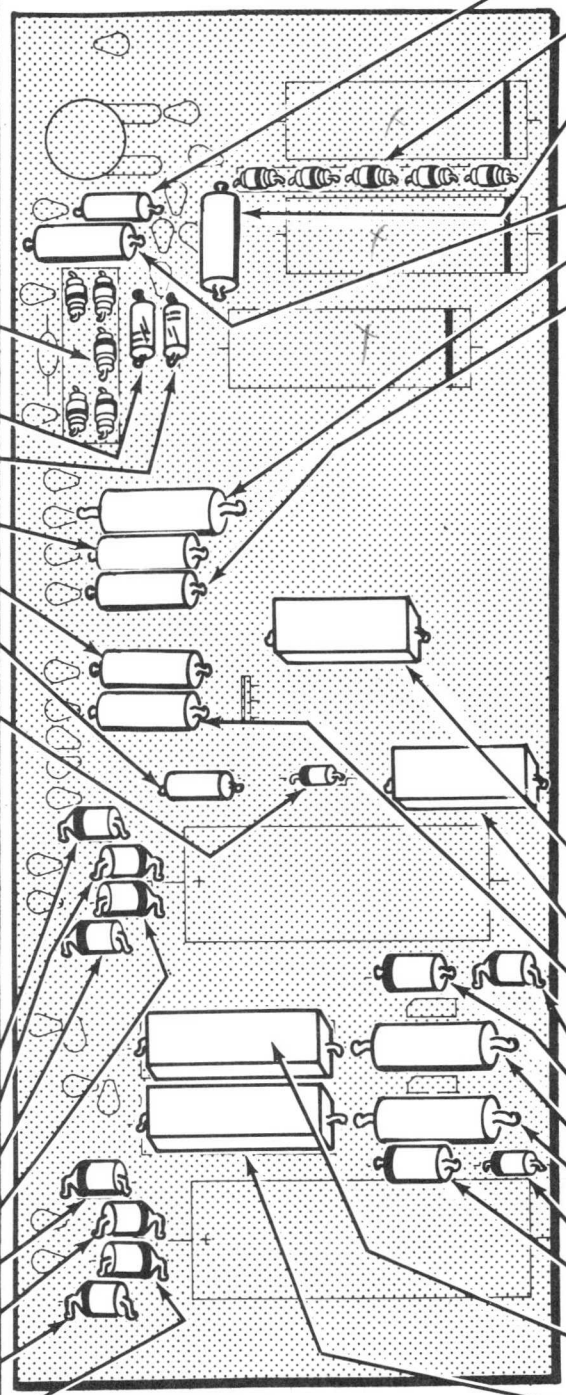
( ) 1N2071 diode at D412.

( ) 1N2071 diode at D411.

( ) 1N2071 diode at D414.

( ) 1N2071 diode at D413.

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



PICTORIAL 1-1

CONTINUE

( ) 1 MΩ, 1/2-watt (brown-black-green).

( ) Five R4507-5 diodes (#56-79) at ZD403. Be sure to position the banded ends as shown.

( ) 470 kΩ, 1-watt (yellow-violet-yellow).

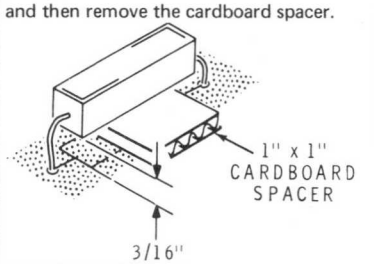
( ) 3.3 MΩ, 1-watt (orange-orange-green).

( ) 220 Ω, 2-watt (red-red-brown).

( ) 270 Ω, 1-watt (red-violet-brown).

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

NOTE: When you are instructed to mount a power resistor 3/16" above the circuit board as shown, use a 1" x 1" piece of 3/16" cardboard (from shipping carton) for a spacer. Solder each resistor as it is installed, cut off the excess lead lengths, and then remove the cardboard spacer.



( ) 140 Ω, 5-watt. Position this resistor 3/16" above the circuit board.

( ) 210 Ω, 5-watt. Position this resistor 3/16" above the circuit board.

( ) 180 Ω, 1-watt (brown-gray-brown).

( ) ZVR-68 diode (#56-68) at ZD416.

( ) BZT110A diode (#56-48) at ZD415.

( ) 5600 Ω, 2-watt (green-blue-red).

( ) 6800 Ω, 2-watt (blue-gray-red).

( ) 1N3035 diode (#56-66) at ZD418.

( ) BZT110A diode (#56-48) at ZD417.

( ) 100 Ω, 7-watt. Position this resistor 3/16" above the circuit board.

( ) 700 Ω, 7-watt. Position this resistor 3/16" above the circuit board.

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

( ) Carefully recheck all the diodes installed in this Pictorial and be sure they are positioned with the banded ends as shown.

HEATHKIT

START

NOTE: In the following steps, you will be instructed to mount two transistors onto heat sinks and to install them onto the circuit board. Read and perform each step carefully. See Pictorial 1-2. When hardware is called for in a step, only the screw size will be given. For instance, if 4-40 x 5/16" hardware is called for, it means that a 4-40 x 5/16" screw, one or more #4 lockwashers, and a 4-40 nut should be used. The Pictorial or Detail will show the proper number of lockwashers used. The plastic nut starter provided with this kit can be used to pick up and start 6-32 and 4-40 nuts on screws.

( ) Refer to Detail 1-2A and mount a D40N1 transistor (#417-245) onto the front of a large heat sink with 4-40 x 5/16" hardware as shown. Be sure the transistor points straight down.

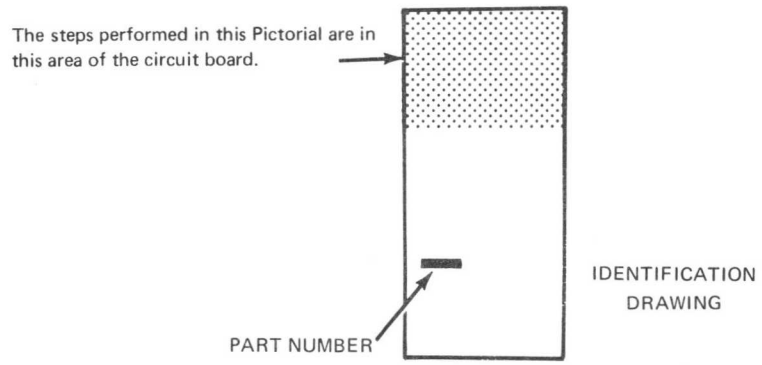
( ) Similarly, mount the other D40N1 transistor (# 417-245) onto the rear of a large heat sink with 4-40 x 5/16" hardware as shown in Detail 1-2C. Refer to the Pictorial to be sure the transistors are properly mounted.

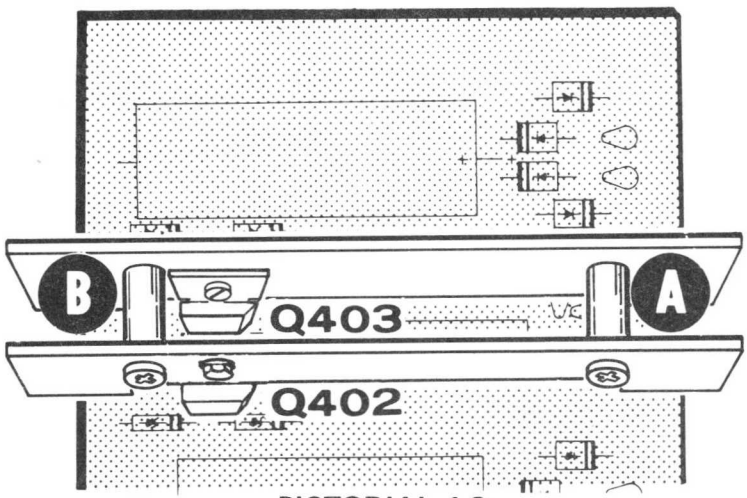
( ) Refer to Detail 1-2B, and place a plastic spacer between the two heat sinks at A. Then loosely secure the spacer and heat sinks with two 6-32 x 1/4" screws as shown.

( ) In the same manner, install a plastic spacer at B with two 6-32 x 1/4" screws.

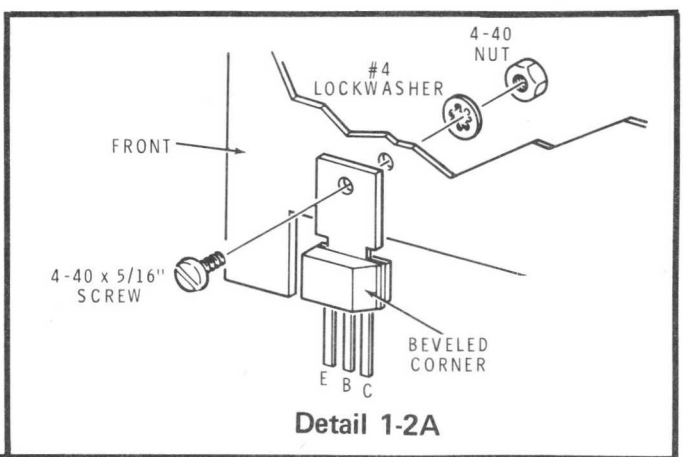
( ) Refer to Detail 1-2C and install the transistor-heat sink assembly onto the circuit board at Q402 and Q403 as shown. Press the transistors into the circuit board until both ends of the two heat sinks touch the board.

( ) Solder all of the transistor leads to the foil and cut off the excess lead lengths. Tighten the four 6-32 x 1/4" screws at A and B.

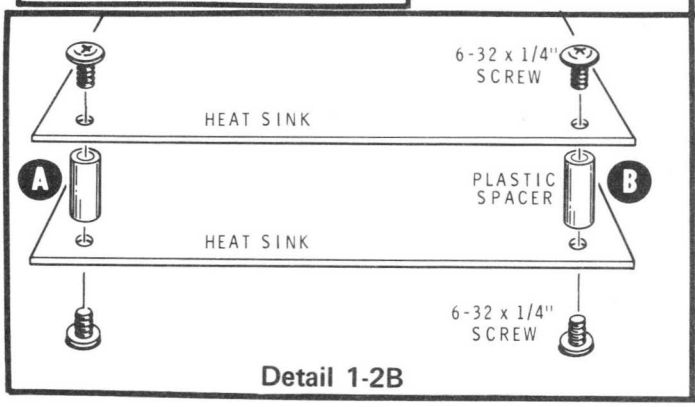




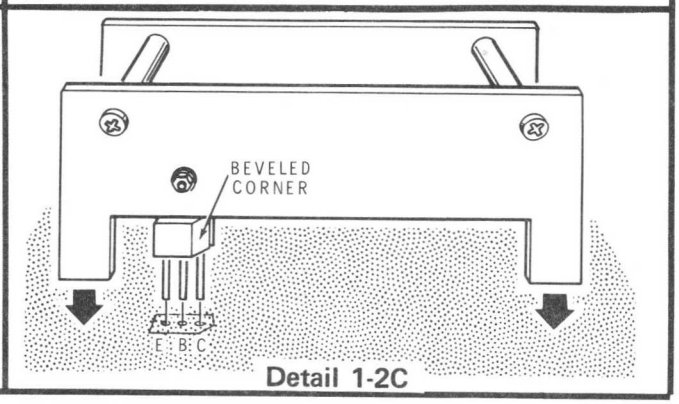
PICTORIAL 1-2



Detail 1-2A

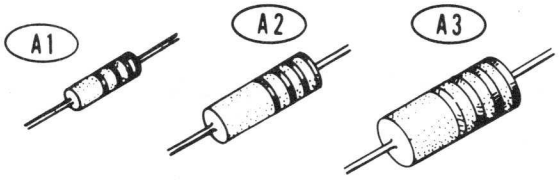


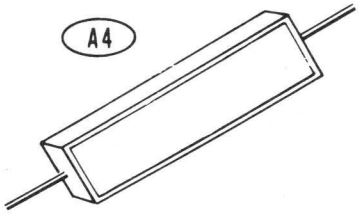
Detail 1-2B

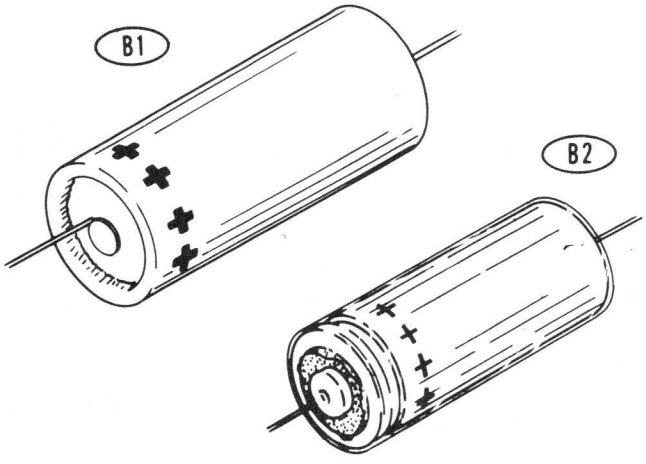


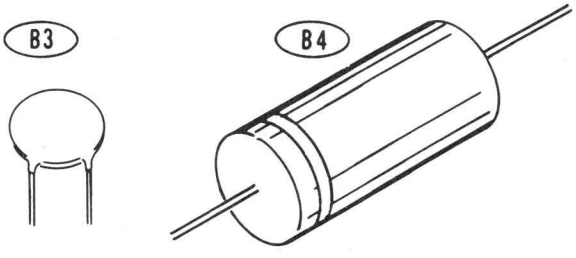
Detail 1-2C

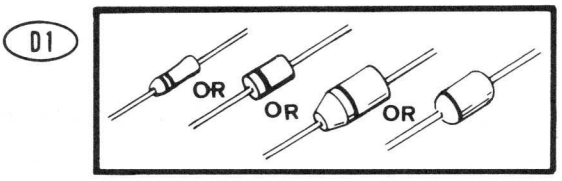
POWER SUPPLY CIRCUIT BOARD
PARTS PICTORIAL

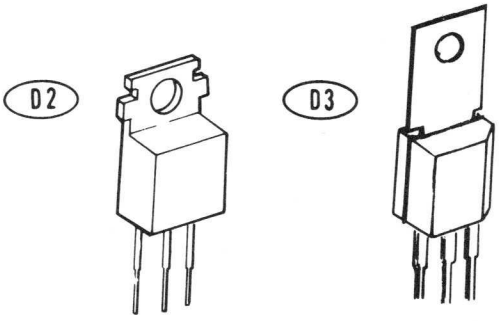


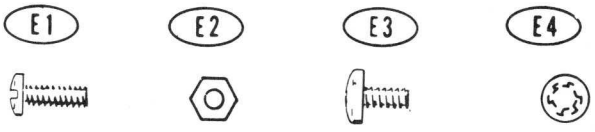


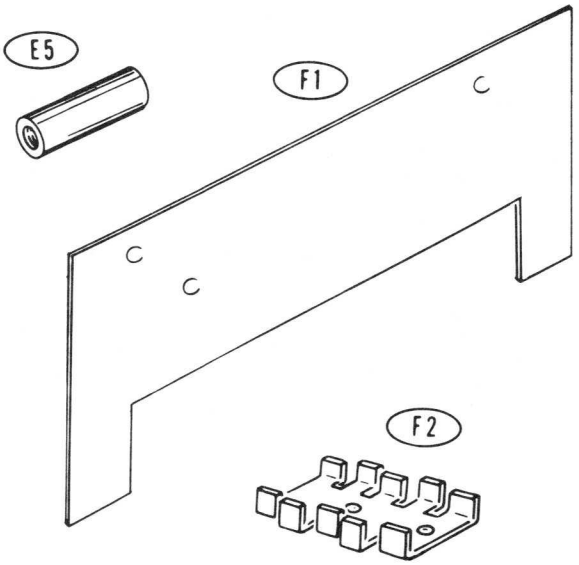


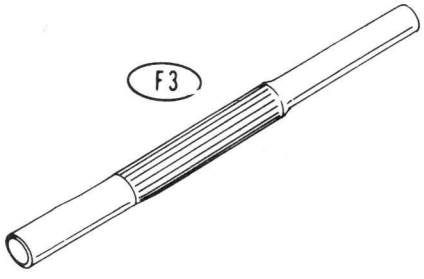




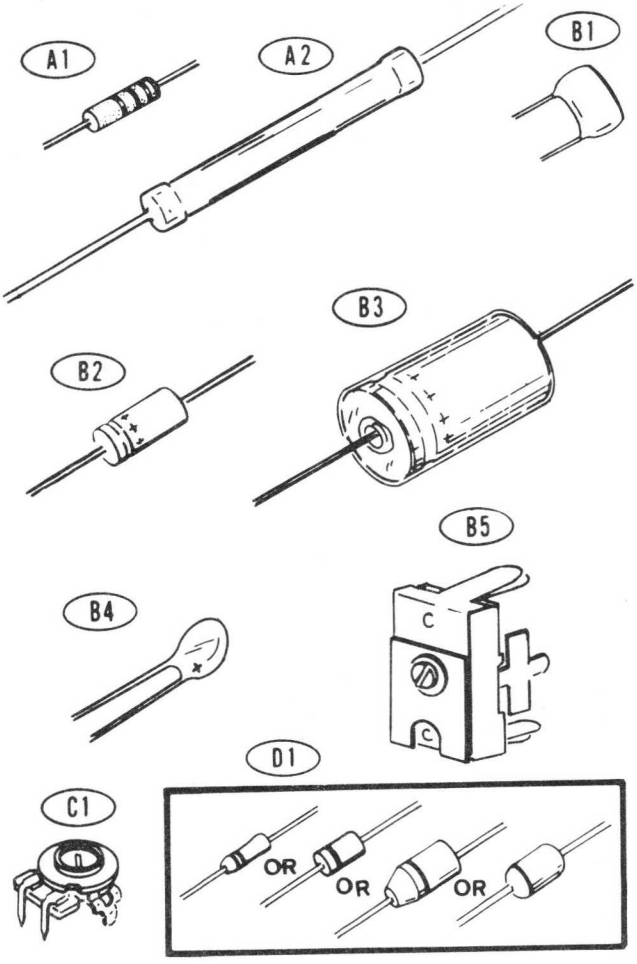


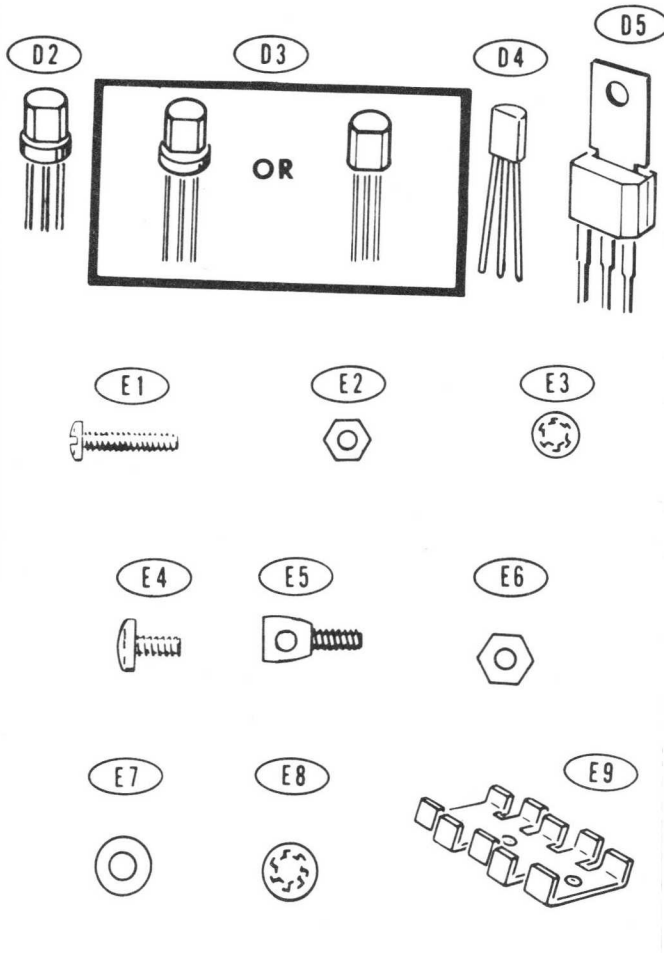






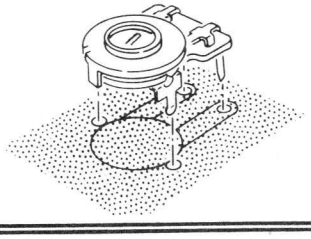
VERTICAL AMPLIFIER CIRCUIT BOARD PARTS PICTORIAL





START

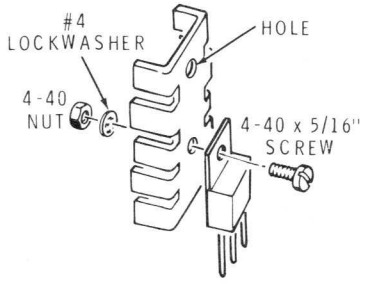
( ) 500 kΩ control (#10-384). Solder the leads to the foil.

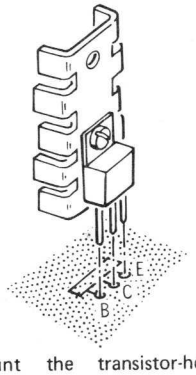


NOTE: Before installing disc capacitors in this kit, use long-nose pliers to remove the excess insulation from the capacitor leads.

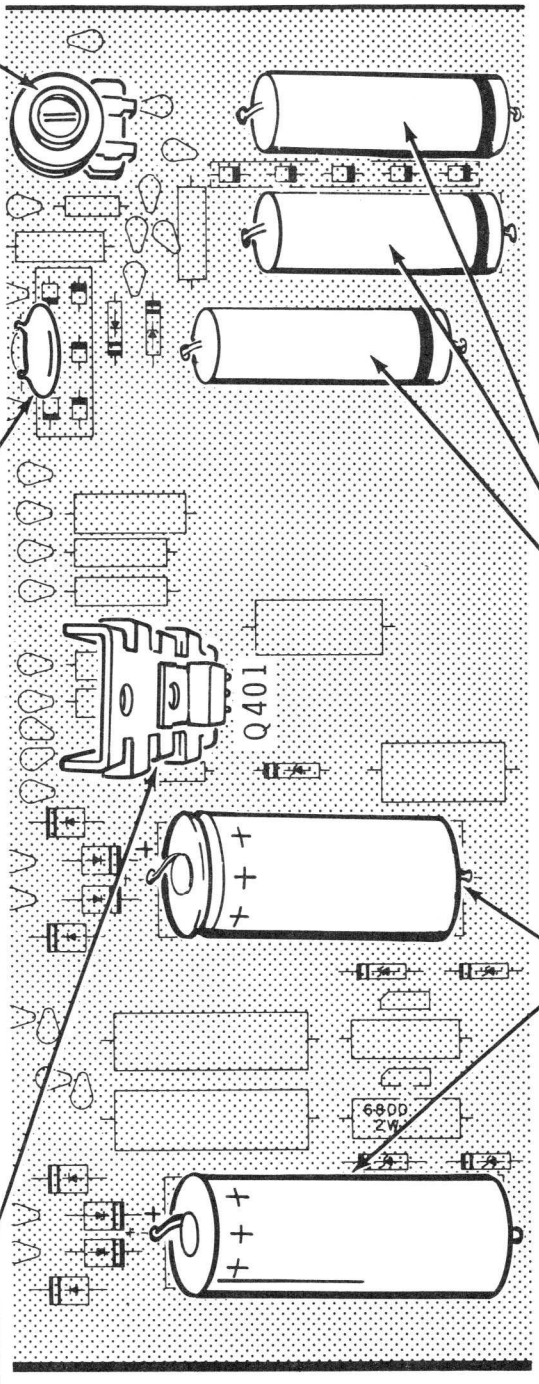
( ) .005 μF, 1.6 kV disc capacitor. Solder the leads to the foil and cut off the excess lead lengths.

( ) Install a 2N5294 transistor (#417-175) onto a small heat sink with 4-40 x 5/16" hardware. Be sure the hole in the end of the heat sink is upward as shown. Be sure the transistor points straight down.



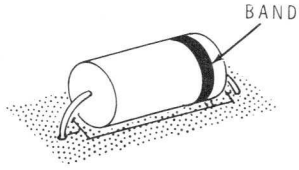


( ) Mount the transistor-heat sink assembly on the circuit board at Q401 as shown. Solder the transistor leads to the foil and cut off the excess lead lengths.



CONTINUE

NOTE: When you install each of the following three capacitors, always match the banded end of the capacitor with the band mark on the circuit board.

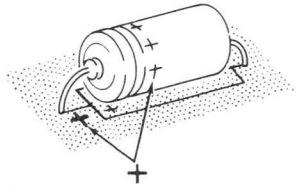


( ) .1 μF, 1.6 kV capacitor.

( ) .1 μF, 1.6 kV capacitor.

( ) .1 μF, 1.6 kV capacitor.

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



( ) 500 μF electrolytic.

( ) 70 μF electrolytic.

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

( ) Carefully inspect the foil side of the circuit board and be sure there are no solder bridges between foils.

Set the circuit board aside temporarily.

PICTORIAL 1-3

VERTICAL AMPLIFIER CIRCUIT BOARD

PARTS LIST

Unpack the package marked 2 and check each part against the following list. The key numbers correspond to the numbers on the "Vertical Amplifier Circuit Board Parts Pictorial" (fold-out from Page 12).

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS				
1/2-Watt				
A1	1-83	4	56 Ω (green-blue-black)	.10
A1	1-3	1	100 Ω (brown-black-brown)	.10
A1	1-112	2	180 Ω (brown-gray-brown)	.10
A1	1-4	2	330 Ω (orange-orange-brown)	.10
A1	1-6	2	470 Ω (yellow-violet-brown)	.10
A1	1-9	2	1000 Ω (brown-black-red)	.10
A1	1-20	1	10 kΩ (brown-black-orange)	.10
Other Resistors				
A2	5-4-10	2	3000 Ω (3 kΩ), 10-watt, film	.35
CAPACITORS				
Mica				
B1	20-108	1	200 pF	.20
B1	20-106	1	390 pF	.30
Electrolytic				
B2	25-54	1	10 μF	.20
B3	25-57	1	100 μF	1.00
B3	25-230	1	2000 μF	1.90
Other Capacitors				
B4	25-221	1	2.2 μF tantalum	.40
B5	31-49	1	250-1000 pF trimmer	.85
CONTROL				
C1	10-381	1	500 Ω control	.35

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
DIODES-TRANSISTORS				
D1	56-19	2	VR-9.1 diode	1.00
D1	56-56	2	1N4149 diode	.20

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

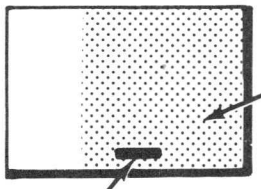
1. Part number.
2. Transistor type number.
3. Part number and transistor type number.
4. Part number with a transistor type number other than the one listed.

D2	417-83	2	L842 transistor	.75
D2	417-118	2	2N3393 transistor	.40
D3	417-201	2	X29A829 transistor	.50
D4	417-169	3	MPF105 transistor	1.50
D5	417-245	2	D40N1 transistor	.95
HARDWARE				
E1	250-34	2	4-40 x 1/2" screw	.05
E2	252-2	2	4-40 nut	.05
E3	254-9	2	#4 lockwasher	.05
E4	250-229	2	6-32 x 1/4" screw	.05
E5	251-1	2	Spade bolt	.05
E6	252-3	4	6-32 nut	.05
E7	253-27	6	#6 flat washer	.05
E8	254-1	4	#6 lockwasher	.05
MISCELLANEOUS				
E9	215-44	2	Heat sink	.65
	85-468-5	1	Vertical amplifier circuit board	1.65

NOTE: See Page 103 for "Replacement Parts and Price Information."

STEP-BY-STEP ASSEMBLY

IDENTIFICATION DRAWING



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

PART NUMBER

START

NOTE: Only part of the vertical amplifier circuit board is shown in the following Pictorials. An identification drawing at the top of each of these Pictorials shows the area of the circuit board to be assembled.

Position the vertical amplifier circuit board with the part number as shown in the identification drawing. Then complete each step on the Pictorial.

( ) 1000 Ω (brown-black-red).

( ) 330 Ω (orange-orange-brown).

( ) 470 Ω (yellow-violet-brown).

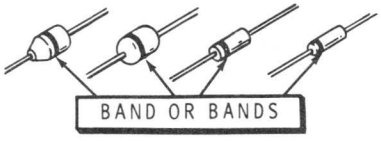
( ) 56 Ω (green-blue-black).

( ) 56 Ω (green-blue-black).

( ) 180 Ω (brown-gray-brown).

( ) 180 Ω (brown-gray-brown).

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. THE CATHODE END OF THE DIODE IS MARKED WITH A BAND OR BANDS. ALWAYS POSITION THIS END AS SHOWN IN THE PICTORIAL.



( ) VR-9.1 diode (#56-19) at ZD104.

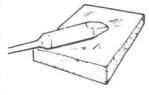
( ) 470 Ω (yellow-violet-brown).

( ) 56 Ω (green-blue-black).

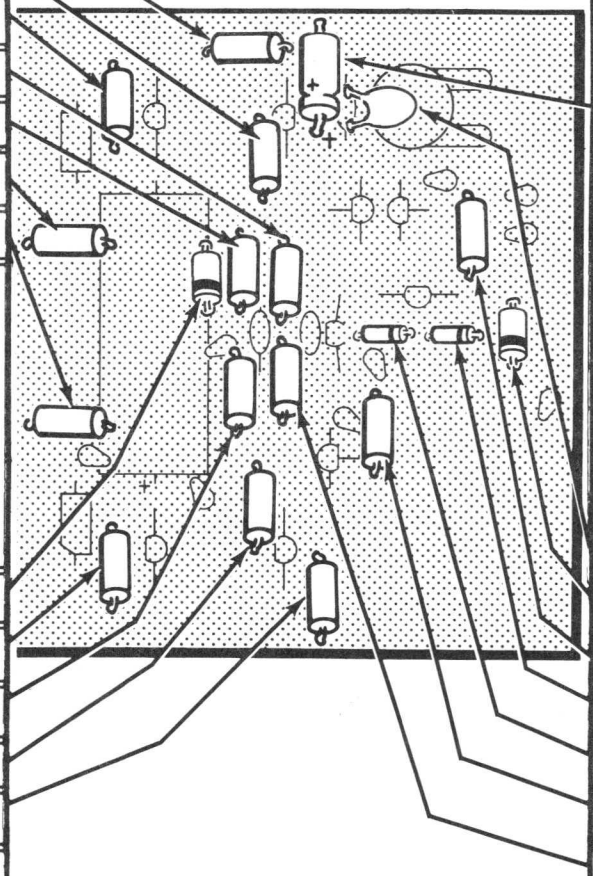
( ) 330 Ω (orange-orange-brown).

( ) 1000 Ω (brown-black-red).

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

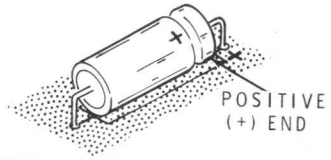


( ) Solder the leads to the foil and cut off the excess lead lengths.



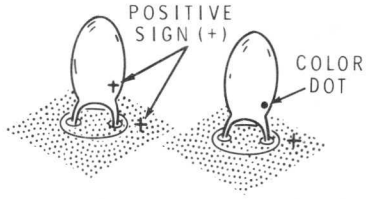
CONTINUE

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



( ) 10 μF electrolytic.

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



( ) 2.2 μF tantalum capacitor.

( ) VR-9.1 diode (#56-19) at ZD101.

( ) 100 Ω (brown-black-brown).

( ) 1N4149 diode (#56-56) at D102.

( ) 1N4149 diode (#56-56) at D103.

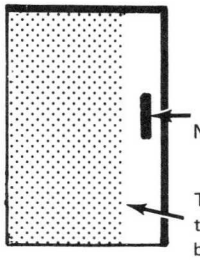
( ) 10 kΩ (brown-black-orange).

( ) 56 Ω (green-blue-black).

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

PICTORIAL 2-1

IDENTIFICATION DRAWING

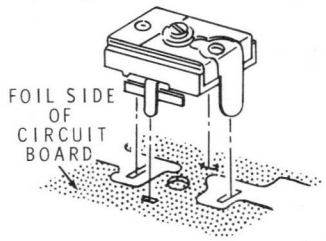


The steps performed in this Pictorial are in this area of the circuit board.

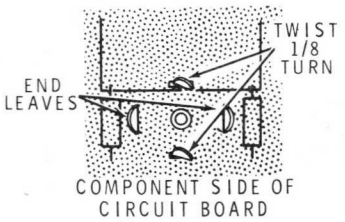
START

NOTE: Position the circuit board as shown in the identification drawing. Then complete the following steps. When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type.

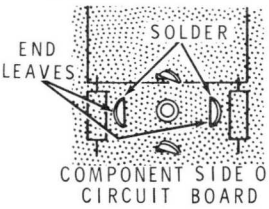
Turn the circuit board foil side up and install the trimmer capacitor (#31-49) in the following manner as shown.



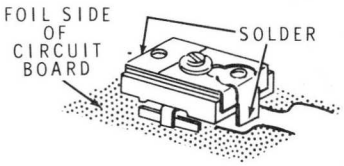
( ) Twist the two indicated side lugs (on the component side of the circuit board) 1/8 turn with pliers.

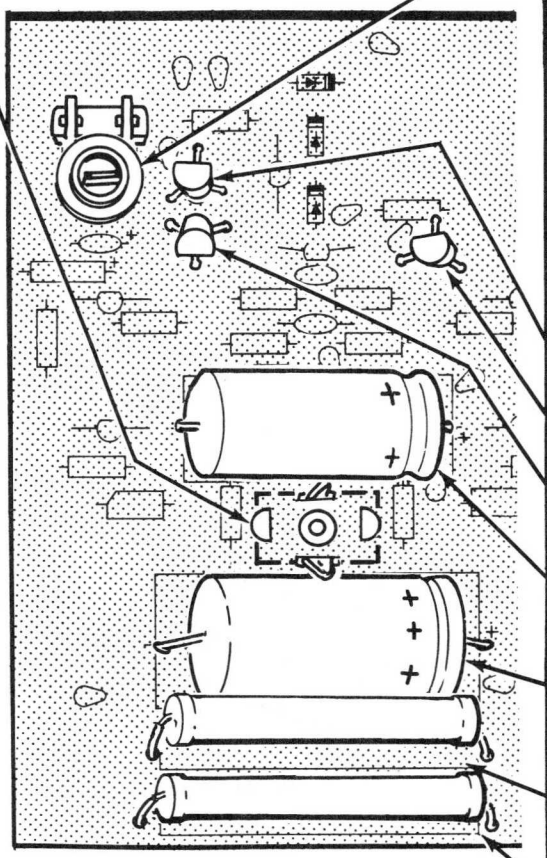


( ) Solder all the small end leaves together on the component side of the circuit board.



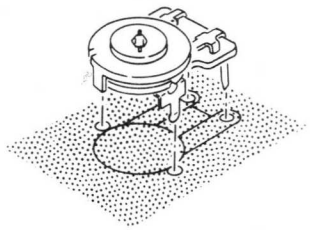
( ) Solder the indicated lugs to the foil on the foil side of the circuit board.



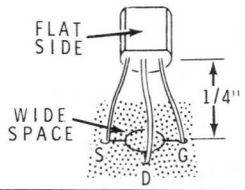


CONTINUE

( ) 500 Ω control (#10-381). Solder the leads to the foil.



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



( ) MPF105 transistor (#417-169) at Q101.

( ) MPF105 transistor (#417-169) at Q104.

( ) MPF105 transistor (#417-169) at Q105.

( ) 2000 μF electrolytic. Be sure to position the positive (+) lead as shown.

( ) 100 μF electrolytic. Be sure to position the positive (+) lead as shown.

( ) 3000 Ω (3 kΩ), 10-watt. Position this resistor 3/16" above the board with a cardboard spacer.

( ) 3000 Ω (3 kΩ), 10-watt. Position this resistor 3/16" above the board with a cardboard spacer.

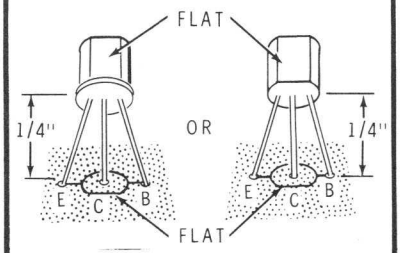
( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-2

START

NOTE: Position the circuit board as shown in the identification drawing, then proceed with the following steps. When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type.

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



( ) X29A829 transistor (#417-201) at Q109.

( ) L842 transistor (#417-83) at Q107.

( ) 2N3393 transistor (#417-118) at Q102.

( ) 200 pF mica. Solder the leads to the foil and cut off any excess lead lengths.

( ) 390 pF mica. Solder the leads to the foil and cut off any excess lead lengths.

( ) 2N3393 transistor (#417-118) at Q103.

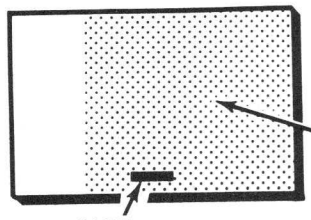
( ) X29A829 transistor (#417-201) at Q108.

( ) L842 transistor (#417-83) at Q106.

( ) Refer to Detail 2-3A and mount a spade lug onto a heat sink with 6-32 x 1/4" hardware as shown. Be sure the shoulder of the spade lug is under the edge of the heat sink.

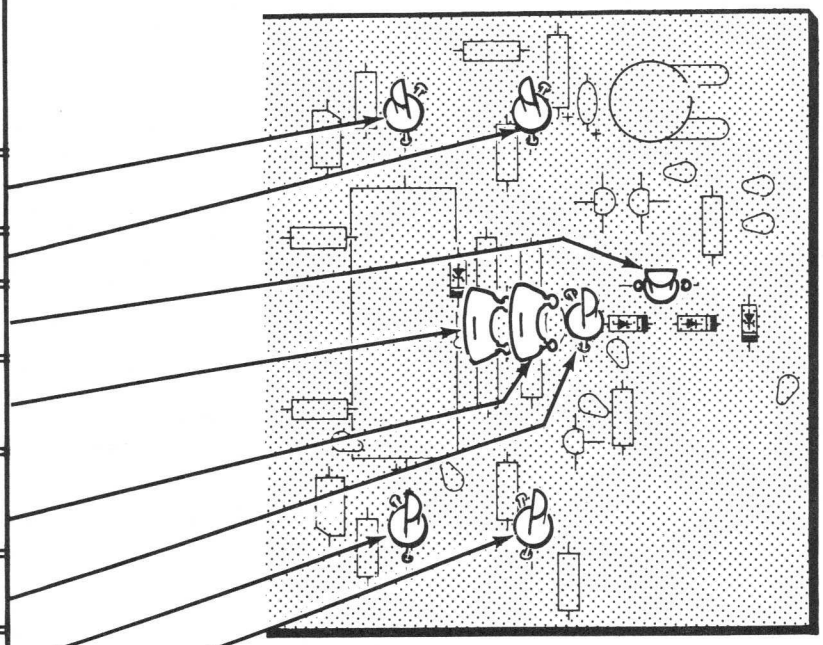
( ) In the same manner, mount another spade lug onto the remaining heat sink with 6-32 x 1/4" hardware.

IDENTIFICATION DRAWING

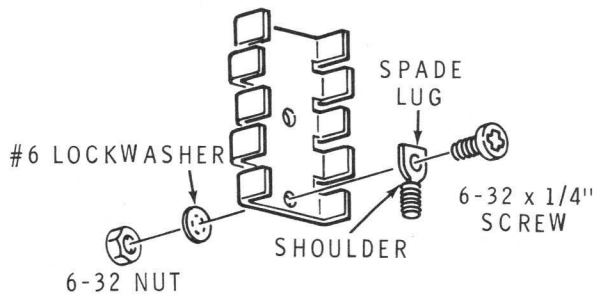


PART NUMBER

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

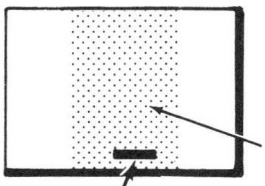


PICTORIAL 2-3



Detail 2-3A

IDENTIFICATION DRAWING



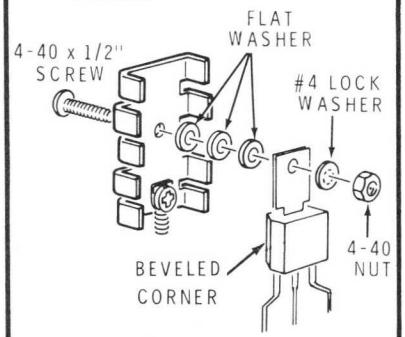
The steps performed in this Pictorial are in this area of the circuit board.

PART NUMBER

START

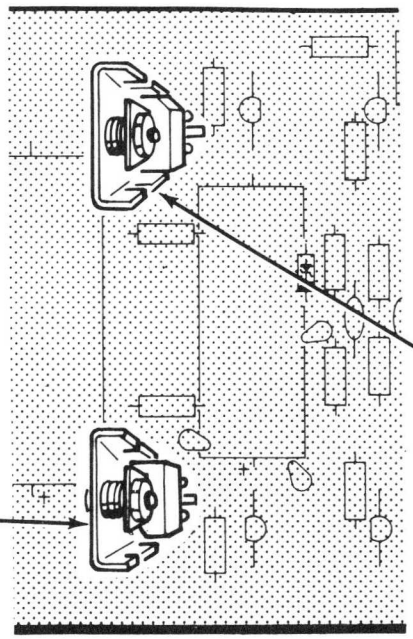
NOTE: In the following steps, you will be instructed to mount two transistors onto separate heat sinks. Carefully observe the outline of transistors Q111 and Q112 on the circuit board and note that they face in opposite directions. The transistors will therefore be mounted onto the heat sinks to face in opposite directions.

( ) Mount a D40N1 transistor onto one of the heat sink assemblies. Position the beveled corner of the transistor toward the heat sink as shown. Use a 4-40 x 1/2" screw, three #6 flat washers, a #4 lockwasher, and a 4-40 nut.

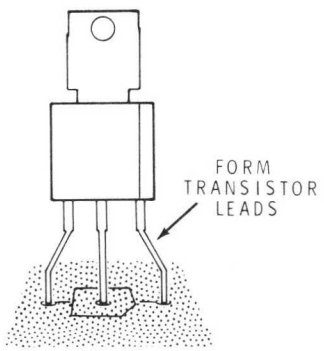


( ) Carefully form the transistor leads as shown in Detail 2-4A. Install the transistor and heat sink onto the circuit board at Q111 as shown.

( ) Secure the heat sink to the circuit board with a 6-32 nut and a #6 lockwasher. Solder the transistor leads to the foil and cut off the excess lead lengths.



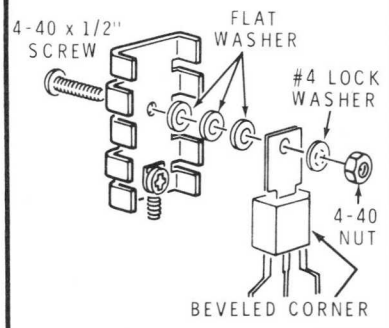
PICTORIAL 2-4



Detail 2-4A

CONTINUE

( ) Mount a D40N1 transistor (#417-245) onto the other heat-sink assembly. Position the beveled corner of the transistor away from the heat sink as shown. Use a 4-40 x 1/2" screw, three #6 flat washers, a #4 lockwasher, and a 4-40 nut.



( ) Form the transistor leads as shown in Detail 2-4A. Install the transistor and the heat sink onto the circuit board at Q112 as shown.

( ) Secure the heat sink to the circuit board with a 6-32 nut and a #6 lockwasher. Solder the transistor leads to the foil and cut off the excess lead lengths.

( ) Carefully check the foil side of the circuit board and make sure all connections are soldered and that there are no solder bridges between foils.

Set the circuit board aside temporarily.

SWEEP GENERATOR-HORIZONTAL AMPLIFIER CIRCUIT BOARD

PARTS LIST

Unpack the package marked 3 and check each part against the following list. The key numbers correspond to the numbers on the "Sweep Generator-Horizontal Amplifier Circuit Board Parts Pictorial" (fold-out from Page 23).

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS				
1/4-Watt, 10%				
A1	1-42-12	3	22 Ω (red-red-black)	.10
A1	1-1-12	1	100 Ω (brown-black-brown)	.10
A1	1-17-10	10	220 Ω (red-red-brown)	.10
A1	1-35-12	1	470 Ω (yellow-violet-brown)	.10
A1	1-2-12	10	1000 Ω (brown-black-red)	.10
A1	1-4-12	4	2200 Ω (red-red-red)	.10
A1	1-6-12	2	3300 Ω (orange-orange-red)	.10
A1	1-7-12	2	3900 Ω (orange-white-red)	.10
A1	1-9-12	2	10 kΩ (brown-black-orange)	.10
A1	1-10-12	1	15 kΩ (brown-green-orange)	.10
A1	1-32-12	2	100 kΩ (brown-black-yellow)	.10
A1	1-19-12	1	1 MΩ (brown-black-green)	.10
1/2-Watt, 10%				
A2	1-3	1	100 Ω (brown-black-brown)	.10
A2	1-45	2	220 Ω (red-red-brown)	.10
A2	1-4	2	330 Ω (orange-orange-brown)	.10
A2	1-6	4	470 Ω (yellow-violet-brown)	.10
A2	1-9	6	1000 Ω (brown-black-red)	.10
A2	1-20	1	10 kΩ (brown-black-orange)	.10
A2	1-35	1	1 MΩ (brown-black-green)	.10
Other Resistor				
A3	5-3-7	3	10 kΩ, 7-watt, film	.25
CAPACITORS				
Mica				
B1	20-52	1	7.5 pF	.35
B1	20-114	1	270 pF	.20
B1	20-113	1	470 pF	.30

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
Disc				
B2	21-9	2	100 pF	.10
B2	21-56	1	470 pF	.10
B2	21-16	3	.01 μF	.10
Electrolytic				
B3	25-221	1	2.2 μF tantalum	.40
B4	25-54	1	10 μF	.20
B5	25-57	1	100 μF	1.00
B5	25-230	2	2000 μF	1.90
CONTROLS				
C1	10-917	1	200 Ω	.50
C1	10-918	1	500 Ω	.45
C1	10-398	2	2000 Ω (2 kΩ)	.30
C1	10-904	2	5000 Ω (5 kΩ)	.55
C1	10-386	2	10 kΩ	.30
DIODES				
D1	56-19	2	VR-9.1	1.00
D1	56-26	1	1N191	.20
D1	56-44	2	1N4653	1.15
D1	56-56	4	1N4149	.20
D1	56-58	1	1N709A	.65
D1	56-68	1	ZVR-68	1.50

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
TRANSISTORS				

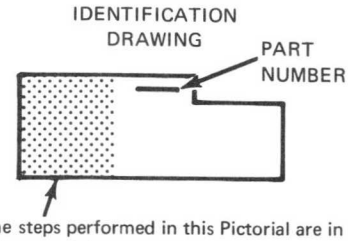
NOTE: Transistors are marked for identification in one of the following four ways.

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

E1	417-83	13	L842	.75
E1	417-118	9	2N3393	.40
E2	417-201	2	X29A829	.50
E3	417-154	3	2N2369	1.65
E4	417-169	4	MPF105 JFET	1.50
E4	417-241	2	EL131 JFET	2.55
E5	417-173	1	ETS083	.45
E6	417-245	2	D40N1	.95
MISCELLANEOUS				
F1	443-44	1	SN7413N integrated circuit	1.95
F2	432-144	14	IC connector	.01
F3	259-20	2	Circuit board pin	.05
PART FROM PACK #5				
	85-1132-1	1	Sweep generator-horizontal amplifier circuit board	3.10

NOTE: See Page 103 for "Replacement Parts and Price Information."

STEP-BY-STEP ASSEMBLY



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

START

Position the sweep generator-horizontal amplifier circuit board as shown in the identification drawing; then proceed with the following steps.

NOTE: The resistors that you will install in this Pictorial are 1/4-watt resistors unless otherwise specified.

( ) 220 Ω (red-red-brown).

( ) 220 Ω (red-red-brown).

( ) 2200 Ω (red-red-red).

( ) 3900 Ω (orange-white-red).

( ) 220 Ω (red-red-brown).

( ) 1000 Ω (brown-black-red).

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

( ) 100 kΩ (brown-black-yellow).

( ) 1 MΩ (brown-black-green).

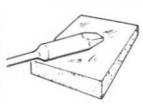
( ) 3300 Ω (orange-orange-red).

( ) 3300 Ω (orange-orange-red).

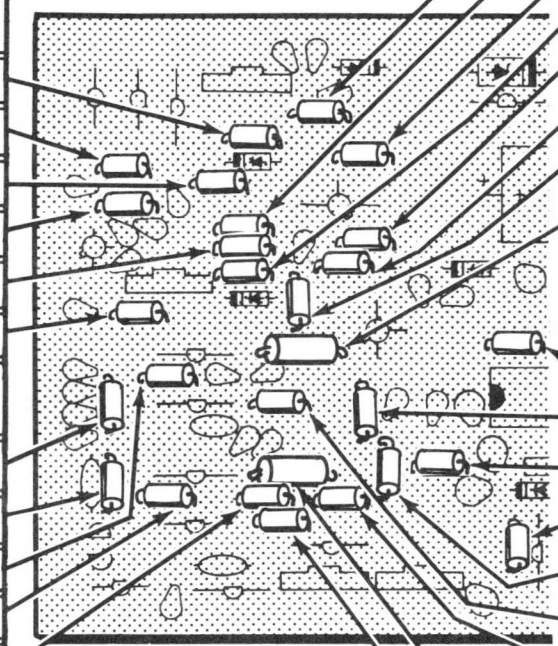
( ) 3900 Ω (orange-white-red).

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

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



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



PICTORIAL 3-1

CONTINUE

( ) 22 Ω (red-red-black).

( ) 1000 Ω (brown-black-red).

( ) 220 Ω (red-red-brown).

( ) 1000 Ω (brown-black-red).

( ) 15 kΩ (brown-green-orange).

( ) 220 Ω (red-red-brown).

( ) 1000 Ω (brown-black-red).

( ) 470 Ω, 1/2-watt (yellow-violet-brown).

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

( ) 220 Ω (red-red-brown).

( ) 10 kΩ (brown-black-orange).

( ) 470 Ω (yellow-violet-brown).

( ) 2200 Ω (red-red-red).

( ) 10 kΩ (brown-black-orange).

( ) 22 Ω (red-red-black).

( ) 2200 Ω (red-red-red).

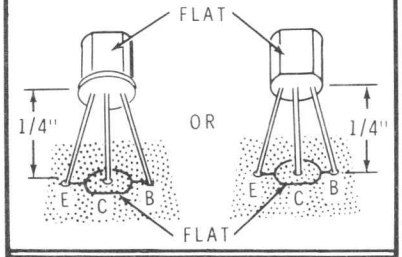
( ) 470 Ω, 1/2-watt (yellow-violet-brown).

( ) 22 Ω (red-red-black).

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

START

NOTE: When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type. Install each of the following transistors as shown. Solder each lead to the foil and cut off the excess lead lengths.



( ) 2N3393 transistor (#417-118) at Q316.

( ) L842 transistor (#417-83) at Q315.

( ) L842 transistor (#417-83) at Q307.

( ) L842 transistor (#417-83) at Q306.

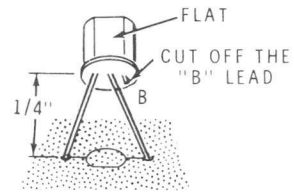
( ) L842 transistor (#417-83) at Q305.

NOTE: Before installing the following disc capacitors, use long-nose pliers to remove the excess insulation from the capacitor leads. Solder the leads as each capacitor is installed.

( ) .01 μF disc.

( ) .01 μF disc.

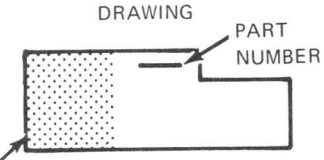
NOTE: Install the next two transistors in the following manner as shown: Cut off the "B" lead and then insert the other two leads into their correct holes in the circuit board. Solder each lead to the foil and cut off the excess lead lengths.



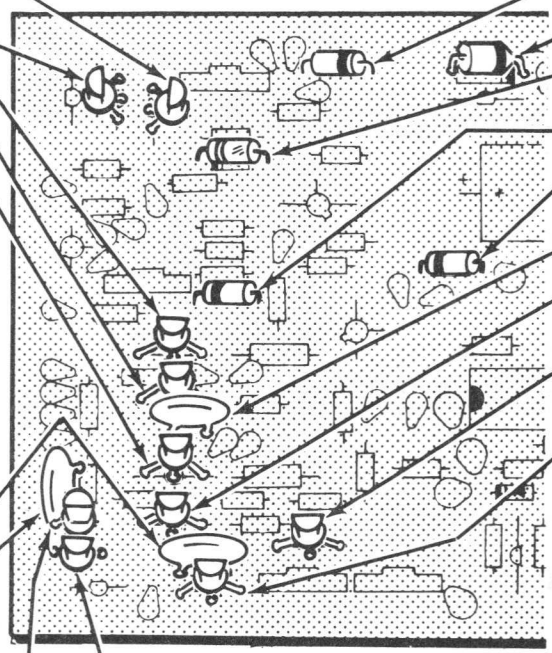
( ) L842 transistor (#417-83) at D301.

( ) L842 transistor (#417-83) at D302.

IDENTIFICATION DRAWING



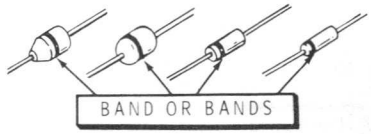
The steps performed in this Pictorial are in this area of the circuit board.



PICTORIAL 3-2

CONTINUE

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. THE CATHODE END OF THE DIODE IS MARKED WITH A BAND OR BANDS. ALWAYS POSITION THIS END AS SHOWN IN THE PICTORIAL.



( ) 1N4653 diode (#56-44) at ZD303.

( ) ZVR-68 diode (#56-68) at ZD309.

( ) 1N191 diode (#56-26) at D307.

( ) 1N4149 diode (#56-56) at D304.

( ) 1N4653 diode (#56-44) at ZD308.

( ) 470 pF disc.

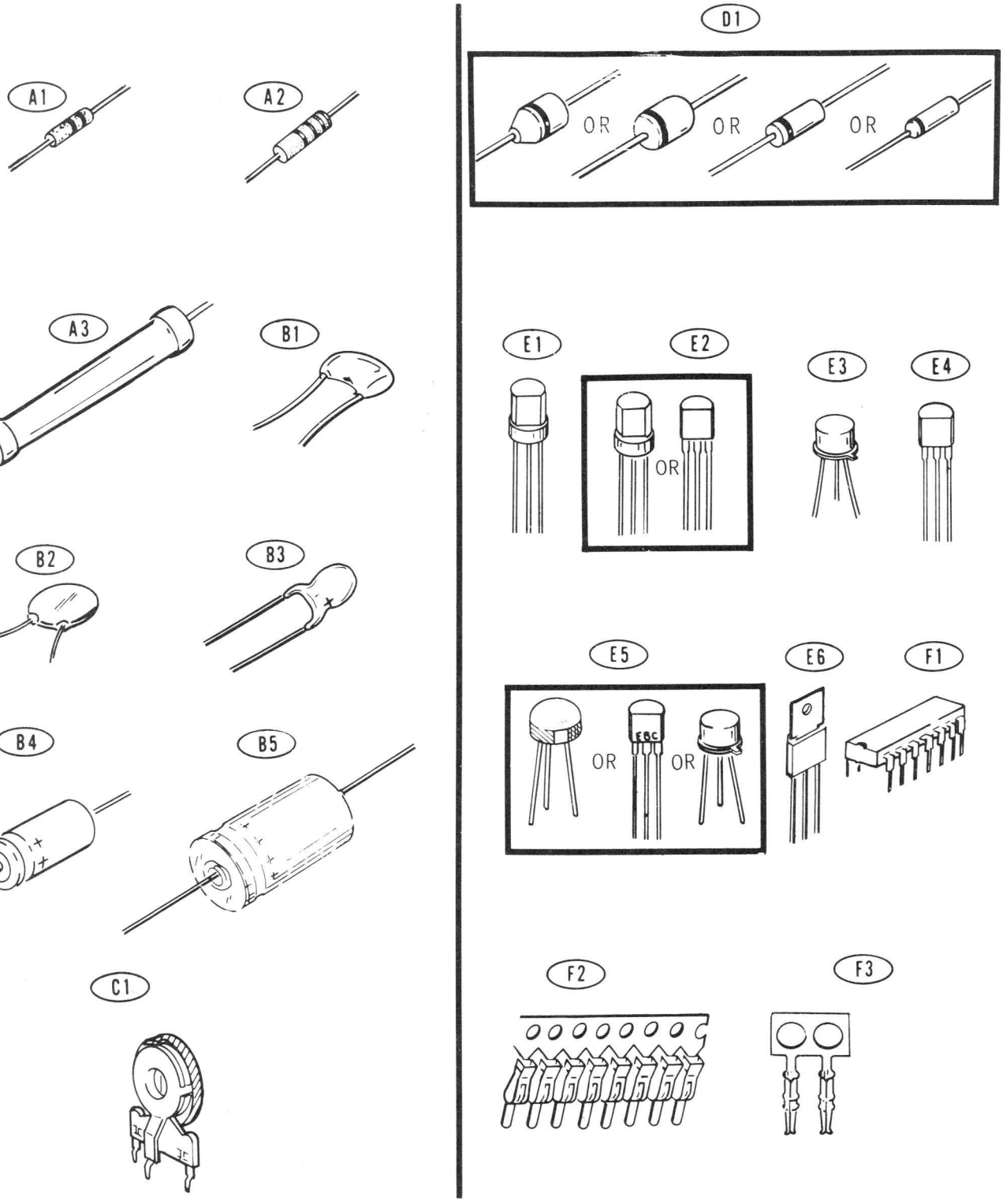
( ) L842 transistor (#417-83) at Q304.

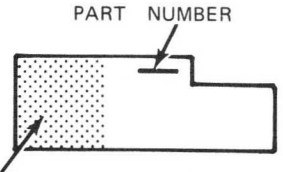
( ) 2N3393 transistor (#417-118) at Q308.

( ) 2N3393 transistor (#417-118) at Q303.

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

SWEEP GENERATOR-HORIZONTAL AMPLIFIER PARTS PICTORIAL



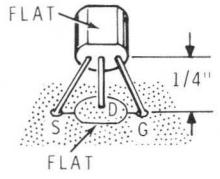


IDENTIFICATION DRAWING

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

START

NOTE: When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type. Install the next two transistors as shown. Solder the leads to the foil and cut off the excess lead lengths.



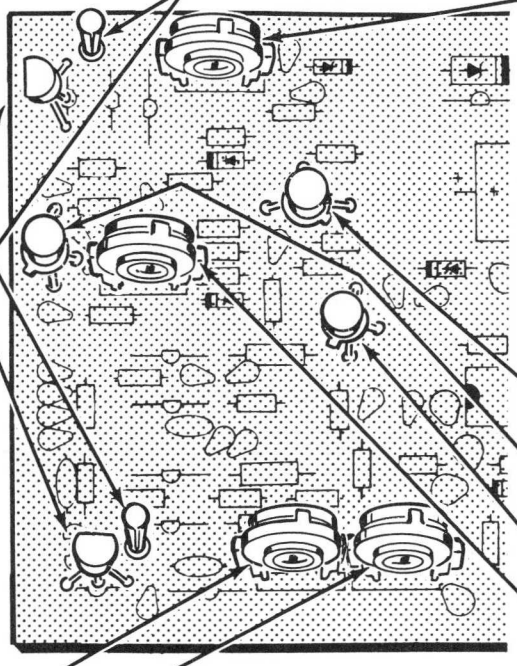
( ) EL131 transistor (#417-241) at Q314.

( ) EL131 transistor (#417-241) at Q302.

NOTE: Install controls when called for in the following steps. Solder the lugs to the foil as the control is installed.

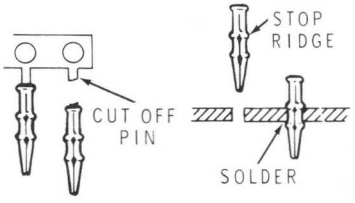
( ) 5000 Ω (5 kΩ) control (#10-904).

( ) 2000 Ω control (#10-398).



CONTINUE

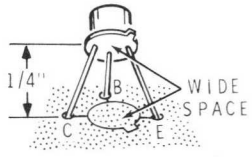
( ) Install and solder circuit board pins at TP1 and TP2 as shown.



( ) Cut the excess pin lengths from the foil side of the board.

( ) 5000 Ω (5 kΩ) control (#10-904). Solder the leads to the foil.

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



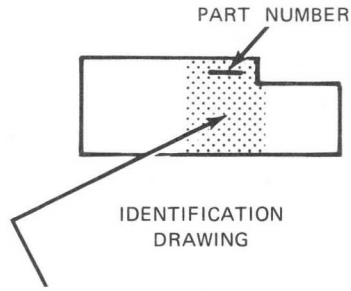
( ) 2N2369 transistor (#417-154) at Q319.

( ) 2N2369 transistor (#417-154) at Q317.

( ) 2N2369 transistor (#417-154) at Q318.

( ) 10 kΩ control (#10-386). Solder the leads to the foil.

PICTORIAL 3-3



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

START

NOTE: The resistors that you will install in this Pictorial are 1/4-watt resistors unless otherwise specified.

( ) 1000 Ω (brown-black-red).

( ) 1000 Ω (brown-black-red).

( ) 7.5 pF mica.

( ) 220 Ω (red-red-brown).

( ) 1000 Ω (brown-black-red).

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

( ) 220 Ω (red-red-brown).

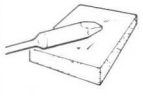
( ) 220 Ω (red-red-brown).

( ) 1N4149 diode (#56-56) at D305.

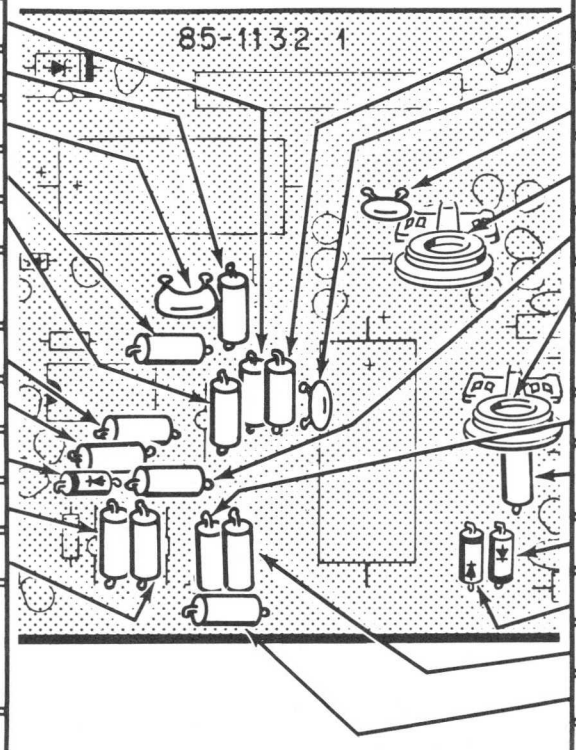
( ) 100 kΩ (brown-black-yellow).

( ) 1000 Ω (brown-black-red).

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



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



CONTINUE

( ) 1000 Ω (brown-black-red).

( ) 100 pF disc.

( ) 100 pF disc.

( ) 10 kΩ control (#10-386). Solder the control leads to the foil.

( ) 220 Ω (red-red-brown).

( ) 200 Ω control (#10-917).

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

( ) 1000 Ω (brown-black-red).

( ) 100 Ω, 1/2-watt (brown-black-brown).

( ) VR-9.1 diode (#56-19) at ZD203.

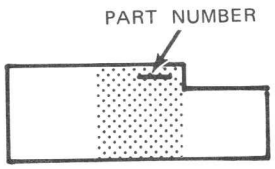
( ) VR-9.1 diode (#56-19) at ZD206.

( ) 2200 Ω (red-red-red).

( ) 100 Ω (brown-black-brown).

