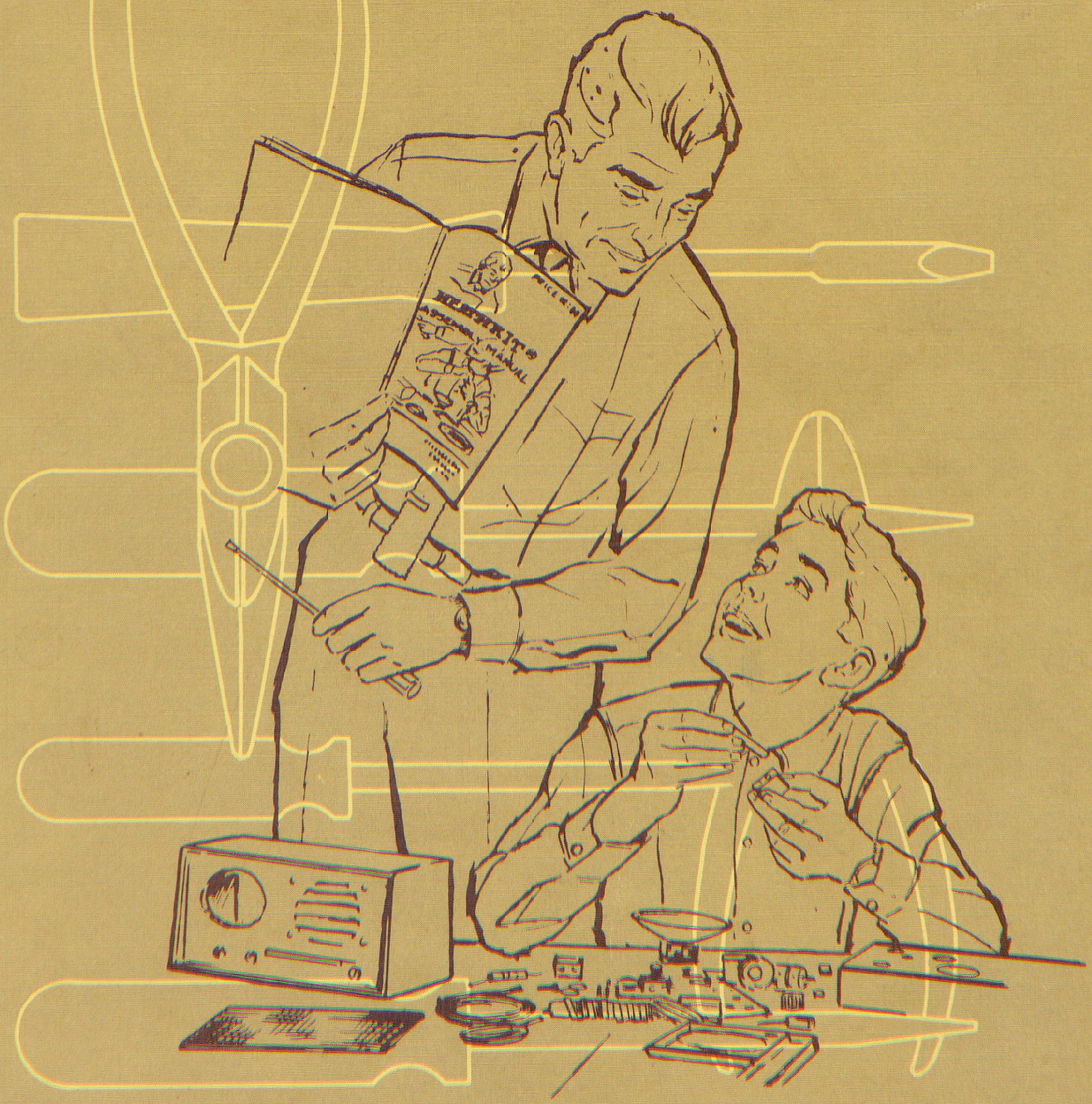
MODEL

# AD-1013 Audio Oscilloscope

# HEATHKIT®

## ASSEMBLY MANUAL



HEATH COMPANY · BENTON HARBOR, MICHIGAN

Model AD-1013 Audio Oscilloscope

HEATHKIT®



PRICE $2.00

I-595-1549-02

Dear Customer:

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

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

## Your Heathkit Warranty

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

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

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

## After-Warranty Service

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

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

Sincerely,

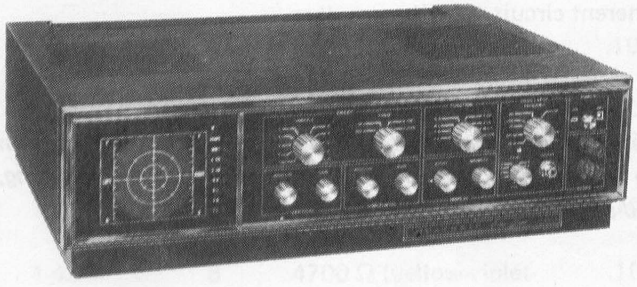
HEATH COMPANY
Benton Harbor, Michigan 49022

# Assembly and Operation of the

HEATHKIT®

# AUDIO OSCILLOSCOPE

## MODEL AD-1013



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HEATH COMPANY

BENTON HARBOR, MICHIGAN 49022

# INTRODUCTION

*The cathode ray oscilloscope is one of the most versatile instruments available. It can be used to measure AC and DC voltages, frequency, and comparative phasing, as well as to study the waveforms of complex signals. These capabilities make it valuable for analyzing the waveforms of the various signals encountered in audio systems.*

The Heathkit Model AD-1013 Audio Oscilloscope is a solid-state instrument especially designed and styled for use with any 2-channel or 4-channel system. Any of the several inputs can be switched and observed on the screen, independently or in combination. The inputs include: Left Front, Left Back, Right Front, Right Back, and Multipath; as well as a front panel input for observing any external source signal. Stereo inputs, either 4-channel or 2-channel, may be viewed in their combined form. All of this provides the ability to check your audio system for channel separation, to check it for phasing, to determine relative signal strengths, to monitor multipath reception, and to center the tuning of your receiver or tuner.

Lighted function indicators, at the edge of the screen on the front panel, eliminate frequent referring to the Function switch setting to determine what is being displayed on the screen.

The front panel Scope input permits you to use the Oscilloscope in a conventional fashion to view any waveshape generated by other sources. You can easily check for malfunctions in various stages of your tape equipment, receiver, amplifier, tuner, and so on.

This Audio Oscilloscope also contains an independent 20 Hz to 20 kHz audio oscillator. It has a knob control for frequency selection and another one to control the amplitude of the generated signal. Outputs from the oscillator are located on both the front and rear panels.

All inputs to the Audio Oscilloscope are direct-coupled except those on the front panel, which are AC-coupled. Integrated circuits are used in the triggered-sweep circuit, making it unnecessary to stabilize the sweep trace by adjusting knobs. Solid-state devices are used throughout the unit for long-life reliability, low power consumption, and inherent circuit stability.

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

# PARTS LIST

As you unpack your kit, you will see that the main carton contains several smaller packages. Open these small packages one at a time, and check each part against the following list.

The key numbers correspond to the numbers on the Parts Pictorial (fold-out from Page 5 and on Page 7). Any part that is packaged in an individual envelope with a part number on it should be placed back in its envelope after you identify it until it is called for in a step.

To order a replacement part, use the Parts Order Form furnished with this kit. If one is not available, refer to "Replacement Parts" inside the rear cover of the Manual. Your Warranty is inside the front cover.

| KEY No. | PART No. | PARTS Per Kit | DESCRIPTION | PRICE Each |
|---|---|---|---|---|
| **RESISTORS** | | | | |
| **1/2-Watt, 10%** | | | | |
| NOTE: The fourth band on 10% resistors is always silver. | | | | |
| A1 | 1-41 | 2 | 10 Ω (brown-black-black) | .10 |
| A1 | 1-67 | 2 | 39 kΩ (orange-white-orange) | .10 |
| A1 | 1-126 | 1 | 180 kΩ (brown-gray yellow) | .10 |
| A1 | 1-33 | 4 | 470 kΩ (yellow-violet-yellow) | .10 |
| A1 | 1-86 | 1 | 5.6 MΩ (green-blue-green) | .10 |

| KEY No. | PART No. | PARTS Per Kit | DESCRIPTION | PRICE Each |
|---|---|---|---|---|
| **Resistors (cont'd.)** | | | | |
| **1/2-Watt, 5%** | | | | |
| NOTE: The fourth band on 5% resistors is always gold. | | | | |
| A1 | 1-123 | 2 | 100 Ω (brown-black-brown) | .10 |
| A1 | 1-111 | 2 | 150 Ω (brown-green-brown) | .10 |
| A1 | 1-63 | 6 | 510 Ω (green-brown-brown) | .10 |
| A1 | 1-95 | 1 | 560 Ω (green-blue-brown) | .10 |
| A1 | 1-131 | 2 | 620 Ω (blue-red-brown) | .10 |
| A1 | 1-96 | 2 | 750 Ω (violet-green-brown) | .10 |
| A1 | 1-79 | 1 | 820 Ω (gray-red-brown) | .10 |
| A1 | 1-172 | 22 | 1000 Ω (brown-black-red) | .10 |
| A1 | 1-80 | 2 | 1200 Ω (brown-red-red) | .10 |
| A1 | 1-144 | 1 | 1800 Ω (brown-gray-red) | .10 |
| A1 | 1-57 | 1 | 2200 Ω (red-red-red) | .10 |
| A1 | 1-89 | 2 | 2400 Ω (red-yellow-red) | .10 |
| A1 | 1-150 | 1 | 3000 Ω (orange-black-red) | .10 |
| A1 | 1-43 | 8 | 4700 Ω (yellow-violet-red) | .10 |
| A1 | 1-113 | 2 | 5600 Ω (green-blue-red) | .10 |
| A1 | 1-51 | 2 | 6800 Ω (blue-gray-red) | .10 |
| A1 | 1-114 | 1 | 8200 Ω (gray-red-red) | .20 |
| A1 | 1-105 | 34 | 10 kΩ (brown-black-orange) | .10 |
| A1 | 1-152 | 2 | 11 kΩ (brown-brown-orange) | .10 |
| A1 | 1-58 | 2 | 22 kΩ (red-red-orange) | .10 |
| A1 | 1-124 | 1 | 27 kΩ (red-violet-orange) | .10 |
| A1 | 1-76 | 2 | 33 kΩ (orange-orange-orange) | .10 |
| **Resistors (cont'd.)** | | | | |
| A1 | 1-115 | 6 | 47 kΩ (yellow-violet-orange) | .10 |
| A1 | 1-128 | 1 | 62 kΩ (blue-red-orange) | .10 |
| A1 | 1-104 | 6 | 100 kΩ (brown-black-yellow) | .10 |
| A1 | 1-87 | 2 | 330 kΩ (orange-orange-yellow) | .10 |
| A1 | 1-101 | 2 | 1 MΩ (brown-black-green) | .10 |
| A1 | 1-169 | 1 | 3.9 MΩ (orange-white-green) | .10 |
| A1 | 1-166 | 1 | 10 MΩ (brown-black-blue) | .10 |
| **Precision, 1%** | | | | |
| A2 | 2-48-12 | 2 | 51.1 Ω | .25 |
| A2 | 2-50-12 | 2 | 80.6 Ω | .25 |
| A2 | 2-51-12 | 2 | 137 Ω | .25 |
| A2 | 2-52-12 | 2 | 178 Ω | .25 |
| A2 | 2-53-12 | 2 | 280 Ω | .25 |
| A2 | 2-54-12 | 2 | 301 Ω | .25 |
| A2 | 2-55-12 | 1 | 432 Ω | .25 |
| A2 | 2-56-12 | 1 | 1000 Ω (1 k) | .25 |
| A2 | 2-58-12 | 1 | 1370 Ω (1.37 k) | .25 |
| A2 | 2-59-12 | 1 | 1780 Ω (1.78 k) | .25 |
| A2 | 2-62-12 | 1 | 4530 Ω (4.53 k) | .25 |
| A2 | 2-64-12 | 1 | 6650 Ω (6.65 k) | .25 |
| **Other Resistors** | | | | |
| A3 | 1-7-1 | 1 | 47 kΩ, 1-watt (yellow-violet-orange) | .10 |
| A4 | 1-4-2 | 2 | 15 kΩ, 2-watt (brown-green-orange) | .15 |
| A4 | 1-6-2 | 2 | 27 kΩ, 2-watt (red-violet-orange) | .15 |
| **CAPACITORS** | | | | |
| **Mica** | | | | |
| B1 | 20-103 | 1 | 150 pF | .15 |
| B1 | 20-106 | 1 | 390 pF | .30 |

| KEY No. | PART No. | PARTS Per Kit | DESCRIPTION | PRICE Each |
|---|---|---|---|---|
| **Disc** | | | | |
| B2 | 21-60 | 2 | 18 pF | .10 |
| B2 | 21-23 | 1 | 420 pF | .10 |
| B2 | 21-171 | 1 | 680 pF | .10 |
| B2 | 21-140 | 1 | .001 μF | .10 |
| B2 | 21-27 | 4 | .005 μF | .10 |
| B2 | 21-47 | 2 | .01 μF, 50 volt | .10 |
| B2 | 21-42 | 2 | .01 μF, 1.6 kV | .15 |
| B2 | 21-143 | 5 | .05 μF | .25 |
| **Paper** | | | | |
| B3 | 23-74 | 1 | .04 μF | .25 |
| B3 | 23-62 | 3 | .1 μF | .75 |
| **Electrolytic** | | | | |
| B4 | 25-75 | 1 | 5 μF, nonpolarized | .70 |
| B5 | 25-254 | 1 | 4 μF | .55 |
| B5 | 25-54 | 3 | 10 μF tubular | .20 |
| B5 | 25-41 | 1 | 40 μF | 1.00 |
| B6 | 25-121 | 2 | 500 μF | 1.30 |
| B6 | 25-111 | 2 | 1000 μF | 2.35 |
| B7 | 25-257 | 9 | 10 μF vertical | .25 |
| B7 | 25-248 | 3 | 100 μF | .40 |
| B8 | 25-223 | 1 | 47 μF tantalum | 1.50 |
| **Mylar*** | | | | |
| B9 | 27-47 | 2 | .1 μF | .20 |
| B9 | 27-85 | 1 | .22 μF | .20 |
| B10 | 27-20 | 1 | .4 μF | .30 |

## DIODES

| | | | | |
|---|---|---|---|---|
| C1 | 56-16 | 2 | 1N751 zener | 1.00 |
| C1 | 56-19 | 2 | VR-9.1 zener | 1.00 |
| C1 | 56-56 | 25 | 1N4149 diode | .20 |
| C1 | 56-63 | 1 | MZ500-10 zener | .90 |
| C1 | 56-67 | 1 | VR-10A zener | 1.10 |
| C1 | 57-27 | 5 | 1N2071 silicon | .50 |
| C1 | 57-52 | 2 | DO-7 silicon | 1.20 |

*Dupont Registered Trademark

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

| | | | | |
|---|---|---|---|---|
| D1 | 417-201 | 9 | X29A829 transistor | .50 |
| D1 | 417-213 | 1 | 2N5249A transistor | 1.30 |
| D1 | 417-222 | 1 | 2N5308 transistor | 1.00 |
| D2 | 417-241 | 2 | JFET transistor | 2.55 |
| D2 | 417-801 | 24 | MPSA20 transistor | .20 |
| D3 | 417-110 | 1 | S2090 transistor | .55 |
| D4 | 417-140 | 1 | 2N4304 transistor | 1.50 |
| D5 | 417-265 | 1 | 2N5033 transistor | 2.05 |
| D6 | 417-834 | 5 | MPSU10 transistor | 1.00 |
| D7 | 417-175 | 2 | 2N5294 transistor | 1.45 |
| D8 | 417-263 | 1 | SJE607 transistor | 1.50 |

## INTEGRATED CIRCUITS (IC's)

NOTE: If either the part number or the "Description" number is on an integrated circuit, you have the correct part. Do not be concerned with any other numbers. (The description number may have additional letters and numbers other than those given in the list.) For example: SN(7472)N or LM(301)AN.

| | | | | |
|---|---|---|---|---|
| E1 | 442-36 | 2 | 311 | 5.00 |
| E2 | 442-39 | 1 | 301 | 1.55 |
| E3 | 442-41 | 2 | 739 | 4.05 |
| E3 | 443-4 | 1 | 7472 | .90 |
| E3 | 443-23 | 1 | 74122 | 2.45 |
| E3 | 443-46 | 1 | 7402 | .55 |

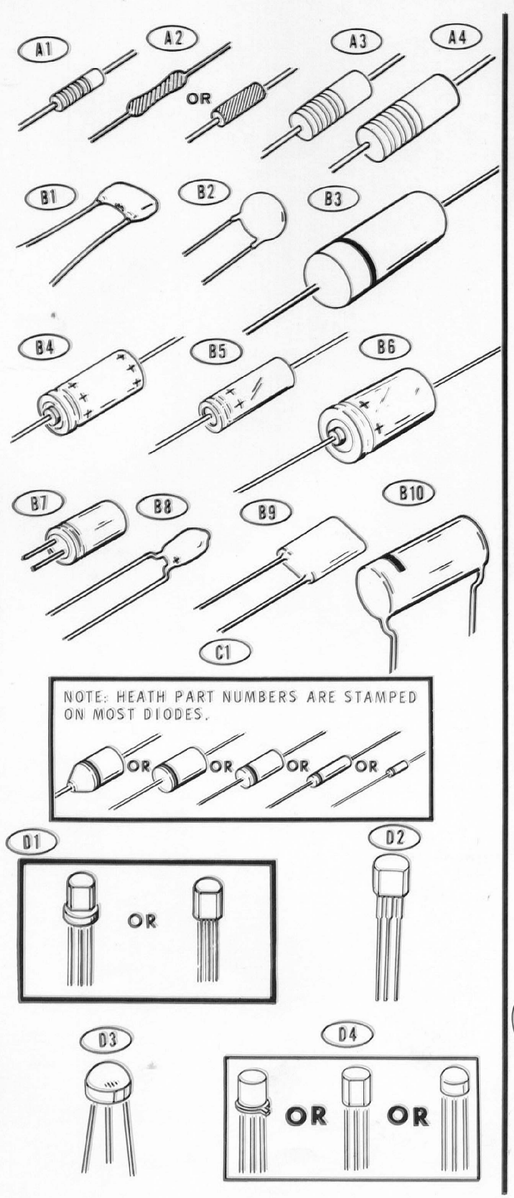
## CONTROLS-SWITCHES

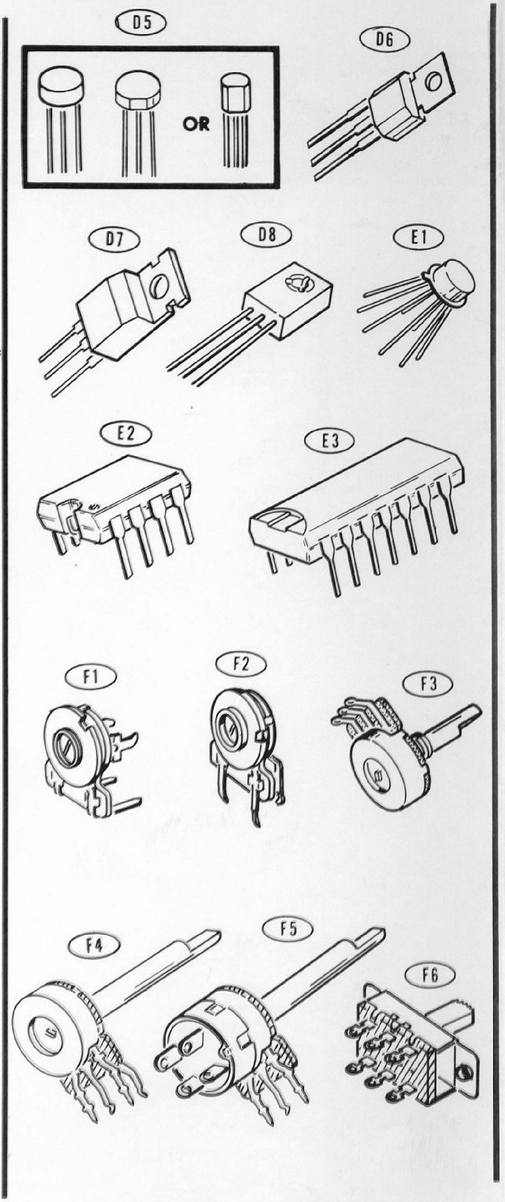
| | | | | |
|---|---|---|---|---|
| F1 | 10-384 | 1 | 500 kΩ control | .30 |
| F2 | 10-936 | 6 | 1000 Ω (1 k) control | .35 |
| F2 | 10-904 | 2 | 5000 Ω (5 k) control | .55 |
| F2 | 10-386 | 4 | 10 kΩ control | .30 |

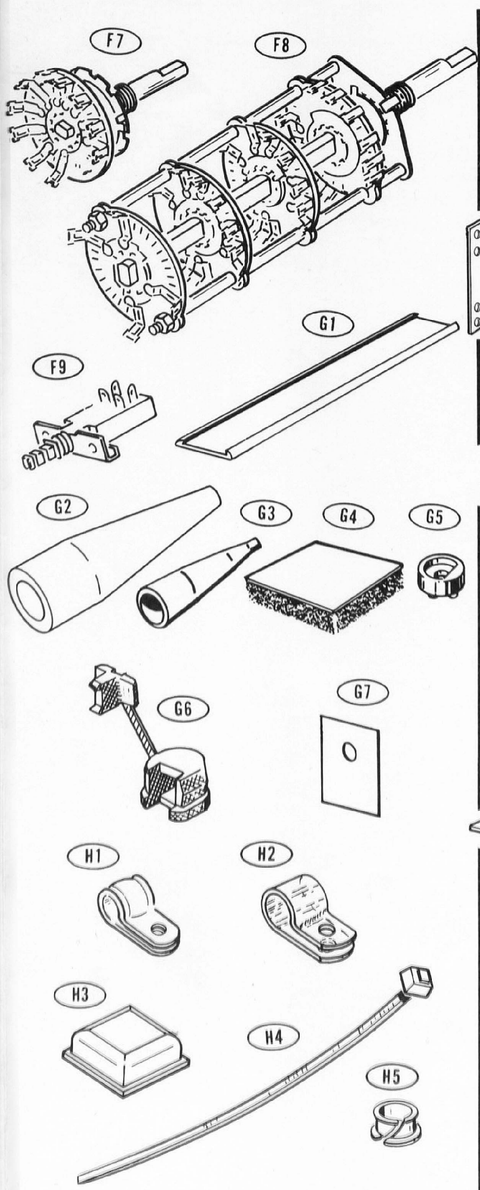
| KEY No. | PART No. | PARTS Per Kit | DESCRIPTION | PRICE Each |
|---|---|---|---|---|
| **Controls-Switches (cont'd.)** | | | | |
| F2 | 10-248 | 1 | 20 kΩ control | 1.05 |
| F3 | 10-968 | 1 | 2000 Ω (2 k) control | .85 |
| F3 | 10-967 | 1 | 20 kΩ control | .80 |
| F4 | 10-969 | 2 | 5000 Ω (5 k) control | .55 |
| F4 | 10-970 | 2 | 100 kΩ control | .60 |
| F4 | 10-971 | 1 | 500 kΩ control | .70 |
| F4 | 10-972 | 1 | 1 MΩ control | .70 |
| F5 | 19-189 | 1 | Control with switch | 1.35 |
| F6 | 60-2 | 1 | Slide switch | .30 |
| F7 | 63-680 | 1 | 1-wafer switch | 1.60 |
| F8 | 63-681 | 1 | 4-wafer switch | 4.80 |
| F9 | 64-88 | 1 | Pushbutton switch | 1.35 |
| **INSULATORS** | | | | |
| G1 | 73-5 | 1 | CRT cushion strip | .10 |
| G2 | 73-12 | 1 | Large test lead insulator | .10 |
| G3 | 73-34 | 5 | Small test lead insulator | .10 |
| G4 | 73-47 | 1 | 1" square insulator | .10 |
| G5 | 75-17 | 4 | Binding post base | .10 |
| G6 | 75-71 | 1 | Strain relief | .10 |
| | 75-109 | 1 | Large paper insulator | .15 |
| G7 | 75-704 | 2 | Transistor insulator (between 2 pieces of cardboard) | .10 |
| **PLASTIC PARTS** | | | | |
| H1 | 207-18 | 4 | 3/8" cable clamp | .10 |
| H2 | 207-22 | 2 | 1/2" cable clamp | .10 |
| H3 | 261-28 | 4 | Foot | .05 |
| H4 | 354-5 | 2 | Cable tie | .10 |
| H5 | 455-44 | 7 | Nylon bearing | .10 |
| H6 | 414-33-1 | 1 | Graticule | 4.60 |
| **METAL PARTS** | | | | |
| J1 | 90-599-1 | 1 | Chassis panel | 7.00 |
| J2 | 200-664 | 1 | Chassis | 4.65 |
| J3 | 203-1508 | 1 | Bezel | 6.60 |
| J4 | 203-1509-1 | 2 | Top or bottom panel | 3.90 |
| J5 | 203-1510 | 1 | Front panel insert | 1.80 |
| J6 | 203-1511 | 1 | Front panel | 5.00 |
| J7 | 206-304 | 1 | CRT shield | 4.50 |
| J8 | 207-1 | 2 | CRT clamp | .10 |
| J9 | 215-49 | 1 | Heat sink | .15 |

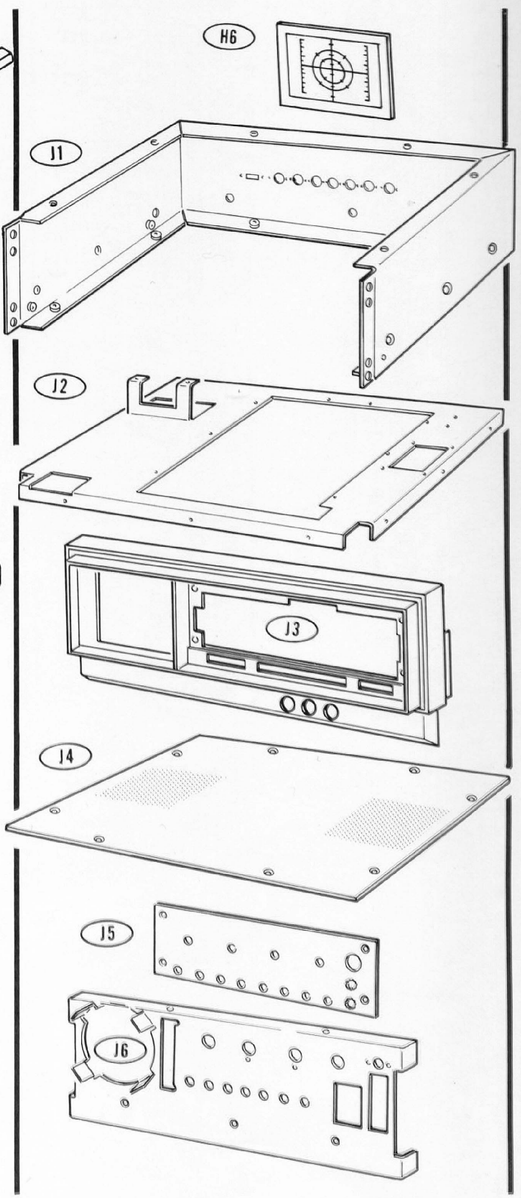
| KEY No. | PART No. | PARTS Per Kit | DESCRIPTION | PRICE Each |
|---|---|---|---|---|
| **HARDWARE** | | | | |
| **#6 Hardware** | | | | |
| K1 | 250-138 | 4 | 6-32 x 3/16" screw | .05 |
| K2 | 250-89 | 9 | 6-32 x 3/8" screw | .05 |
| K3 | 250-270 | 6 | 6-32 x 3/8" black screw | .05 |
| K4 | 250-276 | 40 | 6-32 x 3/8" black flat-head screw | .05 |
| K5 | 250-162 | 8 | 6-32 x 1/2" screw | .05 |
| K6 | 252-3 | 35 | 6-32 nut | .05 |
| K7 | 253-2 | 2 | #6 fiber shoulder washer | .05 |
| K8 | 253-89 | 6 | #6 D-washer | .05 |
| K9 | 254-1 | 36 | #6 lockwasher | .05 |
| K10 | 255-103 | 2 | 5/16" spacer | .10 |
| K11 | 259-1 | 2 | #6 solder lug | .05 |
| **Other Hardware** | | | | |
| L1 | 250-391 | 16 | 4-40 x 5/16" black screw | .05 |
| L2 | 250-34 | 1 | 4-40 x 1/2" screw | .05 |
| L3 | 252-15 | 17 | 4-40 nut | .05 |
| L4 | 252-4 | 4 | 8-32 nut | .05 |
| L5 | 252-7 | 4 | Control nut | .05 |
| L6 | 254-9 | 17 | #4 lockwasher | .05 |
| L7 | 254-2 | 4 | #8 lockwasher | .05 |
| L8 | 254-5 | 4 | Control lockwasher | .05 |
| L9 | 259-22 | 8 | Spade lug | .05 |
| **WIRE-CABLE-SLEEVING** | | | | |
| | 134-36 | 7 | Audio cable | .75 |
| | 344-2 | 1 | Heavy black stranded wire | .05 |
| | 344-21 | 1 | Red stranded wire | .05 |
| | 344-34 | 1 | Brown stranded wire | .05 |
| | 344-35 | 1 | Orange stranded wire | .05 |
| | 344-36 | 1 | Yellow stranded wire | .05 |
| | 344-50 | 1 | Black wire | .05 |
| | 344-56 | 1 | Blue wire | .05 |
| | 344-73 | 1 | White-orange wire | .05 |
| | 344-74 | 1 | White-yellow wire | .05 |
| | 344-75 | 1 | White-green wire | .05 |
| | 344-76 | 1 | White-blue wire | .05 |
| | 344-77 | 1 | White-violet wire | .05 |
| | 343-15 | 1 | Shielded cable | .10 |
| | 347-55 | 1 | 8-wire cable | .25 |
| | 346-1 | 1 | Small sleeving | .05 |
| | 346-46 | 1 | Heat shrinkable sleeving | .20 |

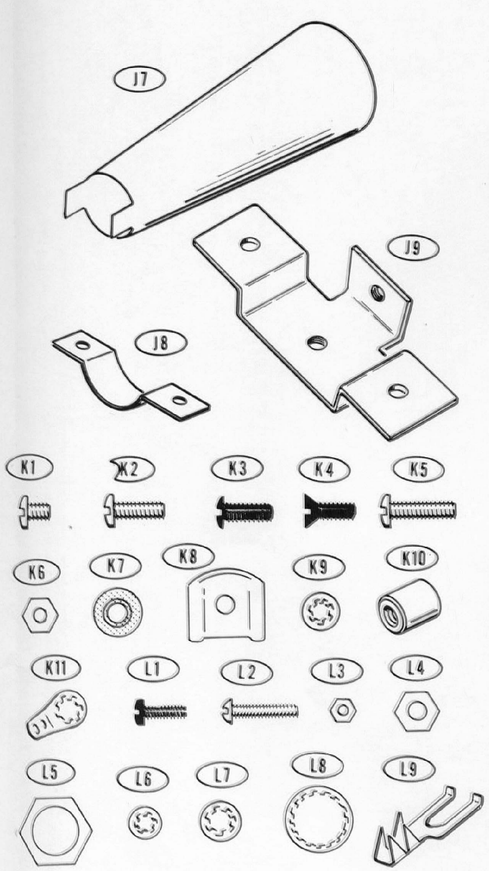
# PARTS PICTORIAL



HEATHKIT

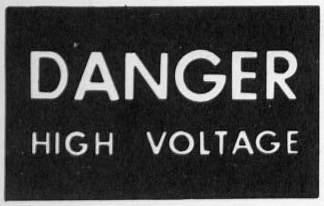
| KEY No. | PART No. | PARTS Per Kit | DESCRIPTION | PRICE Each |
|---|---|---|---|---|
| **LABELS-NAMEPLATE** | | | | |
| M1 | 390-147 | 1 | "Danger" label | .10 |
| M2 | 390-362 | 1 | Fuse label | .10 |
| M3 | 390-926 | 1 | Cord disconnect label | .15 |
| M4 | 390-1014 | 1 | Trim insert | 1.80 |
| M5 | 391-34 | 1 | Blue and white label | .10 |
| M6 | 391-85 | 1 | "Heathkit" nameplate | .45 |
| **TERMINAL STRIP-CONNECTOR-SOCKETS** | | | | |
| N1 | 431-43 | 1 | Terminal strip | .10 |
| N2 | 432-134 | 17 | Wire connector | .10 |
| N3 | 434-42 | 7 | Phono socket | .10 |
| N4 | 434-147 | 1 | AC socket | .20 |
| N5 | 434-159 | 1 | CRT socket | .60 |
| N6 | 434-212 | 1 | Phono-socket-with-hardware | .50 |
| N7 | 434-225 | 5 | 14-pin IC socket | .20 |
| N8 | 434-233 | 1 | 8-pin IC socket | .15 |
| **MISCELLANEOUS** | | | | |
| P1 | 54-837 | 1 | Power transformer | 9.15 |
| | 85-1346-2 | 1 | Main circuit board | 6.30 |
| | 85-1347-1 | 1 | Lamp circuit board | .80 |
| | 89-37 | 1 | Line cord | .65 |
| P2 | 100-16-2 | 2 | Binding post cap | .10 |
| P3 | 427-3 | 2 | Binding post | .10 |

| KEY No. | PART No. | PARTS Per Kit | DESCRIPTION | PRICE Each |
|---|---|---|---|---|
| **Miscellaneous (cont'd.)** | | | | |
| P4 | 352-13 | 1 | Silicone grease | .15 |
| P5 | 411-142 | 1 | CRT (cathode ray tube) | 17.95 |
| P6 | 412-15 | 8 | Neon lamp | .20 |
| P7 | 421-33 | 1 | .25-ampere slow-blow fuse | .30 |
| P8 | 422-1 | 1 | Fuseholder | .25 |
| P9 | 462-912 | 4 | Large knob | .80 |
| P10 | 462-913 | 7 | Medium knob | .75 |
| P11 | 462-914 | 1 | Small knob | .50 |
| P12 | 490-5 | 1 | Nut starter | .10 |
| | 597-260 | 1 | Parts Order Form | |
| | 597-308 | 1 | Kit Builders Guide | |
| | | 1 | Assembly Manual (See front cover for part number.) | 2.00 |
| | | | Solder (Additional 3' rolls of solder, #331-6, can be ordered for 15 cents each.) | |

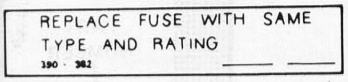
The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax, postage, and handling. Outside the U.S.A. parts and service are available from your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

# PARTS PICTORIAL (Cont'd.)

M1

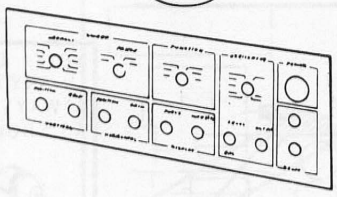



M2



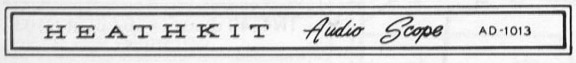

M3


M4

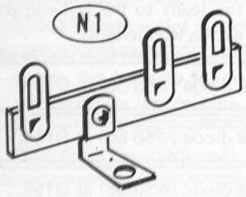


M5


M6

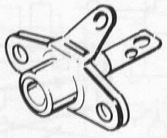



N1



N2

N3



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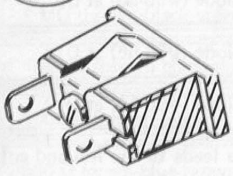
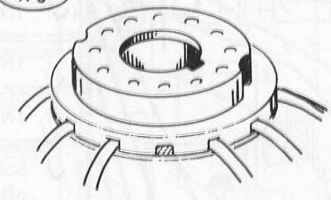
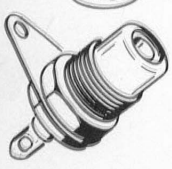


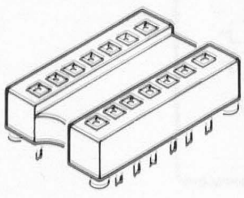
N5



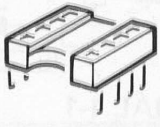
N6



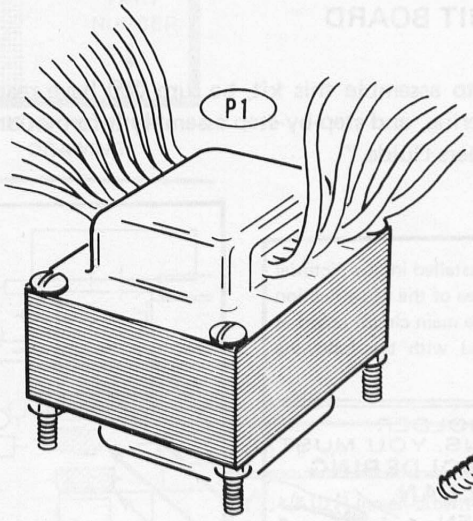
N7



N8

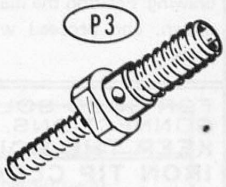


P1



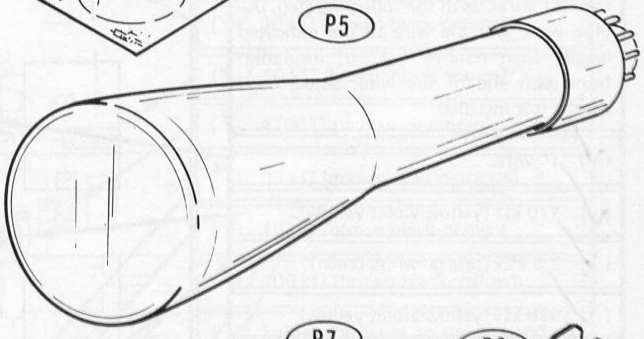
P2

P3

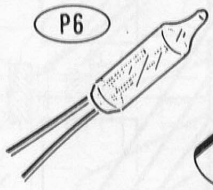


P4

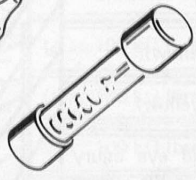
P5



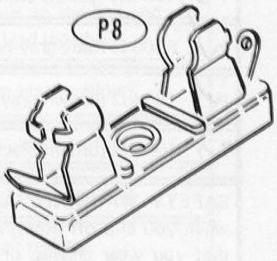
P6



P7



P8

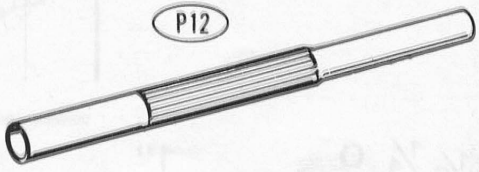


P9

P10

P11

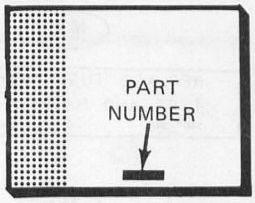
P12



# STEP-BY-STEP ASSEMBLY

## MAIN CIRCUIT BOARD

Before starting to assemble this kit, be sure you have read the wiring, soldering, and step-by-step assembly information in the "Kit Builders Guide."




IDENTIFICATION DRAWING

NOTE: The parts installed in this Pictorial are in the shaded area of the identification drawing. Position the main circuit board as shown, and proceed with the following steps.

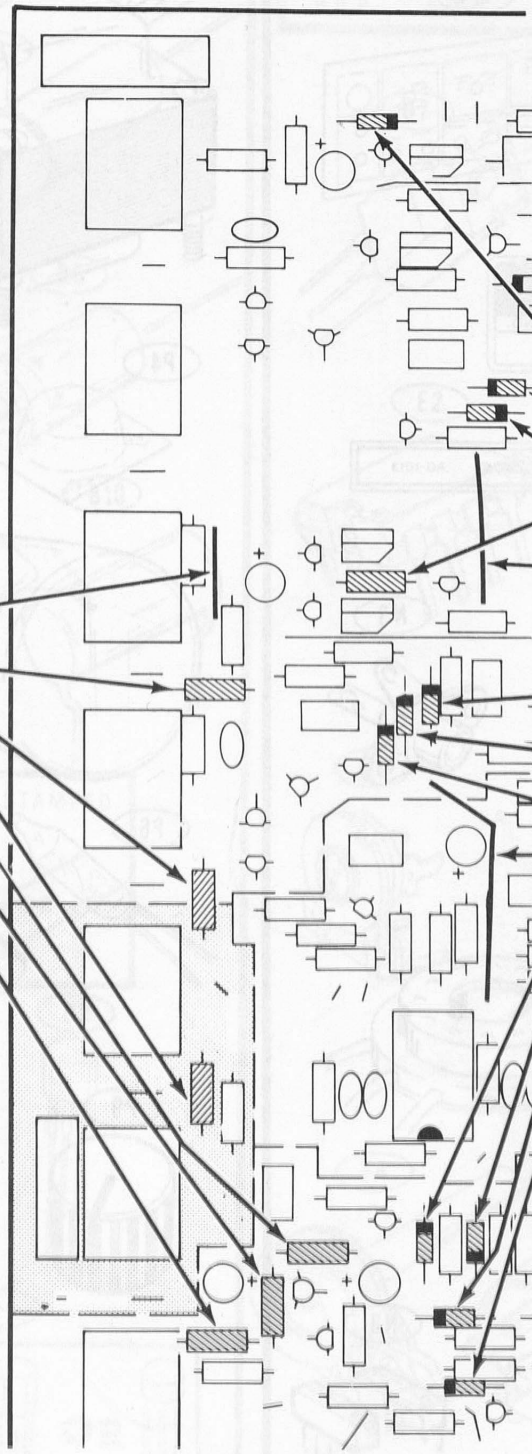
FOR GOOD SOLDER CONNECTIONS, YOU MUST **KEEP THE SOLDERING IRON TIP CLEAN.** WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.

NOTE: When you are instructed to connect wires, as in the following step, use blue wire. Cut the wire to the indicated length; then remove 1/4" of insulation from each end of the wire. Solder each wire as it is installed.

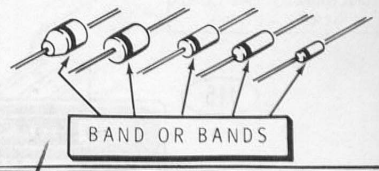
( ) 1" wire.
( ) 470 kΩ (yellow-violet-yellow).
( ) 3.9 MΩ (orange-white-green).
( ) 470 kΩ (yellow-violet-yellow).
( ) 6800 Ω (blue-gray-red).
( ) 180 kΩ (brown-gray-yellow).
( ) 100 kΩ (brown-black-yellow).