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

PICTORIAL 3-4



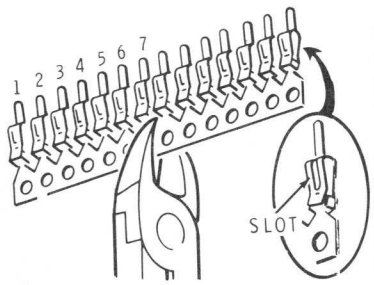
IDENTIFICATION DRAWING

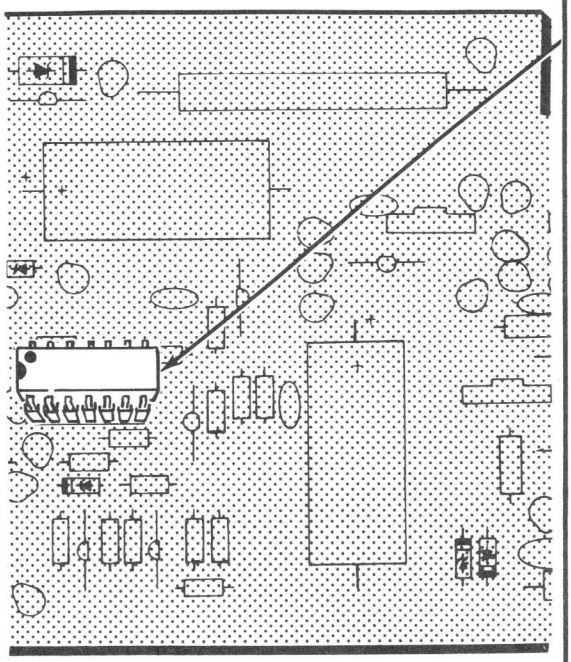
The steps performed in this Pictorial are in this area of the circuit board.

START

( ) Locate the SN7413N integrated circuit (#443-44).

( ) Cut the 14-pin connector strip into two 7-pin strips.



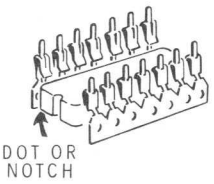


PICTORIAL 3-5

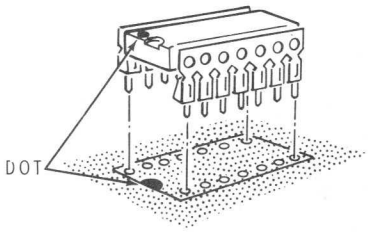
CONTINUE

Install the two 7-pin connector strips and the integrated circuit (IC) in the following manner:

( ) Install the two 7-pin connector strips on the IC.

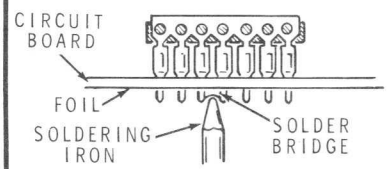


( ) Position the notch or dot end of the IC over the dot screened on the circuit board; then install the connector strips into the circuit board.

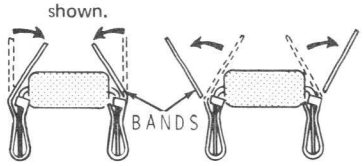


( ) Solder the 7-pin connector strips to the foil on the circuit board. DO NOT solder the IC pins to the connector strips. Use a small-tip soldering iron. Since the IC connectors are close together, do not place the soldering iron tip between them, as this increases the possibility of a solder bridge.

( ) If a solder bridge occurs, turn the circuit board foil-side down and hold the soldering iron tip between the two points that are bridged. The solder will flow down the tip of the soldering iron.



( ) Remove the bands that join the connectors. Do this by first bending the band toward the integrated circuit; then bend it outward as shown.

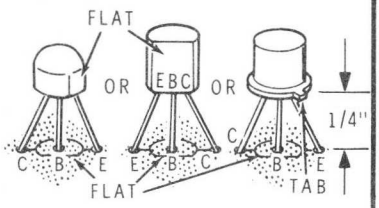


START

NOTE: When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type.

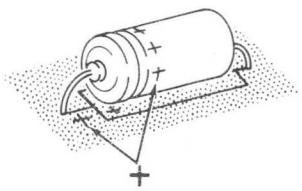
( ) Bend the leads of a 10 kΩ, 7-watt, film resistor to fit the holes in the circuit board. Then install the resistor using a piece of carton cardboard as a spacer. Solder the resistor leads to the foil and cut off the excess lead lengths. Remove the cardboard spacer.

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



( ) ETS083 transistor (#417-173) at Q321.

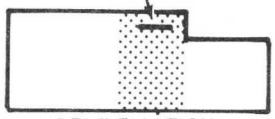
NOTE: When you install an electrolytic capacitor, always match the positive (+) marked end of the capacitor with the positive (+) mark on the circuit board.



( ) 2000 μF electrolytic. Solder the leads to the foil and cut off the excess lead lengths.

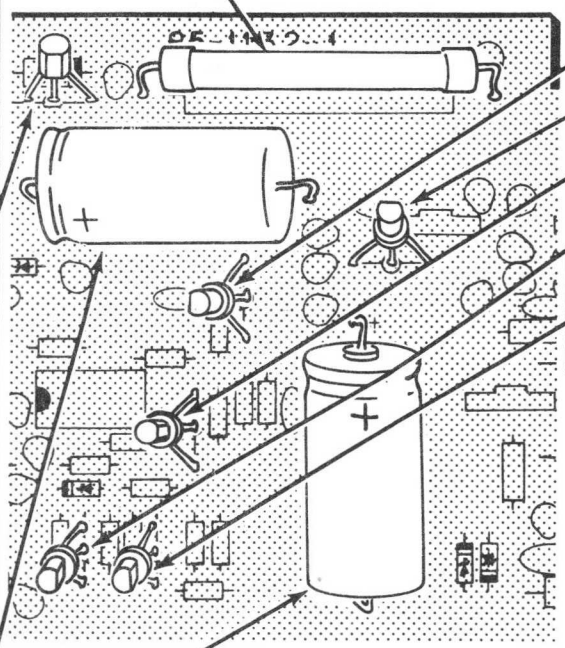
( ) 2000 μF electrolytic. Solder the leads to the foil and cut off the excess lead lengths.

PART NUMBER



IDENTIFICATION DRAWING

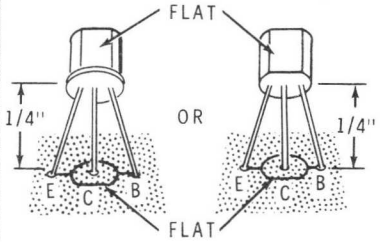
The steps performed in this Pictorial are in this area of the circuit board.



PICTORIAL 3-6

CONTINUE

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



( ) L842 transistor (#417-83) at Q309.

( ) L842 transistor (#417-83) at Q301.

( ) 2N3393 transistor (#417-118) at Q311.

( ) 2N3393 transistor (#417-118) at Q312.

( ) 2N3393 transistor (#417-118) at Q313.

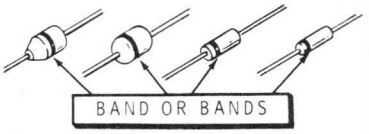
IDENTIFICATION DRAWING

START

Position the sweep generator-horizontal amplifier circuit board as shown in the identification drawing; then proceed with the following steps.

NOTE: The resistors that you will install in this Pictorial are 1/2-watt resistors unless otherwise specified.

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. THE CATHODE END OF THE DIODE IS MARKED WITH A BAND OR BANDS. ALWAYS POSITION THIS END AS SHOWN IN THE PICTORIAL.



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

( ) 1N4149 diode (#56-56) at D205.

( ) 1000 Ω (brown-black-red).

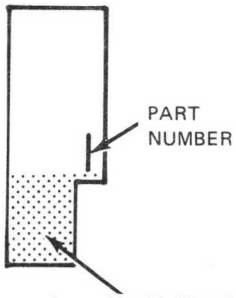
( ) 1000 Ω (brown-black-red).

( ) 1N709A diode (#56-58) at ZD207.

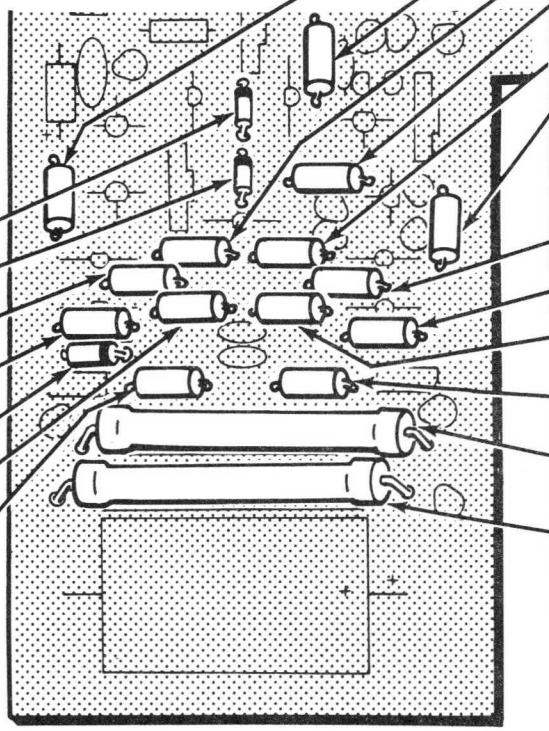
( ) 220 Ω (red-red-brown).

( ) 330 Ω (orange-orange-brown).

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



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



CONTINUE

( ) 1000 Ω (brown-black-red).

( ) 1 MΩ (brown-black-green).

( ) 470 Ω (yellow-violet-brown).

( ) 10 kΩ (brown-black-orange).

( ) 470 Ω (yellow-violet-brown).

( ) 1000 Ω (brown-black-red).

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

( ) 1000 Ω (brown-black-red).

( ) 1000 Ω (brown-black-red).

( ) 220 Ω (red-red-brown).

( ) 330 Ω (orange-orange-brown).

( ) 10 kΩ, 7-watt film. Use a cardboard spacer.

( ) 10 kΩ, 7-watt film. Use a cardboard spacer.

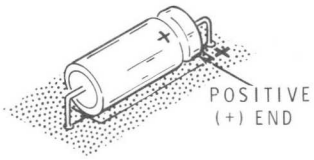
( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 3-7

START

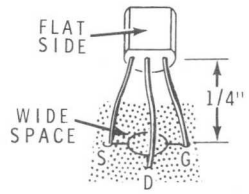
NOTE: When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type.

( ) 10 μF electrolytic. Be sure to match the positive (+) lead of the capacitor with the positive (+) mark on the circuit board.



( ) Solder the capacitor leads to the foil.

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



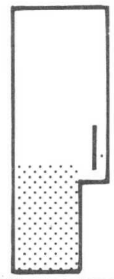
( ) MPF105 transistor (#417-169) at Q202.

( ) MPF105 transistor (#417-169) at Q207.

( ) 100 μF electrolytic. Be sure to match the positive (+) lead of the capacitor with the positive (+) mark on the circuit board.

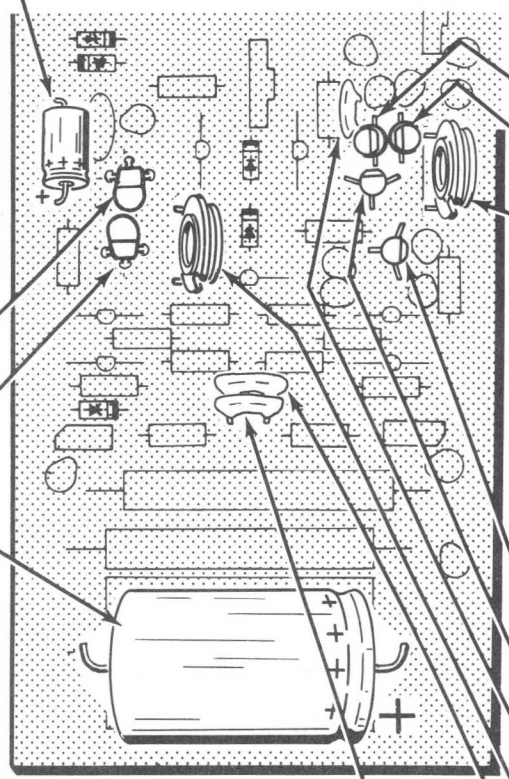
( ) Solder the capacitor leads to the foil and cut off the excess lead lengths.

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



IDENTIFICATION DRAWING

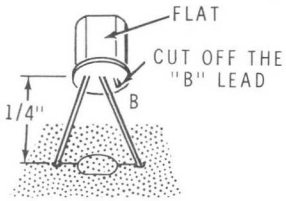
PART NUMBER



PICTORIAL 3-8

CONTINUE

NOTE: Install the next two transistors in the following manner as shown: Cut off the "B" lead and then insert the other two leads into their correct holes in the circuit board. Solder each lead to the foil and cut off the excess lead lengths.

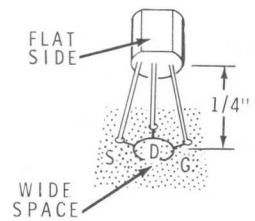


( ) L842 transistor (#417-83) at D201.

( ) L842 transistor (#417-83) at D202.

( ) 2000 Ω control (#10-398). Solder the leads to the foil.

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



( ) MPF105 transistor (#417-169) at Q206.

( ) MPF105 transistor (#417-169) at Q201.

( ) .01 μF disc.

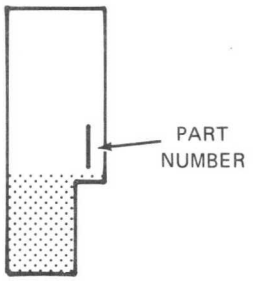
( ) 500 Ω control (#10-918). Solder the leads to the foil.

( ) 270 pF mica.

( ) 470 pF mica.

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

IDENTIFICATION DRAWING

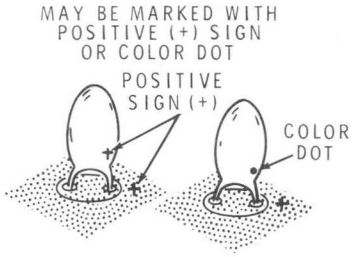


The steps performed in this Pictorial are in this area of the circuit board.

START

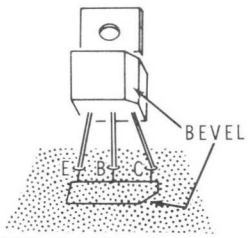
NOTE: When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type.

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



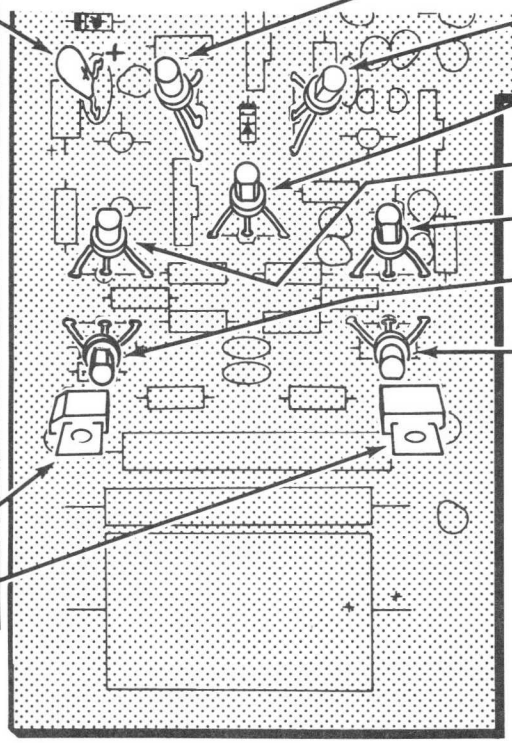
( ) 2.2 µF tantalum capacitor. Solder the leads to the foil and cut off the excess lead lengths.

NOTE: Install the next two transistors as shown. Match the bevel on the transistor with the bevel outline on the circuit board. Solder the leads to the foil and cut off the excess lead lengths.



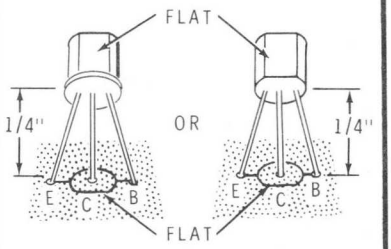
( ) D40N1 transistor (#417-245) at Q214.

( ) D40N1 transistor (#417-245) at Q213.



CONTINUE

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



( ) 2N3393 transistor (#417-118) at Q204.

( ) 2N3393 transistor (#417-118) at Q203.

( ) 2N3393 transistor (#417-118) at Q205.

( ) L842 transistor (#417-83) at Q209.

( ) L842 transistor (#417-83) at Q208.

( ) X29A829 transistor (#417-201) at Q212.

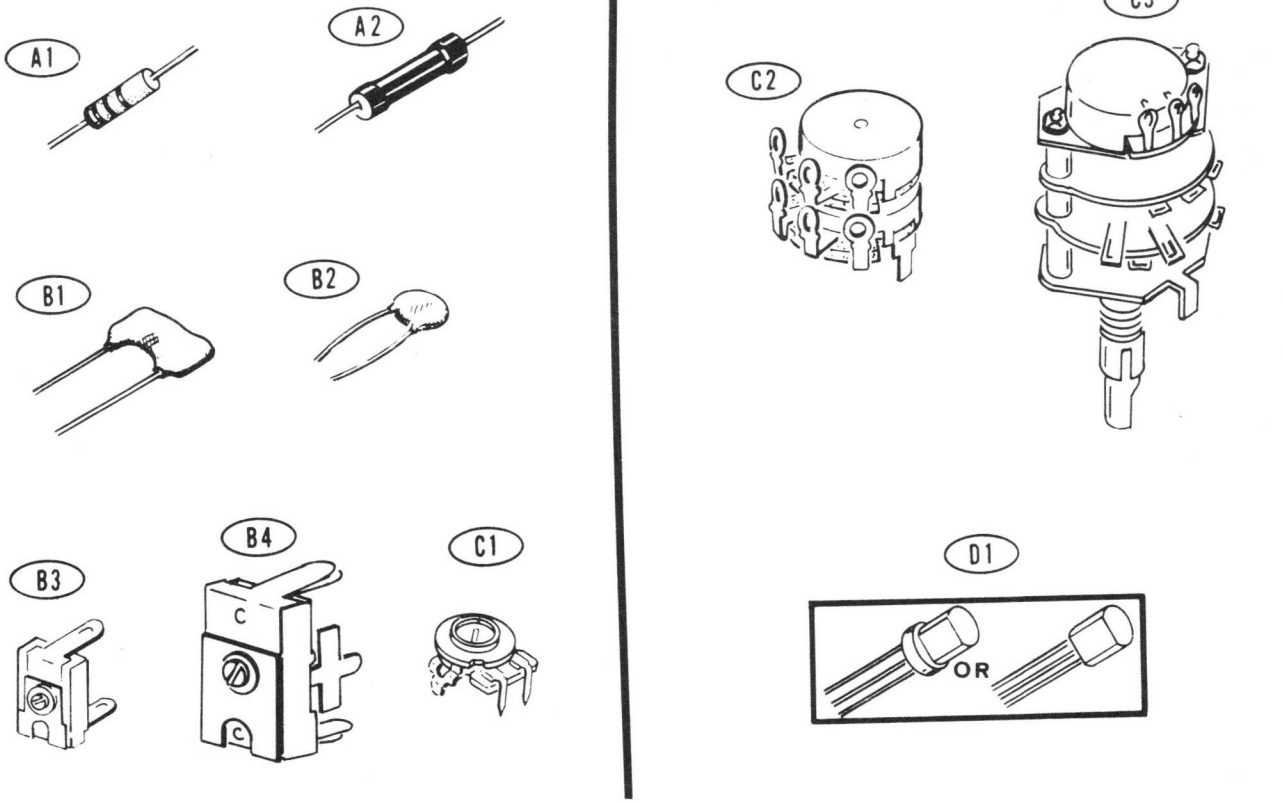
( ) X29A829 transistor (#417-201) at Q211.

( ) Carefully inspect the foil side of the circuit board to make sure all connections are soldered and that there are no solder bridges between foils.

Set the circuit board aside temporarily.

PICTORIAL 3-9

PARTS PICTORIAL



ATTENUATOR CIRCUIT BOARD

PARTS LIST

Unpack the package marked 4 and check each part against the following list. The key numbers correspond to the numbers on the "Parts Pictorial."

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS				
A1	1-35	1	1 MΩ (brown-black-green)	.10
A2	2-159	2	100 Ω precision	.20
A2	2-83	1	200 Ω precision	.25
A2	2-50	1	10 kΩ precision	.20
A2	2-41	1	90 kΩ precision	.20
A2	2-51	1	900 kΩ precision	.20
CAPACITORS				
B1	20-100	1	30 pF mica	.15
B2	21-16	2	.01 μF disc	.10
B3	31-56	2	1.5-20 pF trimmer	.30
B4	31-49	1	250-1000 pF trimmer	.85
CONTROLS-SWITCH				
C1	10-397	1	200 Ω control	.35
C1	10-391	1	1000 Ω (1 kΩ) control	.45
C2	12-80	1	50 kΩ dual control	1.10
C3	63-612	1	2-wafer switch with control	5.00

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
MISCELLANEOUS				
D1	417-83	2	L842 transistor	.75
D1	417-118	1	2N3393 transistor	.40
D1	417-169	1	MPF105 transistor	1.50
	85-1238-1	1	Attenuator circuit board	.85
	344-59	1	White wire	.05/ft

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

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

NOTE: See Page 103 for "Replacement Parts and Price Information."

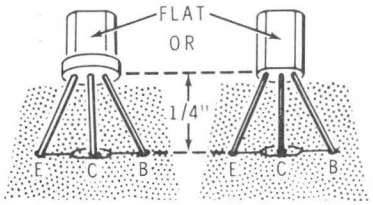
STEP-BY-STEP ASSEMBLY

START

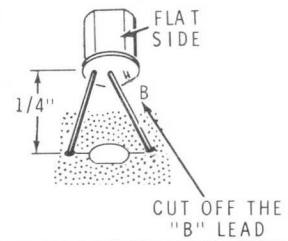
Position the attenuator circuit board as shown in this Pictorial. Then proceed with the following steps.

NOTE: As each of the components is installed on this circuit board, solder its leads to the foil and cut off any excess lead lengths. When you install transistors in this Pictorial, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify each transistor type.

( ) 2N3393 transistor (#417-118) at Q2.



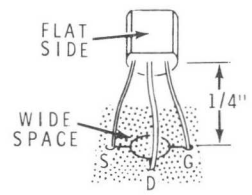
NOTE: Install the next two transistors in the following manner as shown: Cut off the "B" lead and then insert the other two leads into their correct holes in the circuit board.



( ) L842 transistor (#417-83) at D1.

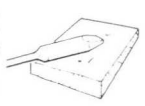
( ) L842 transistor (#417-83) at D2.

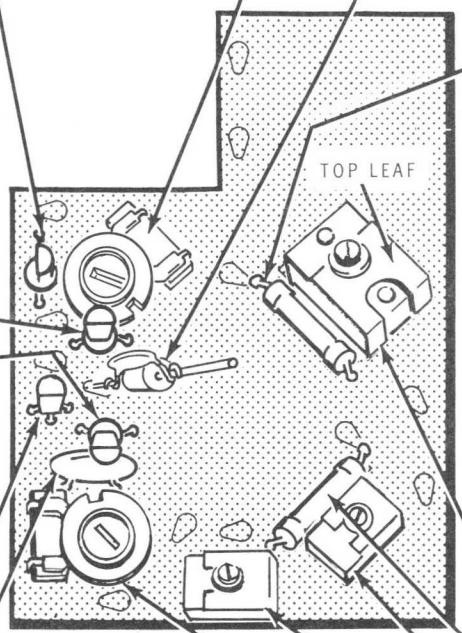
( ) MPF105 transistor (#417-169) at Q1.



( ) .01 μF disc.

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

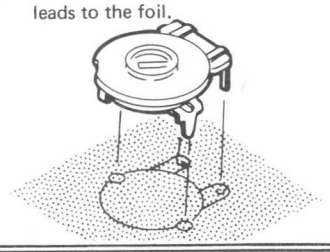




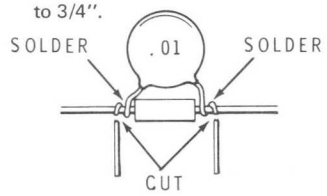
PICTORIAL 4-1

CONTINUE

( ) 200 Ω control (#10-397). Solder the leads to the foil.



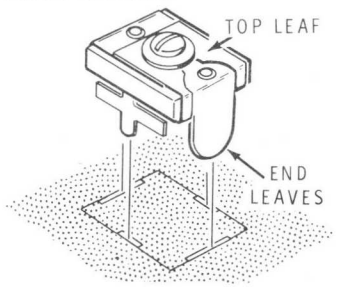
( ) Solder the leads of a .01 μF disc capacitor to a 1 MΩ (brown-black-green) resistor. Cut off the excess capacitor leads. Cut one resistor lead to 3/4".



( ) Install the long resistor lead through the circuit board at D, and push it down until the assembly touches the circuit board. Position the capacitor between D1 and D2; then solder the lead to the foil and cut off the excess lead length.

( ) 10 kΩ precision.

NOTE: Carefully study the top of the 250-1000 pF trimmer capacitor (#31-49) which will be installed in the following step. Note the metal leaf on the top of the capacitor, directly under the screw and washer. This leaf must be positioned exactly as shown in the Pictorial. Be sure to solder all the end leaves together on the foil side of the board.



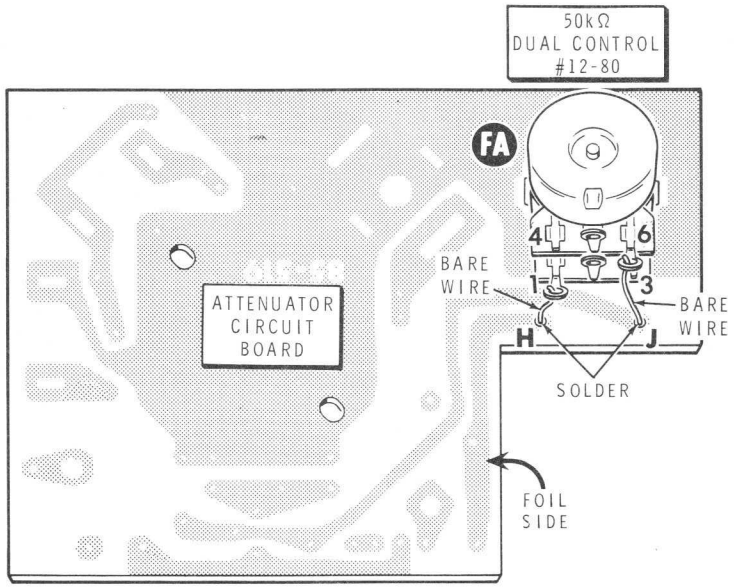
( ) 250-1000 pF (#31-49).

( ) 900 kΩ precision.

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

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

( ) 1000 Ω control (#10-391). Solder the leads to the foil.



PICTORIAL 4-2

Refer to Pictorial 4-2 for the following steps.

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

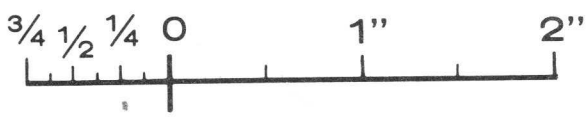
( ) Refer to Detail 4-2A and carefully inspect the dual control (#12-80). Locate lugs 3 and 4; then remove these lugs with a pair of diagonal cutters. Bend lugs 1 and 6 as shown in the Detail.

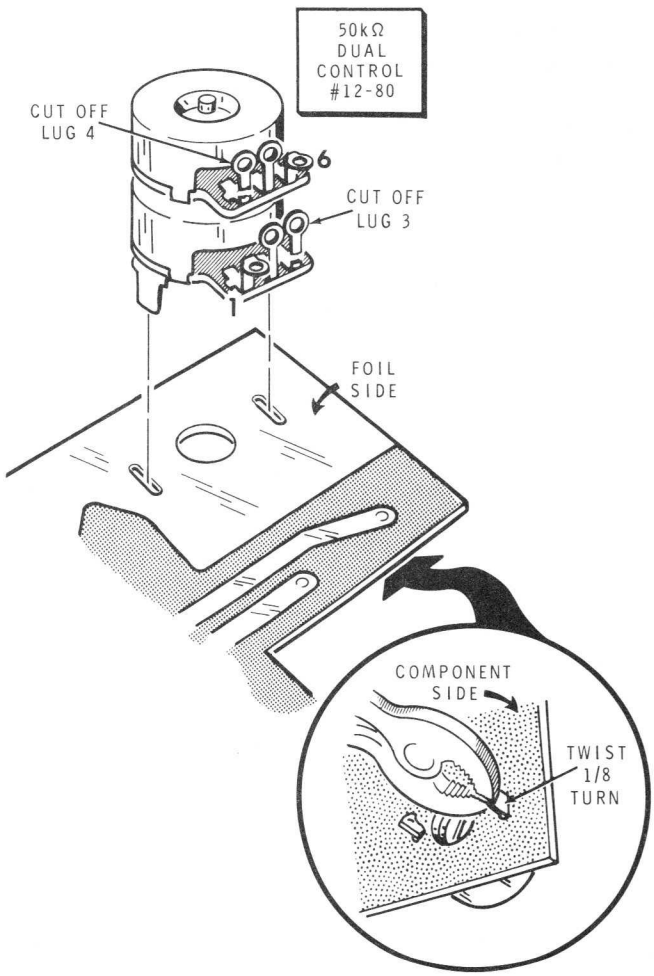
( ) Install the dual 50 kΩ control on the foil side of the circuit board at FA as shown in the Detail. Be sure the control lugs are toward the cutout corner of the circuit board. Then twist the mounting tabs on the component side of the circuit board 1/8 turn to hold the control in place.

NOTE: When bare wire is called for, as in the following step, use white hookup wire. Cut the wire to the length indicated and then remove the insulation from the wire.

( ) Refer to Pictorial 4-2 and pass one end of a 3/4" bare wire through hole H from the component side of the circuit board. Connect this wire to lug 1 of control FA (S-1). Solder the other end of the wire to the circuit board foil and cut off the excess length.

( ) Pass a 1" length of bare wire through hole J. Connect this wire to lug 6 of control FA (S-1). Solder the other end of the wire to the foil and cut off the excess length.





Detail 4-2A

SWITCH PREWIRING

Refer to Pictorial 4-3 for the following steps.

( ) Locate the 2-wafer switch with control (#63-612) and place it on the work area as shown.

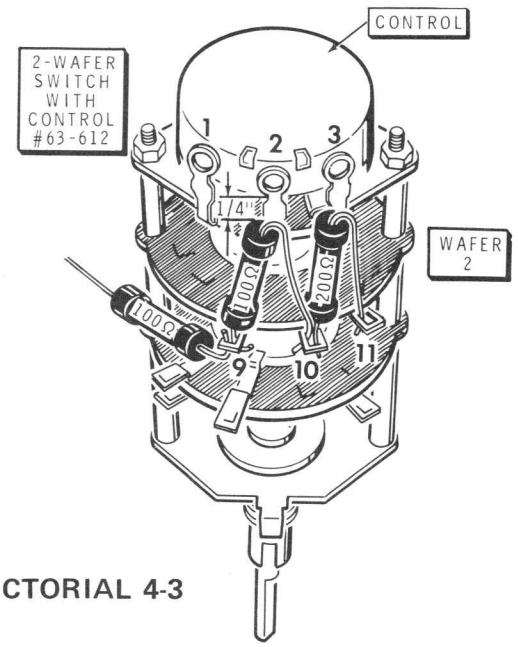
( ) Cut one lead of a 200 Ω precision resistor to 1/4". Bend the longer lead along the side of the resistor body as shown in the Pictorial and install the resistor between lug 11 (NS) and lug 10 (NS) of switch wafer 2.

( ) In the same manner, cut one lead of a 100 Ω precision resistor to 1/4" and form the longer lead down along side the body of the resistor. Install this resistor between lug 10 (S-2) and lug 9 (NS) of switch wafer 2.

( ) Cut the leads of a 100 Ω resistor to 1/2" and 1/4".

( ) Bend the short lead of the 100 Ω resistor 90 degrees to the body of the resistor.

( ) Connect the short lead of the resistor to lug 9 of switch wafer 2 (S-2). The free end will be connected later.



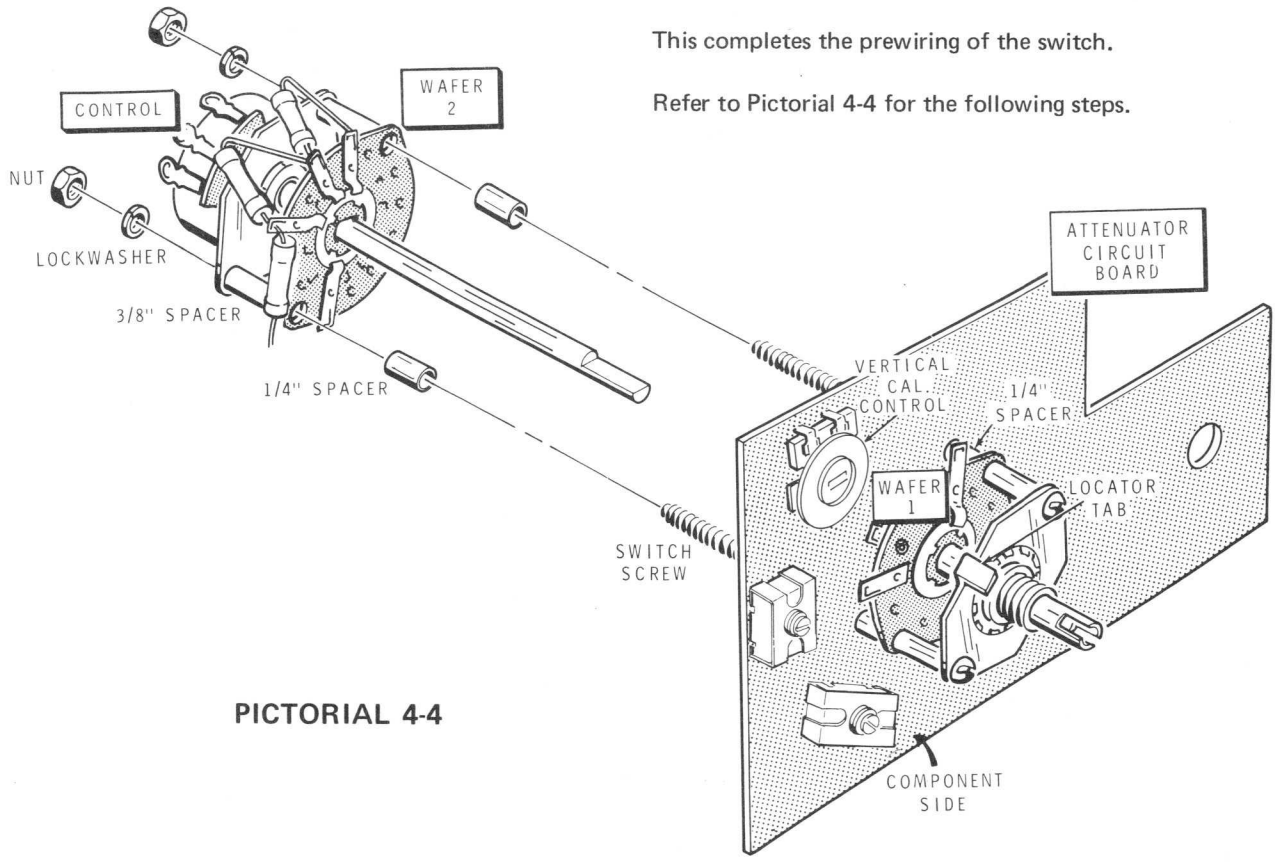
PICTORIAL 4-3

( ) Bend the tops of the two resistors that stand up toward the control lugs so they are approximately 1/4" away from the control.

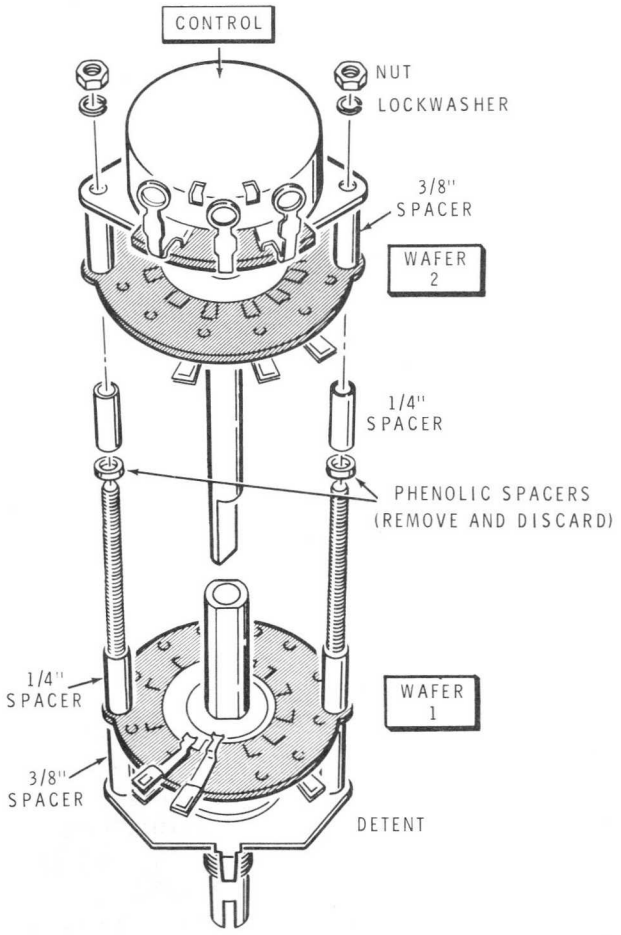
( ) Cut off any excess lead lengths.

This completes the prewiring of the switch.

Refer to Pictorial 4-4 for the following steps.



PICTORIAL 4-4



Detail 4-4A

Refer to Detail 4-4A and disassemble the 2-wafer switch with control as follows:

( ) Remove the two nuts and two lockwashers from the long switch screws.

( ) Carefully remove the control.

( ) Remove the two 3/8" spacers from between the control and wafer 2.

( ) Carefully remove wafer 2, making certain not to rotate the center segment of the wafer (the rotor).

NOTE: Wafer 2 must go back onto the switch assembly exactly as it was originally. Be sure to study it carefully and to reinstall it properly later.

( ) Remove the two rear 1/4" spacers from the screws.

( ) There may be phenolic spacers between the four 1/4" spacers as shown in the Detail. If so, remove and discard these spacers.

Note that the remaining assembly consists of the switch detent, two long screws, two 3/8" spacers, switch wafer 1, and two 1/4" spacers.

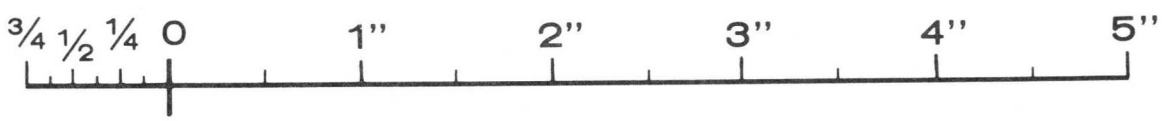
Refer to Pictorial 4-4 and install the switch assembly onto the attenuator circuit board as follows:

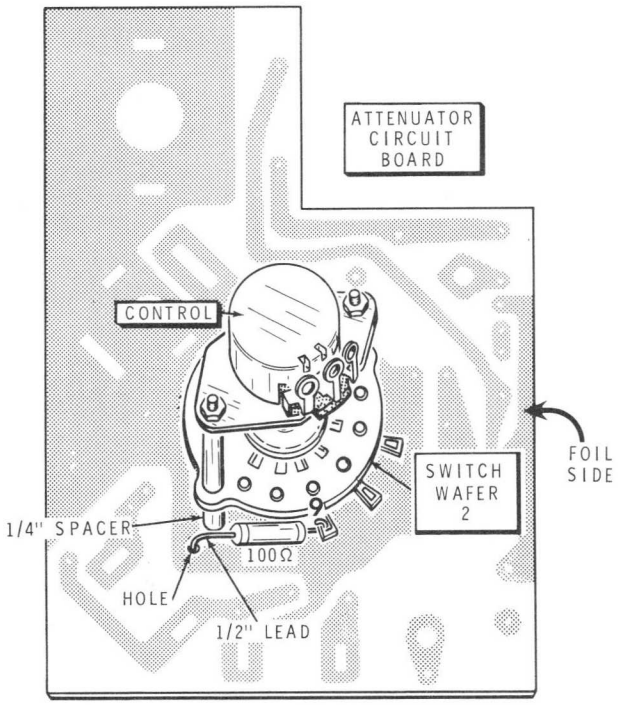
( ) Hold the circuit board so the component side of the board is facing you.

( ) Push the switch screws through the screw holes in the circuit board. Make sure the locator tab on the switch detent is facing toward the Vertical Cal control in the upper left corner of the circuit board.

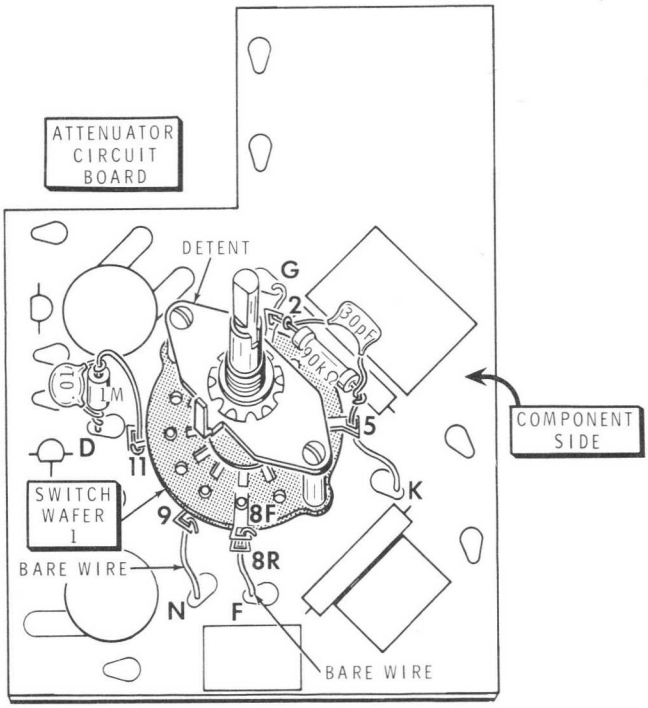
( ) Place the two 1/4" spacers onto the screws, followed by switch wafer 2 with its components positioned toward the upper left corner of the circuit board, two 3/8" spacers, and then the control.

( ) Secure the assembly to the circuit board with the two lockwashers and two nuts previously removed from the assembly.





PICTORIAL 4-5



PICTORIAL 4-6

CIRCUIT BOARD FINAL WIRING

Refer to Pictorial 4-5 for the following steps.

( ) Push the free lead of the 100 Ω precision resistor connected to lug 9 of switch wafer 2 into the hole near the 1/4" switch spacer as shown (S-1). (NOTE: This hole is not marked.)

Refer to Pictorial 4-6 for the following steps.

( ) Bend and connect the free lead of the resistor-capacitor assembly coming from hole D on the circuit board to lug 11 of switch wafer 1 (S-1).

( ) Pass a 1" bare wire through switch lug 9 of wafer 1 and through hole N in the circuit board. Solder the wire to the foil and to switch lug 9 and cut off any excess wire lengths.

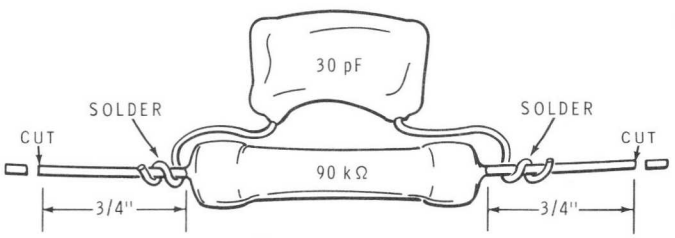
NOTE: When switch lugs are called out as "8F" and "8R", as in the following step, this indicates that lug 8F is on the Front of the wafer, or that lug 8R is on the Rear of the wafer.

( ) Pass a 1" bare wire through lug 8F, through lug 8R, and into hole F in the circuit board. Solder the wire to the foil and to both wafer lugs, then cut off any excess wire length.

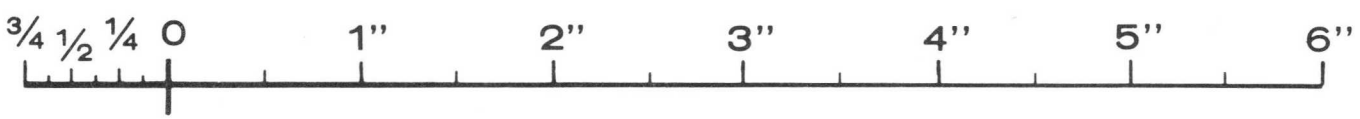
( ) Refer to Detail 4-6A and solder a 30 pF mica capacitor to a 90 kΩ precision resistor. Cut off the excess capacitor leads. Cut the resistor leads to 3/4".

( ) Pass one of the resistor leads through lug 2 of wafer 1 (S-2) and through hole G in the circuit board (S-1). Pass the other resistor lead through lug 5 of wafer 1 (S-2) and through hole K in the circuit board (S-1). Remove any excess lead lengths from the foil side of the board.

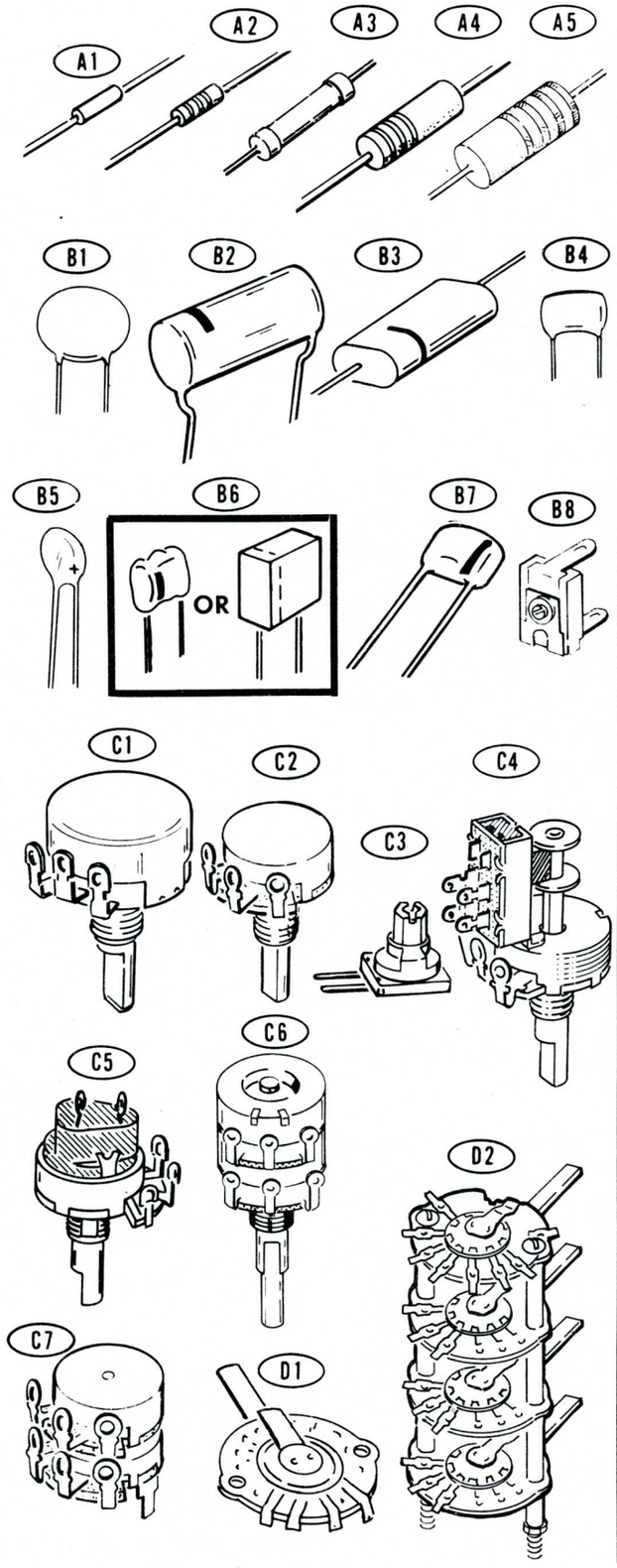
Set the attenuator circuit board assembly aside temporarily.

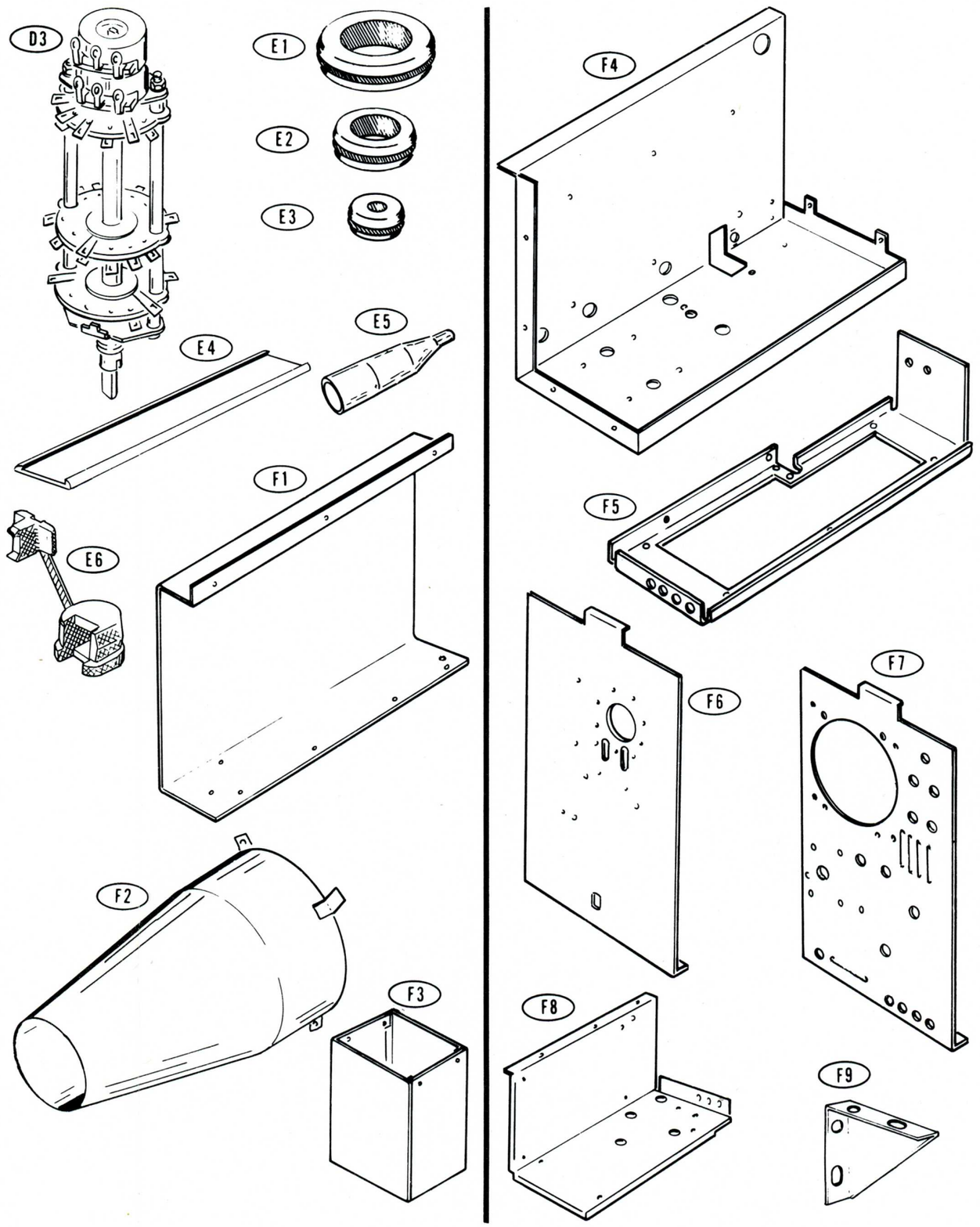


Detail 4-6A



CHASSIS PARTS PICTORIAL





CHASSIS

PARTS LIST

Unpack package 5, which is all of the remaining parts, and check each part against the following list. The key numbers correspond to the numbers on the "Chassis Parts Pictorial" (fold-out from Pages 38 and 41). Any part that is packaged in an individual envelope with a part number on it should be placed back in its envelope after it is identified until that part is called for in a step.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
RESISTORS				
A1	2-19-11	1	825 Ω, 1/8-watt, precision	.40
A2	1-42-12	1	22 Ω, 1/4-watt (red-red-black)	.10
A2	1-32-12	1	100 kΩ, 1/4-watt (brown-black-yellow)	.10
A3	2-184	1	110 kΩ, 1/2-watt, precision	.25
A3	2-50	1	10 kΩ, 1/2-watt, precision	.20
A4	1-35	1	1 MΩ, 1/2-watt (brown-black-green)	.10
A5	1-32-1	1	470 kΩ, 1-watt (yellow-violet-yellow)	.10
CAPACITORS				
Disc				
B1	21-56	1	470 pF	.10
B1	21-27	1	.005 μF	.10
B1	21-48	1	.05 μF	.15
Mylar				
B2	27-112	2	.1 μF	.25
B3	27-82	1	.5 μF	1.95
B3	27-81	1	5 μF	3.90
Other Capacitors				
B4	20-106	1	390 pF mica	.30
B5	25-223	1	47 μF tantalum	1.50
B6	27-83	1	.05 μF polycarbonate	1.55
B7	27-84	1	.005 μF polycarbonate	.75
B8	31-52	1	8-60 pF trimmer	.40
CONTROLS				
C1	11-80	1	200 Ω	1.20
C2	10-271	1	1000 Ω	.65
C2	10-267	1	250 kΩ	.60
C2	10-224	1	1 MΩ	.60
C3	10-373	1	2000 Ω (2 kΩ)	1.05
C4	19-166	1	5000 Ω (5 kΩ) with switch	2.05
C5	19-149	1	250 kΩ with switch	1.15
C6	12-92	1	5000 Ω/10 kΩ dual	1.70
C7	12-80	1	50 kΩ dual	1.10
SWITCHES				
D1	62-36	1	1-wafer lever switch	.60
D2	62-34	1	4-wafer lever switch	3.20
D3	63-613	1	3-wafer rotary switch	5.90

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
INSULATORS				
E1	73-2	6	3/4" grommet	.10
E2	73-3	5	1/2" grommet	.10
E3	73-4	2	5/16" grommet	.10
E4	73-5	1	Cushion strip	.10
E5	73-34	2	Boot	.10
E6	75-71	1	Strain relief	.10
METAL PARTS				
F1	90-513-1	2	Cabinet shell	3.75
F2	100-292	1	CRT shield	19.05
F3	100-1046	1	Transformer shield	2.70
F4	200-598	1	Chassis	2.60
F5	200-630	1	Lower bracket	1.05
F6	203-771-1	1	Rear panel	2.35
F7	203-786-1	1	Front panel	4.60
F8	204-1169	1	Circuit board bracket	1.00
F9	204-1170	2	CRT mounting bracket	.35
F10	204-1171-1	1	Top bracket	1.30
F11	204-1198	1	CRT shield bracket	.10
F12	204-1814	1	L-bracket	.30
F13	206-518	1	Transformer cover	.50
F14	207-1	2	CRT clamp	.20
PLASTIC PARTS				
G1	210-48	1	Bezel	1.20
G2	211-49	1	Handle assembly	2.15
G3	214-117	1	CRT cover	2.20
G4	255-7	1	1-3/4" spacer	.40
G5	261-28	4	Plastic foot	.05
G6	413-10	1	Red lens	.10
G7	414-6	1	Green screen	.40
G8	414-23	1	Graticule	4.90
KNOBS-KNOB INSERTS				
H1	462-247	3	1" pointer knob	.35
H2	462-248	2	11/16" pointer knob	.60
H3	462-249	4	11/16" plain knob	.40
H4	462-276	3	Short pointer knob	.25
H5	462-322	5	Lever knob	.10
H6	455-50	6	Large-shaft knob insert	.10
H7	455-51	3	Small-shaft knob insert	.10
H8	455-52	3	Short knob insert	.10

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
TERMINAL STRIPS-CONNECTOR-SOCKET				
J1	431-42	1	5-lug terminal strip	.10
J2	431-90	1	2-lug terminal strip (foot on right)	.10
J3	431-91	1	2-lug terminal strip (foot on left)	.10
J4	431-82	1	3-lug terminal collar	.10
J5	432-59	1	BNC connector with hardware	1.65
J6	434-41	1	12-lug tube socket	.30
WIRE-CABLE				
	89-23	1	Line cord	.75
	134-237	1	Test cable with BNC connector	2.20
	134-298	1	Wire harness	5.70
	340-3	1	Bare wire (in small envelope)	.05/ft
	343-7	1	Shielded cable	.05/ft
	344-50	1	Black wire	.05/ft
	344-52	1	Red wire	.05/ft
	347-2	1	300-ohm twin lead	.05/ft
HARDWARE				
#6 Hardware				
K1	250-229	54	6-32 x 1/4" screw	.05
K2	250-162	2	6-32 x 1/2" screw	.05
K3	250-26	2	6-32 x 5/8" screw	.05
K4	252-3	20	6-32 nut	.05
K5	254-1	35	#6 lockwasher	.05
K6	255-94	10	17/32" spacer	.10
K7	259-1	1	#6 solder lug	.05
#10 Hardware				
K8	250-50	20	10-32 x 3/8" screw	.05
K9	252-5	6	10-32 nut	.05
K10	254-3	6	#10 lockwasher	.05
Other Hardware				
K11	250-213	11	4-40 x 5/16" screw	.05
K12	250-137	4	8-32 x 3/8" screw	.05
K13	250-287	4	Panel stud	.05
K14	252-2	7	4-40 nut	.05
K15	252-7	9	Control nut	.05
K16	252-73	1	Speed Nut*	.05

*Registered Trademark, Tinnerman Co.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
Other Hardware (cont'd.)				
K17	252-86	4	Knurled nut	.10
K18	253-10	11	Control flat washer	.05
K19	254-4	5	Control lockwasher	.05
K20	254-9	12	#4 lockwasher	.05
K21	255-151	2	4-40 tapped spacer	.15
K22	259-27	1	Control solder lug	.05
MISCELLANEOUS				
L1	54-285	1	Power transformer	13.40
L2	56-26	1	1N191 diode	.25
L3	260-16	2	Alligator clip	.10
	411-265	1	5DEP1F CRT	23.50
L4	412-15	1	NE-2H neon lamp	.20
L5	412-31	2	Incandescent lamp	.50

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION	PRICE Each
Miscellaneous (cont'd.)				

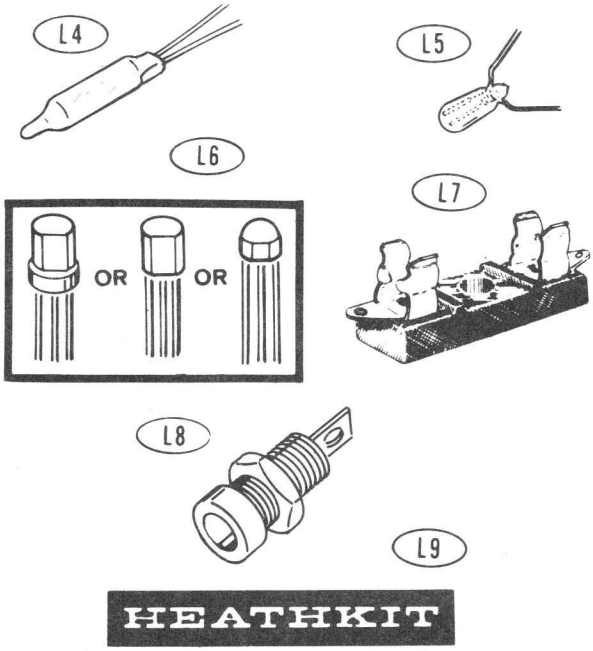
NOTE: Transistors are marked for identification in one of the following four ways.

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

L6	417-201	1	X29A829 transistor	.50
	421-23	1	1-ampere, slow-blow fuse	.30
L7	422-1	1	Fuseholder	.25
L8	436-11	3	Red banana jack	.15
L8	436-22	1	Black banana jack	.15
	390-362	1	Fuse label	.10
	391-34	1	Blue and white label	
L9	391-54	1	"Heathkit" nameplate	.15

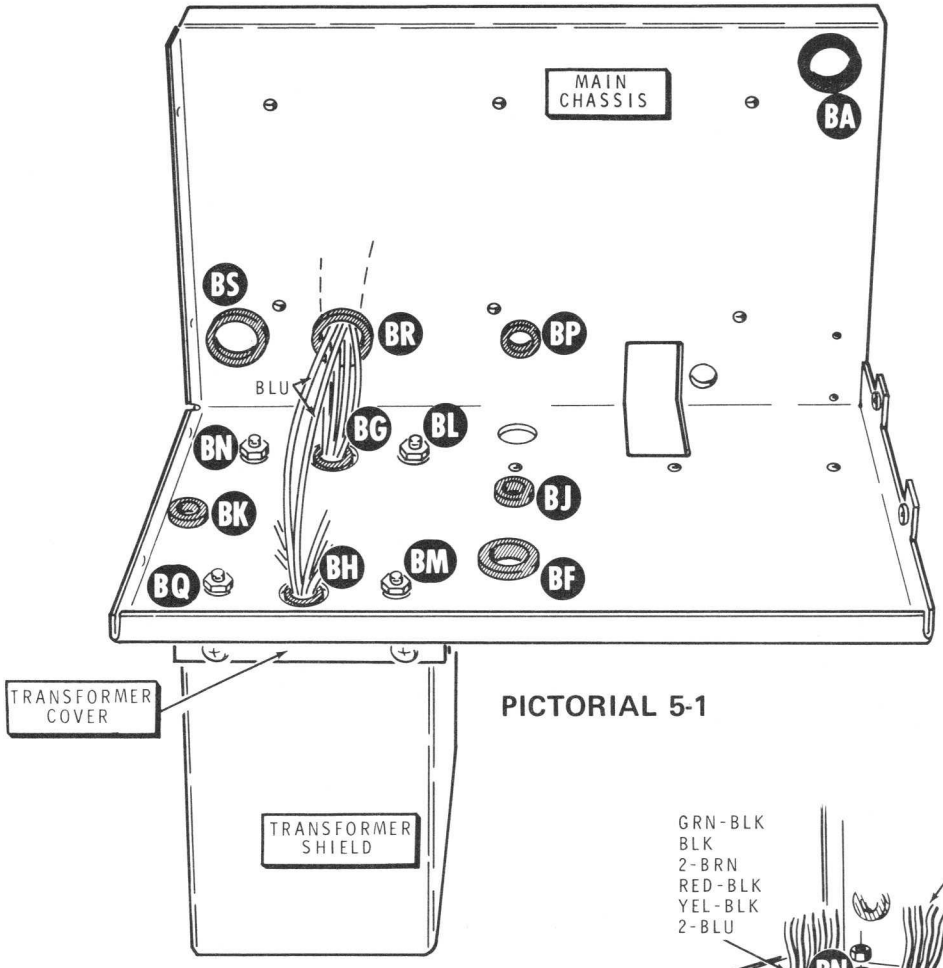
NOTE: See Page 103 for "Replacement Parts and Price Information."

Chassis Parts Pictorial (Cont'd.)

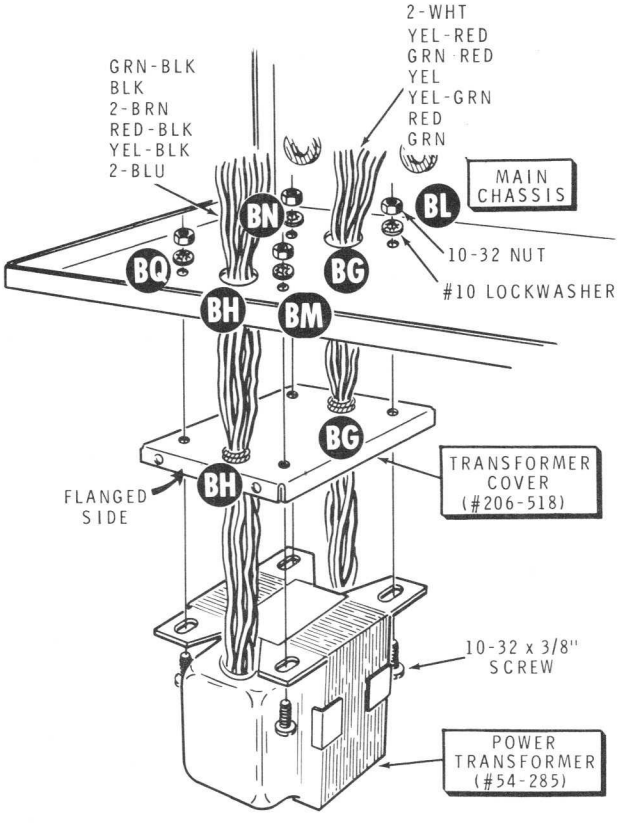


HEATHKIT

STEP-BY-STEP ASSEMBLY



PICTORIAL 5-1



Detail 5-1A

MAIN CHASSIS ASSEMBLY

Refer to Pictorial 5-1 for the following steps.

( ) Install 3/4" grommets at BS, BR, BF and BA as shown.

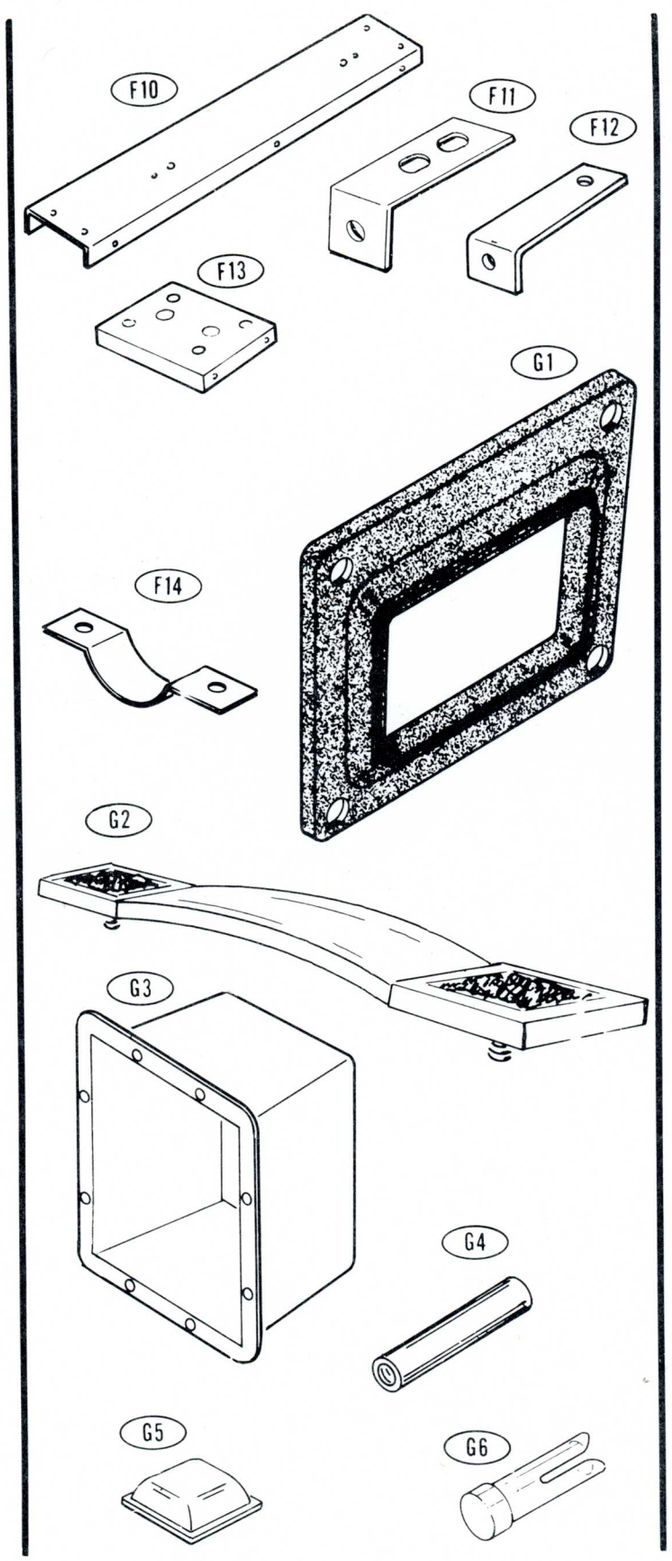
( ) Install 1/2" grommets at BJ, BK, and BP.

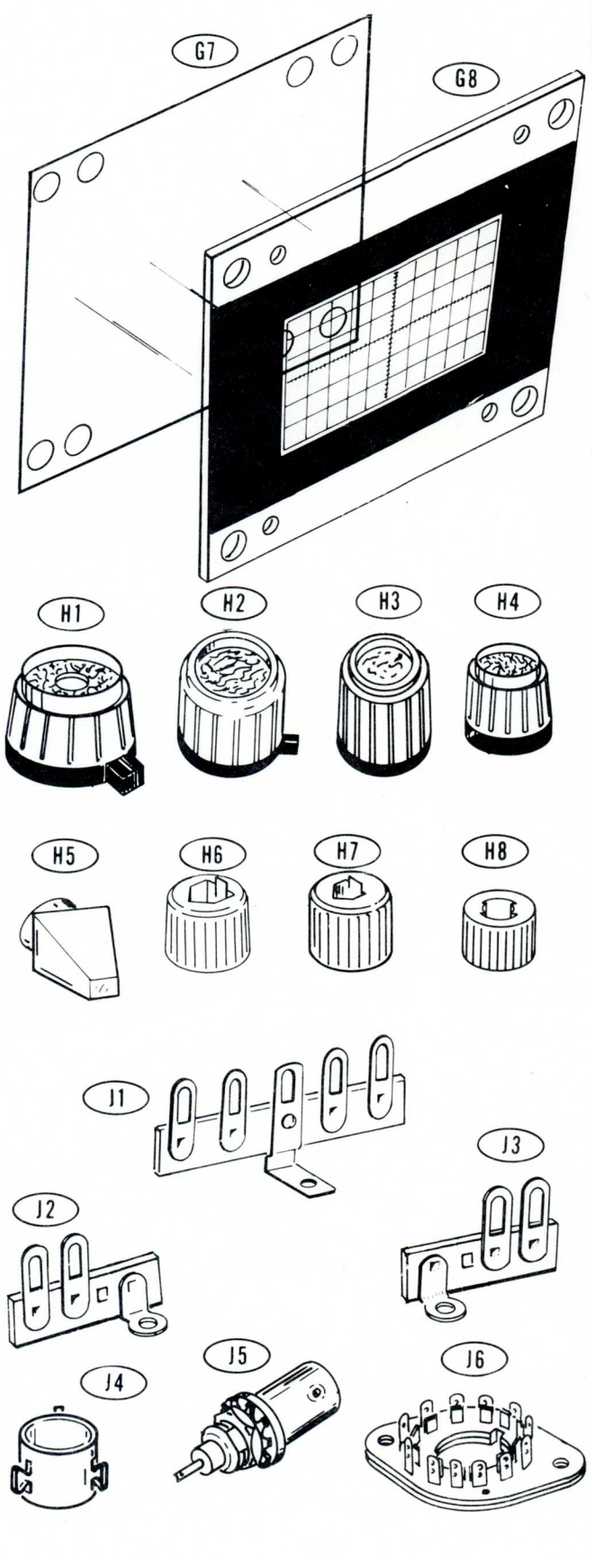
Refer to Detail 5-1A for the following steps.

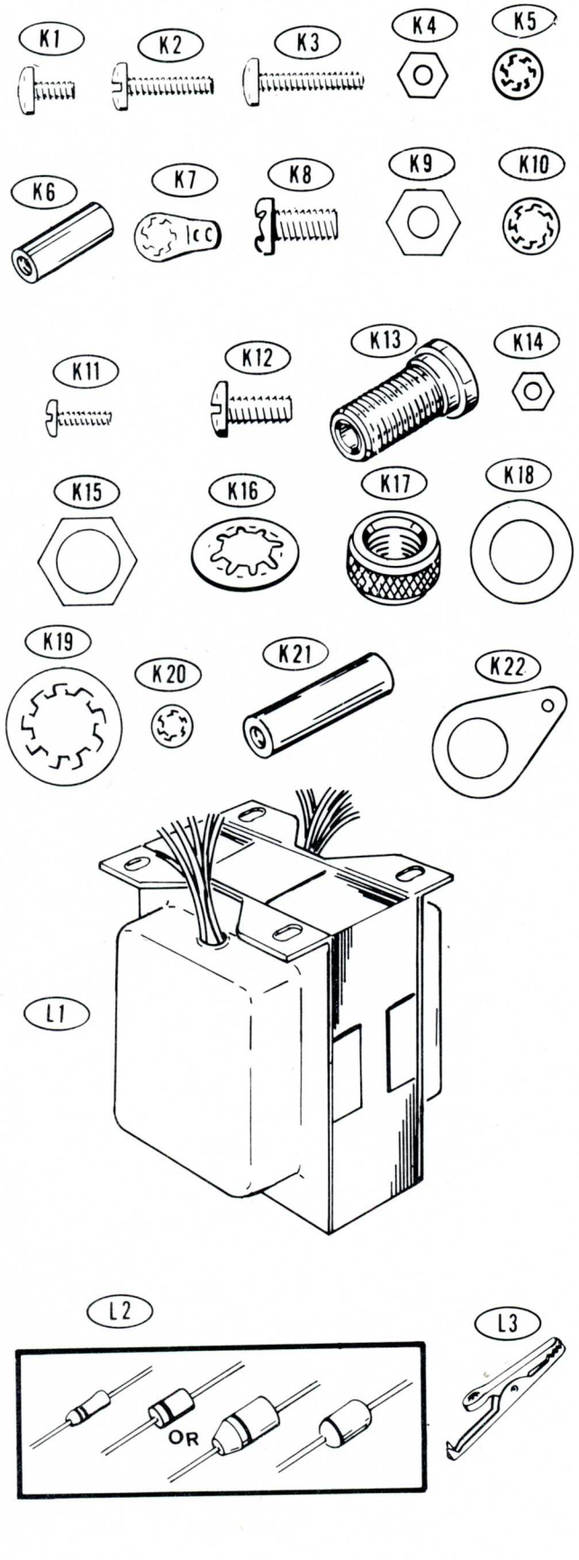
( ) Locate the transformer cover (#206-518) and install 1/2" grommets in holes BG and BH as shown.

( ) Position the power transformer (#54-285) on its top as shown. NOTE: The flanged sides of the transformer cover will face downward, and the transformer will be mounted on the underside of the chassis, upside down.

Chassis Parts Pictorial (Cont'd.)







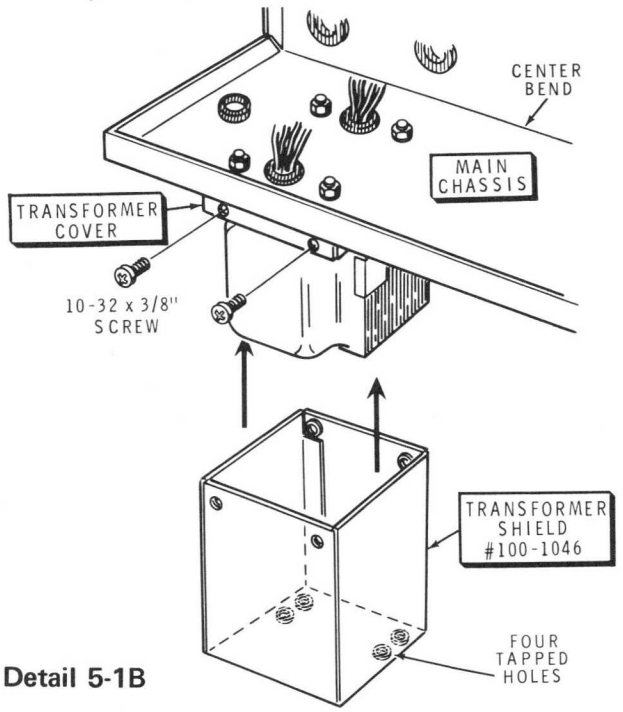
( ) Pass the following transformer leads through transformer cover grommet BG: two white, yellow-red, green-red, yellow, yellow-green, red, and green.

( ) Pass the following transformer leads through transformer cover grommet BH: green-black, black, two brown, red-black, yellow-black, and two blue.

( ) Pass the transformer wires coming from grommet BH through hole BH in the main chassis as shown in Pictorial 5-1.

( ) Pass the wires coming from grommet BG through hole BG in the main chassis.

( ) Secure the transformer and the transformer cover to the chassis with 10-32 x 3/8" hardware, at BL, BM, BN, and BQ.



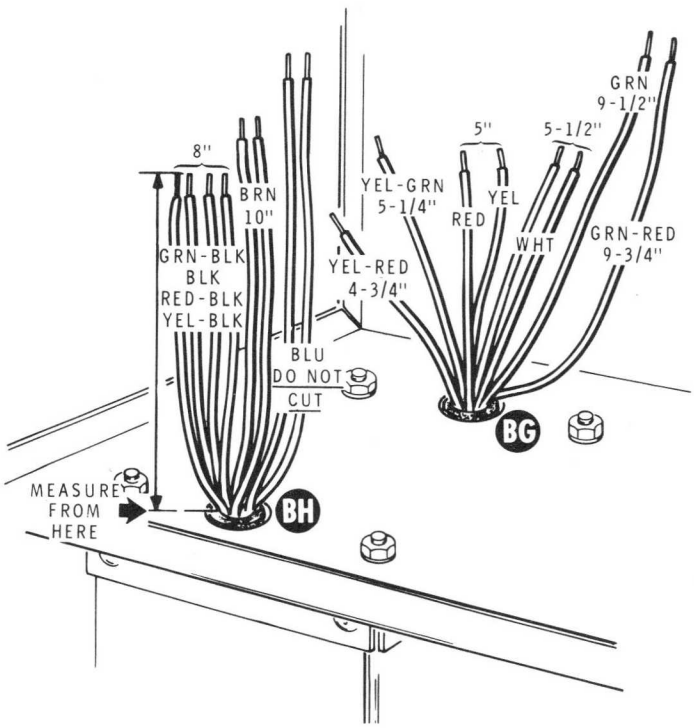
Detail 5-1B

( ) Refer to Detail 5-1B and place the transformer shield (#100-1046) over the top of the transformer. Then secure the shield to the cover with four 10-32 x 3/8" screws as shown. NOTE: The four tapped holes shown in the Detail must be on the same side as the center bend in the main chassis as shown.

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

( ) Cut each of the power transformer leads coming from grommet BG to the following lengths.

Green-red	9-3/4"
Green	9-1/2"
Both white	5-1/2"
Yellow-green	5-1/4"
Red	5"
Yellow	5"
Yellow-red	4-3/4"



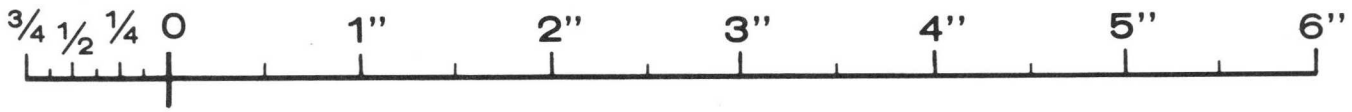
Detail 5-1C

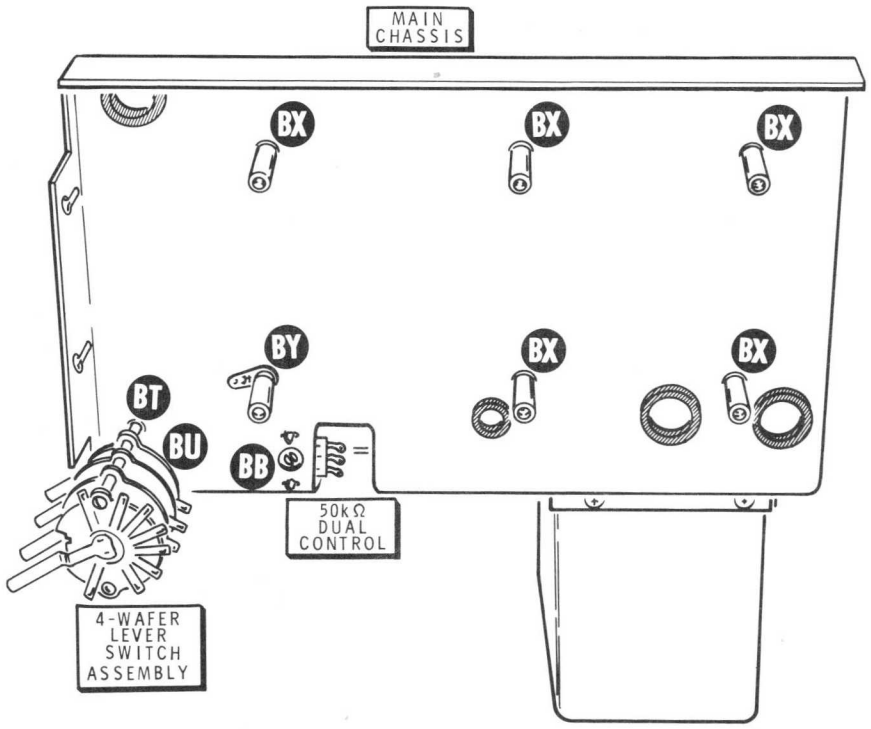
( ) Cut each of the power transformer leads coming from grommet BH to the following lengths.

Both blue	(do not cut).
Both brown	10"
Yellow-black	8"
Red-black	8"
Green-black	8"
Black	8"

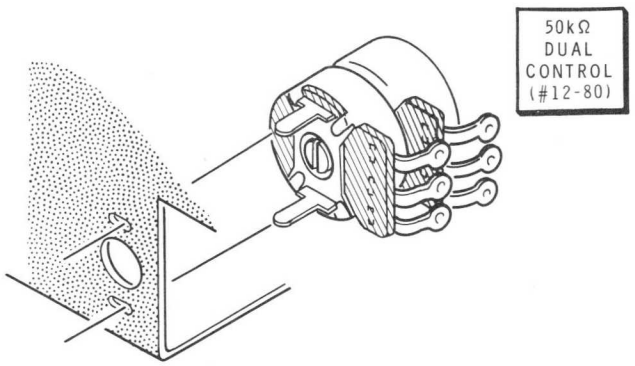
( ) Remove 1/4" of insulation from each of the leads coming from grommets BG and BH. Tightly twist the wire ends; then apply a small amount of solder to the ends to hold the small strands together. (NOTE: Some transformers are supplied with "pre-tinned" leads, making this operation unnecessary.)

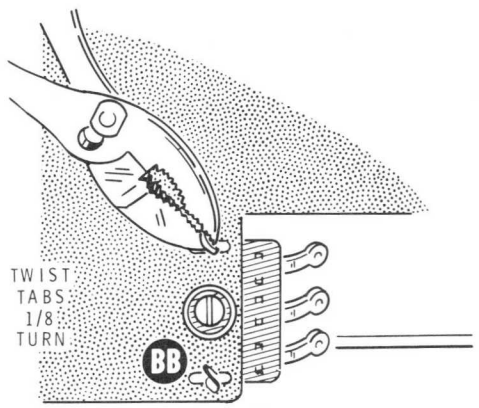
( ) Pass all the wires coming from grommet BG, and the two blue wires coming from grommet BH, through grommet BR as shown in Pictorial 5-1.





PICTORIAL 5-2





Detail 5-2A

Refer to Pictorial 5-2 for the following steps.

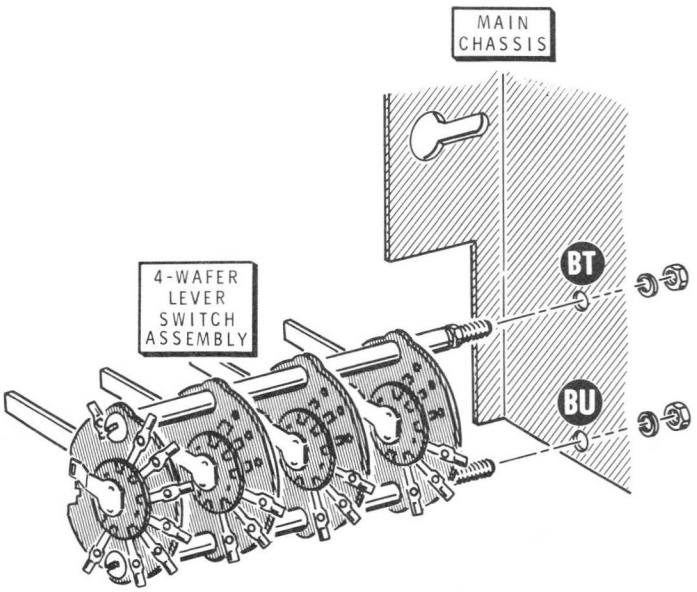
( ) Refer to Detail 5-2A and mount a 50 kΩ dual control (#12-80) at BB. Position the control as shown in the Pictorial. Twist the mounting tabs 1/8 turn to hold the control to the chassis.

( ) Locate the 4-wafer lever switch assembly (#62-34) and remove one nut and one lockwasher from each of the mounting screws as shown in Detail 5-2B. Mount this switch assembly as shown in the Pictorial at BT and BU on the chassis and secure it with the lockwasher and nut previously removed from the assembly.

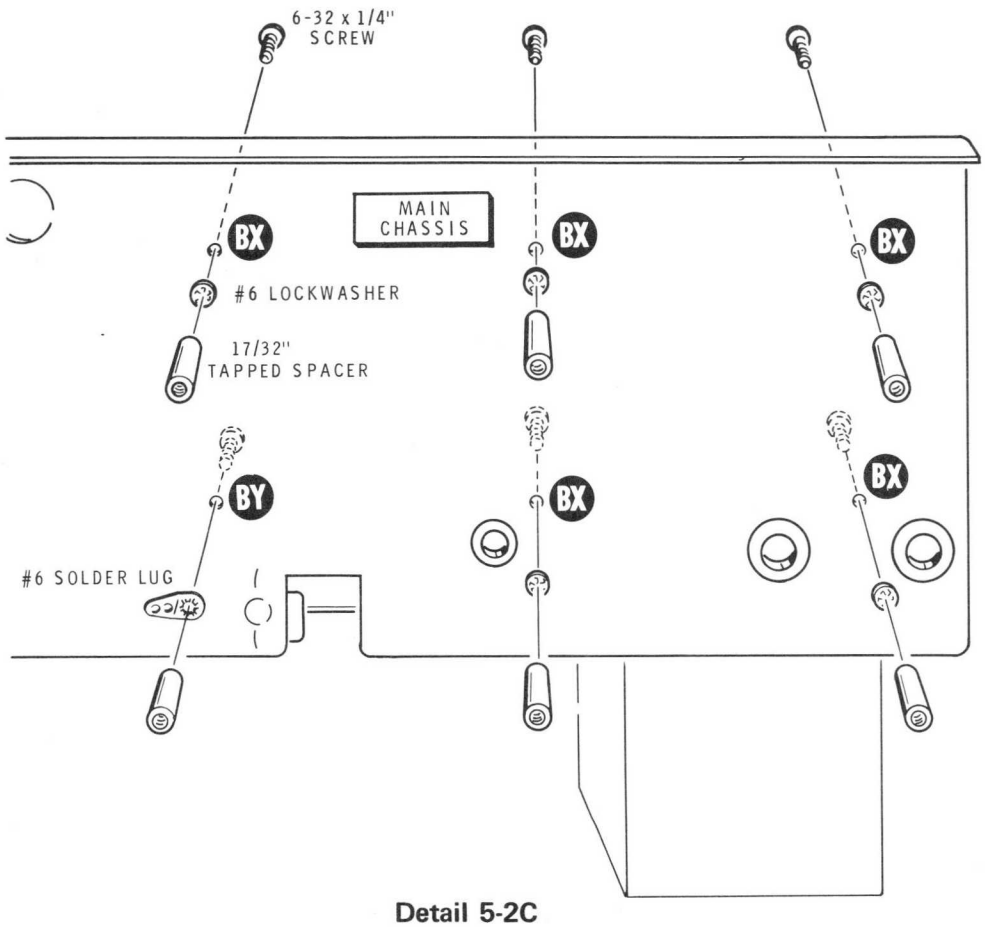
( ) Install five 17/32" spacers at the five chassis locations marked BX. Use 6-32 x 1/4" screws and #6 lockwashers as shown in Detail 5-2C.

( ) Install one 17/32" spacer at BY with a #6 solder lug and a 6-32 x 1/4" screw as shown.

Set the chassis assembly aside temporarily.



Detail 5-2B

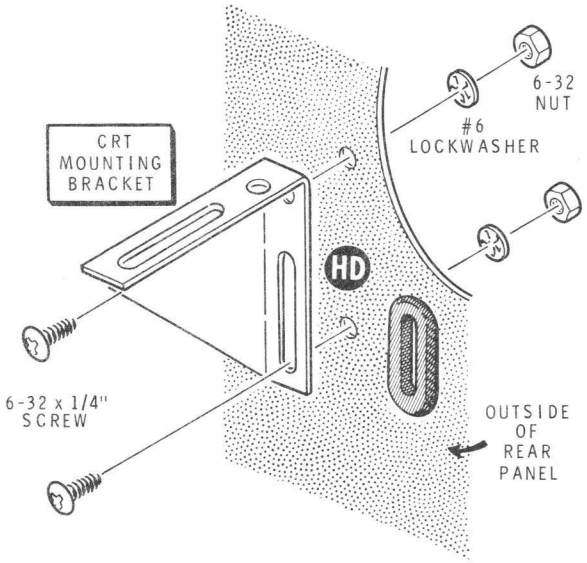


Detail 5-2C

REAR PANEL ASSEMBLY

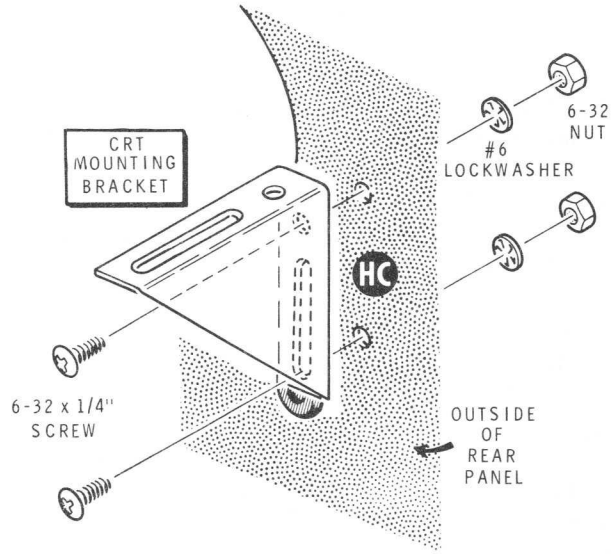
Refer to Pictorial 6-1 (fold-out from Page 47) for the following steps.

( ) Install 3/4" grommets at HA and HB.



Detail 6-1A

( ) Mount a CRT mounting bracket at HD on the outside of the rear panel with 6-32 x 1/4" hardware as shown in Detail 6-1A.

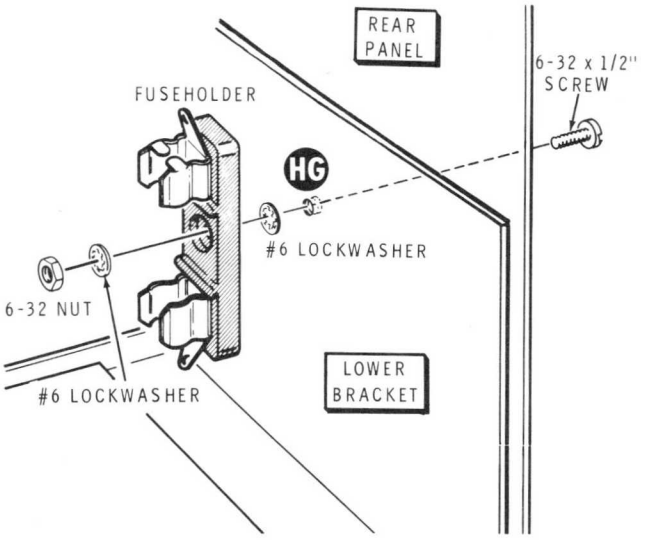


Detail 6-1B

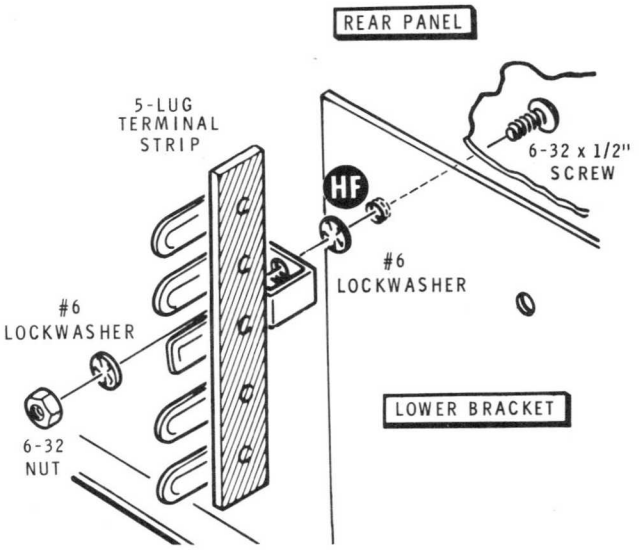
( ) Mount another CRT mounting bracket at HC as shown in Detail 6-1B.

( ) Position the lower bracket (#200-630) against the rear panel as shown in the Pictorial.

( ) Refer to Detail 6-1C and loosely mount the fuseholder at HG with 6-32 x 1/2" hardware.



Detail 6-1C



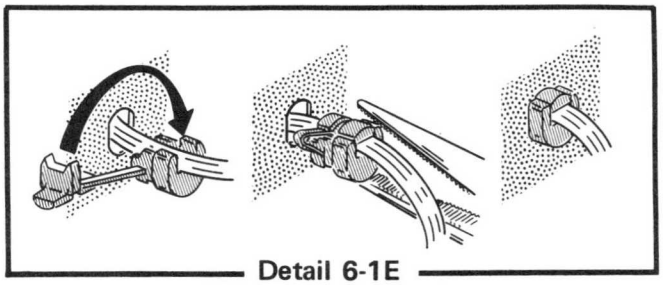
Detail 6-1D

( ) Refer to Detail 6-1D and loosely mount a 5-lug terminal strip at HF with 6-32 x 1/2" hardware. Position the terminal strip as shown in the Pictorial.

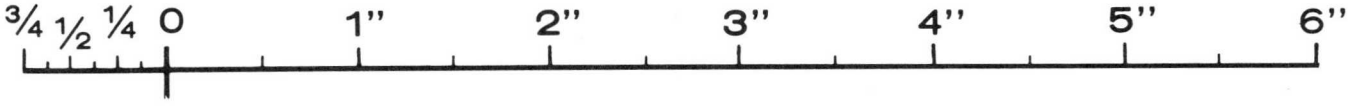
( ) Space the edge of the lower bracket parallel to the edge of the rear panel. Then tighten the fuseholder and terminal strip screws.

( ) Prepare the line cord as follows: Separate the wires for 2-1/2"; then twist the wire ends tightly and apply a small amount of solder to each wire end to hold the strands together.

( ) Pass the line cord wire ends 3-1/2" through the rear panel at HE. Refer to Detail 6-1E and install a strain relief on the line cord and install it in the rear panel as shown.



Detail 6-1E

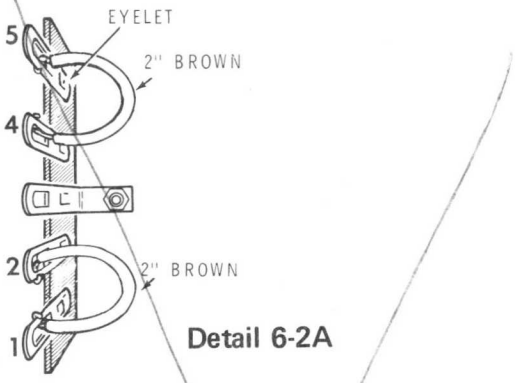


ALTERNATE LINE VOLTAGE WIRING

Refer to Pictorial 6-2 (fold-out from this page) for the following steps.

Two sets of line voltage wiring instructions are given below, one for 120 Vac line voltage and the other for 240 Vac line voltage. In the United States, 120 Vac is most often used, while in countries other than the United States 240 Vac is more common. USE ONLY THE INSTRUCTIONS THAT AGREE WITH THE LINE VOLTAGE IN YOUR AREA.

120 Vac Wiring



Detail 6-2A

( ) Temporarily refer to Detail 8-1A and Page 56 and cut two 2" lengths of stranded brown wire from the indicated leads at BO#8 of the wire harness.

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

Prepare the two lengths of brown wire cut off the wiring harness as follows:

( ) Remove 1/4" of insulation from the ends of both wires.

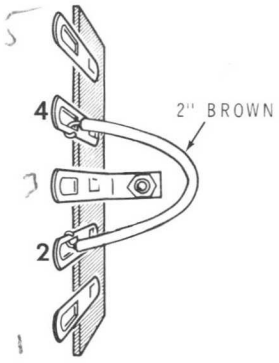
( ) Twist the bare wire strands together and melt a small amount of solder on the four ends to hold the strands together.

NOTE: In the following steps, be sure to wrap the wire ends firmly around the terminal strip lugs to assure a good mechanical connection.

( ) Connect a 2" length of brown wire between lug 1 (NS) and lug 2 (NS) of terminal strip HF.

( ) Connect a 2" length of brown wire between lug 4 (NS) and lug 5 (NS) of terminal strip HF.

240 Vac Wiring



Detail 6-2B

( ) Temporarily refer to Detail 8-1A on Page 56 and cut two 2" lengths of stranded brown wire from the indicated leads at BO#8 of the wire harness.

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

( ) Prepare one 2" length of brown wire from the wiring harness by removing 1/4" of insulation from each end. Discard the second 2" length of brown wire.

NOTE: In the following step, be sure to wrap the wire ends firmly around the terminal strip lugs to assure a good mechanical connection.

( ) Connect the prepared 2" brown wire between lug 2 (NS) and lug 4 (NS) of terminal strip HF.

( ) Connect the green line cord wire to lug 3 of terminal strip HF (S-1).

( ) Connect the ribbed line cord wire to lug 5 of terminal strip HF (NS).

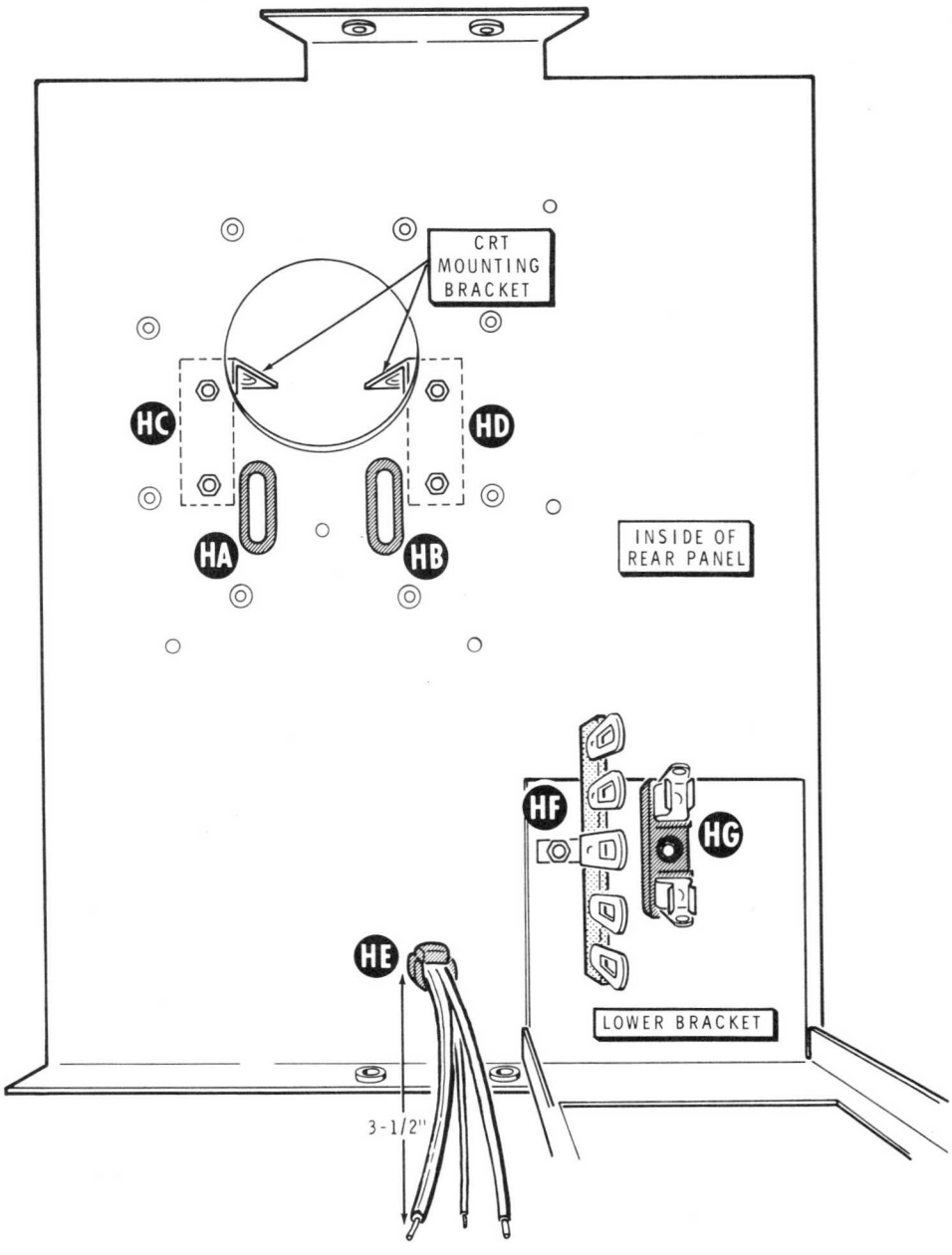
( ) Connect the smooth line cord wire to lug 2 of the fuseholder (S-1).

( ) Pass the following transformer wires down through grommet BK on the main chassis: black, green-black, yellow-black, and red-black.

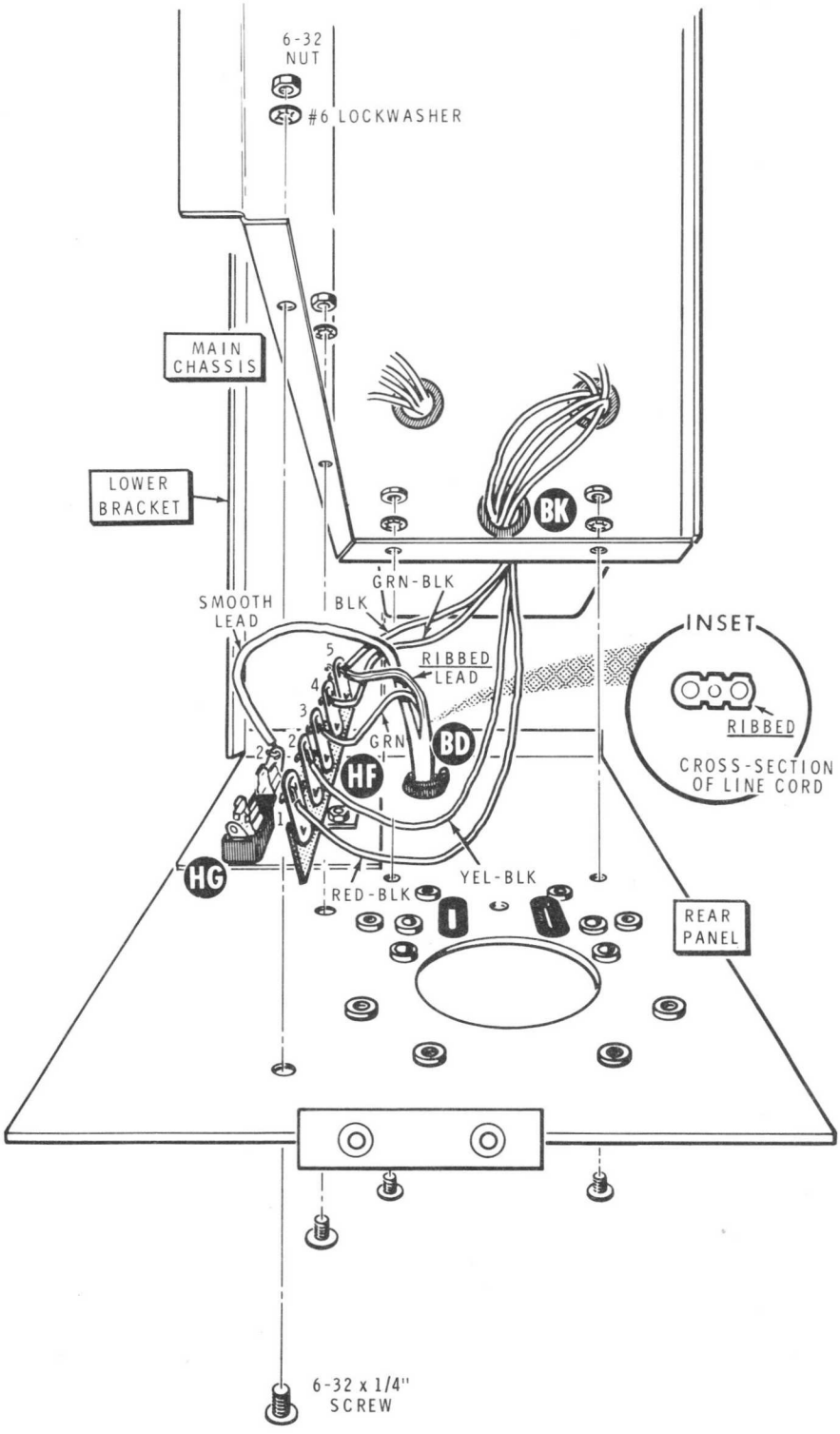
( ) Position the rear panel close to the main chassis as shown in Pictorial 6-2.

Connect the following transformer wires to terminal strip HF as directed:

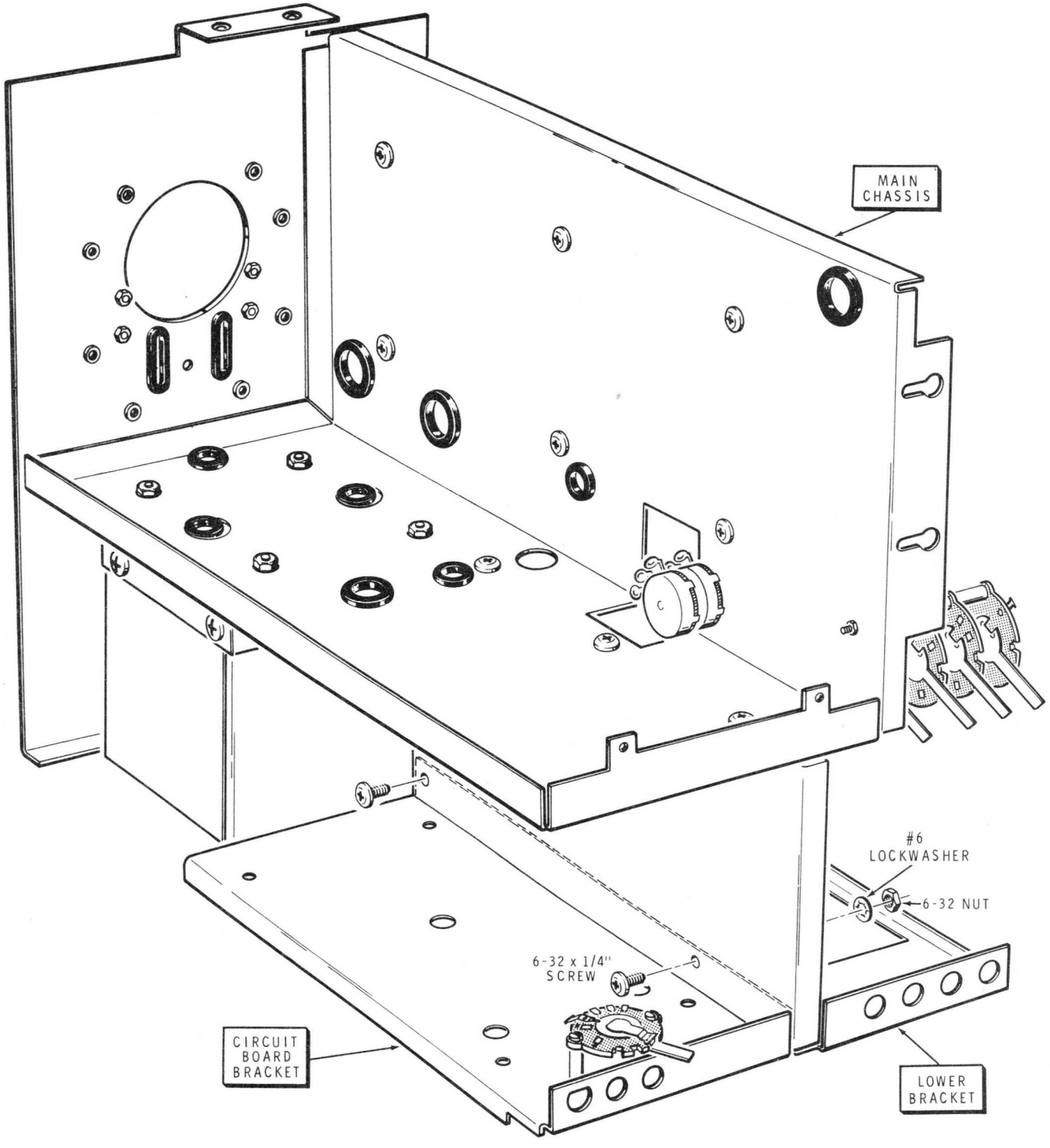
( ) Black to lug 5 (S-3). NOTE: Solder step is (S-2) if your oscilloscope is wired for 240 Vac.



PICTORIAL 6-1



PICTORIAL 6-2



PICTORIAL 6-3

( ) Green-black to lug 4 (S-2).

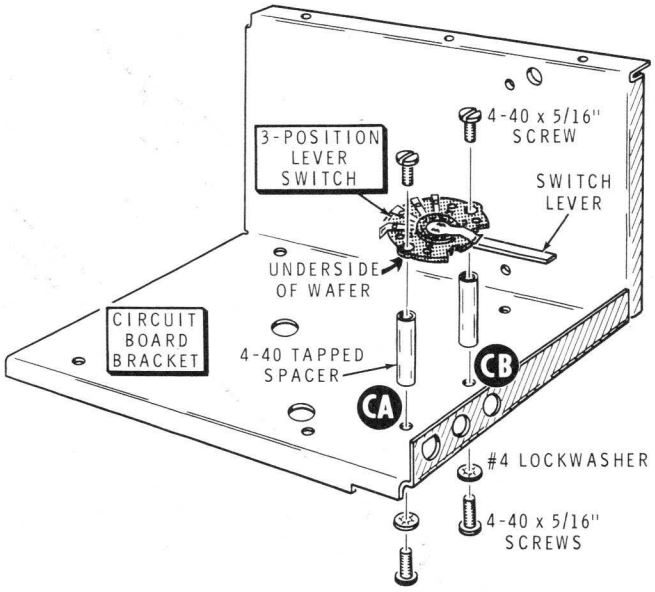
( ) Yellow-black to lug 2 (S-2).

( ) Red-black to lug 1 (NS).

( ) Mount the rear panel onto the main chassis with four 6-32 x 1/4" hardware as shown.

CIRCUIT BOARD BRACKET ASSEMBLY

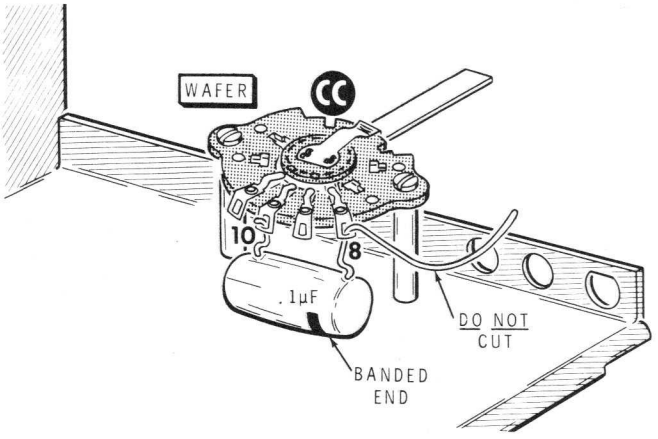
Refer to Pictorial 6-3 (fold-out from Page 48) for the following steps.



Detail 6-3A

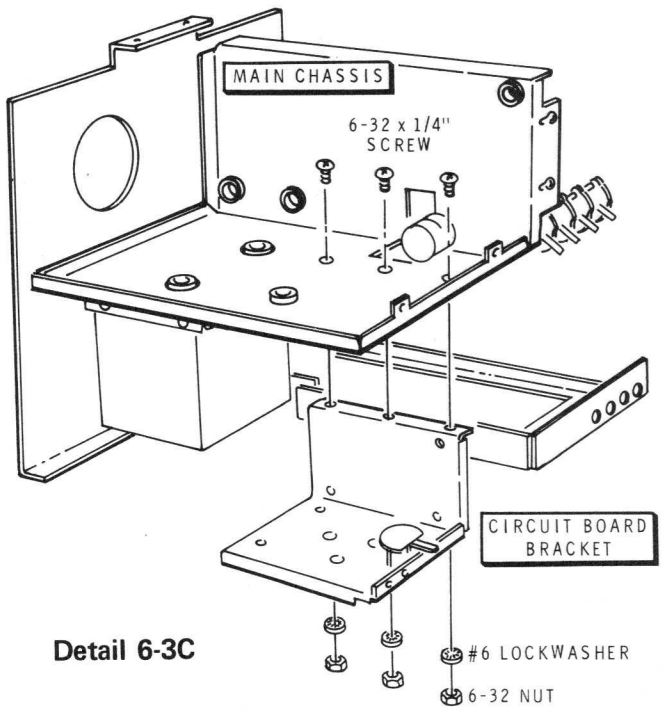
( ) Loosely mount 4-40 tapped spacers at CA and CB on the circuit board bracket with 4-40 x 5/16" hardware as shown in Detail 6-3A.

( ) Mount the 1-wafer lever switch on spacers CA and CB with 4-40 x 5/16" screws. Position the switch wafer so the lugs are toward the bracket and the switch lever emerges from the underside of the wafer. Tighten the screws on the underside of the bracket.



Detail 6-3B

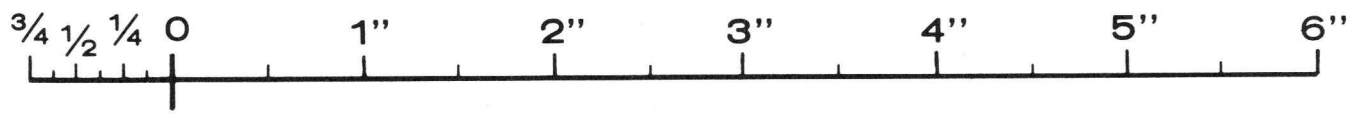
( ) Refer to Detail 6-3B and pass the lead on the banded end of a .1 µF Mylar capacitor through lug 8 of switch CC (S-2). Do not cut this lead. Connect the other capacitor lead to lug 10 of the switch (S-1). Position the capacitor under the switch wafer as shown.

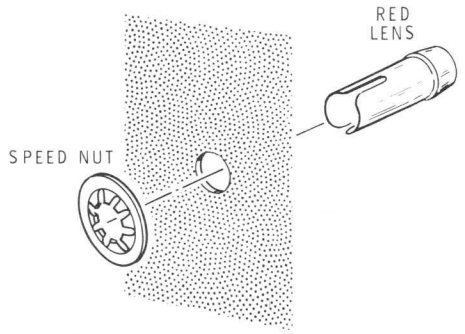


Detail 6-3C

( ) Refer to Detail 6-3C and secure the circuit board bracket to the main chassis with 6-32 x 1/4" hardware as shown.

( ) Secure the circuit board bracket to the lower bracket with 6-32 x 1/4" hardware as shown in the Pictorial.



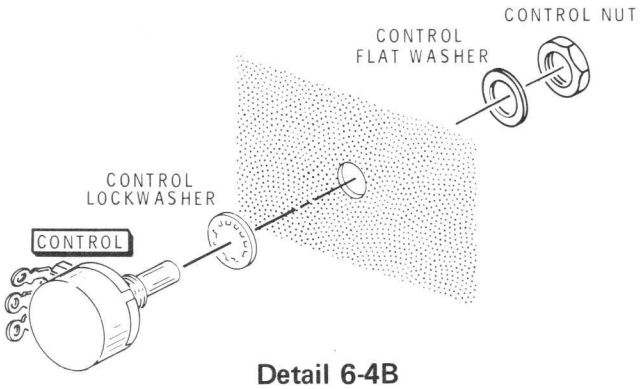


Detail 6-4A

FRONT PANEL PARTS MOUNTING

Refer to Pictorial 6-4 (fold-out from Page 51) for the following steps.

( ) Refer to Detail 6-4A and mount a red lens at A as shown. Secure it in place by pushing the Speed Nut onto the lens.



Detail 6-4B

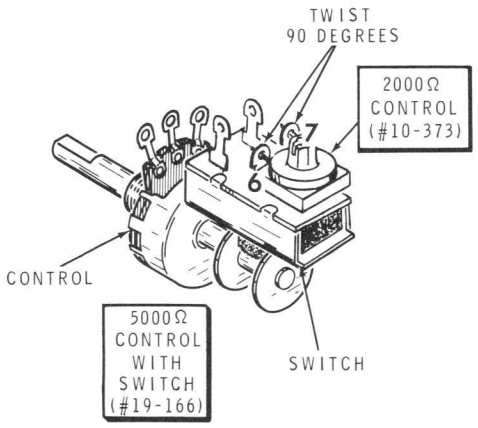
Refer to Detail 6-4B for the following steps.

( ) Mount a 200 Ω control (#11-80) at B with control hardware as shown.

( ) Mount a 250 kΩ control (#10-267) at D with control hardware as shown.

( ) Mount a 5000 Ω/10 kΩ dual control (#12-92) at AA with control hardware as shown.

( ) Mount 5/16" grommets at N and P.



Detail 6-4C

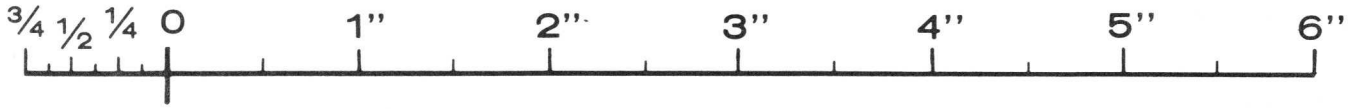
Refer to Detail 6-4C for the following steps.

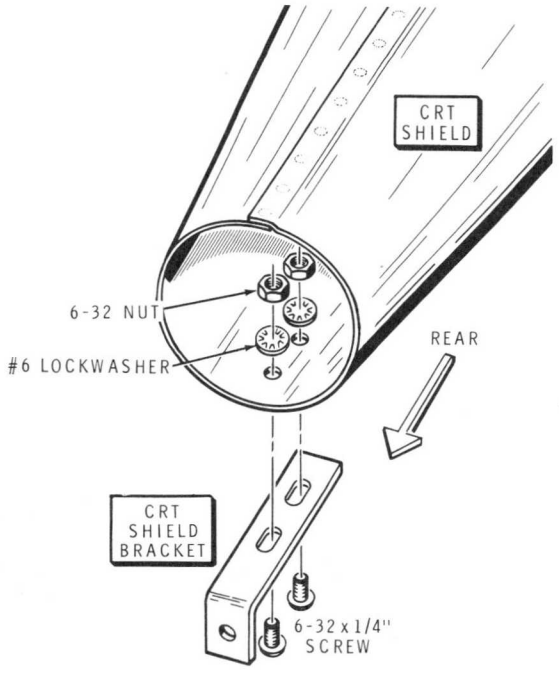
( ) Locate the 5000 Ω control with switch (#19-166). Twist lugs 6 and 7 of the switch 90 degrees as shown.

( ) Connect the 2000 Ω (2 kΩ) control (#10-373) between switch lugs 6 (S-1) and 7 (S-1). Hold the control as close as possible to the switch lugs while soldering the leads. Then cut off the excess lead lengths.

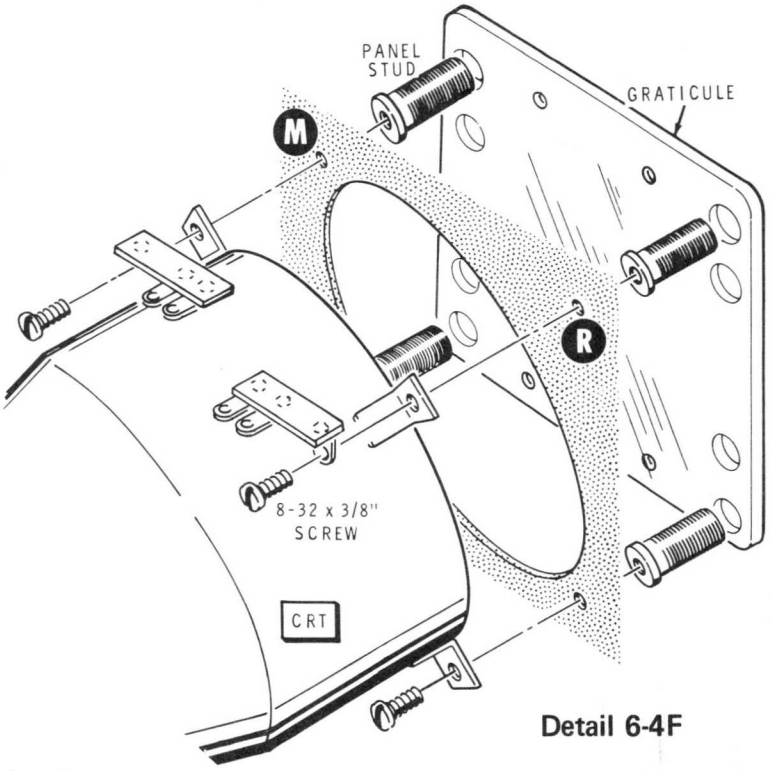
( ) Refer to Pictorial 6-4 and mount the 5000 Ω control with switch assembly at Y on the front panel as shown. Use a control lockwasher, a control flat washer, and a control nut.

( ) Refer to Detail 6-4D and mount the CRT shield bracket to the CRT shield with 6-32 x 1/4" hardware as shown. Slide the bracket to the rear as far as possible. Then tighten the screws lightly (so you can still move the bracket when you apply pressure); the screws will have a final adjustment later.





Detail 6-4D



Detail 6-4F

( ) Refer to Detail 6-4E (fold-out from this page) and mount the CRT shield on the front panel as shown. Be sure the CRT shield bracket at the rear is pointing downward. Loosely secure the CRT shield at S and X with 8-32 x 3/8" screws and panel studs.

( ) Loosely mount a 2-lug terminal strip (with the foot positioned to the left) at M with an 8-32 screw and a panel stud. Position the terminal strip as shown in Pictorial 6-4.

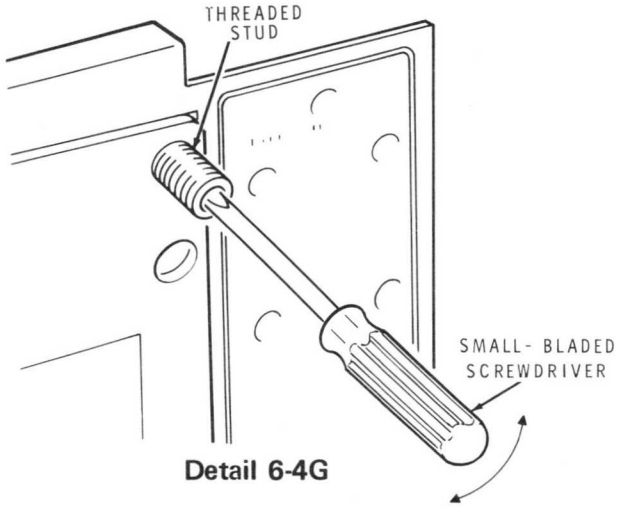
( ) Loosely mount a 2-lug terminal strip (with the foot positioned to the right) at R with an 8-32 x 3/8" screw and a panel stud. Position the terminal strip as shown in the Pictorial.

( ) Locate the graticule (#414-23).

( ) Mount the graticule on the front panel studs as shown in Detail 6-4F. Tighten the 8-32 x 3/8" screw slightly; then check the graticule to see that it slides easily off and onto the studs. If necessary, use a small-bladed screwdriver as shown in Detail 6-4G and reposition the studs slightly. Then recheck the graticule to see that it slides easily off and onto the mounting studs.

( ) Tighten the mounting screws securely.

Set the graticule aside temporarily.



Detail 6-4G

Refer to Pictorial 6-5 (fold-out from this page) for the following steps.

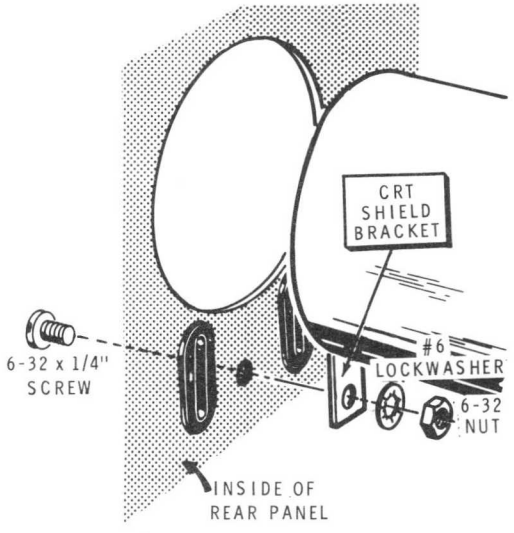
NOTE: As a result of tightening the screws in the following step, the CRT shield bracket (against the rear panel) will be pressed forward slightly and will be in its final position. It will be necessary to temporarily mount the front panel in order to tighten the CRT shield bracket screws.

( ) Carefully align the lever switches with their slots in the front panel and secure the front panel to the chassis with two 6-32 x 1/4" screws as shown.

( ) Remove the two screws holding the front panel to the chassis, and lift the front panel from the chassis.

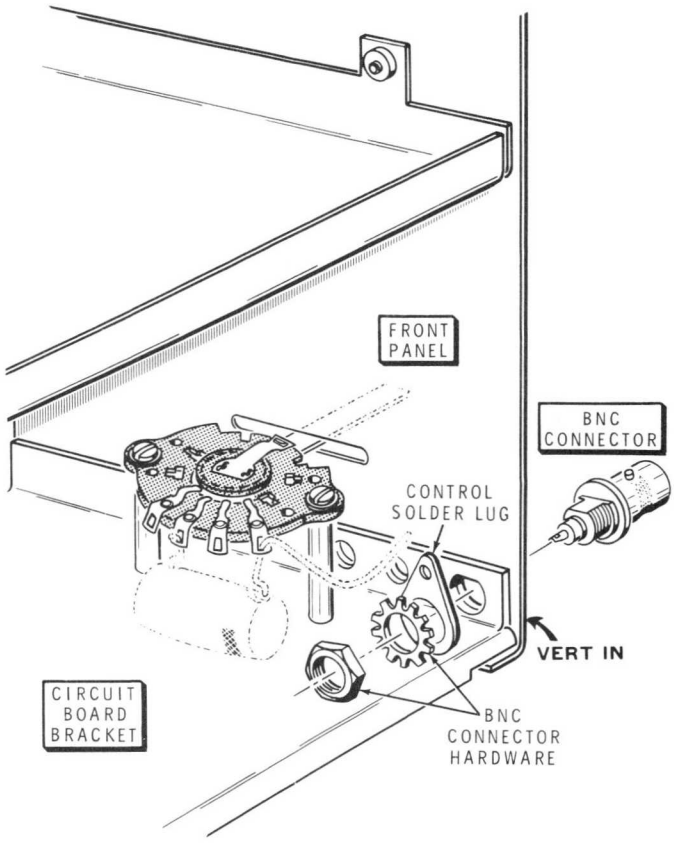
( ) Securely tighten the two screws holding the CRT shield bracket to the CRT shield.

( ) Once again, place the front panel onto the chassis as shown in the Pictorial, and loosely secure it with the two 6-32 x 1/4" screws.



Detail 6-5A

( ) Refer to Detail 6-5A and secure the CRT shield bracket to the rear panel with 6-32 x 1/4" hardware as shown.