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

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

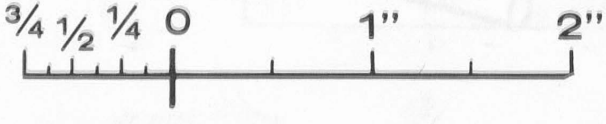


NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.

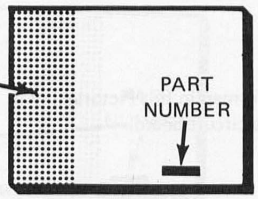



( ) VR-9.1 diode (#56-19) at ZD106.
( ) 1N4149 diode (#56-56) at D104.
( ) 1N4149 diode (#56-56) at D103.
( ) 620 Ω (blue-red-brown).
( ) 1-1/2" wire.
( ) Solder the leads to the foil and cut off the excess lead lengths.
( ) 1N4149 diode (#56-56) at D155.
( ) 1N4149 diode (#56-56) at D154.
( ) 1N4149 diode (#56-56) at D153.
( ) 2" wire.
( ) 1N4149 diode (#56-56) at D5.
( ) 1N4149 diode (#56-56) at D6.
( ) 1N4149 diode (#56-56) at D13.
( ) 1N4149 diode (#56-56) at D12.
( ) Solder the leads to the foil and cut off the excess lead lengths.

**PICTORIAL 1-1**



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




IDENTIFICATION DRAWING

( ) 4700 Ω (yellow-violet-red).

( ) 4700 Ω (yellow-violet-red).

( ) 470 kΩ (yellow-violet-yellow).

( ) 620 Ω (blue-red-brown).

( ) 2400 Ω (red-yellow-red).

( ) 4700 Ω (yellow-violet-red).

( ) 4700 Ω (yellow-violet-red).

( ) 47 kΩ (yellow-violet-orange).

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

( ) 1000 Ω (brown-black-red).

( ) 1200 Ω (brown-red-red).

( ) 10 Ω (brown-black-black).

( ) 4700 Ω (yellow-violet-red).

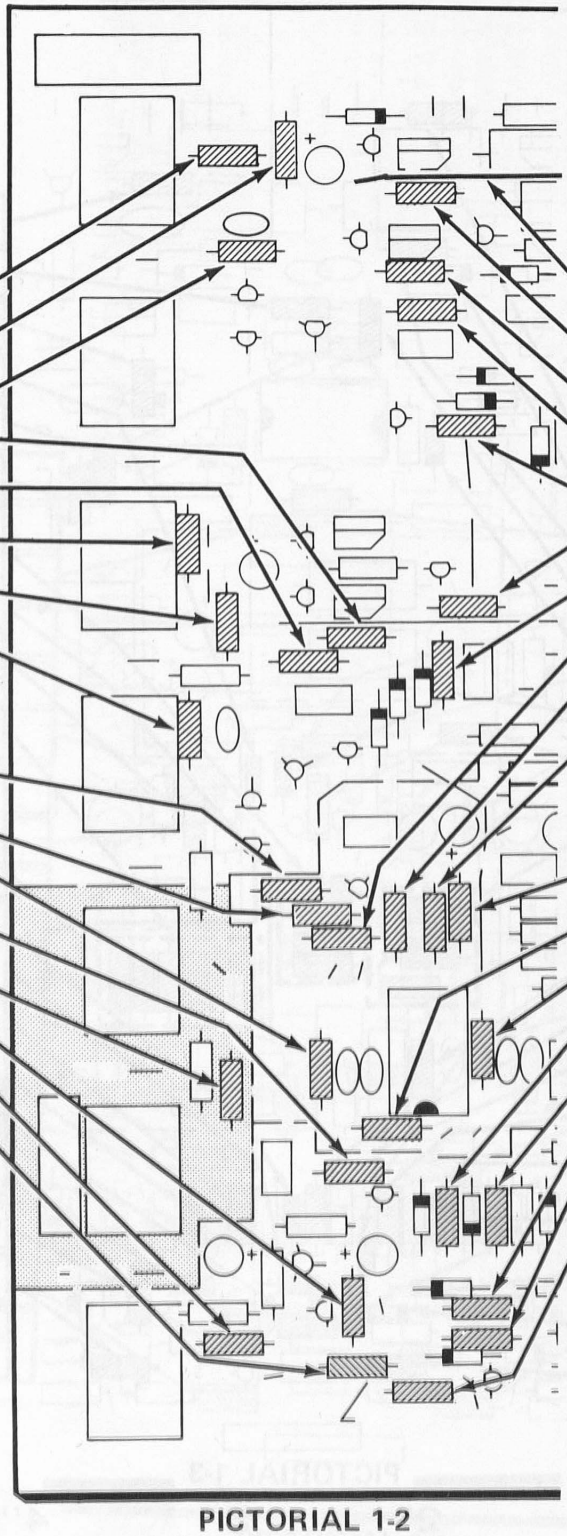
( ) 1 MΩ (brown-black-green).

( ) 1000 Ω (brown-black-red).

( ) 1000 Ω (brown-black-red).

( ) 560 Ω (green-blue-brown).

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



( ) 2" wire.

( ) 510 Ω (green-brown-brown).

( ) 510 Ω (green-brown-brown).

( ) 2400 Ω (red-yellow-red).

( ) 10 kΩ (brown-black-orange).

( ) 10 kΩ (brown-black-orange).

( ) 4700 Ω (yellow-violet-red).

( ) 33 kΩ (orange-orange-orange).

( ) 10 kΩ (brown-black-orange).

( ) 100 kΩ (brown-black-yellow).

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

( ) 100 kΩ (brown-black-yellow).

( ) 100 kΩ (brown-black-yellow).

( ) 100 kΩ (brown-black-yellow).

( ) 51.1 Ω precision resistor.

( ) 432 Ω precision resistor.

( ) 80.6 Ω precision resistor.

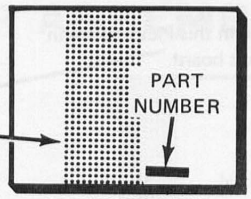
( ) 51.1 Ω precision resistor.

( ) 5600 Ω (green-blue-red).

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

**PICTORIAL 1-2**

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




IDENTIFICATION DRAWING

( ) 10 kΩ (brown-black-orange).

( ) 1N4149 diode (#56-56) at D105.

( ) 4700 Ω (yellow-violet-red).

( ) 1000 Ω (brown-black-red).

( ) VR-9.1 diode (#56-19) at ZD156.

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

( ) 10 kΩ (brown-black-orange).

( ) Four 10 kΩ (brown-black-orange) resistors.

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

( ) 10 Ω (brown-black-black).

( ) 178 Ω precision resistor.

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

( ) 137 Ω precision resistor.

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

( ) 80.6 Ω precision resistor.

( ) 1N4149 diode (#56-56) at D14.

( ) 1N4149 diode (#56-56) at D15.

( ) 4700 Ω (yellow-violet-red).

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

( ) 1 MΩ (brown-black-green).

( ) 47 kΩ (yellow-violet-orange).

( ) 100 Ω (brown-black-brown).

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

( ) 27 kΩ (red-violet-orange).

( ) 1000 Ω (brown-black-red).

( ) Four 10 kΩ (brown-black-orange) resistors.

( ) 1-3/4" wire.

( ) 1000 Ω (brown-black-red).

( ) Six 10 kΩ (brown-black-orange) resistors.

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

( ) 2-3/4" wire.

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

( ) 1N4149 diode (#56-56) at D16.

( ) 6650 Ω (6.65 k) precision resistor.

( ) 1N4149 diode (#56-56) at D11.

( ) 178 Ω precision resistor.

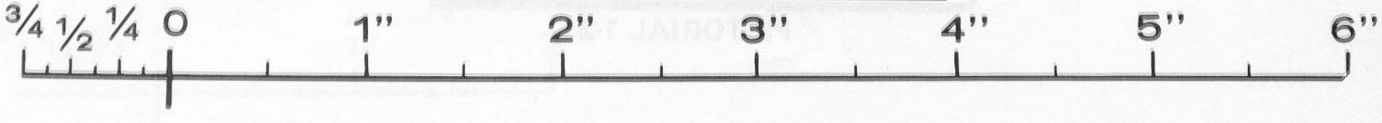
( ) 1N4149 diode (#56-56) at D17.

( ) 301 Ω precision resistor.

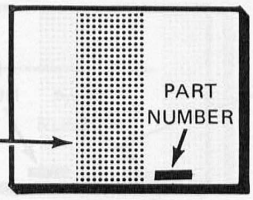
( ) 10 MΩ (brown-black-blue).

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

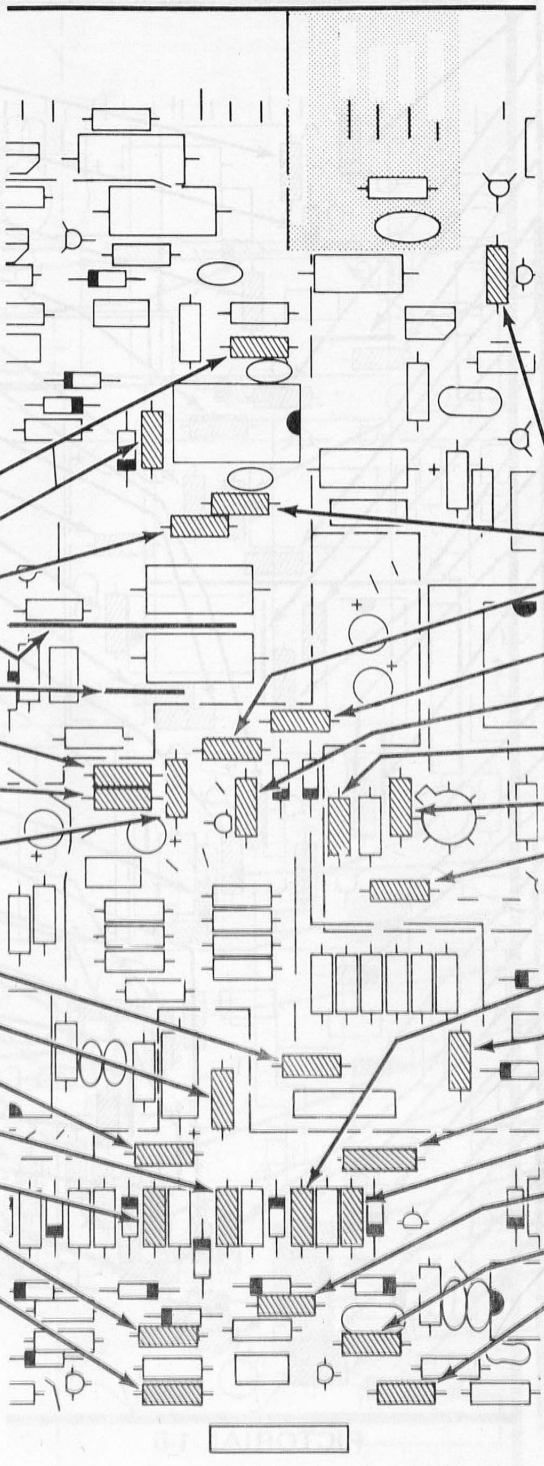
PICTORIAL 1-3



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




IDENTIFICATION DRAWING

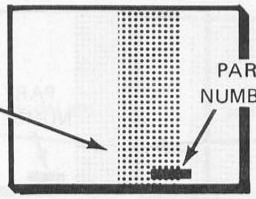


( ) 150 Ω (brown-green-brown).
( ) 1000 Ω (brown-black-red).
( ) 39 kΩ (orange-white-orange).
( ) 3" wire.
( ) 1" wire.
( ) 1200 Ω (brown-red-red).
( ) 33 kΩ (orange-orange-orange).
( ) 10 kΩ (brown-black-orange).
( ) Solder the leads to the foil and cut off the excess lead lengths.
( ) 10 kΩ (brown-black-orange).
( ) 750 Ω (violet-green-brown).
( ) 1000 Ω (brown-black-red).
( ) 1780 Ω (1.78 k) precision resistor.
( ) 1370 Ω (1.37 k) precision resistor.
( ) 137 Ω precision resistor.
( ) 1000 Ω (brown-black-red).
( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) 100 Ω (brown-black-brown).
( ) 150 Ω (brown-green-brown).
( ) 10 kΩ (brown-black-orange).
( ) 10 kΩ (brown-black-orange).
( ) 1000 Ω (brown-black-red).
( ) 47 kΩ (yellow-violet-orange).
( ) 39 kΩ (orange-white-orange).
( ) 47 kΩ (yellow-violet-orange).
( ) Solder the leads to the foil and cut off the excess lead lengths.
( ) 4530 Ω (4.53 k) precision resistor.
( ) 10 kΩ (brown-black-orange).
( ) 1000 Ω (1 k) precision resistor.
( ) 280 Ω precision resistor.
( ) 280 Ω precision resistor.
( ) 301 Ω precision resistor.
( ) 750 Ω (violet-green-brown).
( ) Solder the leads to the foil and cut off the excess lead lengths..

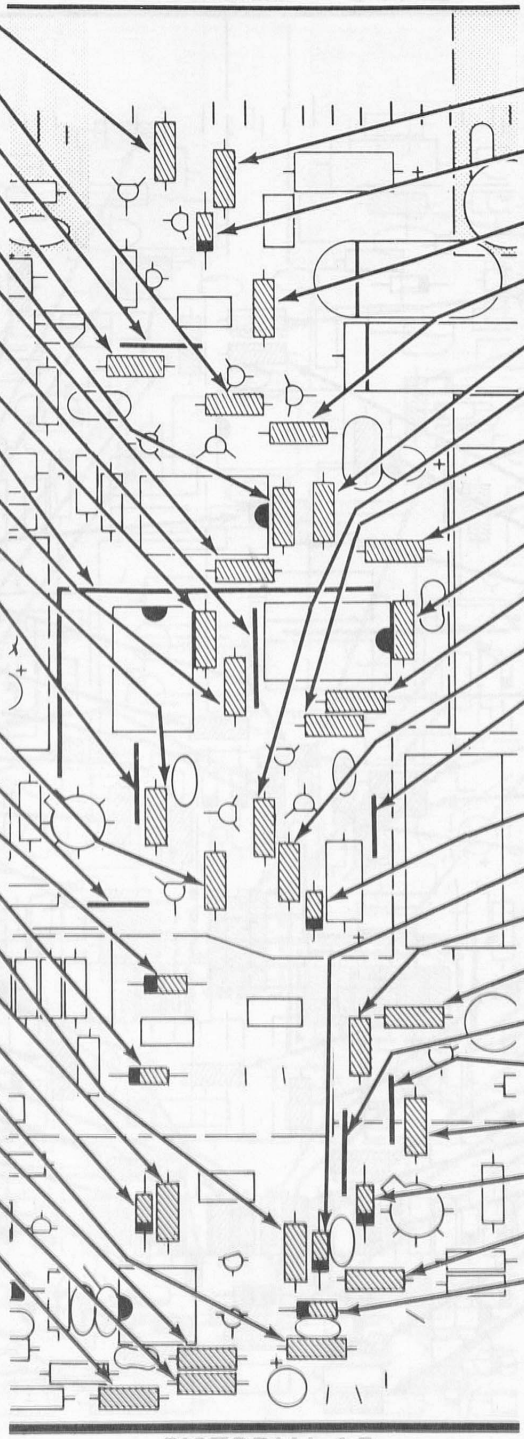
**PICTORIAL 1-4**

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



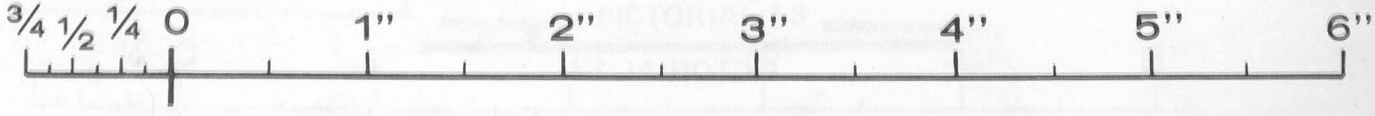

IDENTIFICATION DRAWING

( ) 10 kΩ (brown-black-orange).
( ) 10 kΩ (brown-black-orange).
( ) 1" wire.
( ) 1000 Ω (brown-black-red).
( ) 1000 Ω (brown-black-red).
( ) 47 kΩ (yellow-violet-orange).
( ) 1" wire.
( ) 1000 Ω (brown-black-red).
( ) 3-3/4" wire.
( ) 1000 Ω (brown-black-red).
( ) 100 kΩ (brown-black-yellow).
( ) 1" wire.
( ) Solder the leads to the foil and cut off the excess lead lengths.
( ) 10 kΩ (brown-black-orange).
( ) 3/4" wire.
( ) 1N4149 diode (#56-56) at D203.
( ) 1N4149 diode (#56-56) at D202.
( ) 330 kΩ (orange-orange-yellow).
( ) 5.6 MΩ (green-blue-green).
( ) 1N751 diode (#56-16) at ZD3.
( ) 47 kΩ (yellow-violet-orange).
( ) 10 kΩ (brown-black-orange).
( ) 22 kΩ (red-red-orange).
( ) 22 kΩ (red-red-orange).
( ) Solder the leads to the foil and cut off the excess lead lengths.

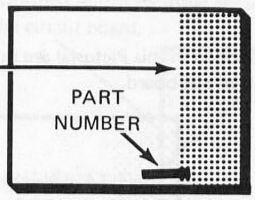


( ) 510 Ω (green-brown-brown).
( ) MZ500-10 diode (#56-63) at ZD402.
( ) 10 kΩ (brown-black-orange).
( ) 10 kΩ (brown-black-orange).
( ) 10 kΩ (brown-black-orange).
( ) 1000 Ω (brown-black-red).
( ) 470 kΩ (yellow-violet-yellow).
( ) 1000 Ω (brown-black-red).
( ) 1000 Ω (brown-black-red).
( ) 820 Ω (gray-red-brown).
( ) 10 kΩ (brown-black-orange).
( ) 3/4" wire.
( ) Solder the leads to the foil and cut off the excess lead lengths.
( ) 1N4149 diode (#56-56) at D401.
( ) 1N4149 diode (#56-56) at D1.
( ) 1800 Ω (brown-gray-red).
( ) 5600 Ω (green-blue-red).
( ) 1" wire.
( ) 1" wire.
( ) 3000 Ω (orange-black-red).
( ) 1N751 diode (#56-16) at ZD4.
( ) 10 kΩ (brown-black-orange).
( ) 1N4149 diode (#56-56) at D2.
( ) Solder the leads to the foil and cut off the excess lead lengths.

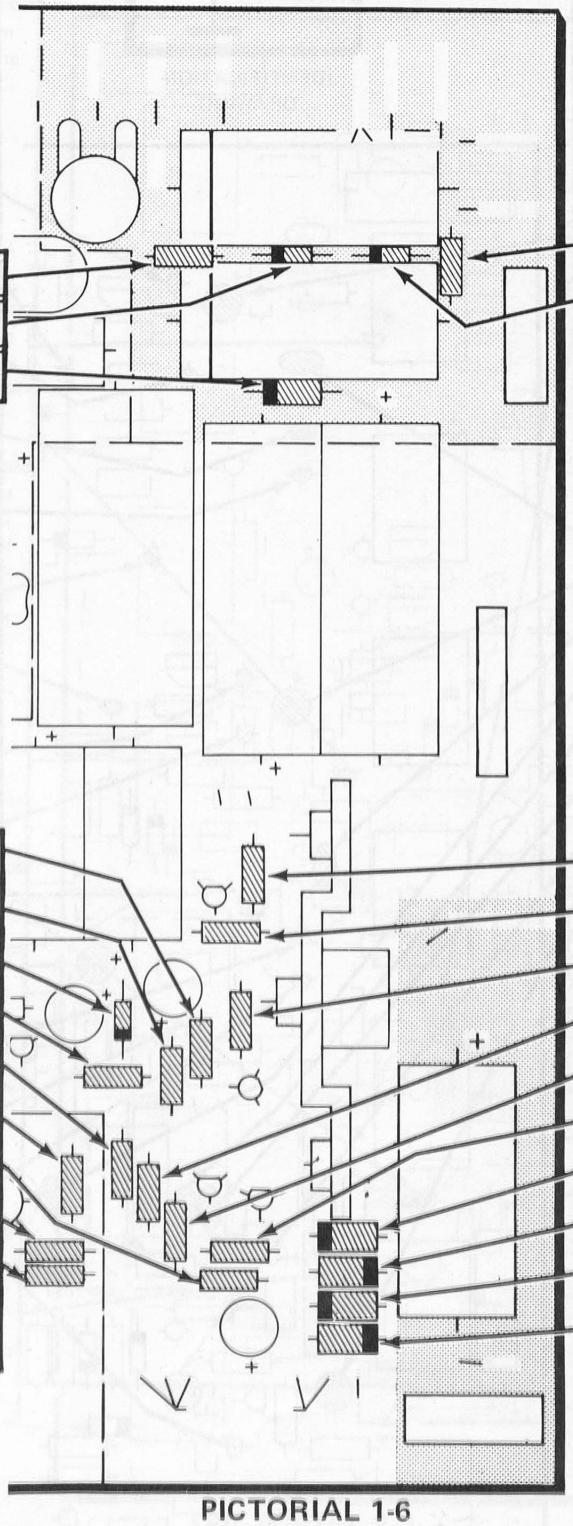
**PICTORIAL 1-5**



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




IDENTIFICATION DRAWING



( ) 62 kΩ (blue-red-orange).
( ) DO-7 diode (#57-52) at D502.
( ) 1N2071 diode (#57-27) at D503.

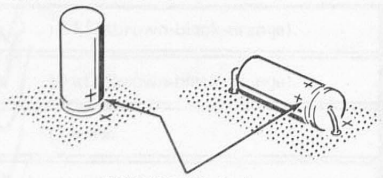
( ) 330 kΩ (orange-orange-yellow).
( ) DO-7 diode (#57-52) at D501.

( ) 510 Ω (green-brown-brown).
( ) 510 Ω (green-brown-brown).
( ) VR-10A diode (#56-67) at ZD508.
( ) 1000 Ω (brown-black-red).
( ) 11 kΩ (brown-brown-orange).
( ) 2200 Ω (red-red-red).
( ) 510 Ω (green-brown-brown).
( ) 1000 Ω (brown-black-red).
( ) 1000 Ω (brown-black-red).
( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) 11 kΩ (brown-brown-orange).
( ) 8200 Ω (gray-red-red).
( ) 1000 Ω (brown-black-red).
( ) 10 kΩ (brown-black-orange).
( ) 1000 Ω (brown-black-red).
( ) 6800 Ω (blue-gray-red).
( ) 1N2071 diode (#57-27) at D504.
( ) 1N2071 diode (#57-27) at D505.
( ) 1N2071 diode (#57-27) at D506.
( ) 1N2071 diode (#57-27) at D507.
( ) Solder the leads to the foil and cut off the excess lead lengths.

**PICTORIAL 1-6**

NOTE: When you install electrolytic capacitors, always match the positive (+) marked end of the capacitor with the positive (+) mark on the circuit board. The illustration shows a vertically-mounted capacitor as well as a tubular type.




( ) 10 μF vertical electrolytic.

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


( ) .05 μF disc.

( ) 10 μF vertical electrolytic.

( ) .05 μF disc.

( ) .005 μF disc.

( ) .005 μF disc.

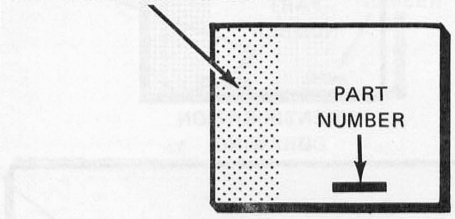
( ) .05 μF disc.

( ) 10 μF vertical electrolytic.

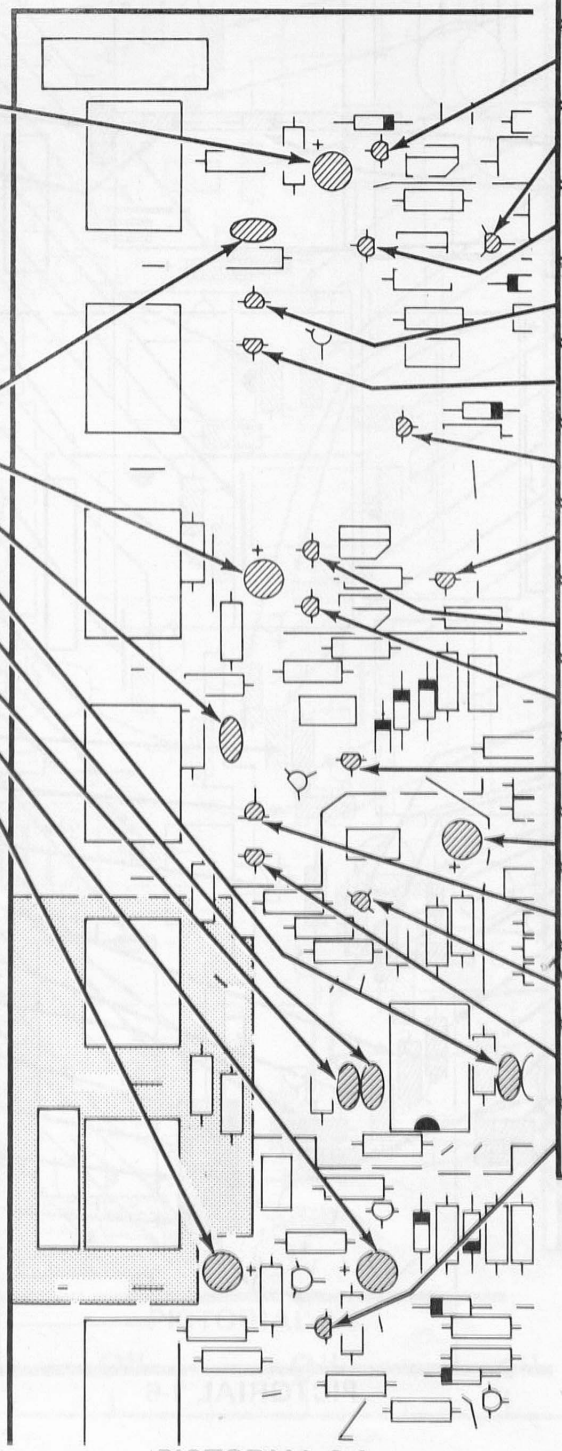
( ) 10 μF vertical electrolytic.

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

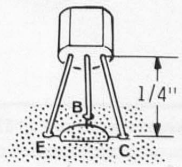
The steps performed in this Pictorial are in this area of the circuit board.




IDENTIFICATION DRAWING



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




( ) MPSA20 transistor (#417-801) at Q105.

( ) MPSA20 transistor (#417-801) at Q103.

( ) MPSA20 transistor (#417-801) at Q104.

( ) MPSA20 transistor (#417-801) at D102.

( ) MPSA20 transistor (#417-801) at D101.

( ) MPSA20 transistor (#417-801) at Q102.

( ) MPSA20 transistor (#417-801) at Q153.

( ) MPSA20 transistor (#417-801) at Q155.

( ) MPSA20 transistor (#417-801) at Q154.

( ) MPSA20 transistor (#417-801) at Q152.

( ) 10 μF vertical electrolytic.

( ) MPSA20 transistor (#417-801) at D152.

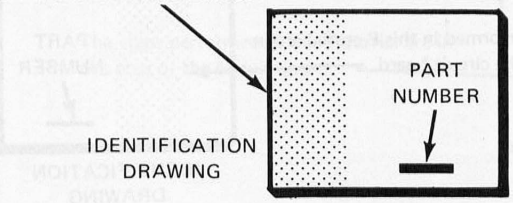
( ) MPSA20 transistor (#417-801) at Q201.

( ) MPSA20 transistor (#417-801) at D151.

( ) MPSA20 transistor (#417-801) at Q7.

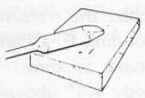
**PICTORIAL 2-1**

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

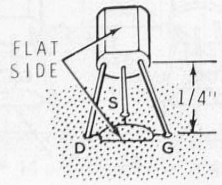



FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



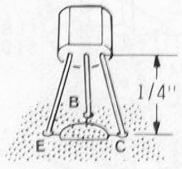
Install the next two transistors as shown. Solder the leads to the foil and cut off the excess lead lengths.




( ) EL131 transistor (#417-241) at Q101.

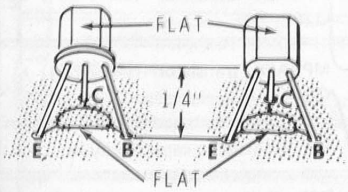
( ) EL131 transistor (#417-241) at Q151.

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



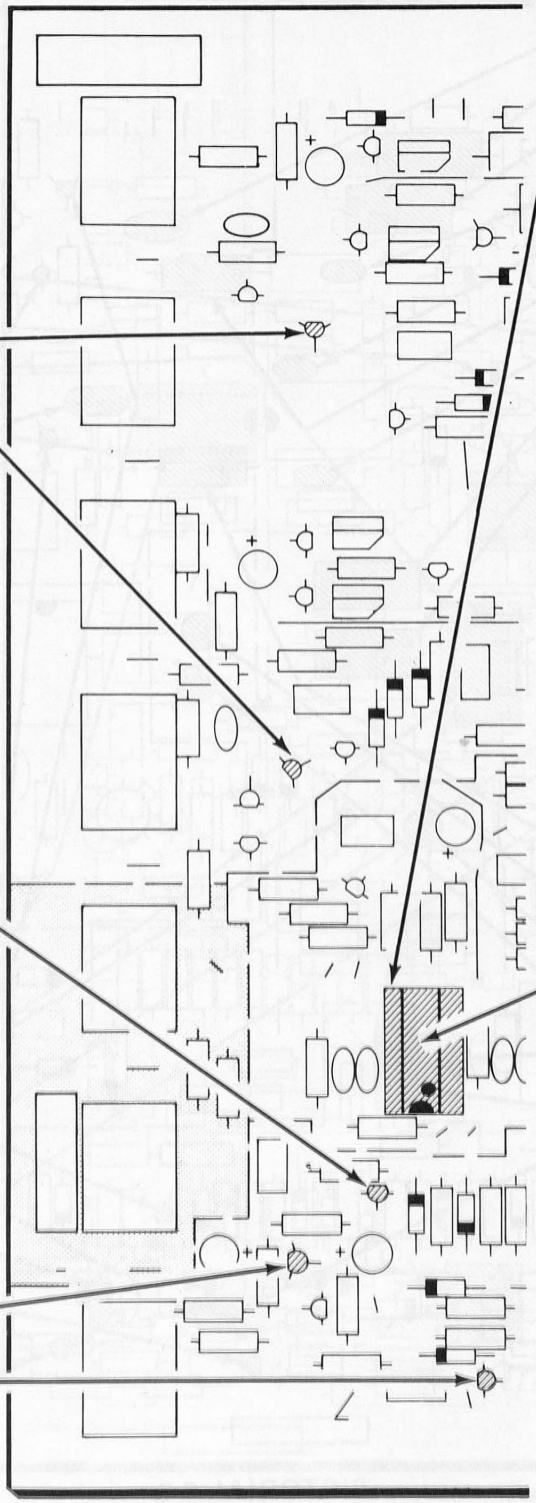

( ) MPSA20 transistor (#417-801) at Q3.

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

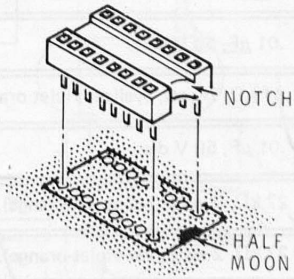



( ) X29A829 transistor (#417-201) at Q8.

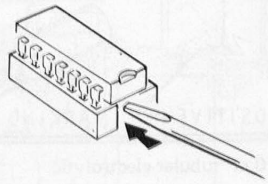
( ) X29A829 transistor (#417-201) at Q4.



( ) Integrated circuit socket at IC201. Be sure the socket leads are straight. Match up the notch at one end of the socket with the half-moon mark on the circuit board. Then insert the socket pins and solder them to the foil.

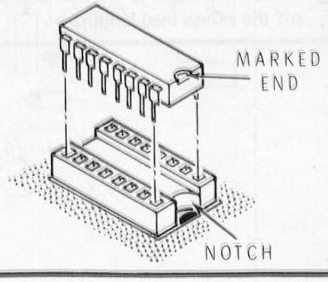



NOTE: In case you should have to remove an IC from its socket, use a screwdriver and insert it beneath the IC; then gently rock the screwdriver up and down to lift the IC.



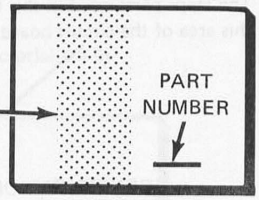
Locate the 2-channel amplifier integrated circuit (#442-41). Note that one end will be marked with a notch or dot.

( ) Position the marked end of this integrated circuit toward the notched end of the socket. Then carefully install the integrated circuit. Make sure all the pins are in their respective holes.




**PICTORIAL 2-2**

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




IDENTIFICATION DRAWING

( ) .01 μF, 1.6kV, disc.

( ) 15 kΩ, 2-watt (brown-green-orange).

( ) 15 kΩ, 2-watt (brown-green-orange).

( ) 420 pF disc.

( ) .01 μF, 50 V disc.

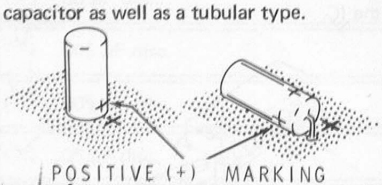
( ) 47 kΩ, 1-watt, (yellow-violet-orange).

( ) .01 μF, 50 V disc.

( ) 27 kΩ, 2-watt (red-violet-orange).

( ) 27 kΩ, 2-watt (red-violet-orange).

NOTE: When you install electrolytic capacitors, always match the positive (+) marked end of the capacitor with the positive (+) mark on the circuit board. The illustration shows a vertically-mounted capacitor as well as a tubular type.




( ) 10 μF tubular electrolytic.

( ) 10 μF vertical electrolytic.

( ) 10 μF vertical electrolytic.

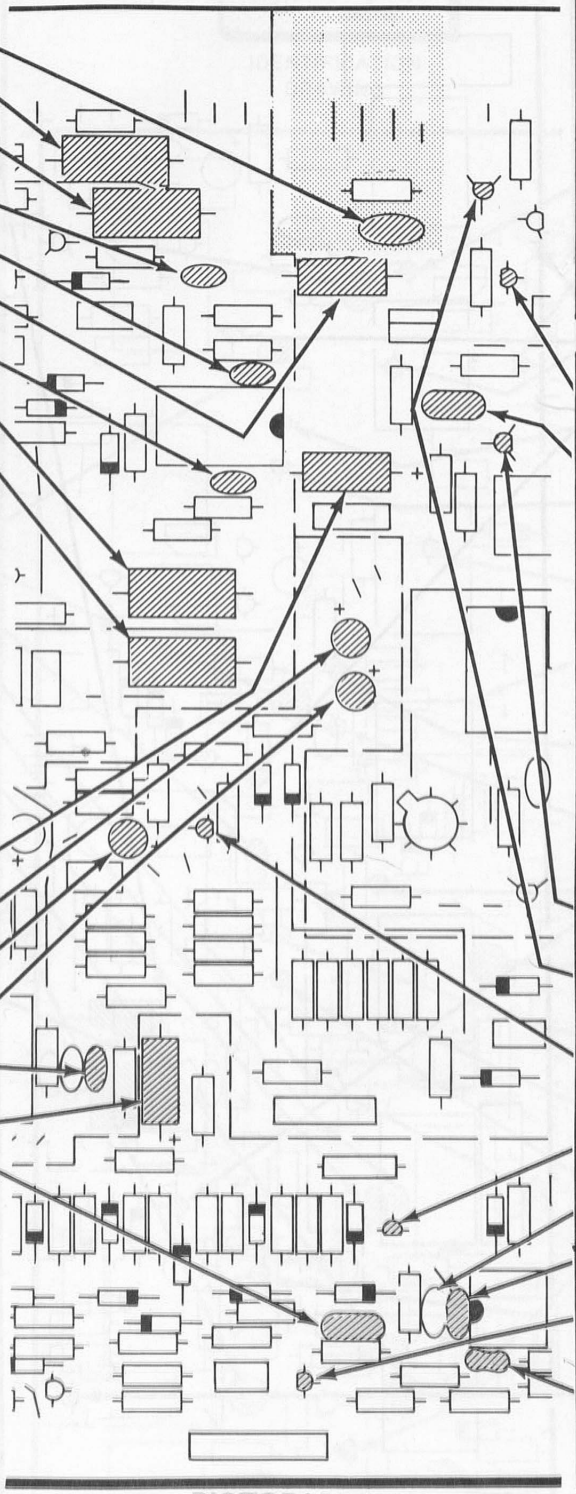
( ) 10 μF vertical electrolytic.

( ) .05 μF disc.

( ) 10 μF tubular electrolytic.

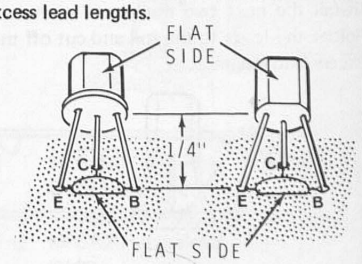
( ) .1 μF Mylar.

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



PICTORIAL 2-3

NOTE: The following transistor may be one of the two types shown below. Determine which type you received and insert the transistor leads into the corresponding E, C, and B holes in the circuit board as shown. Position the transistor body 1/4" above the circuit board, solder each lead to the foil, and cut off the excess lead lengths.

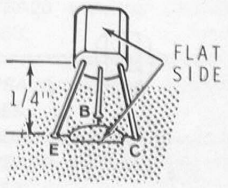



Detail 2-3A

( ) 2N5308 transistor (#417-222) at Q409.

( ) .1 μF Mylar.

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




( ) MPSA20 transistor (#417-801) at Q408.

( ) MPSA20 transistor (#417-801) at Q405.

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

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

( ) Do not install a capacitor here.

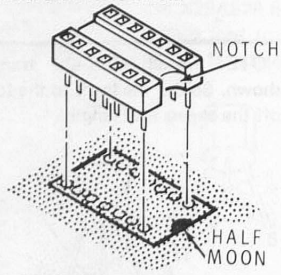
( ) 680 pF disc.

( ) X29A829 transistor (#417-201) at Q6. (See Detail 2-3A, above.)

( ) 150 pF mica.

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

You will install IC sockets in the following steps. Be sure the socket leads are straight. Match up the notch at one end of the socket with the half-moon mark on the circuit board. Then insert the socket pins and solder them to the foil.



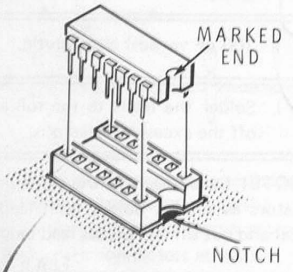

( ) 14-pin IC socket at IC402.

( ) 14-pin IC socket at IC404.

( ) 14-pin IC socket at IC403.

( ) 14-pin IC socket at IC101.

( ) Position the marked end of each integrated circuit in the following steps toward the notched end of the socket. Then carefully install the integrated circuit. Make sure all the pins are in their respective holes.




( ) 739 integrated circuit (#442-41) at IC101.

( ) 7472 integrated circuit (#443-4) at IC403.

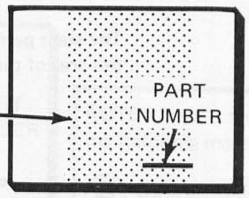
( ) 74122 integrated circuit (#443-23) at IC404.

( ) 7402 integrated circuit (#443-46) at IC402.

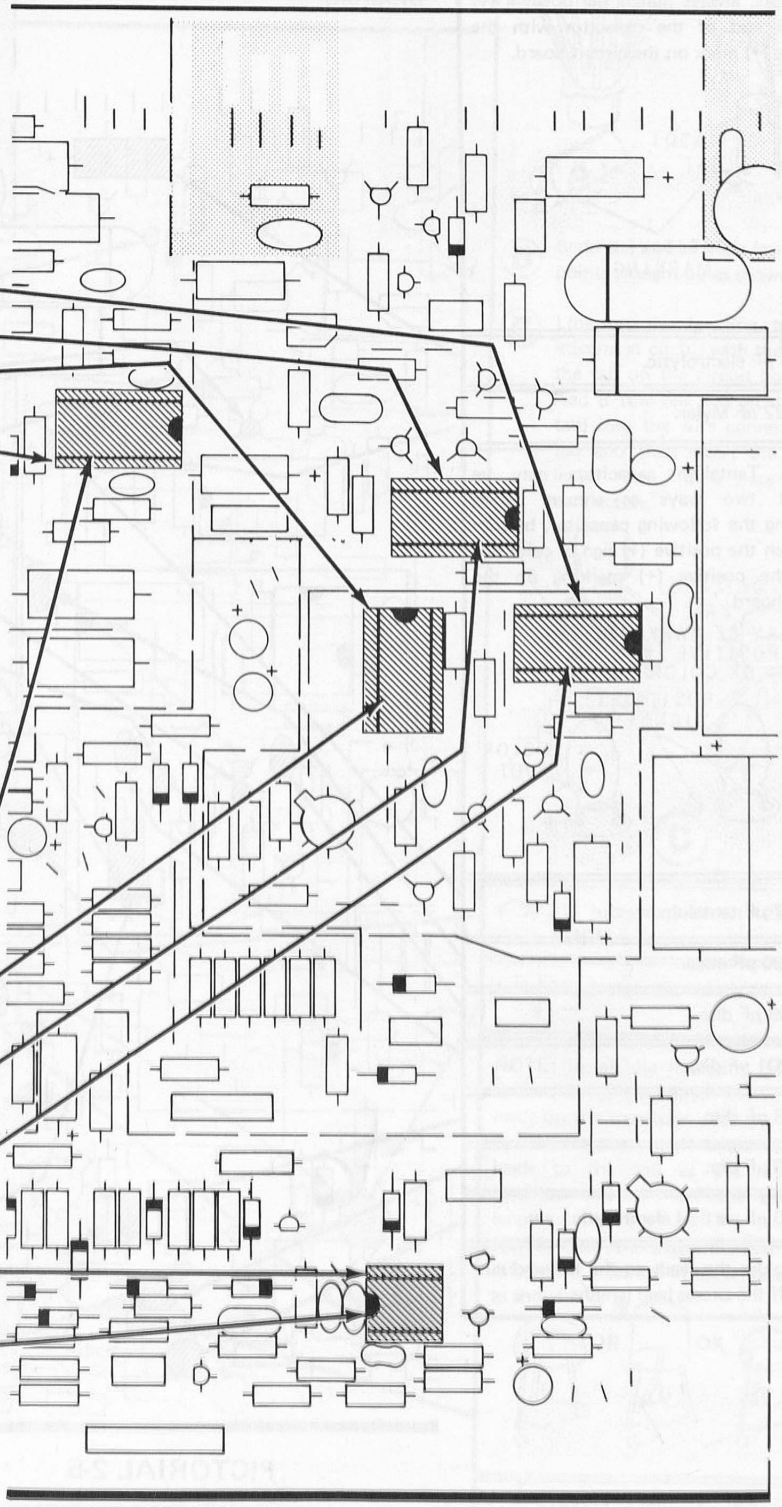
( ) 8-pin IC socket at IC1. Solder the pins to the foil.