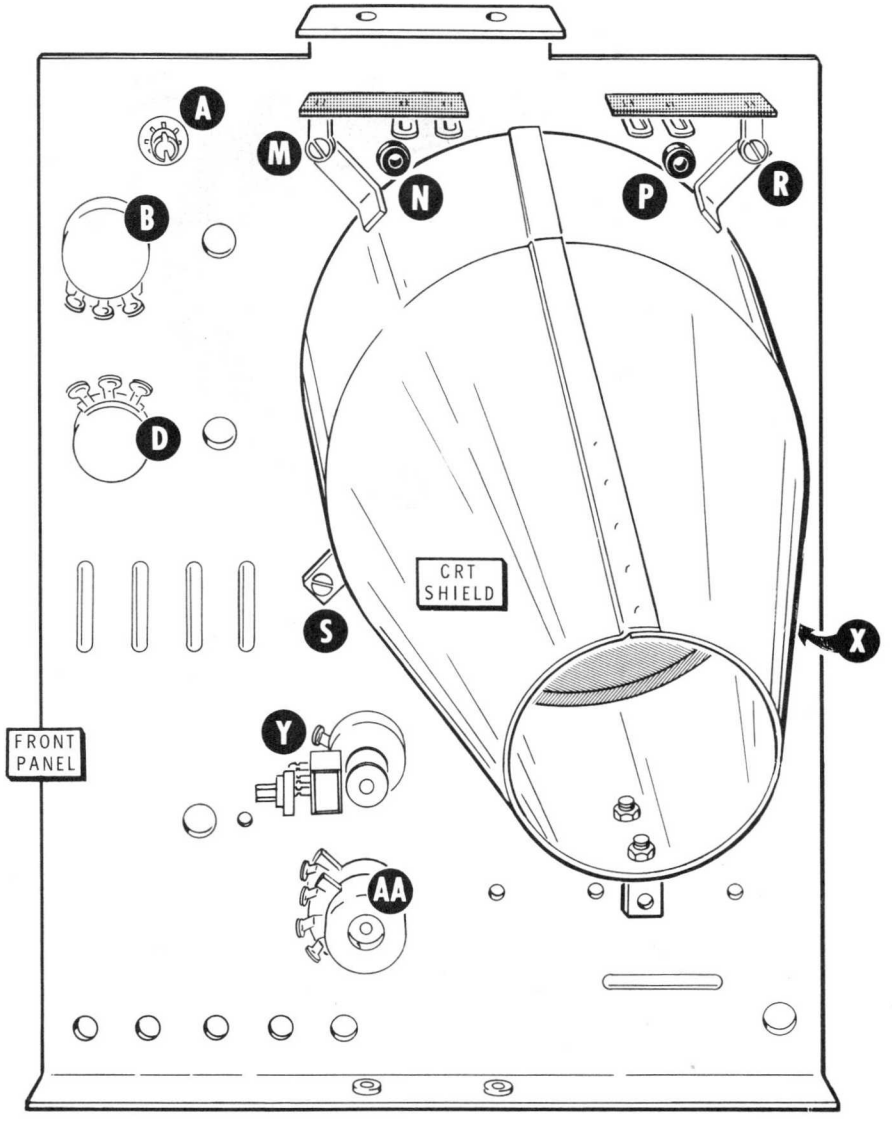


Detail 6-6A

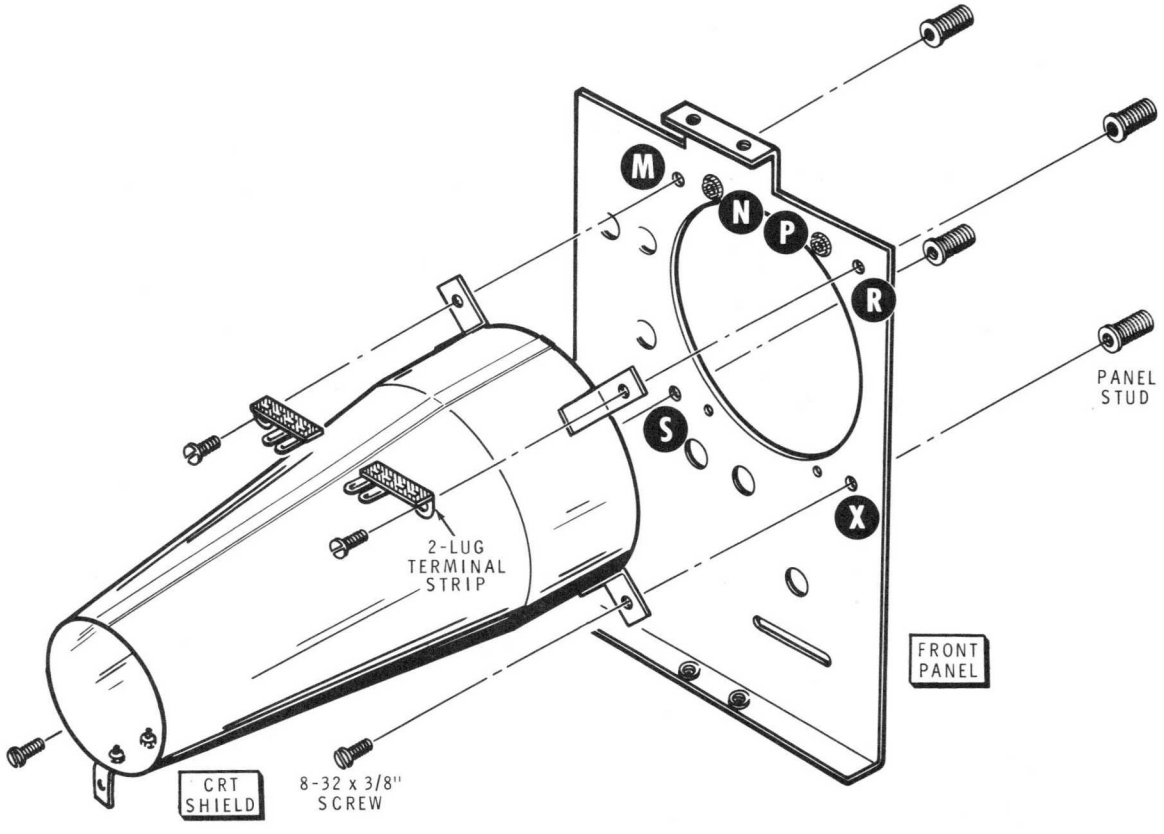
Refer to Pictorial 6-6 (fold-out from this page) for the following steps.

( ) Refer to Detail 6-6A and install a BNC connector at the VERT IN location on the front panel. Use the hardware supplied with the connector and a control solder lug. Do not tighten the nut.

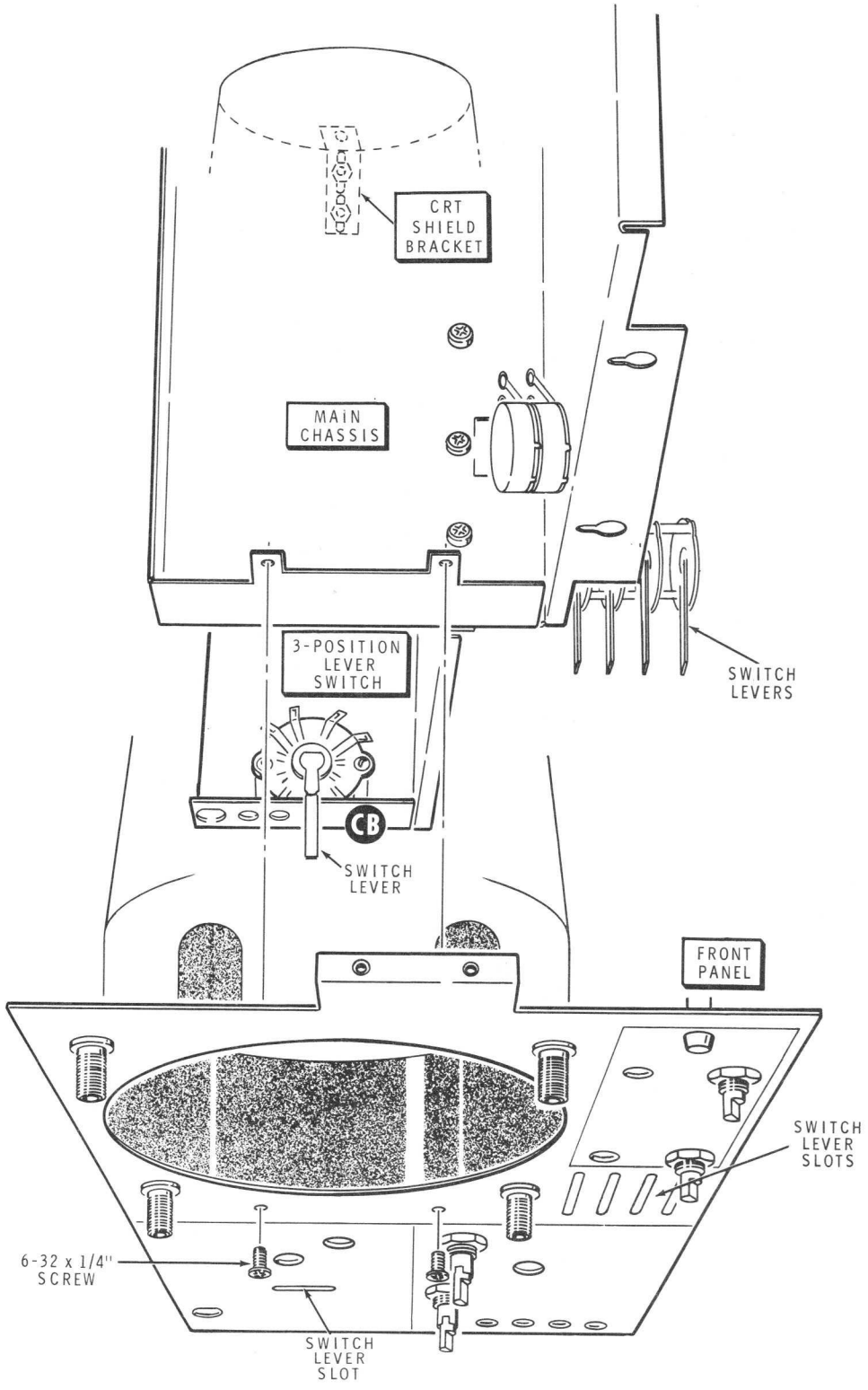
( ) Install a 250 kΩ control with switch (#19-149) at BC in the main chassis and through the front panel. Use a control flat washer and a control nut as shown in Detail 6-6B. Position the three control lugs downward. Do not tighten the control nut.



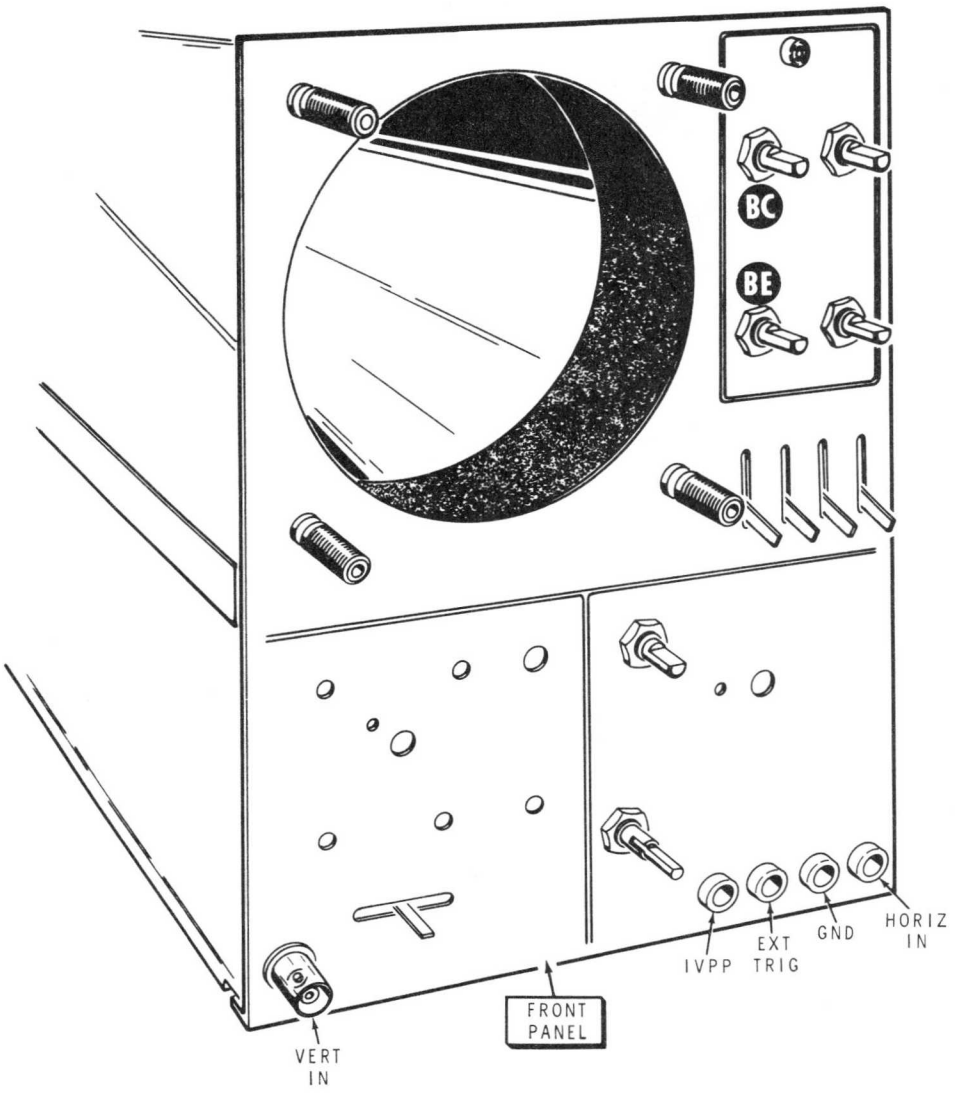
PICTORIAL 6-4


M
N
P
R
S
X
PANEL
STUD
2-LUG
TERMINAL
STRIP
FRONT
PANEL
CRT
SHIELD
8-32 x 3/8"
SCREW

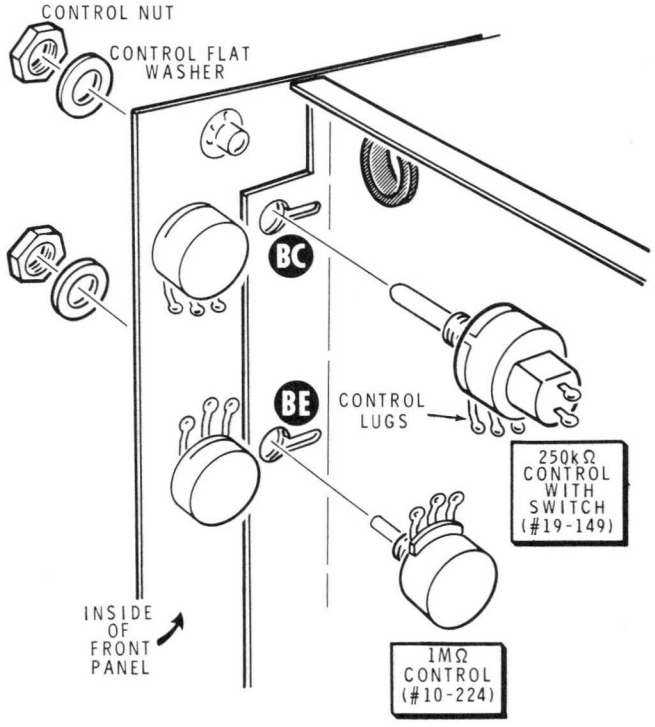
Detail 6-4E



PICTORIAL 6-5



PICTORIAL 6-6



Detail 6-6B

( ) Install a 1 MΩ control (#10-224) at BE as shown in the Pictorial with a control flat washer and a control nut. Position the control lugs upward, then tighten this and the control nut in the previous step securely.

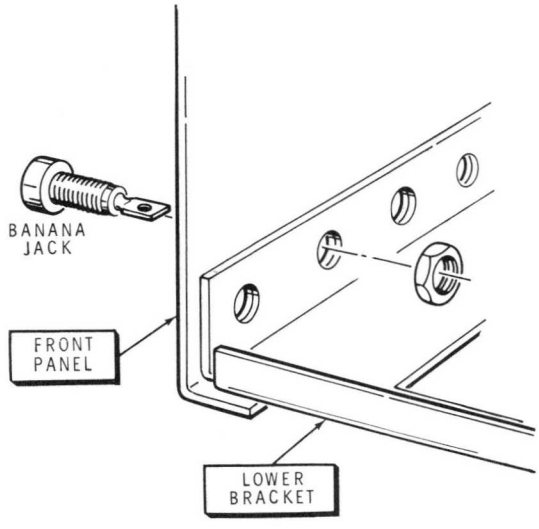
( ) Tighten the two front panel screws and the BNC connector nut.

Refer to Detail 6-6C for the following steps.

( ) Locate the hole labeled GND in the lower right edge of the front panel. Install a black banana jack (#436-22) in this hole; then loosely fasten the jack to the front panel and lower bracket with the nut supplied with the jack.

( ) In the same manner, install the three red banana jacks (#436-11) at 1VPP, EXT TRIG, and HORIZ IN.

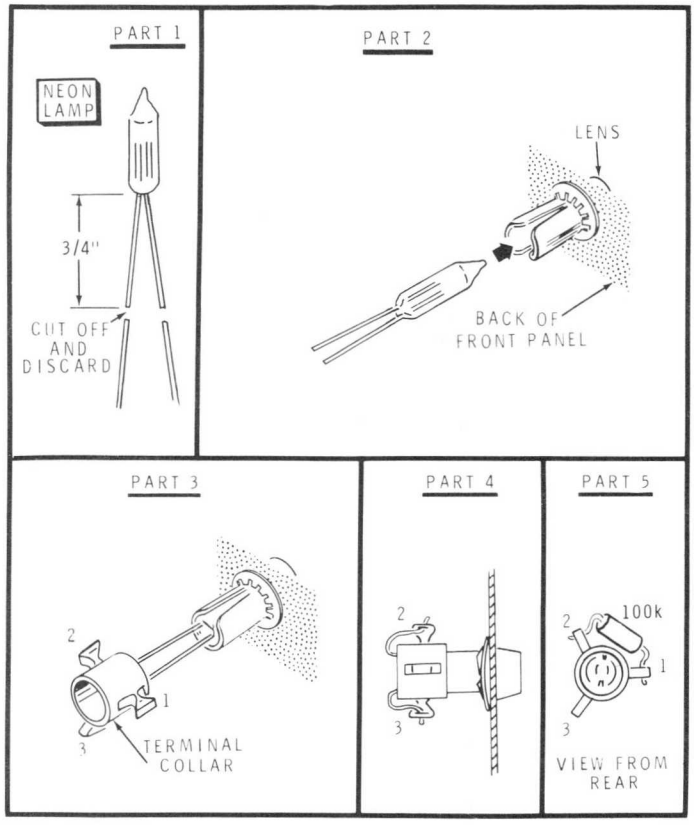
( ) Tighten the nuts on all four banana jacks securely.



Detail 6-6C

FRONT PANEL WIRING

Refer to Pictorial 7-1 (fold-out from Page 55) and Detail 7-1A for the following steps. Detail 7-1A is divided into parts, and each step will refer to one of these parts.



Detail 7-1A

( ) Refer to Part 1 and cut the leads of the neon lamp to a length of 3/4".

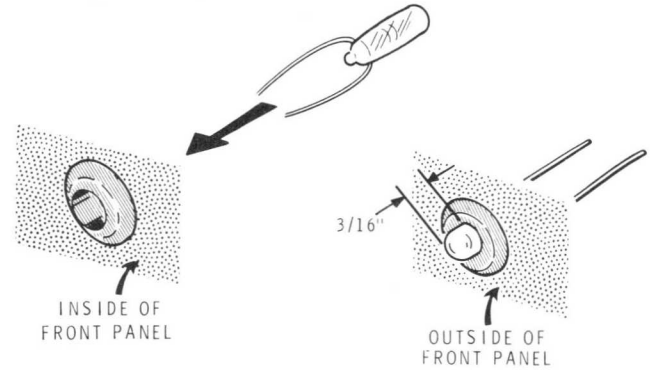
( ) Refer to Part 2 and insert the lamp as far as it will go into the lens at A.

( ) Position the terminal collar as shown in the Pictorial and in Part 3 of the Detail, and push the collar onto the lens until the ends of the collar and lens are flush with each other as shown in Part 4.

( ) Refer to the Pictorial and Part 4 of the Detail and connect one lamp lead to lug 2 (NS) and the other lamp lead to lug 3 (NS) of the terminal collar.

( ) Refer to Part 5 and connect a 100 kΩ (brown-black-yellow), 1/4-watt resistor between lug 1 (NS) and lug 2 (S-2) of the terminal collar. Cut off any excess lead lengths.

( ) Locate the two incandescent lamps (#412-31).



Detail 7-1B

( ) Refer to Detail 7-1B and place one of these lamps into grommet P. Install the lamp so that 3/16" of the bulb protrudes from the front of the grommet.

( ) Connect one lamp lead to the eyelet of lug 1 (S-1) and the other lamp lead to the eyelet of lug 2 (S-1) of terminal strip R.

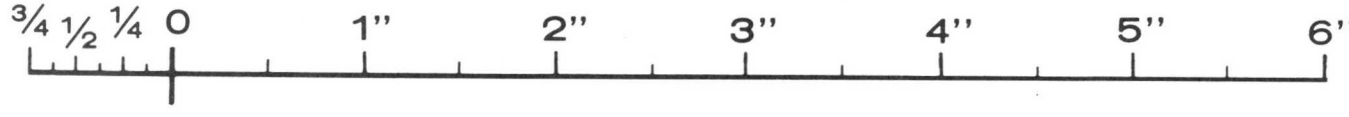
( ) In the same manner, install the other incandescent lamp into grommet N. Leave 3/16" of the bulb of this lamp protruding from the front of the grommet.

( ) Connect one lamp lead to the eyelet of lug 1 (S-1) and the other lead to the eyelet of lug 2 of terminal strip M.

( ) Connect a 470 kΩ, 1-watt resistor from lug 3 of control BC (S-1) to lug 1 of control BE (S-1). Cut off any excess lead lengths.

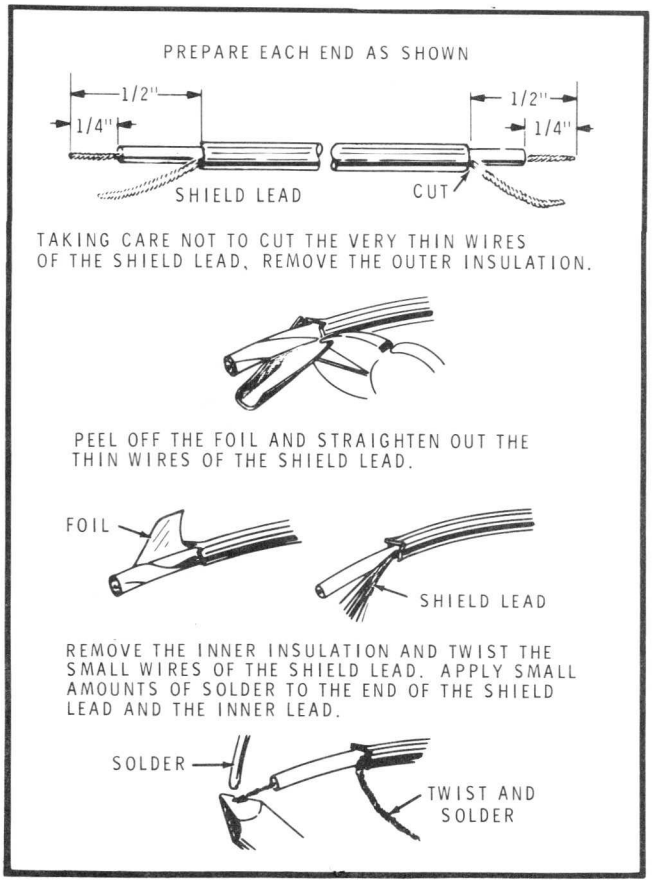
NOTE: When wire is called for, as in the following step, cut the wire to the indicated length and remove 1/4" of insulation from each end.

( ) Connect a 1-3/4" white wire from lug 6 of wafer 2 (S-1) to lug 2 of wafer 1 (NS) of switch BW.



( ) Connect the positive (+) lead of a 47 μF tantalum capacitor to lug 4 (NS), and the other lead to lug 2 (S-2) of wafer 1 of switch BW. Cut off any excess lead lengths.

( ) Pass the lead from the banded end of a .1 μF Mylar capacitor through lug 6 of wafer 4 (S-2) to lug 4 of wafer 3 (S-1) of switch BW. Connect the other capacitor lead to lug 6 of wafer 3 of switch BW (NS).



Detail 7-1C

( ) Refer to Detail 7-1C and prepare an 8" length of shielded cable as shown.

( ) Connect the end of the cable without a shield lead to lug 4 of switch wafer 4 (S-1).

( ) Route the cable close to controls Y and AA as shown and connect the inner lead of the free cable end to banana jack K (S-1). Connect the shield lead to banana jack J (NS).

NOTE: When you are instructed to prepare lengths of wire ahead of time, as in the following step, use the white wire supplied with the kit. To prepare a wire, cut it to the indicated length; then remove 1/4" of insulation from each end.

( ) Prepare the following lengths of wire:

3-1/4"	3-1/2"
4"	3-1/2"
5"	5-1/2"

( ) Connect a 3-1/4" length of wire from lug 1 of terminal strip R (S-1) to lug 2 of terminal strip M (NS).

( ) Connect a 4" length of wire from lug 2 of terminal strip R(S-1) to lug 1 of terminal strip M (NS).

( ) Route a 5" length of wire through grommet BA and connect it from lug 1 of terminal strip M (S-2) to lug 2 of control B (S-1).

( ) Connect a 3-1/2" length of wire from lug 3 of terminal collar A (S-2) to lug 3 of control D (NS).

( ) Connect a 3-1/2" length of wire from lug 1 of terminal collar A (S-2) to lug 1 of control D (NS).

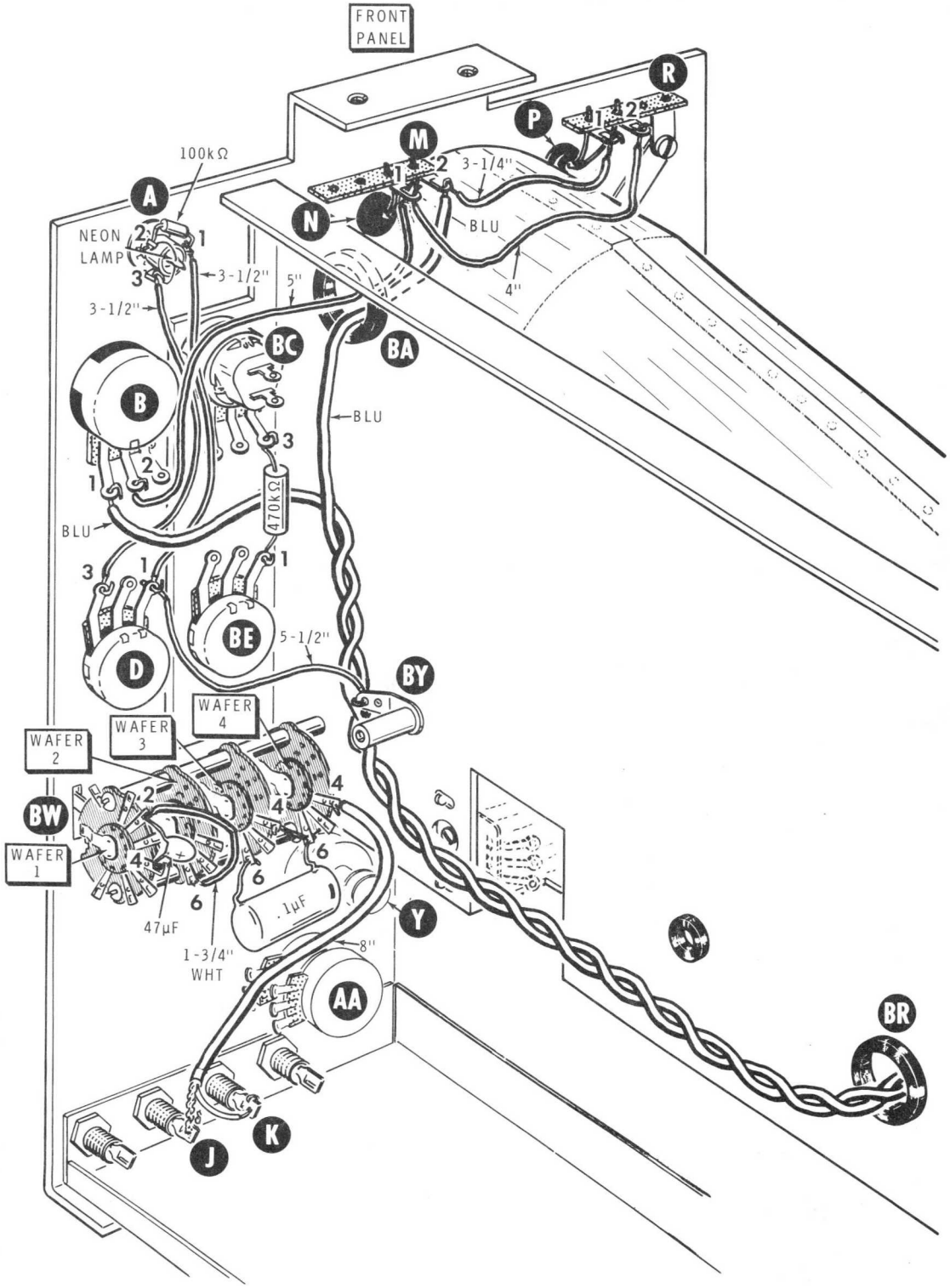
( ) Connect a 5-1/2" length of wire from lug 1 of control D (S-2) to ground lug BY (NS).

( ) Locate the two blue transformer leads at grommet BR on the main chassis. Twist these leads together and route them as shown.

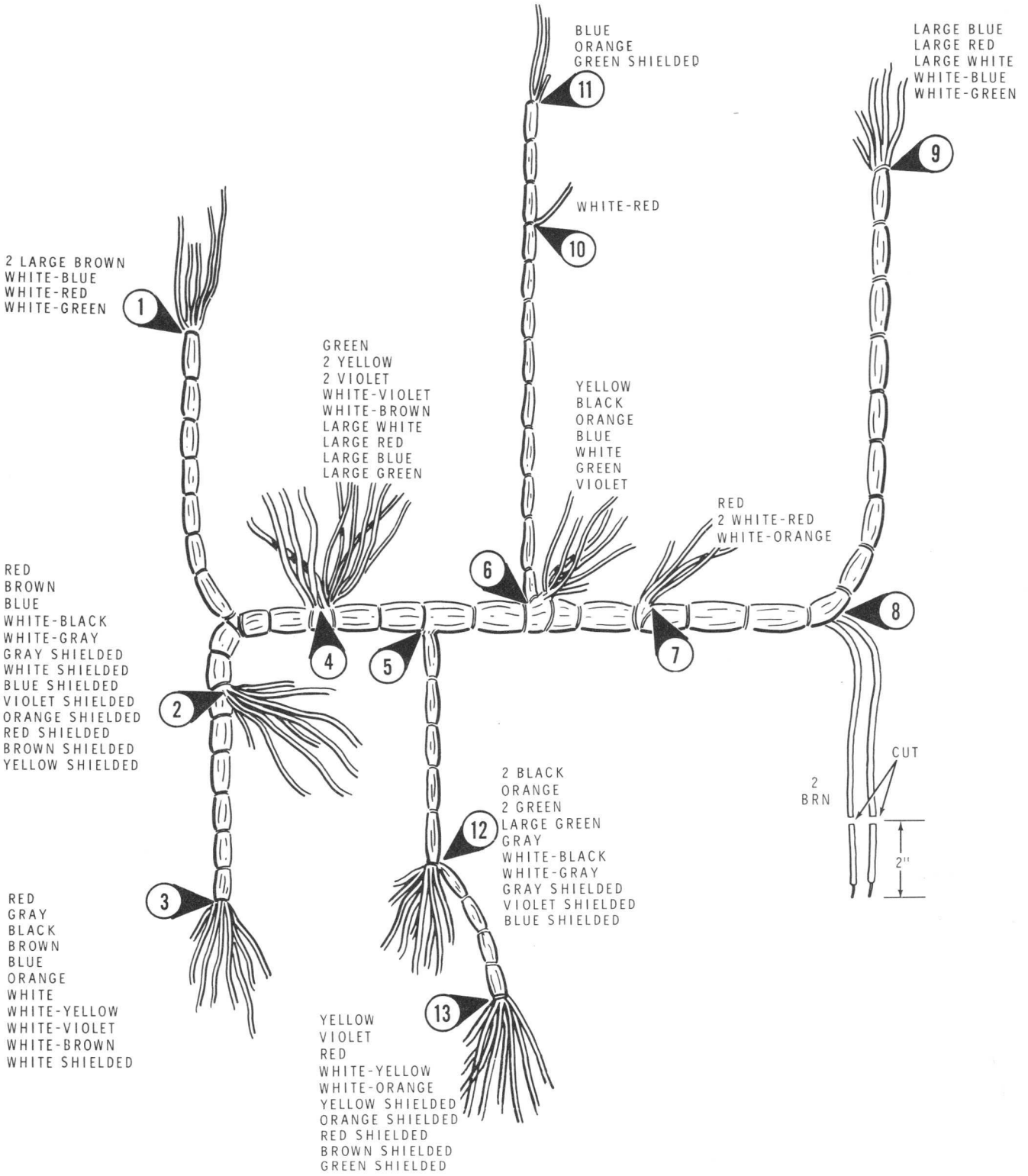
NOTE: After you route the two blue leads to their proper lugs in the following steps, cut off the excess lead lengths. Then remove 1/4" of insulation from each lead end before you connect it to a lug.

( ) Pass one blue transformer lead through grommet BA and connect it to lug 2 of terminal strip M (S-2).

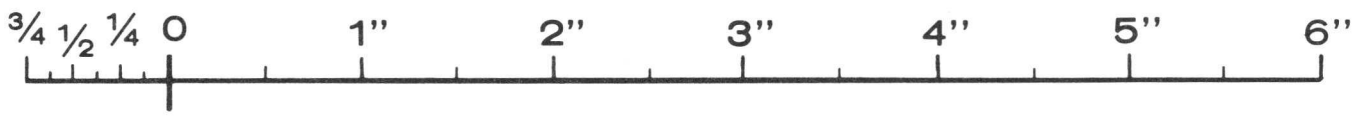
( ) Connect the remaining blue transformer lead to lug 1 of control B (S-1).

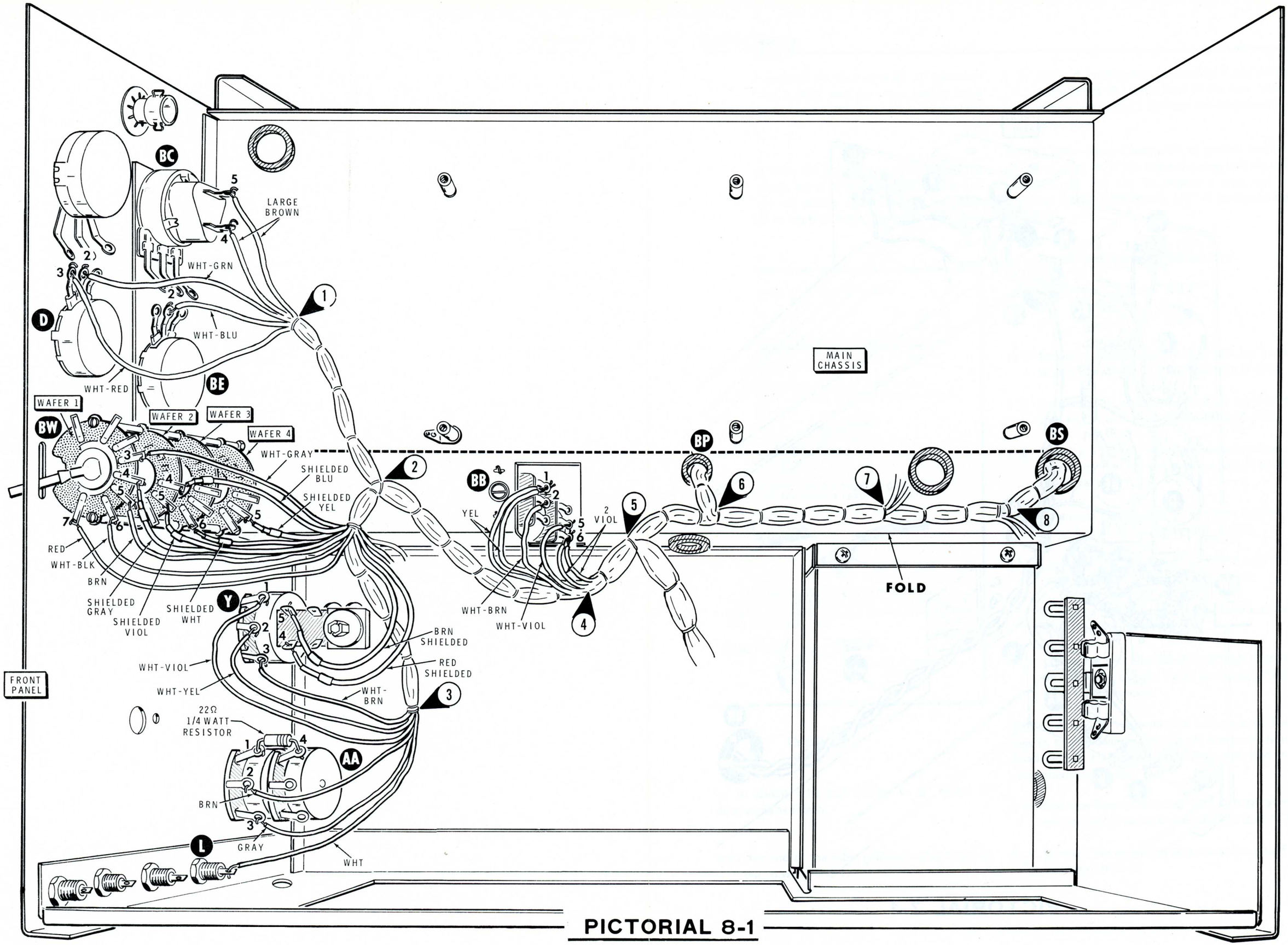


PICTORIAL 7-1


BLUE
ORANGE
GREEN SHIELDED
11
LARGE BLUE
LARGE RED
LARGE WHITE
WHITE-BLUE
WHITE-GREEN
9
WHITE-RED
10
2 LARGE BROWN
WHITE-BLUE
WHITE-RED
WHITE-GREEN
1
GREEN
2 YELLOW
2 VIOLET
WHITE-VIOLET
WHITE-BROWN
LARGE WHITE
LARGE RED
LARGE BLUE
LARGE GREEN
YELLOW
BLACK
ORANGE
BLUE
WHITE
GREEN
VIOLET
RED
2 WHITE-RED
WHITE-ORANGE
6
8
RED
BROWN
BLUE
WHITE-BLACK
WHITE-GRAY
GRAY SHIELDED
WHITE SHIELDED
BLUE SHIELDED
VIOLET SHIELDED
ORANGE SHIELDED
RED SHIELDED
BROWN SHIELDED
YELLOW SHIELDED
4
5
7
2
CUT
2
BRN
2"
2 BLACK
ORANGE
2 GREEN
LARGE GREEN
GRAY
WHITE-BLACK
WHITE-GRAY
GRAY SHIELDED
VIOLET SHIELDED
BLUE SHIELDED
12
RED
GRAY
BLACK
BROWN
BLUE
ORANGE
WHITE
WHITE-YELLOW
WHITE-VIOLET
WHITE-BROWN
WHITE SHIELDED
3
13
YELLOW
VIOLET
RED
WHITE-YELLOW
WHITE-ORANGE
YELLOW SHIELDED
ORANGE SHIELDED
RED SHIELDED
BROWN SHIELDED
GREEN SHIELDED

Detail 8-1A


¾ ½ ¼ 0
1"
2"
3"
4"
5"
6"



PICTORIAL 8-1

WIRE HARNESS INSTALLATION

Refer to Pictorial 8-1 (fold-out from Page 56) for the following steps.

( ) Locate the wire harness and form it as shown in Detail 8-1A. When the wire harness is placed into the kit, Breakouts (BO) 1, 2, and 3 will be toward the front panel.

( ) Install the wire harness as shown in the Pictorial, so the main cable of the harness from front to rear is above the fold in the main chassis, along the heavy dashed line.

( ) Locate the four long wires wrapped together (BO#10 and BO#11) coming from BO#6. Push these wires through grommet BP; they will be connected later.

( ) Similarly, locate the five wires wrapped together at BO#9. Push these wires through grommet BS as shown; they will be connected later.

Connect the wires of BO#1 to the front panel as follows:

( ) Either large brown wire to lug 4 of control BC (S-1).

( ) The other large brown wire to lug 5 of control BC (S-1).

( ) White-blue to lug 2 of control BE (S-1).

( ) White-green to lug 2 of control D (S-1).

( ) White-red to lug 3 of control D (S-2).

Connect the wires of BO#2 as follows:

( ) Yellow shielded cable to lug 5, wafer 4 of switch BW (S-1).

( ) White shielded cable to lug 6, wafer 3 of switch BW (S-2).

( ) Violet shielded cable to lug 5, wafer 2 of switch BW (S-1).

( ) Blue shielded cable to lug 4, wafer 2 of switch BW (S-1).

( ) White-gray to lug 3, wafer 1 of switch BW (S-1).

( ) Gray shielded cable to lug 4, wafer 1 of switch BW (S-2).

( ) Brown shielded cable to lug 5 of control Y (S-1).

( ) Red shielded cable to lug 4 of control Y (S-1).

( ) Brown wire to lug 5, wafer 1 of switch BW (S-1).

( ) White-black wire to lug 6, wafer 1 of switch BW (S-1).

( ) Red wire to lug 7, wafer 1 of switch BW (S-1).

NOTE: The blue wire and the orange shielded cable from BO#2 will be connected later.

( ) Cut both leads of a 22 Ω (red-red-black), 1/4-watt resistor to 1/4". Install this resistor between lug 1 (S-1) and lug 4 (NS) of control AA. Cut off the excess lead length at lug 1.

Connect the wires of BO#3 to the front panel as follows:

( ) White-brown to lug 3 of control Y (S-1).

( ) White-yellow to lug 2 of control Y (S-1).

( ) White-violet to lug 1 of control Y (S-1).

( ) White to banana jack L (S-1).

( ) Brown to lug 2 of control AA (S-1).

( ) Gray to lug 3 of control AA (S-1).

The remaining wires from BO#3 will be connected later.

Connect the wires from BO#4 as follows:

( ) White-violet to lug 5 of control BB (S-1).

( ) Two violet wires to lug 6 of control BB (S-2).

( ) Two yellow wires to lug 1 of control BB (S-2).

( ) White-brown to lug 2 of control BB (S-1).

The remaining wires from BO#4 will be connected later.

POWER SUPPLY FINAL WIRING AND INSTALLATION

Refer to Pictorial 8-2 (fold-out from Page 59) for the following steps.

Prepare and install the following wires on the power supply circuit board. NOTE: The free end of each wire will be connected later.

( ) 2" white wire at A (S-1).

( ) 4" white wire at B (S-1).

( ) 4-1/2" black wire at F (S-1).

( ) 4-1/2" red wire at D (S-1).

NOTE: In the following steps, you will be instructed to connect wires from the wiring harness to the power supply circuit board. Do this by turning the oscilloscope on its side so the working area will be in a horizontal position. Solder each wire to the foil as it is installed and cut off any excess wire lengths.

Connect the wires from BO#4 to the power supply circuit board in the following steps.

( ) Large green to J (S-1).

( ) Large blue to E (S-1).

( ) Large red to K (S-1).

( ) Large white to C (S-1).

NOTE: The green wire will be connected later.

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

( ) Green to L (S-1).

( ) Black to M (S-1).

( ) Violet to N (S-1).

( ) Blue to P (S-1).

( ) Yellow to R (S-1).

( ) Orange to S (S-1).

( ) White to T (S-1).

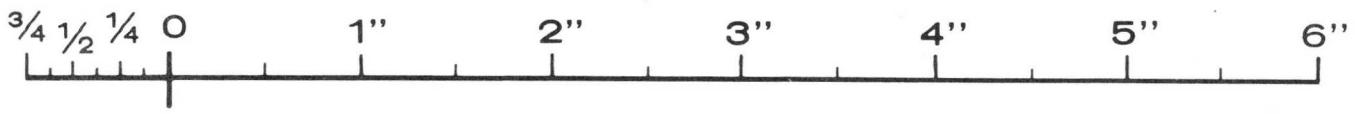
Connect the wires of BO#7 to the power supply circuit board as follows:

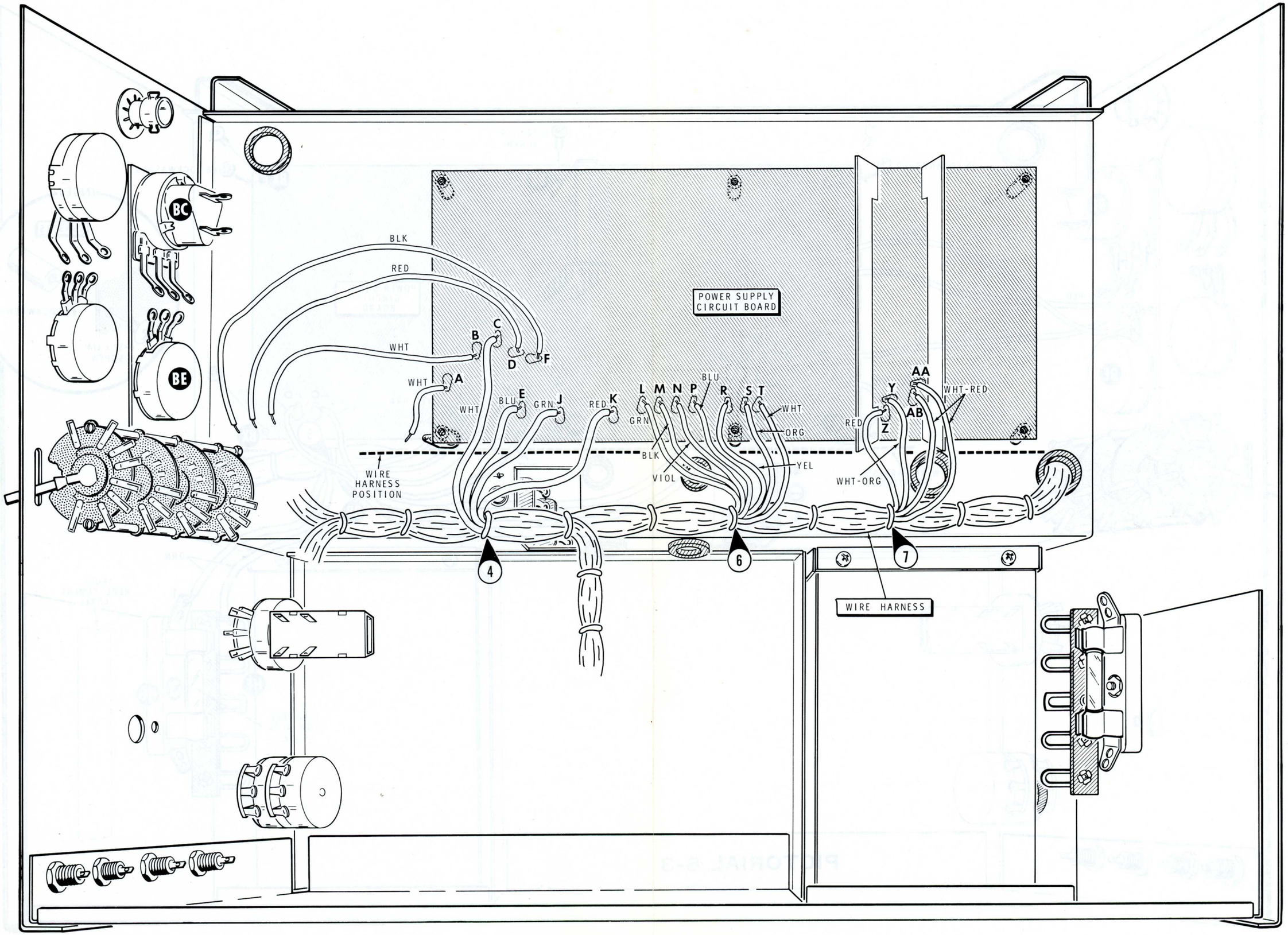
( ) Red to Z (S-1).

( ) White-orange to Y (S-1).

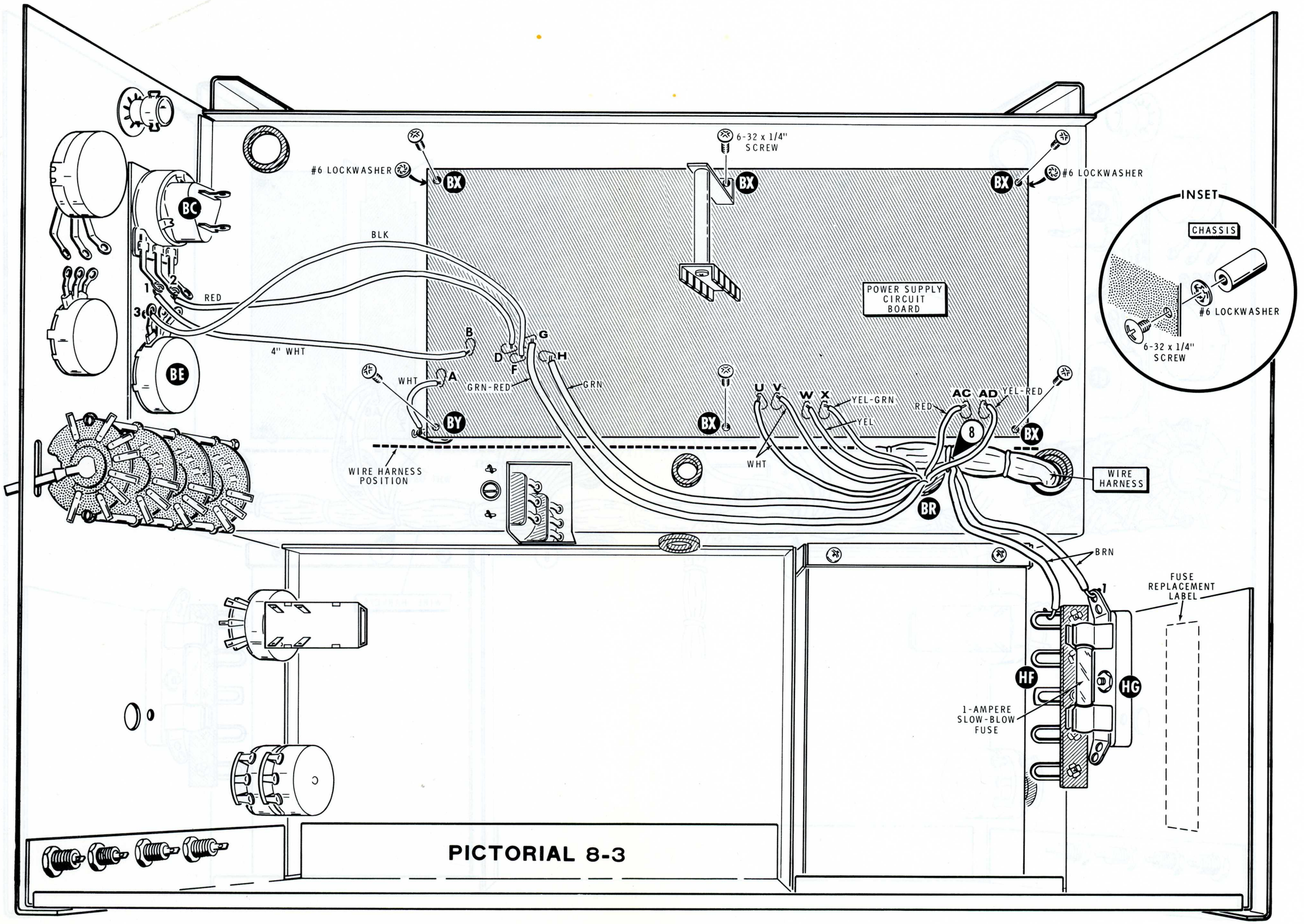
( ) Either white-red to AB (S-1).

( ) The remaining white-red to AA (S-1).





PICTORIAL 8-2



PICTORIAL 8-3

Refer to Pictorial 8-3 (fold-out from Page 60) for the following steps.

Connect the power transformer leads coming from grommet BR to the power supply circuit board in the following steps. Solder each lead as it is installed and cut off any excess lead lengths.

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

( ) Yellow-red to hole AD (S-1).

( ) Yellow-green to hole X (S-1).

( ) Yellow to hole W (S-1).

( ) Either white to hole V (S-1).

( ) The other white lead to hole U (S-1).

( ) Green to hole H (S-1).

( ) Green-red to hole G (S-1).

Connect the following two wires coming from BO#8 of the wire harness.

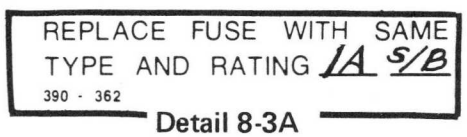
( ) Remove 1/4" of insulation from each of the brown wires. Add a small amount of solder to hold the small strands together.

( ) Either brown to lug 1 of terminal strip HF (S-3). NOTE: The solder step is (S-2) if your oscilloscope is wired for 240 Vac.

( ) The other brown wire to lug 1 of fuseholder HG (S-1).

( ) Install a 1-ampere slow-blow fuse in fuseholder HG.

NOTE: If your Oscilloscope is wired for 240 volts, install a 1/2-ampere, slow-blow fuse (not supplied) in fuseholder HG.



Detail 8-3A

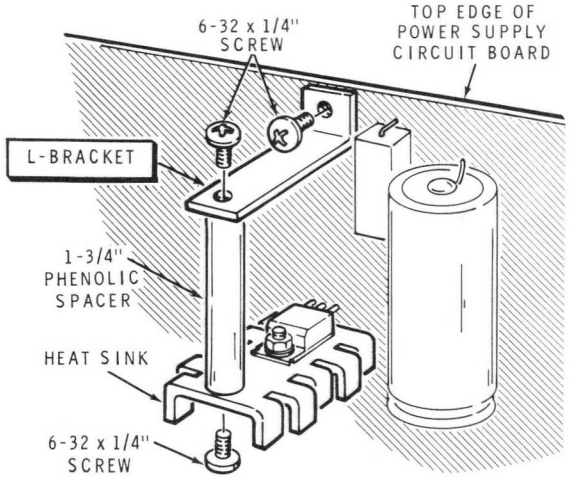
( ) Locate the fuse replacement label (#390-362). Write the size and type of fuse you are using in the space provided on the label; for example, "1-A, S/B." See Detail 8-3A.

( ) Remove the paper backing from the fuse replacement label and place it along side the fuseholder as shown in Pictorial 8-3.

Refer to the inset drawing on Pictorial 8-3 and install the power supply circuit board on the chassis in the following manner:

( ) Place a #6 lockwasher between each of the two spacers and the circuit board at the upper right and upper left corners of the circuit board. Just start the two 6-32 x 1/4" screws into the spacers.

( ) Secure the lower edge of the power supply circuit board with three 6-32 x 1/4" screws. Tighten these screws securely.



Detail 8-3B

Refer to Detail 8-3B for the following steps.

( ) Install a 1-3/4" phenolic spacer on the top of the heat sink with a 6-32 x 1/4" screw.

( ) Loosely mount the L-bracket on the top edge of the power supply circuit board as shown in Pictorial 8-3. Use a 6-32 x 1/4" screw.

( ) Tighten the top two corner screws securely.

( ) Fasten the top of the L-bracket to the 1-3/4" phenolic spacer from Q401 with a 6-32 x 1/4" screw as shown in the Pictorial.

( ) Tighten the three 6-32 x 1/4" spacer and L-bracket mounting screws.

Connect the wires coming from the power supply circuit board in the following steps. As each wire is connected, solder it to the designated point and cut off any excess wire lengths.

( ) White wire from A to ground lug BY (S-2).

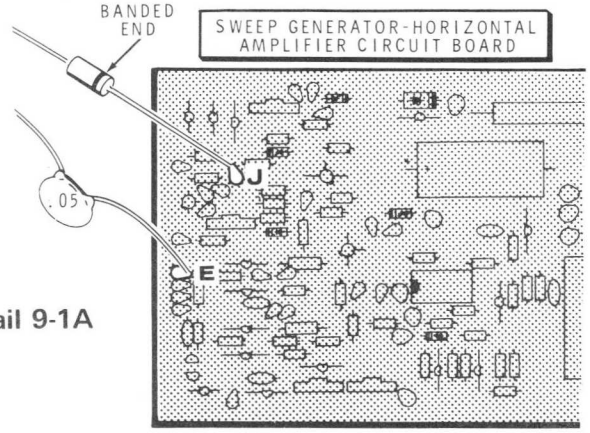
( ) White wire from B to lug 1 of control BC (S-1).

( ) Red wire from D to lug 2 of control BC (S-1).

( ) Black wire from F to lug 3 of control BE (S-1).

SWEEP GENERATOR-HORIZONTAL AMPLIFIER WIRING

Refer to Pictorial 9-1 (fold-out from Page 63) for the following steps.



Detail 9-1A

NOTE: When you install components in the next two steps, push just the tip of the lead through the circuit board; then solder the lead to the foil. Do not cut either lead of the components; they will be connected later. Refer to Detail 9-1A for the following steps.

( ) Connect the banded end of a 1N191 diode (#56-26) to J on the sweep generator-horizontal amplifier circuit board (S-1).

( ) Install one lead of a .05 μF disc capacitor at E on the circuit board (S-1).

Prepare and install the indicated lengths of hookup wire in the following steps. The free ends will be connected later. After each wire has been soldered to the foil, cut off any excess wire lengths.

( ) 1-1/2" white wire to F (S-1).

( ) 2" white wire to K (S-1).

( ) 3" white wire to A (S-1).

( ) 3-1/2" red wire to B (S-1).

( ) 3" black wire to C (S-1).

NOTE: In the following steps, you will connect the wires and shielded cables from wire harness BO#12 and BO#13 to the sweep generator-horizontal amplifier circuit board. As each wire or cable is installed, solder it to the circuit board foil and cut off any excess wire lengths. The circuit board will be installed in the chassis later.

Connect the wires from BO#13 to the sweep generator-horizontal amplifier circuit board as follows:

( ) White-orange to ZZ (S-1).

( ) Red to XX (S-1).

NOTE: In the next two steps only, install the shielded cable inner conductors first, as instructed. Then install the shield lead as directed and pull the shield lead as far as possible through the circuit board before soldering the shield to the foil.

( ) Red shielded cable; inner lead to UU (S-1), shield lead to SS (S-1).

( ) Brown shielded cable; inner lead to VV (S-1), shield lead to TT (S-1).

( ) Orange shielded cable; inner lead to PP (S-1), shield lead to NN (S-1).

( ) Yellow shielded cable; inner lead to KK (S-1), shield lead to LL (S-1).

( ) Green shielded cable; inner lead to HH (S-1), shield lead to GG (S-1).

( ) Yellow wire to JJ (S-1).

( ) White-yellow wire to RR (S-1).

( ) Violet wire to MM (S-1).

Connect the wires from BO#12 to the sweep generator-horizontal amplifier circuit board as follows:

( ) Large green to AA (S-1).

( ) Either black wire to T (S-1).

( ) The other black wire to S (S-1).

( ) Gray wire to U (S-1).

( ) Gray shielded cable; inner lead to CC (S-1), shield lead to Z (S-1).

( ) Blue shielded cable; inner lead to M (S-1), shield lead to N (S-1).

( ) Violet shielded cable; inner lead to P (S-1), shield lead to R (S-1).

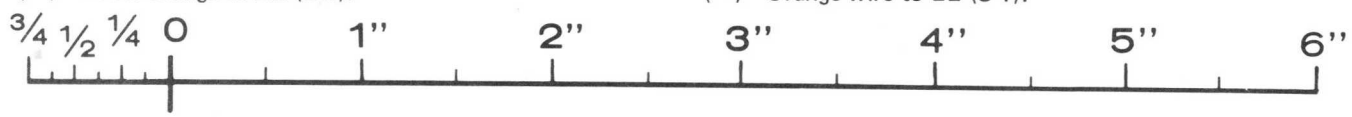
( ) Either green wire to W (S-1).

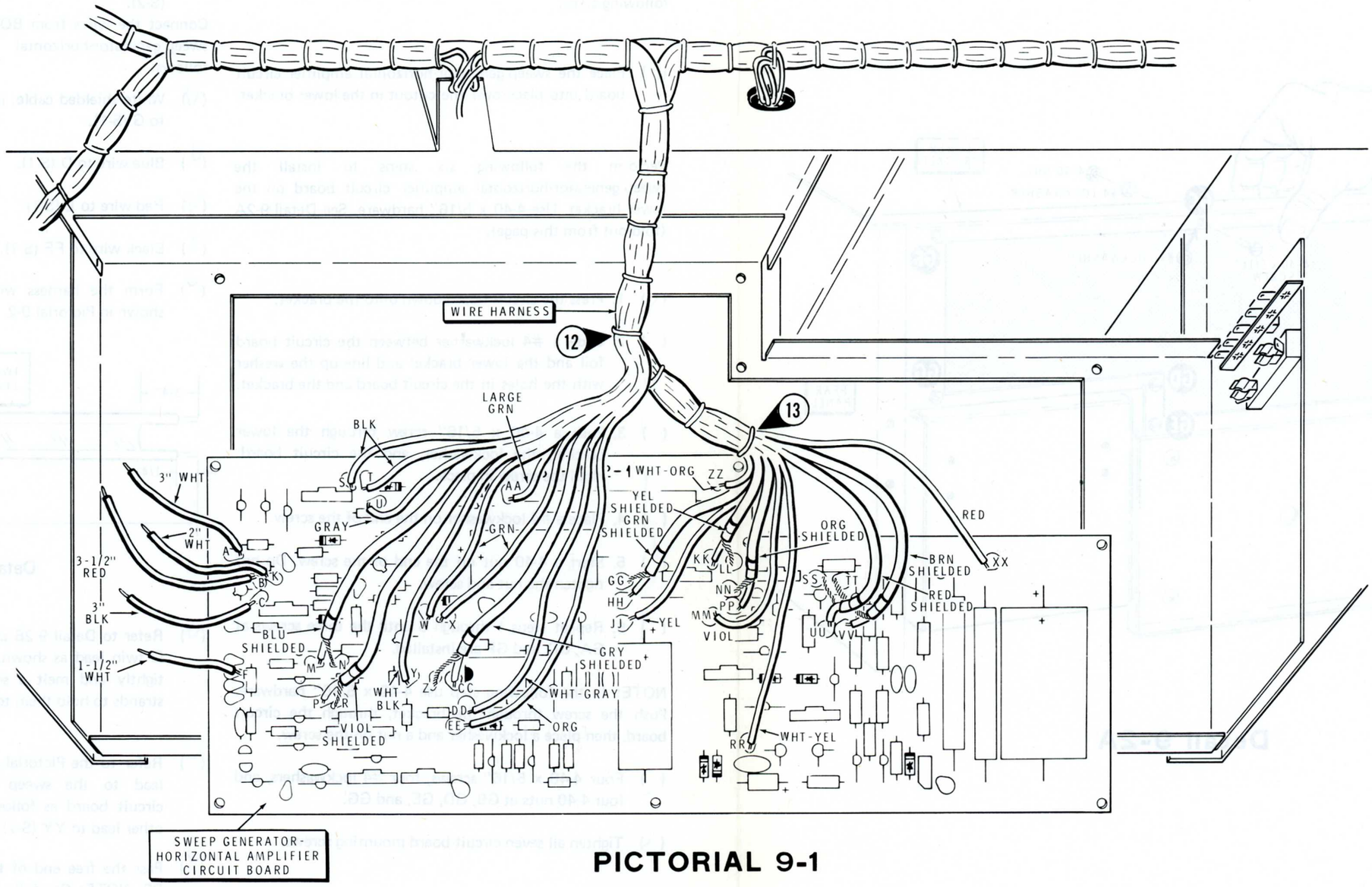
( ) The other green wire to X (S-1).

( ) White-black wire to Y (S-1).

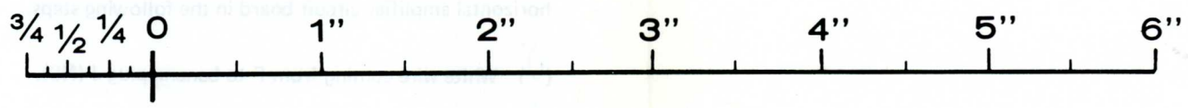
( ) White-gray wire to DD (S-1).

( ) Orange wire to EE (S-1).





PICTORIAL 9-1



Refer to Pictorial 9-2 (fold-out from Page 65) for the following steps.

( ) Place the sweep generator-horizontal amplifier circuit board into place over the cutout in the lower bracket.

Perform the following six steps to install the sweep generator-horizontal amplifier circuit board on the lower bracket. Use 4-40 x 5/16" hardware. See Detail 9-2A (fold-out from this page).

( ) 1. Press the circuit board down onto the bracket.

( ) 2. Slide a #4 lockwasher between the circuit board foil and the lower bracket and line up the washer with the holes in the circuit board and the bracket.

( ) 3. Push a 4-40 x 5/16" screw through the lower bracket, the lockwasher, and the circuit board. Hold the screw in place.

( ) 4. Place a #4 lockwasher on the end of the screw.

( ) 5. Start a 4-40 nut on the end of the screw. Do not tighten the nut and screw.

( ) 6. Repeat steps 1 through 5 until the three screws at GA, GC, and GF are installed.