( ) 301 integrated circuit (#442-39) at IC1.

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

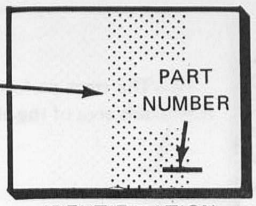



IDENTIFICATION DRAWING



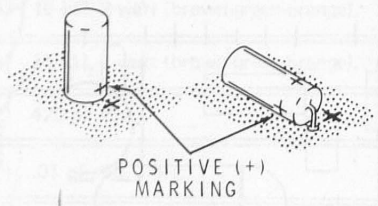
PICTORIAL 2-4

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




IDENTIFICATION DRAWING

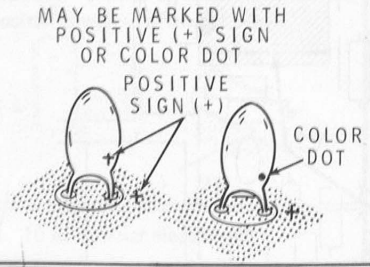
NOTE: When you install electrolytic capacitors, always match the positive (+) marked end of the capacitor with the positive (+) mark on the circuit board.




( ) 4 μF electrolytic.

( ) .22 μF Mylar.

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.




( ) 47 μF tantalum.

( ) 390 pF mica.

( ) .05 μF disc.

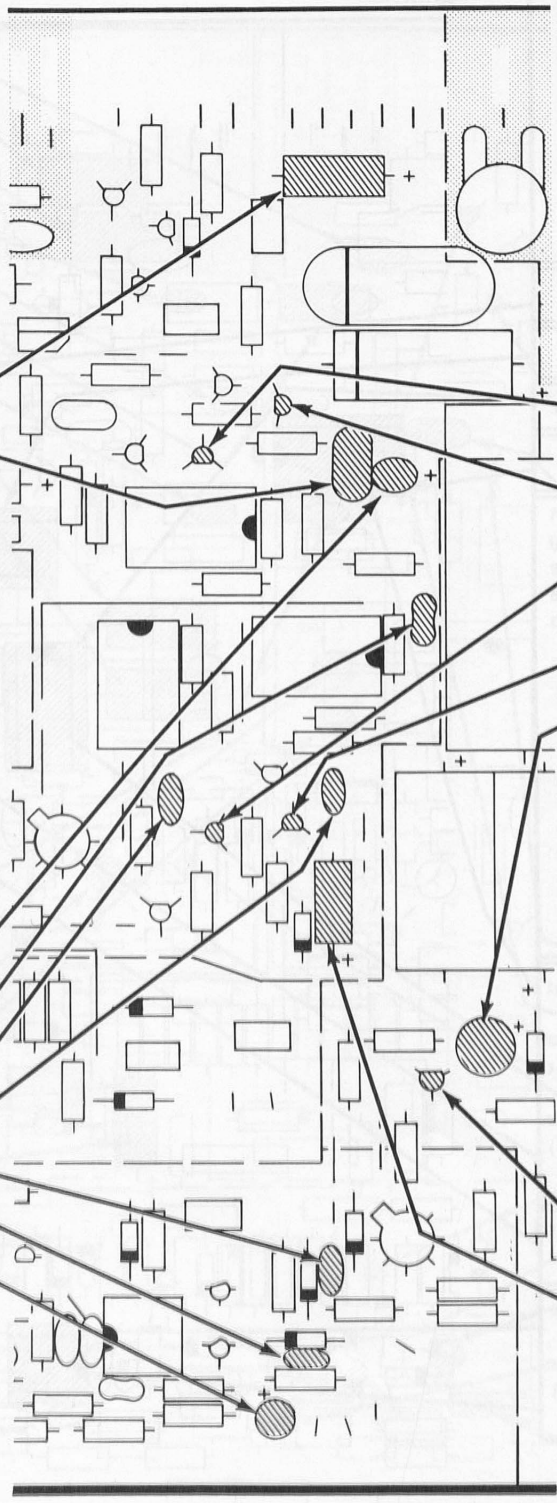
( ) .001 μF disc.

( ) 18 pF disc.

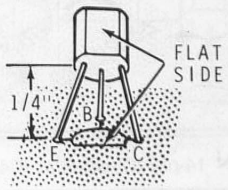
( ) 18 pF disc.

( ) 10 μF vertical electrolytic.

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



NOTE: Install MPSA20 transistors as shown. Solder the leads to the foil and cut off the excess lead lengths.




( ) MPSA20 transistor (#417-801) at Q413.

( ) MPSA20 transistor (#417-801) at Q412.

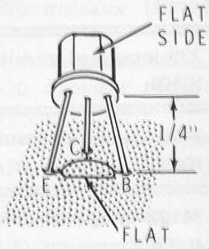
( ) MPSA20 transistor (#417-801) at Q402.

( ) MPSA20 transistor (#417-801) at Q403.

( ) 100 μF vertical electrolytic.

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

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

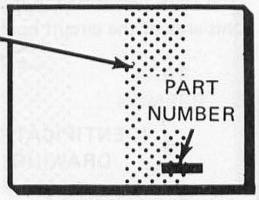



( ) 2N5249A transistor (#417-213) at Q503.

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

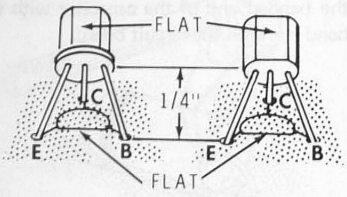
**PICTORIAL 2-5**

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




IDENTIFICATION DRAWING

NOTE: Install each of the X29A829 transistors as shown. Solder each lead to the foil and cut off the excess lead lengths.



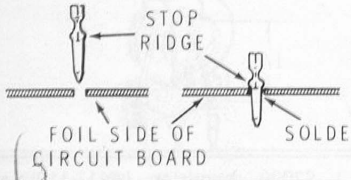

( ) X29A829 transistor (#417-201) at Q406.

( ) X29A829 transistor (#417-201) at Q411.

( ) X29A829 transistor (#417-201) at Q404.

( ) X29A829 transistor (#417-201) at Q401.

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

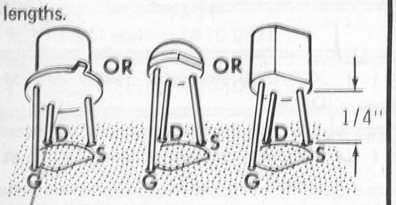



( ) Eight wire connectors at IC401.

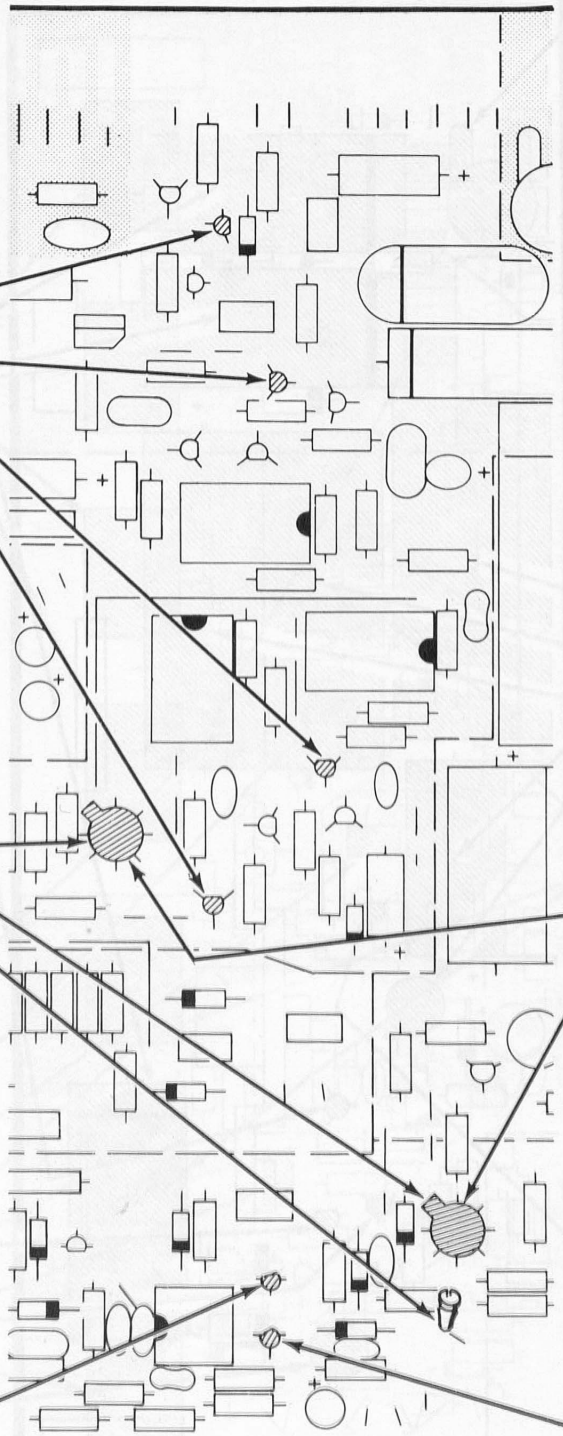
( ) Eight wire connectors at IC2.

( ) One wire connector at TP1.

NOTE: Install the following transistor as shown. Be sure to match the G, D, and S leads on the transistor with the G, D, and S holes in the circuit board. Solder the leads to the foil as the transistor is installed and cut off the excess lead lengths.

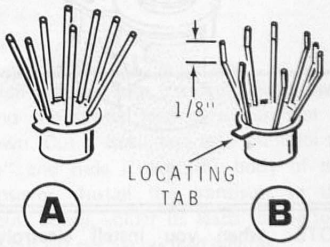



( ) 2N4304 transistor (#417-140) at Q1.



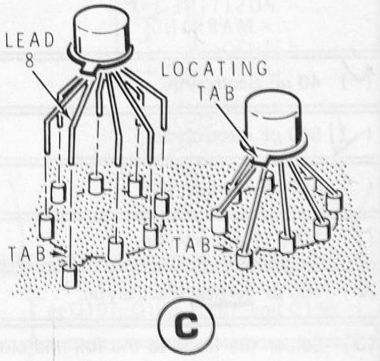
NOTE: Install the integrated circuits in the following manner, as shown.

**A** Bend all leads out.




**B** Bend the end of each lead so that it points straight up as shown.

**C** Line up the locating tab of the integrated circuit with the outline of the tab on the circuit board. Insert lead 8 (the one nearest the locating tab) into the wire connector at the tab and then insert the remaining leads into their correct wire connectors.

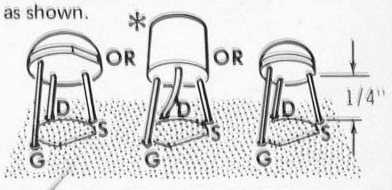



( ) 311 integrated circuit (#442-36) at IC401.

( ) 311 integrated circuit (#442-36) at IC2.

NOTE: Install the following transistor as shown. Be sure to match the G, D, and S leads on the transistor with the G, D, and S holes in the circuit board. Solder the leads to the foil as the transistor is installed and cut off the excess lead lengths.

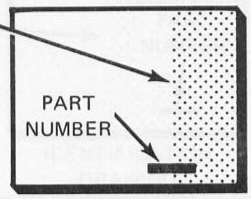
NOTE: The transistor marked with the asterisk is installed in an unusual manner as shown.




( ) 2N5033 transistor (#417-265) at Q2.

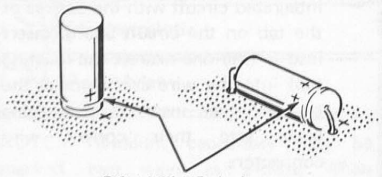
PICTORIAL 2-6

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




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

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




( ) 40 μF electrolytic.

( ) 500 μF electrolytic.

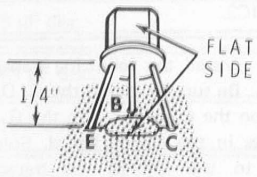
( ) 500 μF electrolytic.

( ) 1000 μF electrolytic.

( ) 100 μF vertical electrolytic.

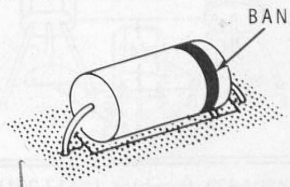
( ) Solder the leads to the foil and cut off the excess lead lengths.

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




( ) MPSA20 transistor (#417-801) at Q507.

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.

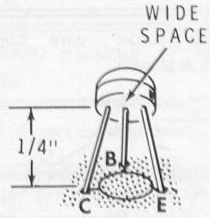



( ) .1 μF, 1.6kV capacitor.

( ) .1 μF, 1.6kV capacitor.

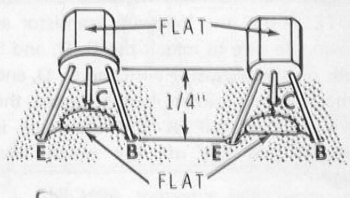
( ) .1 μF, 1.6kV capacitor.

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




( ) S2090 transistor (#417-110) at Q502.

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



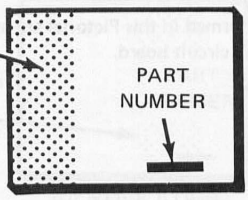

( ) X29A829 transistor (#417-201) at Q505.

( ) X29A829 transistor (#417-201) at Q506.

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

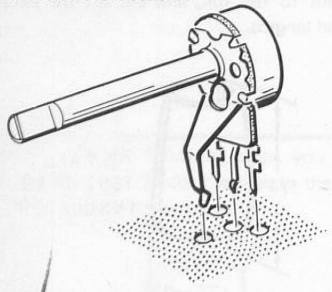
**PICTORIAL 2-7**

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




IDENTIFICATION DRAWING

NOTE: In the following steps, you will install controls onto the main circuit board. Be sure all of the control lugs are pressed into the circuit board holes as far as possible. Solder all the lugs to the foil as each control is installed.



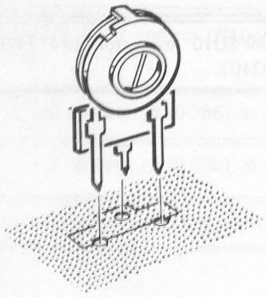
( ) 5000 Ω (5 k) control (#10-969).

( ) 100 kΩ control (#10-970).

( ) 5000 Ω (5 k) control (#10-969).

( ) 100 kΩ control (#10-970).

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



( ) 1000 Ω (1 k) control (#10-936) at R103.

( ) 1000 Ω (1 k) control (#10-936) at R154.

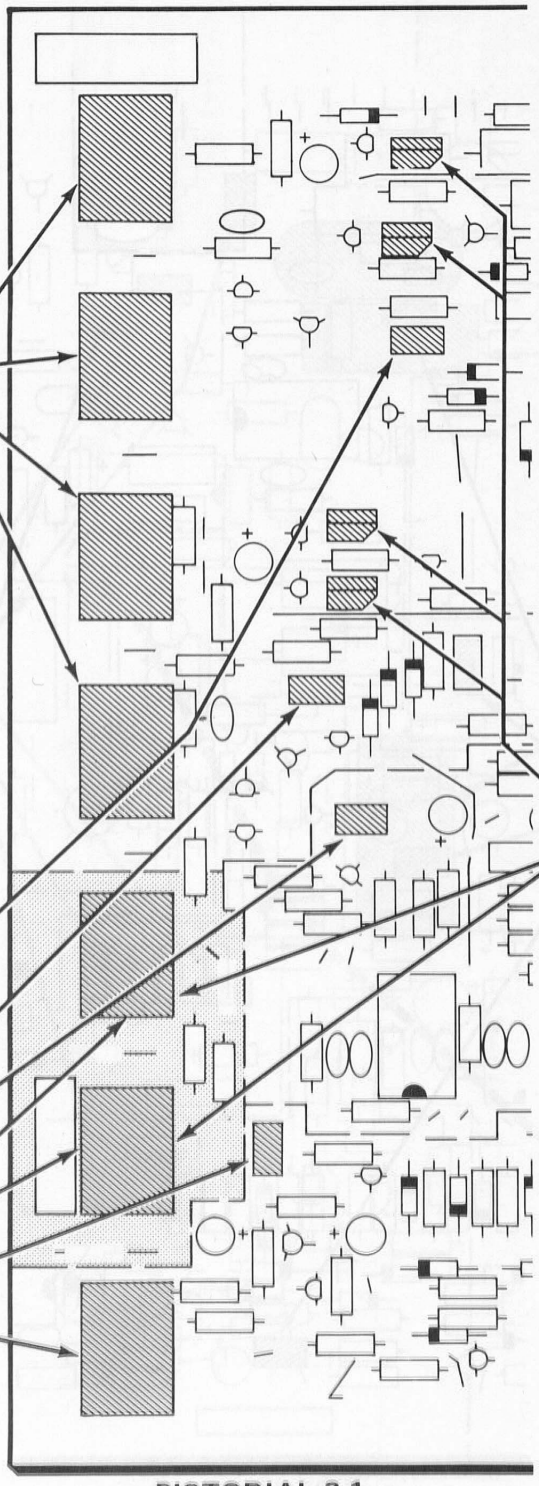
( ) 10 kΩ control (#10-386) at R205.

( ) 1 MΩ control (#10-972).

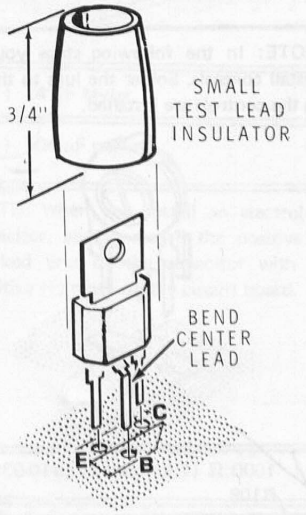
( ) 500 kΩ control (#10-971).

( ) 5000 Ω (5 k) control (#10-904) at R17.

( ) Control with switch (#19-189).



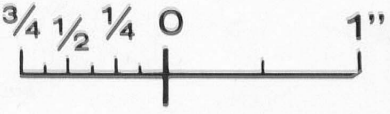
Install the next four transistors as follows: Bend the center lead of a transistor as shown. Cut a small test lead insulator to 3/4" and slide it over the body of the transistor. Install the transistor in the circuit board, solder its leads to the foil, and cut off the excess lead lengths.



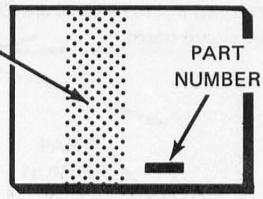

( ) Four MPSU10 transistors (#417-834) at Q107, Q106, Q157, and Q156.

( ) Recheck these controls to be sure all four lugs are soldered.

PICTORIAL 3-1



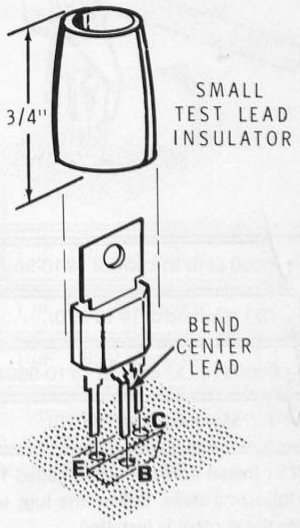
The steps performed in this Pictorial are in this area of the circuit board.




IDENTIFICATION DRAWING

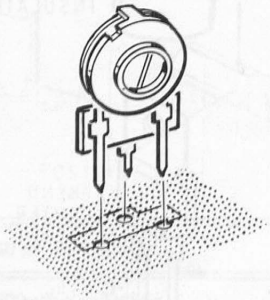
**Install the next transistor as follows:**

NOTE: Bend the center lead of the transistor as shown. Cut a small test lead insulator to 3/4" and slide it over the body of the transistor. Install the transistor in the circuit board, solder its leads to the foil, and cut off the excess lead lengths.




( ) MPSU10 transistor (#417-834) at Q407.

NOTE: In the following steps you will install controls. Solder the lugs to the foil as the controls are installed.

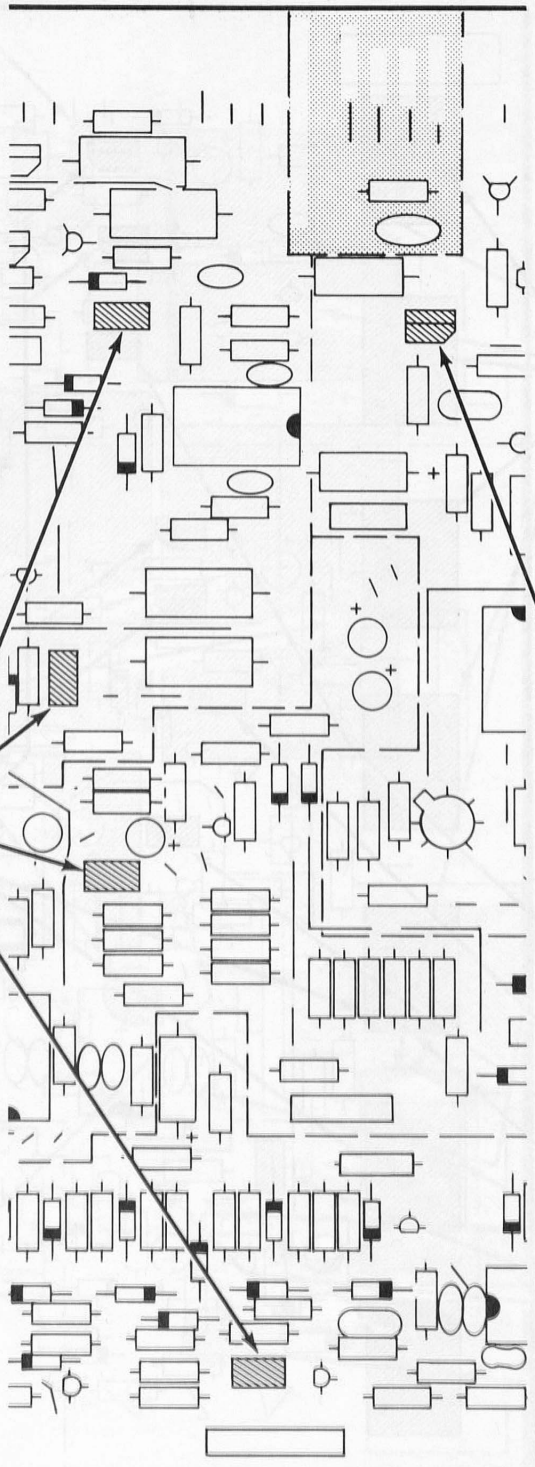


( ) 1000 Ω (1 k) control (#10-936) at R108.

( ) 1000 Ω (1 k) control (#10-936) at R159.

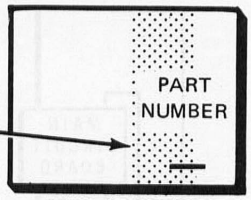
( ) 10 kΩ control (#10-386) at R211.

( ) 5000 Ω (5 k) control (#10-904) at R44.



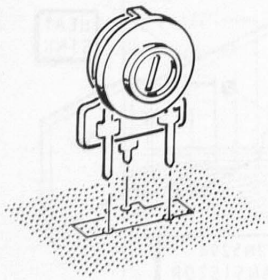
**PICTORIAL 3-2**

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




IDENTIFICATION DRAWING

NOTE: In the following steps you will install controls. Solder the lugs to the foil as the controls are installed.



( ) 1000 Ω (1 k) control (#10-936) at R428.

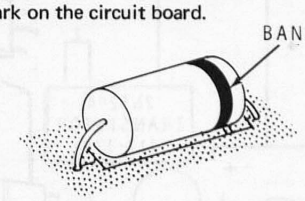
( ) 1000 Ω (1 k) control (#10-936) at R427.

( ) 10 kΩ control (#10-386) at R214.

( ) 10 kΩ control (#10-386) at R213.

( ) 20 kΩ control (#10-248) at R7.

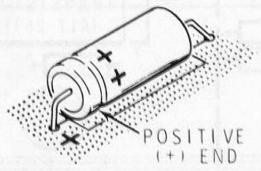
NOTE: When you install each of the following capacitors, always match the banded end of the capacitor with the band mark on the circuit board.




( ) .4 μF Mylar.

( ) .04 μF paper.

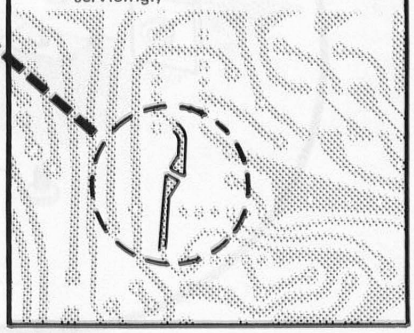
NOTE: When you install an electrolytic capacitor, always match the positive (+) marked end of the capacitor with the positive (+) mark on the circuit board.

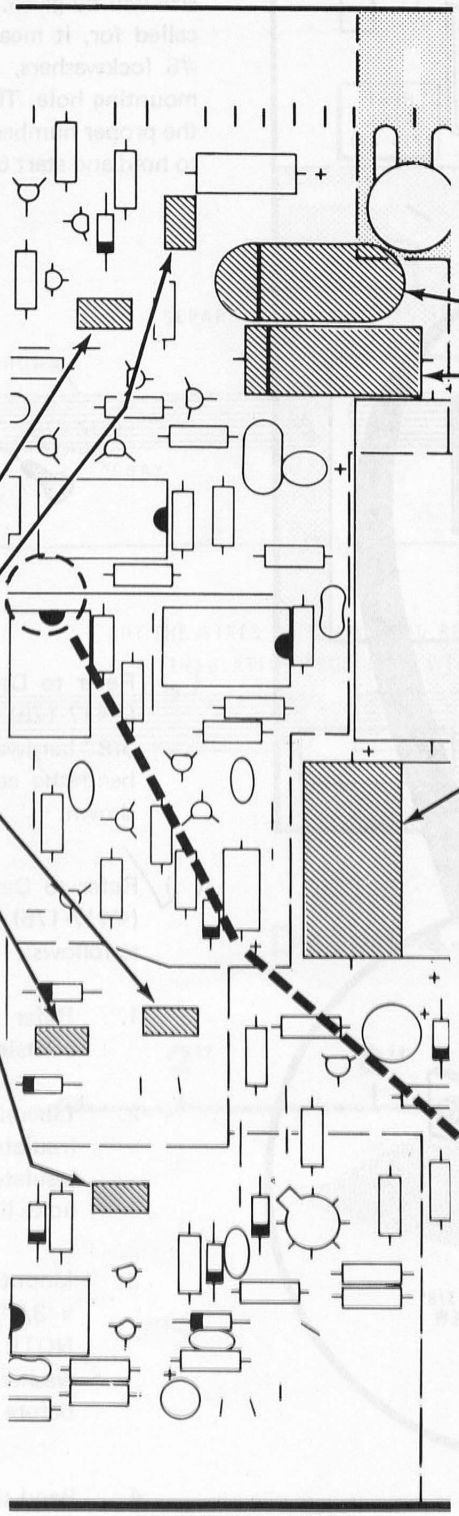



( ) 1000 μF electrolytic.

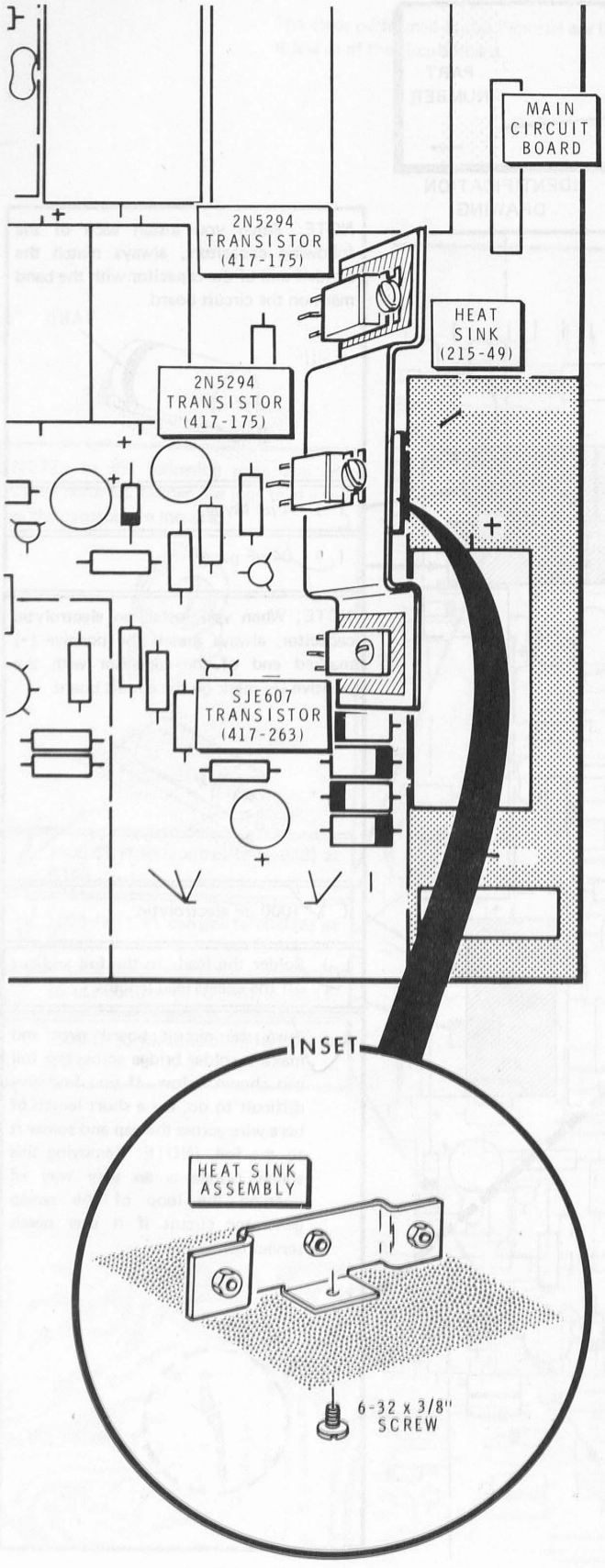
( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) Turn the circuit board over and make a solder bridge across the foil gap shown below. If you find this difficult to do, lay a short length of bare wire across the gap and solder it to the foil. (NOTE: Removing this solder bridge is an easy way of opening the loop of the sweep generator circuit if it ever needs servicing.)





PICTORIAL 3-3

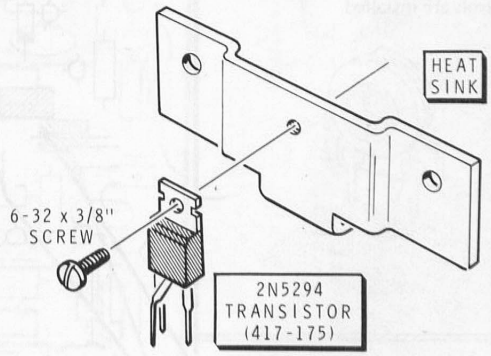



PICTORIAL 3-4

## Heat Sink Assembly

Refer to Pictorial 3-4 for the following steps.

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




Detail 3-4A

( ) Refer to Detail 3-4A and mount a 2N5294 transistor (#417-175) to the center of the heat sink. Use 6-32 x 3/8" hardware. Position the transistor as shown; then bend the center (collector) lead outward slightly as shown.

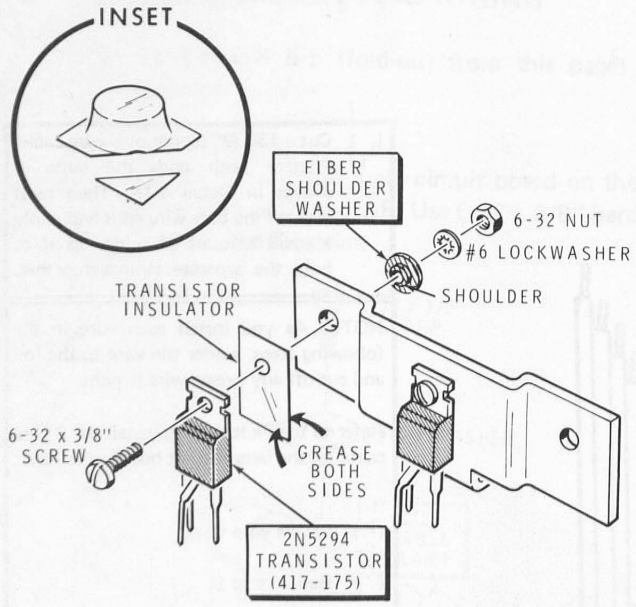
( ) Refer to Detail 3-4B and mount a 2N5294 transistor (#417-175) on the left side of the heat sink assembly as follows:

1. Refer to the inset drawing and open the pod containing the silicone grease.

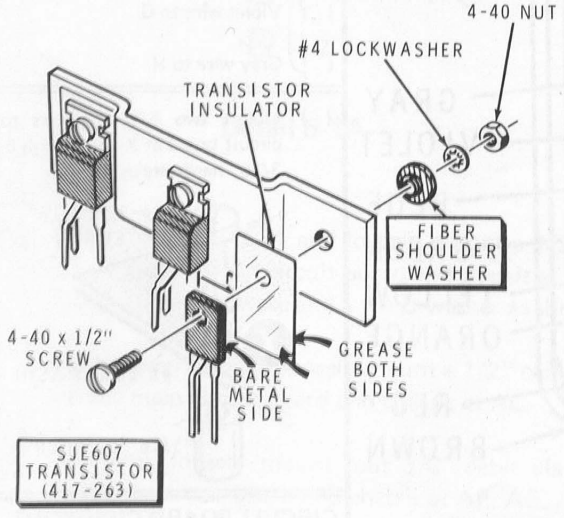
2. Liberally coat both sides of the transistor insulator with silicone grease; then place the insulator on the rear of the transistor so both holes line up as shown.

3. Mount the transistor to the heat sink with 6-32 x 3/8" hardware and a fiber shoulder washer. NOTE: Be sure the shoulder of the shoulder washer fits properly into the heat sink hole before you tighten the screw.

4. Bend the center lead of the transistor as shown.




**Detail 3-4B**




**Detail 3-4C**

( ) Refer to Detail 3-4C and mount an SJE607 transistor (#417-263) to the right side of the heat sink as follows:

1. Liberally coat both sides of a transistor insulator with silicone grease; then place the insulator on the side of the transistor with the bare metal area, so both holes line up as shown.

2. Mount the transistor to the heat sink with 4-40 x 1/2" hardware. Use a #6 fiber shoulder washer. NOTE: Be sure the shoulder of the shoulder washer fits properly into the heat-sink hole before you tighten the screw.

3. Bend the center lead of the transistor as shown.

( ) Refer to Pictorial 3-4 and mount the heat-sink assembly onto the main circuit board as shown in the inset drawing with a 6-32 x 3/8" screw. Solder the 9 transistor leads to the foil side of the main circuit board and cut off the excess lead lengths.

## Circuit Board Checkout

Carefully inspect the main circuit board for the following conditions.

( ) Unsoldered connections.

( ) "Cold" solder connections.

( ) Solder bridges between foil patterns.

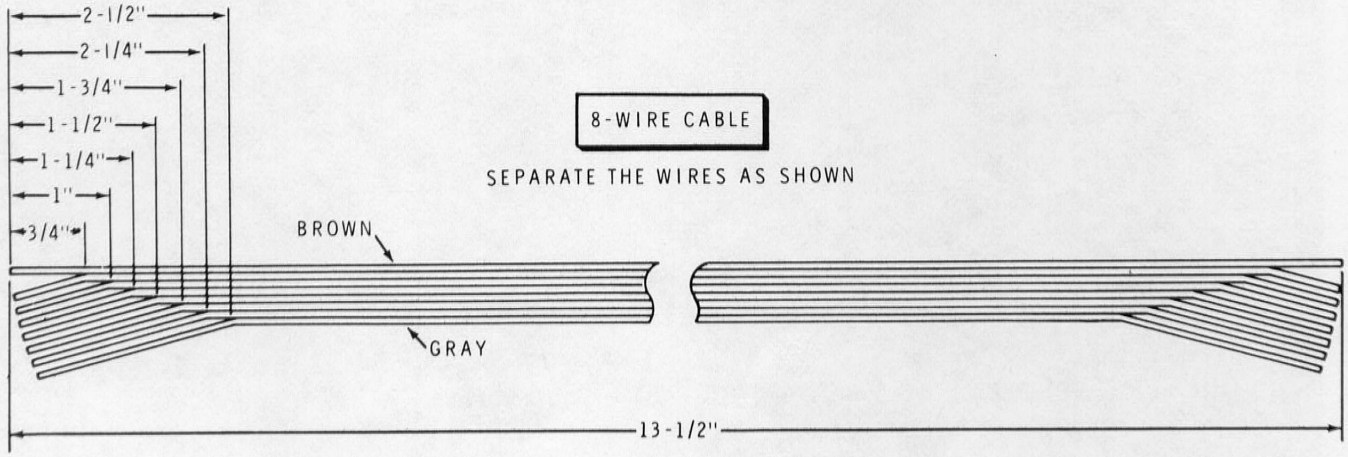
( ) Protruding leads which could touch together.

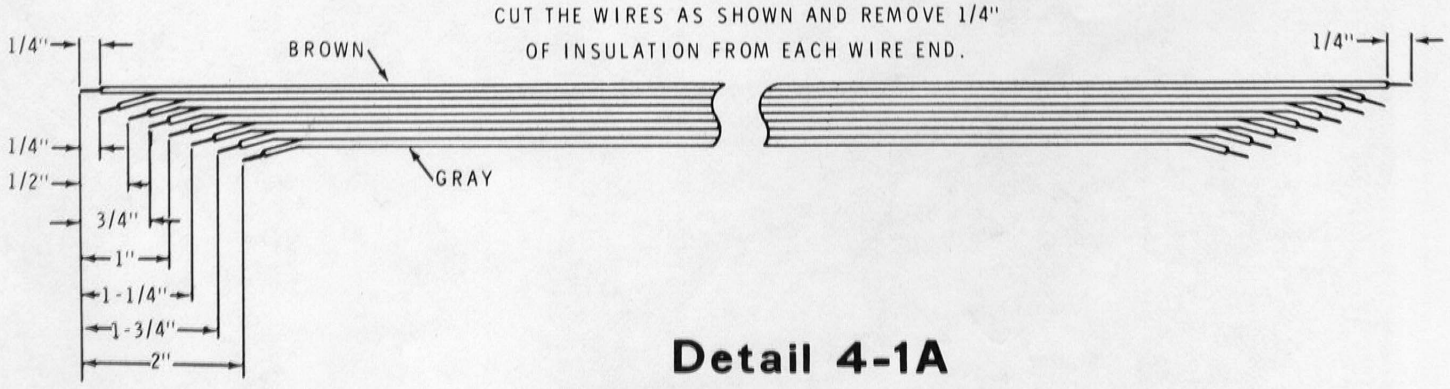
( ) Transistors for the proper type and installation.

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

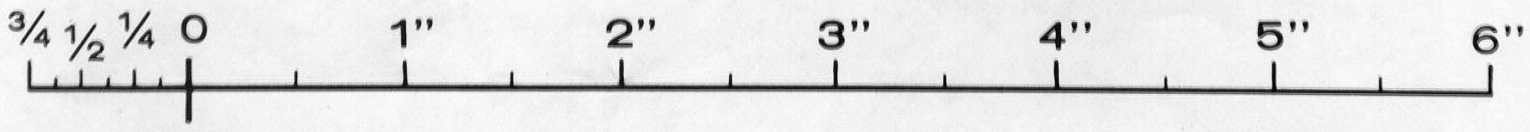
( ) Diodes for the correct position of the banded end.

Set the main circuit board aside temporarily.


2-1/2"
2-1/4"
1-3/4"
1-1/2"
1-1/4"
1"
3/4"
8-WIRE CABLE
SEPARATE THE WIRES AS SHOWN
BROWN
GRAY
13-1/2"


CUT THE WIRES AS SHOWN AND REMOVE 1/4"
OF INSULATION FROM EACH WIRE END.
1/4"
BROWN
1/4"
GRAY
1/4"
1/2"
3/4"
1"
1-1/4"
1-3/4"
2"

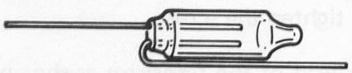
**Detail 4-1A**


3/4 1/2 1/4 0
1"
2"
3"
4"
5"
6"

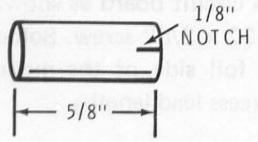
## LAMP CIRCUIT BOARD

Position the lamp circuit board as shown. Then proceed with the following steps.

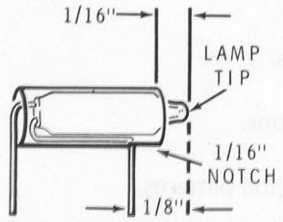
Prepare eight neon lamps as shown.



(A) Bend one lead of each neon lamp close to the glass envelope.

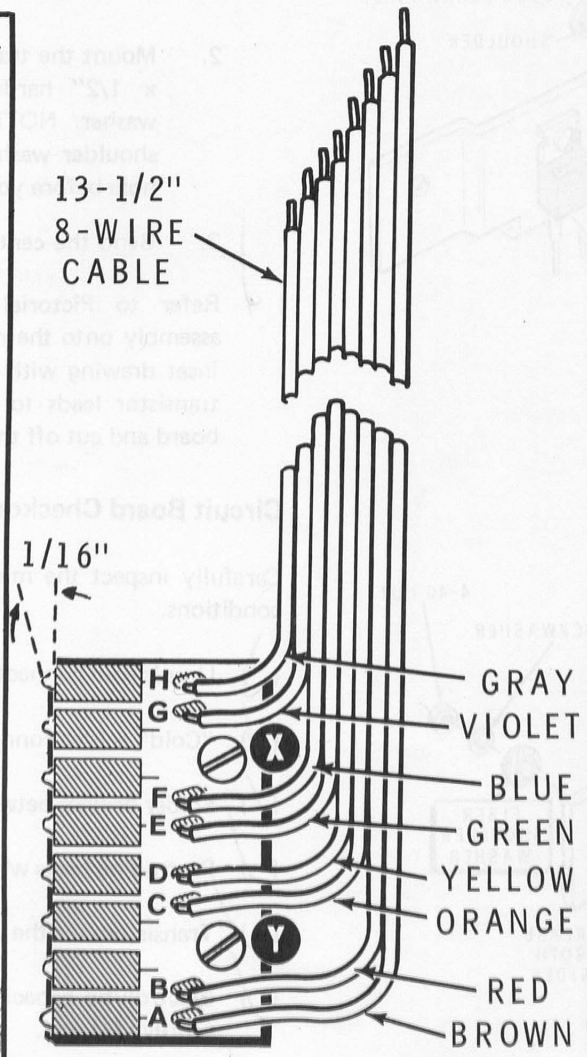



(B) Cut eight 5/8" lengths of heat shrinkable sleeving (#346-46). Then cut a 1/8" notch in one end of each piece as shown.