NOTE: In the following step use 4-40 x 5/16" hardware. Push the screw through the bracket, through the circuit board, then place a lockwasher and a nut on the screw.

( ) Four 4-40 x 5/16" screws, four #4 lockwashers, and four 4-40 nuts at GB, GD, GE, and GG.

( ) Tighten all seven circuit board mounting screws.

Connect the wires coming from the sweep generator-horizontal amplifier circuit board in the following steps.

( ) White wire coming from F to banana plug J (NS).

( ) White wire coming from K to lug 6 of control AA (S-1).

( ) Free end of diode coming from J to lug 5 of control AA (S-1).

( ) White wire coming from A to lug 4 of control AA (S-2).

Connect the wires from BO#3 of the wire harness to the sweep generator-horizontal amplifier circuit board as follows:

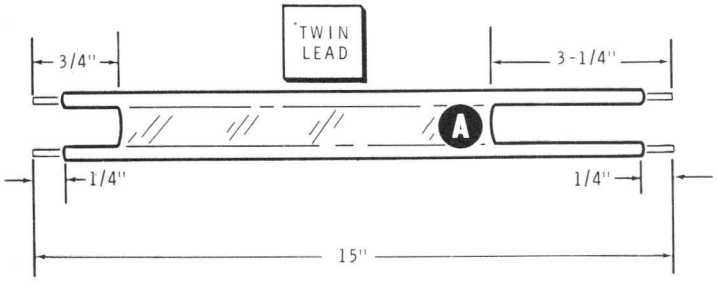
( ) White shielded cable; inner lead to H (S-1), shield lead to G (S-1).

( ) Blue wire to D (S-1).

( ) Red wire to L (S-1).

( ) Black wire to FF (S-1).

( ) Form the harness wires toward the front panel as shown in Pictorial 9-2.



Detail 9-2B

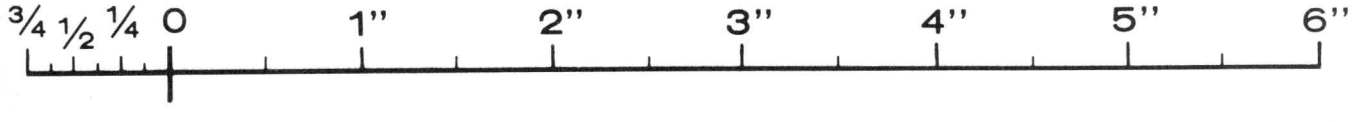
( ) Refer to Detail 9-2B and prepare a 15" length of 300 Ω twin lead as shown. Then twist the bare wire ends tightly and melt a small amount of solder on the strands to hold them together.

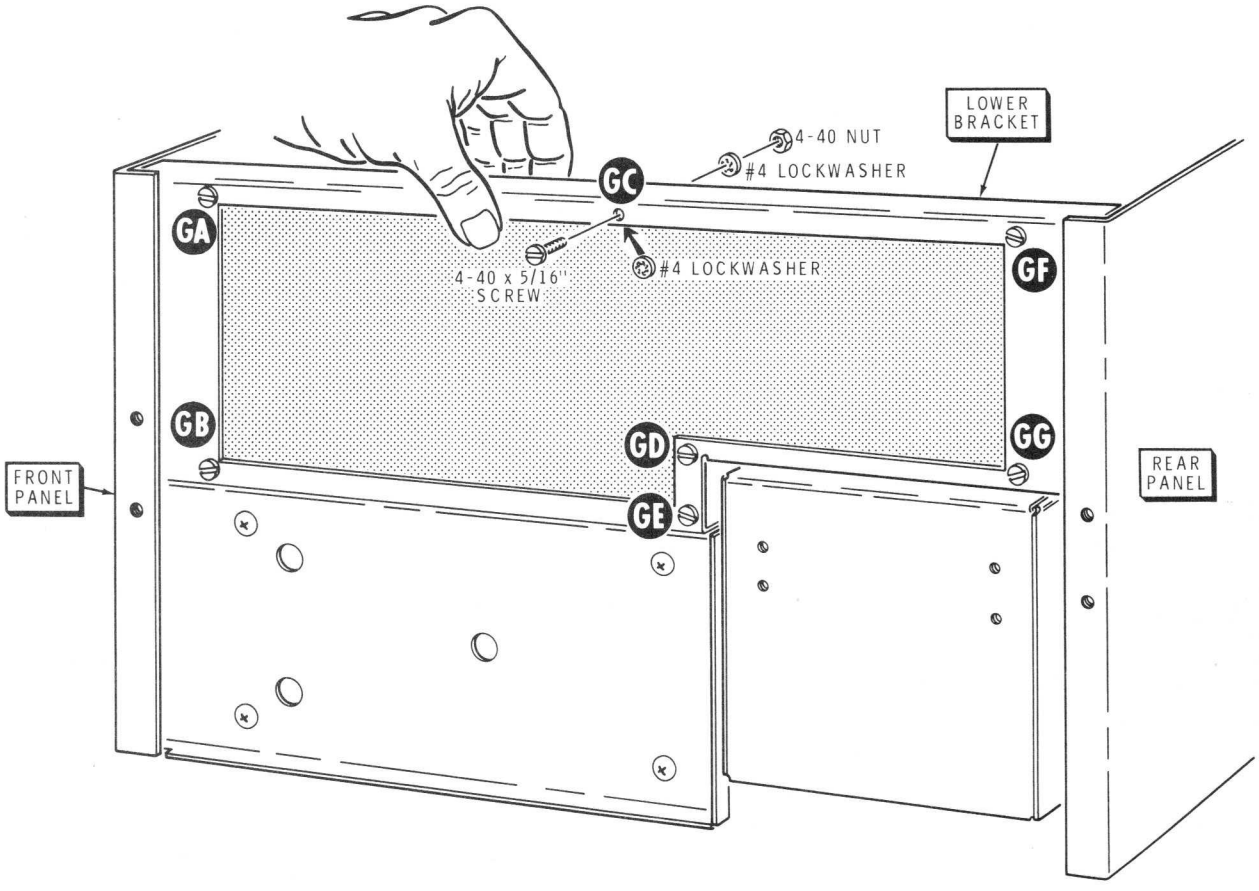
( ) Refer to the Pictorial and connect end A of the twin lead to the sweep generator-horizontal amplifier circuit board as follows: one lead to WW (S-1); the other lead to YY (S-1). Cut off the excess lead lengths.

( ) Pass the free end of the twin lead through grommet BS. NOTE: Carefully trace the side of the twin lead connected to YY on the circuit board.

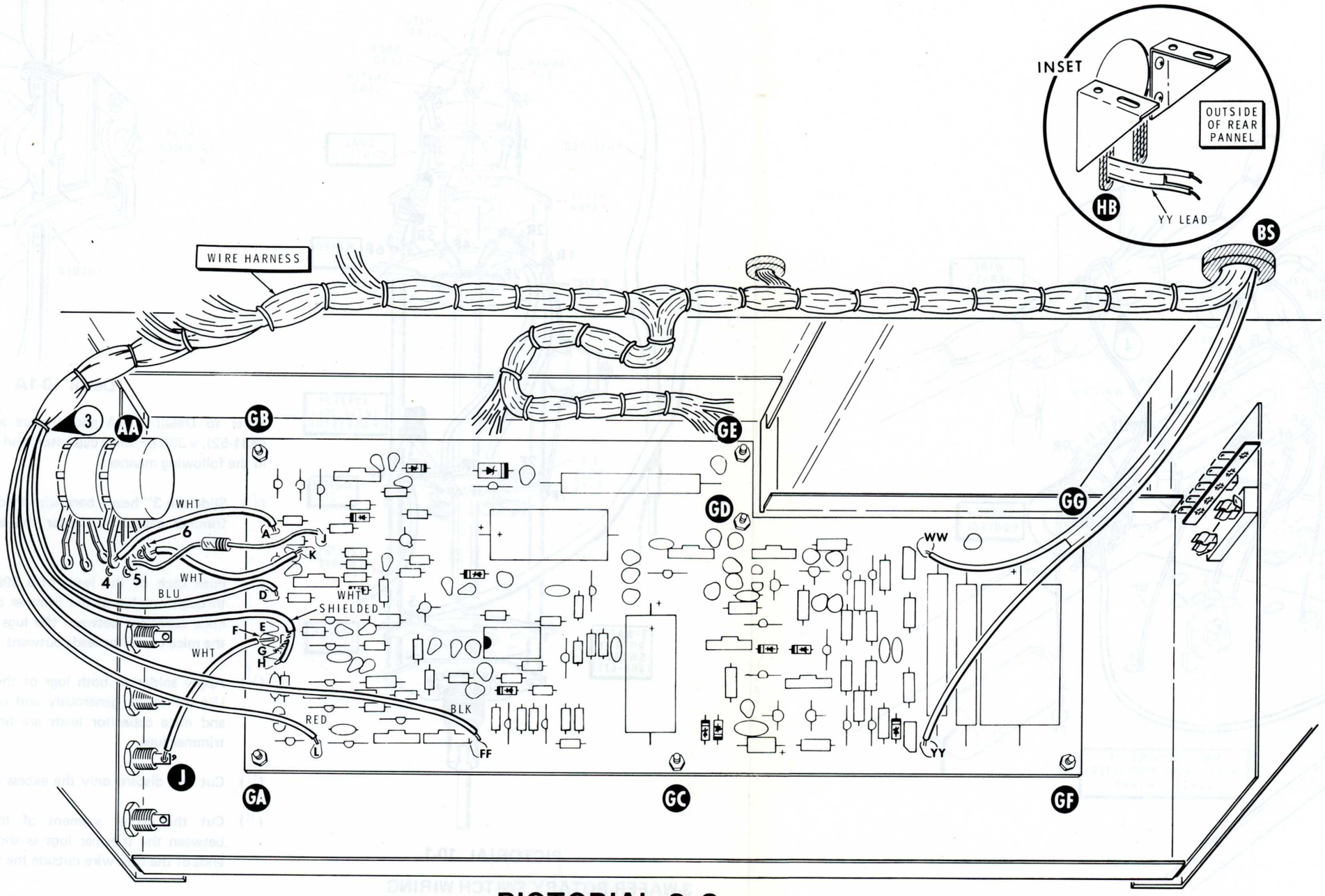
( ) Pass the free end of the twin lead through grommet HB in the rear panel, as shown, so the wire lead from YY on the circuit board is toward the bottom of this grommet. The free end of this twin lead will be connected later.

Set the Oscilloscope aside temporarily.

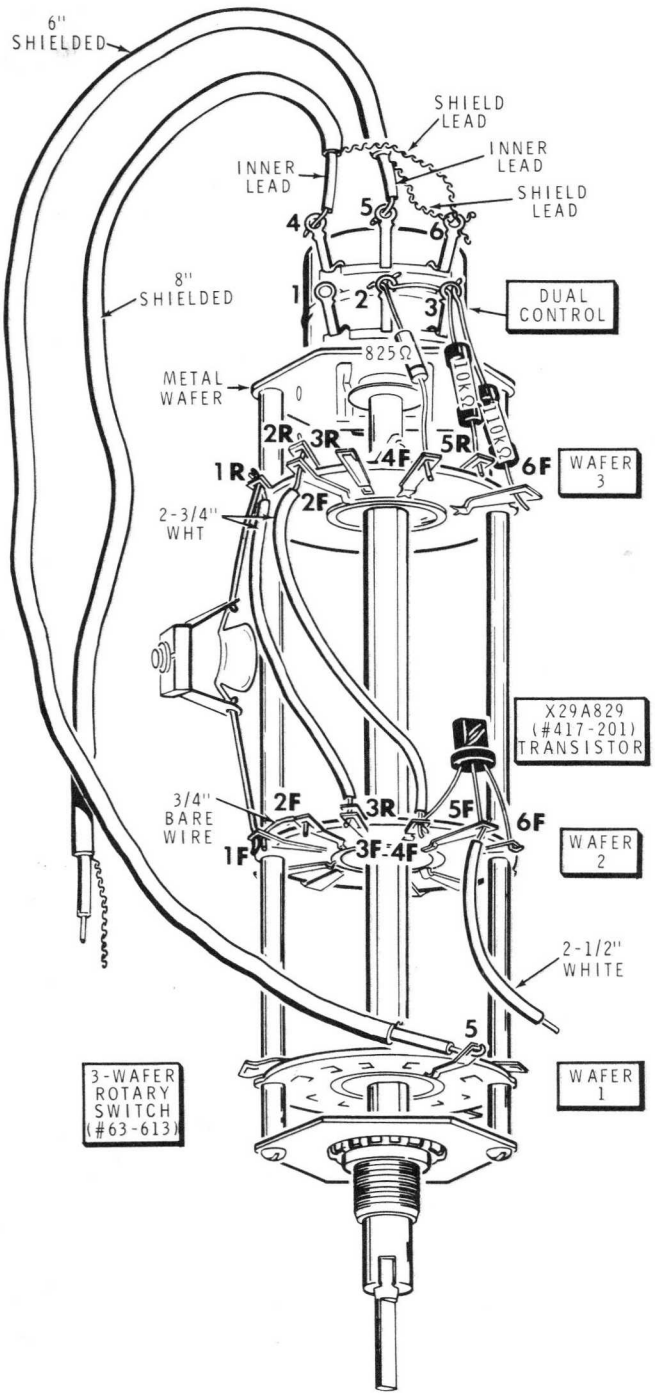



LOWER BRACKET
4-40 NUT
#4 LOCKWASHER
GC
GA
4-40 x 5/16" SCREW
#4 LOCKWASHER
GF
GB
GD
GG
FRONT PANEL
GE
REAR PANEL

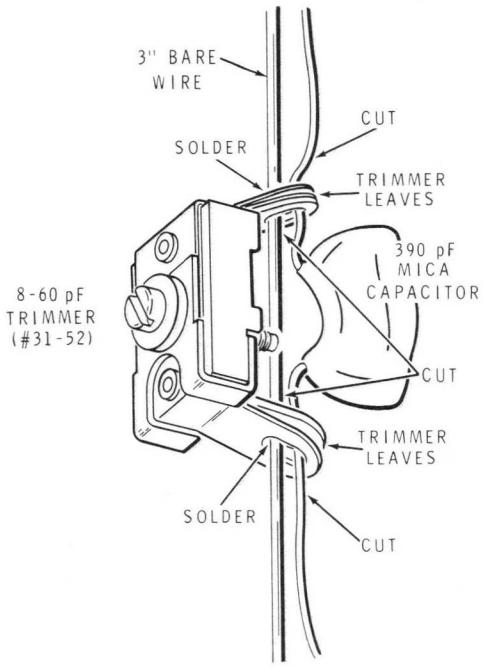
Detail 9-2A



PICTORIAL 9-2



PICTORIAL 10-1



Detail 10-1A

3-WAFER ROTARY SWITCH WIRING AND INSTALLATION

Refer to Pictorial 10-1 for the following steps.

( ) Locate the 3-wafer rotary switch with dual control (#63-613) and position it so the control lugs are up as shown.

Refer to Detail 10-1A and prepare an 8-60 pF trimmer (#31-52), a 390 pF mica capacitor, and a 3" heavy bare wire in the following manner:

( ) Slide the 3" heavy bare wire through both lugs of the trimmer capacitor. Center the trimmer on the bare wire.

( ) Push each of the leads of a 390 pF mica capacitor through one lug of the trimmer capacitor. Center the mica capacitor between the lugs as shown, and bend the mica capacitor leads outward.

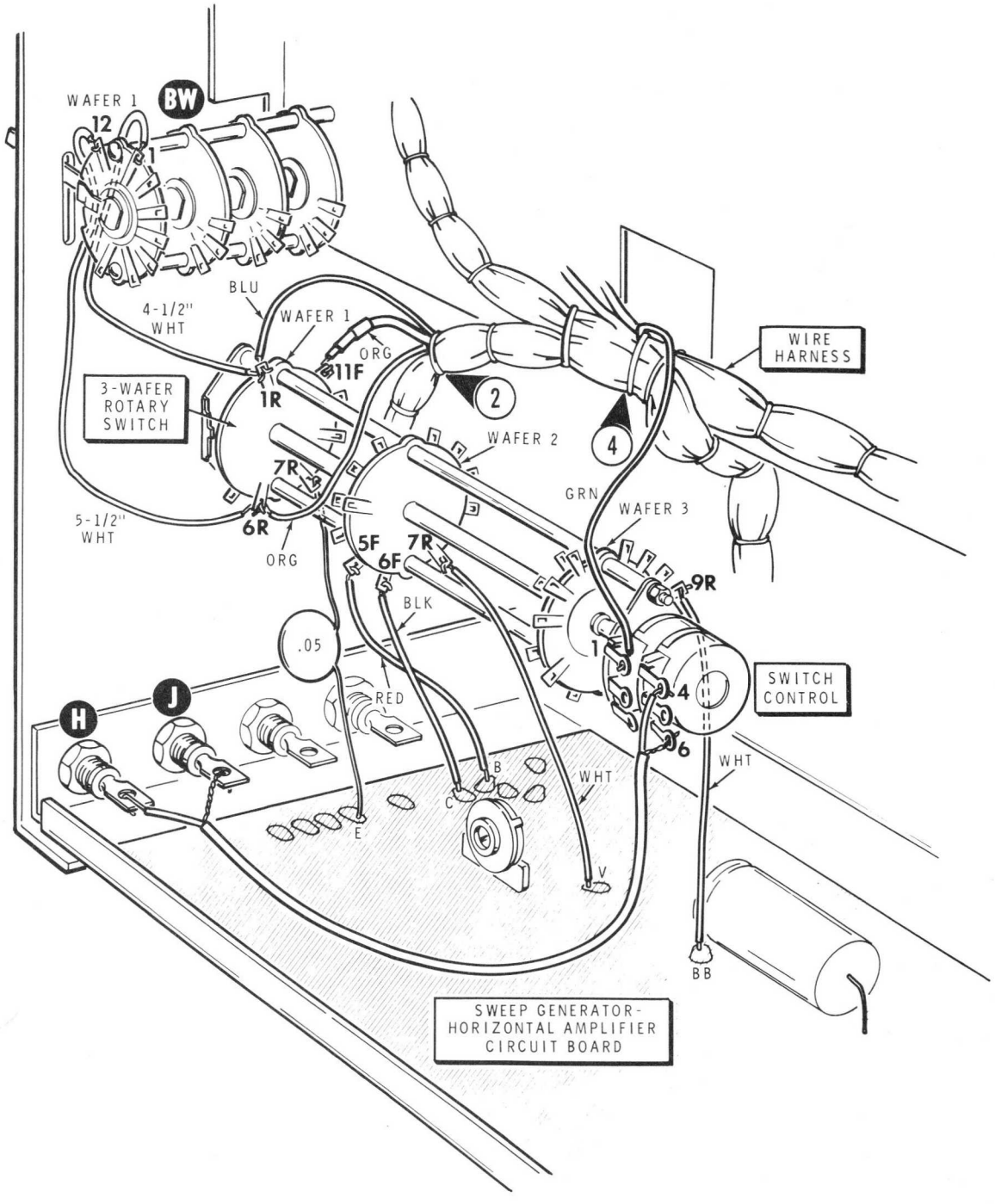
( ) Apply solder to both lugs of the trimmer capacitor. Use the solder generously and be sure the bare wire and mica capacitor leads are firmly soldered to the trimmer lugs.

( ) Cut and discard only the excess mica capacitor leads.

( ) Cut the center segment of the heavy bare wire between the trimmer lugs as shown. Do not cut the ends of the bare wire outside the trimmer lugs.

( ) Connect the assembly between lugs 1R of wafer 3 (NS) and 1F of wafer 2 (S-2) of the switch. Cut off the excess bare wire lengths.

( ) Connect a 3/4" bare wire between lugs 1F (NS) and 2F (S-1) of wafer 2. Be sure to position the trimmer capacitor outward as shown in the Pictorial.



PICTORIAL 10-3

( ) Connect one end of a 2-3/4" white wire to lug 1R of wafer 3 (NS). Connect the other end of this wire to lugs 3R (S-2) and 3F (S-1) of wafer 2.

( ) Connect one end of a 2-3/4" white wire to lugs 2R and 2F of wafer 3. Solder both lugs and the wire together. Connect the other end of this wire to lug 4F of wafer 2 (NS).

( ) Connect one end of an 825 Ω precision resistor to lug 4F of switch wafer 3 (S-1). Connect the other end of the resistor to lug 2 of the dual control (NS). Cut off the excess lead lengths.

( ) Connect one end of a 10 kΩ precision resistor to lug 5R of switch wafer 3 (S-1). Pass the other end of this resistor through lug 3 (NS) to lug 2 (S-2) of the dual control. Cut off the excess lead lengths.

( ) Connect one end of a 110 kΩ precision resistor to lug 6F of switch wafer 3 (S-1). Connect the other end of this resistor to lug 3 of the dual control (S-3). Cut off the excess lead lengths.

Refer to Detail 10-1B and prepare a 6" length and an 8" length of shielded cable as shown.

( ) Connect the inner lead of the 6" shielded cable to lug 5 (S-1) and the shield lead to lug 6 (NS) of the dual control.

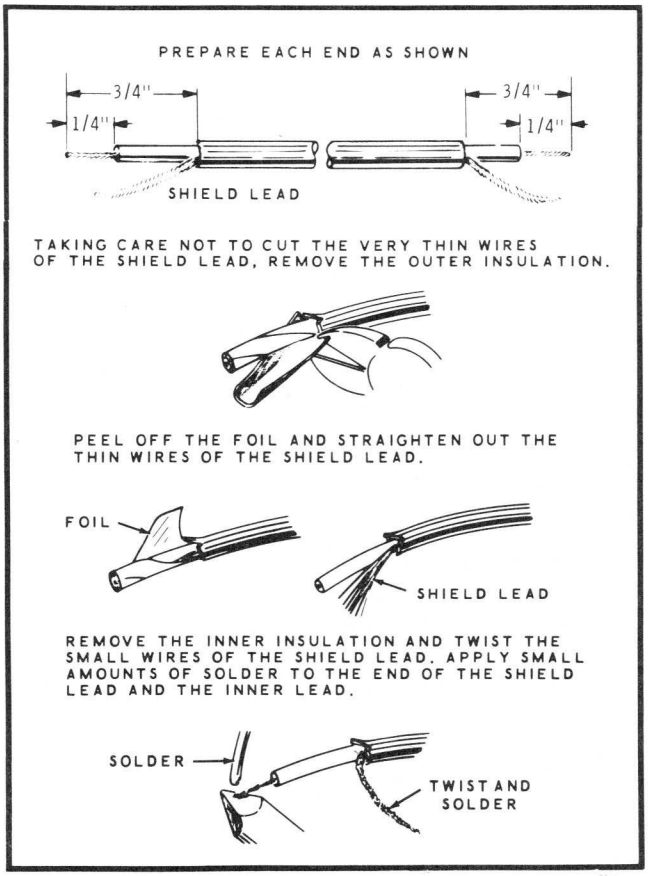
( ) Remove the shield lead from the free end of the 6" cable.

( ) Connect the inner lead of the 6" shielded cable to lug 5F of switch wafer 1 (S-1).

( ) Connect the inner lead of the 8" shielded cable to lug 4 (S-1) and the shield lead to lug 6 (S-2) of the dual control. The free end of the 8" shielded cable will be connected later.

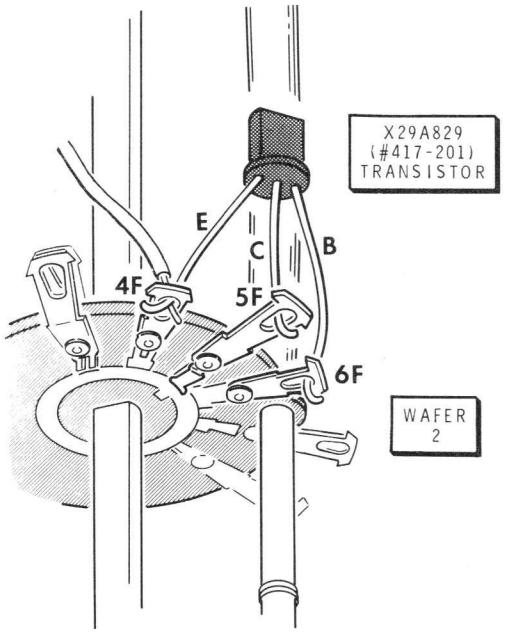
NOTE: When you install the transistor in the following step, refer to "Transistor Installation" (fold-out from Page 10) to help you correctly identify the transistor type.

( ) Refer to Detail 10-1C and install an X29A829 (#417-201) transistor on switch wafer 2 as follows: emitter (E) lead to lug 4F (S-2), collector (C) lead to lug 5F (NS), and base (B) lead to lug 6F (NS). Cut off the excess lead lengths.

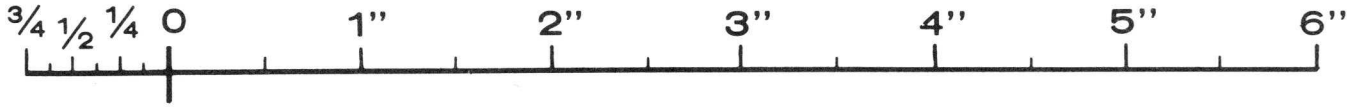


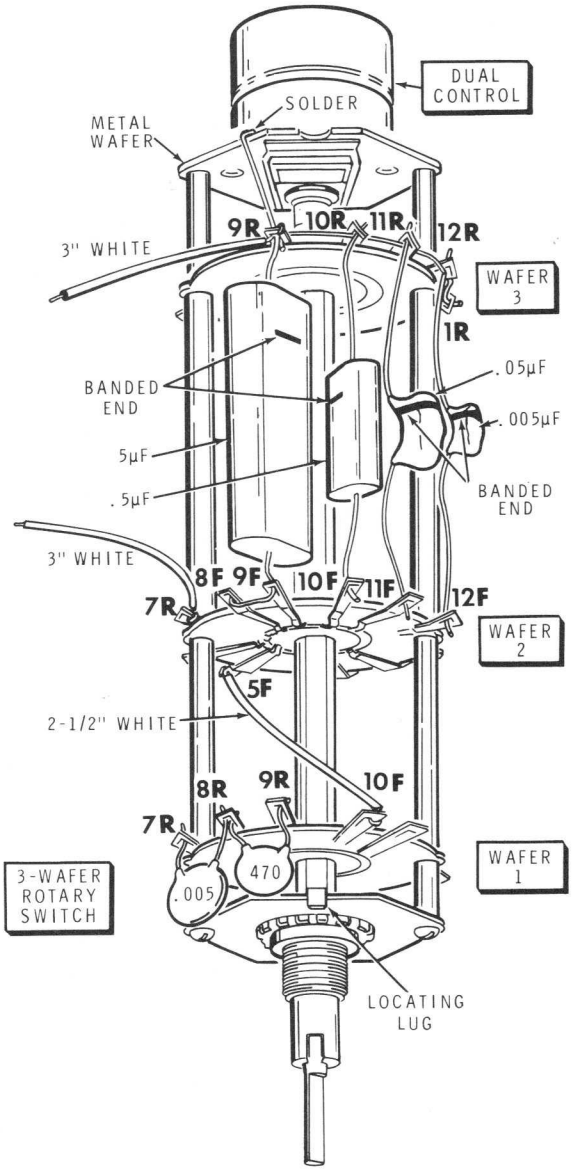
Detail 10-1B

( ) Connect a 2-1/2" white wire to lug 5F of switch wafer 2 (NS). The free end will be connected later.



Detail 10-1C





PICTORIAL 10-2

Refer to Pictorial 10-2 for the following steps.

( ) Twist switch wafer 3 lugs 10R, 11R, and 12R, 45 degrees as shown.

( ) Pass a 2" bare wire from lug 1R (S-3), through lug 12R (NS), through lug 11R (NS), through lug 10R (NS), to lug 9R (NS) of switch wafer 3.

( ) Prepare a 3" length of white wire.

( ) Connect one end of the 3" wire to lug 9R of switch wafer 3 (NS). The free end will be connected later.

( ) Pass the lead from the banded end of a 5 μF Mylar capacitor through lug 9R of switch wafer 3 (S-4) to the metal wafer on the front of the dual control as shown. Cut the lead 1/8" beyond the metal wafer; then bend it down over the wafer edge and solder it to the flat side of the wafer.

( ) Pass the free lead of the 5 μF capacitor through lug 9F (S-2) to lug 8F (S-1) of switch wafer 2. Cut off the excess lead length.

( ) Connect a .5 μF Mylar capacitor from lug 10R of wafer 3 (S-3) to lug 10F of wafer 2 (S-1) of the switch. Be sure the banded end of the capacitor is toward wafer 3. Cut off the excess lead lengths.

( ) Connect a .05 μF polycarbonate capacitor from lug 11R of switch wafer 3 (S-3) to lug 11F of switch wafer 2 (S-1). Position the banded end toward wafer 3. Cut off the excess lead lengths.

( ) Connect a .005 μF polycarbonate capacitor from lug 12R of switch wafer 3 (S-3) to lug 12F of switch wafer 2 (S-1). Position the banded end toward wafer 3. Cut off the excess lead lengths.

( ) Prepare a 3" length of white wire.

( ) Connect the 3" white wire to lug 7R of switch wafer 2 (S-1). The free end will be connected later.

( ) Connect a .005 μF disc capacitor between lug 7R (NS) and lug 8R (NS) of switch wafer 1.

( ) Connect a 470 pF disc capacitor between lug 8R (S-2) and lug 9R (S-1) of switch wafer 1.

( ) Cut the excess lead lengths from both disc capacitors.

( ) Locate the free end of the 2-1/2" white wire coming from lug 5F of switch wafer 2. Connect this wire to lug 10F (S-1) of switch wafer 1.

Refer to Pictorial 10-3 (fold-out from Page 66) for the following steps.

NOTE: Before you install the 3-wafer rotary switch, study the Pictorial and previous Pictorials once again to be sure the wires, cables, and harness wires are properly positioned as illustrated.

( ) Place a control flat washer on the shaft of the three-wafer rotary switch. Install the switch assembly through the front panel as shown in the Pictorial. Be sure the locating lug enters the small hole along side the large shaft hole. Secure the switch with a control flat washer and a control nut.

( ) Connect the red wire coming from B on the sweep generator-horizontal amplifier circuit board to lug 5F, wafer 2 of the 3-wafer rotary switch (S-3).

( ) Connect the black wire coming from C on the sweep generator-horizontal amplifier circuit board to lug 6F, wafer 2 of the 3-wafer rotary switch (S-2).

( ) Connect the .05 disc capacitor coming from E on the circuit board to lug 7R of switch wafer 1 (S-2).

( ) Locate the free end of the white wire coming from lug 7R of switch wafer 2. Connect this wire to sweep generator-horizontal amplifier circuit board location V (S-1).

( ) Locate the free end of the white wire coming from lug 9R of switch wafer 3. Connect this wire to circuit board location BB (S-1).

( ) Locate the green wire coming from BO#4 of the wire harness. Connect the free end of this wire to lug 1 of the switch control (S-1).

( ) Connect the blue wire coming from wire harness BO#2 to lug 1R, wafer 1 of the 3-wafer rotary switch (NS).

( ) Connect the inner lead of the orange shielded cable coming from BO#2 to lug 11F, wafer 1 of the 3-wafer rotary switch (S-1).

( ) Connect the orange wire coming from harness BO#2 to lug 6R, wafer 1 of the 3-wafer rotary switch (NS).

( ) Locate the free end of the shielded cable coming from lugs 4 and 6 of the switch control. Connect the shield lead of this cable to banana jack J (S-3). Connect the inner lead of this cable to banana jack H (S-1).

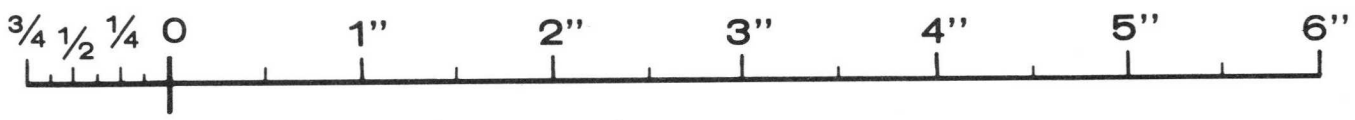
( ) Prepare a 4-1/2" length of white wire.

( ) Connect one end of the 4-1/2" wire to lug 1R, wafer 1 of the 3-wafer rotary switch (S-2). Connect the other end of this wire to lug 1, wafer 1 of switch BW (S-1).

( ) Prepare a 5-1/2" length of white wire.

( ) Connect one end of the 5-1/2" wire to lug 6R, wafer 1 of the 3-wafer rotary switch (S-2). Connect the other end of this wire to lug 12, wafer 1 of switch BW (S-1).

NOTE: Check wires and component leads to be sure they are not touching one another nor any metal parts of the switch assembly.

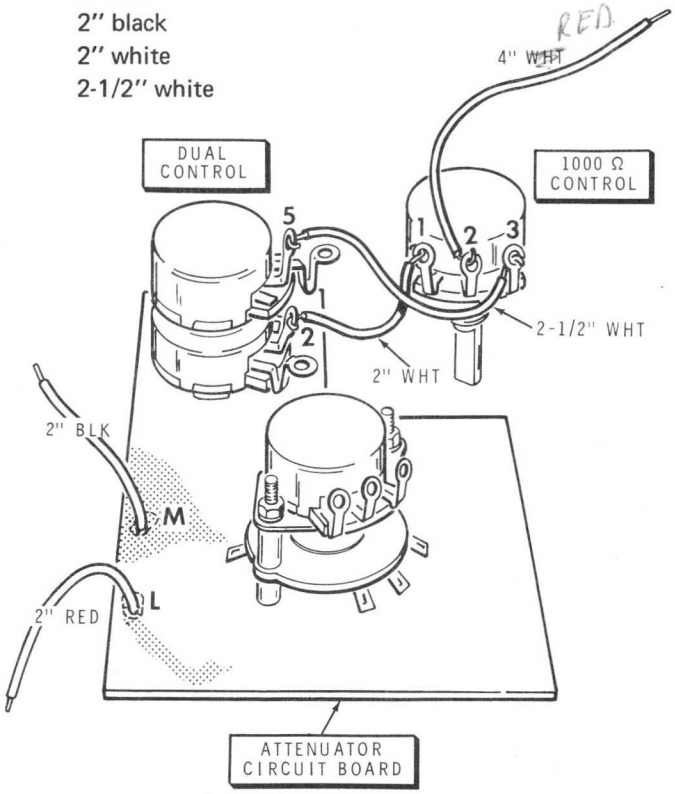


VERTICAL CIRCUIT ASSEMBLY AND WIRING

NOTE: In the following steps you will interwire several components that make up the vertical input and amplifier circuits. You will need the vertical amplifier circuit board, the attenuator circuit board, and some other components that will be called for in the steps.

( ) Prepare the following lengths of wire.

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



Detail 11-1A

Refer to Pictorial 11-1 and Detail 11-1A. NOTE: In the following steps, you will install wires on the foil side of the attenuator circuit board. Locate the hole on the component side, turn the board over, and install the wire. Solder the wire to the board and cut off any excess wire lengths.

( ) 2" red wire to L (S-1). This hole is lettered on the component side of the circuit board.

( ) 2" black wire to M (S-1). This hole is lettered on the component side of the circuit board.

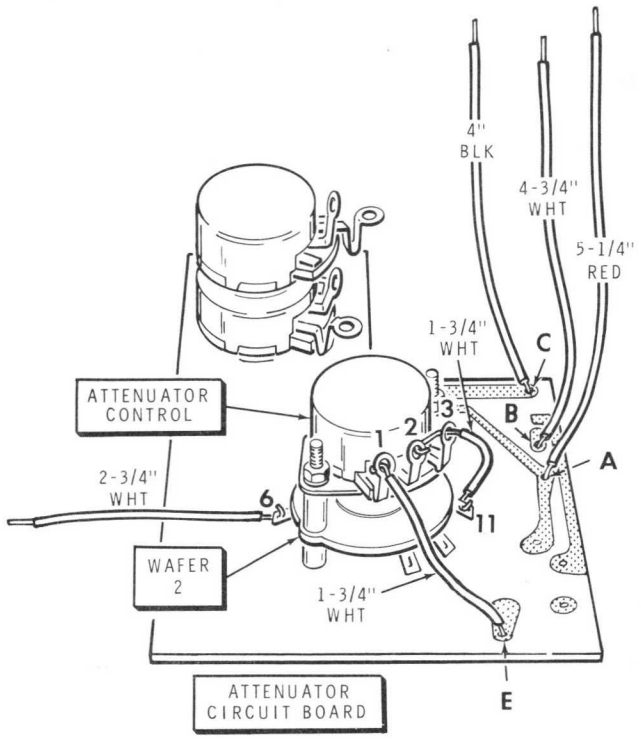
( ) 2" white wire to lug 2 of the dual control (S-1).

( ) 2-1/2" white wire to lug 5 of the dual control (S-1).

( ) Locate the 1000 Ω (1 kΩ) control (#10-271).

( ) Position this control near the attenuator circuit board. Then connect the wire from lug 5 of the dual control to lug 3 of the 1000 Ω control (#10-271) (S-1). Connect the wire from lug 2 of the dual control to lug 1 of the 1000 Ω control (S-1).

( ) Prepare a 4" white wire. Connect one end of this wire to lug 2 of the 1000 Ω control (S-1). The free end will be connected later.



Detail 11-1B

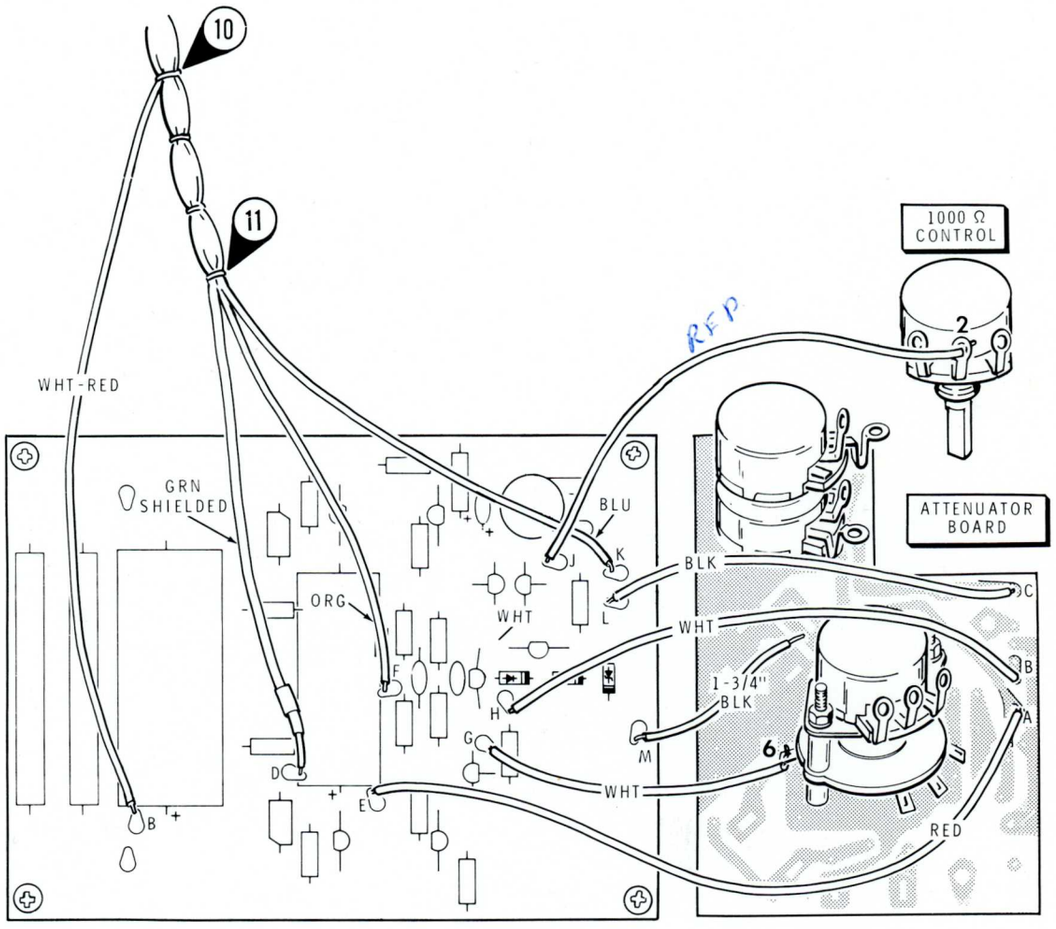
Refer to Detail 11-1B for the following steps.

( ) Prepare the following lengths of wire.

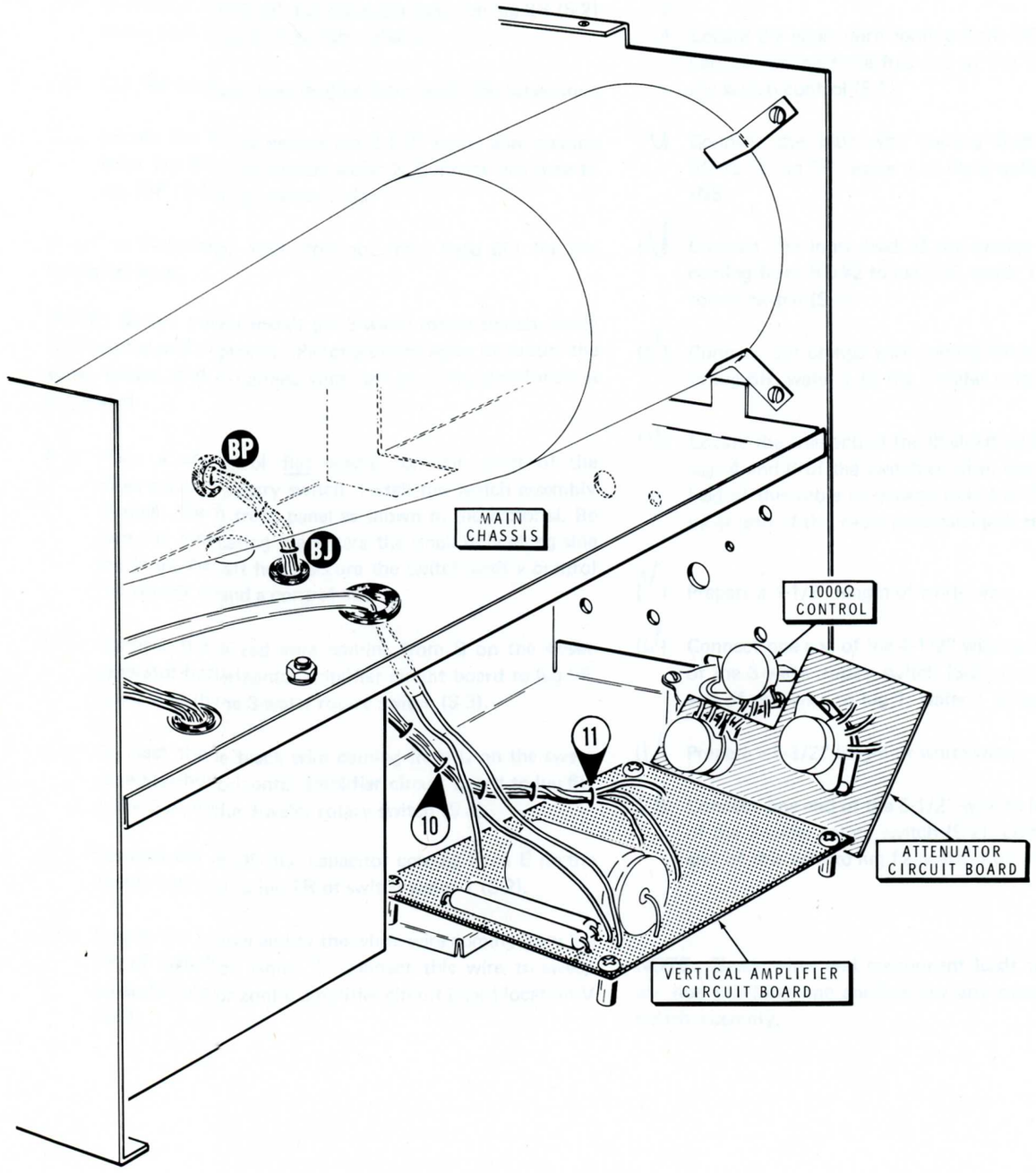
1-3/4" white	4-3/4" white
2-3/4" white	5-1/4" red
4" black	2-1/4" white

( ) Remove an additional 1/4" of insulation from a 1-3/4" length of white wire. Pass this end of the wire through lug 3 (S-2) to lug 2 (S-1) of the attenuator control. Connect the free end of this wire to lug 11, wafer 2 of the attenuator switch (S-2).

( ) Connect one end of a 2-3/4" white wire to lug 6, wafer 2 of the attenuator switch (S-1). The free end will be connected later.



Detail 11-1D



PICTORIAL 11-1

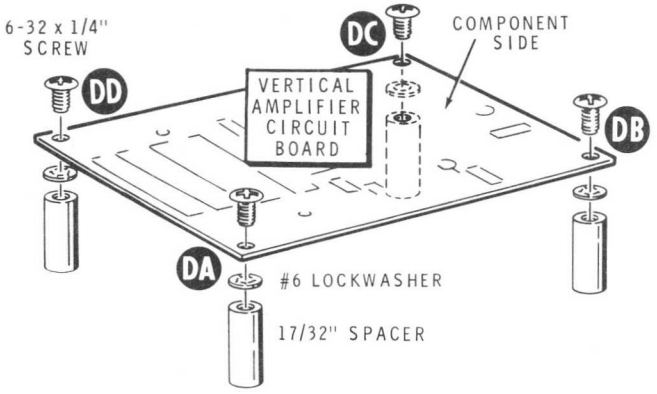
( ) 4" black wire to C (S-1). The free end will be connected later.

( ) 4-3/4" white wire to B (S-1). The free end will be connected later.

( ) 5-1/4" red wire to A (S-1). The free end will be connected later.

( ) 2-1/4" white wire to E (S-1). Connect the other end of this wire to lug 1 of the attenuator control (S-1).

( ) Refer to Detail 11-1C and install 17/32" spacers at DA, DB, DC, and DD on the vertical amplifier circuit board. Use 6-32 x 1/4" hardware as shown.



Detail 11-1C

Refer to Detail 11-1D (fold-out from Page 70) for the following steps.

NOTE: You will wire the vertical amplifier circuit board in the following steps. As each wire is installed, solder it to the foil and cut off the excess length.

WIRE COMING FROM:	WIRE COLOR:	CONNECT TO VERTICAL AMPLIFIER:
( ) C on Attenuator board	Black	Hole L (S-1).
( ) B on Attenuator board	White	Hole H (S-1).
( ) A on Attenuator board	Red	Hole E (S-1).
( ) Lug 2 of the 1000 Ω control	~~White~~ RED	Hole J (S-1).
( ) Lug 6, wafer 2 of the attenuator switch	White	Hole G (S-1).

( ) Connect a 1-3/4" length of black wire to M (S-1) on the vertical amplifier circuit board. The free end will be connected later.

( ) Locate the wire harness coming through the main chassis grommet at BP. The wires make up BO#10 and BO#11. Pass these wires downward through grommet BJ as shown in Pictorial 11-1. NOTE: These wires will be connected to the vertical amplifier in the following steps.

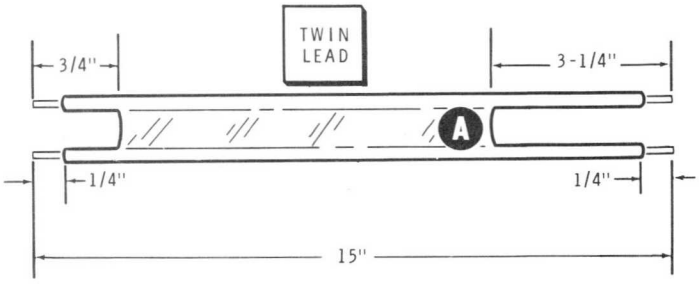
Connect the wires from BO#11 in the following steps.

( ) Blue wire to K (S-1).

( ) Orange wire to F (S-1).

( ) Green shielded cable; inner lead to D (S-1).

( ) Connect the white-red wire from BO#10 to B on the vertical amplifier circuit board (S-1).

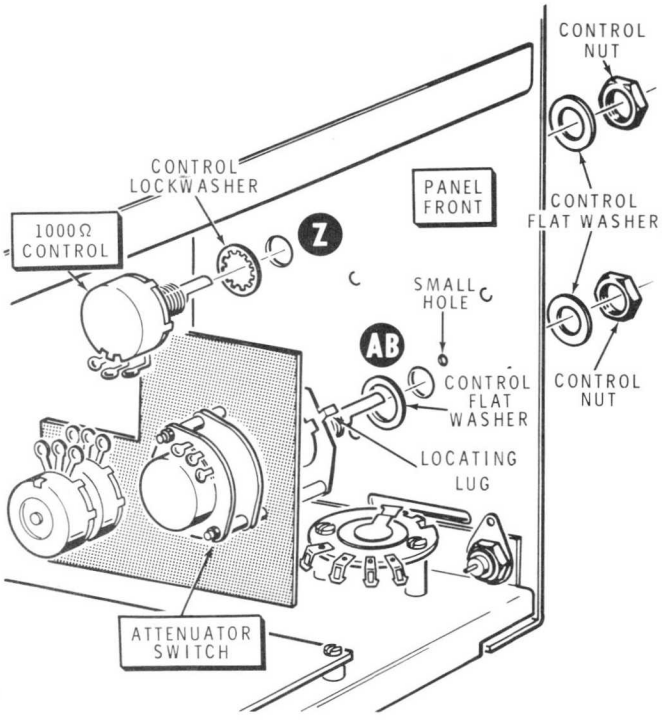


Detail 11-2A

Refer to Pictorial 11-2 (fold-out from Page 73) for the following steps.

( ) Refer to Detail 11-2A and prepare a 15" length of 300 Ω twin lead as shown. Then twist the bare wire ends tightly and melt a small amount of solder on the strands to hold them together.

( ) Connect the wires of end A of the twin lead to the vertical amplifier circuit board as follows: One wire to hole A (S-1) and the other wire to hole C (S-1). Cut off any excess wire lengths.



Detail 11-2B

NOTE: Before you install the 1000 Ω control, the vertical amplifier circuit board, and the attenuator circuit board, study the Pictorial and position these components approximately as they appear when installed. Once this is done, it will be easy to lift them into the compartment and position them so the control and switch shafts can be installed properly into the front panel holes.

Refer to Detail 11-2B for the following steps.

( ) Place a control lockwasher on the 1000 Ω control.

( ) Place a control flat washer on the shaft of the attenuator switch.

( ) Position the two circuit boards and the control into the vertical compartment as shown in the Detail.

( ) Install the 1000 Ω control at Z on the front panel. Use a control flat washer and a control nut.

( ) Install the attenuator switch into hole AB in the front panel. Be sure to align the locating lug with the small hole in the panel. Then secure the switch to the panel with a control flat washer and a control nut.

( ) Refer to Detail 11-2C and install the vertical amplifier circuit board on the circuit board bracket with four 6-32 x 1/4" screws and two #6 lockwashers as shown. Be sure to place the lockwashers between the spacers indicated and the circuit board bracket.

( ) Pass the 300 Ω twin lead upward through grommet BF; then to the rear and through grommet HA as shown in the Pictorial. Be sure the wire connected to C on the vertical amplifier is toward the bottom of grommet HA.

( ) Connect the red wire coming from L on the attenuator circuit board to lug 11 of switch CC (S-1).

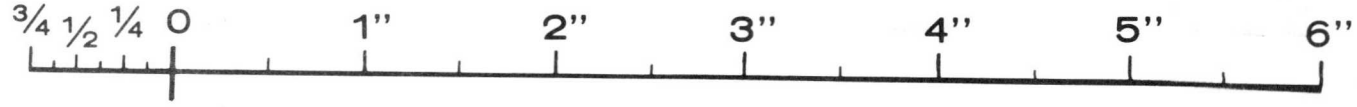
( ) Connect the black wire coming from M on the attenuator circuit board to lug 9 of switch CC (NS).

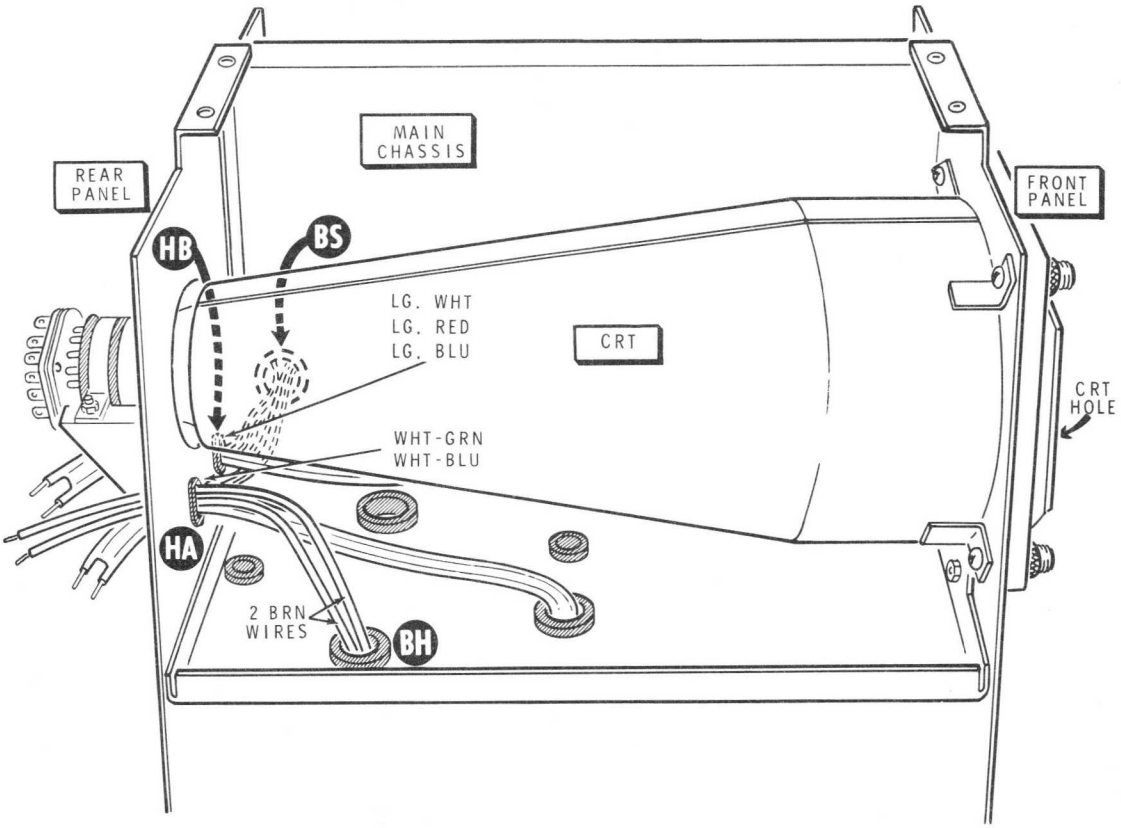
( ) Connect the short black wire coming from M on the vertical amplifier circuit board to lug 9 of switch CC (NS).

( ) Connect one end of a 2-1/2" black wire to the BNC solder lug (S-1). Connect the other end to lug 9 of switch CC (S-3).

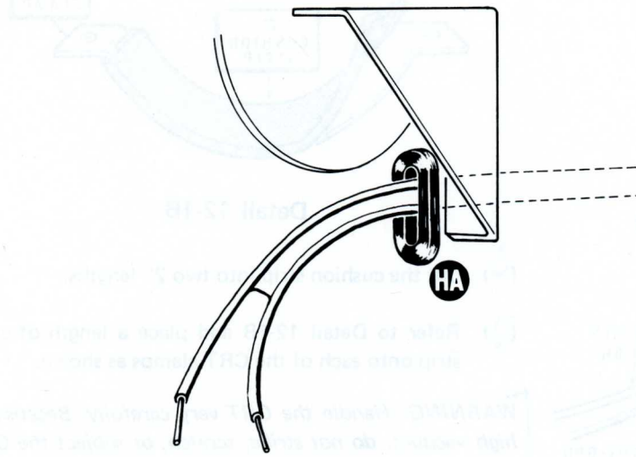
( ) Locate the free end of the bare wire at lug 8 of switch CC. Cut this wire to 1-3/8". Measure from lug 8.

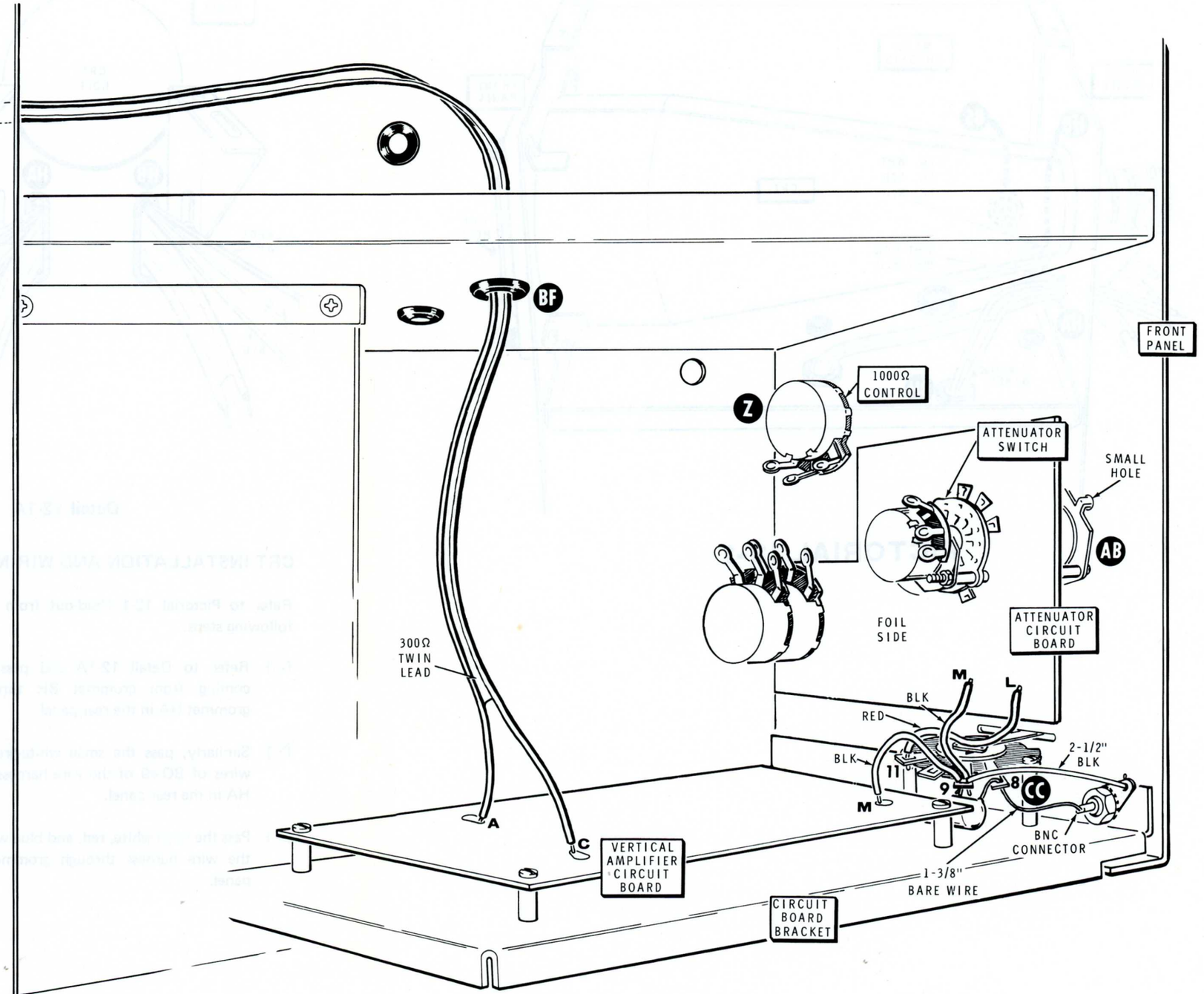
( ) Connect the free end of this wire to the center conductor of the BNC jack (S-1).



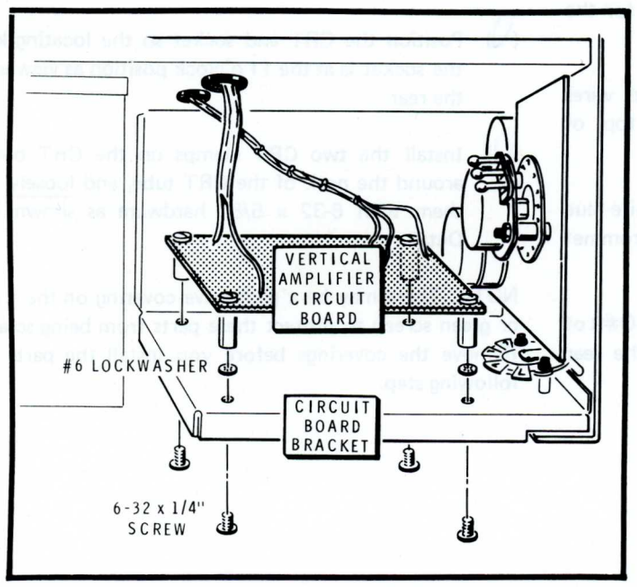


PICTORIAL 12-1

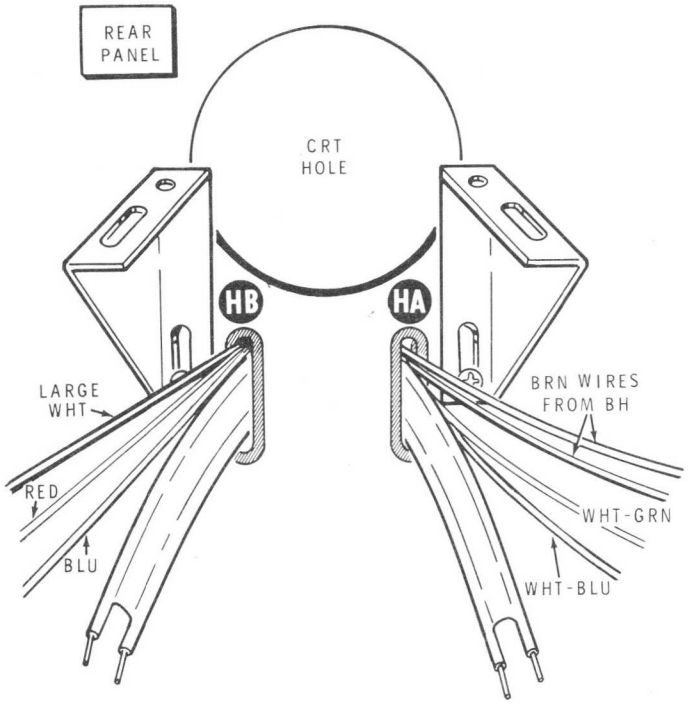




PICTORIAL 11-2



Detail 11-2C



Detail 12-1A

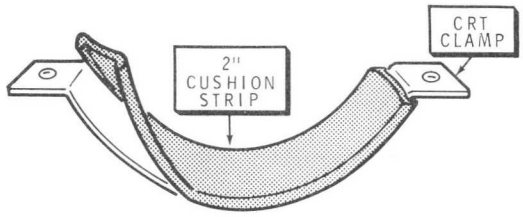
CRT INSTALLATION AND WIRING

Refer to Pictorial 12-1 (fold-out from this page) for the following steps.

( ) Refer to Detail 12-1A and pass the brown wires coming from grommet BH through the top of grommet HA in the rear panel.

( ) Similarly, pass the small white-green and white-blue wires of BO#9 of the wire harness through grommet HA in the rear panel.

( ) Pass the large white, red, and blue wires from BO#9 of the wire harness through grommet HB in the rear panel.



Detail 12-1B

( ) Cut the cushion strip into two 2" lengths.

( ) Refer to Detail 12-1B and place a length of cushion strip onto each of the CRT clamps as shown.

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.

( ) Place the CRT face down on a cloth pad and press the 12-pin tube socket onto the pins of the CRT.