(C) Push each lamp into a length of sleeving so that the notch is at the tip of the lamp. Bend the leads as shown.

(D) Install the eight lamps on the lamp circuit board at I1 through I8 as shown in the Pictorial. Solder the leads to the foil and cut off the excess lead lengths. Be sure the tips of the lamps extend 1/16" beyond the edge of the circuit board and the lengths of sleeving are even with the edge of the circuit board.




PICTORIAL 4-1

( ) Cut a 13-1/2" length of 8-wire cable. Prepare both ends the same as shown in Detail 4-1A. Then twist each of the bare wire ends and apply a small amount of solder to it to hold the separate strands together.

NOTE: As you install each wire in the following steps, solder the wire to the foil and cut off any excess wire lengths.

Refer to the Pictorial and install the 8-wire cable on the lamp circuit board as follows:

( ) Brown wire to A.

( ) Red wire to B.

( ) Orange wire to C.

( ) Yellow wire to D.

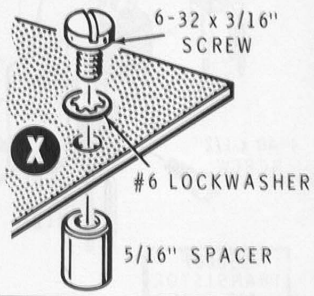
( ) Green wire to E.

( ) Blue wire to F.

( ) Violet wire to G.

( ) Gray wire to H.

( ) Mount two 5/16" spacers to the circuit board at X and Y with 6-32 x 3/16" hardware as shown.




### CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) "Cold" solder connections.

( ) Solder bridges between foil patterns.

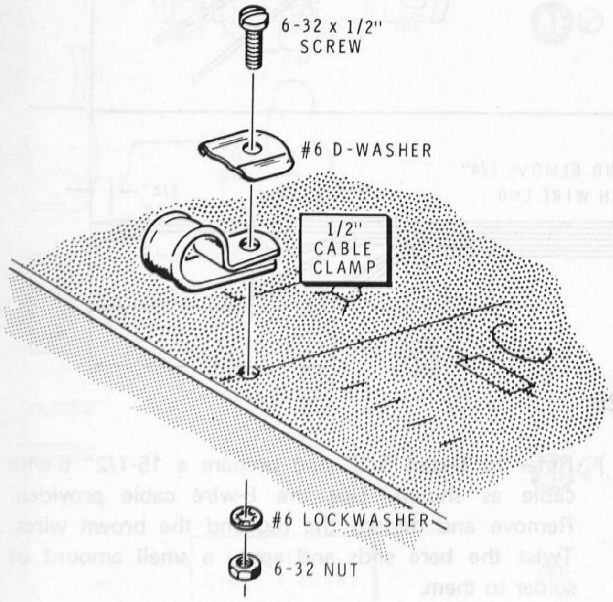
( ) Protruding leads which could touch together.

Set the lamp circuit board aside temporarily.

## CHASSIS ASSEMBLY AND WIRING

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

( ) Loosely mount the main circuit board on the chassis at AA, AB, AD, and AE. Use 6-32 x 3/8" hardware as shown in the Pictorial.



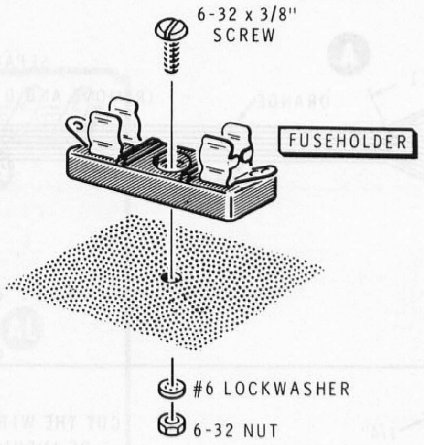

**Detail 5-1A**

( ) Refer to Detail 5-1A and loosely mount a 1/2" cable clamp on the main circuit board and chassis at AJ. Use 6-32 x 1/2" hardware and a #6 D-washer as shown.

( ) In the same manner, loosely mount a 1/2" cable clamp on the main circuit board and chassis at AC.

( ) Similarly, loosely mount four 3/8" cable clamps on the main circuit board and chassis at AF, AG, AH, and AK.

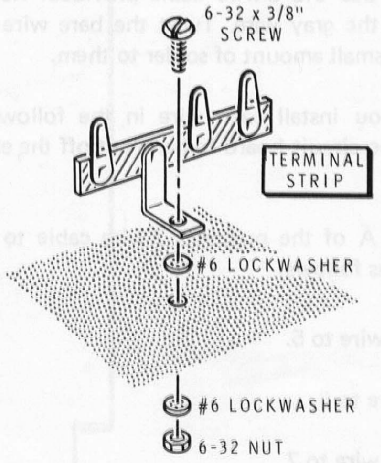
( ) Tighten the ten circuit board mounting screws.



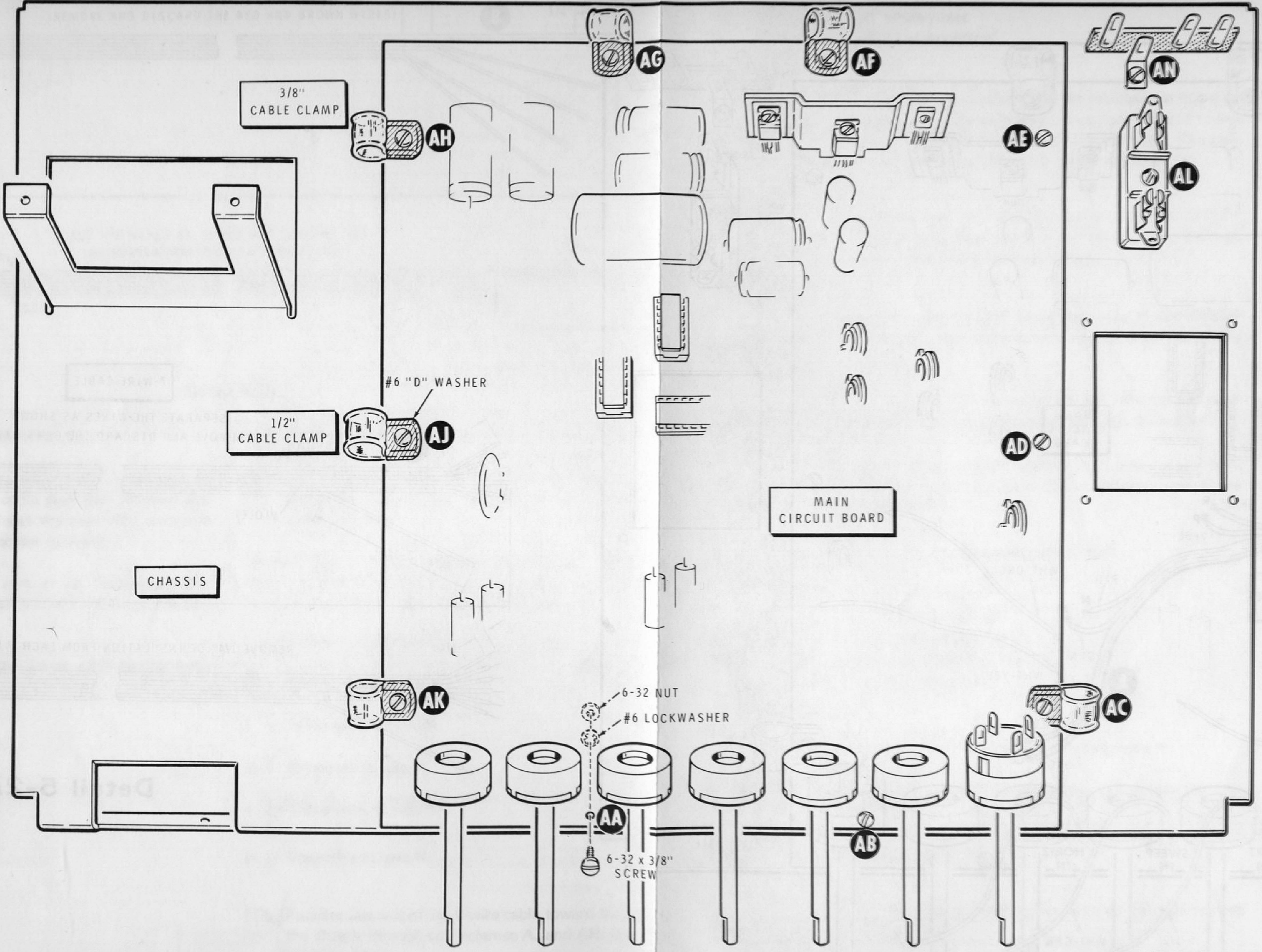

**Detail 5-1B**

( ) Refer to Detail 5-1B and mount the fuseholder at AL as shown. Position it as shown in the Pictorial.

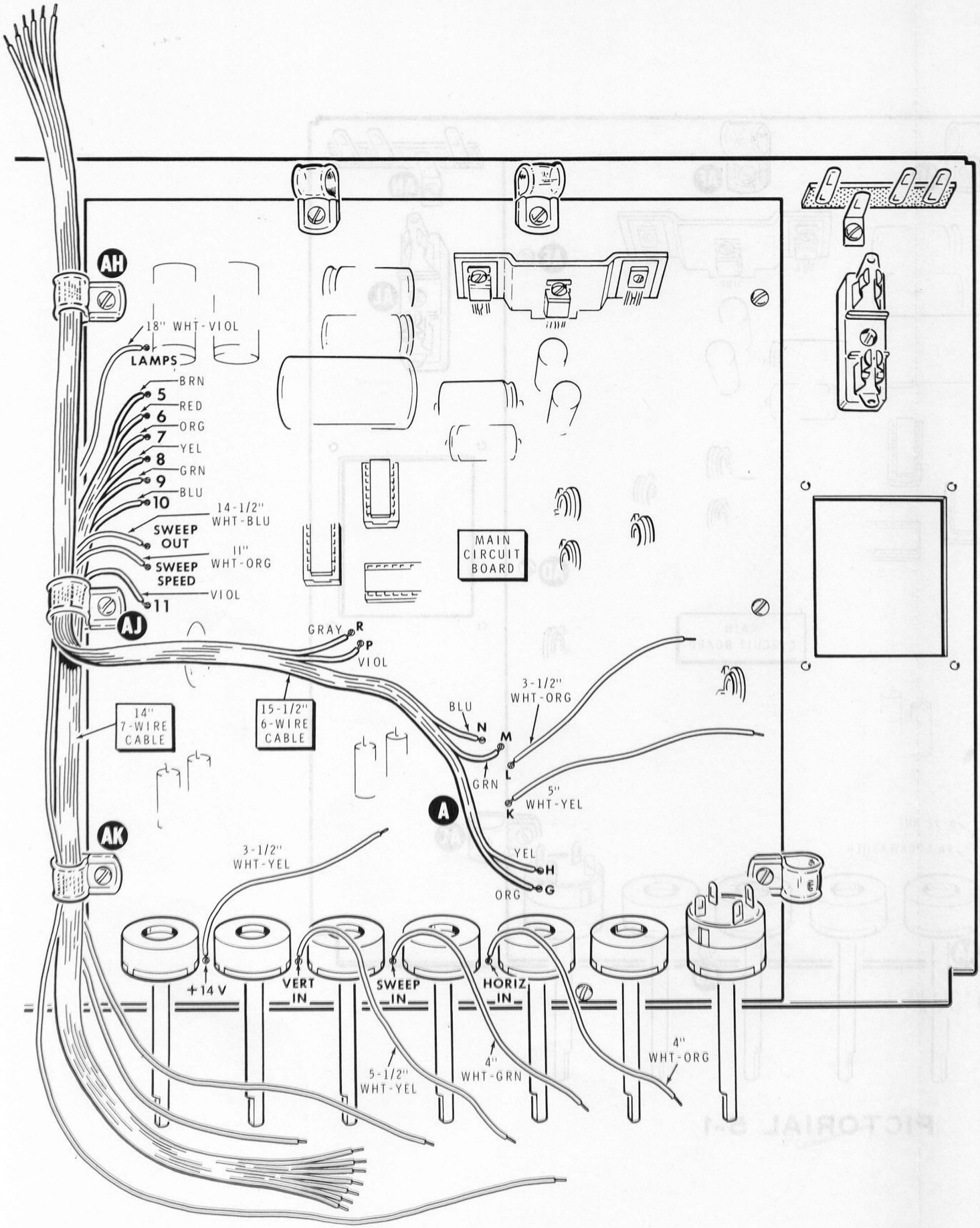
( ) Refer to Detail 5-1C and mount the terminal strip at AN as shown. Position it as shown in the Pictorial.



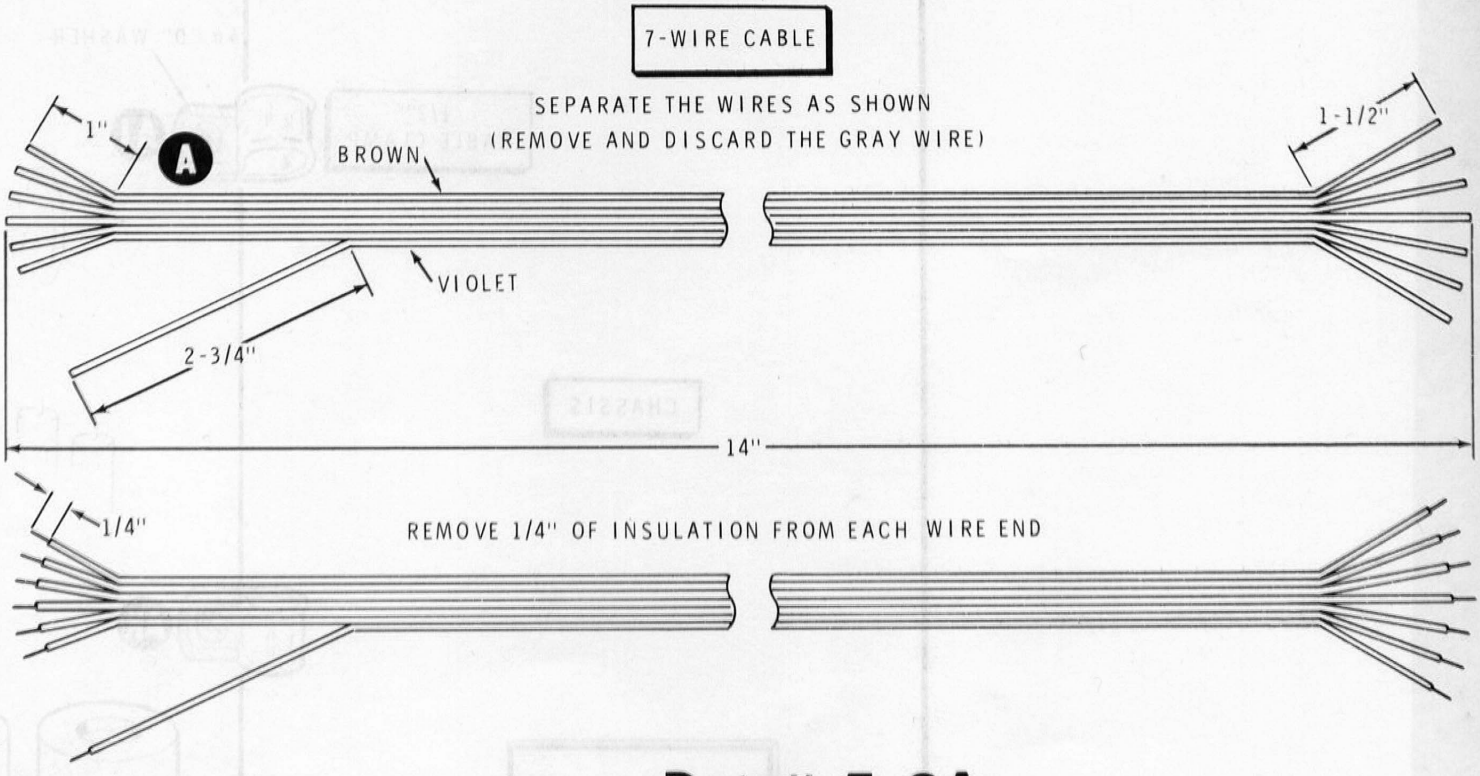

**Detail 5-1C**



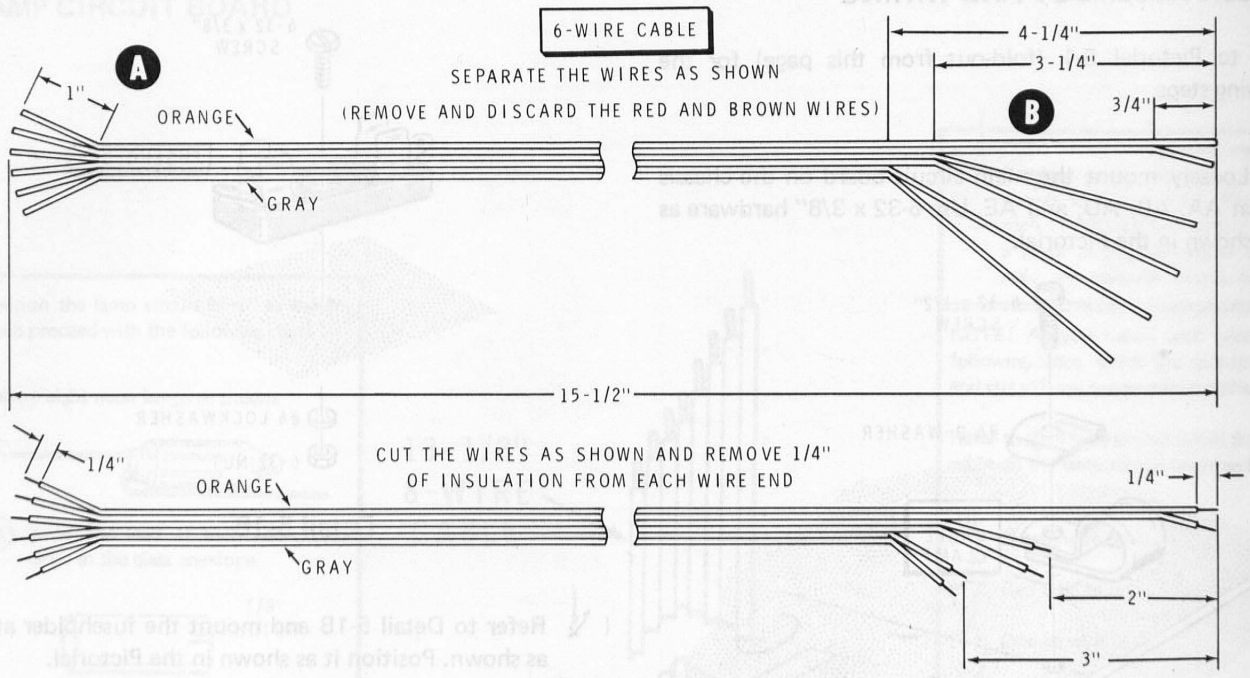

**PICTORIAL 5-1**




PICTORIAL 5-2


7-WIRE CABLE
SEPARATE THE WIRES AS SHOWN
(REMOVE AND DISCARD THE GRAY WIRE)
1"
A
BROWN
1-1/2"
VIOLET
2-3/4"
14"
1/4"
REMOVE 1/4" OF INSULATION FROM EACH WIRE END

**Detail 5-2A**




**Detail 5-2B**

Refer to Pictorial 5-2 for the following steps.

( ) Refer to Detail 5-2A and prepare a 14" 7-wire cable as shown. Use the 8-wire cable provided. Remove and discard the gray wire. Twist the bare wire ends and apply a small amount of solder to them.

NOTE: As you install each wire in the following steps, solder it to the circuit board foil and cut off the excess wire length.

Connect end A of the prepared 7-wire cable to the main circuit board as follows:

( ) Brown wire to 5.

( ) Red wire to 6.

( ) Orange wire to 7.

( ) Yellow wire to 8.

( ) Green wire to 9.

( ) Blue wire to 10.

( ) Violet wire to 11.

( ) Push the free end of the 7-wire cable through cable clamps AJ and AK. It will be connected later.

( ) Refer to Detail 5-2B and prepare a 15-1/2" 6-wire cable as shown. Use the 8-wire cable provided. Remove and discard the red and the brown wires. Twist the bare ends and apply a small amount of solder to them.

Connect end B of the prepared 6-wire cable to the main circuit board as follows. Solder each wire to the circuit board foil and cut off the excess wire lengths.

( ) Orange wire to hole G.

( ) Yellow wire to hole H.

( ) Green wire to hole M.

( ) Blue wire to hole N.

( ) Violet wire to hole P.

( ) Gray wire to hole R.

( ) Pass the free end of the 6-wire cable toward the rear of the chassis through cable clamps AJ and AH. It will be connected later.

NOTE: To prepare wires, as in the following step, cut them to the indicated lengths and remove 1/4" of insulation from each end. The wires are listed in the order they will be used.

( ) Prepare the following lengths of wire:

11" white-orange
14-1/2" white-blue
18" white-violet
3-1/2" white-yellow

NOTE: Wires will be connected to the main circuit board in the following steps. As each wire is installed, solder it to the circuit board foil and cut off the excess wire length. The free ends of most of these wires will be connected later.

( ) Connect the 11" white-orange wire to the SWEEP SPEED hole. Pass the free end of this wire through cable clamps AJ and AK as shown.

( ) Connect the 14-1/2" white-blue wire to the SWEEP OUT hole. Pass the free end through cable clamps AJ and AK.

( ) Connect the 18" white-violet wire to the LAMPS hole. Pass the free end through cable clamps AJ and AK.

( ) Connect the 3-1/2" white-yellow wire to the hole labeled +14V, located in the front left corner of the circuit board.

( ) Prepare the following lengths of wire:

5" white-yellow
3-1/2" white-orange
5-1/2" white-yellow
4" white-green
4" white-orange

( ) Connect the 5" white-yellow wire to hole K.

( ) Connect the 3-1/2" white-orange wire to hole L.

( ) Connect the 5-1/2" white-yellow wire to the hole marked VERT IN.

( ) Connect the 4" white-green wire to the hole marked SWEEP IN.

( ) Connect the 4" white-orange wire to the hole marked HORIZ IN.

Refer to Pictorial 5-3 (fold-out from this page) for the following steps.

NOTE: To prepare heavy stranded wires, as in the following steps, cut each wire to the indicated length and remove 1/4" of insulation from each end. Then twist the bare strands together and apply a small amount of solder.

( ) Prepare the following stranded wires:

7" red stranded
8" orange stranded
19-1/2" orange stranded
12-1/2" yellow stranded
12" brown stranded

( ) Connect a 7" red stranded wire to +200V near the left rear of the main circuit board.

( ) Pass the free end of this wire forward through cable clamp AJ and connect it to +200V near the front on the left edge of the board.

( ) Connect an 8" orange stranded wire to one of the holes marked -1200V near the left rear corner of the main circuit board.

( ) Pass this wire forward through cable clamps AH and AJ and connect it to the hole marked -1200V on the left edge of the board.

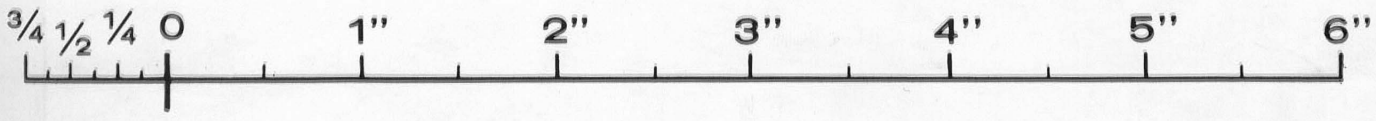
( ) Connect the 19-1/2" orange stranded wire to the other hole marked -1200V near the left rear corner of the circuit board.

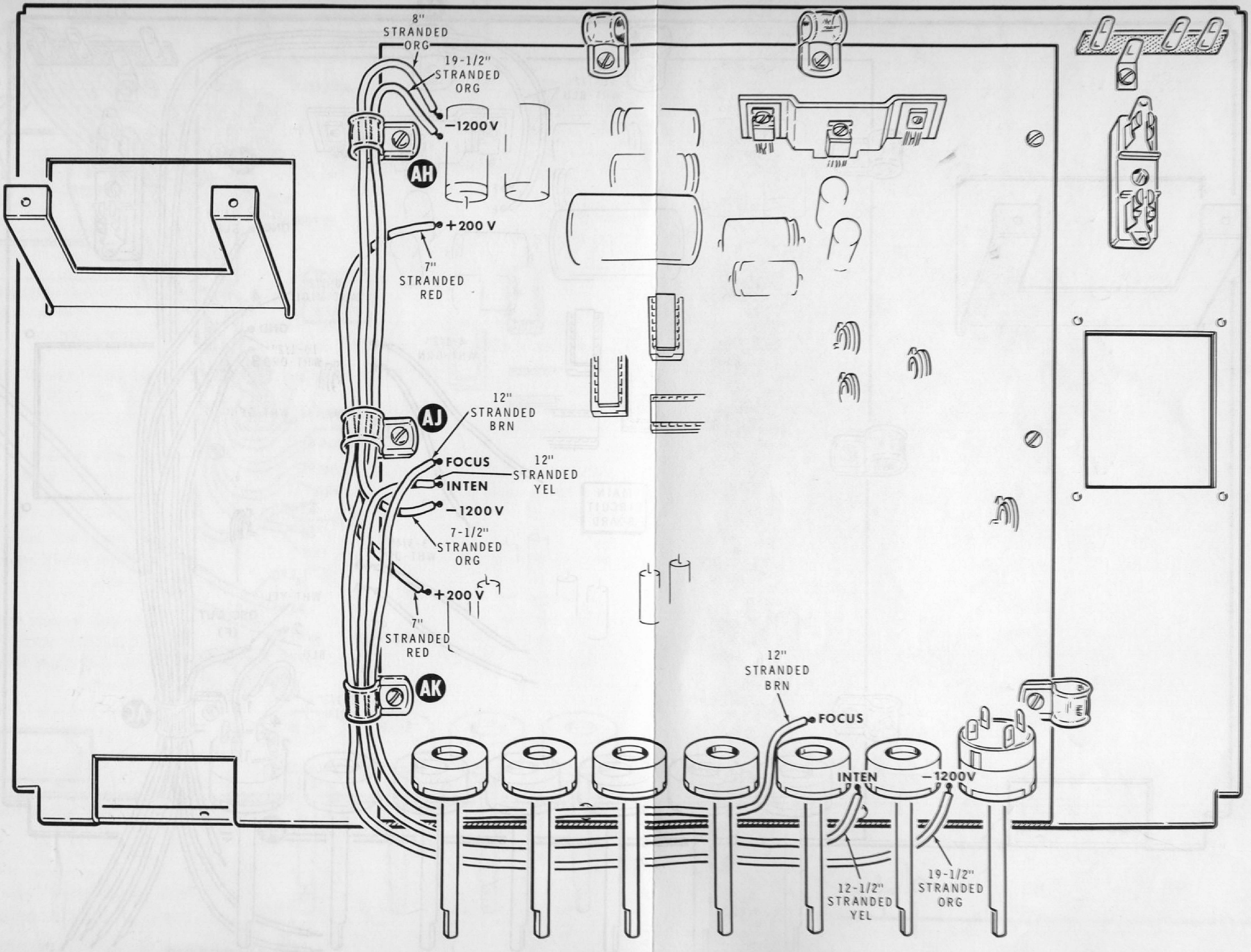
( ) Pass this wire forward through cable clamps AH, AJ, and AK, and then across the front of the circuit board under the controls as shown. Connect it to the hole marked -1200V.

( ) Connect one end of a 12-1/2" yellow stranded wire to the hole marked INTEN near the left edge of the board. (Use the right-hand hole.) Form this wire as shown in the Pictorial. Then pass it through cable clamp AK, across the front of the circuit board, and connect it to the hole marked INTEN near the front edge of the board.

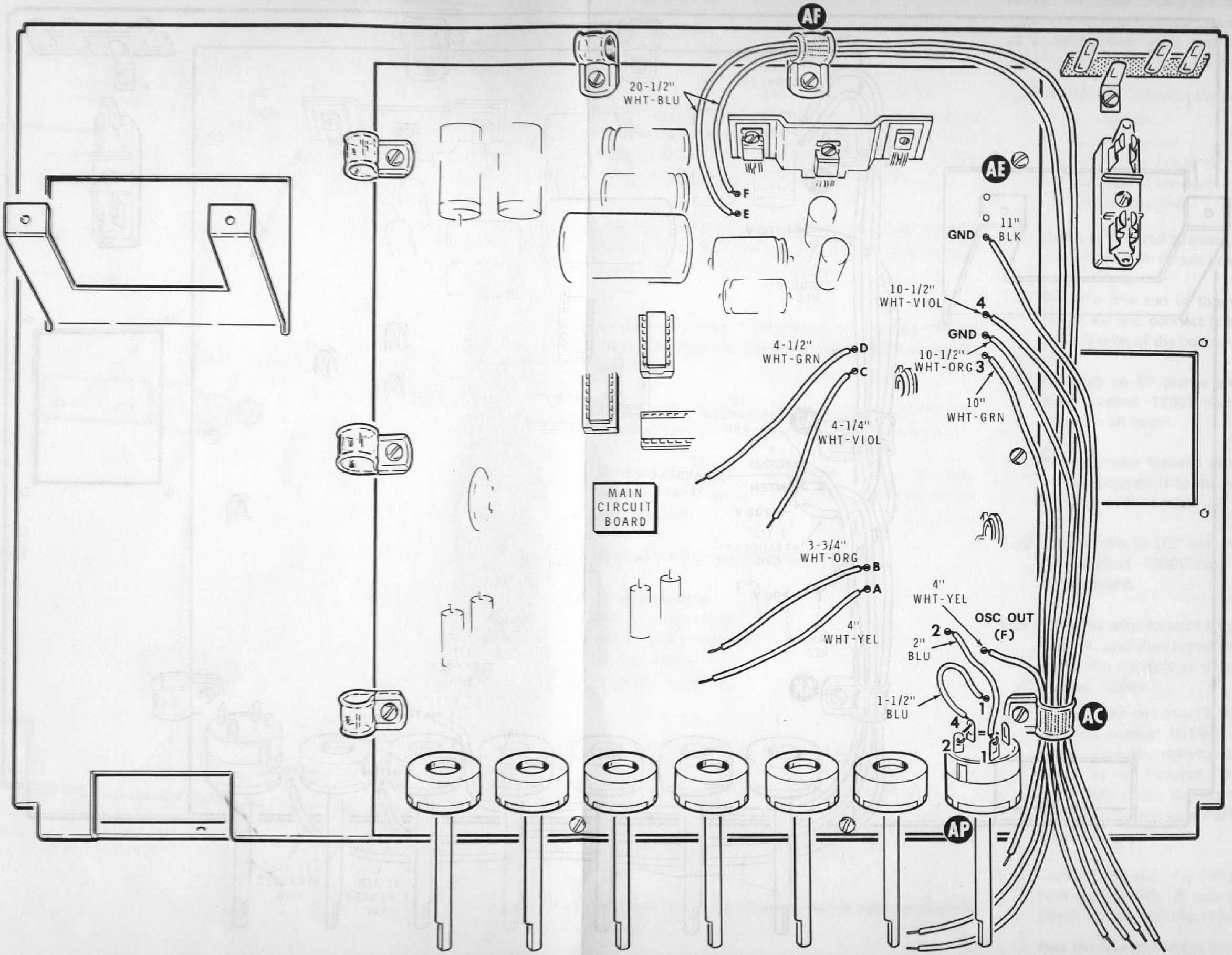
( ) Connect one end of a 12" brown stranded wire to the hole marked FOCUS near the left edge of the circuit board. Use the right-hand hole.

( ) Pass the free end of this wire through cable clamp AK, and connect it to the hole marked FOCUS near the front edge of the board.

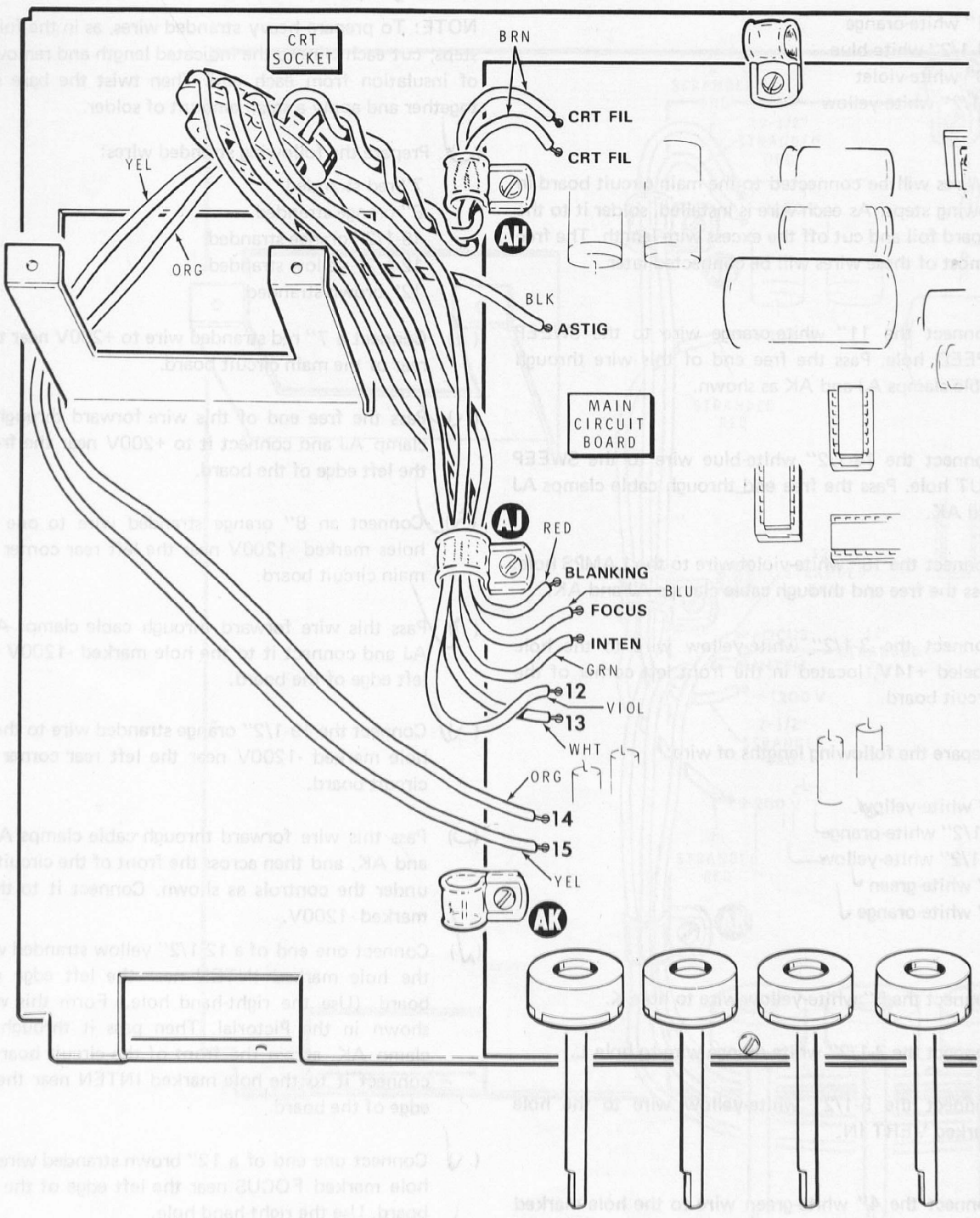




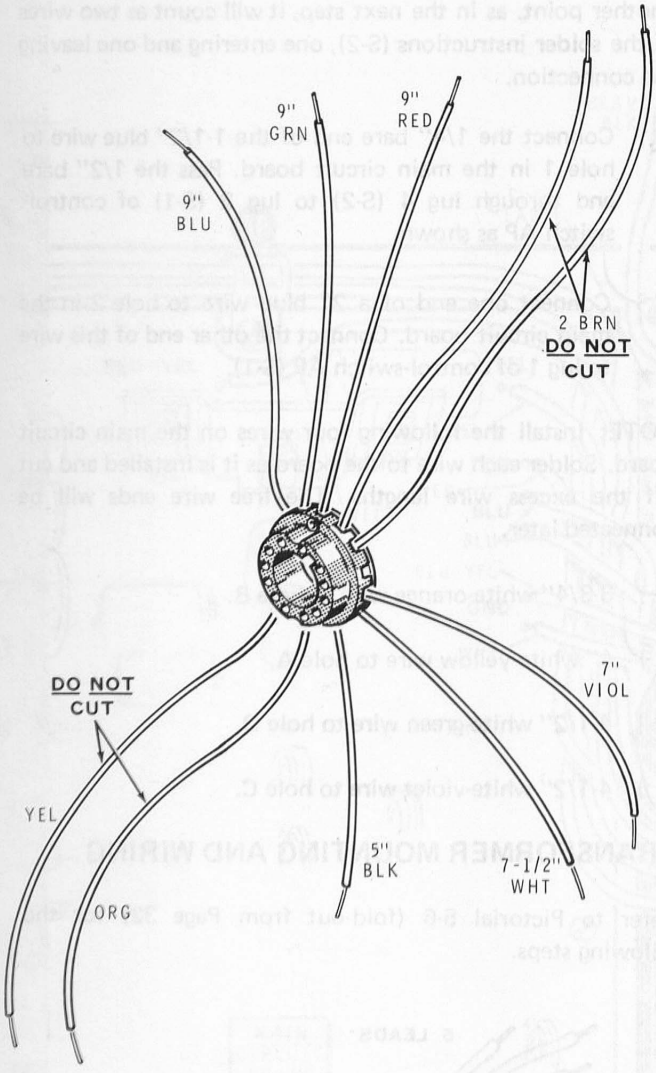

PICTORIAL 5-3




PICTORIAL 5-5




**PICTORIAL 5-4**




Detail 5-4A

Refer to Pictorial 5-4 for the following steps.

( ) Refer to Detail 5-4A and cut the wires on the CRT socket to the indicated lengths. Then remove 1/4" of insulation from each wire end and apply a small amount of solder.

Connect the CRT socket wires to the main circuit board in the following steps.

( ) Twist the two brown wires together and pass them rearward through cable clamp AH as shown. Connect these wires to the holes marked CRT FIL.

( ) Connect the black wire to the hole marked ASTIG.

( ) Pass the red, white, blue, green, and violet wires forward through cable clamp AJ.

( ) Connect the red wire to the hole marked BLANKING.

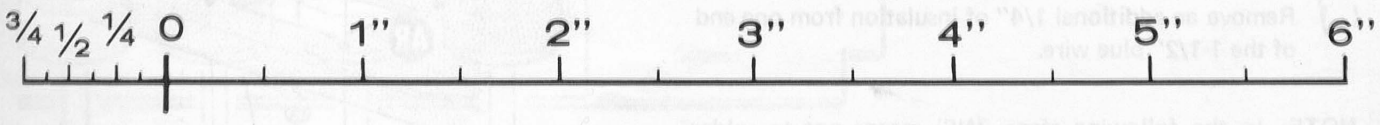
( ) Connect the blue wire to the remaining hole marked FOCUS.

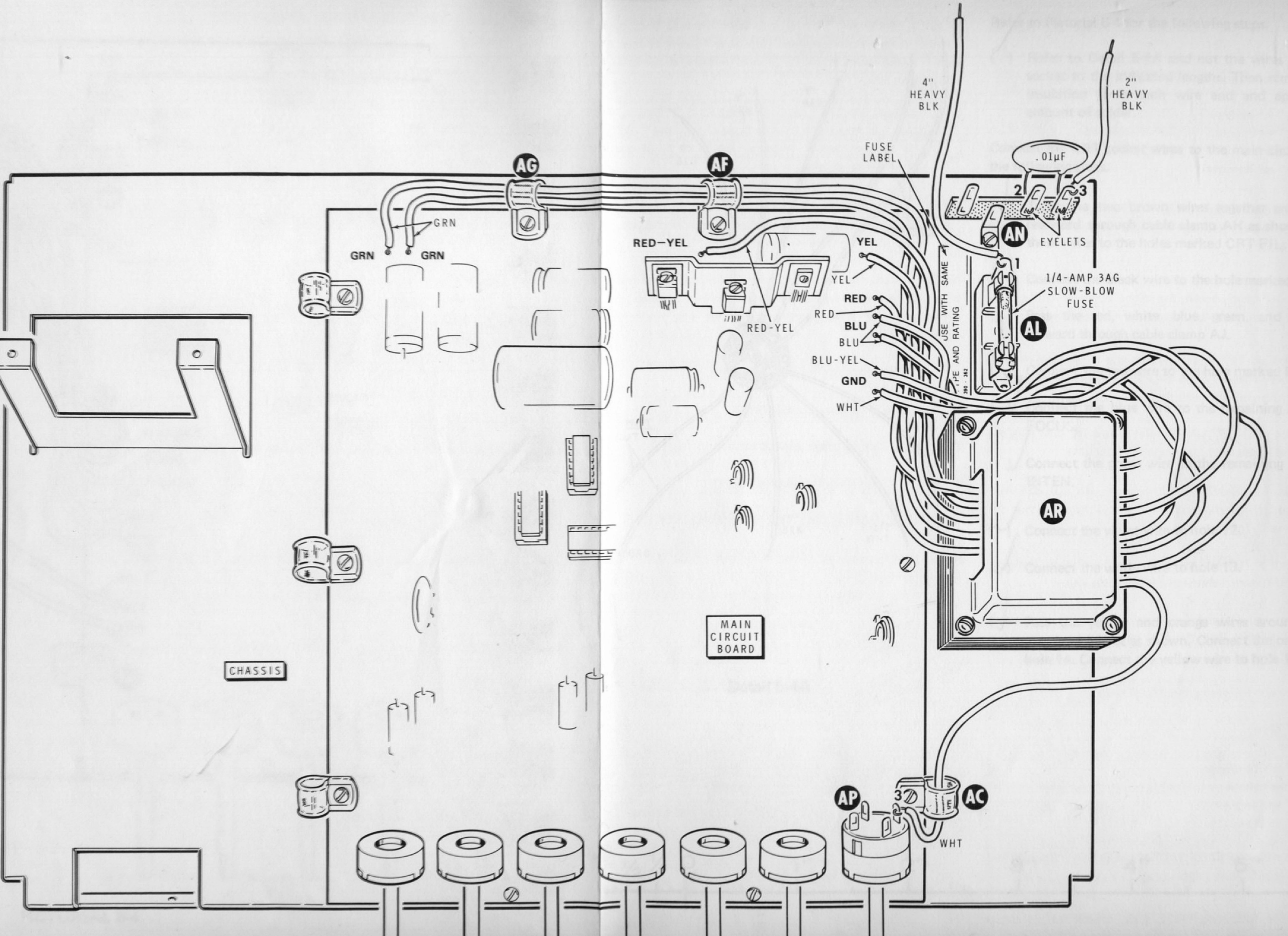
( ) Connect the green wire to the remaining hole marked INTEN.