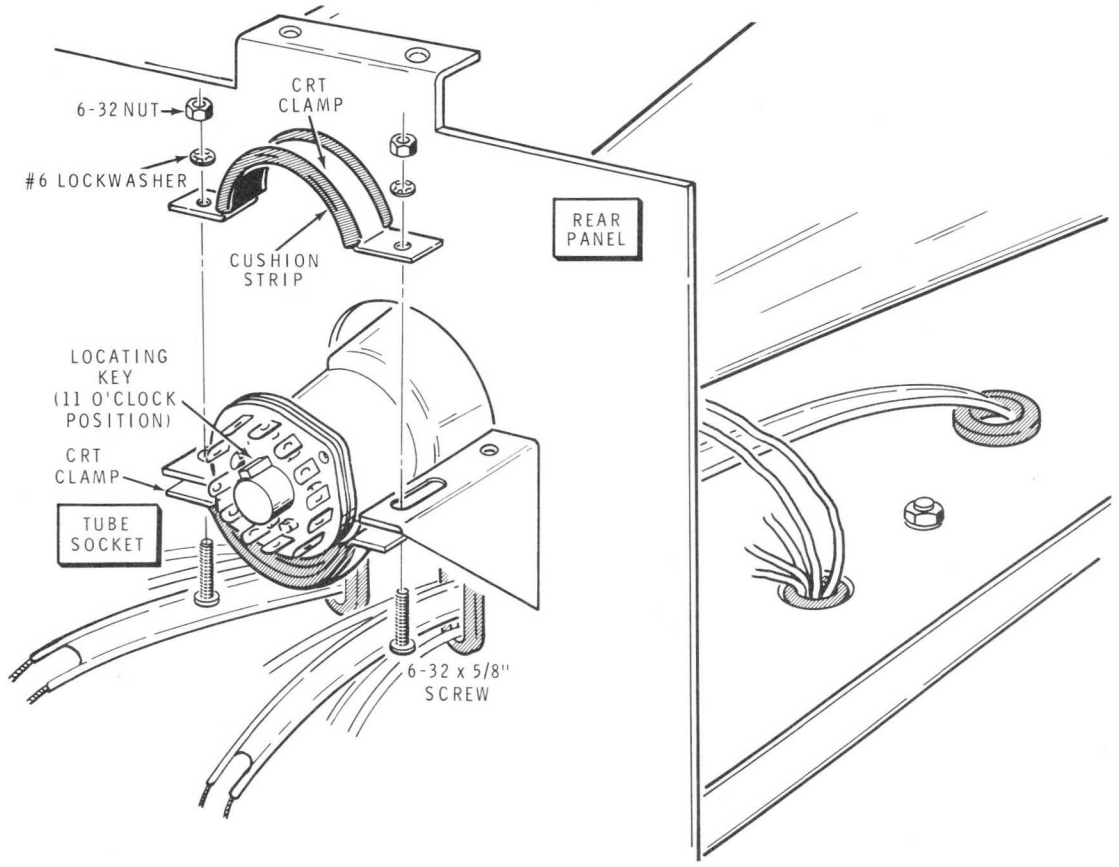
( ) Install the CRT through the opening in the front panel.

Refer to Detail 12-1C for the following steps.

( ) Position the CRT and socket so the locating key on the socket is at the 11 o'clock position as viewed from the rear.

( ) Install the two CRT clamps on the CRT brackets, around the neck of the CRT tube, and loosely secure them with 6-32 x 5/8" hardware as shown in the Detail.

NOTE: There may be a protective covering on the graticule or green screen to protect these parts from being scratched. Remove the coverings before you install the parts in the following step.



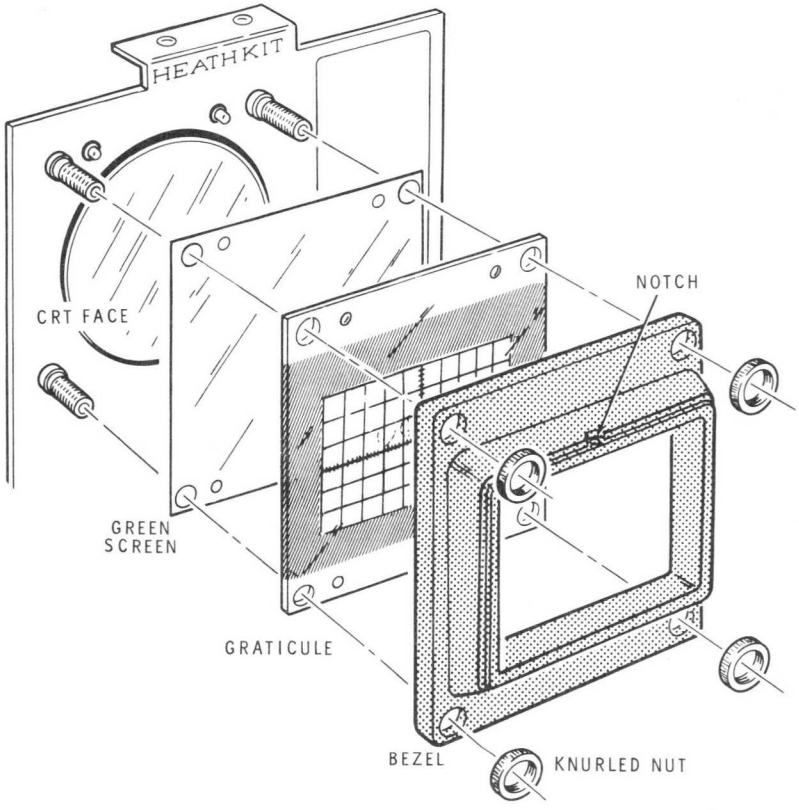
Detail 12-1C

( ) Carefully remove any dust from the face of the CRT.

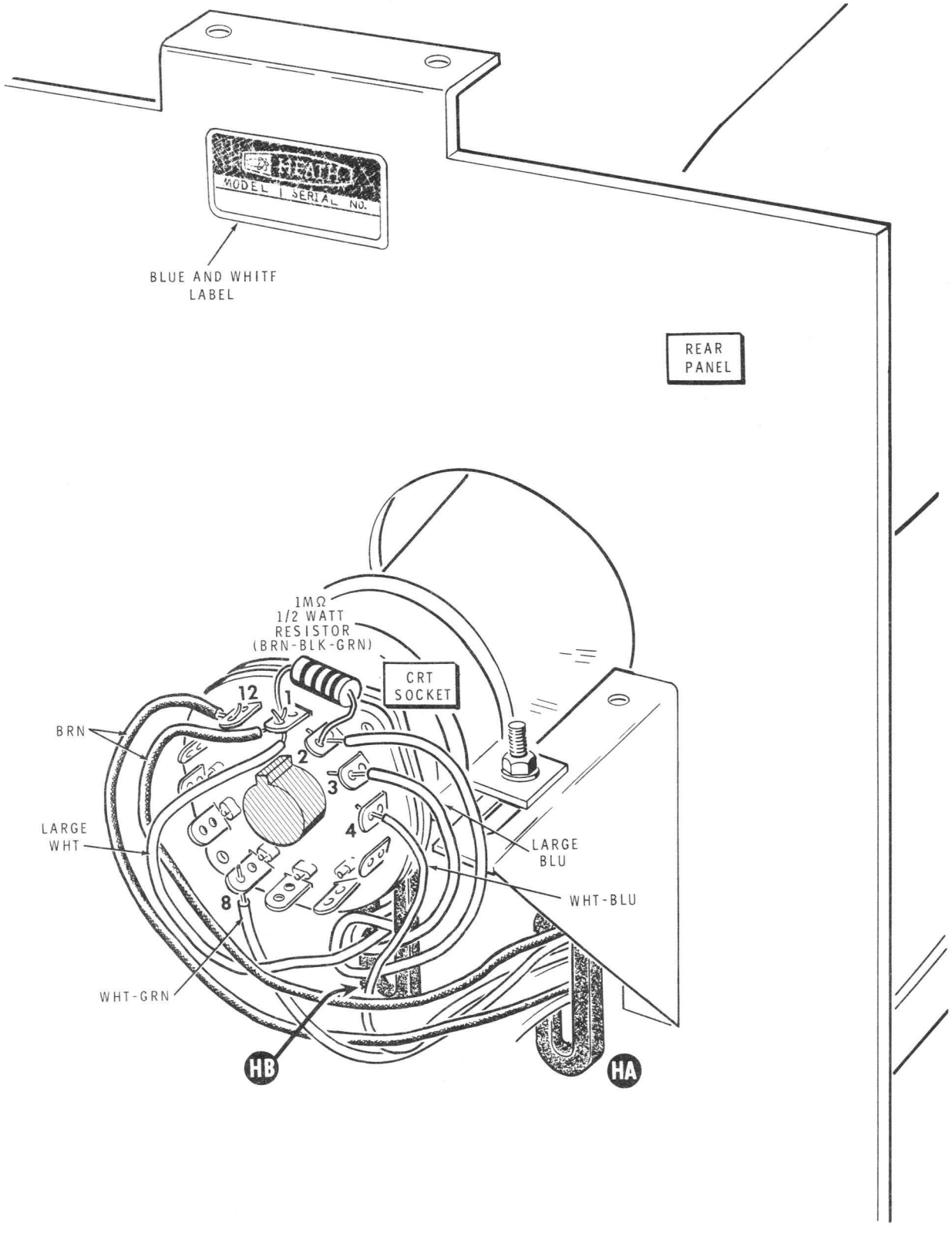
When you install the graticule in the following step, position the black painted side toward the CRT.

( ) Refer to Detail 12-1D and install the green screen, graticule, and bezel over the face of the CRT. Position the notch in the bezel upward as shown.

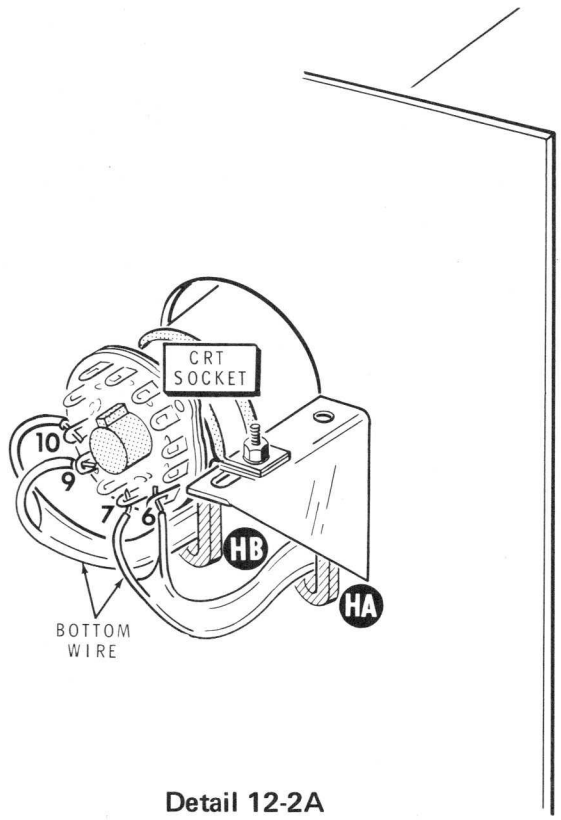
( ) Push the CRT forward through the rear panel until its face rests against inside surface of the green screen. Slide the CRT clamps as far forward as they will go in their notched holes.



Detail 12-1D



PICTORIAL 12-2



Detail 12-2A

Refer to Pictorial 12-2 and Detail 12-2A for the following steps.

( ) Connect the bottom wire of the twin lead coming from grommet HA to lug 7 of the CRT socket (S-1).

( ) Connect the top wire of the twin lead coming from grommet HA to lug 6 of the CRT socket (S-1).

( ) Connect the bottom wire of the twin lead coming from grommet HB to lug 9 of the CRT socket (S-1).

( ) Connect the top wire of the twin lead coming from grommet HB to lug 10 of the CRT socket (S-1).

Refer to Pictorial 12-2 (on Page 76) for the following steps.

Connect the wire harness leads and a resistor to the CRT socket in the following steps.

( ) White-green wire to lug 8 (S-1).

( ) White-blue wire to lug 4 (S-1).

( ) Large blue wire to lug 3 (S-1).

( ) Cut both leads of a 1 MΩ (brown-black-green), 1/2-watt resistor to 1/2". Connect this resistor between lug 1 (NS) and lug 2 (NS).

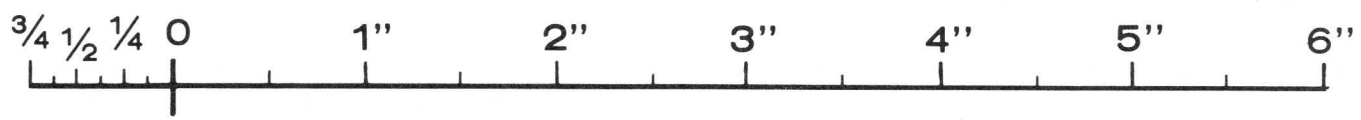
( ) Large red wire to lug 2 (S-2).

( ) Large white wire to lug 1 (NS).

( ) Connect either of the brown transformer leads to lug 1 (S-3).

( ) Connect the remaining brown transformer lead to lug 12 (S-1).

( ) Remove the paper backing from the blue and white label and press the label into place on the upper center portion of the rear panel. Be sure to refer to the numbers on the label in any communications you have with the Heath Company about this kit.



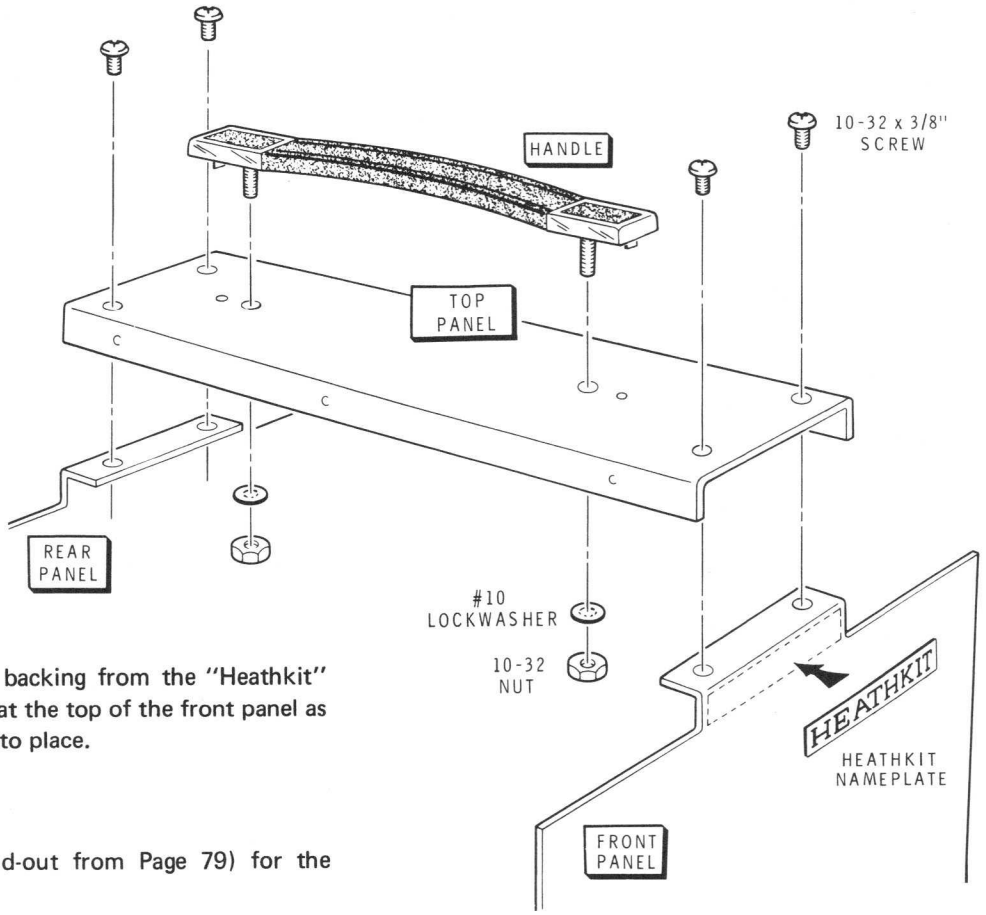
HANDLE MOUNTING

Refer to Pictorial 13-1 for the following steps.

( ) Mount the handle to the top bracket as shown. Use two #10 lockwashers and two 10-32 nuts.

( ) Mount the top bracket to the front and rear panels. Use four 10-32 x 3/8" screws and be sure that the handle is toward the rear of the Oscilloscope as shown.

( ) Remove the protective backing from the "Heathkit" nameplate and install it at the top of the front panel as shown. Press it firmly into place.



PICTORIAL 13-1

KNOB INSTALLATION

Refer to Pictorial 14-1 (fold-out from Page 79) for the following steps.

( ) Turn all the control and switch shafts on the front panel to their full counterclockwise positions.

( ) Push a large-shaft knob insert onto the Trace shaft. Then press an 11/16" plain knob onto the insert.

( ) Remove both the knob and the knob insert as one unit. Refer to the inset drawing on the Pictorial and press the insert all the way into the knob cavity with a nut driver or other suitable tool. Replace the knob on the Trace switch shaft.

In the same manner, install knobs at the following locations.

( ) 11/16" plain knob on the Focus control shaft.

( ) 11/16" plain knob on the Graticule control shaft.

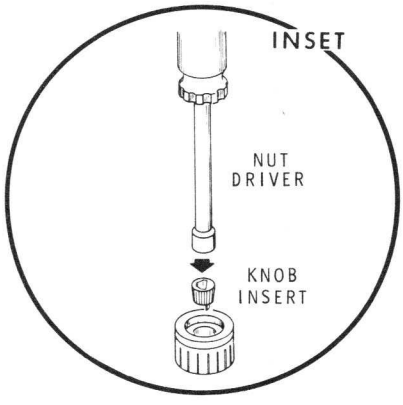
( ) 11/16" plain knob on the Astig control shaft.

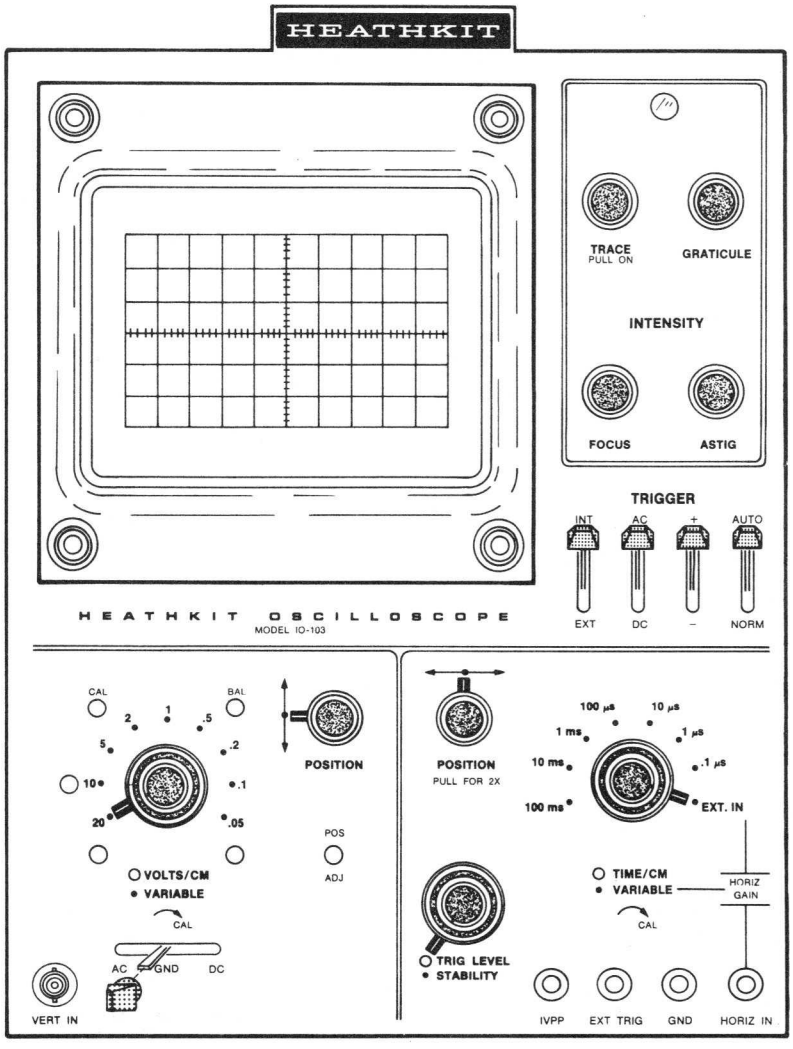
NOTE: In the following steps, pointer knobs will be installed on the various remaining control and switch shafts. Do not press the knob firmly onto the knob insert until you are sure the knob is correctly aligned.

( ) Place large-shaft knob inserts on the two Position control shafts. Then turn both of these controls to their center positions. Repeat this step until you are sure the controls are at the center of their rotation.

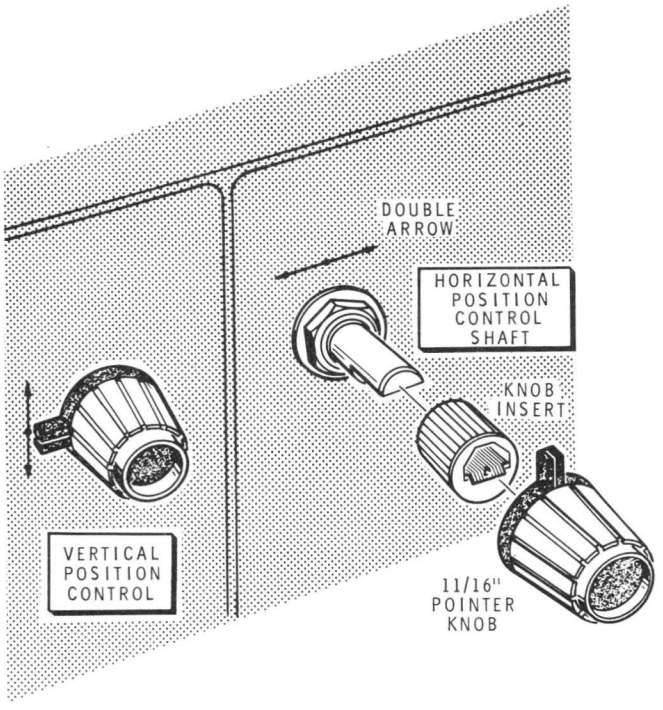
( ) Refer to Detail 14-1A and install an 11/16" pointer knob on the horizontal (right) Position control shaft so the pointer is directly in line with the small dot in the center of the double arrow. Then remove the knob and knob insert from the shaft and seat the insert into the knob cavity as in previous steps. Replace the knob on the horizontal Position control shaft.

( ) In the same manner, install an 11/16" pointer knob on the vertical (left) Position control shaft.

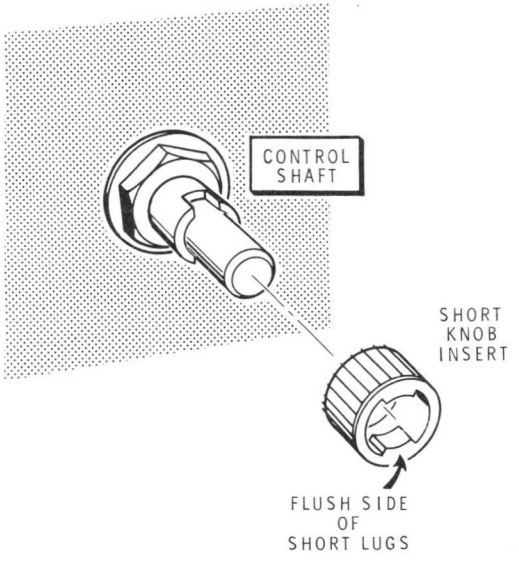




PICTORIAL 14-1



Detail 14-1A



Detail 14-1B

NOTE: In the following three steps, the short knob inserts and their respective knobs will be installed. Each of the short knob inserts are made so they will fit the control shaft incorrectly if they are inverted. To properly install the short insert, it must be placed on the shaft so the recessed part of the short lug is toward the front panel as shown in Detail 14-1B. The flush side of the short lugs will face outward.

( ) Install three short knob inserts on the Volts/cm, the Time/cm, and the Trig Level control shafts.

( ) Place a 1" pointer knob on the Time/cm switch shaft, and align the pointer with the "100 ms" dot. Press the knob onto the insert. Then remove the knob and insert as a unit and press the insert into the knob as in the previous steps. Replace the knob onto the Time/cm switch shaft.

( ) In the same manner, install a 1" pointer knob on the Volts/cm switch shaft. Position the knob pointer at the dot by the "20."

NOTE: The knob will be installed on the Trig Level control later.

( ) Place a small-shaft knob insert onto each of the following controls: Volts/cm Variable, Time/cm Variable, and Stability.

NOTE: In the following steps, short pointer knobs will be installed on the controls indicated in the previous step. Make sure each control is fully counterclockwise; then position white dot on the small pointer knob at 7 o'clock. Install the insert into the knob cavity as in the previous steps.

( ) Small pointer knob on the Volts/cm (Variable) control shaft.

( ) Small pointer knob on the Time/cm (Variable) control shaft.

The small pointer knob will be installed on the Stability control shaft later.

Refer to Pictorial 14-1 for the following steps.

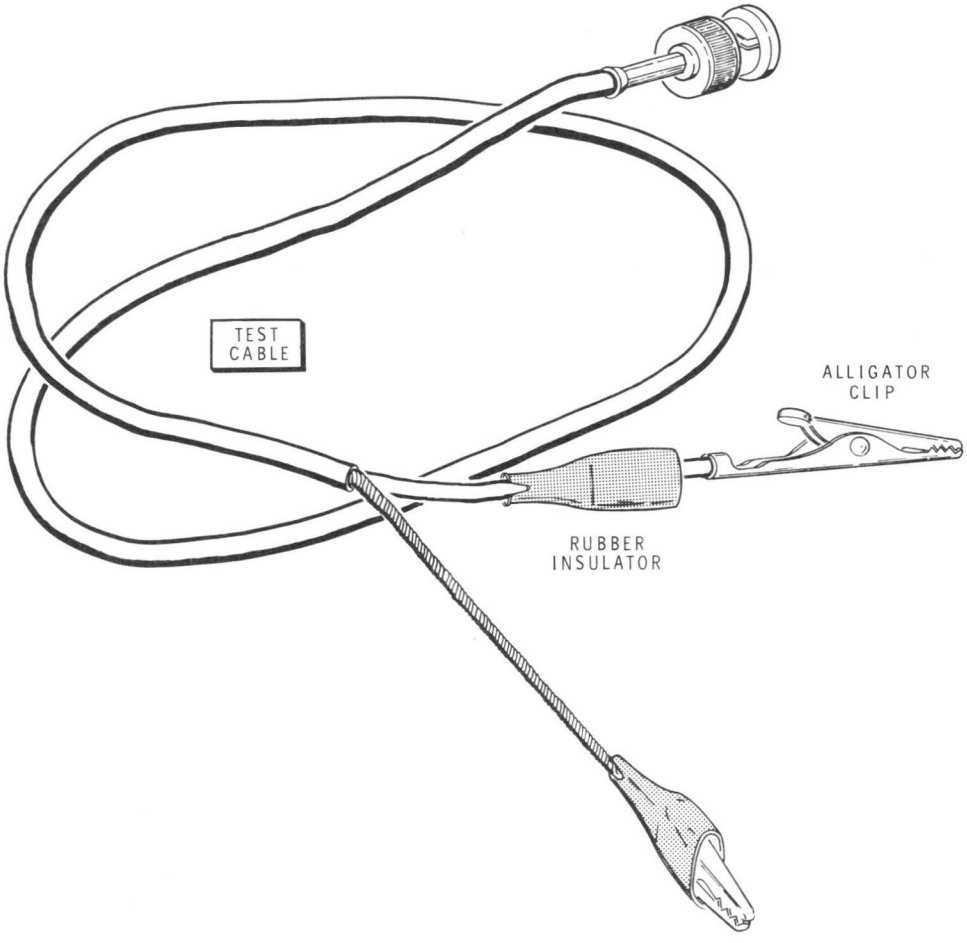
( ) Lever knob on the AC-GND-DC switch shaft.

( ) Lever knob on the INT-EXT switch shaft.

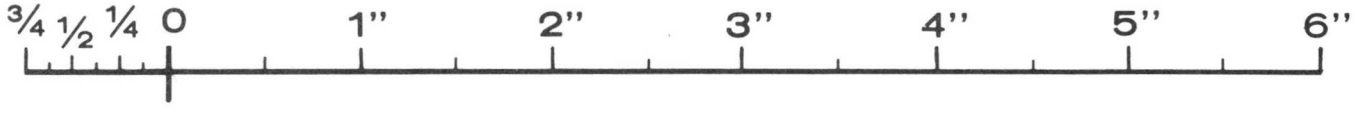
( ) Lever knob on the AC-DC switch shaft.

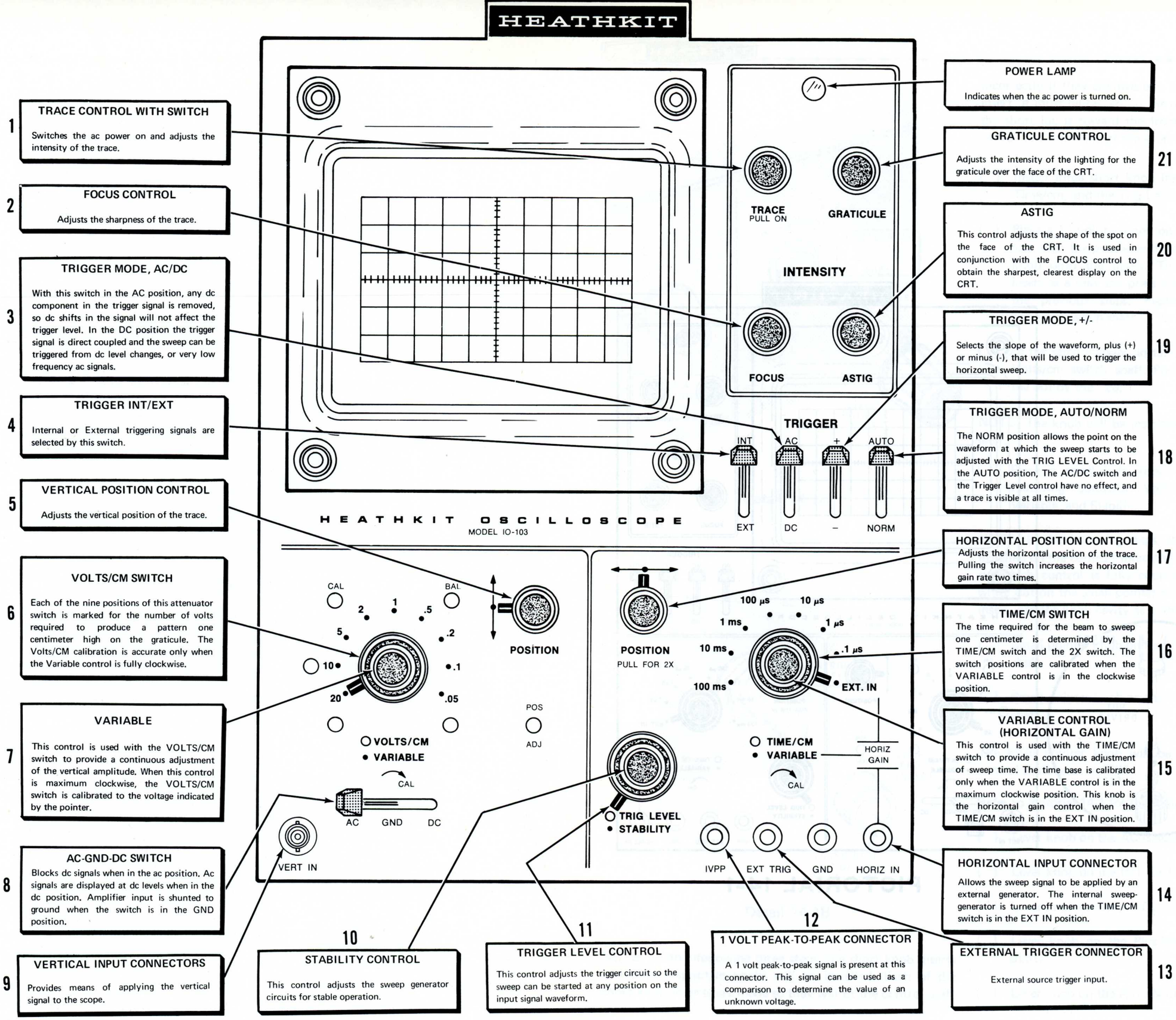
( ) Lever knob on the Plus-Minus ("+ and –") switch shaft.

( ) Lever knob on the Auto-Norm switch shaft.



PICTORIAL 15-1





1 TRACE CONTROL WITH SWITCH

Switches the ac power on and adjusts the intensity of the trace.

2 FOCUS CONTROL

Adjusts the sharpness of the trace.

3 TRIGGER MODE, AC/DC

With this switch in the AC position, any dc component in the trigger signal is removed, so dc shifts in the signal will not affect the trigger level. In the DC position the trigger signal is direct coupled and the sweep can be triggered from dc level changes, or very low frequency ac signals.

4 TRIGGER INT/EXT

Internal or External triggering signals are selected by this switch.

5 VERTICAL POSITION CONTROL

Adjusts the vertical position of the trace.

6 VOLTS/CM SWITCH

Each of the nine positions of this attenuator switch is marked for the number of volts required to produce a pattern one centimeter high on the graticule. The Volts/CM calibration is accurate only when the Variable control is fully clockwise.

7 VARIABLE

This control is used with the VOLTS/CM switch to provide a continuous adjustment of the vertical amplitude. When this control is maximum clockwise, the VOLTS/CM switch is calibrated to the voltage indicated by the pointer.

8 AC-GND-DC SWITCH

Blocks dc signals when in the ac position. Ac signals are displayed at dc levels when in the dc position. Amplifier input is shunted to ground when the switch is in the GND position.

9 VERTICAL INPUT CONNECTORS

Provides means of applying the vertical signal to the scope.

10 STABILITY CONTROL

This control adjusts the sweep generator circuits for stable operation.

11 TRIGGER LEVEL CONTROL

This control adjusts the trigger circuit so the sweep can be started at any position on the input signal waveform.

12 1 VOLT PEAK-TO-PEAK CONNECTOR

A 1 volt peak-to-peak signal is present at this connector. This signal can be used as a comparison to determine the value of an unknown voltage.

13 EXTERNAL TRIGGER CONNECTOR

External source trigger input.

14 HORIZONTAL INPUT CONNECTOR

Allows the sweep signal to be applied by an external generator. The internal sweep-generator is turned off when the TIME/CM switch is in the EXT IN position.

15 VARIABLE CONTROL (HORIZONTAL GAIN)

This control is used with the TIME/CM switch to provide a continuous adjustment of sweep time. The time base is calibrated only when the VARIABLE control is in the maximum clockwise position. This knob is the horizontal gain control when the TIME/CM switch is in the EXT IN position.

16 TIME/CM SWITCH

The time required for the beam to sweep one centimeter is determined by the TIME/CM switch and the 2X switch. The switch positions are calibrated when the VARIABLE control is in the clockwise position.

17 HORIZONTAL POSITION CONTROL

Adjusts the horizontal position of the trace. Pulling the switch increases the horizontal gain rate two times.

18 TRIGGER MODE, AUTO/NORM

The NORM position allows the point on the waveform at which the sweep starts to be adjusted with the TRIG LEVEL Control. In the AUTO position, The AC/DC switch and the Trigger Level control have no effect, and a trace is visible at all times.

19 TRIGGER MODE, +/-

Selects the slope of the waveform, plus (+) or minus (-), that will be used to trigger the horizontal sweep.

20 ASTIG

This control adjusts the shape of the spot on the face of the CRT. It is used in conjunction with the FOCUS control to obtain the sharpest, clearest display on the CRT.

21 GRATICULE CONTROL

Adjusts the intensity of the lighting for the graticule over the face of the CRT.

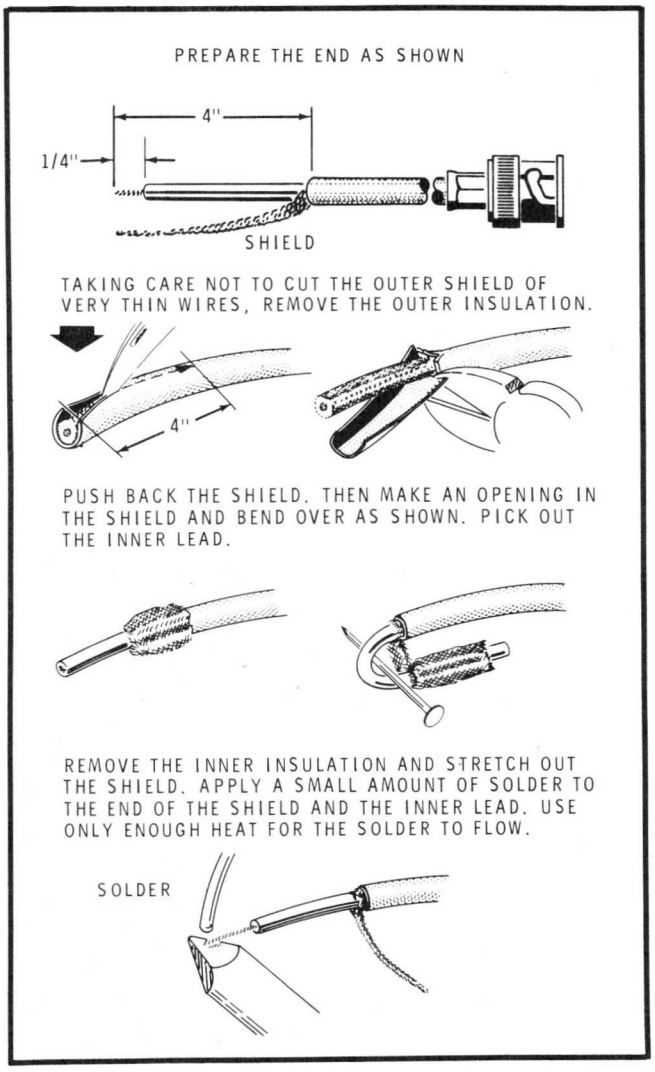
POWER LAMP

Indicates when the ac power is turned on.

FIGURE 1-1

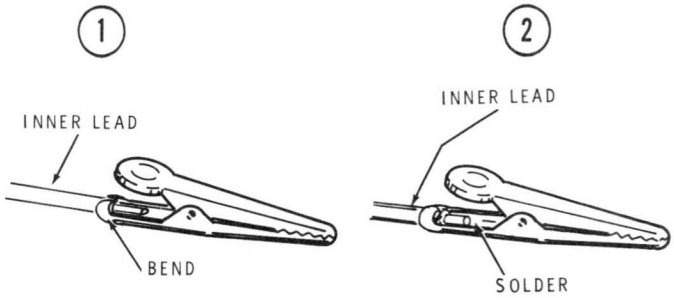
TEST CABLE ASSEMBLY

Refer to Pictorial 15-1 (on Page 80) for the following steps.



Detail 15-1A

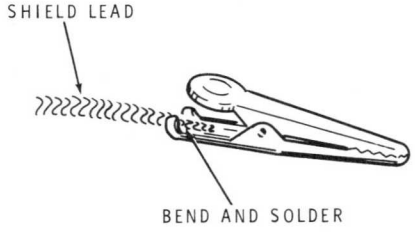
( ) Refer to Detail 15-1A and prepare the indicated end of the cable assembly as shown.



Detail 15-1B

( ) Refer to Pictorial 15-1 and push rubber insulators onto the inner lead and the shield lead of the cable.

( ) Refer to Detail 15-1B and install an alligator clip on the inner lead of the cable as shown in Parts 1 and 2 of the Detail.



Detail 15-1C

( ) Refer to Detail 15-1C and install an alligator clip on the shield lead of the cable as shown. Then push the rubber insulators down over the alligator clips after the clips have cooled.

This completes the "Step-by-Step Assembly" of your Oscilloscope except for "Cabinet Assembly" to follow later.

INITIAL TESTS

CONTROL SETTINGS

FRONT PANEL

NOTE: Refer to Figure 1-1 (fold-out from Page 80). In the following steps, all front panel controls will be called out in capital letters just as they appear on the front of the Oscilloscope. The following markings are on the front panel in abbreviated form. The numbers in parentheses refer to the control key numbers on Figure 1-1.

MARKING	FULL MEANING
ASTIG (20)	Astigmatism
INT (4)	Internal
EXT (4)	External
AUTO (18)	Automatic
NORM (18)	Normal
VOLTS/CM (6)	Volts per centimeter
CAL (7) (15)	Calibration or Calibrated
POS ADJ (5) (17)	Position adjust
BAL	Balance
TIME/CM (16)	Time per centimeter
TRIG LEVEL (11)	Trigger level
EXT IN (16)	External input
HORIZ GAIN (15)	Horizontal gain
1VP-P (12)	1 volt peak-to-peak
EXT TRIG (13)	External trigger
GND	Ground
HORIZ IN (14)	Horizontal input

NOTE: Do not plug the ac line cord into an outlet until you are instructed to do so.

Set the front panel controls as directed in the following groups of steps.

Beam and Scale Controls

( ) TRACE (1): Full clockwise and pushed in.

( ) GRATICULE (21): Full clockwise.

( ) FOCUS (2): Center of rotation.

( ) ASTIG (20): Center of rotation.

Position Controls

( ) VERTICAL: Center of range (dot).

( ) HORIZONTAL: Center of range (dot), and pushed in.

Vertical Controls

( ) VOLTS/CM: 20.

( ) VARIABLE: Full clockwise (CAL).

( ) AC-GND-DC: GND.

Time Base

( ) TRIGGER LEVEL: Counterclockwise.

( ) STABILITY: Counterclockwise.

( ) TIME/CM: EXT IN.

( ) HORIZ GAIN: Counterclockwise.

( ) TRIGGER switches: INT, AC, +, AUTO.

INTERNAL

In the following steps the internal controls will be preset. These controls should be set when looking at the control from the position shown in a specific Figure.

Refer to Figures 2-1 through 2-3 (fold-out from Page 84) for the following steps. Set these controls to the center of rotation unless instructed to do otherwise.

Front Panel (Figure 2-1)

( ) BAL.

( ) POS ADJ.

( ) CAL.

Chassis Right Side (Figure 2-3)

( ) Position Adjust.

( ) CRT Bias.

( ) SWEEP CAL.

( ) FEEDBACK ADJUST.

( ) LEVEL SET.

( ) TRIGGER BALANCE.

( ) DC LEVEL.

( ) DC BALANCE.

( ) GAIN CAL.

( ) HORIZONTAL 100 V ADJUST.

Bottom of Chassis (Figure 2-2A)

( ) Vert 100 Volt Adjust: Maximum clockwise.

ADJUSTMENTS

If the Oscilloscope operates abnormally at any time during the following adjustments, turn it off immediately and refer to the "In Case of Difficulty" section of the Manual on Page 101.

You will need an 11-megohm input voltmeter, or equivalent, for the following adjustments.

Figure 1-1 (fold-out from Page 80) shows the front panel of the Oscilloscope. Study the Figure carefully, as well as the chart on Figure 1-2, to identify the function of each switch, control, jack, and connector. The chart shows which of the controls interact with each other.

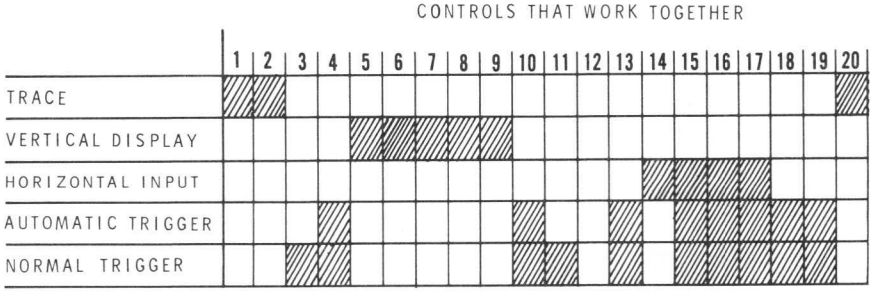
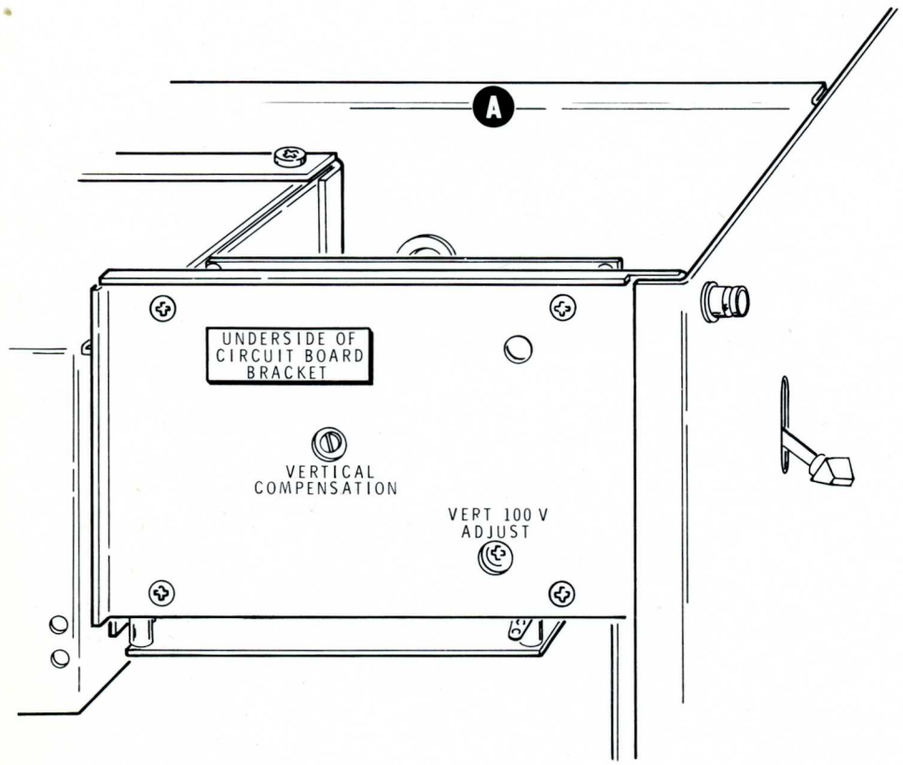


Figure 1-2



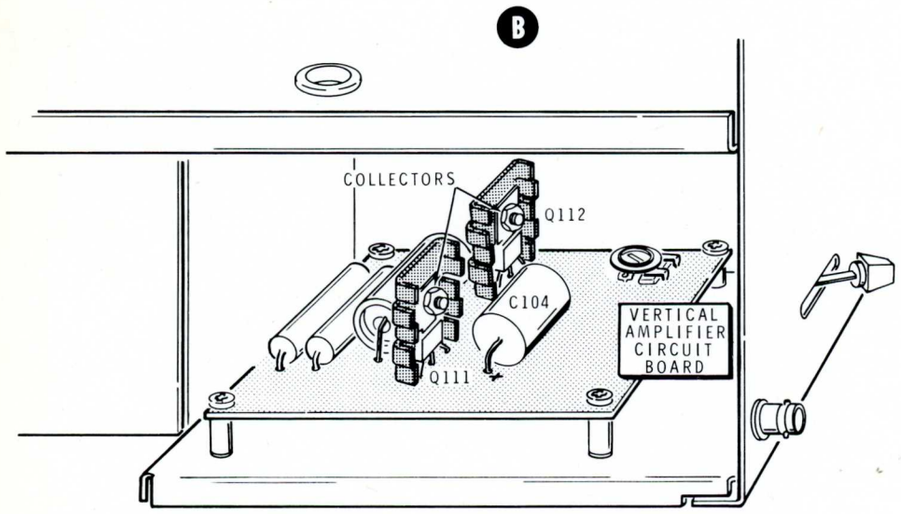


FIGURE 2-2

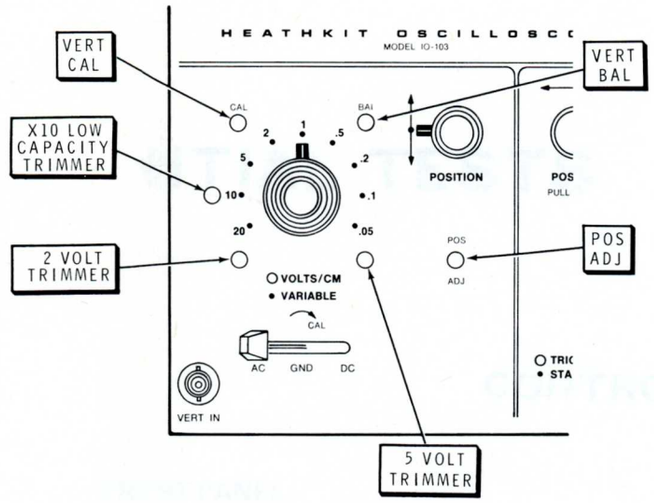


FIGURE 2-1

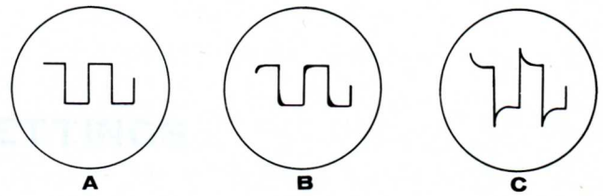


FIGURE 2-7

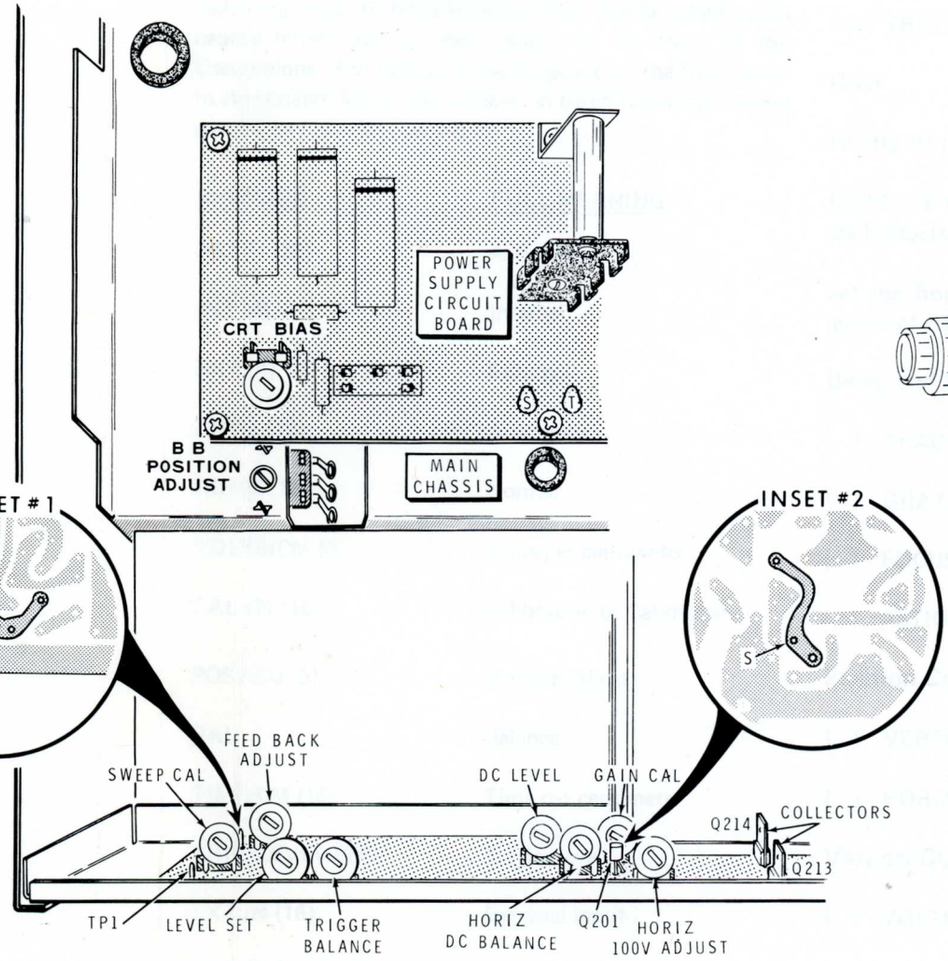


FIGURE 2-3

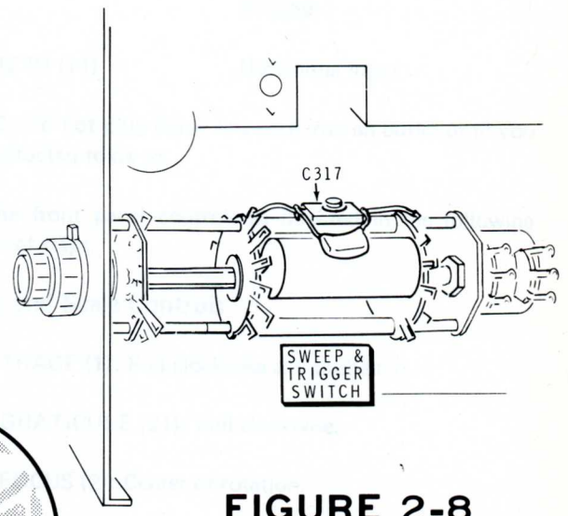


FIGURE 2-8

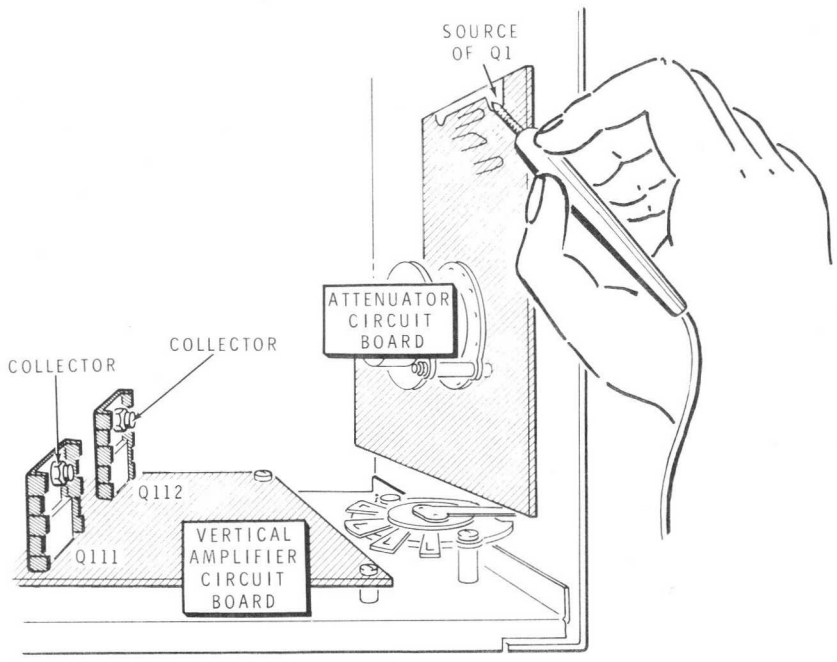


Figure 2-4

CAUTION: PROCEED WITH CARE DURING THE FOLLOWING STEPS UNTIL THE SIDE COVERS ARE INSTALLED. BOTH AC AND DC VOLTAGES IN SOME AREAS MAY EXCEED 1300 VOLTS. SEE PHOTOGRAPHS (FOLD-OUT FROM PAGE 89).

NOTE: Several adjustments will be made by inserting a slender screwdriver or other alignment tool through a metal panel. If the tool is made of metal, care must be taken that the side of the tool does not come in contact with the panel. Wrap plastic electrical tape around the shank of the metal tool prior to making any through-the-panel adjustments.

( ) Connect the Oscilloscope line cord plug to an ac outlet.

( ) Ground the negative voltmeter test lead to the Oscilloscope chassis. Turn the voltmeter on and set the controls to measure +10 volts dc.

( ) Pull the TRACE control on the Oscilloscope to the ON position and allow the Oscilloscope to warm up for at least 1 minute. During warmup, turn the GRATICULE control and observe the lighting; check to see that the red power light is operating. You may also wish to check, at this time, for any unusual occurances such as over-heating components, etc.

( ) Connect your voltmeter to the vertical +9 volt supply. A convenient point would be the positive (+) lead of capacitor C104, shown in Figure 2-2B. This voltage should read low.

( ) Refer to Figure 2-2A and turn the VERT 100 V ADJUST control counterclockwise until the voltage on the positive (+) lead of C104 reaches +9 volts (±10%) and no further change is noted on the voltmeter.

( ) Refer to Figure 2-4 and place the positive VTVM lead on the Source (S) of transistor Q1. Adjust the vertical BAL control (Figure 2-1) until a reading of zero volts is obtained. NOTE: As the VTVM reading approaches zero, reduce the setting of the VTVM attenuator switch for greater sensitivity.

( ) Set the VTVM attenuator to measure +200 volts dc.

( ) Refer to Figure 2-4 and measure the voltages on the collectors of transistors Q111 and Q112 on the vertical amplifier circuit board. Adjust the POS ADJ control through the front panel until these voltages are equal. NOTE: As this control is rotated, the voltage on one collector will decrease, while the voltage on the other collector will increase.

( ) Refer to Figure 2-2 (fold-out from Page 84) and turn the Vert 100-volt Adjust control counterclockwise for a 100-volt reading on the collectors of Q111 and Q112. NOTE: It may be necessary to readjust the POS ADJ control, as this interacts with the Vert 100-volt Adjust control; carefully readjust both controls as required.

( ) Recheck the +9 volt supply. If low, readjust the Vert 100-volt Adjust control.

( ) Set the VTVM to measure +10 volts dc.

( ) Refer to Figure 2-3 and place the positive VTVM lead on the Source (S) of transistor Q201. Adjust the HORIZ DC BALANCE control until a reading of zero volts is obtained. NOTE: As the VTVM reading approaches zero, reduce the setting of the VTVM range switch for greater sensitivity.

( ) Reset the VTVM to measure +200 volts dc.

( ) Refer to Figure 2-3 and measure the voltage on the collectors of transistors Q213 and Q214. Adjust POSITION ADJUST control BB until these voltages are equal.

( ) Turn the Horiz 100V ADJUST control for 100-volt meter reading on the collectors of transistors Q213 and Q214. NOTE: It may be necessary to readjust POSITION ADJUST control BB; then once again adjust the Horiz 100V ADJUST control until the desired results are obtained. Do this carefully.

( ) Turn the CRT BIAS control on the power supply circuit board until a spot appears on the face of the CRT.

( ) Turn the TRACE control (Figure 1-1) full counterclockwise. Then adjust the CRT BIAS control until the spot just disappears (or until the CRT BIAS control is fully counterclockwise).

( ) Turn the TRACE control until the spot reappears on the face of the CRT. Adjust the FOCUS and ASTIG controls for minimum spot size.

CALIBRATION

TRIGGER CIRCUITS

Refer to Figure 1-1 (fold-out from Page 80) and set the front panel controls as follows:

( ) TIME/CM: 100 μs.

( ) VARIABLE (Time/CM): Maximum clockwise.

( ) TRIGGER switches: INT, AC, +, AUTO.

( ) TRIGGER LEVEL: Maximum counterclockwise.

( ) STABILITY: Full counterclockwise.

( ) Refer to Figure 2-3 (fold-out from Page 84) and connect the common VTVM lead to the Oscilloscope chassis and the positive lead to TP 1 (source of transistor Q302). Set the VTVM range to +5 volts. Then adjust the LEVEL SET control for zero volts.

( ) Connect the positive lead of the VTVM to TP 2 (source of transistor Q314). Adjust the FEEDBACK ADJ control for .2 volts.

( ) Turn the STABILITY control (Figure 1-1) until the trace appears on the face of the CRT.

( ) Adjust the FOCUS and ASTIG (Astigmatism) controls for the sharpest trace.

( ) Adjust the horizontal POSITION control (Figure 1-1) to its mid-position (dot).

( ) Refer to Figure 2-3 and adjust POS ADJ BB control so the trace starts at the left vertical graticule line.

( ) Check to see that the horizontal trace is parallel with the horizontal graticule lines. If these lines are parallel, proceed to step 5. If they are not parallel, complete all the following numbered steps.

1. Note the relative position of the horizontal trace and unplug the line cord.

2. Rotate the CRT.

3. Plug in the line cord and again check the position of the horizontal trace.

4. Repeat steps 1 through 3 as necessary to align the horizontal trace.

5. After the trace has been correctly aligned, unplug the line cord and tighten the CRT clamp nuts. Plug the line cord into an ac outlet.

NOTE: To properly perform the following calibration steps, you will need a signal generator capable of producing a sine wave of 10 kHz and square waves at 1000 Hz and 100 kHz.

( ) Set the output of the signal generator to produce a sine wave of approximately 10 kHz.

( ) Connect the output of the generator to the VERT IN jack (Figure 1-1) of the Oscilloscope.

( ) Set the VOLTS/CM switch to .5 and the VARIABLE control fully clockwise.

( ) Set the Oscilloscope AC-GND-DC switch to AC.

( ) Set the amplitude control on the signal generator to display approximately 4 cm on the CRT screen.

( ) Center the CRT display by adjusting the vertical POSITION control.

( ) Refer to Figure 2-3 and adjust the TRIGGER BALANCE control until the signal on the CRT is stabilized or "synchronized." This will be a condition where the sine wave displayed is steady and unshifting.

( ) Move the Trigger AUTO-NORM switch on the front panel to the NORM position. The CRT display should disappear. If it does not, return the switch to AUTO, turn the STABILITY control slightly counterclockwise and readjust the TRIGGER BALANCE control. After that is done, once again set the AUTO-NORM switch to the NORM position to cause the trace to disappear.

( ) Adjust the TRIGGER LEVEL control (Figure 1-1) to lock in the signal display.

( ) Move the TRIGGER +/– switch to the "–" position. If the trace disappears from the CRT, carefully note the position of the TRIGGER LEVEL control. Turn the TRIGGER LEVEL control until the trace appears on the CRT. Note the position of the TRIGGER LEVEL control again.

( ) Set the TRIGGER LEVEL control to a position midway between the two noted settings.

( ) Adjust the TRIGGER BALANCE control (Figure 2-3) until the signal on the CRT locks in. Switch the TRIGGER +/– switch between the + position and the – position while further adjusting the TRIGGER BALANCE control until the trace starts at the same point in both switch positions.

( ) Place the AUTO-NORM switch in the AUTO position.

( ) Work the TRIGGER +/– switch up and down while observing the trace on the CRT. The trace should start an equal distance above and below the centerline of the graticule. If it does not, adjust the LEVEL SET control (Figure 2-3) until the traces for the switch positions are the same distance above and below the centerline.

( ) Set the TRIGGER AC-DC switch to DC.

( ) Work the AC-DC switch up and down while observing the trace on the CRT. Adjust the DC LEVEL control (Figure 2-3) until the trace starts at the same point in both switch positions.

( ) Set the TRIGGER switches to: INT, AC, +, NORM.

( ) Work the TRIGGER +/– switch up and down while observing the trace on the CRT. Adjust the TRIGGER LEVEL control until the trace starts at the same point on the horizontal centerline.

( ) Remove the knob bushing from the STABILITY control on the front panel (Figure 1-1).

( ) Install the remaining 1" pointer knob on the TRIG LEVEL knob insert so the pointer is at the 12 o'clock position (See Page 79 for details on knob installation.)

( ) Replace the knob insert on the shaft of the STABILITY control. Turn the control shaft fully counterclockwise.

( ) Install the remaining small pointer knob on the STABILITY shaft insert so the pointer dot is at the 7 o'clock position. (See Page 79 for details on knob installation.)

SWEEP CALIBRATION

( ) Set the trigger switches: INT, AC, +, AUTO.

( ) Reset the STABILITY control for a steady trace on the CRT.

( ) Refer to Figure 2-3 and adjust the GAIN CAL control so there is an 8 cm horizontal display on the CRT. NOTE: Each graticule square is 1 cm x 1 cm.

( ) Connect a 1000 Hz square wave signal to the VERT IN jack of the Oscilloscope.

( ) Adjust the SWEEP CAL control (Figure 2-3) for a display of 1-1/2 cycles on the CRT. NOTE: The accuracy of the time base is directly related to the accuracy of the 1000 Hz input signal.

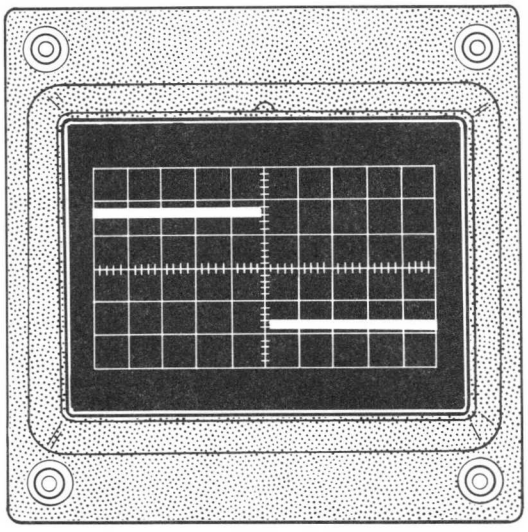


Figure 2-5

( ) Adjust the GAIN CAL control (Figure 2-3) until one cycle is 10 cm in length as shown in Figure 2-5. Note that in viewing a 1000 Hz square wave, the vertical lines may not be visible. This is because the rise time is too rapid to be seen on the CRT.

( ) Turn the TIME/CM switch (Figure 1-1) to 1 ms. Pull the horizontal POSITION control out to the X2 position.

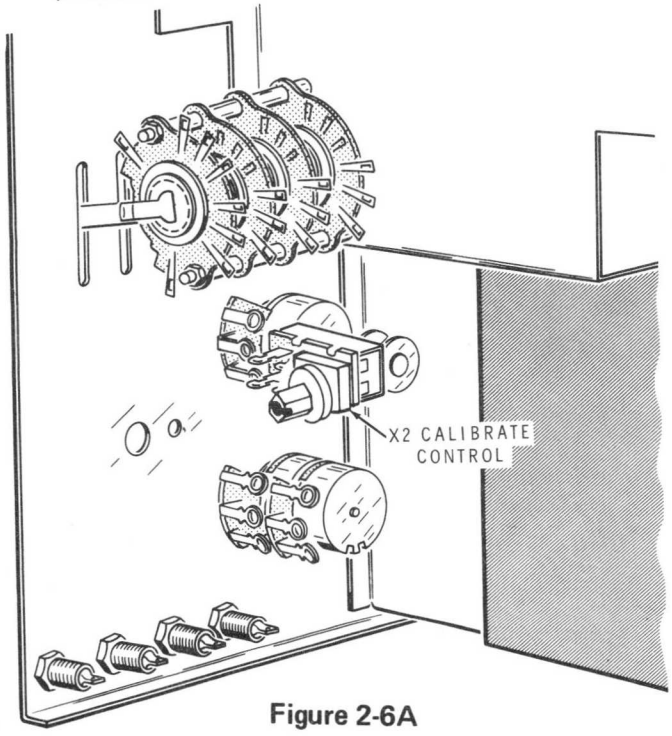


Figure 2-6A

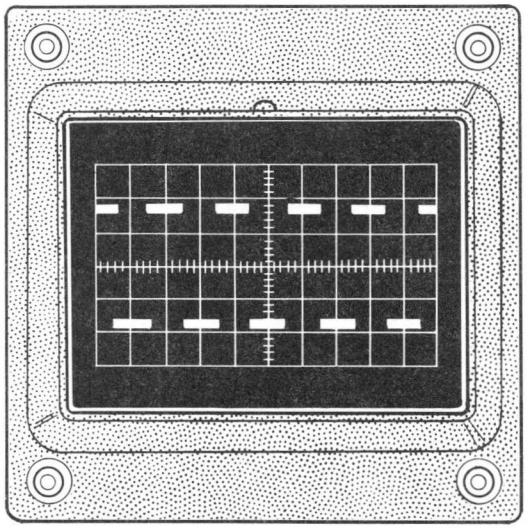


Figure 2-6B

( ) Refer to Figure 2-6A and adjust the X2 Calibrate control until 5 complete cycles equal 10 cm as shown in Figure 2-6B.

( ) Push the X2 switch on the horizontal POSITION control in, then turn the TIME/CM switch to the 1 μs position.

( ) Adjust the output of the signal generator to provide a 100 kHz square wave signal to the VERT IN jack of the Oscilloscope. The signal on the CRT may resemble A, B, or C of Figure 2-7 (fold-out from Page 84) at this time.

( ) Refer to Figure 2-8 (fold-out from Page 84) and adjust trimmer capacitor C317 until 1 cycle produces a 10 cm display on the CRT. Use the Horiz Pos control to move the trace to the left so that you do not use the first 1/2 cycle of the square wave. If you cannot obtain one full cycle on the CRT, check the 1000 Hz calibration (7 steps prior to this one).

( ) Set the VOLTS/CM switch to the .05 position.

( ) Set the signal to approximately 4 cm of vertical deflection on the CRT.

( ) Turn the (Time/cm) VARIABLE control counter-clockwise to display several cycles.

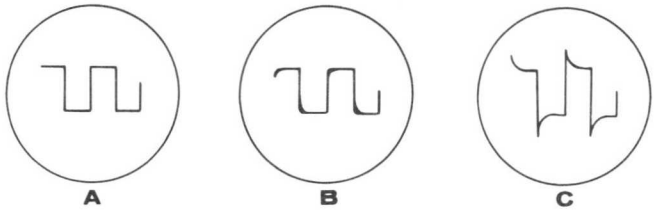


Figure 2-7 (Repeat)

VERTICAL COMPENSATION

Figure 2-7 shows the conditions of the correct amount of circuit compensation, too little and too much. After making the following adjustments, the waveform should appear as shown in Part A of Figure 2-7.

( ) Adjust the Vertical Compensation trimmer (Figure 2-2) on the vertical amplifier circuit board until the waveform appears as shown in Part A of Figure 2-7.

( ) Set the signal generator to produce a 1000 Hz square wave.

( ) Set the VOLTS/CM switch (Figure 1-1) to 2.

( ) Set the TIME/CM switch to 100 μs, and the VARIABLE control to display several cycles on the CRT.

( ) Adjust the signal generator amplitude to produce a 4 cm vertical display on the CRT.

( ) Adjust 2 volt trimmer capacitor C1 (Figure 2-1) until the waveform appears as shown in Part A of Figure 2-7.

( ) Turn the VOLTS/CM switch to the 5 volt position.

( ) If possible, increase the signal generator output amplitude to display 4 cm of vertical signal on the CRT.

( ) Adjust 5 volt trimmer capacitor C5 until the waveform appears as shown in Part A of Figure 2-7.

( ) Repeat all of the "Vertical Compensation" steps until no further improvement is noted.

NOTE: In the following steps, you will adjust the X10 low capacity trimmer. If you do not have an X10 low capacity probe, adjust trimmer C2 in the following step. If you do have a low capacity probe, proceed to "With Low Capacity Probe."

Without Low Capacity Probe

( ) Turn X10 Low Capacity Trimmer C2 clockwise until it is just snug, then turn it counterclockwise one-quarter turn. Proceed to "Vertical Calibration."

With Low Capacity Probe

( ) Set the signal generator to produce a 1000 Hz square wave signal to the VERT IN jack on the Oscilloscope.

( ) Turn the VOLTS/CM switch (Figure 1-1) to the .05 volt position.

( ) Set the amplitude of the signal generator to produce a 4 cm vertical deflection on the CRT.

( ) Adjust the trimmer capacitor on the X10 low capacity probe to produce a waveform as shown in Part A of Figure 2-7.

( ) Turn the VOLTS/CM switch to the .5 volt position.

( ) If possible, increase the amplitude of the CRT display to 4 cm.

( ) Adjust X10 Low Capacity Trimmer C2 (Figure 2-1) to produce a waveform as shown in Part A of Figure 2-7.

VERTICAL CALIBRATION

( ) Set the TIME/CM switch to 1 ms.

( ) Set the VOLTS/CM switch to .2.

( ) Connect the VERT IN test cable to the 1V P-P. (It is not necessary to connect the test cable shield lead.)

( ) AC-GND-DC switch: AC.

( ) Adjust (Time/cm) VARIABLE to produce several cycles on the CRT.

( ) Refer to Figure 2-1 and adjust the CAL control for 5 cm of vertical deflection.

( ) Disconnect all cables from the Oscilloscope.

( ) Push in the TRACE knob on the front panel to turn the Oscilloscope off; then remove the ac line cord plug from the wall outlet.

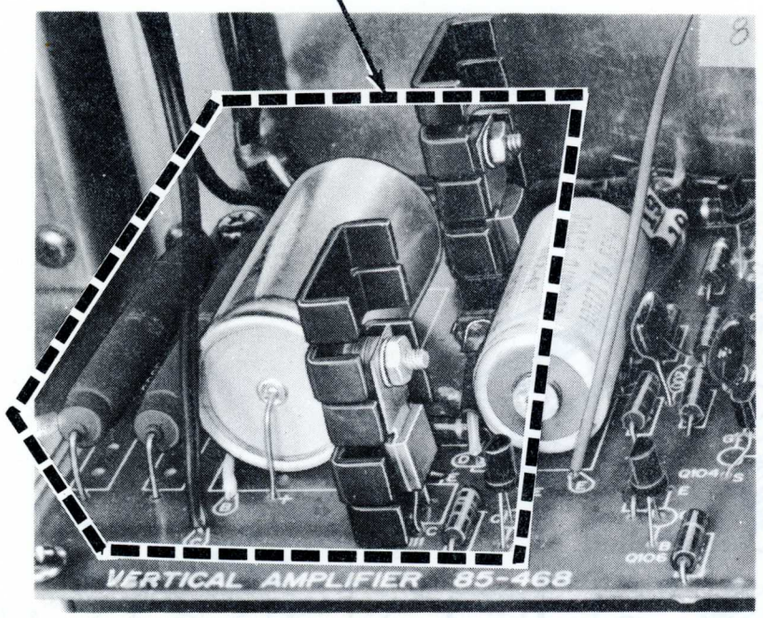
This completes the calibration of your Oscilloscope.

NOTE: It is suggested you repeat the "Calibration" after your Oscilloscope has operated several hours, and periodically thereafter. Allow sufficient warm-up time (at least 30 minutes) before you start the calibration.

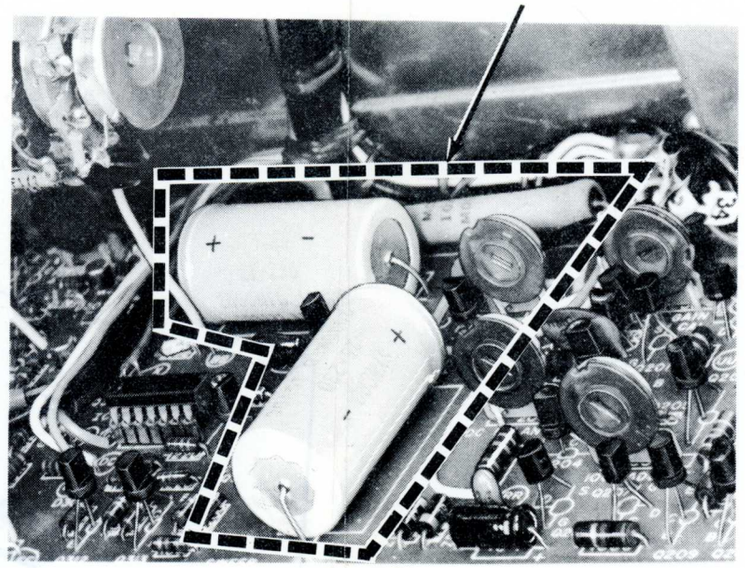
Proceed to "Cabinet Assembly."

PHOTOGRAPHS

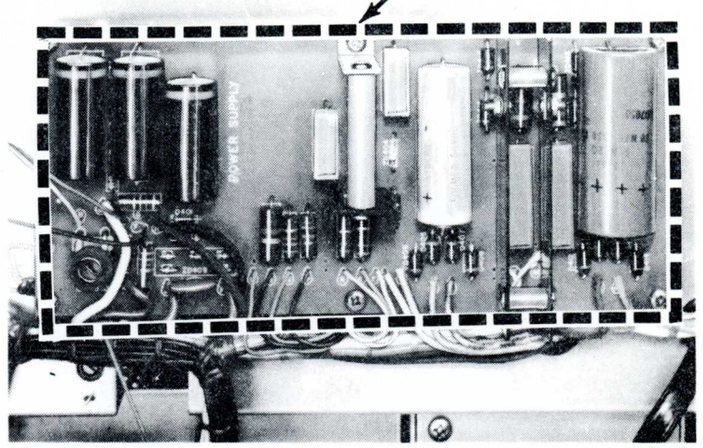
HIGH VOLTAGE AREA

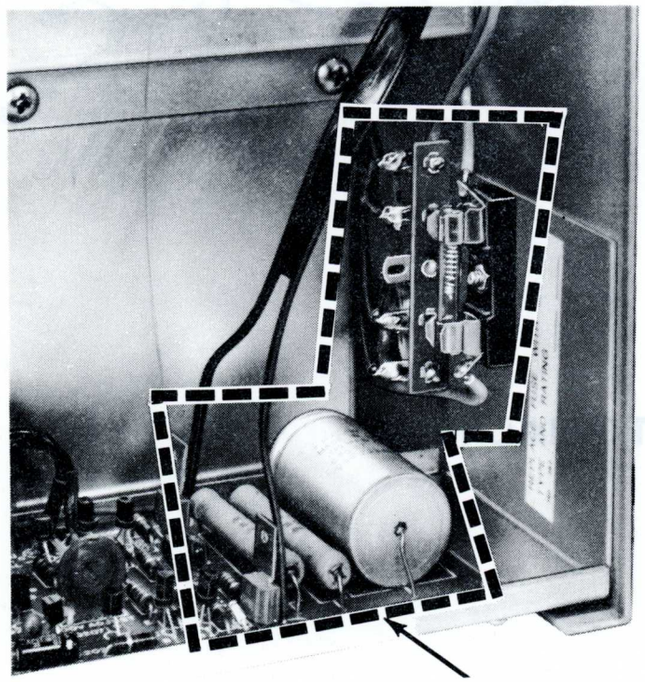


HIGH VOLTAGE AREA



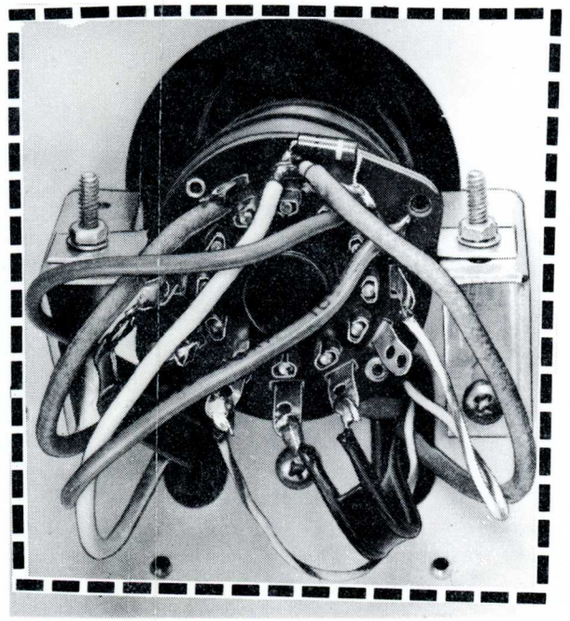
HIGH VOLTAGE AREA



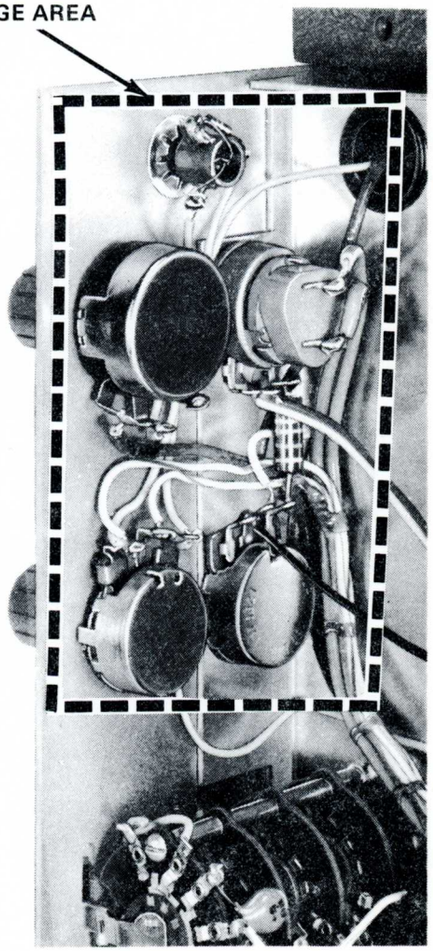


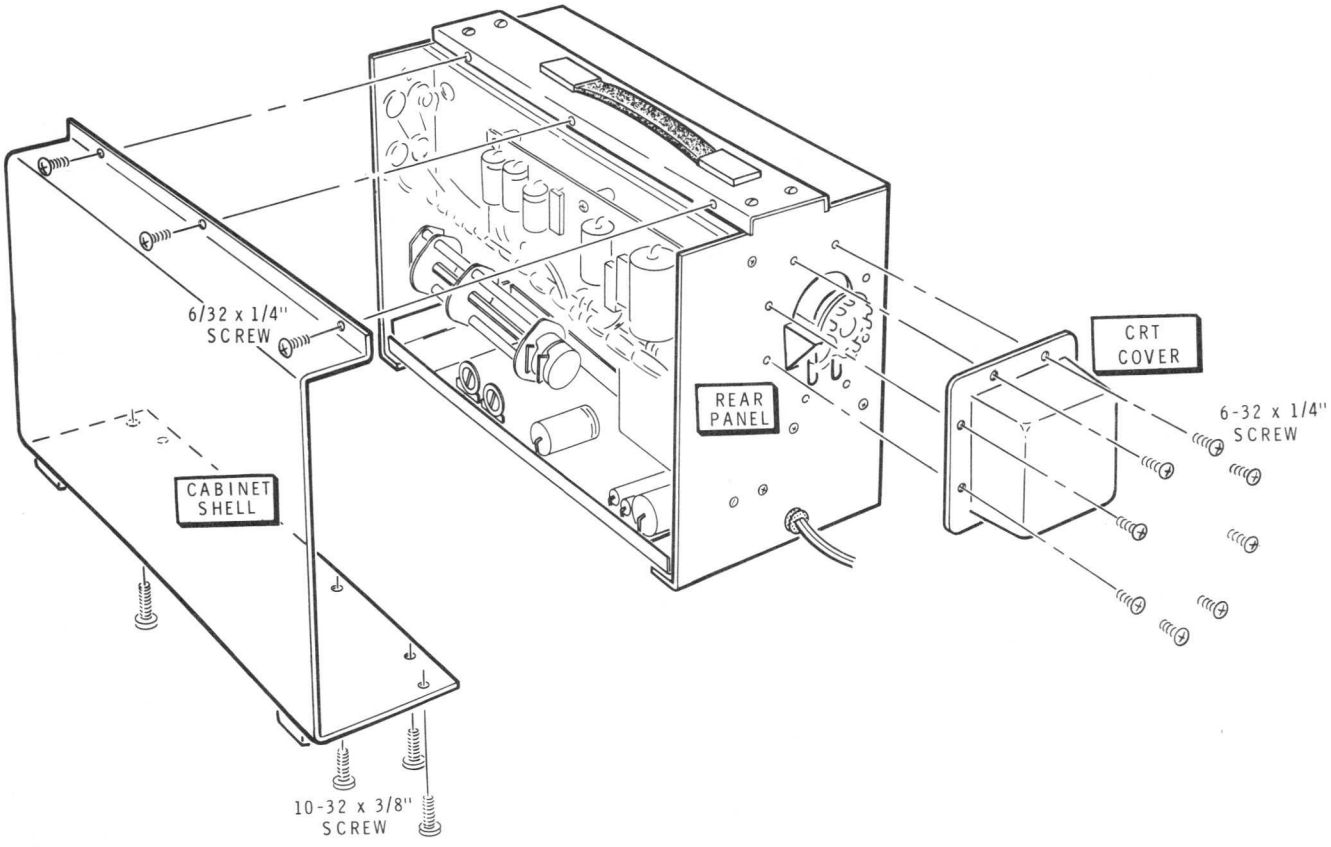
HIGH VOLTAGE AREA

HIGH VOLTAGE AREA



HIGH VOLTAGE AREA





PICTORIAL 16-1

CABINET ASSEMBLY

Refer to Pictorial 16-1 (fold-out from Page 90) and Detail 16-1A for the following steps.

( ) Remove the backing paper from two plastic feet. Install the feet on the bottom side of one cabinet shell at the indicated locations.

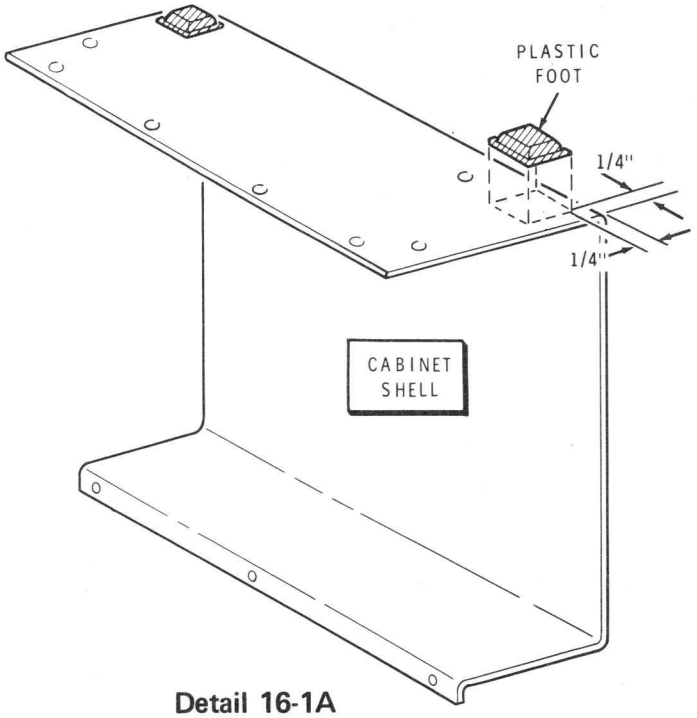
( ) Similarly, install two plastic feet on the other cabinet shell.

Refer to Pictorial 16-1 for the following steps.

( ) Mount both cabinet shells. Use eight 10-32 x 3/8" screws and six 6-32 x 1/4" screws. Do not tighten any screws until they are all started in their holes.

( ) Install the CRT cover on the rear panel as shown. Use eight 6-32 x 1/4" screws.

NOTE: Be sure to refer to the numbers on the blue and white identification label in any communications you have with the Heath Company about this kit.



Detail 16-1A

OPERATION AND APPLICATIONS

The "Initial Tests" and "Calibration" sections of the Manual introduced you to the operation of your Oscilloscope (see Figure 1-1, fold-out from Page 80). This section will help you obtain the greatest use from your instrument by showing you various uses and applications for it.

NOTE: Your Oscilloscope has a highly sensitive dc amplifier. It is therefore normal for the trace to drift vertically somewhat during the first half hour or so after it is turned on. Occasionally, the DC BALANCE control should be readjusted. Perform this adjustment carefully, in the following manner:

1. Set the AC-GND-DC switch to GND.

2. Turn the VOLTS/CM switch to .05.

3. Turn the (Volts/cm) VARIABLE control alternately clockwise and counterclockwise and note the shift in the trace location.

4. Adjust the BAL control through the front panel until no trace movement is observed between the clockwise and counterclockwise positions of the VARIABLE control.

trace – spot

WAVEFORM DISPLAY

Lines or waveforms appear on the face of a cathode ray tube (CRT) when its electron beam is deflected by varying charges on its deflection plates. Generally, an internal sweep generator in the oscilloscope varies the charge on the horizontal deflection plates and moves the beam rapidly from left to right. Horizontal sweep can also be produced by applying an external sweep signal to the HORIZ IN jack of the Oscilloscope.

Vertical deflection results from a signal applied to the VERT IN jack of the Oscilloscope. The signal is amplified and applied to the vertical deflection plates in the CRT.

When the period of the vertical input signal is equal to the horizontal sweep time, one complete cycle will be displayed on the CRT face. If the signal frequency is higher, more than one cycle will be displayed. The height of the waveform on the screen will be proportional to the amplitude of the vertical input signal, and can be controlled by the setting of the VARIABLE control and the VOLTS/CM switch.

With this very brief theory of operation you can see that an oscilloscope will display the waveform of the signal voltage that is fed to its vertical input. The signal voltage may be taken from an audio amplifier, a television receiver, a transmitter, or almost any electronic circuit. Some of the more common oscilloscope applications are described in the following paragraphs.

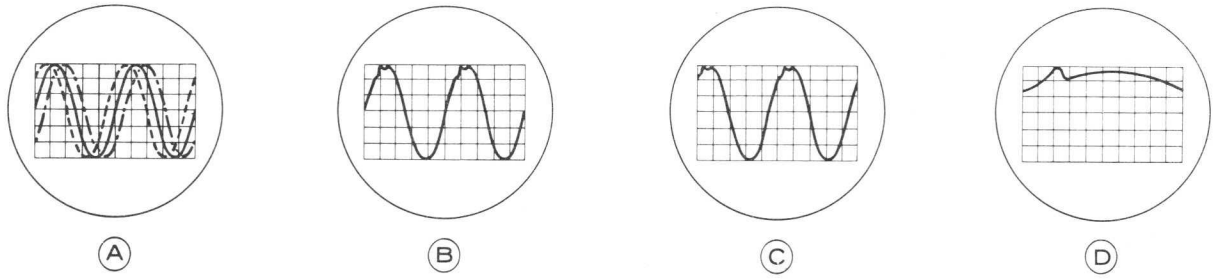


Figure 3-1

OPERATIONAL EXAMPLE

The following example will help you become more familiar with the control functions, especially the sweep and trigger controls.

Connect a sine wave source to the vertical INPUT connector. Set the TRIGGER switches to INT, AC, (+), and NORM.

Set the TRIGGER LEVEL control all the way to either end of its rotation, and turn the STABILITY control clockwise. When a trace appears on the screen, slowly turn the STABILITY control counterclockwise until the trace just disappears; the STABILITY control should remain in that position, as it will seldom need adjustment. If the STABILITY control is ever adjusted for a complex or unusual waveform, it should be readjusted by following the instructions of this paragraph.

Now turn the TRIGGER LEVEL control to about the center of rotation, where the trace should reappear. Adjust the VOLTS/CM switch to obtain a trace 3 or 4 centimeters high. Adjust the HORIZONTAL POSITION 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 VERTICAL POSITIONING control to center the trace vertically. Now carefully readjust the TRIGGER 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 Figure 3-1. Switch the TRIGGER +/– switch to the "–" position, and note that the TRIGGER 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 TRIGGER LEVEL control, as no two waveforms are alike. For example, assume that you want to examine the "spike" on waveform B of Figure 3-1. By adjusting the TRIGGER LEVEL control so the sweep starts just before the spike, as in C in Figure 3-1, and decreasing the time required for one complete sweep by changing the position of the TIME/CM and/or X2 multiplier switches, the spike can be spread out across a large area of the screen for closer observation, as in D of Figure 3-1.

By reading the TIME/CM and X2 multiplier switch settings, the duration of the spike can be determined. This feature is also useful to observe distortion in circuits using square wave signals.

The TIME/CM and X2 multiplier switches 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 on Page 99, or the "TIME/CM FREQUENCY Correlation Chart" on Page 100 to determine unknown frequencies or sweep times when the calibrated positions of the TIME/CM and X2 multiplier switches are used.

The TRIGGER INT/EXT switch permits you to choose between internal or external triggering signals. The INT (internal) trigger uses a portion of the vertical input 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 TRIGGER AUTO/NORM switch is in the AUTO position, the TRIGGER LEVEL control is disabled, and 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 100 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 TRIGGER AC/DC switch will normally be in the AC position except when using very low frequency or DC signals as a trigger source.

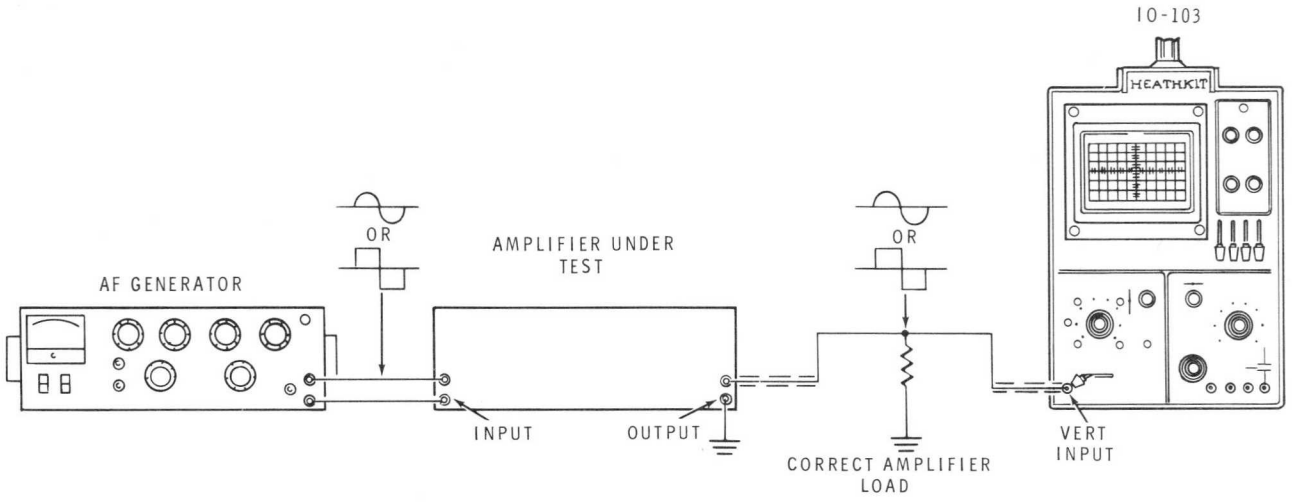


Figure 3-2

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 the amplifier input.

Figure 3-2 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 this load.

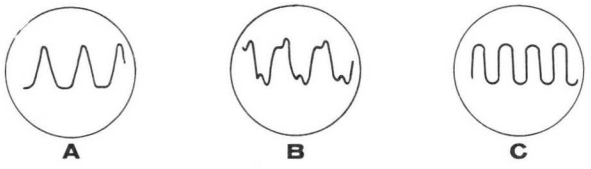


Figure 3-3

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.

Figure 3-3A 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 in a push-pull stage. Figure 3-3B indicates third harmonic distortion, which is a particularly objectionable amplifier fault. Figure 3-3C shows a flattening of both peaks, which usually indicates an overdriven stage somewhere in the amplifier.

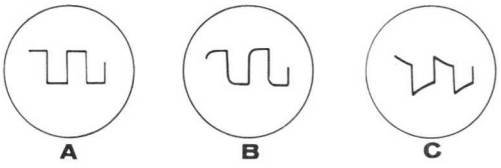


Figure 3-4

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 Figure 3-4A.

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 Figure 3-4B, 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 Figure 3-4C, indicates poor low frequency response.

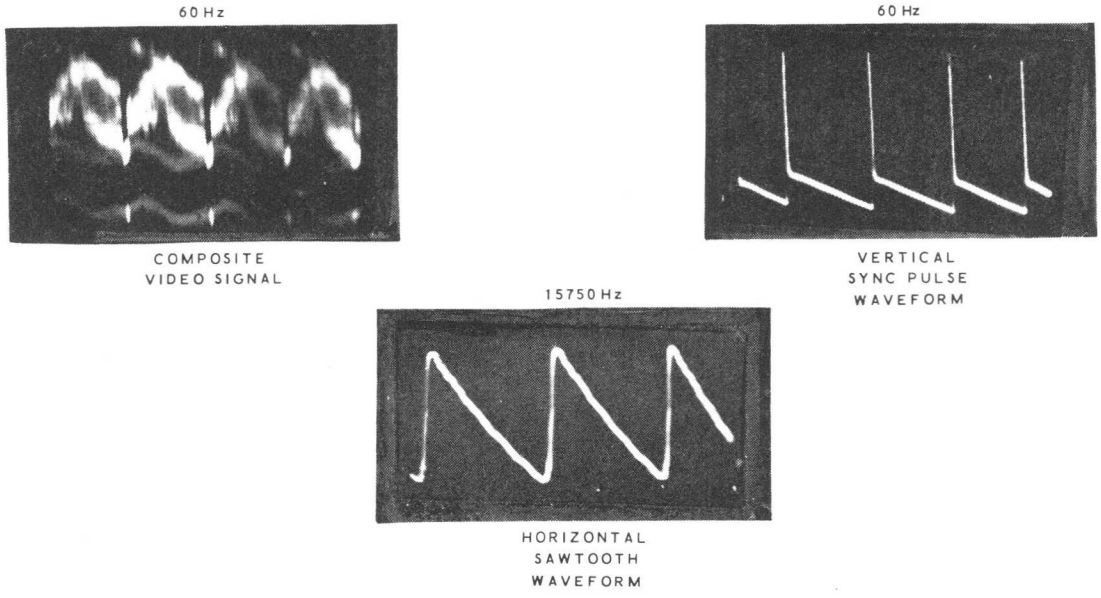


Figure 3-5

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 manufacturers 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 Figure 3-5, 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 i-f or rf amplifier sections.

Figure 3-6 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 5 ms/cm
	A Audio test frequency

NOTE: For simplicity, all amplifier stages are shown within one block of the diagram in Figure 3-6. 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 5 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.

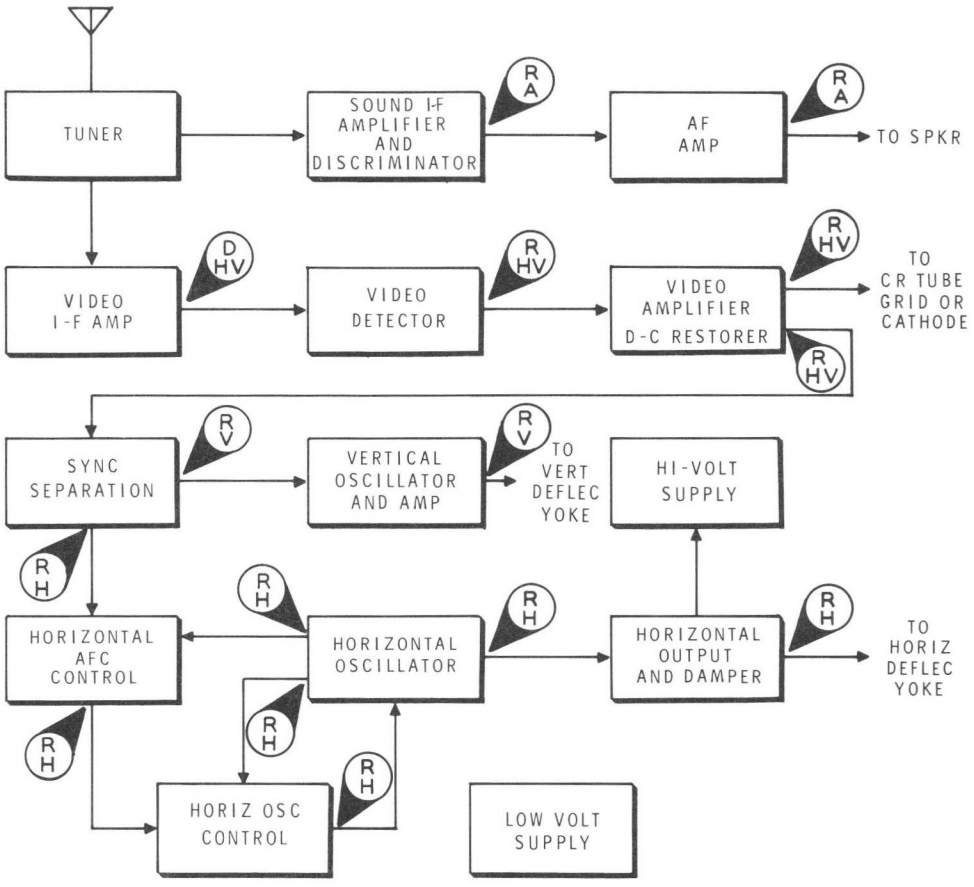


Figure 3-6

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.

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 Figure 3-4B (on Page 95) are responsible for poor picture detail or fuzziness while distortion of the waveform shown in Figure 3-4C can cause shading of the picture from top to bottom.

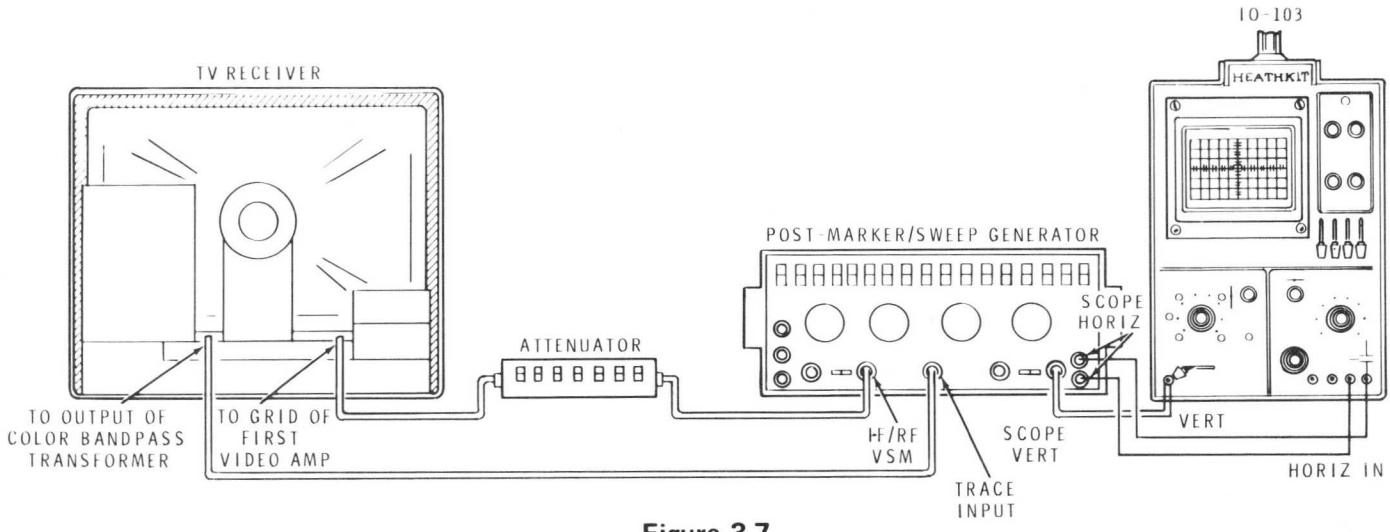


Figure 3-7

Receiver Alignment

Alignment of television rf and i-f 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 i-f amplifier 60 times a second. The sweep generator also supplies 60 Hz sweep voltage to the Horizontal input of the Oscilloscope. Figure 3-7 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. Manufacturer's service data usually includes alignment procedures and correct response waveforms.

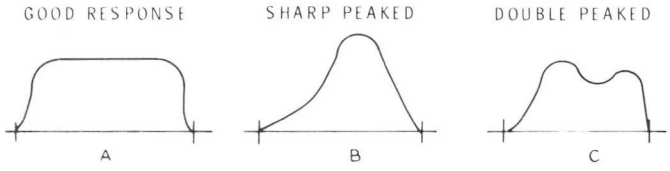


Figure 3-8

Figure 3-8A 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 Figure 3-8B might result if the i-f 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 i-f stages would produce a waveform like that shown in Figure 3-8C, 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 oscilloscope can be used to display and accurately measure these voltages. It can be easily calibrated for this purpose by using a known accurate external ac voltage source or, in the case of this Oscilloscope, the built-in 1 volt peak-to-peak reference source.

This oscilloscope will normally measure 120 volts, but can be calibrated for measuring higher voltages by "uncalibrating" to a lower 1 volt reference mark on the graticule with the VARIABLE control.

The following relationships exist for sine wave ac voltages:

rms x 1.414 = Peak Voltage
rms x 2.828 = Peak-to-Peak Voltage
Peak Voltage x .707 = rms Voltage
Peak-to-Peak Voltage x 0.3535 = rms Voltage

FREQUENCY MEASUREMENTS

Frequency measurements can be made with an accuracy limited only by the reference source available. At times, this can be the 60 Hz line frequency which is usually controlled very closely. The unknown frequency is applied to the vertical input and the reference frequency to the horizontal input. The internal sweep generator is not used. The resultant pattern may take on any one of a number of shapes. Typical patterns are shown in Figure 3-9. These patterns are called Lissajous figures. They are obtained when sinusoidal ac voltages are applied simultaneously to the two sets of oscilloscope plates. The resultant pattern depends upon the relative amplitudes, frequencies, and phase of the two voltages. The frequency ratio can be figured from the formula:

$$f_x = \frac{Th \times f}{Tv} \quad ;$$

where f_x is the unknown frequency. Th is the number of loops which touch the horizontal tangent line; Tv is the number of loops which touch the vertical tangent line; f is the known frequency.

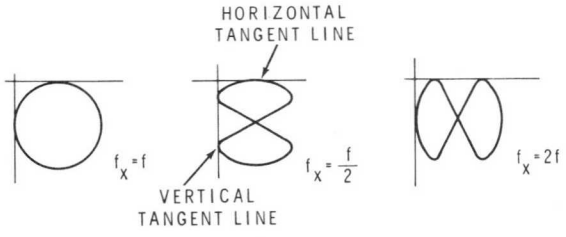


Figure 3-9

When using Lissajous figures, it is good practice to have the figure rotating slowly rather than stationary. This eliminates the possibility of an error in counting the tangent points. If the pattern is stationary, a double image may be formed. In such cases, the end of the trace should be counted as one-half a tangent point rather than a full point. This condition may occur when neither frequency can be varied.

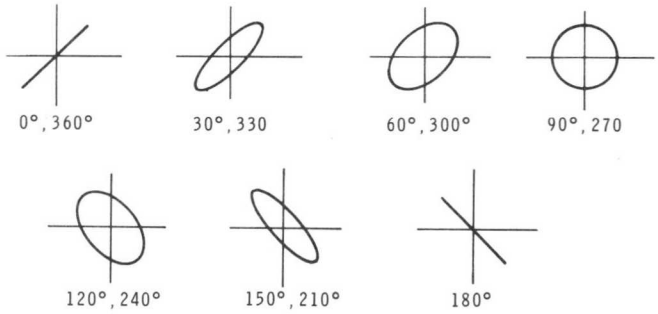


Figure 3-10

PHASE MEASUREMENTS

It is sometimes necessary to determine the phase relationship between two ac voltages of the same frequency. This can be accomplished quite easily by applying one of the voltages to the horizontal input and the other voltage to the vertical input. The phase relationship can be estimated from Figure 3-10.

NOTE: For proper displays, the horizontal amplifier gain must be set to equal the vertical gain.

To calculate the phase relationship, use the following formula:

$$\text{Sin } \theta = \frac{A}{B}$$

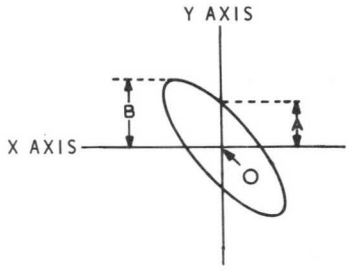


Figure 3-11

As shown in Figure 3-11, the distance A is measured from the X axis to the intercept point of the trace and the Y axis. The distance to B represents the heights of the pattern above the X axis. The axis of the ellipse must pass through the point 0.

TIME/CM-TO-FREQUENCY CORRELATION

Use the following formula to determine the frequency of a waveform displayed on the CRT:

$$\text{Frequency} = \frac{\text{Multiplier switch setting (X1 or X2)}}{\text{TIME/CM switch setting X number of centimeters on CRT for 1 cycle of the unknown frequency.}}$$

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 6 cm high and 10 cm wide.

NOTE: The VARIABLE control cannot be used in computing this equation since there are no calibrated values associated with it. This control must be kept in the CAL position to make proper calculations.

TIME/CM-FREQUENCY CORRELATION CHART

TIME/CM SWITCH	MULTI-PLIER	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)
.1 μ sec	X2	.05 μ sec	2,000,000	10,000,000
.1 μ sec	X1	.1 μ sec	1,000,000	5,000,000
1 μ sec	X2	.5 μ sec	200,000	1,000,000
1 μ sec	X1	1 μ sec	100,000	500,000
10 μ sec	X2	5 μ sec	20,000	100,000
10 μ sec	X1	10 μ sec	10,000	50,000
100 μ sec	X2	50 μ sec	2,000	10,000
100 μ sec	X1	100 μ sec	1,000	5,000
1 m sec	X2	.5 m sec	200	1,000
1 m sec	X1	1 m sec	100	500
10 m sec	X2	5 m sec	20	100
10 m sec	X1	10 m sec	10	50
100 Ms	X2	50 m sec	2	10
100 Ms	X1	100 m sec	1	5

IN CASE OF DIFFICULTY

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

The second part, titled "Finding the Area of Trouble," describes a method for locating trouble in the differential amplifiers.

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

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

GENERAL TROUBLESHOOTING INFORMATION

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

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

2. About 90% of the kits that are returned for repair do not function properly due to poor solder connections. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the Kit Builders Guide.

3. Check to make sure that all transistors are in their proper locations. Make sure each transistor lead is connected to the proper point and 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 pictorial diagrams and called out in the wiring instructions.

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" on Pages 111 and 112.

Finding the Area of Trouble

A review of the Circuit Description and Block Diagram (fold-out from Page 106) may also be helpful in locating the trouble.

If, after careful checks, the trouble is still not located and a voltmeter is available, check the voltage readings against those shown on the Schematic Diagram (fold-out from Page 121) and Voltage Charts on Page 114. NOTE: All voltage readings were taken with an 11 megohm input voltmeter. Voltages may vary as much as ±20%.

Because most of the circuits are dc coupled, it is almost impossible to list troubles in a "cause and effect" type of chart. For example, a saturated transistor on one side of a differential amplifier may appear as a trouble on the other side. However, a Troubleshooting Chart is provided to help you isolate the probelm to a particular area of the Oscilloscope.

Since the POSITION controls are at the front of each differential amplifier and affect each succeeding stage, they serve as troubleshooting aids. When troubleshooting the vertical amplifier, for instance, first check the associated power supply voltages. Then check the collector voltages of transistors Q111 and Q112. These voltages should vary as the vertical POSITION control is turned. If these voltages change accordingly, the trouble is in the CRT circuit. If the voltages do not change, the problem is either in Q111 or Q112, or the preceding stages. Move the voltmeter to the preceding stage (Q108 or Q109) and repeat the procedure until the trouble is located.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Service" section and the Warranty in the "Kit Builders Guide," and to the "Factory Repair Service" information on Page 103 of this Manual.

Troubleshooting Chart

DIFFICULTY	POSSIBLE CAUSE
Neither pilot lamp nor CRT filaments light.	1. Fuse blown. 2. On-Off switch. 3. No ac power from outlet. 4. Transformer.
Pilot lamp lights, CRT filament does not light.	1. Transformer. 2. CRT.
No spot or trace on CRT.	1. Positioning or intensity controls improperly adjusted. 2. High voltage power supply. 3. CRT.
Dot cannot be centered vertically.	1. Vertical position controls. 2. Vertical amplifier.
Dot cannot be positioned horizontally.	1. Horizontal position controls. 2. Horizontal amplifier.
No vertical deflection.	1. Vertical amplifier.
No horizontal deflection,	1. Horizontal amplifier. 2. Sweep circuits.
Poor focus.	1. CRT. 2. Focus control. 3. Astigmatism control. 4. Resistors R401, R402, R404, R503, R504, and R505.
Trace acts erratic when the window is touched.	1. Clean the window with detergent to eliminate static charge.
Cannot synchronize sweep generator with input signal frequency.	1. Trigger switch in the EXT position. 2. STABILITY control misadjusted. 3. Transistor Q301.
No retrace blanking or poor retrace blanking.	1. Transistor Q321. 2. Diode ZD309.

FACTORY REPAIR SERVICE

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

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

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

Prepare a letter in duplicate, containing the following information:

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

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

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

Heath Company
Service Department
Benton Harbor, Michigan 49022

NOTE: Do not send Manuals or test cables to Heath Company.

REPLACEMENT PARTS AND PRICE INFORMATION

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

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

SPECIFICATIONS

VERTICAL CHANNEL

Input Impedance	1 megohm shunted by 30 pF.
Sensitivity	50 mV/centimeter.
Frequency Response	DC to 10 MHz ±3 dB @ 3 cm deflection. DC to 8 MHz ±3 dB @ 6 cm deflection.
Rise Time	Less than 50 nanoseconds.
Attenuator	9-position, .05 to 20 volts/cm (1, 2, 5 sequence), ±3%.

HORIZONTAL CHANNEL

Input Impedance	100 kΩ.
Sensitivity	0.25 volt/cm (uncalibrated).
Frequency Response	DC to 500 kHz ±3 dB.

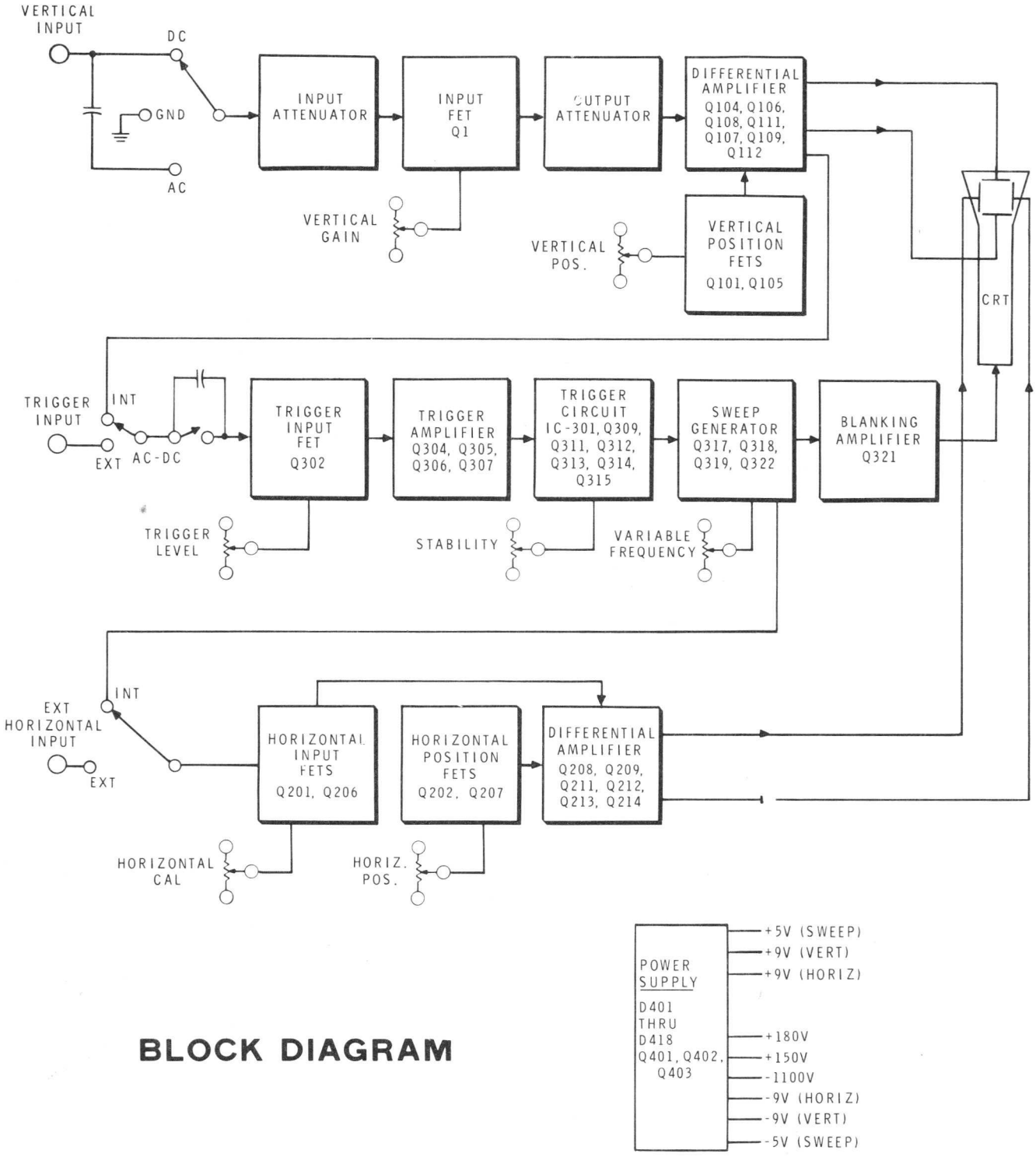
TIME BASE

Sweep	7 decade steps, 100 milliseconds to 100 nanoseconds/cm, ±5%.
Horizontal Expansion	X2 ±5%.
Trigger Modes (switch selected)	AUTO/NORMAL. +/– (plus or minus). AC/DC. INT/EXT.
Trigger Sensitivity	
(internal)	1 cm display.
(external)	0.5 volt peak-to-peak.

GENERAL

CRT	5DEP1F, 6 x 10 centimeter viewing area, green, medium persistence phosphor.
Graticule	Engraved, 6 x 10 cm, edge lighted.
Power Supplies	All solid-state rectifiers. All amplifier supplies regulated.
Power Requirements	110-130 or 220-260 Vac 50/60 Hz 35 watts.
Overall Dimensions	12-3/4" high, 9-1/4" wide, 16-1/4" long. These dimensions include all protruding surfaces: knobs, handle, feet, etc.
Net Weight	26-1/2 lbs.

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



BLOCK DIAGRAM

ASSUME - AANNEMEN, veronderstellen

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 119) and the Block Diagram (fold-out from Page 106) while reading this Circuit Description.

To help you locate specific parts in the Oscilloscope or on the Schematic, the resistors, capacitors, transistors, and diodes are numbered in the following groups.

0-99	Parts mounted on the attenuator circuit board.
100-199	Parts mounted on the vertical amplifier circuit board.
200-299	Parts in the horizontal amplifier circuit.
300-399	Parts in the sweep generator circuit.
400-499	Parts mounted on the power supply circuit board.
500-599	Parts mounted on the chassis.

ATTENUATOR

A signal applied to the VERT IN connector is coupled through the AC-GND-DC switch to the frequency-compensated attenuator network. Capacitor C501 blocks the dc when the AC-GND-DC switch is in the AC position and the vertical amplifier input is grounded when the switch is in the GND position.

The attenuator system consists of three parts: the input attenuator with compensating capacitors, source follower Q1 and associated components, and the output attenuator. The input and output attenuators work together to provide the total attenuation selected by the attenuator switch.

The output attenuator is a voltage divider circuit made up of resistors R4, R5, R7, R8, and R9. Assume the attenuator switch to be in its most clockwise position. Counterclockwise movement of the switch will then move the output attenuator through its other two positions. In position four, the output attenuator returns to its most sensitive position while the input attenuator moves to its second position, decreasing the input sensitivity by a factor of 10. This sequence is repeated through the seventh switch position, decreasing the input sensitivity by a total of 100. The output attenuator provides a 1-2-5 sequence repeatedly, while the input section attenuates by decades.

The input signal is coupled through resistor R2 and capacitor C3 to the gate of transistor Q1. Resistor R2 limits the current in the circuit, while diodes D1 and D2 provide zener voltage-limiting on the gate of Q1. This prevents damage to the transistor if the VOLTS/CM switch is in a low range and a high potential is applied to the input. Capacitor C3 improves high frequency response by forming a high frequency path around R2. The action of diodes D1 and D2 limits the gate voltage on Q1 to ±9 volts.

Transistor Q1 is a field-effect transistor (FET) connected as a source follower. This type of transistor provides the high impedance input necessary to prevent loading of the input attenuator. Transistor Q2 is a constant current source for the input FET. Diodes D102 and D103 in the Vertical Amplifier each provide a .6 volt drop (total 1.2 volts) and hold the bases of Q2, Q102, and Q103 at a constant voltage. Since the emitter voltage on Q2 remains at a fixed potential difference from the base voltage, the constant voltage across emitter resistor R11 (DC Bal) holds the current through R11, Q2, and Q1 constant. Resistor R11 is adjusted to establish the source of Q1 at zero volts when there is no input signal.

A signal applied to the gate of Q1 will emerge noninverted at the source due to source follower action. This voltage is then coupled to the output attenuator from which a portion of the signal is coupled to the gate of source follower Q104.

VERTICAL AMPLIFIER

Source-follower Q104 provides high impedance coupling to the output attenuator circuit to prevent loading, and a low impedance output to amplifier transistor Q106. Transistor Q103 forms a constant current source for differential amplifier transistors Q106 and Q107. Since the emitter of each transistor is connected to this constant current source, the current source serves as a common emitter resistor. Transistors Q101 and Q105, and their associated components, form a temperature compensation network. If one side of the amplifier becomes warm, then the other side is similarly affected and the output voltage remains unchanged.

When the output from source follower transistor Q104 is amplified by transistor Q106, a portion of the signal applied to the base is seen at the emitter. Because transistors Q106 and Q107 have a common emitter resistor (constant current source Q103), the signal present at the emitter of Q106 is coupled to the emitter of Q107. The signal at the collector of transistor Q107 is 180 degrees out of phase with that at the collector of Q106. This creates a push-pull type of amplifier required to drive the deflection plates of the CRT. Capacitor C103 is an emitter bypass capacitor to boost the gain at high frequencies. Emitter resistors R107 and R108 establish the dc gain of the vertical amplifier.

The vertical positioning voltage is applied to the gate of transistor Q101 and then coupled through transistor Q105 to amplifier transistor Q107. Q107 functions as a grounded-base amplifier whose base is controlled by the voltage present at Position control R514. This control can move the trace up or down by changing the dc voltage at the base of transistor Q107. This either balances or upsets the balance of the differential amplifier. When the amplifier is balanced the trace will be in the center of the screen.

Driver transistors Q108 and Q109 are high gain common emitter amplifiers that drive the output transistors. Capacitor C105 ac couples the emitters of Q108 and Q109 at high frequencies and improves the high frequency response.

Output amplifiers Q111 and Q112 again amplify the differential signal and drive the vertical deflection plates of the CRT. The vertical deflection plate voltages (collectors of Q111 and Q112) are adjusted to 100 volts dc by constant current source Q103 and the 100 V adjust control, R104, in its emitter circuit.

HORIZONTAL AMPLIFIER

The horizontal amplifier is part of the circuitry on the sweep generator-horizontal amplifier circuit board.

Operation of the horizontal amplifier is similar to that of the vertical amplifier. The major difference is in the attenuator system. In the horizontal amplifier, the input is coupled from the HORIZ IN connector and control R348, through the Time/cm switch, to the input of transistor Q201. The source resistance of Q201 is provided by the action of constant current source transistor Q203. The horizontal trace X2 function is accomplished by reducing the emitter-to-emitter resistance of deflection amplifiers Q208 and Q209. X2 CAL control R513 is adjusted to produce exactly twice the deflection voltage at the output.

The sawtooth voltage produced by the sweep generator is amplified by the horizontal amplifier and applied to the horizontal deflection plates of the CRT. This linearly increasing voltage causes the electron beam to sweep across the face of the CRT from left to right. The sweep speed of the electron beam is determined by the Time/cm switch on the front panel.

SWEEP AND TRIGGER CIRCUITS

The sweep generator circuits are part of the circuitry on the sweep generator-horizontal amplifier circuit board.

The INT-EXT trigger switch on the front panel determines whether the internal trigger signal or an external trigger signal will be used to start the sweep. In either case, the selected signal is coupled to the gate of transistor Q302.

Internal triggering is accomplished by coupling a signal from the vertical amplifier, through transistor Q301 and DC Level control R301, to trigger amplifier input stage Q302. R301 is adjusted to obtain zero volts dc at the gate of Q302. The Level Set control varies the voltage on the source of transistor Q302 by changing the current level through transistor Q303. The source voltage of Q302 is set at zero volts when the Auto-Norm trigger switch is in the Auto position. When the Auto-Norm switch is in the Norm position, the Trig Level control on the front panel performs the function of selecting the current through transistor Q303; thus controlling the point at which the sweep generator will trigger.

emerge – te voorschijn komen, uit komen
boost – duwen, helpen
booster – reclamemaker, hulpdynamo, stalen
gain – winst voordeel
upset – uit evenwicht brengen
common – gemeenschappelijk, normaal

Both gain and dc level control are achieved as the signal is coupled through transistors Q304 and Q306, a differential amplifier. Capacitor C303 is a high frequency ac coupler between the emitters of the differential amplifier. The output of this amplifier is coupled through emitter follower output transistors Q305 and Q307 to the +/– switch on the front panel. Transistor Q308 is a constant current source for transistors Q304 and Q306. The collector current of Q308 is determined by Trig Bal control R315 in its emitter circuit. The Trig Bal control is adjusted to present the proper dc level to the input of integrated circuit IC-301.

IC-301 is a dual Schmitt trigger. The A section of the IC is used to shape the wave of the trigger signal, while the B section is used as a voltage sensor to turn the sweep off at the end of each sweep cycle.

Refer to Figure 4-1. The output of IC-301B (pin 8) is high most of the time. This positive voltage turns on transistor Q318 which, in turn, turns off Q317 and allows the selected sweep capacitor to charge. The high output from IC301B also turns on transistor Q311 which grounds one input (pin 4) of IC-301A. This keeps other input pulses at pin 1 out of the circuit so that IC-301B will not trigger before the sweep is completed.

STABILITY control R508B is set to bias the input of IC-301B to a voltage level slightly more positive than the reset voltage. As the sweep capacitor charges, it overrides this voltage (after being coupled through source follower and emitter follower transistors Q314 and Q315) and continues to increase until the output of IC-301B goes low. Then transistor Q318 is turned off and transistor Q317 is turned on shorting out the sweep capacitor. Transistor Q311 is also turned off which causes pin 4 of IC-301A to go high.

The next positive-going input pulse to pin 1 then drives the output low turning off transistor Q309. A positive pulse is then coupled through capacitor C313 and sets the output of IC-301B low. After the input pulse at IC-301A is gone, pin 1 again is low and pin 6 then goes high and turns on transistor Q309. The negative pulse coupled through capacitor C313 causes the output of IC-301B to go high. The output stays high because this input is biased between the turn on and turn off points of the Schmitt trigger. Then the process repeats itself.

Transistor Q321 is the unblanking amplifier. This amplifier receives signals from the sweep circuits to properly bias the CRT, turning the electron beam on and off as required. Feedback from Q321, through transistor Q319, holds the start of the trace until Q321 has returned to its quiescent condition from the preceding sweep. This prevents shortening of the trace due to insufficient rise time in transistor Q321.

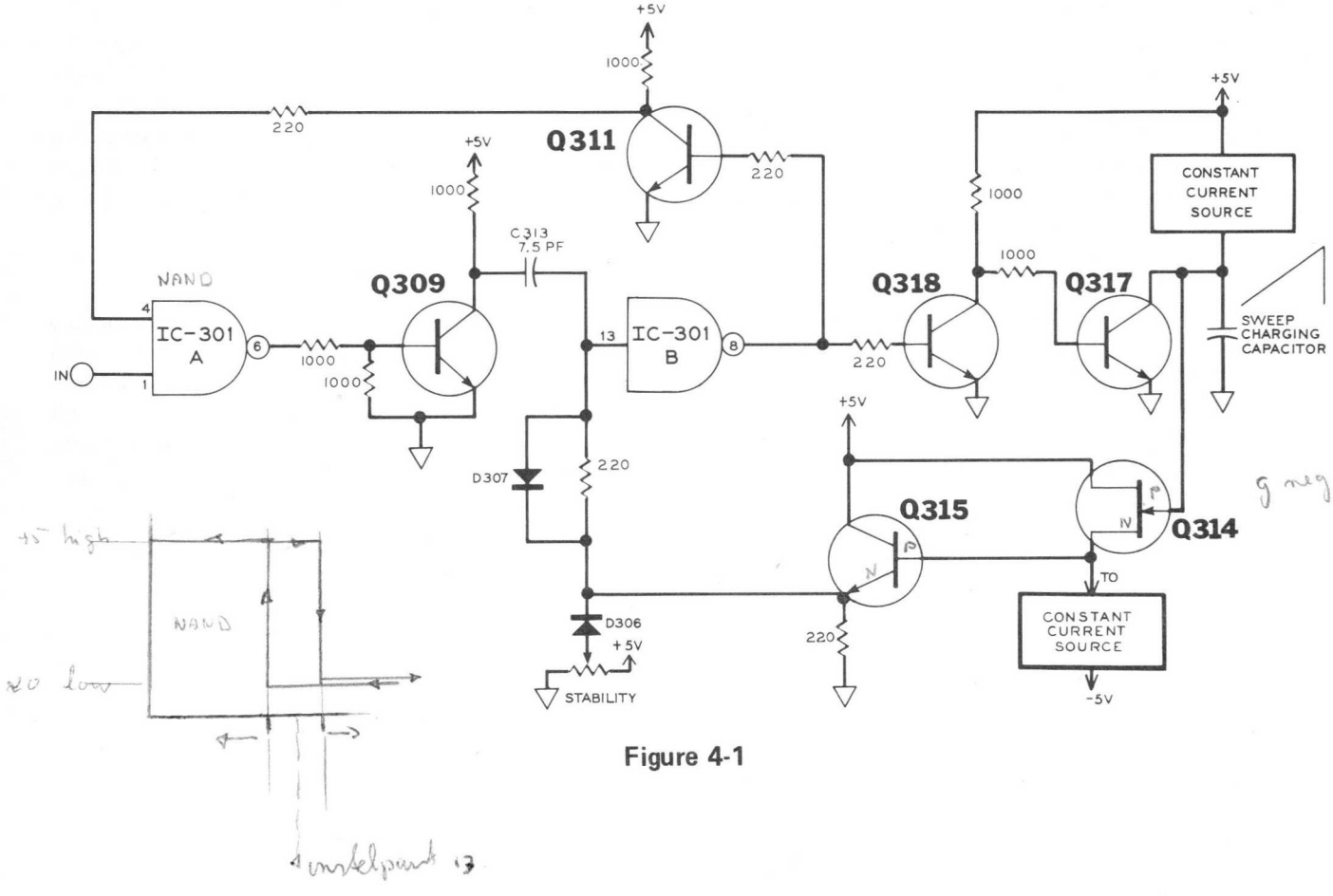


Figure 4-1

Transistors Q312 and Q313 form a Schmitt trigger circuit which is modified by a negative feedback signal coupled from the collector of Q312 back to its base through resistor R320. The base of Q312 is capacitively coupled to ground to form a free-running multivibrator. This multivibrator operates on the three high ranges of the TIME/CM switch and is used to provide a better baseline on the CRT. Normally when a triggered sweep circuit is operating in the automatic mode, the baseline will fade as the sweep rate is increased. To prevent this, the mulitivibrator is used to provide an increasing trigger repetition rate as the sweep speed is increased. At the lower sweep speeds, the generator will be automatically "retriggered" at about 50 Hz. Should a higher frequency be available, such as that from the multivibrator described above, the generator circuit will lock onto the faster rate.