( ) Connect the violet wire to hole 12.

( ) Connect the white wire to hole 13.

( ) Pass the yellow and orange wires around the CRT support bracket as shown. Connect the orange wire to hole 14. Connect the yellow wire to hole 15.




AG
AF
GRN
GRN
GRN
RED–YEL
RED-YEL
YEL
YEL
RED
RED
BLU
BLU
BLU-YEL
GND
WHT
4"
HEAVY
BLK
2"
HEAVY
BLK
FUSE
LABEL
.01µF
2
3
AN
EYELETS
1
1/4-AMP 3AG
SLOW-BLOW
FUSE
AL
USE WITH SAME
TYPE AND RATING
390 . 362
AR
CHASSIS
MAIN
CIRCUIT
BOARD
AP
3
AC
WHT

Refer to Pictorial 5-5 (fold-out from Page 30) for the following steps.

( ) Prepare the following lengths of wire:

20-1/2" white-blue
20-1/2" white-blue
11" black
10-1/2" white-violet
10-1/2" white-orange
10" white-green
4" white-yellow

( ) Connect one of the 20-1/2" white-blue wires to hole E and the other to hole F near the rear of the main circuit board.

( ) Route both of these white-blue wires through cable clamp AF and down the right edge of the circuit board. Then pass the free ends through cable clamp AC.

( ) Connect an 11" black wire to the front hole marked GND near screw AE on the circuit board. Pass the free end of the wire forward through cable clamp AC.

( ) Connect a 10-1/2" white-violet wire to hole 4. Pass the free end forward through cable clamp AC.

( ) Connect a 10-1/2" white-orange wire to the hole marked GND, between holes 3 and 4. Pass the free end of this wire forward through cable clamp AC.

( ) Connect a 10" white-green wire to hole 3. Pass the free end forward through cable clamp AC.

( ) Connect the 4" white-yellow wire to the hole marked OSC OUT (F). Pass the free end of this wire through cable clamp AC.

( ) Prepare the following lengths of wire:

1-1/2" blue
2" blue
3-3/4" white-orange
4" white-yellow
4-1/2" white-green
4-1/2" white-violet

( ) Remove an additional 1/4" of insulation from one end of the 1-1/2" blue wire.

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

Where a wire passes through a connection and then goes to another point, as in the next step, it will count as two wires in the solder instructions (S-2), one entering and one leaving the connection.

( ) Connect the 1/4" bare end of the 1-1/2" blue wire to hole 1 in the main circuit board. Pass the 1/2" bare end through lug 4 (S-2) to lug 2 (S-1) of control-switch AP as shown.

( ) Connect one end of a 2" blue wire to hole 2 in the main circuit board. Connect the other end of this wire to lug 1 of control-switch AP (S-1).

NOTE: Install the following four wires on the main circuit board. Solder each wire to the board as it is installed and cut off the excess wire lengths. The free wire ends will be connected later.

( ) 3-3/4" white-orange wire to hole B.

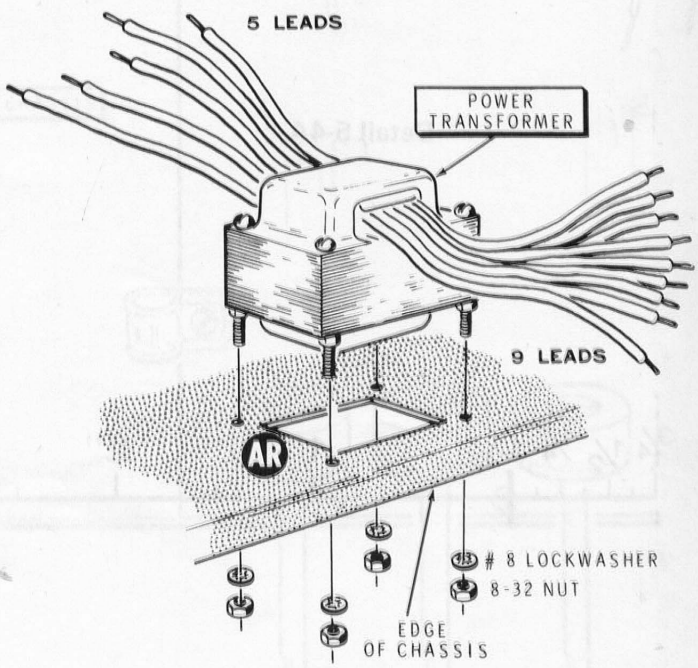
( ) 4" white-yellow wire to hole A.

( ) 4-1/2" white-green wire to hole D.

( ) 4-1/2" white-violet wire to hole C.

## TRANSFORMER MOUNTING AND WIRING

Refer to Pictorial 5-6 (fold-out from Page 32) for the following steps.




Detail 5-6A

( ) Refer to Detail 5-6A and securely mount the power transformer at AR on the chassis with four #8 lockwashers and four 8-32 nuts. Position the transformer leads as shown in Pictorial 5-6.

NOTE: In the following steps, the power transformer will be wired to the main circuit board. Do not shorten any leads. Solder each lead as it is installed and cut off the excess lead lengths. Route each of the transformer leads as shown in the Pictorial.

( ) Route each of the two green leads across the back of the circuit board and through cable clamps AF and AG. Connect the green leads to the two circuit board holes labeled GREEN near the left rear corner of the board.

( ) Connect the red-yellow lead to the RED-YELLOW hole in the circuit board. Form the lead as shown in the Pictorial.

( ) Connect the red lead to the RED hole.

( ) Connect the yellow lead to the YELLOW hole near the right rear corner of the circuit board.

( ) Twist the two blue wires together. Connect these wires to the two holes labeled BLUE.

( ) Twist the blue-yellow and one of the white wires together. Connect these wires to the two remaining holes labeled GND near the right rear edge of the circuit board.

( ) Pass the remaining white wire forward along the right edge of the circuit board and through cable clamp AC. Connect this lead to lug 3 of control AP (S-1).

NOTE: The remaining power transformer leads will be connected later.

( ) Pass the leads of a .01 $\mu$F, 1.6 kV disc capacitor through the eyelets of lugs 2 and 3 of terminal strip AN. Solder the leads to the eyelets and cut off the excess lead lengths.

( ) Prepare a 2" and a 4" length of heavy black stranded wire.

NOTE: When you are instructed to mechanically secure a wire, this means to wrap the wire end tightly at the connection.

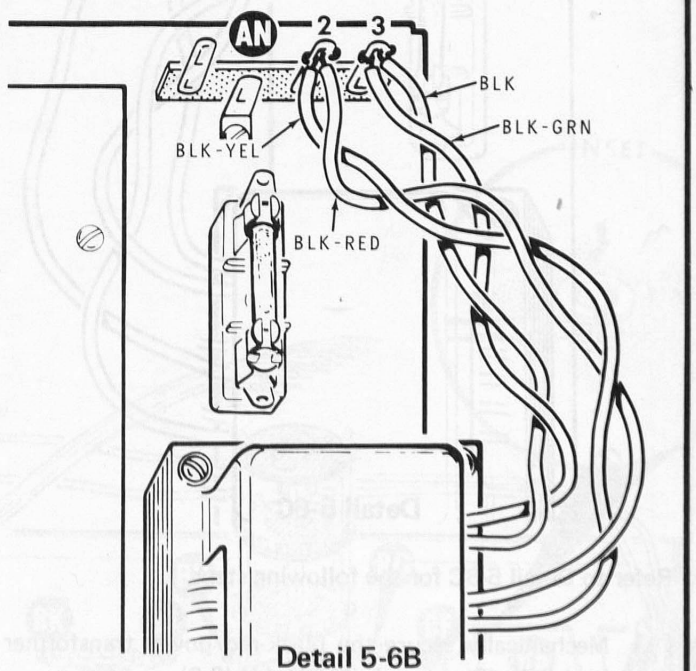
( ) Mechanically secure the 2" heavy black wire to lug 3 of terminal strip AN (NS). The free end will be connected later.

( ) Mechanically secure the 4" heavy black wire to lug 1 of fuseholder AL (S-1). The free end will be connected later.

## ALTERNATE LINE VOLTAGE WIRING

Two sets of line voltage wiring instructions are given below, one for 120 VAC and the other for 240 VAC line voltage. 120 VAC is most often used, though in some countries 240 VAC is used. USE ONLY THE INSTRUCTIONS THAT AGREE WITH THE LINE VOLTAGE IN YOUR AREA.

### 120 VAC Wiring




Detail 5-6B

Refer to Detail 5-6B for the following steps.

( ) Twist the black and the black-green power transformer leads together. Mechanically secure both of these wires to lug 3 of terminal strip AN (S-3).

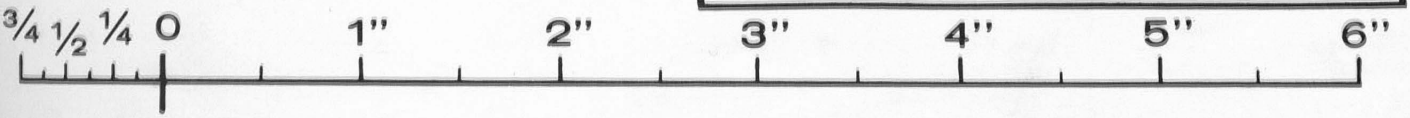
( ) Twist the black-red and the black-yellow power transformer leads together. Mechanically secure both of these leads to lug 2 of terminal strip AN (NS).

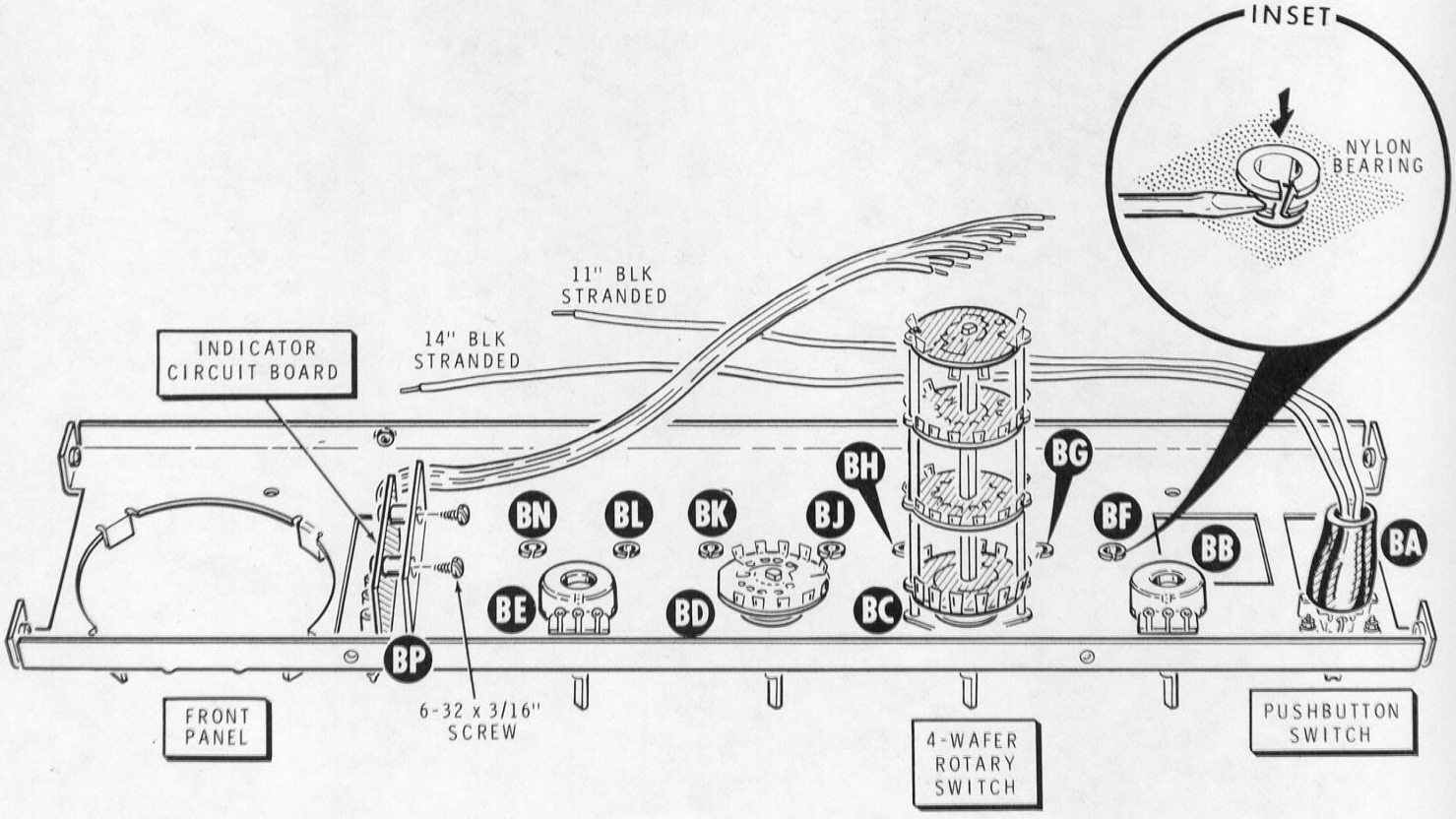
( ) Place a 1/4-ampere, 3AG, slow-blow fuse in fuseholder AL.

( ) Locate the fuse label and write the fuse information (for example: "1/4-amp, 3AG, S-B") in the blank space provided for that purpose.

( ) Remove the paper backing from the fuse lable. Then press the label in place beside fuseholder AL as shown in the Pictorial.

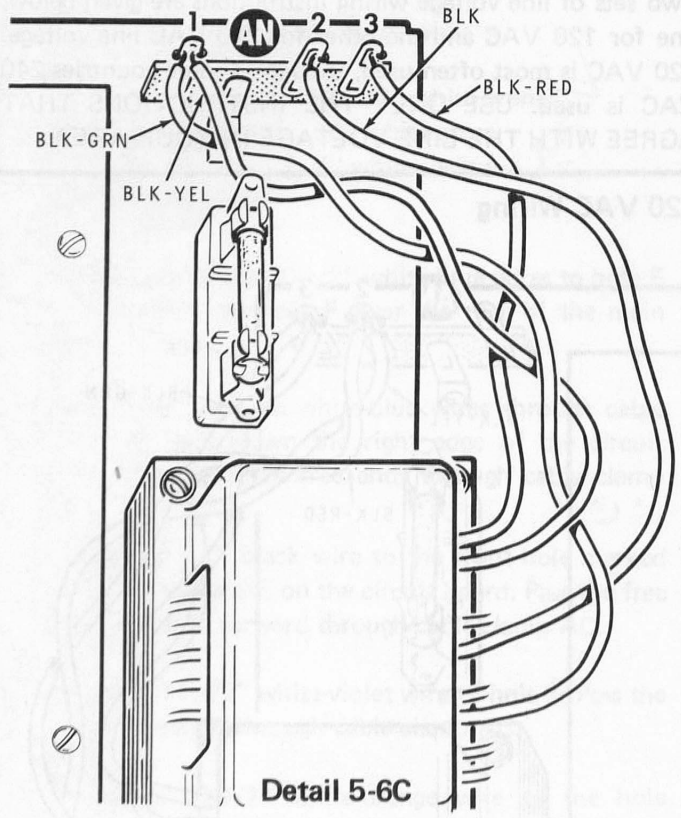
Proceed to "Front Panel Assembly and Wiring."






**PICTORIAL 6-1**

## 240 VAC Wiring




Detail 5-6C

Refer to Detail 5-6C for the following steps.

( ) Mechanically secure the black-red power transformer lead to lug 3 of terminal strip AN (S-2).

( ) Mechanically secure the black power transformer lead to lug 2 of terminal strip AN (NS).

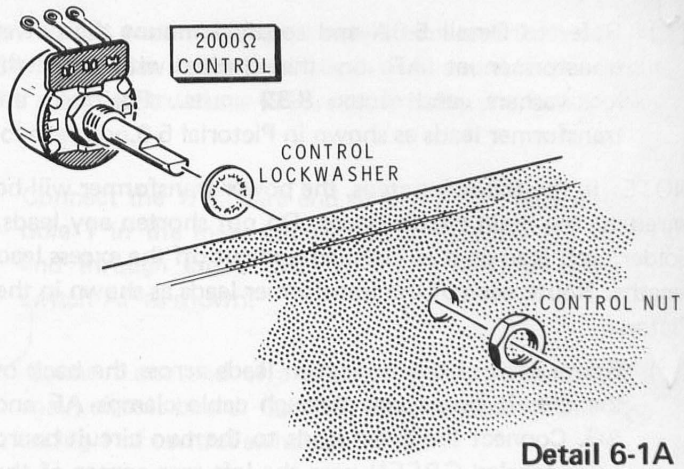
( ) Twist the black-yellow and the black-green power transformer leads together. Mechanically secure both of these leads to lug 1 of terminal strip AN (S-2).

NOTE: The 1/8-ampere, 3 AG, slow-blow fuse to be installed in the following step is not supplied with this kit and must be obtained locally.

( ) Place a 1/8-ampere, 3 AG, slow-blow fuse in fuseholder AL.

( ) Locate the fuse label and write the fuse information (for example: "1/8-amp, 3 AG, S-B") in the blank space provided for that purpose.

( ) Remove the paper backing from the fuse label. Then press the label in place beside fuseholder AL as shown in the Pictorial.




Detail 6-1A

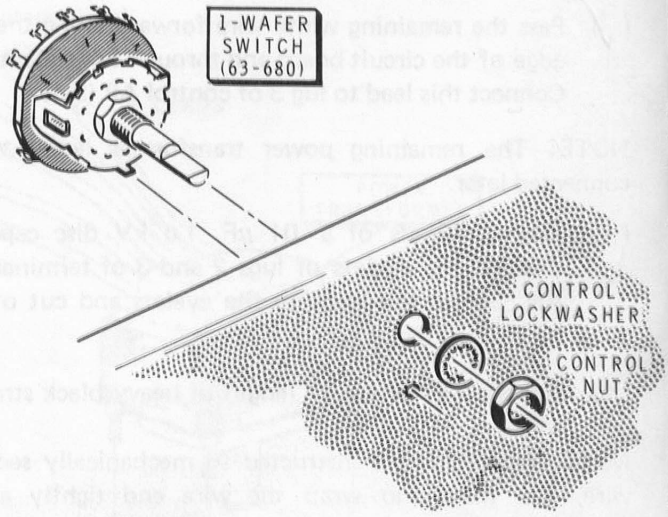
## FRONT PANEL ASSEMBLY AND WIRING

( ) Temporarily set the chassis aside.

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

( ) Refer to Detail 6-1A and mount a 2000 Ω (2 k) control (#10-968) at BB on the front panel as shown. Use a control lockwasher and a control nut. Position the control as shown in the Pictorial.

( ) In the same manner, mount a 20 kΩ control (#10-967) at BE on the front panel.



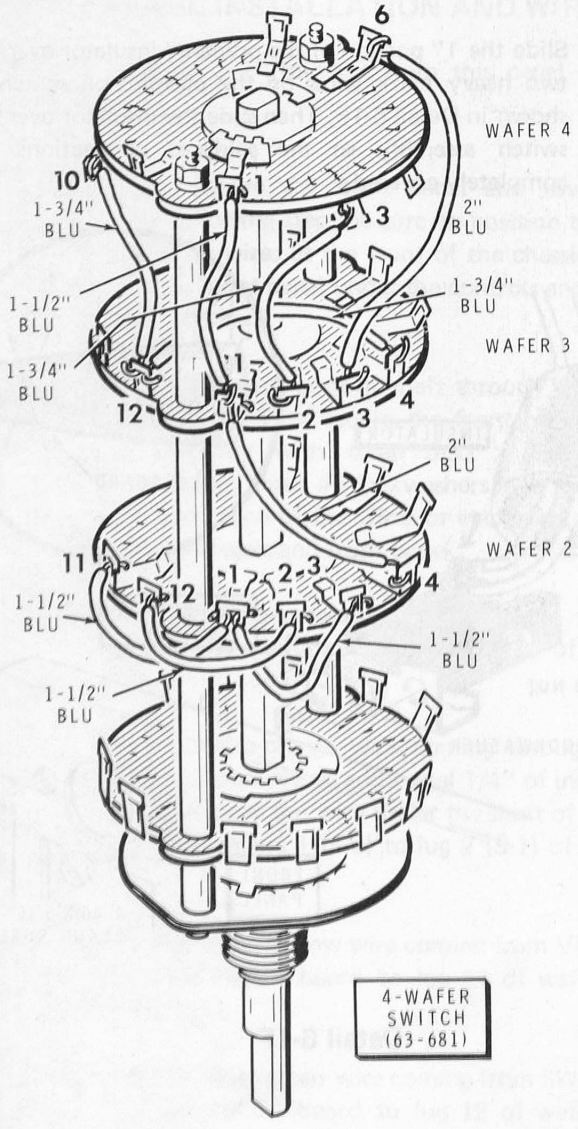

Detail 6-1B

( ) Refer to Detail 6-1B and mount the 1-wafer switch (#63-680) at BD. Be sure the small tab on the front of the switch fits into the small hole in the front panel. Place the lockwasher and the control nut on the outside of the panel as shown.

( ) Prepare the following lengths of blue wire.

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

Position the 4-wafer switch (#63-681) as shown in Detail 6-1C. Then connect the blue wires to this switch as directed in the following steps.




**Detail 6-1C**

( ) Connect a 1-1/2" blue wire between lug 11 (S-1) and lug 1 (NS) of switch wafer 2.

( ) Connect a 1-1/2" blue wire between lug 1 (NS) and lug 3 (S-1) of switch wafer 2.

( ) Connect a 1-1/2" blue wire between lug 12 (NS) and lug 2 (S-1) of switch wafer 2.

( ) Connect a 2" blue wire from lug 4 of switch wafer 2 (NS) to lug 1 of switch wafer 3 (NS).

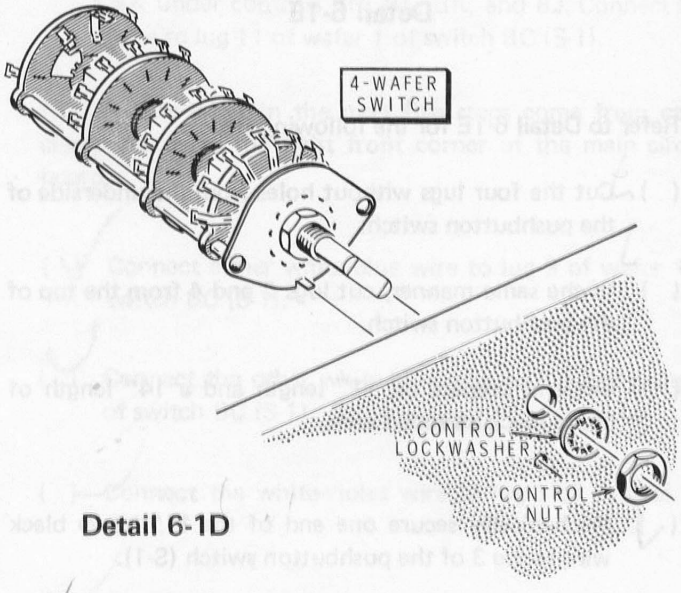
( ) Connect a 1-1/2" blue wire from lug 1 of switch wafer 3 (S-2) to lug 1 of switch wafer 4 (S-1).

( ) Connect a 1-3/4" blue wire from lug 12 of switch wafer 3 (NS) to lug 10 of switch wafer 4 (S-1).

( ) Connect a 1-3/4" blue wire between lug 12 (S-2) and lug 4 (NS) of switch wafer 3.

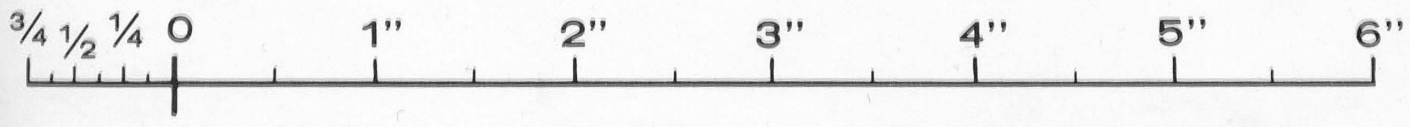
( ) Connect a 2" blue wire from lug 3 of switch wafer 3 (NS) to lug 6 of switch wafer 4 (S-1).

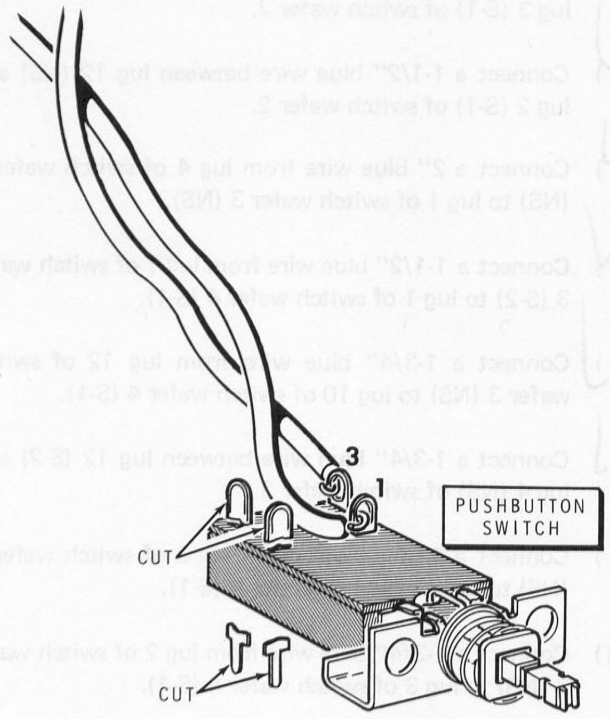
( ) Connect a 1-3/4" blue wire from lug 2 of switch wafer 3 (NS) to lug 3 of switch wafer 4 (S-1).




**Detail 6-1D**

( ) Refer to Detail 6-1D and mount the 4-wafer switch on the front panel at BC as shown. Be sure the small tab on the front of the switch fits into the small hole in the front panel. Use a control lockwasher and a control nut on the outside of the front panel as shown.






**Detail 6-1E**

Refer to Detail 6-1E for the following steps.

( ) Cut the four lugs without holes from the underside of the pushbutton switch.

( ) In the same manner, cut lugs 2 and 4 from the top of the pushbutton switch.

( ) Cut and prepare an 11" length and a 14" length of heavy black stranded wire.

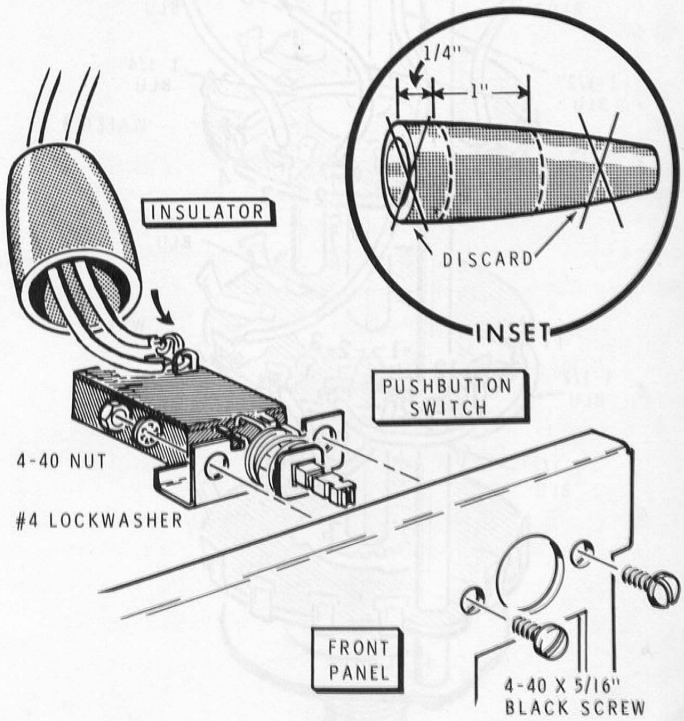
( ) Mechanically secure one end of the 11" heavy black wire to lug 3 of the pushbutton switch (S-1).

( ) Mechanically secure one end of the 14" heavy black wire to lug 1 of the pushbutton switch (S-1).

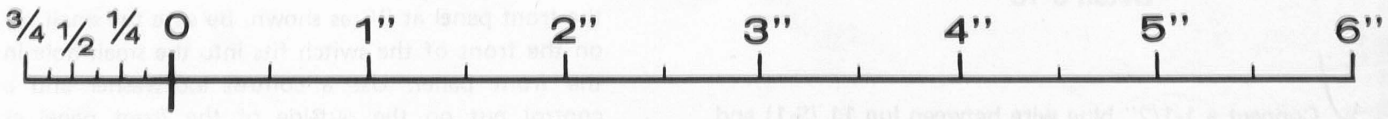
( ) Refer to Detail 6-1F and mount the pushbutton switch on the front panel. Use 4-40 x 5/16" hardware. Position the lugs of the switch upward as shown.

( ) Refer to the inset drawing on Detail 6-1F and prepare the large test lead insulator as shown. Remove 1/4" of material from the wide end. Then measure 1" toward the small end. Cut off and discard the ends of the insulator.

( ) Slide the 1" portion of the prepared insulator over the two heavy black wires on the pushbutton switch as shown in Detail 6-1F. Then slide the insulator over the switch assembly so the soldered connections are completely covered.




**Detail 6-1F**



( ) Refer to the Pictorial and install seven nylon bearings in the front panel at BF, BG, BH, BJ, BK, BL, and BN. See the inset drawing on the Pictorial.

( ) Mount the lamp circuit board assembly to the front panel at BP with two 6-32 x 3/16" screws as shown in the Pictorial. Slide the assembly toward the inside of the panel before you tighten the screws. NOTE: The lamp circuit board will be repositioned later.

## FRONT PANEL INSTALLATION AND WIRING

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

NOTE: As you secure the front panel and the chassis together in the following step, be sure to position the wires as shown. Place the wires at the front of the chassis and at the bottom of the front panel under the controls and on top of the main circuit board.

( ) Carefully push each control shaft through its hole in the front panel. Then secure the front panel to the chassis assembly with three 6-32 x 3/8" black flat-head screws, three #6 lockwashers, and three 6-32 nuts. Be sure none of the wires or cables are pinched between the chassis and front panel.

( ) Connect the white-yellow wire coming from +14V at the front of the main circuit board to lug 3 of control BE (S-1).

( ) Locate the white-orange wire coming through cable clamp AK and remove an additional 1/4" of insulation from it. Then pass the wire under the shaft of control BN and through lug 1 (S-2) to lug 2 (S-1) of control BE.

( ) Connect the white-yellow wire coming from VERT IN on the main circuit board to lug 11 of wafer 3 of switch BC (S-1).

( ) Connect the white-green wire coming from SWEEP IN on the main circuit board to lug 12 of wafer 2 of switch BC (S-2).

( ) Connect the white-orange wire coming from HORIZ IN on the main circuit board to lug 7 of wafer 2 of switch BC (S-1).

( ) Connect the white-orange wire coming from L to lug 7 of wafer 4 of switch BC (S-1).

( ) Connect the white-yellow wire coming from K to lug 4 of wafer 4 of switch BC (S-1).

( ) Connect the white-green wire coming from D to lug 12 of wafer 4 of switch BC (S-1).

( ) Connect the white-violet wire coming from C to lug 9 of wafer 4 of switch BC (S-1).

( ) Connect the white-orange wire coming from B to lug 5 of wafer 3 of switch BC (S-1).

( ) Connect the white-yellow wire coming from A to lug 5 of wafer 2 of switch BC (S-1).

( ) Pass the white-blue wire coming from cable clamp AK under controls BN, BL, BK, and BJ. Connect this wire to lug 1 of wafer 2 of switch BC (S-3).

( ) Pass the white-violet wire coming from cable clamp AK under controls BN, BL, BK, and BJ. Connect this wire to lug 11 of wafer 1 of switch BC (S-1).

NOTE: The wires in the next five steps come from cable clamp AC, near the right front corner of the main circuit board.

( ) Connect either white-blue wire to lug 9 of wafer 1 of switch BC (S-1).

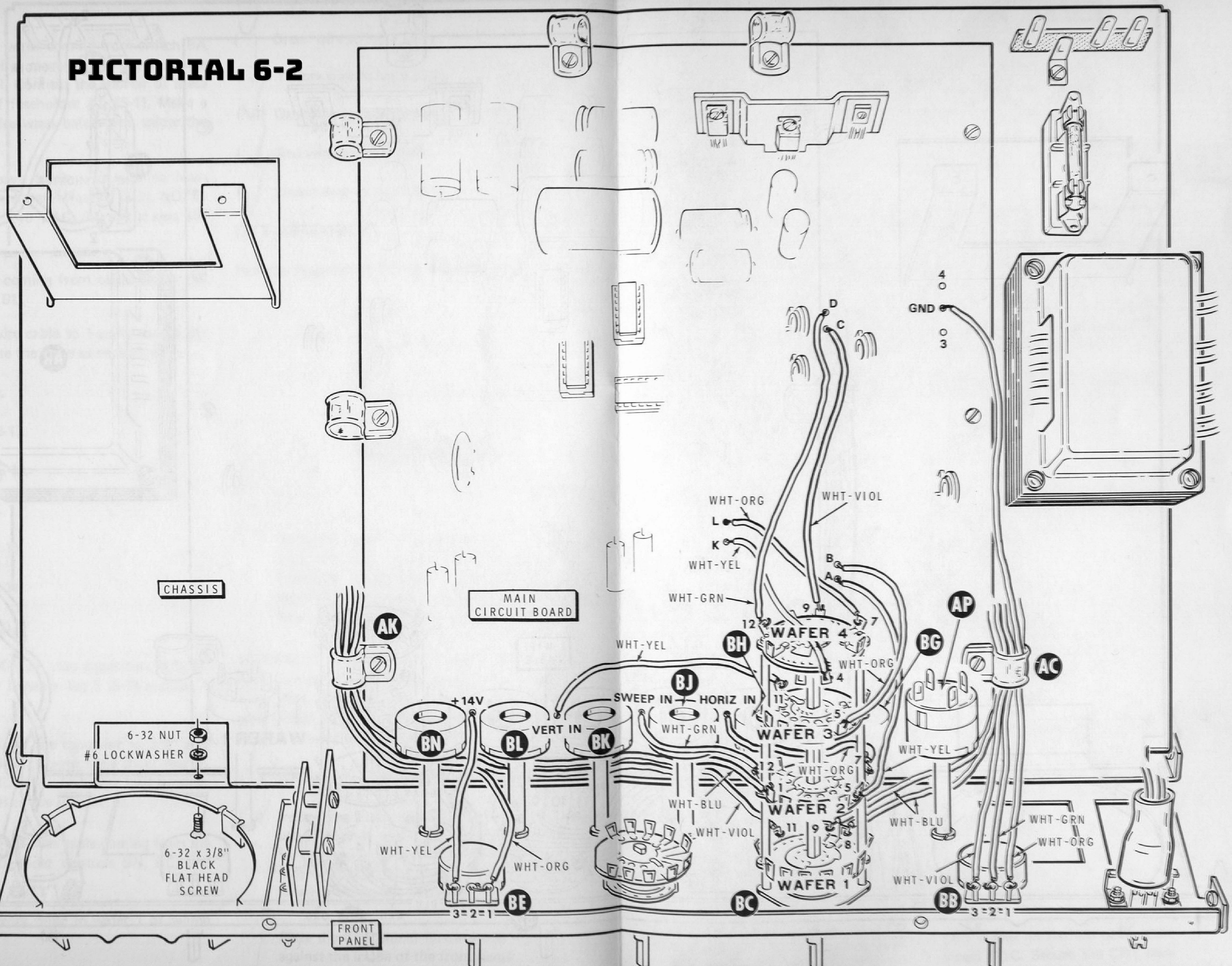
( ) Connect the other white-blue wire to lug 8 of wafer 1 of switch BC (S-1).

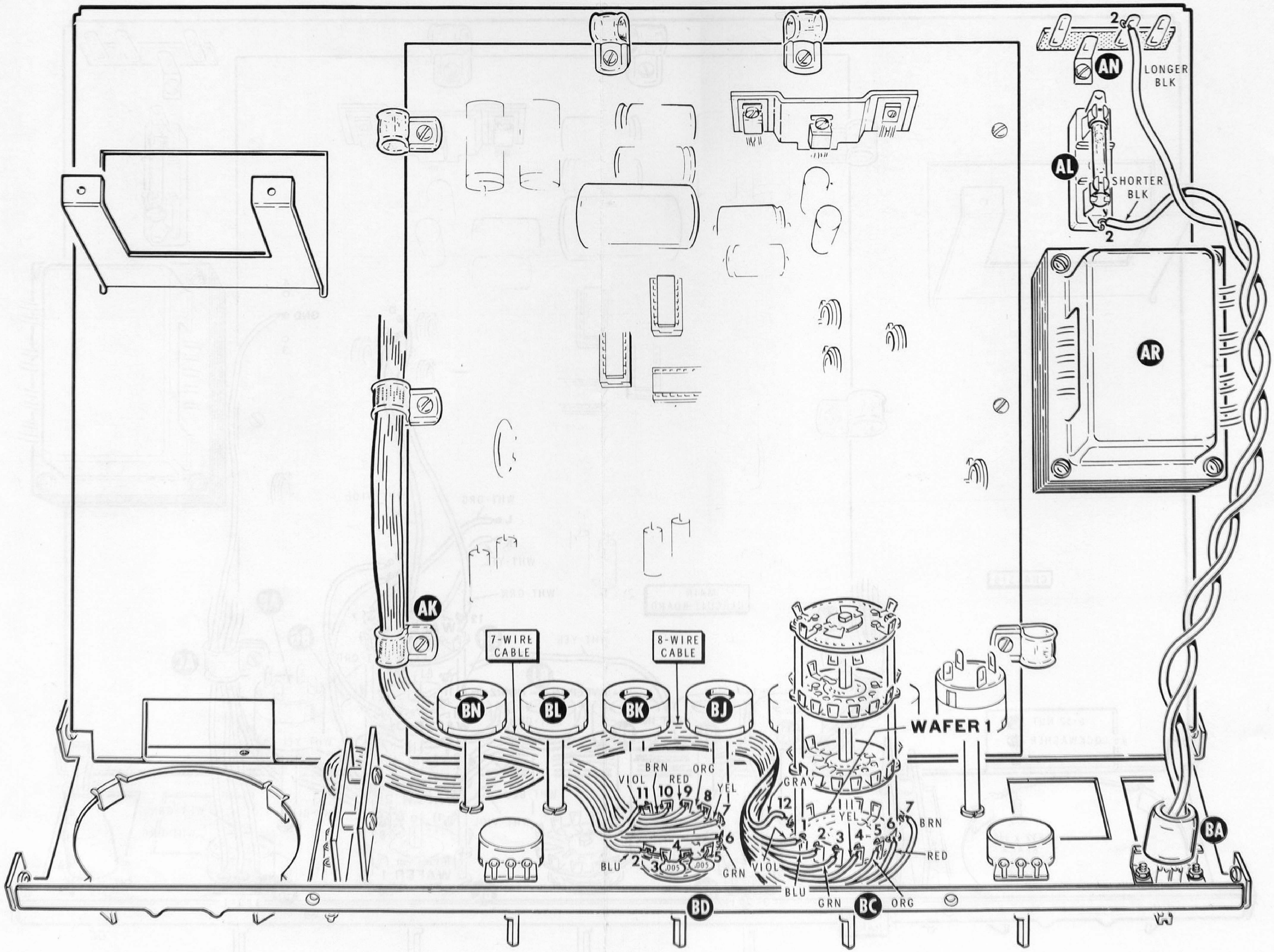
( ) Connect the white-violet wire to lug 3 of control BB (S-1).

( ) Connect the white-green wire to lug 2 of control BB (S-1).

( ) Connect the white-orange wire to lug 1 of control BB (S-1).

# PICTORIAL 6-2






**PICTORIAL 6-3**

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

( ) Twist the heavy black wires coming from switch BA together. Route the wires rearward, over the outside top of transformer AR. Connect the shorter of these two wires to lug 2 of fuseholder AL (S-1). Make a mechanically secure wire wrap before you solder the connection.

( ) Connect the other heavy black wire coming from switch BA to lug 2 of terminal strip AN (S-3). NOTE: If your kit is wired for 240 VAC, this solder step will be (S-2).

( ) Pass the 7-wire cable coming from cable clamp AK under controls BN and BL.

Connect the wires of the 7-wire cable to 1-wafer switch BD in the following steps. Separate the wires as necessary.

( ) Blue wire to lug 2 (NS).

( ) Violet wire to lug 11 (S-1).

( ) Brown wire to lug 10 (S-1).

( ) Red wire to lug 9 (S-1).

( ) Orange wire to lug 8 (S-1).

( ) Yellow wire to lug 7 (S-1).

( ) Green wire to lug 6 (S-1).

( ) Cut the leads of a .005 $\mu$F disc capacitor to 3/8". Connect this capacitor between lug 5 (S-1) and lug 4 (NS) of switch BD.

( ) Cut one lead of a .005 $\mu$F disc capacitor to 3/8" and cut the other lead to 5/8". Connect the short lead to lug 4 (S-2) of switch BD. Pass the longer lead through lug 3 (S-2) to lug 2 (S-2) of the switch.

( ) Pass the free end of the 8-wire cable coming from the indicator circuit board under controls BN, BL, BK, and BJ.

Connect the wires of the 8-wire cable to wafer 1 of switch BC in the following steps.

( ) Gray wire to lug 12 (S-1).

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

( ) Blue wire to lug 2 (S-1).

( ) Green wire to lug 3 (S-1).

( ) Yellow wire to lug 4 (S-1).

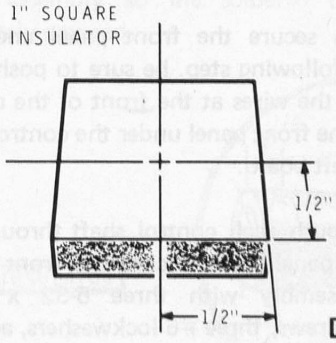
( ) Orange wire to lug 5 (S-1).

( ) Red wire to lug 6 (S-1).

( ) Brown wire to lug 7 (S-1).

## CRT ASSEMBLY

Refer to Pictorial 7-1 for the following steps.




Detail 7-1A

( ) Refer to Detail 7-1A and cut the 1" square insulator into four 1/2" squares. Remove the paper backing from the small pieces and press them in place, as shown on the inset drawing in the Pictorial, on the four tabs projecting from the front panel.

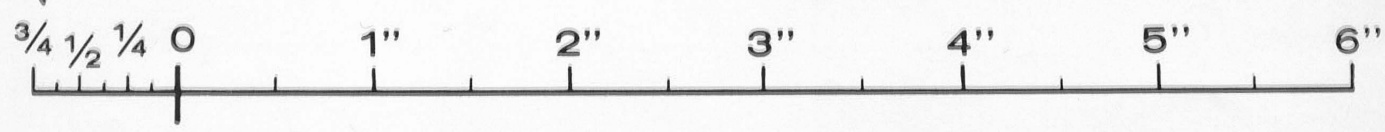
*WARNING: Handle the CRT very carefully. Because of its high vacuum, do not strike, scratch, or subject the CRT to more than moderate pressure at any time. A fracture of the glass could result in an implosion of considerable violence capable of causing personal injury.*

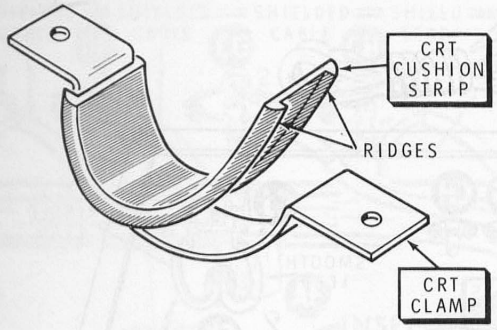
( ) Carefully unpack the CRT from its carton.

( ) Install the CRT through the opening in the front panel. Push it toward the rear of the chassis until its face is even with the front edges of the four projecting tabs. Refer to the inset drawing and position the locating key at the 12 o'clock position as shown.

( ) Slide the CRT shield forward over the CRT until it is against the inside of the front panel.

( ) Hold the face of the CRT and push the CRT socket onto the CRT pins until it is fully seated.



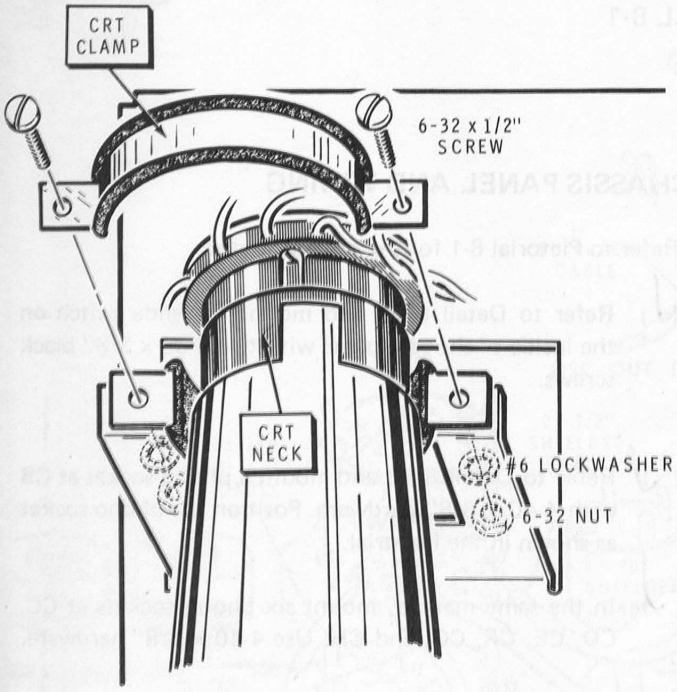



**Detail 7-1B**

( ) Refer to Detail 7-1B and cut the CRT cushion strip into two equal lengths. Then place a cushion strip onto one of the two CRT clamps as shown. Be sure the clamp fits inside the ridges in the cushion strip.

( ) Place the prepared CRT clamp and cushion strip under the CRT, lift the CRT slightly, and rest the ends of the CRT clamp on the raised tabs of bracket AS.

( ) Place the remaining cushion strip on the other CRT clamp.

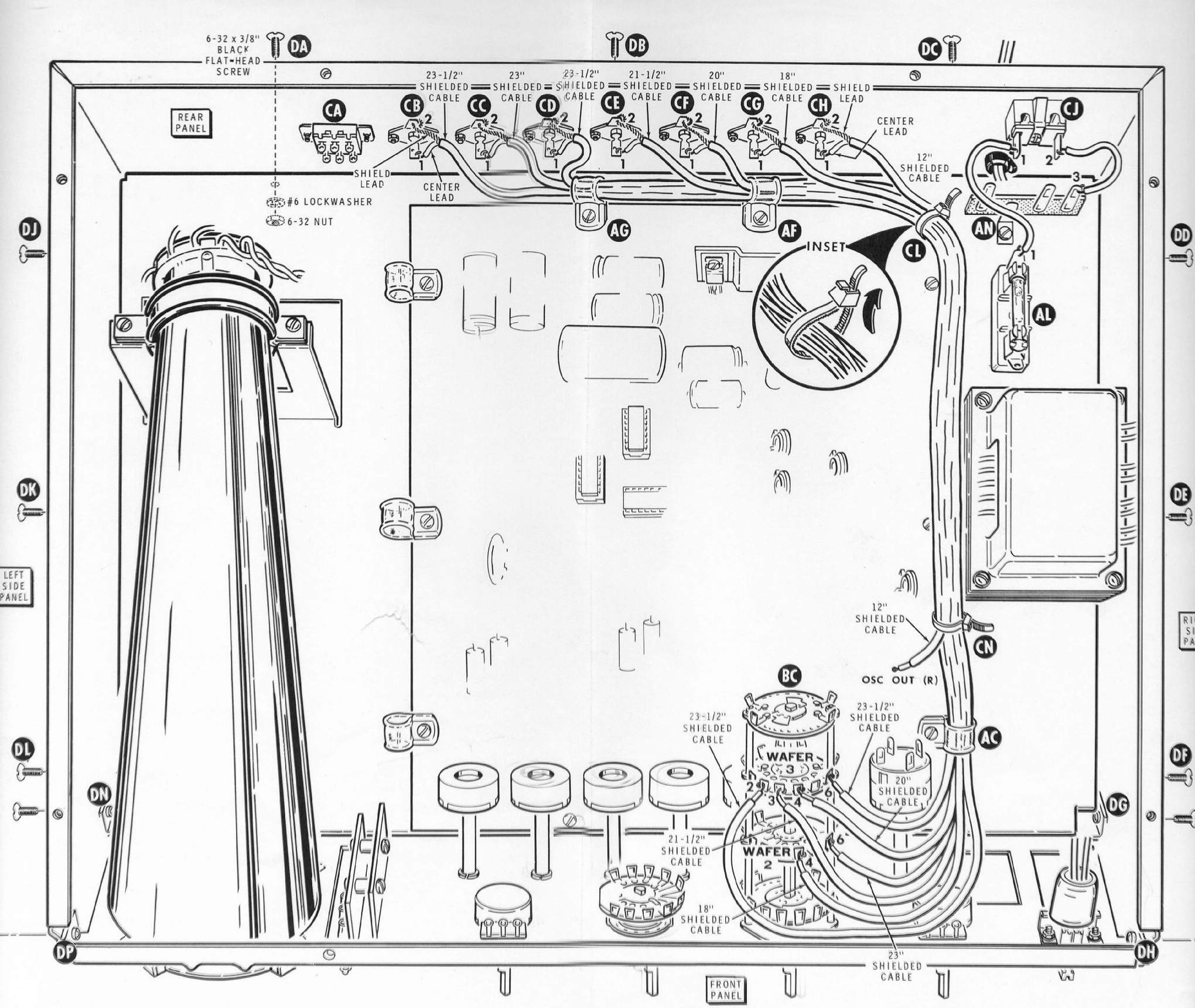



**Detail 7-1C**

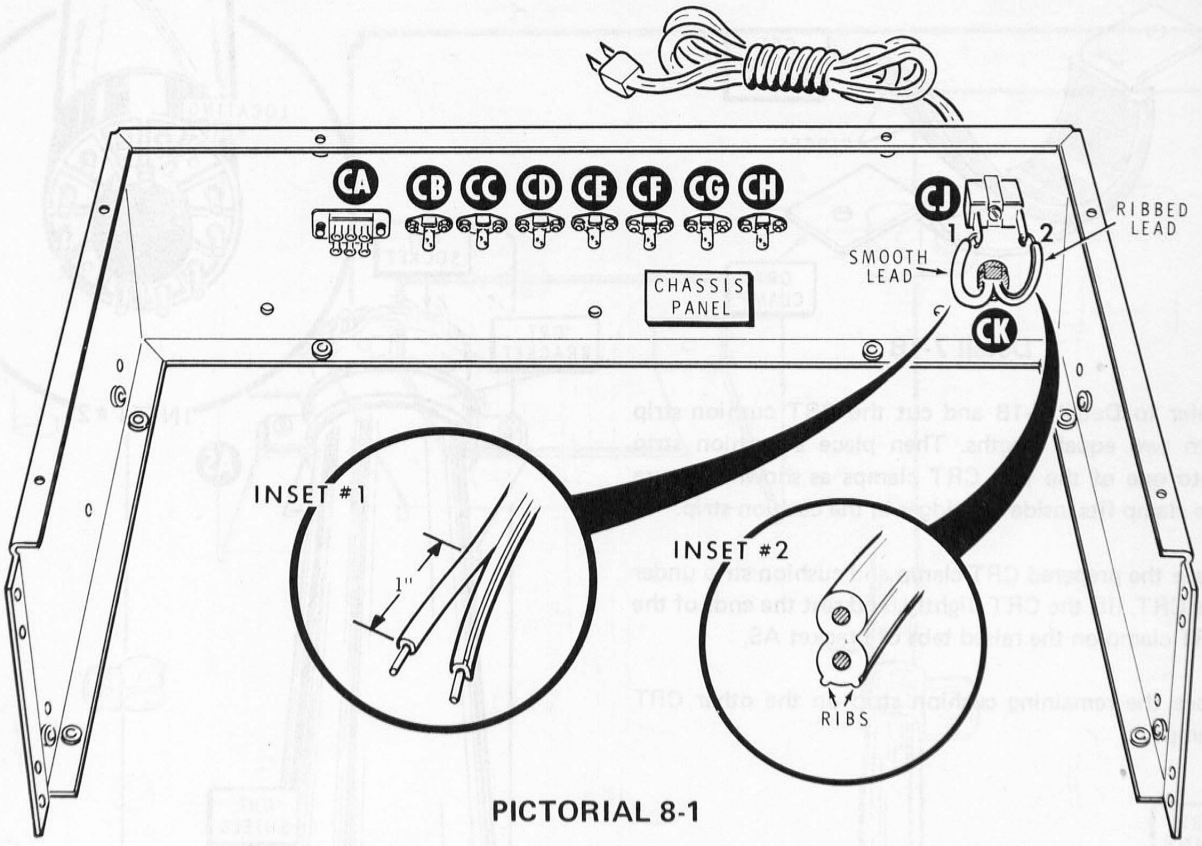
( ) Mount the second CRT clamp on the top of the CRT neck as shown in Detail 7-1C. Secure the CRT neck and the two clamps to bracket AS with 6-32 x 1/2" hardware. NOTE: These screws will be loosened later when you position the CRT.


**PICTORIAL 7-1**

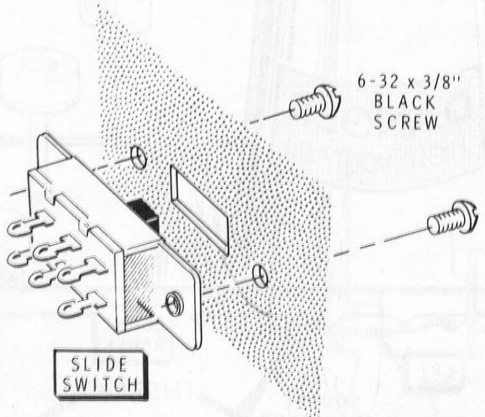
( ) Remove the paper backing from the "Danger" label and press the label on the top of the CRT shield as shown in the Pictorial.




**PICTORIAL 8-2**




**PICTORIAL 8-1**




**Detail 8-1A**

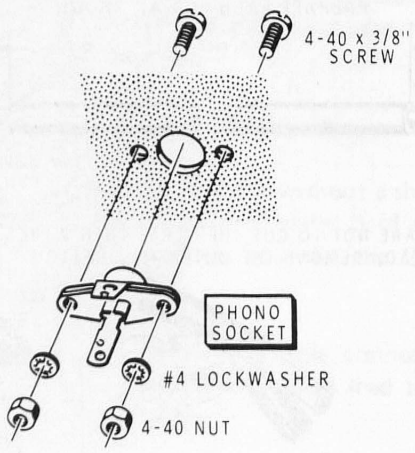
## CHASSIS PANEL AND WIRING

Refer to Pictorial 8-1 for the following steps.

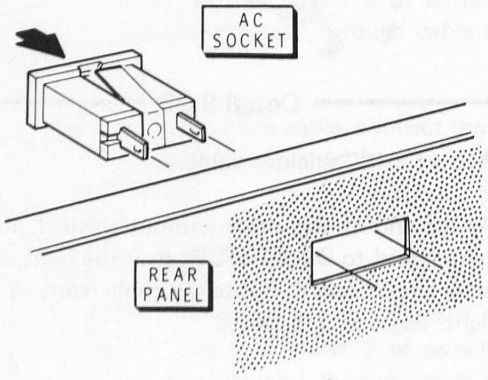
( ) Refer to Detail 8-1A and mount the slide switch on the inside of the rear panel with two 6-32 x 3/8" black screws.

( ) Refer to Detail 8-1B and mount a phono socket at CB with 4-40 x 3/8" hardware. Position the phono socket as shown in the Pictorial.

( ) In the same manner, mount six phono sockets at CC, CD, CE, CF, CG, and CH. Use 4-40 x 3/8" hardware.




Detail 8-1B



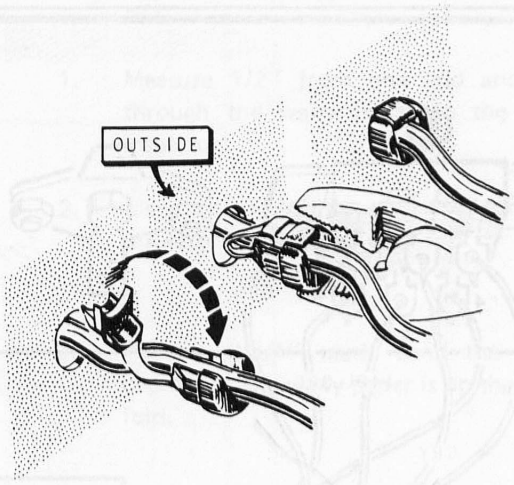

Detail 8-1C

( ) Refer to Detail 8-1C and mount the AC socket at CJ. Push the socket from the outside until the socket is completely seated in its opening.

( ) Refer to inset drawing #1 on the Pictorial and separate the end of the line cord for 1".

( ) Tightly twist each of the bare wire ends of the line cord. Then apply a small amount of solder to each wire end to hold the small strands together.

( ) Push the end of the line cord through rear panel hole CK from the outside. Refer to inset drawing #2 on the Pictorial and connect the smooth lead to lug 1 of socket CJ (NS). Connect the ribbed lead to lug 2 of socket CJ (NS). Be sure to wrap each wire end securely around the socket lug.




Detail 8-1D

( ) Refer to Detail 8-1D and install the line cord strain relief at CK.

Refer to Pictorial 8-2 (fold-out from Page 40) for the following steps.

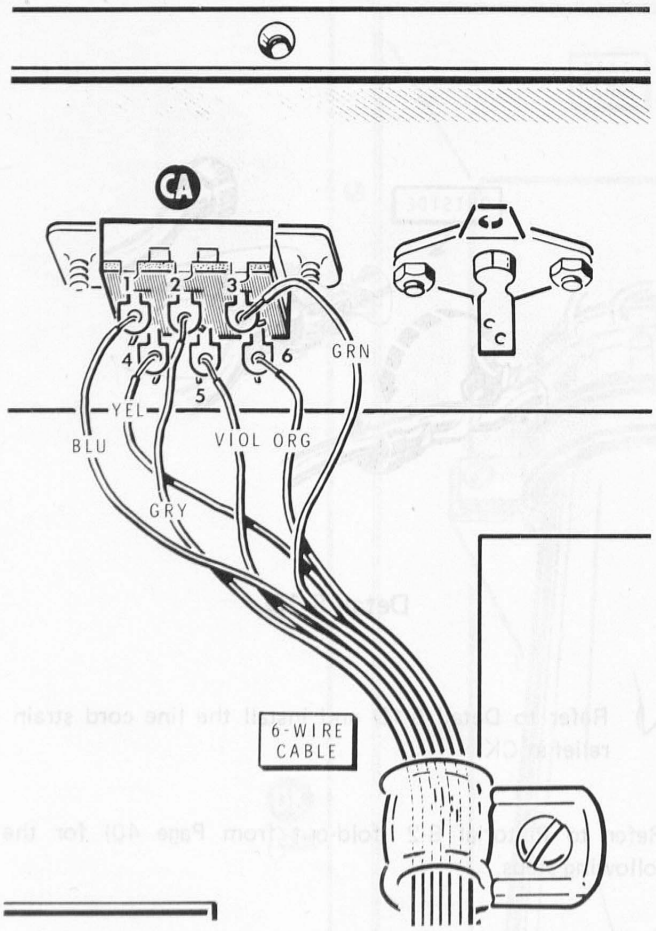
( ) Slide the chassis panel around the chassis assembly as shown. Secure the panel to the chassis at DA, DB, and DC on the rear panel with 6-32 x 3/8" black flat-head screws, #6 lockwashers, and 6-32 nuts.

( ) In the same manner, secure the right and left side panels to the chassis at DD, DE, DF, DJ, DK, and DL. Use a 6-32 x 3/8" black flat-head screw, a #6 lockwasher, and a 6-32 nut at each location.

( ) Secure the right and left side panels to the front panel at DG, DH, DN, and DP with one 6-32 x 3/8" black flat-head screw at each location.

( ) Connect the end of the wire coming from lug 1 of the fuseholder to lug 1 of AC socket CJ (S-2). Wrap the end of the wire securely around the socket lug.

( ) Connect the end of the wire coming from lug 3 of terminal strip AN to lug 2 of AC socket CJ (S-2). Wrap the end of the wire securely around the socket lug.




**Detail 8-2A**

Refer to Detail 8-2A and connect the 6-wire cable to slide switch CA in the following six steps.

( ) Yellow wire to lug 4 (S-1).

( ) Violet wire to lug 5 (S-1).

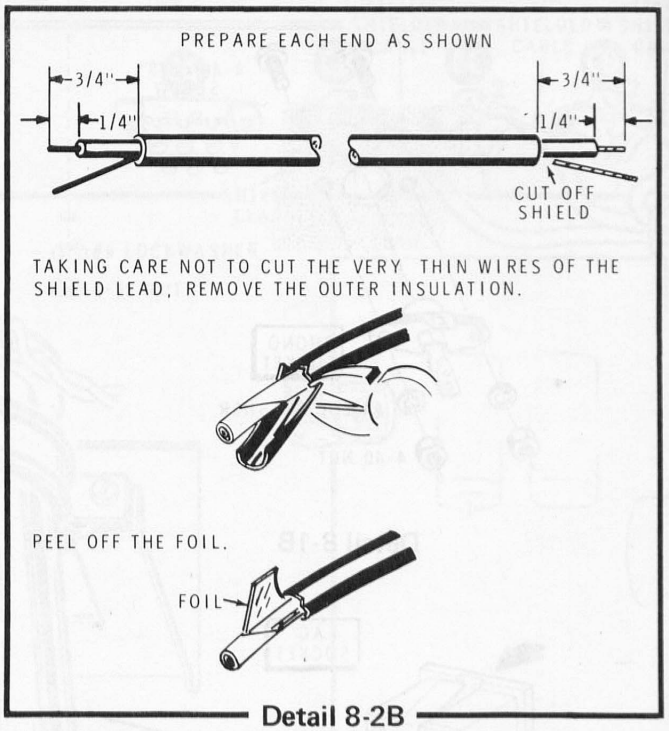
( ) Orange wire to lug 6 (S-1).

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

( ) Gray wire to lug 2 (S-1).

( ) Green wire to lug 3 (S-1).

NOTE: You will prepare and install seven shielded cables in the following steps. Each cable will be prepared as shown in Detail 8-2B; only the length of each cable will be different. As a cable is installed, solder each lead to the indicated point and cut off the excess lead lengths.




**Detail 8-2B**

( ) Prepare a 12" shielded cable.

( ) At the end of this cable without a shield, connect the center lead to OSC OUT (R) near the right edge of the main circuit board. Route the cable rearward along the right edge of the board.

( ) At the other end of this cable, connect the center lead to lug 1 (S-1) and the shield lead to lug 2 (S-1) of phono socket CH.

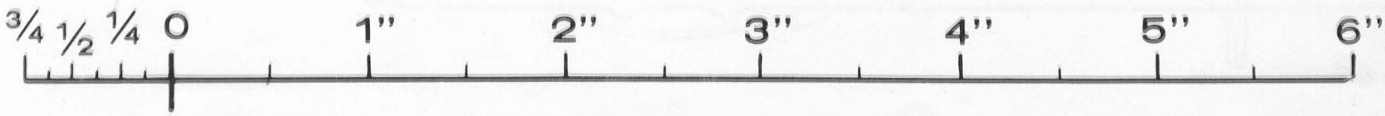
( ) Prepare an 18" shielded cable.

( ) At the end of this cable without a shield, connect the center lead to lug 4 of wafer 2 of switch BC (S-2). Route the cable rearward through cable clamp AC.

( ) At the other end of this cable, connect the center lead to lug 1 (S-1) and the shield lead to lug 2 (S-1) of phono socket CG. Position the cable around the corner of the circuit board as shown in the Pictorial.

( ) Prepare a 20" shielded cable.

( ) At the end of this cable without a shield, connect the center lead to lug 4 of wafer 3 of switch BC (S-2). Route the cable rearward through cable clamp AC, around the right rear corner of the circuit board, and through cable clamp AF.



( ) At the other end of this cable, connect the center lead to lug 1 (S-1) and the shield lead to lug 2 (S-1) of phono socket CF.

( ) Prepare a 21-1/2" shielded cable.

( ) At the end of this cable without a shield, connect the center lead to lug 3 of wafer 3 of switch BC (S-2). Route the cable as you did the 20" cable in the previous step.

( ) At the other end of this cable, connect the center lead to lug 1 (S-1) and the shield lead to lug 2 (S-1) of phono socket CE.

( ) Prepare a 23-1/2" shielded cable.

( ) At the end of this cable without a shield, connect the center lead to lug 2 of wafer 3 of switch BC (S-2). Route this cable rearward through cable clamps AC, AF, and AG.

( ) At the other end of this cable, connect the center lead to lug 1 (S-1) and the shield lead to lug 2 (S-1) of phono socket CD.

( ) Prepare a 23" shielded cable.

( ) At the end of this cable without a shield, connect the center lead to lug 6 of wafer 2 of switch BC (S-1). Route this cable rearward through cable clamps AC, AF, and AG.

( ) At the other end of this cable, connect the center lead to lug 1 (S-1) and the shield lead to lug 2 (S-1) of phono socket CC.

( ) Prepare a 23-1/2" shielded cable.

( ) At the end of this cable without a shield, connect the center lead to lug 6 of wafer 3 of switch BC (S-1). Route this cable rearward through cable clamps AC, AF, and AG.

( ) At the other end of this cable, connect the center lead to lug 1 (S-1) and the shield lead to lug 2 (S-1) of phono socket CB.

( ) Refer to the inset drawing on Pictorial 8-2 and install wire ties at CL and CN as shown. Slide the wire tie under all of the wires at each location and pull it securely around the wires. Then cut off all but 1/4" of the excess tie lengths.

12 21.5
18 2×23.5
20 23

( ) Refer to Detail 8-2C and prepare the large paper insulator as follows:

1. Measure 1/2" from one end and cut lightly through the waxy paper on the back of the insulator.

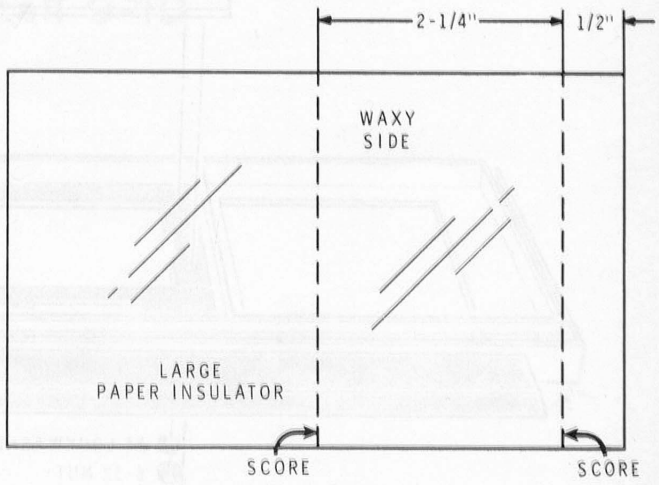
2. Measure an additional 2-1/4" and score the insulator once again.

3. At this 2-3/4" mark bend the insulator 90 degrees so the waxy paper is on the inside of the fold.

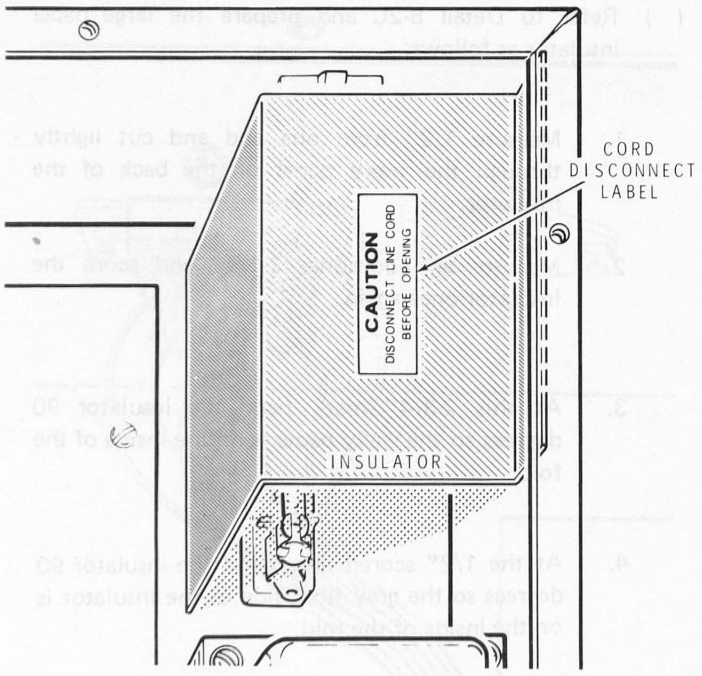
4. At the 1/2" scored line, bend the insulator 90 degrees so the gray fiber side of the insulator is on the inside of the fold.

5. Remove the paper backing from the 1/2" area just folded.

( ) Press this paper insulator into the upper right rear panel of the cabinet. Be sure the narrow sticky portion of the insulator is against the top edge of the panel along its entire width. Tuck the free end down between the wires and cables and the fuseholder as shown in Detail 8-2D on the next page.




**Detail 8-2C**




Detail 8-2D

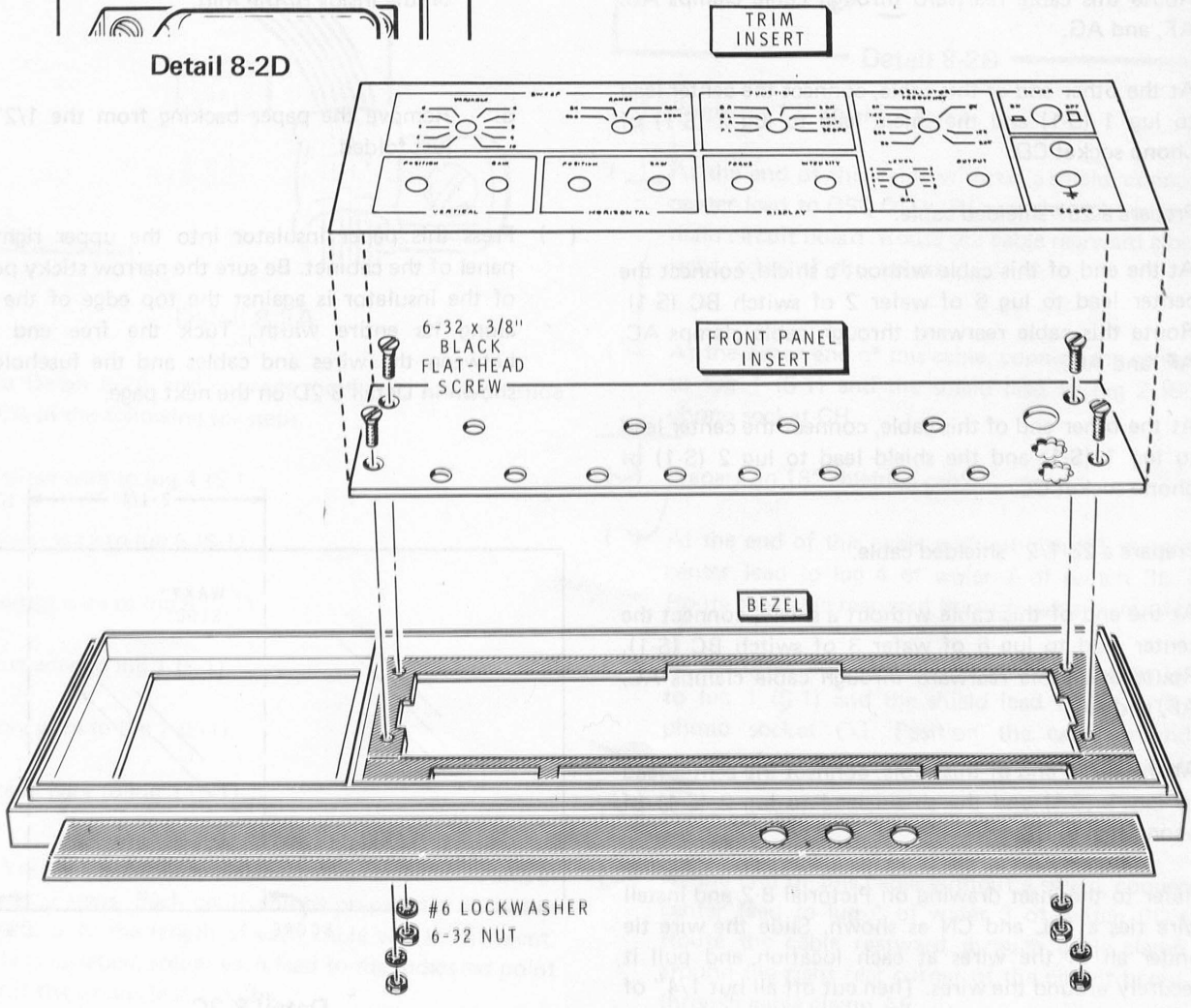
( ) Remove the paper backing from the Cord Disconnect label and press the label in place on the top of the insulator as shown in Detail 8-2D.

## BEZEL ASSEMBLY

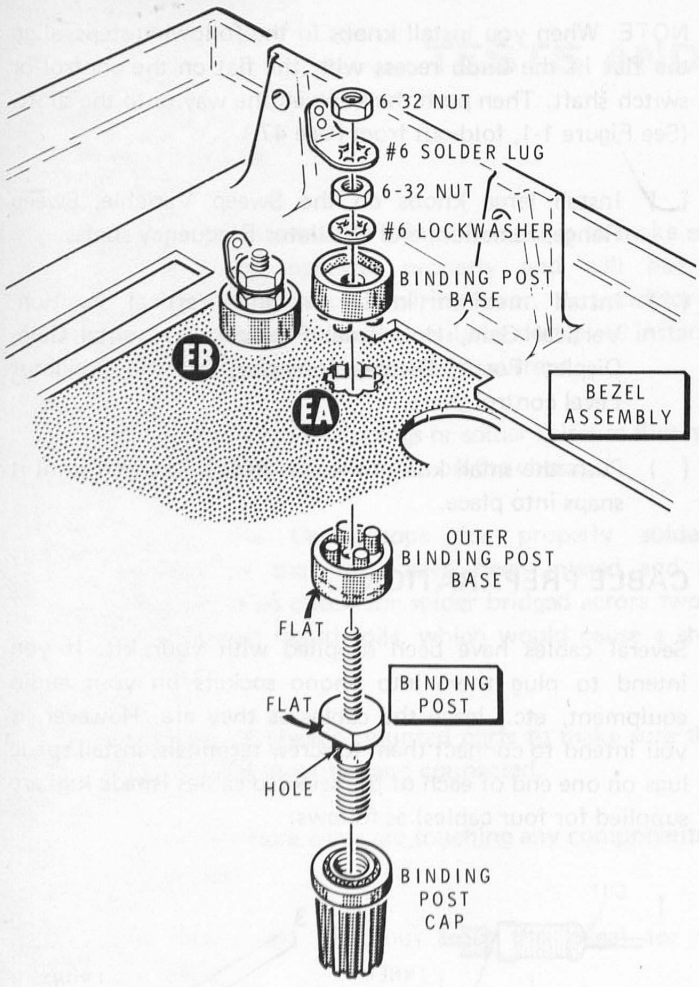
Refer to Pictorial 9-1 (fold-out from Page 45) for the following steps.

( ) Refer to Detail 9-1A and mount the front panel insert in the bezel with four 6-32 x 3/8" black flat-head screws, four #6 lockwashers, and four 6-32 nuts.

( ) Remove the protective covering from each side of the trim insert and carefully press the insert in place on the front panel as shown in Pictorial 9-1 and Detail 9-1A.




Detail 9-1A




**Detail 9-1B**

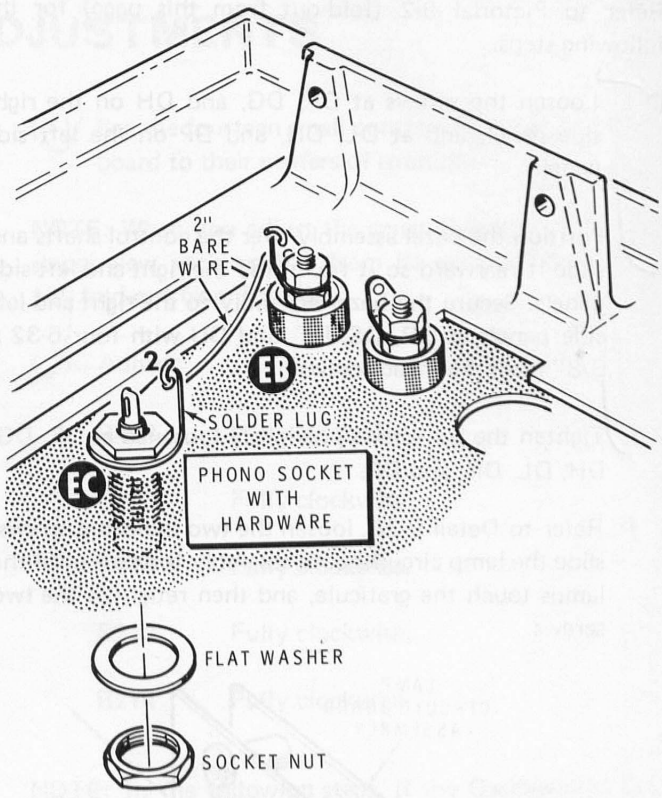
Refer to Detail 9-1B and mount two scope input jacks in the following steps.

( ) Mount a binding post in a binding post base and place it into the opening at EA in the bezel assembly. Place another binding post base on the inside of the panel and turn it so the small tabs fit into the holes. Secure the assembly to the panel with a #6 lockwasher and a 6-32 nut. Be sure the flat on the binding post fits the flat recess in the outer binding post base and the hole in the binding post is as shown.

( ) Place a #6 solder lug on the binding post shank and secure it with a second 6-32 nut. Position the solder lug as shown in the Detail.

( ) In the same manner, mount another binding post at EB with two binding post bases, a #6 lockwasher, a #6 solder lug, and two 6-32 nuts.

( ) Turn two binding post caps onto the binding posts at EA and EB.




**Detail 9-1C**

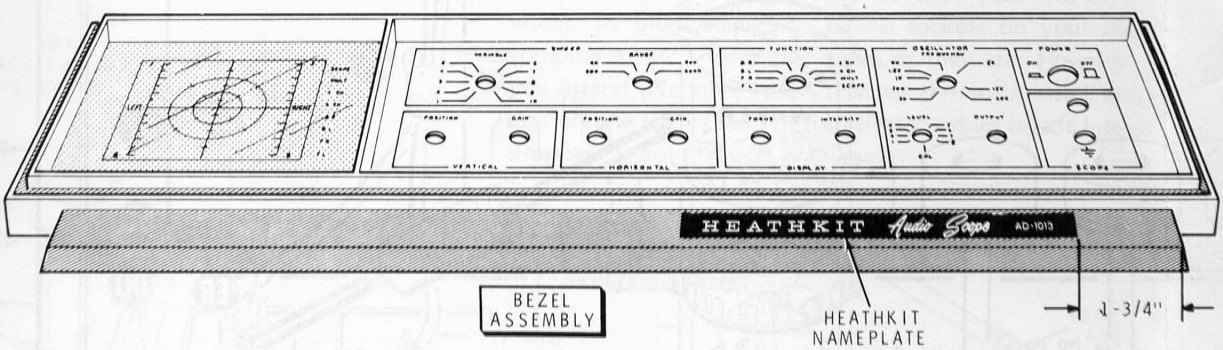
( ) Refer to Detail 9-1C and mount the phono-socket-with-hardware. Place the solder lug on the socket, push the socket through hole EC from the inside of the panel, and secure the socket to the panel with the flat washer and the socket nut supplied. Position the solder lug as shown.

( ) Remove the insulation from a 2" length of wire (any color). Connect this wire from lug 2 of phono socket EC (S-1) to the solder lug on binding post EB (NS).

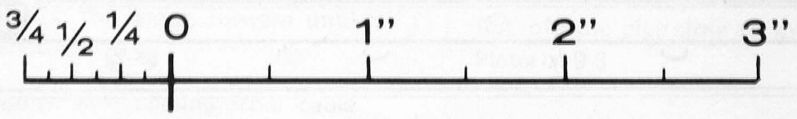
( ) Remove the protective covering from each side of the "Heathkit" nameplate and press the nameplate on the bezel assembly 1-3/4" from the end as shown in the Pictorial. Be sure it covers the three holes in the bezel.

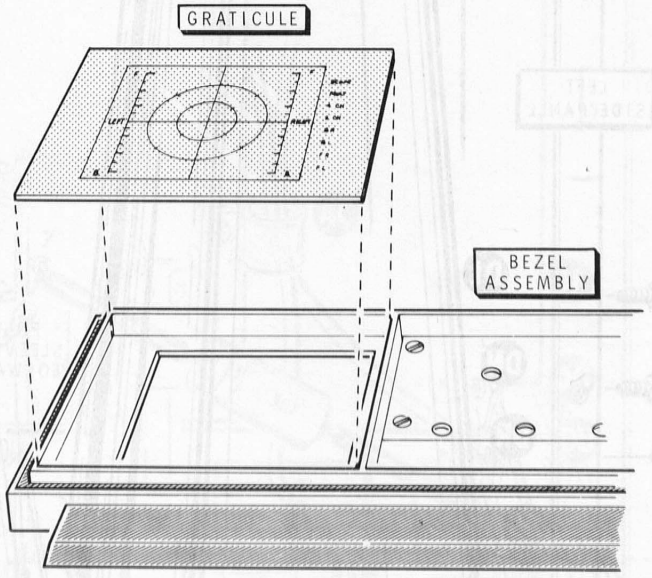
NOTE: The graticule that will be installed in the following step may have a paper backing on both sides. When you are instructed to remove the paper backing, remove it from both sides of the graticule (if it is on both sides).

( ) Refer to Detail 9-1D and remove the paper backing from the graticule. Press the graticule in place on the bezel assembly as shown. Position the graticule upright in its opening as shown in the Pictorial.

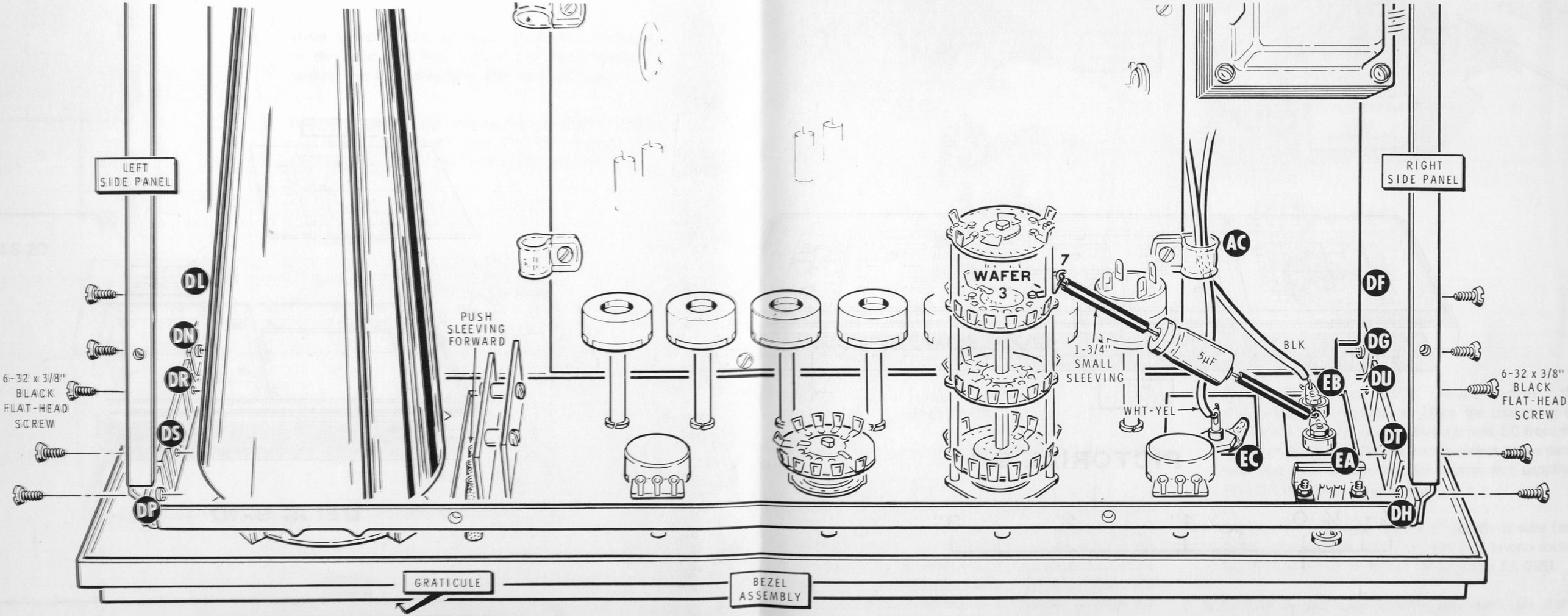



**PICTORIAL 9-1**






**Detail 9-1D**




**PICTORIAL 9-2**

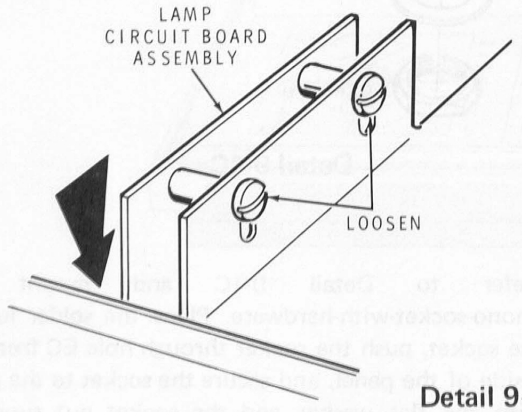
Refer to Pictorial 9-2 (fold-out from this page) for the following steps.