The TIME/CM switch determines the value of the sweep capacitor, and the amount of current flowing through transistor Q322. As the sweep capacitor charges, a positive-going ramp voltage (sawtooth) is generated. The speed of the horizontal sweep is determined by the particular timing capacitor chosen and by its charging current.

POWER SUPPLY

Line voltage is connected through the slow-blow fuse and the power switch on the TRACE control to the primary windings of the power transformer. The dual-primary transformer windings may be connected in parallel for 120-volt operation or in series for 240-volt operation.

The high-voltage secondary winding of the power transformer is connected to the voltage doubler circuit consisting of D401, D402, C403, and C404. Resistor R403 and capacitor C402 filter this negative high voltage which is coupled through resistor R502 to the grid of the CRT. The intensity and focusing voltages are also supplied to the CRT from the voltage divider network consisting of resistors R404, R505, R504, R503, and R402. A separate 6.3 volt winding supplies the CRT filament voltage.

Two secondary transformer windings supply graticule lighting and calibration voltages to the front panel. One of these windings supplies a 1 volt peak-to-peak voltage to the

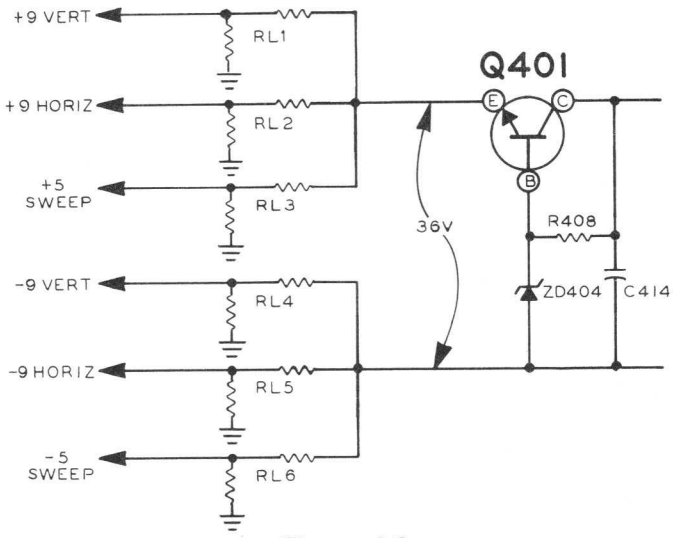


Figure 4-2

1V P-P banana jack on the front panel. The other winding provides the necessary voltage to illuminate the graticule lights, the intensity of which is varied by GRATICULE control R507.

The low voltage secondary winding is connected to the full-wave rectifier diodes D405, D406, D407, and D408. Zener diode ZD404 and resistor R408 maintain a constant voltage to the base of pass transistor Q401. (Figure 4-2 shows a simplified schematic of this power supply.) The output from the series pass transistor is a regulated 36 volts. By connecting equal loads from each side of the supply to ground, shown as RL1 through RL6, six separate dc output voltages are obtained. These are: +9 volts (vert), +9 volts (horiz), +5 volts (sweep), -5 volts (sweep), -9 volts (vert), and -9 volts (horiz).

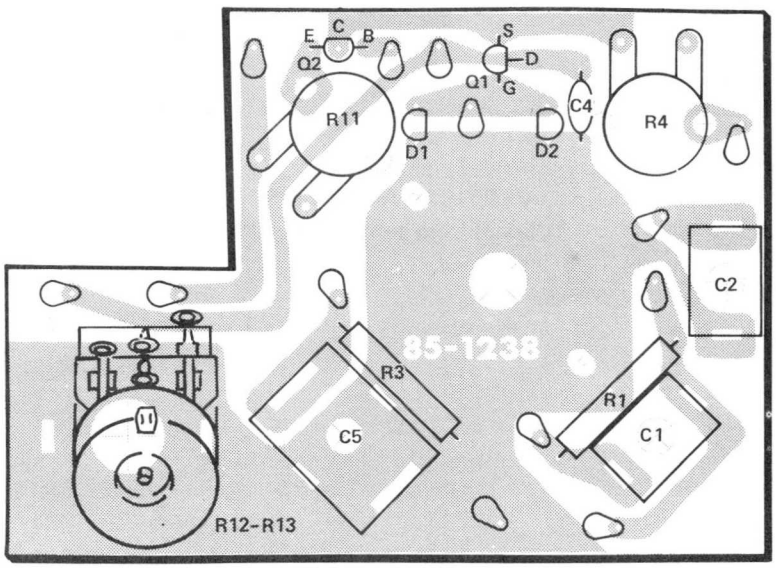
Deflection potentials are obtained from another secondary winding connected to the full-wave bridge rectifier diodes D411, D412, D413, and D414. Zener diodes ZD417 and ZD418 provide a regulated +150 volt dc output through transistor Q403 and dropping resistor R416. Zener diodes ZD415 and ZD416, provide a regulated +180 volt dc output through transistor Q402 and dropping resistor R417.

CIRCUIT BOARD X-RAY VIEWS

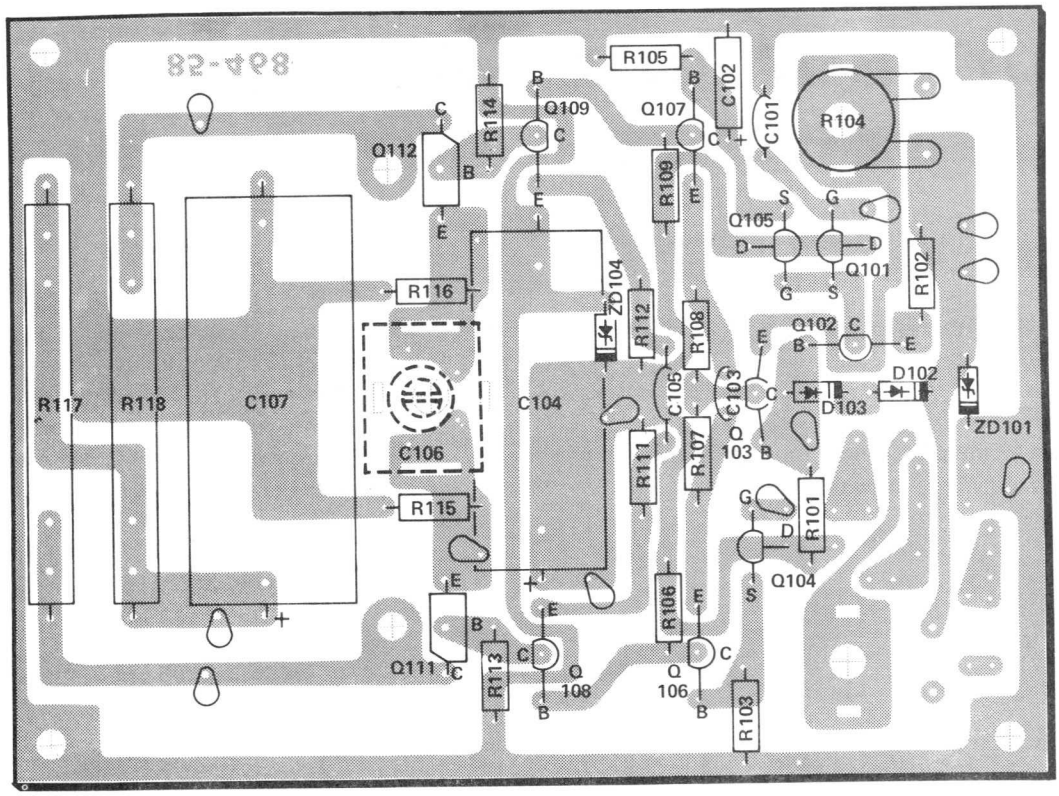
NOTE: To determine the value (22 kΩ, .05 μF, etc.) of one of these parts, you may proceed in either of the following ways.

1. Refer to the place where the part is installed in the Step-by-Step instructions.

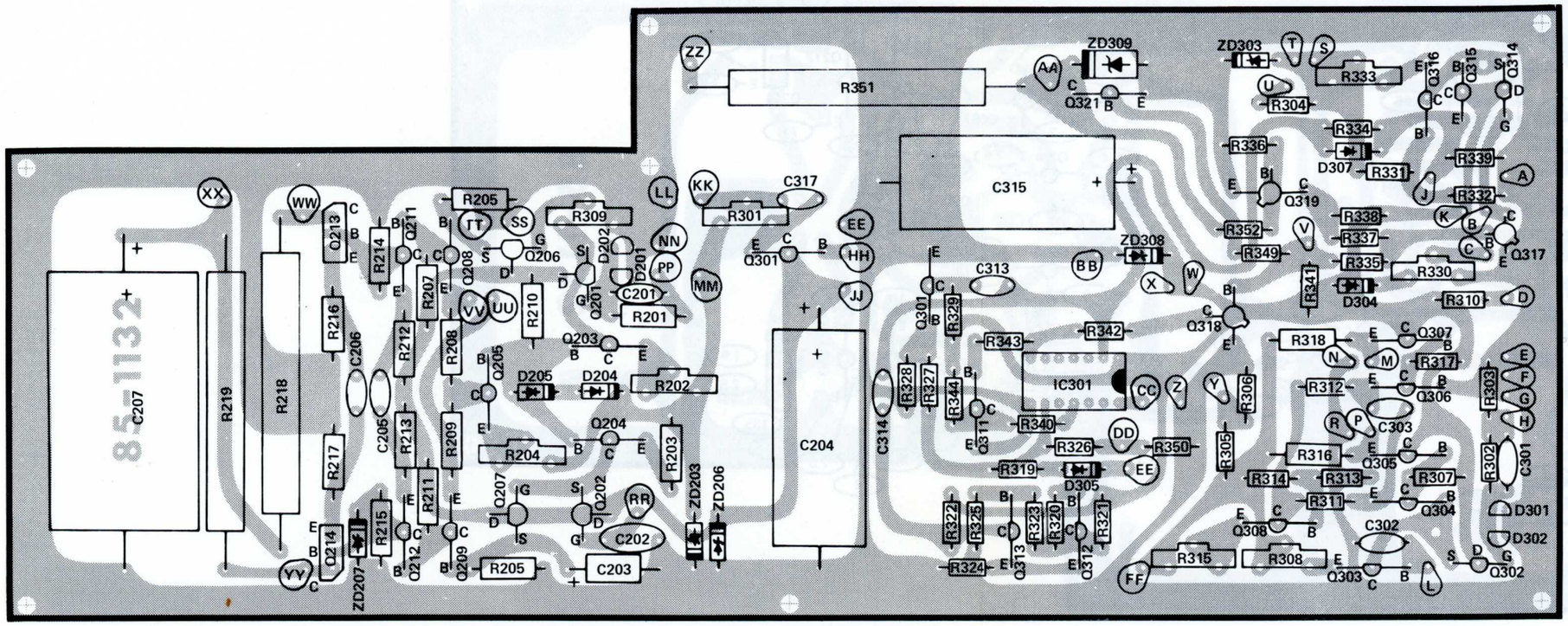
2. Note the identification number of the part (R-number, C-number, etc.). Then locate the same identification number next to the part on the Schematic. The value, or "description," of most parts will be near this number. For diodes and transistors, refer to the transistor-diode identification chart on Pages 117 and 118.



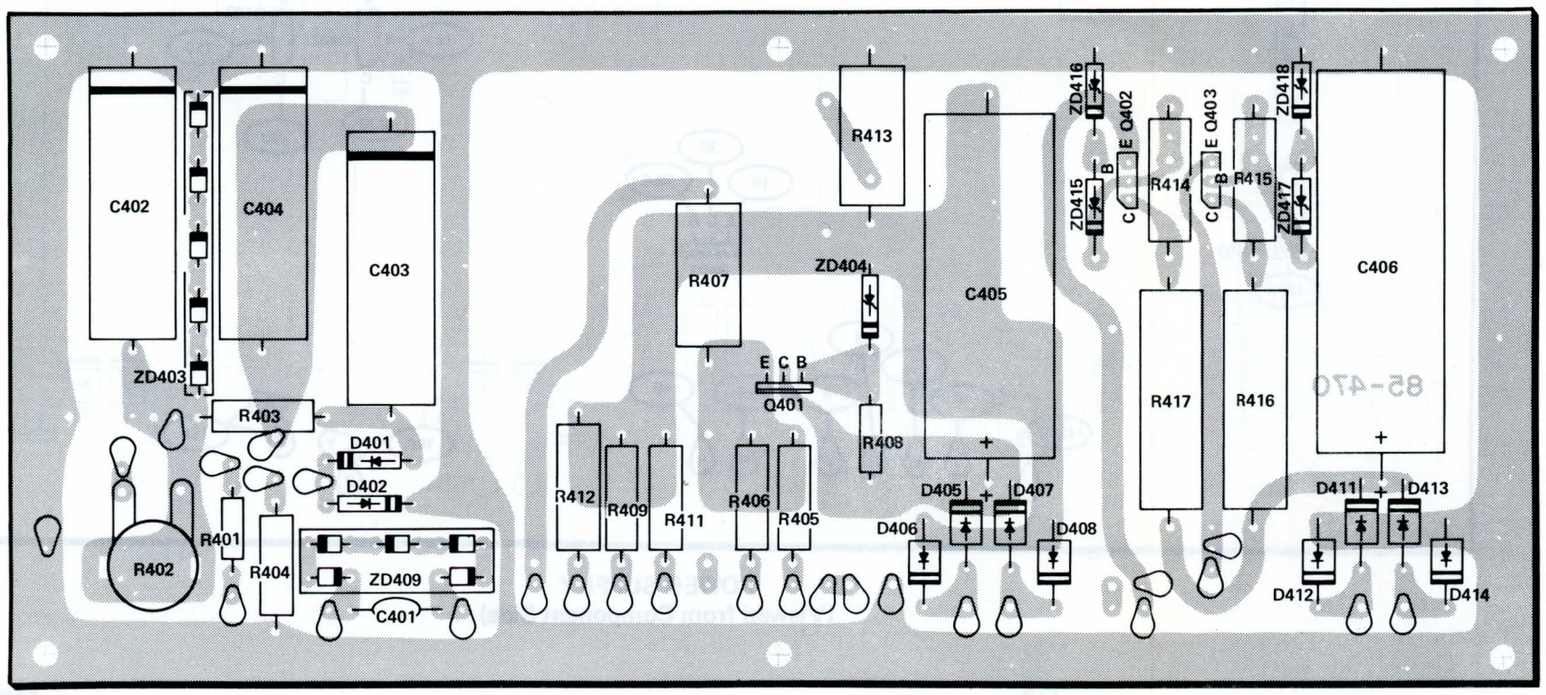
ATTENUATOR
(Viewed from foil side)



VERTICAL AMPLIFIER
(Viewed from component side)

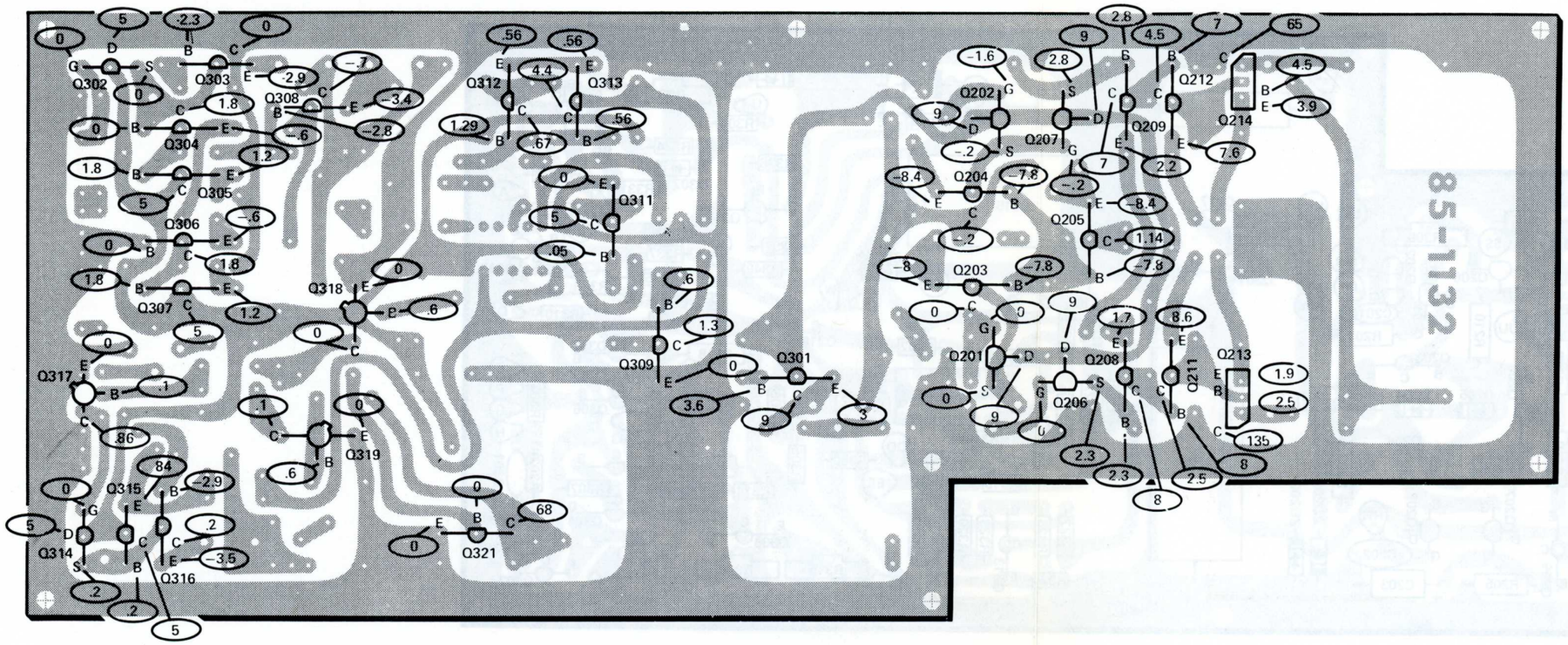


SWEEP GENERATOR-HORIZONTAL AMPLIFIER
(Viewed from Foil Side)

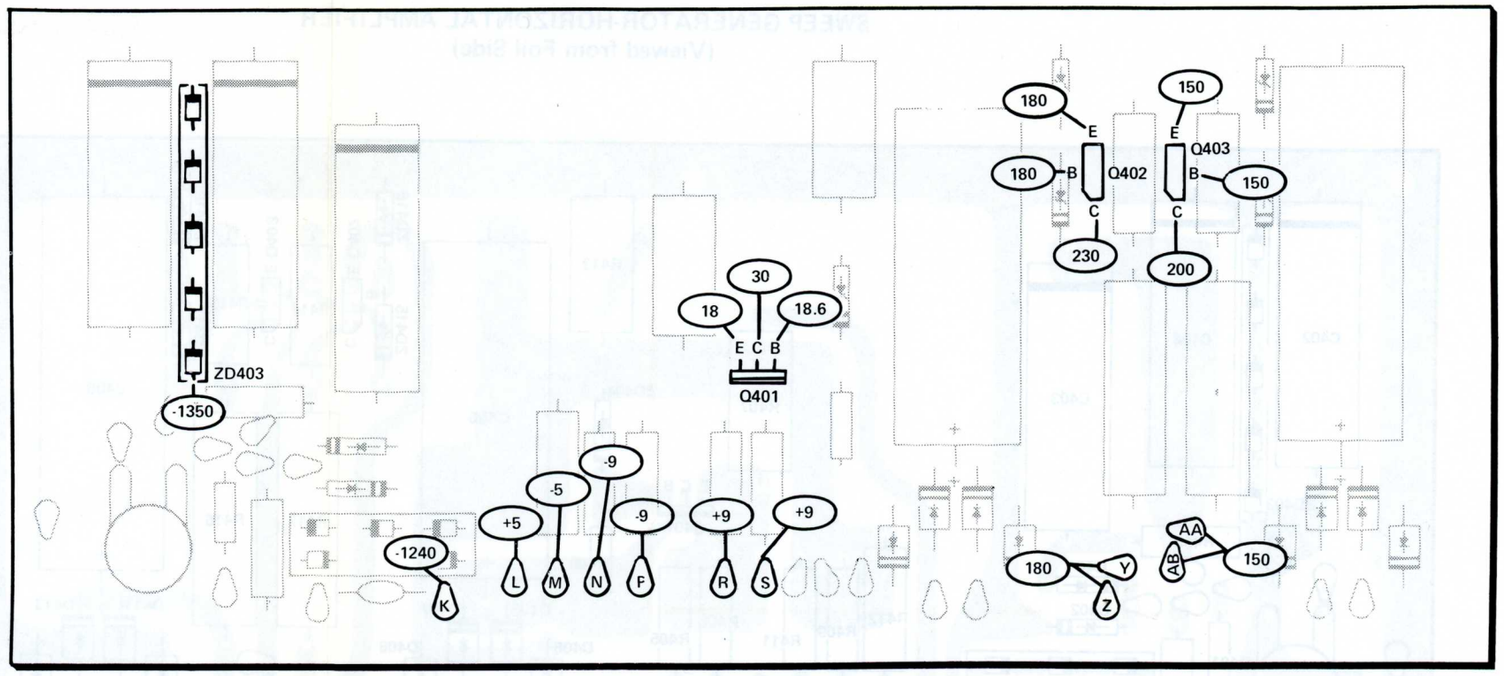


POWER SUPPLY
(Viewed from Component Side)

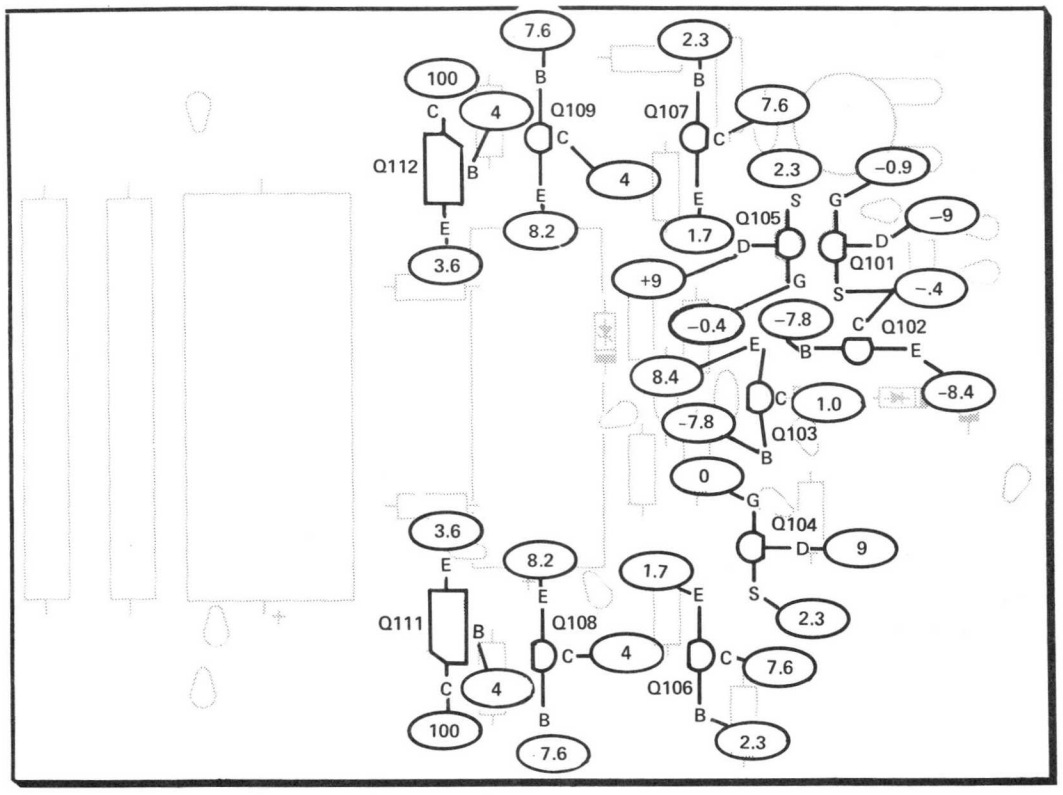
CIRCUIT BOARD VOLTAGE CHARTS



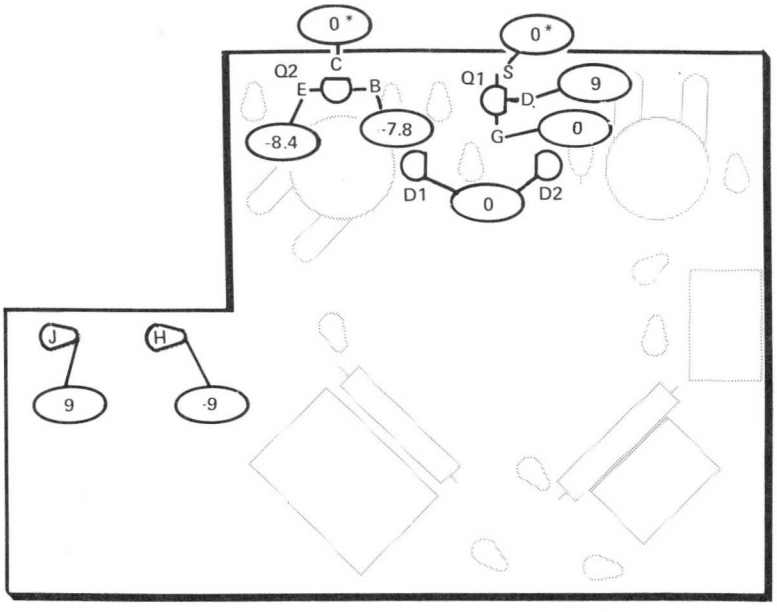
(SWEEP GENERATOR-HORIZONTAL AMPLIFIER
(Viewed from Foil Side)



POWER SUPPLY
(Viewed from Component Side)



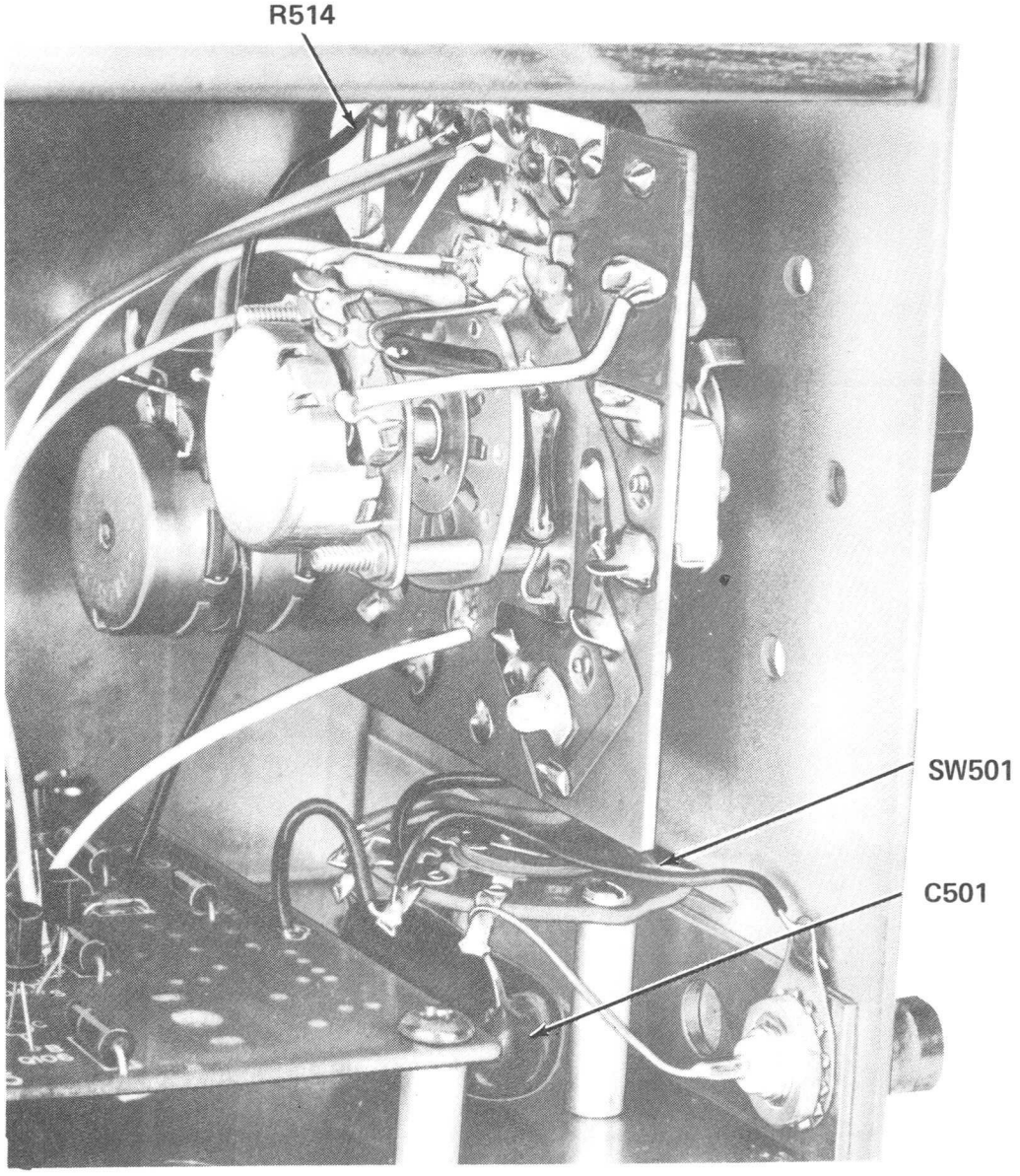
VERTICAL AMPLIFIER
(Viewed from component side)

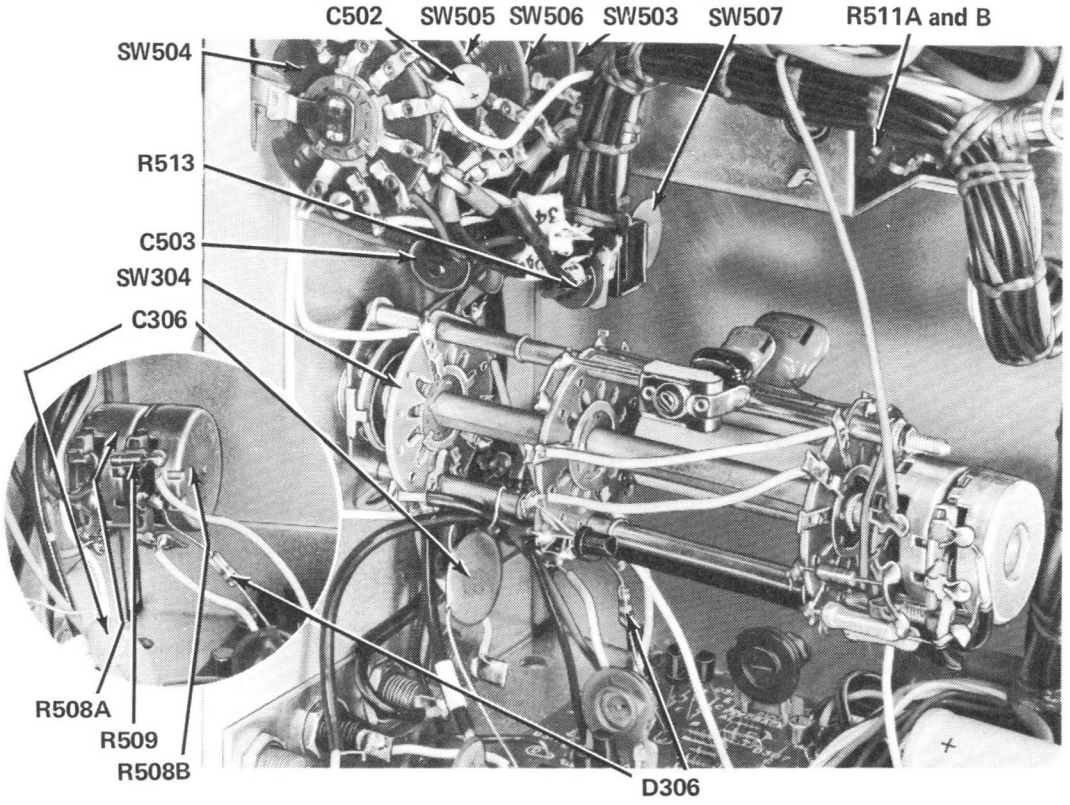


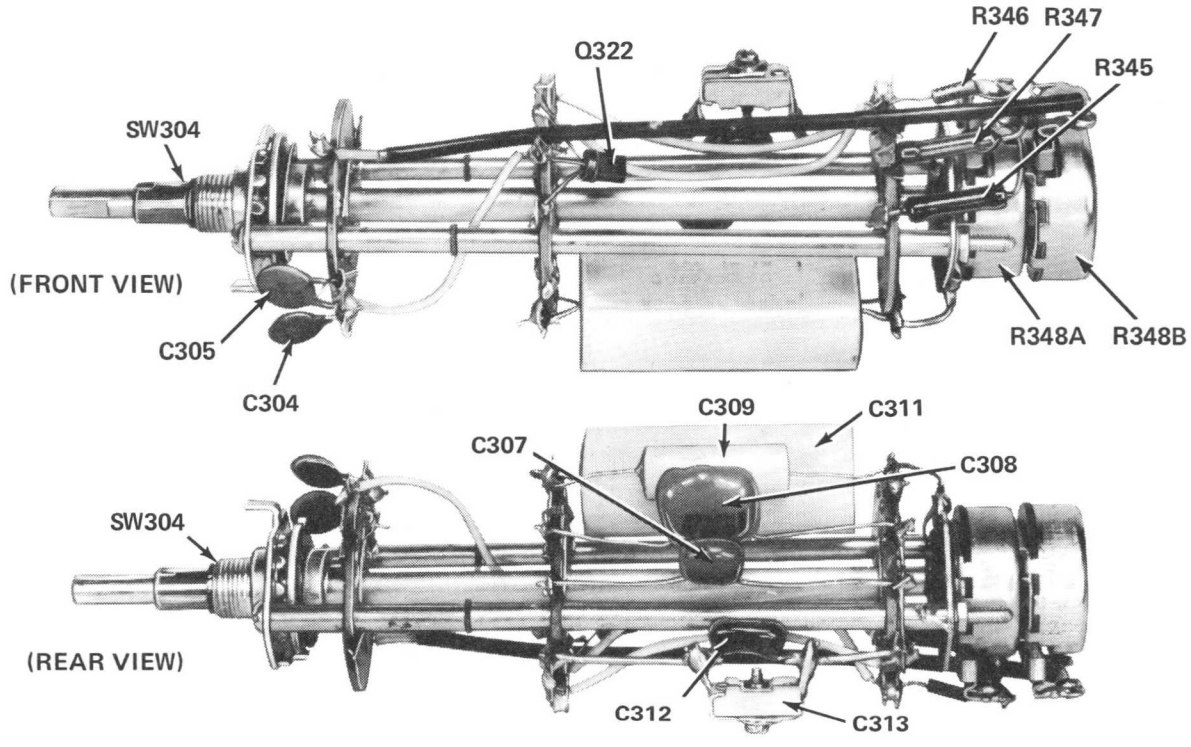
*Depends on setting of DC Balance control.

ATTENUATOR
(Viewed from foil side)

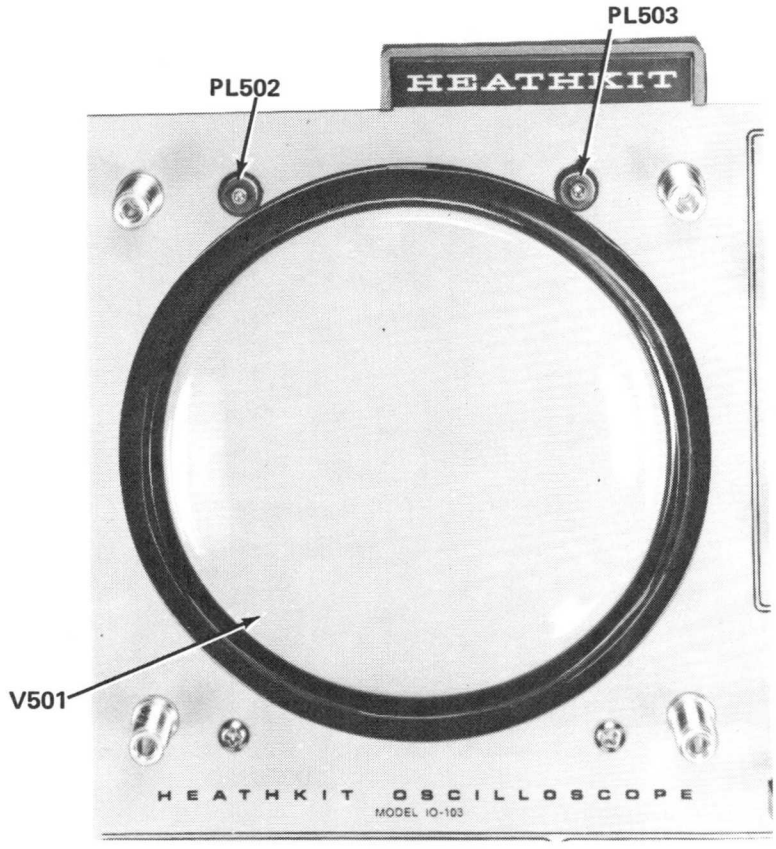
CHASSIS PHOTOGRAPHS

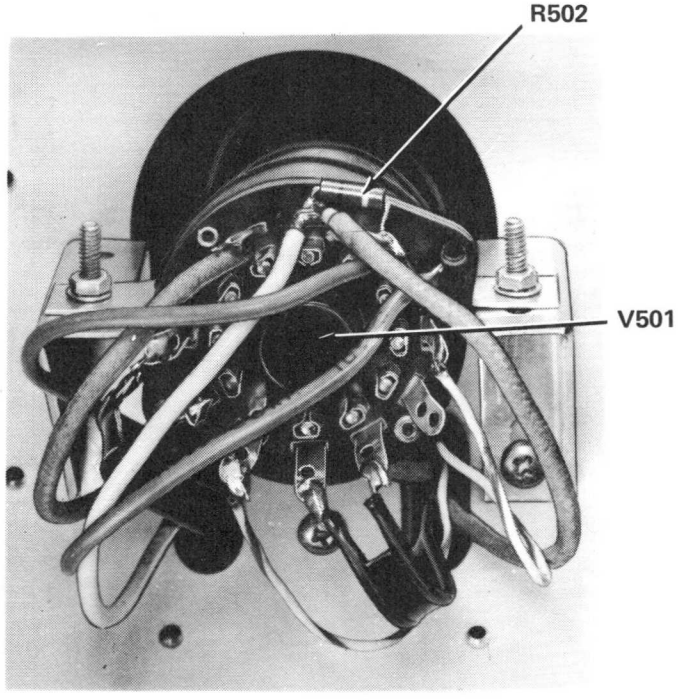


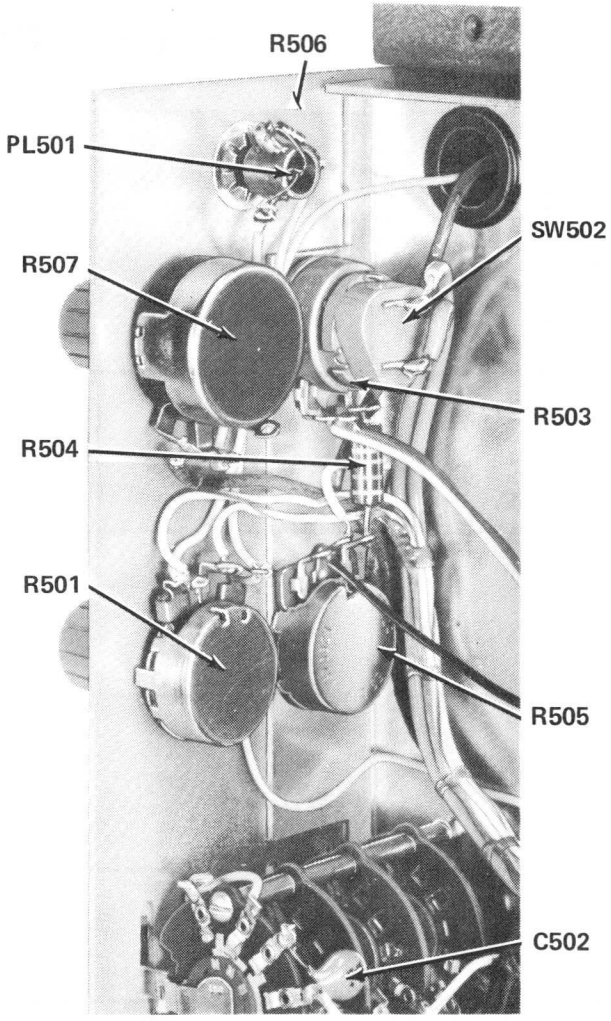


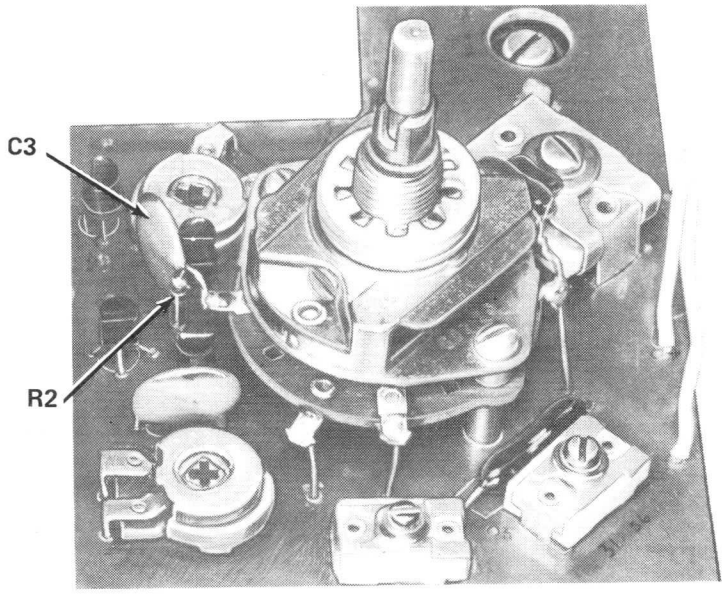


TIME/CM SWITCH

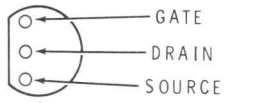
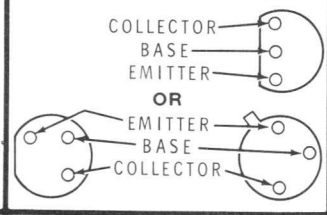
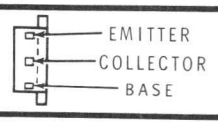

PL503
PL502
HEATHKIT
V501
HEATHKIT OSCILLOSCOPE
MODEL IO-103


R502
V501

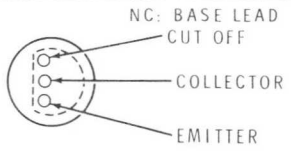
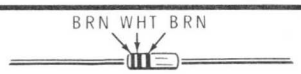

R506
PL501
SW502
R507
R503
R504
R501
R505
C502


C3
R2

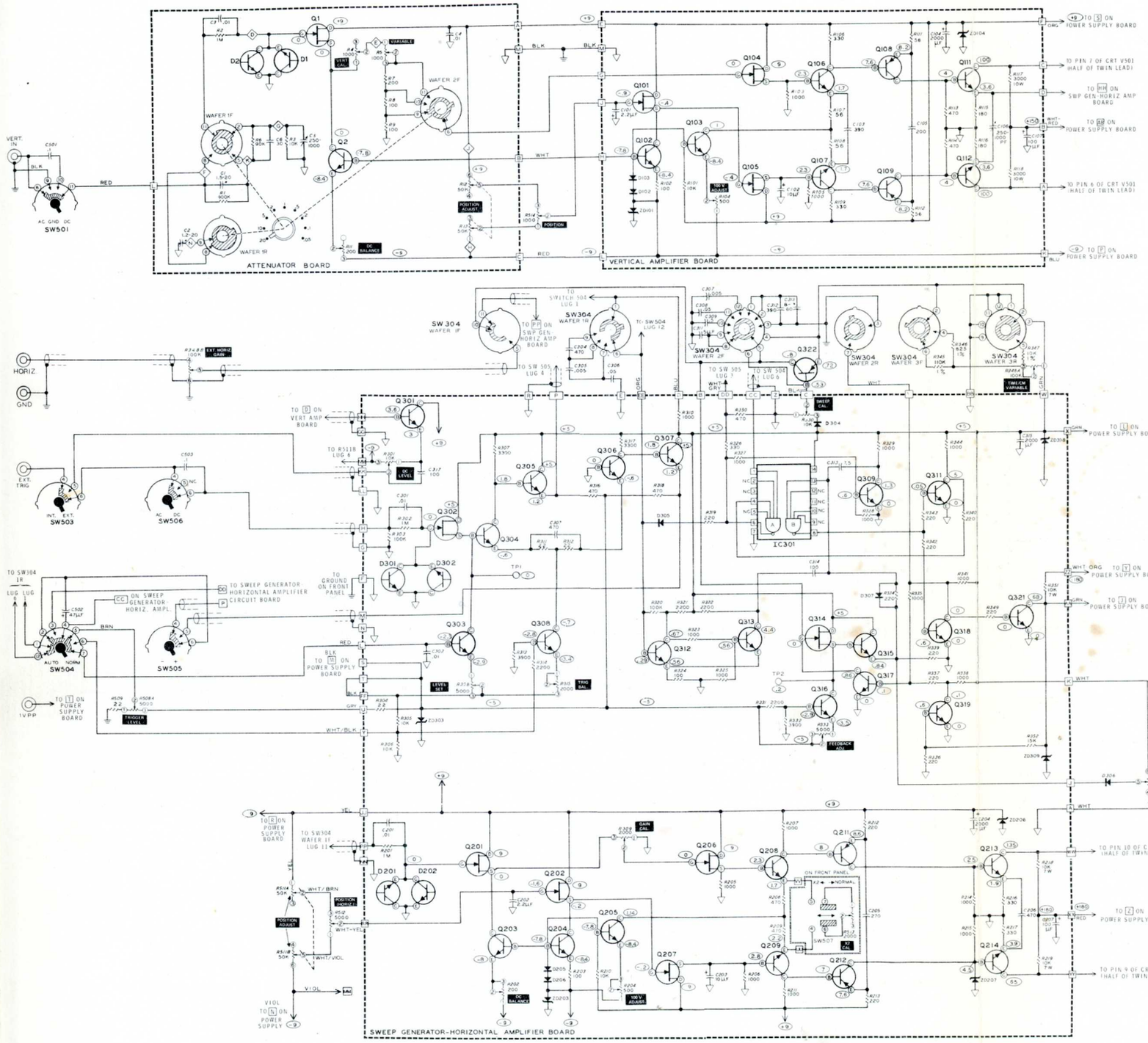
TRANSISTOR CROSS REFERENCE CHART

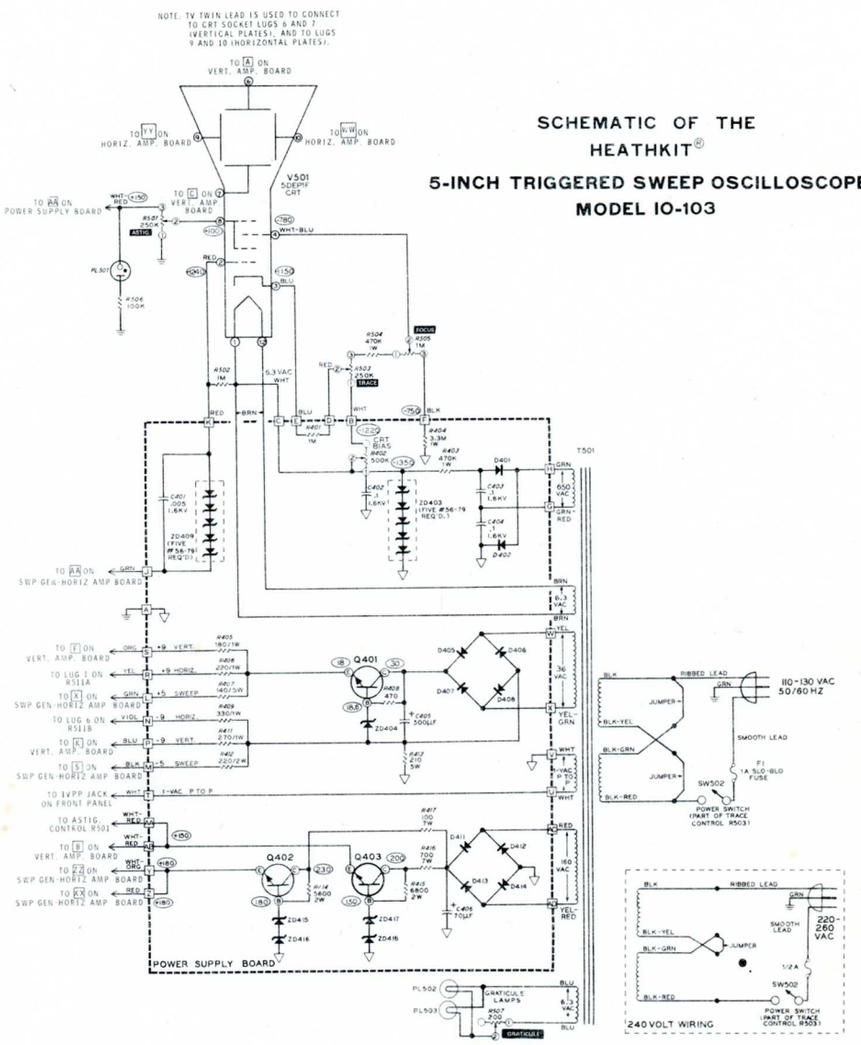
DESIGNATION	HEATH NUMBER	MANUFACTURER'S TYPE NUMBER	BASING DIAGRAM
Q1, Q2 Q101, Q104, Q105, Q201, Q202, Q206, Q207	417-169	MPF105	
Q302, Q314	417-241	EL131	
Q108, Q109, Q211, Q212, Q322	417-201	X29A829	
Q2, Q102, Q103, Q203, Q204, Q205, Q303, Q308, Q311, Q312, Q313, Q316	417-118	2N3393	
Q106, Q107, Q208, Q209, Q301, Q304, Q305, Q306, Q307, Q309, Q315	417-83	L842	
Q111, Q112, Q213, Q214, Q402, Q403	417-245	D40N1	
Q317, Q318, Q319	417-154	2N2369	
Q321	417-173	ETSO83	
Q401	417-175	2N5294	

DIODE CROSS REFERENCE CHART

DESIGNATION	HEATH NUMBER	MANUFACTURER'S TYPE NUMBER	IDENTIFICATION
D1, D2, D201, D202, D301, D322	417-83	L842 (TRANSISTOR USED AS DIODE)	
D102, D103, D204, D205, D304, D305	56-56	1N4149	
D306, D307	56-26	1N191	
D401, D402	57-52	5D20	
D405, D406, D407, D408, D411, D412, D413, D414	57-27	1N2071	
ZD101, ZD102, ZD104, ZD203, ZD206	56-19	VR-9.1 (9.1 VOLT, 25mA ZENER DIODE)	
ZD-207	56-58	1N709A (6.2 VOLT, 25mA ZENER DIODE)	
ZD303, ZD308	56-44	1N4653 (4.7 VOLT, 53mA ZENER DIODE)	
ZD309, ZD416	56-68	ZVR-68 (68 VOLT, 7mA ZENER DIODE	
ZD403, ZD409	FIVE EACH #56-79 REQUIRED	R4507-5 (275 VOLT, 23mA ZENER DIODE)	
ZD404	56-55	VR-36A (36 VOLT, 4mA ZENER DIODE)	
ZD415, ZD417	56-48	BZT110A (110 VOLT, 6.9mA ZENER DIODE)	
ZD418	56-66	1N3035 (43 VOLT, 6mA ZENER DIODE	

SCHEMATIC OF THE HEATHKIT®
5-INCH TRIGGERED SWEEP OSCILLOSCOPE
MODEL IO-103





NOTES:

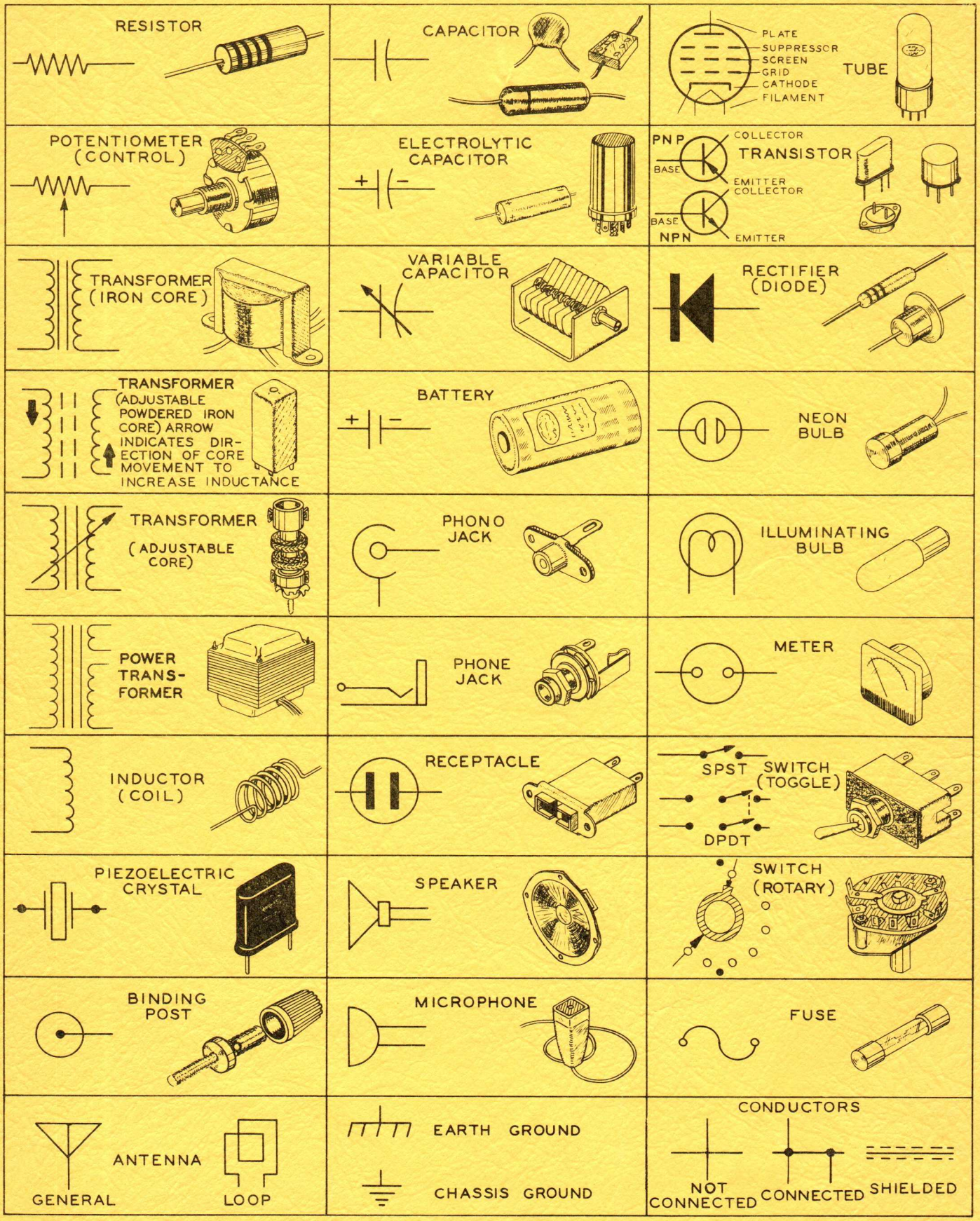
1. ALL RESISTORS IN THE SWEEP GENERATOR CIRCUIT ARE 1/4 WATT UNLESS OTHERWISE INDICATED.
2. ALL OTHER RESISTORS ARE 1/2 WATT UNLESS OTHERWISE INDICATED.
3. ALL CAPACITORS LESS THAN ONE (.01 ETC.) ARE IN µF. ALL OTHER CAPACITORS ARE IN PF UNLESS OTHERWISE INDICATED.
4. THE AC-GND-DC SWITCH, SW-501, IS SHOWN IN THE DC POSITION.
5. TRIGGER SWITCHES SW-503, SW-504, SW-505, AND SW-506 ARE SHOWN WITH THEIR LEVERS IN THE DOWN POSITION.
6. THE VOLTS/CM AND TIME/CM SWITCHES ARE SHOWN IN THEIR FULLY COUNTER-CLOCKWISE POSITIONS.
7. ⬭ THIS SYMBOL INDICATES THE DC VOLTAGE THAT SHOULD BE PRESENT AT THE INDICATED CIRCUIT POINT.
8. ALL VOLTAGES WERE MEASURED WITH A HIGH IMPEDANCE INPUT VOLTMETER FROM THE POINT INDICATED TO CHASSIS GROUND. VOLTAGES MAY VARY ±10% AND ARE TAKEN UNDER THE FOLLOWING CONDITIONS:
   - A. SW-501 IN GND POSITION.
   - B. NO HORIZONTAL INPUT SIGNAL.
   - C. ALL TRIGGER SWITCHES UP.
   - D. TIME/CM (SWEEP) SWITCH SW-304 IN THE FULLY CLOCKWISE "EXT. IN" POSITION.
   - E. STABILITY CONTROL MAXIMUM CCW.
9. ▽ THIS SYMBOL INDICATES CIRCUIT BOARD GROUND.
10. ⏚ THIS SYMBOL INDICATES CHASSIS GROUND.
11. ROTARY SWITCHES ARE VIEWED FROM THE SHAFT END OF THE SWITCHES.
12. LEVER SWITCHES ARE VIEWED FROM THE CONTACT SIDE OF THE SWITCH WAFER.

NOTE: LETTER-NUMBER DESIGNATIONS FOR RESISTORS, CAPACITORS, ETC., HAVE BEEN PLACED IN THE FOLLOWING GROUPS.

1-99	ATTENUATOR BOARD.
101-199	VERTICAL AMPLIFIER BOARD.
201-299	HORIZONTAL AMPLIFIER CIRCUITS.
301-399	SWEEP GENERATOR CIRCUITS.
401-499	POWER SUPPLY BOARD.
501-599	CHASSIS MOUNTED PARTS.

TYPICAL COMPONENT TYPES

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



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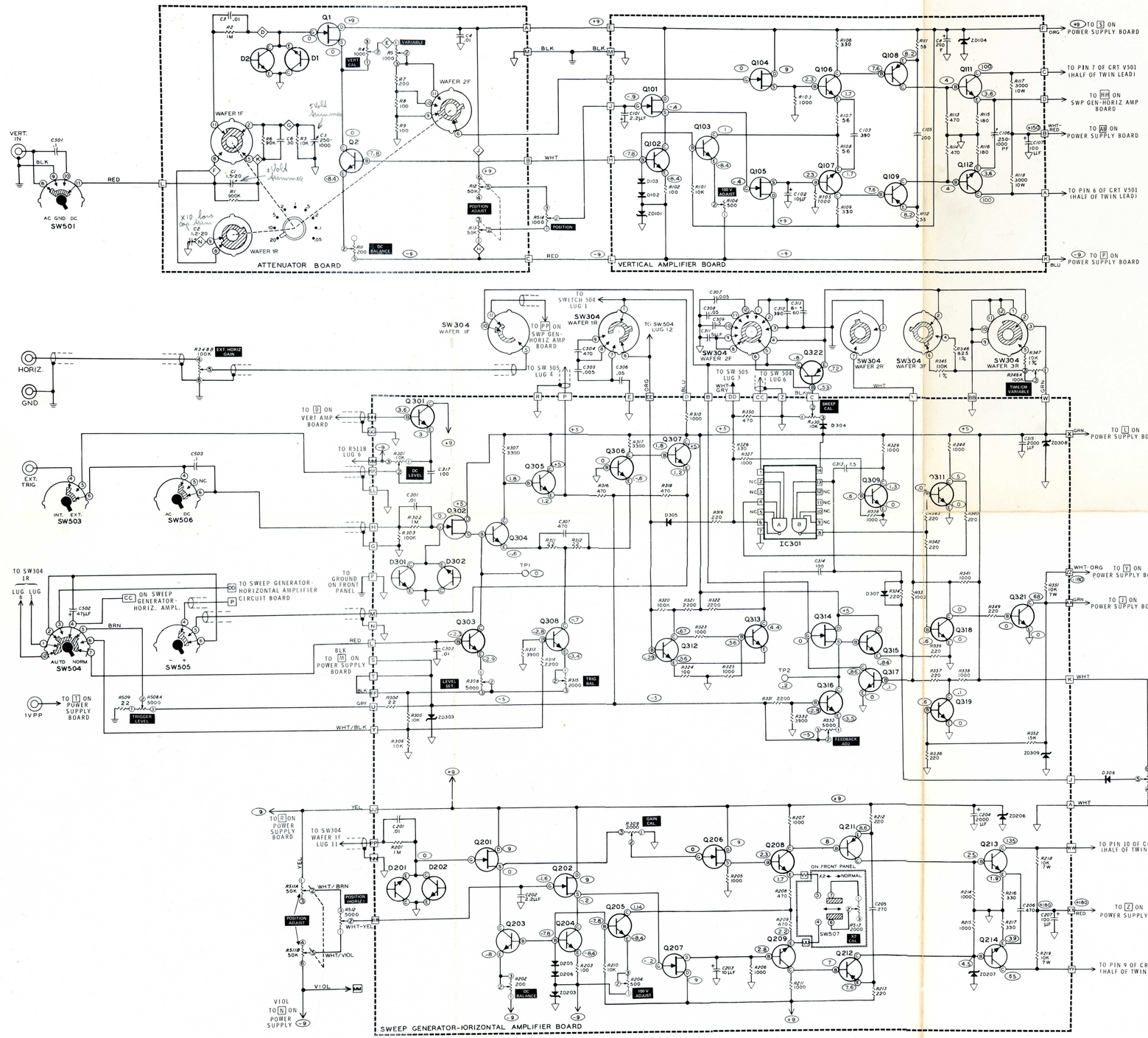
MODEL IO-103



NOTES:

1. ALL RESISTORS IN THE SWEEP GENERATOR CIRCUIT ARE 1/4 WATT UNLESS OTHERWISE INDICATED.
2. ALL OTHER RESISTORS ARE 1/2 WATT UNLESS OTHERWISE INDICATED.
3. ALL CAPACITORS LESS THAN ONE (.01 ETC.) ARE IN µF. ALL OTHER CAPACITORS ARE IN PF UNLESS OTHERWISE INDICATED.
4. THE AC-GND-DC SWITCH, SW-501, IS SHOWN IN THE DC POSITION.
5. TRIGGER SWITCHES SW-503, SW-504, SW-505, AND SW-506 ARE SHOWN WITH THEIR LEVERS IN THE DOWN POSITION.
6. THE VOLTS/CM AND TIME/CM SWITCHES ARE SHOWN IN THEIR FULLY COUNTER-CLOCKWISE POSITIONS.
7. ⬭ THIS SYMBOL INDICATES THE DC VOLTAGE THAT SHOULD BE PRESENT AT THE INDICATED CIRCUIT POINT.
8. ALL VOLTAGES WERE MEASURED WITH A HIGH IMPEDANCE INPUT VOLTMETER FROM THE POINT INDICATED TO CHASSIS GROUND. VOLTAGES MAY VARY ±10% AND ARE TAKEN UNDER THE FOLLOWING CONDITIONS:
   - A. SW-501 IN GND POSITION.
   - B. NO HORIZONTAL INPUT SIGNAL.
   - C. ALL TRIGGER SWITCHES UP.
   - D. TIME/CM (SWEEP) SWITCH SW-304 IN THE FULLY CLOCKWISE "EXT. IN" POSITION.
   - E. STABILITY CONTROL MAXIMUM CCW.
9. ▽ THIS SYMBOL INDICATES CIRCUIT BOARD GROUND.
10. ⏚ THIS SYMBOL INDICATES CHASSIS GROUND.
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