( ) Loosen the screws at DF, DG, and DH on the right side panel, and at DL, DN, and DP on the left side panel.

( ) Position the bezel assembly over the control shafts and slide it rearward so it fits inside the right and left side panels. Secure the bezel assembly to the right and left side panels at DR, DS, DT, and DU with four 6-32 x 3/8" black flat-head screws.

( ) Tighten the six screws previously loosened at DF, DG, DH, DL, DN, and DP.

( ) Refer to Detail 9-2A, loosen the two indicated screws, slide the lamp circuit board assembly forward until the lamps touch the graticule, and then retighten the two screws.




Detail 9-2A

( ) Refer to Pictorial 9-2 and (with a screwdriver) push the lengths of sleeving, on the lamps, forward until they just touch the graticule.

( ) Connect the white-yellow wire coming from cable clamp AC to phono socket EC (S-1).

( ) Connect the black wire coming from cable clamp AC to scope jack solder lug EB (S-2).

( ) Cut one lead of the 5 $\mu$F nonpolarized electrolytic capacitor to 2".

( ) Cut two 1-3/4" pieces of small sleeving. Place one length of sleeving on each lead of the 5 $\mu$F capacitor.

( ) Connect the lead from either end of the 5 $\mu$F electrolytic capacitor to lug 7 of wafer 3 of switch BC (S-1). Connect the other lead of the capacitor to the solder lug on binding post EA (S-1). Cut off the excess lead length.

NOTE: When you install knobs in the following steps, align the flat in the knob recess with the flat on the control or switch shaft. Then push the knob all the way onto the shaft. (See Figure 1-1, fold-out from Page 47.)

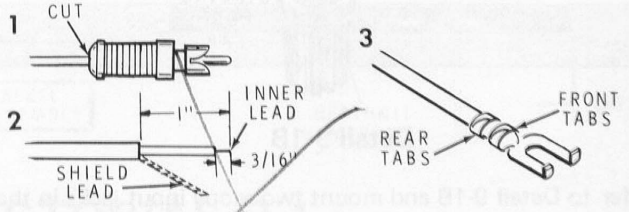
( ) Install large knobs on the Sweep Variable, Sweep Range, Function, and Oscillator Frequency shafts.

( ) Install medium knobs on the Vertical Position, Vertical Gain, Horizontal Position, Horizontal Gain, Display Focus, Display Intensity, and the Oscillator Level control shafts.

( ) Push the small knob onto the POWER switch until it snaps into place.

## CABLE PREPARATION

Several cables have been supplied with your kit. If you intend to plug them into phono sockets on your audio equipment, etc., leave the cables as they are. However, if you intend to connect them to screw terminals, install spade lugs on one end of each of the selected cables (spade lugs are supplied for four cables) as follows:




PICTORIAL 9-3

( ) Cut off the plug close to the body of the plug. See Pictorial 9-3.

( ) Remove 1" of outer insulation and then 3/16" of insulation from the inner lead.

( ) Twist together the fine wire strands and apply a small amount of solder to hold them together.

( ) Bend the front tabs of a spade lug over the bare wire end of the inner lead and solder the connection. Then, after the lug cools, bend the rear tabs over the insulation.

( ) In a similar manner, install a spade lug on the shield lead.

This completes the "Step-by-Step Assembly" of your Audio Oscilloscope. Proceed to the "Tests and Adjustments."

# TESTS AND ADJUSTMENTS

## INITIAL TESTS

The purpose of this section of the Manual is to make sure your Oscilloscope operates properly and will not be damaged as the result of a wiring error. A transistor or integrated circuit, for example, could be destroyed instantly by a short circuit that causes excessive current.

( ) Remove any wire clippings or solder splashes that may have lodged in the wiring or on the chassis.

( ) Inspect the Oscilloscope for properly soldered connections that may have been missed and not soldered. Also check for solder bridged across two or more circuit board foils, which would cause a short circuit.

( ) Examine all chassis-mounted parts to make sure they are properly mounted and connected.

( ) Be sure no bare wires are touching any components or the chassis.

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

( ) Push the POWER switch to the OFF (out) position.

( ) Turn the FUNCTION switch (on the front panel) to 2 CH.

( ) Turn the INTENSITY control (on the front panel) fully clockwise.

( ) Turn the VERTICAL and HORIZONTAL GAIN controls (on the front panel) fully counterclockwise. See Figure 1-1.

( ) Set the fourteen small controls mounted on the circuit board to their centers of rotation.

NOTE: When you adjust the small controls in the following steps, view each control from its plastic side. (See Figure 1-2, fold-out from Page 49.)

( ) Adjust:

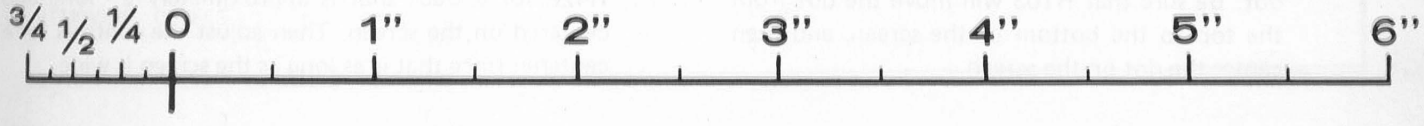
| | |
|---|---|
| R428 | Fully clockwise. |
| R205 | Fully clockwise. |
| R211 | Fully clcokwise. |
| R213 | Fully clockwise. |
| R214 | Fully clockwise. |

NOTE: In the following steps, if the Oscilloscope does not operate as described, immediately unplug the line cord and refer to the "In Case of Difficulty" section of the Manual on Page 62. Then correct the problem before you proceed with the "Initial Tests."

***CAUTION: High voltages are exposed in the Oscilloscope when the line cord is plugged into an AC outlet. Refer to the "Chassis Photographs" on Page 73 for the location of these high voltage areas.***

( ) Plug the line cord into an AC outlet of the proper voltage (120 or 240 VAC, depending upon the connection of the power transformer) and push the POWER switch to the ON position. A dot may or may not appear on the screen after a couple of minutes. The 2 CH Function Lamp should light.

( ) Turn the POWER switch off.



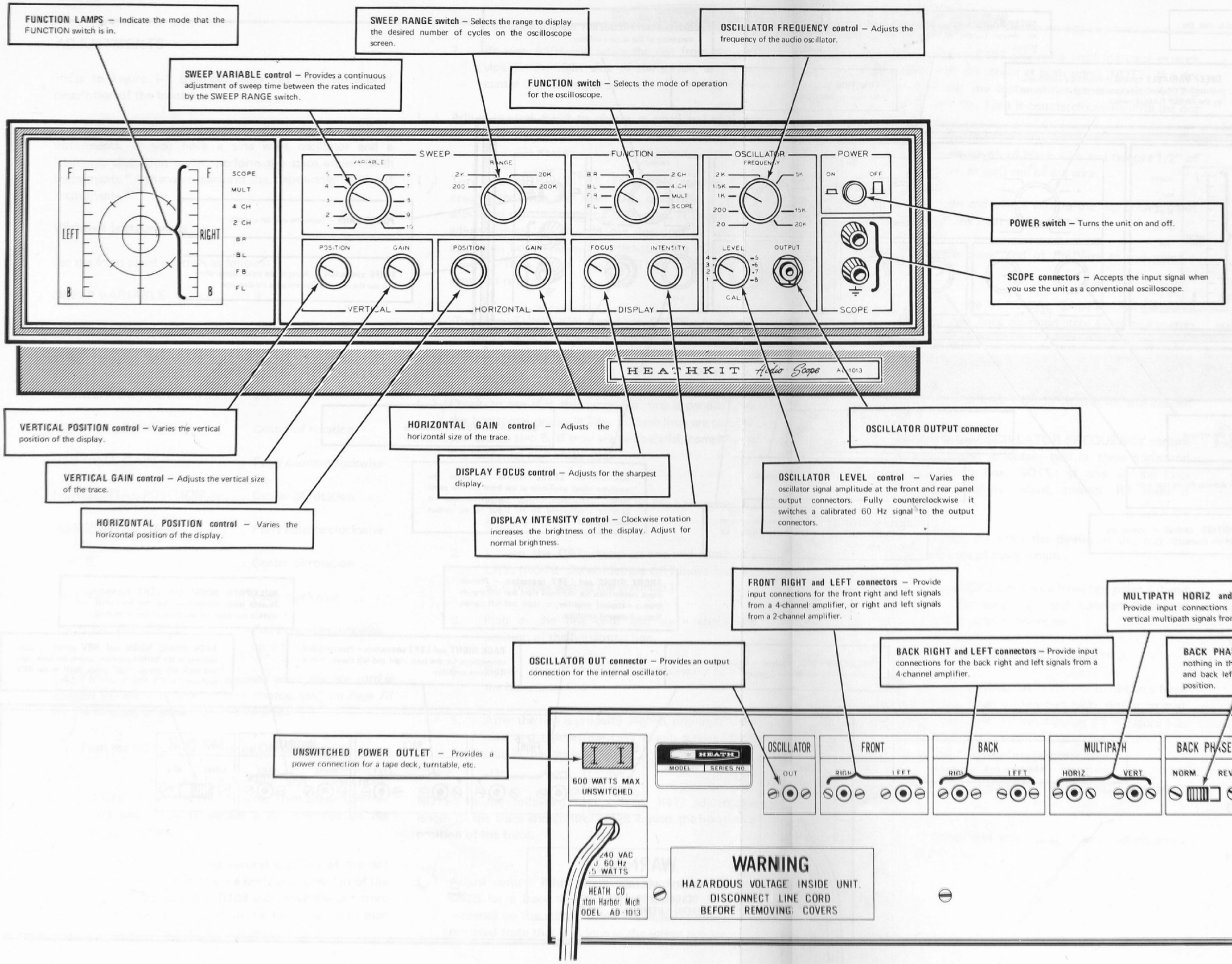

FUNCTION LAMPS – Indicate the mode that the FUNCTION switch is in.
SWEEP RANGE switch – Selects the range to display the desired number of cycles on the oscilloscope screen.
OSCILLATOR FREQUENCY control – Adjusts the frequency of the audio oscillator.
SWEEP VARIABLE control – Provides a continuous adjustment of sweep time between the rates indicated by the SWEEP RANGE switch.
FUNCTION switch – Selects the mode of operation for the oscilloscope.
POWER switch – Turns the unit on and off.
SCOPE connectors – Accepts the input signal when you use the unit as a conventional oscilloscope.
VERTICAL POSITION control – Varies the vertical position of the display.
HORIZONTAL GAIN control – Adjusts the horizontal size of the trace.
OSCILLATOR OUTPUT connector
VERTICAL GAIN control – Adjusts the vertical size of the trace.
DISPLAY FOCUS control – Adjusts for the sharpest display.
OSCILLATOR LEVEL control – Varies the oscillator signal amplitude at the front and rear panel output connectors. Fully counterclockwise it switches a calibrated 60 Hz signal to the output connectors.
HORIZONTAL POSITION control – Varies the horizontal position of the display.
DISPLAY INTENSITY control – Clockwise rotation increases the brightness of the display. Adjust for normal brightness.
FRONT RIGHT and LEFT connectors – Provide input connections for the front right and left signals from a 4-channel amplifier, or right and left signals from a 2-channel amplifier.
MULTIPATH HORIZ and VERT connectors – Provide input connections for the horizontal and vertical multipath signals from a tuner or receiver.
BACK RIGHT and LEFT connectors – Provide input connections for the back right and left signals from a 4-channel amplifier.
BACK PHASE NORM and REV switch – Does nothing in the NORM position. Inverts the back right and back left signals (180° phase shift) in the REV position.
OSCILLATOR OUT connector – Provides an output connection for the internal oscillator.
UNSWITCHED POWER OUTLET – Provides a power connection for a tape deck, turntable, etc.
SWEEP
VARIABLE
RANGE
FUNCTION
OSCILLATOR
FREQUENCY
POWER
ON
OFF
SCOPE
MULT
4 CH
2 CH
BR
BL
FR
FL
LEFT
RIGHT
POSITION
GAIN
FOCUS
INTENSITY
LEVEL
OUTPUT
CAL
VERTICAL
HORIZONTAL
DISPLAY
HEATHKIT Audio Scope AD-1013
600 WATTS MAX UNSWITCHED
MODEL
SERIES NO.
OSCILLATOR
OUT
FRONT
BACK
MULTIPATH
HORIZ
VERT
BACK PHASE
NORM
REV
WARNING
HAZARDOUS VOLTAGE INSIDE UNIT.
DISCONNECT LINE CORD
BEFORE REMOVING COVERS

**Figure 1-1**

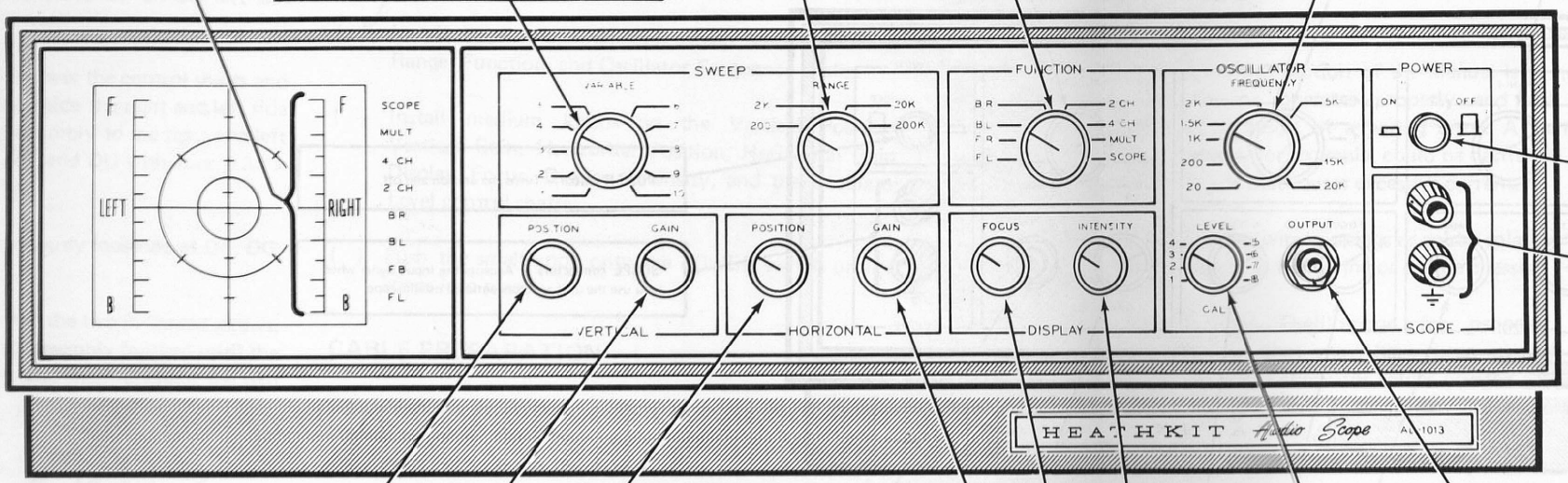
**FUNCTION LAMPS** – Indicate the mode that the FUNCTION switch is in.

**SWEEP RANGE switch** – Selects the range to display the desired number of cycles on the oscilloscope screen.

**OSCILLATOR FREQUENCY control** – Adjusts the frequency of the audio oscillator.

**SWEEP VARIABLE control** – Provides a continuous adjustment of sweep time between the rates indicated by the SWEEP RANGE switch.

**FUNCTION switch** – Selects the mode of operation for the oscilloscope.




**POWER switch** – Turns the unit on and off.

**SCOPE connectors** – Accepts the input signal when you use the unit as a conventional oscilloscope.

**VERTICAL POSITION control** – Varies the vertical position of the display.

**VERTICAL GAIN control** – Adjusts the vertical size of the trace.

**HORIZONTAL POSITION control** – Varies the horizontal position of the display.

**HORIZONTAL GAIN control** – Adjusts the horizontal size of the trace.

**DISPLAY FOCUS control** – Adjusts for the sharpest display.

**DISPLAY INTENSITY control** – Clockwise rotation increases the brightness of the display. Adjust for normal brightness.

**OSCILLATOR OUTPUT connector**

**OSCILLATOR LEVEL control** – Varies the oscillator signal amplitude at the front and rear panel output connectors. Fully counterclockwise it switches a calibrated 60 Hz signal to the output connectors.

**FRONT RIGHT and LEFT connectors** – Provide input connections for the front right and left signals from a 4-channel amplifier, or right and left signals from a 2-channel amplifier.

**MULTIPATH HORIZ and VERT connectors** – Provide input connections for the horizontal and vertical multipath signals from a tuner or receiver.

**BACK RIGHT and LEFT connectors** – Provide input connections for the back right and left signals from a 4-channel amplifier.

**BACK PHASE NORM and REV switch** – Does nothing in the NORM position. Inverts the back right and back left signals (180° phase shift) in the REV position.

**OSCILLATOR OUT connector** – Provides an output connection for the internal oscillator.

**UNSWITCHED POWER OUTLET** – Provides a power connection for a tape deck, turntable, etc.

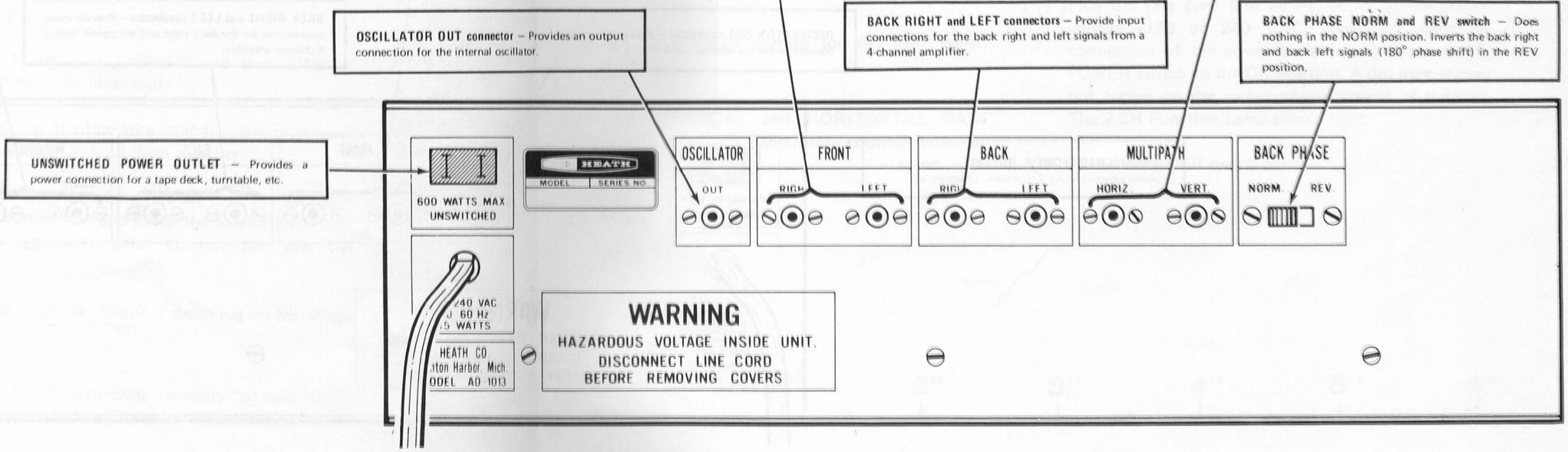



**Figure 1-1**

## ADJUSTMENTS

Refer to Figure 1-1 (fold-out from this page) for a brief description of the front panel controls.

The following adjustments can be done with or without instruments. If you have a sine wave oscillator and a harmonic distortion meter, perform the steps under "With Instruments." Otherwise, perform the steps under "Without Instruments."

### Without Instruments

Set the front panel controls as follows:

| | |
|---|---|
| SWEEP VARIABLE | 6 |
| SWEEP RANGE | 200 |
| FUNCTION | 2 CH |
| OSCILLATOR FREQUENCY | 2K |
| VERTICAL POSITION | Center of rotation |
| VERTICAL GAIN | Fully counterclockwise |
| HORIZONTAL POSITION | Center of rotation |
| HORIZONTAL GAIN | Fully counterclockwise |
| FOCUS | Center of rotation |
| INTENSITY | Fully clockwise |
| OSCILLATOR LEVEL | Fully counterclockwise until it clicks |

*CAUTION: High voltages are exposed when the line cord is plugged in. Refer to the "Chassis Photograph" on Page 73 for the location of these high voltage areas.*

( ) Push the POWER switch to the ON position.

( ) Be sure the HORIZONTAL and VERTICAL POSITION controls are centered. Then adjust controls R103 and R154 to obtain a dot centered on the screen, as follows:

1. R103 controls the vertical position of the dot and R154 controls the horizontal position of the dot. Be sure that R103 will move the dot from the top to the bottom of the screen, and then center the dot on the screen.
2. Be sure R154 will move the dot from the left side to the right side of the screen, and then center the dot on the screen.

( ) Adjust control R108 to obtain as small and round a dot as possible.

( ) Turn the HORIZONTAL POSITION control fully counterclockwise and then fully clockwise. The dot should go off the screen on both sides. If it does not, adjust control R159 until the dot does go off the screen on both sides when you rotate the POSITION control. Then return the POSITION control to its center of rotation.

( ) Turn the FUNCTION switch to SCOPE. A flashing horizontal line should appear on the screen with a dot superimposed near the center of the line.

( ) Check to see that the horizontal line is parallel with the horizontal graticule line. 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 line and unplug the line cord.
2. Loosen the CRT clamp screws and rotate the CRT. (NOTE: Do not let the CRT move forward so it presses against the graticule.)
3. Plug in the line cord and again check the position of the horizontal line.
4. Repeat steps 1 through 3 as necessary to align the horizontal line.
5. After the line is properly aligned, unplug the line cord and tighten the CRT clamp screws. Then plug in the line cord again.

NOTE: In the following step, control R427 adjusts the length of the trace and control R428 adjusts the horizontal position of the trace.

( ) Adjust control R427 (counterclockwise) and control R428 for a trace that is approximately 2" long and centered on the screen. Then adjust the controls for a centered trace that is as long as the screen is wide.

( ) Turn control R427 clockwise until the trace extends slightly off the screen at both sides. (NOTE: If a dot appears near the center of the trace, control R427 is turned too far. Turn it counterclockwise until the dot disappears.)

( ) Cut a 2-foot length of black wire and remove 1/2" of insulation from each end of the wire.

( ) Connect one end of the wire to the top SCOPE input connector. See inset drawing #1.

( ) Connect the other end of the wire to test point 1 (TP1).

( ) Slowly turn the VERTICAL GAIN control clockwise to obtain two lines approximately three centimeters apart on the screen.

( ) Adjust control R503 for the clearest lines.

( ) Adjust the DISPLAY FOCUS control for the clearest lines.

( ) Slowly turn the OSCILLATOR FREQUENCY control counterclockwise to obtain two or three horizontal dashes in each line. NOTE: If one of the lines disappears, carefully adjust control R7 until it reappears.

( ) Adjust control R7 until the dashes in the top and bottom lines are of equal length.

( ) Remove the SCOPE input wire from test point 1, bend a hook in the wire end, and connect it to the OSCILLATOR output connector.

( ) Set the OSCILLATOR LEVEL control to 3.

( ) Adjust the VERTICAL GAIN control to obtain a trace approximately three centimeters high, similar to that shown on the screen in inset drawing #2 in Figure 1-2.

( ) Set the SWEEP RANGE switch to 20K.

( ) Adjust the OSCILLATOR FREQUENCY control to 5K.

( ) Adjust controls R44 and R17 for the smoothest peaks on the waveform.

( ) Set the OSCILLATOR FREQUENCY control to 20K.

( ) Set the SWEEP VARIABLE control fully clockwise.

( ) If the trace is undistorted, proceed to the next step. However, if the left edge of the trace is distorted, adjust control R159 until the distortion is gone. Do not adjust the control any further than necessary.

( ) Remove the black wire from the Audio Oscilloscope.

( ) Turn off the Oscilloscope and unplug the line cord.

This completes the "Tests and Adjustments." Proceed to "Final Assembly."

## With Instruments

( ) Turn on your sine wave oscillator and harmonic distortion meter, and allow them to warm up.

**Set the front panel controls of your Audio Oscilloscope as follows:**

| | |
|---|---|
| SWEEP VARIABLE | Fully counterclockwise |
| SWEEP RANGE | 2K |
| FUNCTION | 2 CH |
| OSCILLATOR FREQUENCY | 20 |
| VERTICAL POSITION | Center of rotation |
| VERTICAL GAIN | Fully counterclockwise |
| HORIZONTAL POSITION | Center of rotation |
| HORIZONTAL GAIN | Fully counterclockwise |
| FOCUS | Center of rotation |
| INTENSITY | Fully clockwise |
| OSCILLATOR LEVEL | Full counterclockwise until it clicks |
| POWER | OFF |

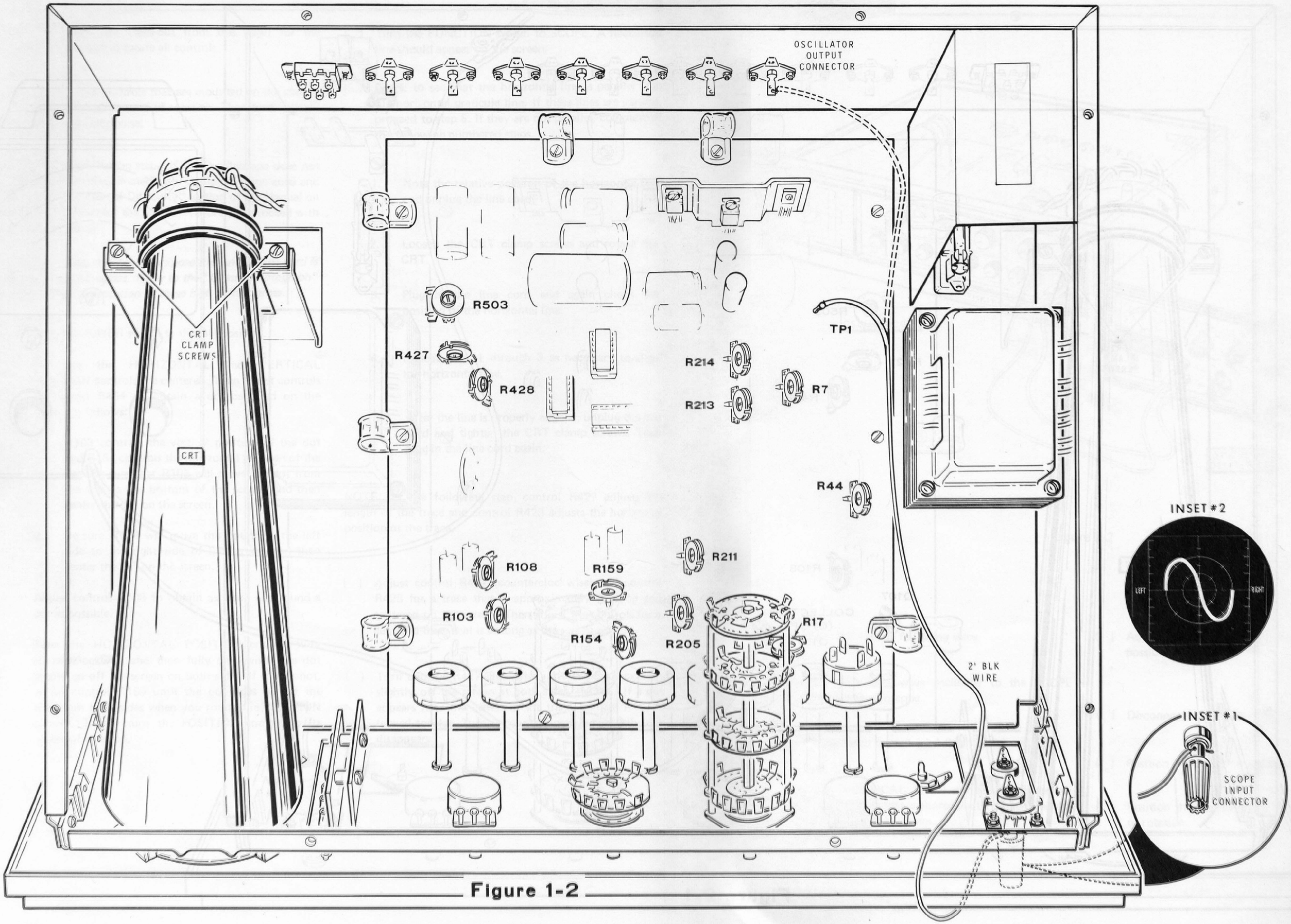

OSCILLATOR
OUTPUT
CONNECTOR
CRT
CLAMP
SCREWS
CRT
R503
R427
R428
R214
R213
R7
TP1
R44
R108
R159
R211
R103
R154
R205
R17
2' BLK
WIRE
INSET #2
LEFT
RIGHT
INSET #1
SCOPE
INPUT
CONNECTOR

**Figure 1-2**

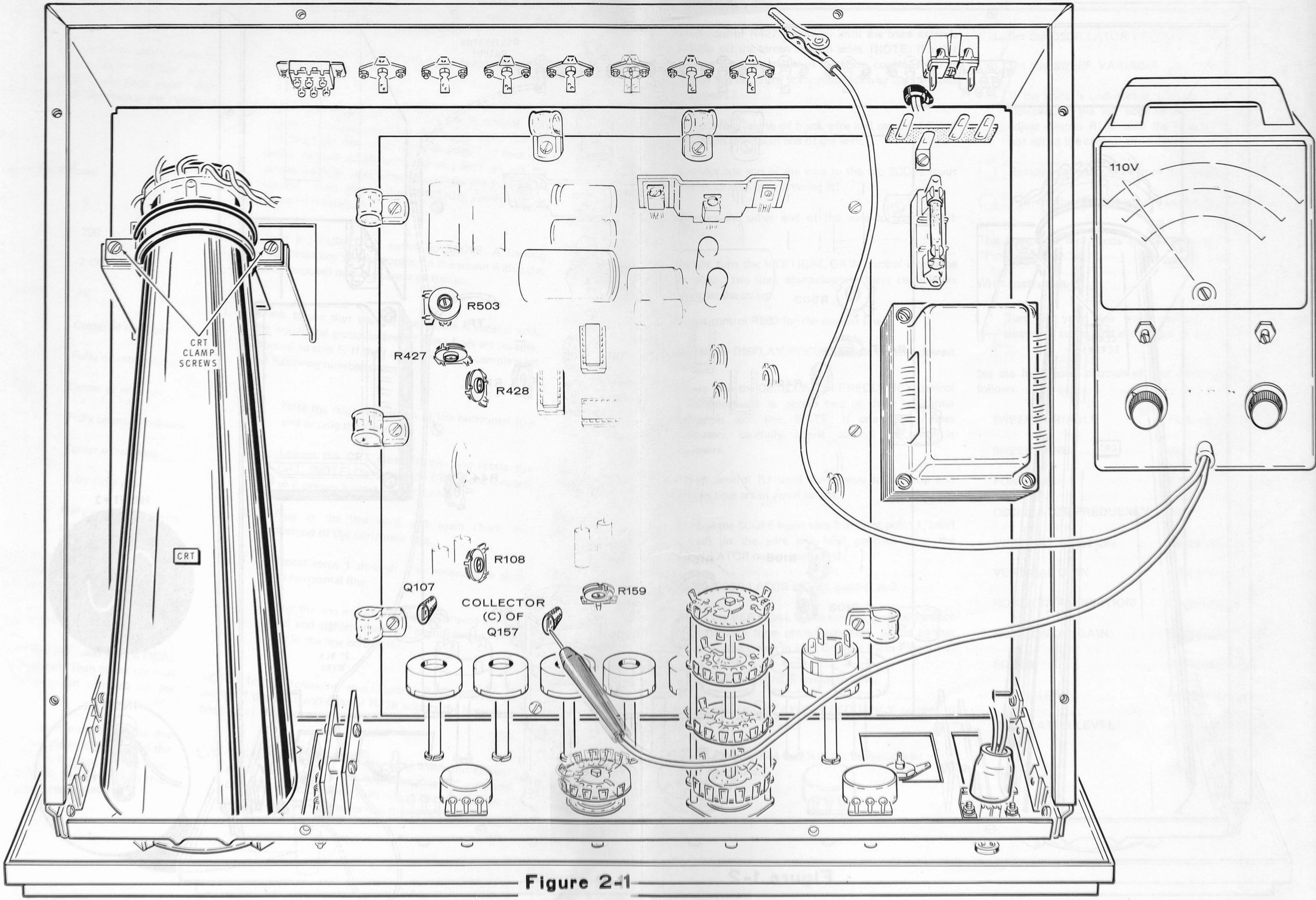

CRT
CLAMP
SCREWS
CRT
R503
R427
R428
R108
Q107
COLLECTOR
(C) OF
Q157
R159
110V

**Figure 2-1**

Refer to Figure 2-1 (fold-out from this page) for the following steps, and to locate all controls.

( ) Set the small controls that are mounted on the circuit board to their centers of rotation. Then turn control R428 fully clockwise.

NOTE: In the following steps, if the Oscilloscope does not operate as described, immediately unplug the line cord and refer to the "In Case of Difficulty" section of the Manual on Page 62. Then correct the problem before you proceed with the "Adjustments."

*CAUTION: High voltages are exposed when the line cord is plugged in an AC outlet. Refer to the "Chassis Photograph" on Page 73 for the location of these high voltage areas.*

( ) Push the POWER switch to the ON position.

( ) Be sure the HORIZONTAL and VERTICAL POSITION controls are centered. Then adjust controls R103 and R154 to obtain a dot centered on the screen, as follows:

1. R103 controls the vertical position of the dot and R154 controls the horizontal position of the dot. Be sure that R103 will move the dot from the top to the bottom of the screen, and then center the dot on the screen.

2. Be sure R154 will move the dot from the left side to the right side of the screen, and then center the dot on the screen.

( ) Adjust control R108 to obtain as small and round a dot as possible.

( ) Turn the HORIZONTAL POSITION control fully counterclockwise and then fully clockwise. The dot should go off the screen on both sides. If it does not, adjust control R159 until the dot does go off the screen on both sides when you rotate the POSITION control. Then return the POSITION control to its center of rotation.

( ) Turn the FUNCTION switch to SCOPE. A horizontal line should appear on the screen.

( ) Check to see that the horizontal line is parallel with the horizontal graticule line. 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 line and unplug the line cord.

2. Loosen the CRT clamp screws and rotate the CRT.

3. Plug in the line cord and again check the position of the horizontal line.

4. Repeat steps 1 through 3 as necessary to align the horizontal line.

5. After the line is properly aligned, unplug the line cord and tighten the CRT clamp screws. Then plug in the line cord again.

NOTE: In the following step, control R427 adjusts the length of the trace and control R428 adjusts the horizontal position of the trace.

( ) Adjust control R427 (counterclockwise) and control R428 for a trace that is approximately 2" long and centered on the screen. Then adjust the controls for a centered trace that is as long as the screen is wide.

( ) Turn control R427 clockwise until the trace extends slightly off the screen at both sides. (NOTE: If a dot appears near the center of the trace, control R427 is turned too far. Turn it counterclockwise until the dot disappears.)

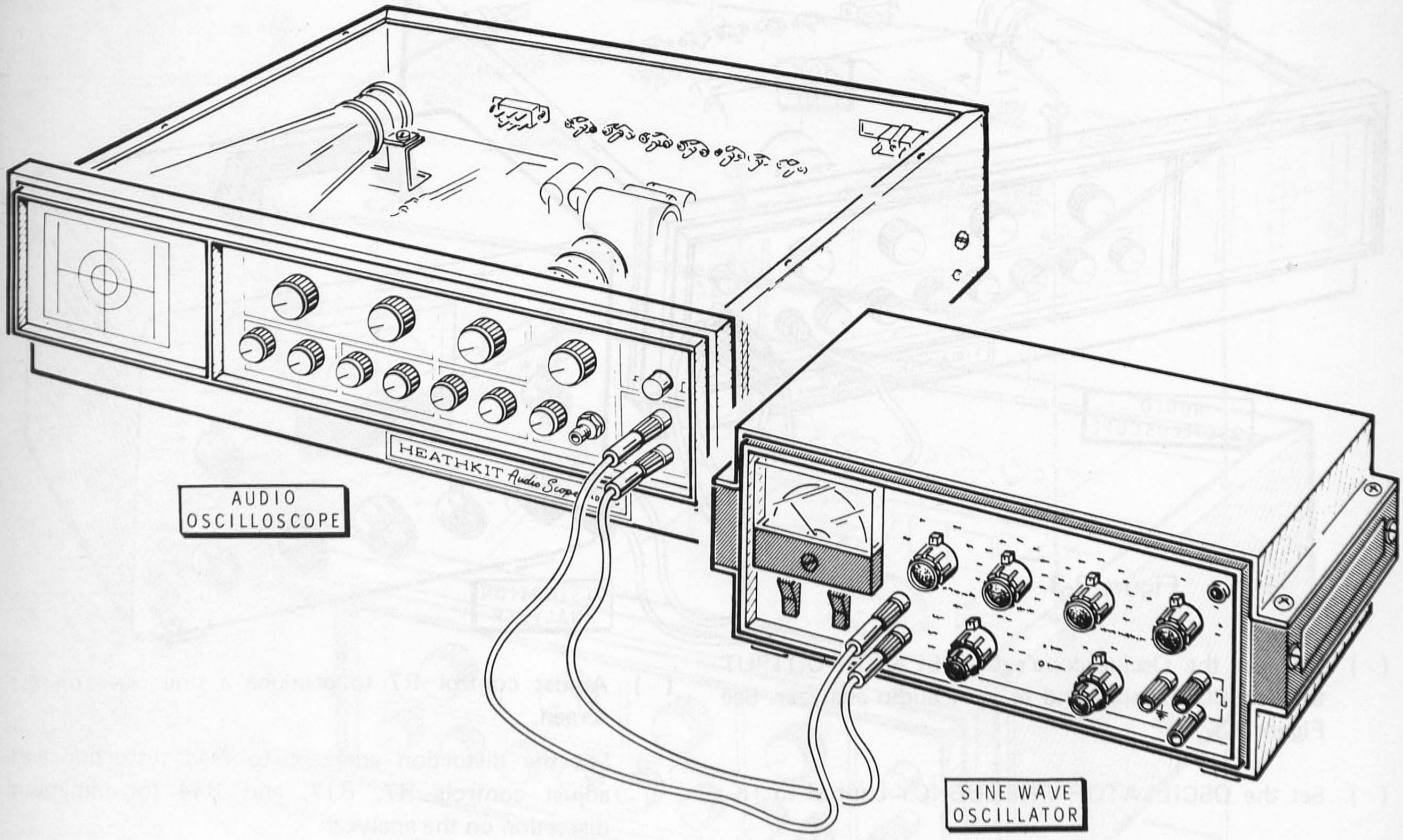



**Figure 2-2**

Refer to Figure 2-2 for the following steps.

( ) Connect your sine wave oscillator to the SCOPE inputs of the Oscilloscope.

( ) Set the oscillator output for 1,000 Hz at 1 volt rms.

( ) Turn the VERTICAL GAIN control clockwise to obtain a sine wave that is approximately 4 centimeters high on the screen, as shown.

( ) Adjust control R503 for as clear and sharp a trace as possible.

( ) Disconnect the sine wave oscillator.

( ) Position the SWEEP RANGE switch to 200.

( ) Position the SWEEP VARIABLE control to its center of rotation.

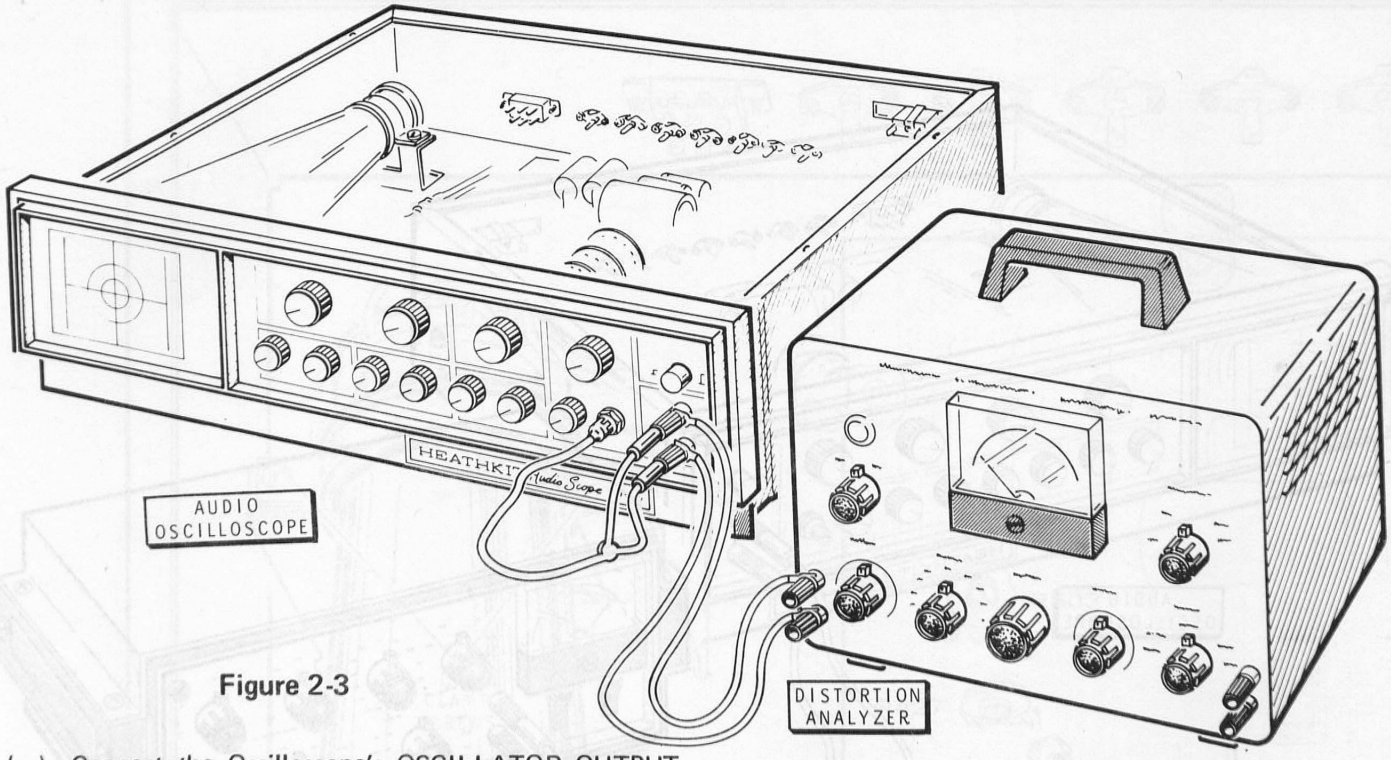



**Figure 2-3**

( ) Connect the Oscilloscope's OSCILLATOR OUTPUT to the SCOPE input and to your audio analyzer. See Figure 2-3.

( ) Set the OSCILLATOR FREQUENCY control to 1K.

( ) Turn the OSCILLATOR LEVEL control clockwise for a trace that is approximately three centimeters high.

( ) Adjust the OSCILLATOR FREQUENCY control on the Audio Oscilloscope for approximately a 20 Hz output.

( ) Adjust control R7 to produce a sine wave on the screen.

( ) Set the distortion analyzer to read distortion and adjust controls R7, R17, and R44 for minimum distortion on the analyzer.

( ) Turn off the equipment and unplug the line cord plugs.

( ) Disconnect the leads from the equipment.

This completes the "Tests and Adjustments."

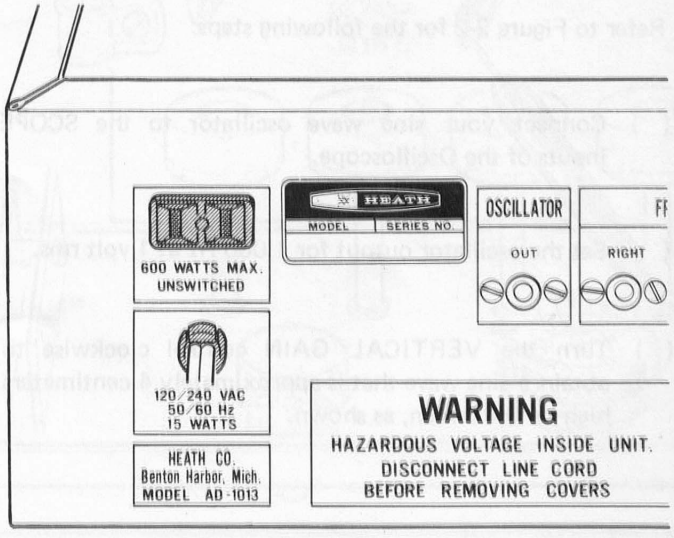
# FINAL ASSEMBLY

Refer to Pictorial 10-1 for the following steps.

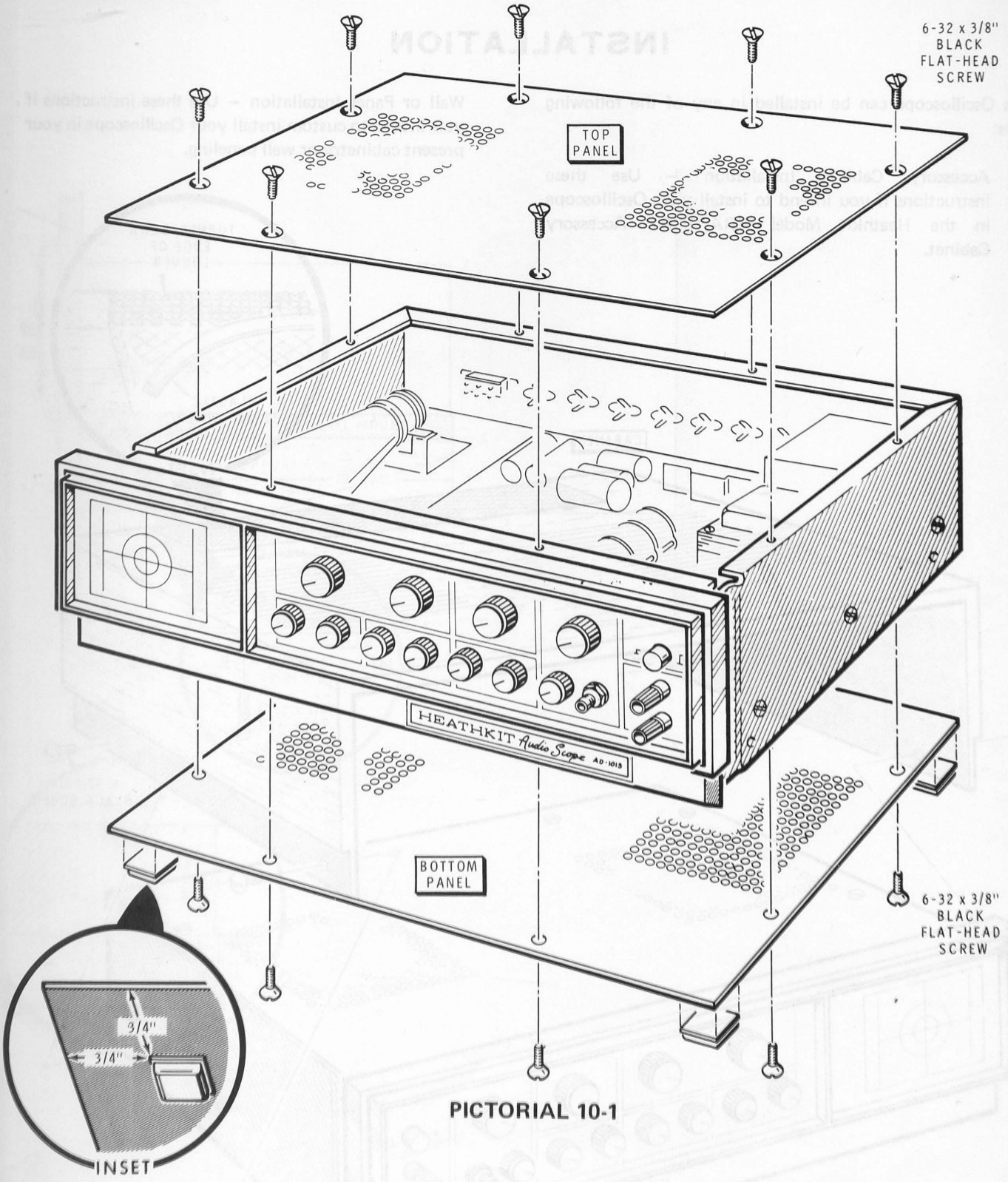
( ) Install the bottom panel on the underside of the cabinet assembly as shown. Use eight 6-32 x 3/8" black flat-head screws.

( ) Measure 3/4" inward from each edge of the cabinet corner. Remove the paper backing from each of the four feet and press them in place, as shown in the inset drawing, at the corners you have marked.

( ) Install the top panel. Use eight 6-32 x 3/8" black flat-head screws.




**Detail 10-1A**




**PICTORIAL 10-1**

( ) Remove the paper backing for the blue and white label. Then refer to Detail 10-1A and press the label in place near the AC socket on the rear panel. NOTE: The blue and white label shows the model number and production series number of your kit. Refer to these numbers in any communications you have with Heath Company about this kit; this assures you that you will receive the most complete and up-to-date information in return.

NOTE: Four 6-32 x 3/8" black screws should be left. Use these to install the cabinet if you choose this type of installation. See Page 54.

# INSTALLATION

This Oscilloscope can be installed in any of the following ways:

Accessory Cabinet Installation – Use these instructions if you intend to install your Oscilloscope in the Heathkit Model ARA-1500-1 Accessory Cabinet.

Wall or Panel Installation – Use these instructions if you intend to custom install your Oscilloscope in your present cabinetry or wall paneling.

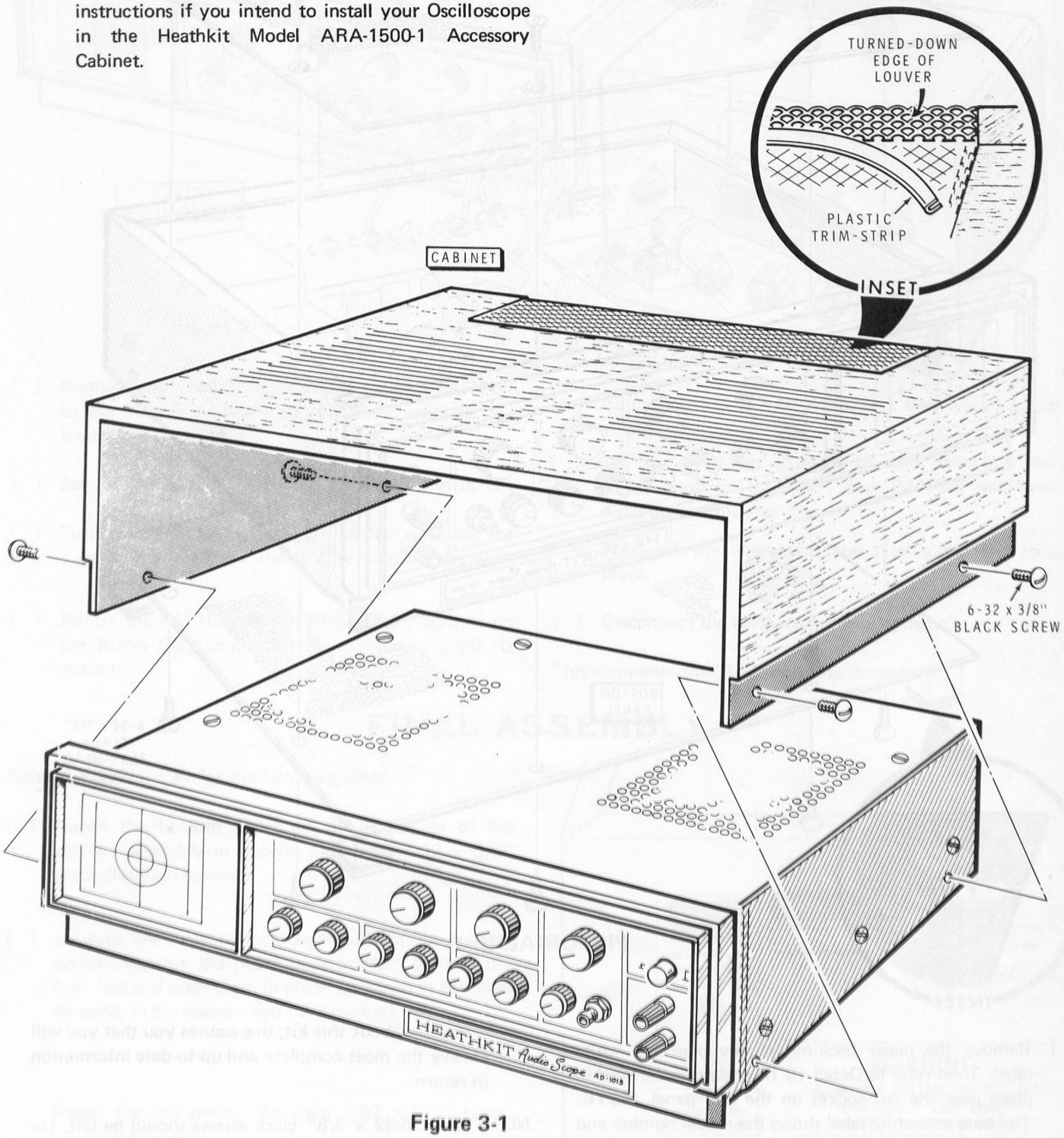



Figure 3-1

If you wish to set your Oscilloscope on a shelf as it is, without the cabinet, proceed to "Connecting the Oscilloscope to your System."

## ACCESSORY CABINET INSTALLATION

( ) Place soft cloth on your work area. Then position the cabinet upside down on the cloth.

Refer to Figure 3-1 for the following steps.

( ) Refer to the inset drawing and install the plastic trim strip, supplied with the cabinet, on the turned-up edge of the ventilating louver at the rear of the cabinet top. Start at one end and press the trim strip onto the entire length of the louver.

( ) Set the Oscilloscope right side up on your work area. Mount the cabinet on the Oscilloscope as shown using four 6-32 x 3/8" black screws.

This completes the "Accessory Cabinet Installation." Proceed to "Connecting the Oscilloscope to Your System."

## WALL OR PANEL INSTALLATION

When planning your installation, keep in mind that the Oscilloscope requires some ventilation and that the input sockets, output socket, and AC socket on the rear of the chassis must be accessible. The connecting cables should be long enough so they can be connected or disconnected when the Oscilloscope is removed from its installed position.

Figure 3-2 (fold-out from this page) shows a typical installation in a wall or panel. The Figure shows the dimensions of the panel cutout and the depth required behind the panel. The mounting board should be cut out to allow adequate ventilation through the holes in the Oscilloscope bottom plate. The method you use to secure the mounting board to the panel or wall area will depend on the specific conditions you encounter in your installation.

Proceed to "Connecting the Oscilloscope to Your System."

## CONNECTING THE OSCILLOSCOPE TO YOUR SYSTEM.

### Input Connections

For the rear panel connectors, use shielded cables with phono connectors on one end and appropriate connectors (phono connectors, spade lugs, alligator clips, etc.) on the other end to connect to the outputs of your system.

Also use shielded cable for the front panel oscilloscope (scope) input. You can use bare wire ends, banana plugs, or a dual banana plug to connect to the Oscilloscope. Use alligator clips on the other end of the cable.

For a complete system evaluation, the Front Left, Front Right, Back Left, and Back Right inputs of the Oscilloscope should be connected to the speaker terminals of the system under test. This insures that phase measurements will show what is actually being applied to the speakers. If you're sure the speakers are correctly connected to the amplifiers, the SCOPE inputs can be connected directly to the amplifiers.

CAUTION: It is important that the shield leads of the input cables go to the ground or common terminals of the system. If a shield lead were connected to a "hot" amplifier terminal, your system could be damaged.

If your amplifier has tape output amplifiers, you can connect the SCOPE inputs to the tape out connectors. This will allow you to monitor the system up to this point, but will not allow you to monitor the output to the speakers.

Your receiver or tuner may have multipath output connectors. In this case, connect the horizontal output of the receiver to the Multipath Horiz input of the Oscilloscope. Connect the vertical output of the receiver to the Multipath Vert input of the Oscilloscope.

You may want to permanently connect the oscillator to your system. Connect the rear panel oscillator output to any unused input of your system. Be sure the oscillator output level is not set so high that it will damage your equipment.

### 120 VAC Unswitched Outlet

This outlet supplies power (600 watts maximum) to a receiver, record changer, tape deck, etc.

NOTE: If your Oscilloscope is wired for 240 volt AC operation, the voltage at the outlet will be 240 volts AC.

This completes the "Installation" of your Oscilloscope.

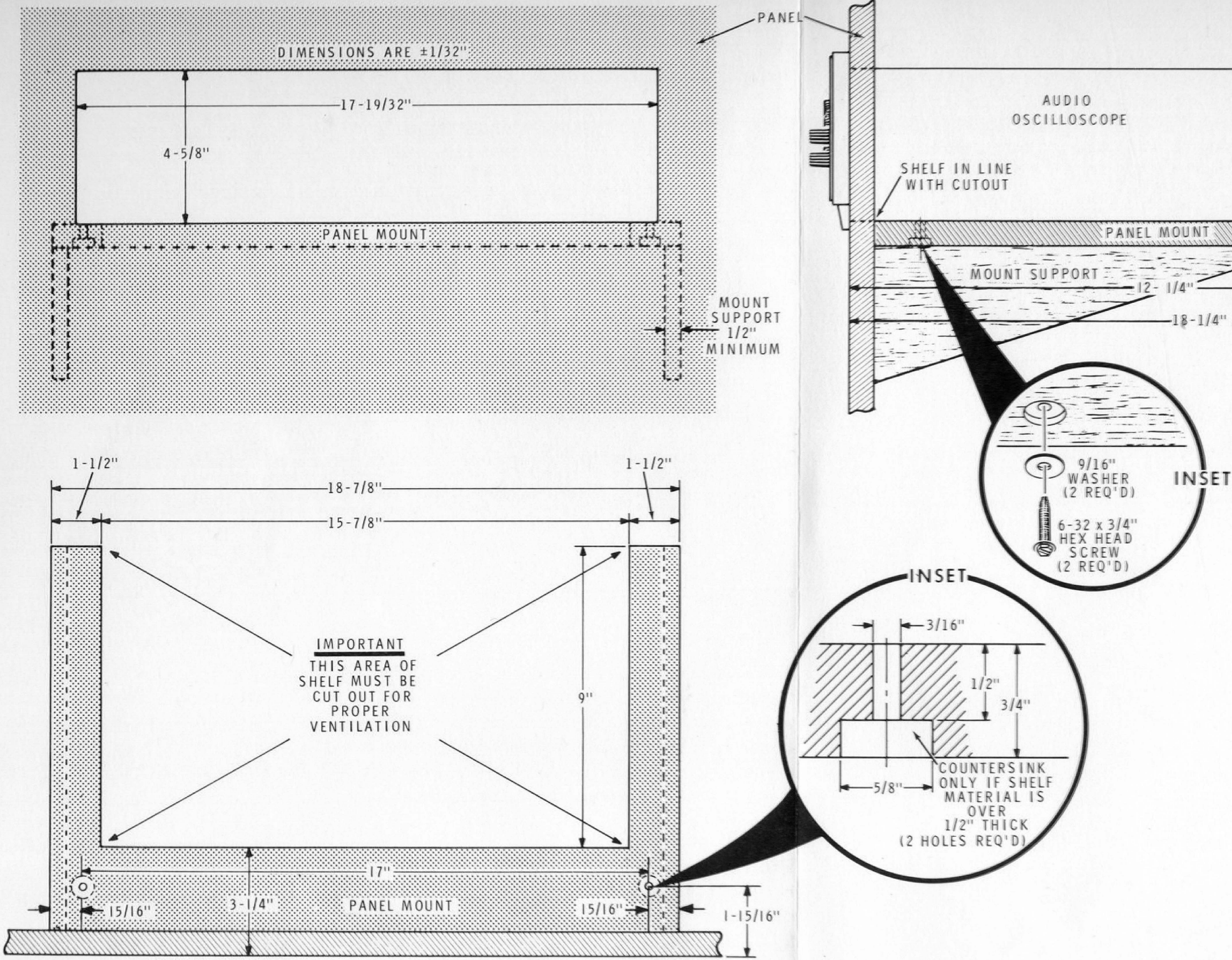

DIMENSIONS ARE ±1/32"
17-19/32"
4-5/8"
PANEL MOUNT
PANEL
MOUNT SUPPORT 1/2" MINIMUM
1-1/2"
1-1/2"
18-7/8"
15-7/8"
IMPORTANT
THIS AREA OF SHELF MUST BE CUT OUT FOR PROPER VENTILATION
9"
17"
15/16"
3-1/4"
PANEL MOUNT
15/16"
1-15/16"
AUDIO OSCILLOSCOPE
SHELF IN LINE WITH CUTOUT
PANEL MOUNT
MOUNT SUPPORT
12-1/4"
18-1/4" MINIMUM
9/16" WASHER (2 REQ'D)
6-32 x 3/4" HEX HEAD SCREW (2 REQ'D)
INSET
INSET
3/16"
1/2"
3/4"
5/8"
COUNTERSINK ONLY IF SHELF MATERIAL IS OVER 1/2" THICK (2 HOLES REQ'D)

**Figure 3-2**

# OPERATION AND APPLICATIONS

Always observe the following precautions when you use your Audio Oscilloscope.

1. Never connect the oscilloscope ground leads to the "hot" terminals of the amplifier.

2. Never apply more than 100 volts DC to the front panel oscilloscope input connectors.

3. Never connect the oscillator output directly to a point that has greater than 15 volts DC on it.

4. When you make full power tests on an amplifier, use noninductive resistance loads unless you know for sure that your speakers can handle the power developed by your amplifier.

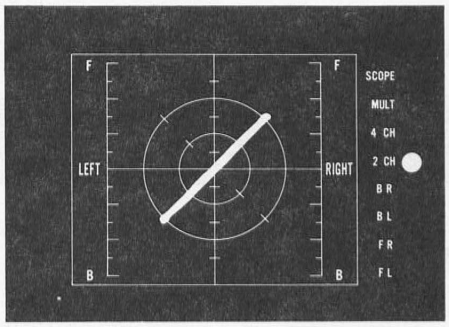
WARNING: Be careful when using the oscillator in the Audio Oscilloscope as a signal source for your system. The oscillator signal is continuous and may cause the amplifier to operate at its full rated RMS power. This may damage your speakers. Also, the oscillator can generate frequencies above the hearing range. Therefore, if the oscillator was set at 20 kHz, you could turn up the amplifier volume control to hear the signal and destroy the high frequency section of your speaker system and not know it.

Refer to Figure 1-1 (fold-out from Page 48) for a brief description of each control function.

## FUNCTION SWITCH

When the FUNCTION switch is in the FL, FR, BL, BR, or SCOPE position; the Oscilloscope operates as a standard oscilloscope. The internal sweep circuits are activated and any signal in the range of 10 Hz to 200 kHz can be displayed on the oscilloscope screen using the SWEEP, VERTICAL, HORIZONTAL, and DISPLAY controls.

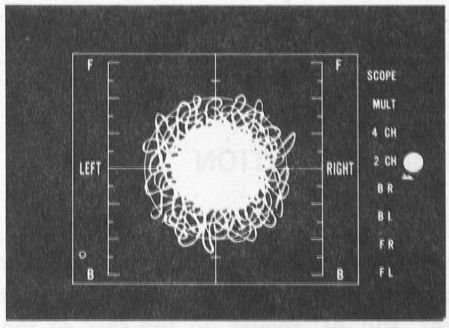
In the 2 CH (2-channel) position, the internal sweep circuits are turned off. The front left signal is coupled through the VERTICAL GAIN control, and the front right signal is coupled through the HORIZONTAL GAIN control. With a monaural signal applied to both channels, adjust the VERTICAL and HORIZONTAL GAIN and POSITION control to obtain the following display.




MONAURAL

Figure 4-1

With a stereo signal applied, the display will tend to become a fuzzy ball in the center of the screen. The rounder and fuller the ball, the better the separation.




STEREO

Figure 4-2

In the 4 CH (4-channel) position, the FRONT RIGHT, FRONT LEFT, BACK RIGHT, and BACK LEFT inputs (on the rear panel) are internally decoded and connected to the VERTICAL and HORIZONTAL GAIN controls. With the GAIN controls set at equal levels, the following displays can be seen.

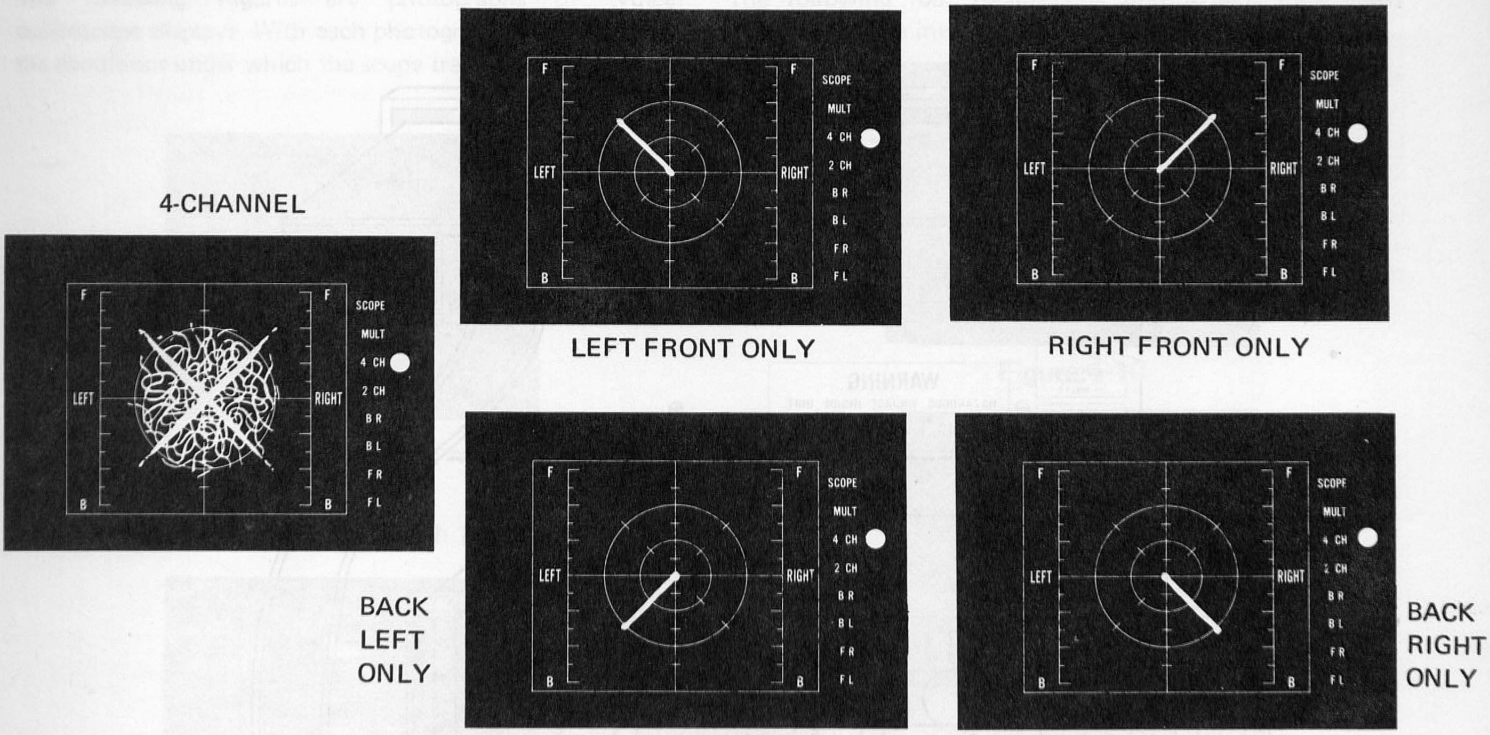



**Figure 4-3**

With a stereo signal to the FRONT RIGHT and FRONT LEFT connectors:

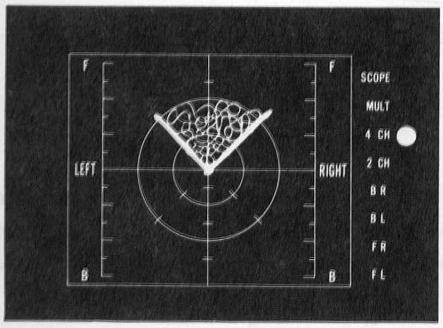



**Figure 4-4**

With a monaural signal to the FRONT LEFT and FRONT RIGHT connectors:

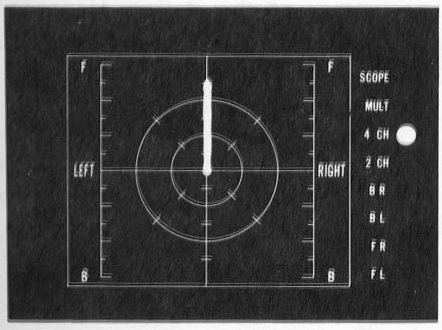



**Figure 4-5**

In the MULT (multipath) position, the vertical multipath signal is applied to the VERTICAL GAIN control and the horizontal multipath signal is applied to the HORIZONTAL GAIN control. The position of the trace along the vertical axis indicates the relative signal strength of the received signal and the horizontal position indicates center tuning of the signal. Unevenness of the displayed waveform indicates multipath.

Multipath signals originate as one signal from the FM transmitting station. Part of this signal is transmitted directly to your receiver antenna, while another part of the signal is reflected off mountains or buildings and then received by your antenna. The signal that is transmitted directly to your antenna will arrive there ahead of the reflected signal.

This reflected signal can degrade the quality of the direct signal and cause noise, distortion, or poor stereo separation in the receiver. Also, this reflected signal may cause your receiver to switch in and out of stereo operation, or it may cause the squelch to switch off and on.

Multipath interference can usually be minimized by turning your receiver antenna until only the direct signal is received. Strong, clear reception indicates that your antenna is receiving the direct signal with little or no multipath interference.

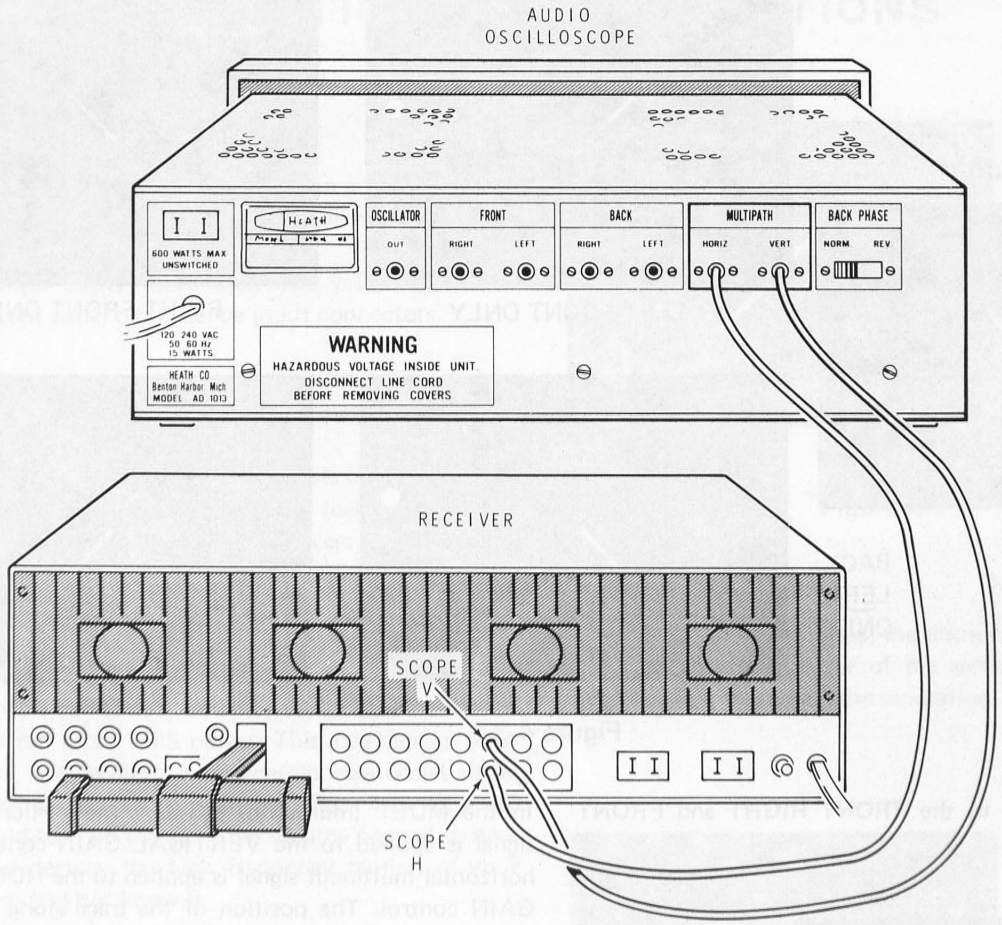



**Figure 4-6**

Refer to Figure 4-6 for the following instructions.

Connect the MULTIPATH HORIZ Input of the Oscilloscope to the Scope H output on the receiver.

Connect the MULTIPATH VERT input of the Oscilloscope to the Scope V output on the receiver.

Tune in a strong station. Adjust the HORIZONTAL and VERTICAL GAIN controls to obtain a trace that is 1/3 inch long. With the receiver center tuned, adjust the HORIZONTAL POSITION control and center the trace horizontally. Adjust the VERTICAL GAIN control until the trace is near the top of the screen. Then tune the receiver off station and adjust the VERTICAL POSITION control until the trace is near the bottom of the screen. Repeat this process until the trace is near the top of the screen with the station tuned in, and near the bottom of the screen with the receiver tuned off station. This will give the best display for observing multipath conditions.

Now, the position of the display along the vertical scale on the oscilloscope will indicate the relative strength of the station, and the width of the display will indicate the relative modulation percentage of the station. Horizontal centering of the display on the oscilloscope screen will indicate center tune.

Depending on the receiver used, the direction of travel horizontally on the screen may or may not be in the same direction as the center tuning meter – if your unit has one.

The following Figures are photographs of typical oscilloscope displays. With each photograph is an analysis of the conditions under which the scope trace was received.

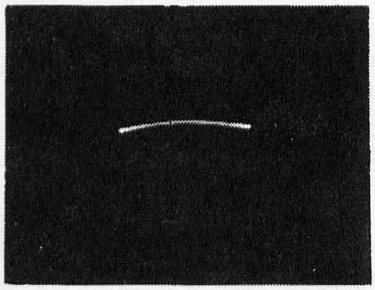


**Figure 4-7**

Perfectly tuned monophonic signal with 100% modulation.

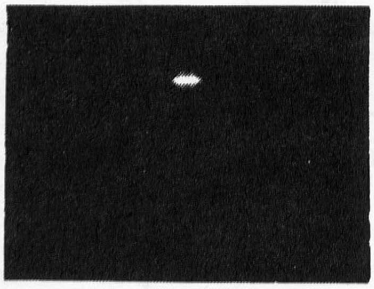


**Figure 4-8**

Station transmitting 19 kHz pilot only.

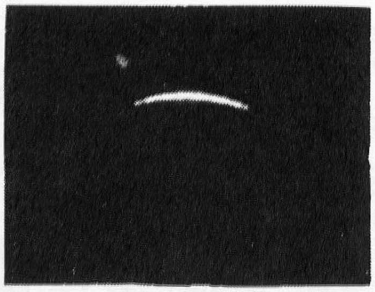


**Figure 4-9**

Station transmitting stereo at near 100% modulation: near perfect signal.

The following four oscilloscope photographs were taken under multipath interference conditions.

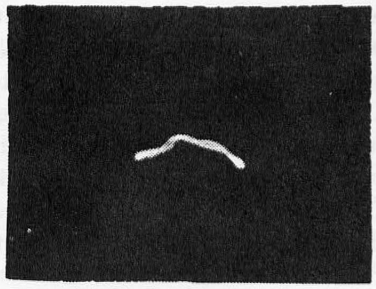


**Figure 4-10**

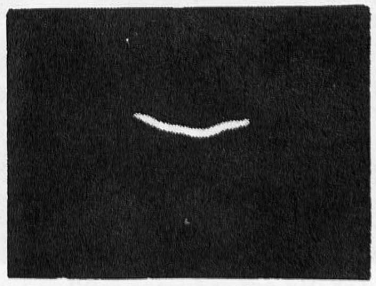


**Figure 4-11**

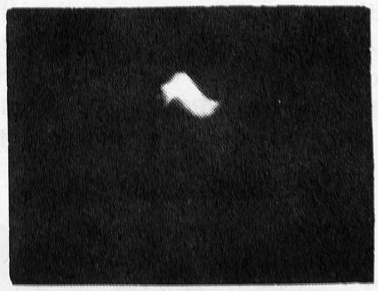


**Figure 4-12**

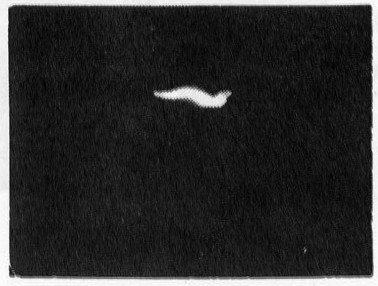


**Figure 4-13**

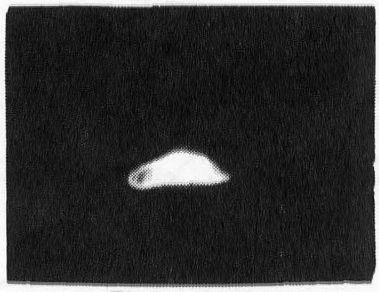


**Figure 4-14**

Signal that shows very rapid fluctuations in signal strength.

## MATRIX 4-CHANNEL

Connect the amplifier outputs, speaker terminals, or amplifier tape output jacks to the four FRONT and BACK, RIGHT and LEFT rear panel connectors on the Oscilloscope. With the 4-channel system operating at the desired output level and with 4-channel information at its outputs, turn the FUNCTION switch to 4 CH. Then adjust the HORIZONTAL and VERTICAL GAIN controls until the lines of the display are at 90° with respect to each other.

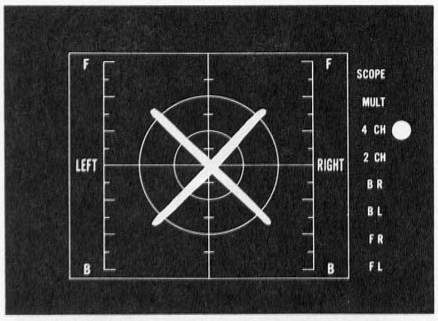



**Figure 4-15**

Center the display on the screen with the VERTICAL and HORIZONTAL POSITION controls. If distortion appears at the edges of the display, with the amplifier operating properly, adjust controls R205, R211, R213, and R214 (inside the Audio Oscilloscope) until the distortion disappears.

DISTORTION

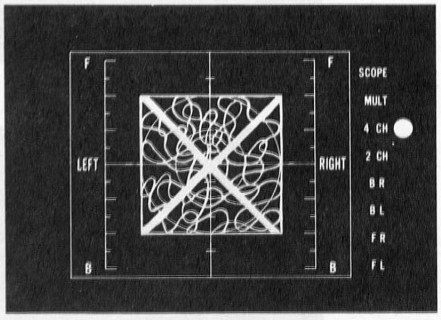



**Figure 4-16**

## DC OSCILLOSCOPE

To use the Audio Oscilloscope as a DC oscilloscope, connect the input signal to any of the four rear panel input connectors (FRONT RIGHT or FRONT LEFT, or BACK RIGHT or BACK LEFT). Then place the FUNCTION switch in the corresponding position.

## AC OSCILLOSCOPE

Connect the input signal to the front panel SCOPE input connectors and place the FUNCTION switch in the SCOPE position. Never connect this input to any point that has greater than 100 volts DC present. To measure a signal at a point that has greater than 100 volts DC present, place a capacitor with a high voltage rating in series with the input lead.

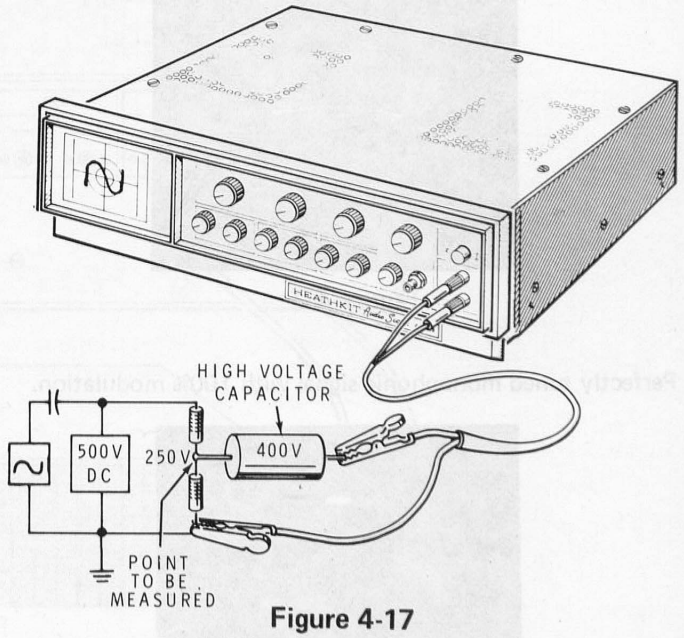



**Figure 4-17**

If you ever want to measure signals that are so large that they cannot be completely displayed on the screen, even with the GAIN control turned fully counterclockwise, construct the following attenuator that will reduce the signal 50%.

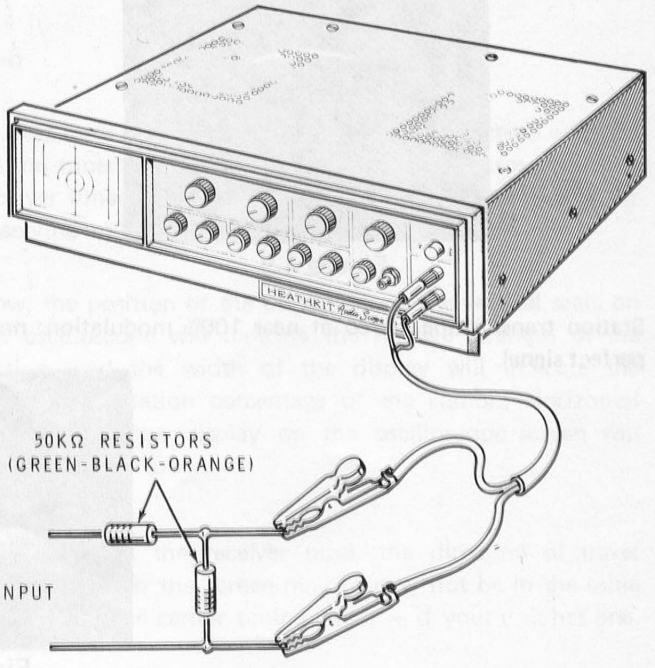



**Figure 4-18**

When the GAIN controls are set to a high position and high amplitude inputs are applied, foldover (distortion) can occur. To be sure that the correct display is obtained, start with a low setting of the GAIN control and increase it until the desired display height is obtained.

Always set the INTENSITY control to the lowest position that gives a trace that is easily seen. This will prolong the life of the phosphor on the screen.

## AUDIO OSCILLATOR

CAUTION: Read the warning on Page 56 before you connect the audio oscillator to your amplifier.

The purpose of the audio oscillator is to provide an audio test signal to check the operation of your audio equipment.

Connect the oscillator output (either the front panel or the rear panel output) of the Audio Oscilloscope to the desired input of the system. Adjust the oscillator frequency and level controls for the desired output level. The Oscilloscope can now also be used to monitor the output of the unit under test.

When the oscillator is not being used, set the frequency to minimum and the level to zero. This will make sure that a high frequency, high level signal is not accidentally connected to your system.

The FREQUENCY control markings are approximate, but normally within 30% of the indicated value except at the extreme low end.

### Check Frequency Response

CAUTION: If speakers are connected to the amplifier, operate the amplifier at a very low level to insure that the speakers do not get damaged. We suggest you use nonreactive, resistive loads instead of speakers during the tests.

Connect the output of the oscillator to the input of the amplifier.

Set the FUNCTION switch to the desired amplifier channel to be checked.

Adjust the oscillator output for the desired level, and the amplifier gain controls for the desired output level from the amplifier.

Adjust the VERTICAL GAIN control of the Oscilloscope to obtain a display 3 centimeters high. Slowly turn the oscillator frequency from 20 Hz to 20 kHz and observe the amplitude of the waveform. Any change in amplitude indicates a change in output from the amplifier.

### Measuring Phase Shift

Connect the oscillator output to the amplifier input and to the FRONT RIGHT input of the Oscilloscope.

Set the FUNCTION switch to 2 CH and adjust the HORIZONTAL GAIN control for a horizontal trace of 4 centimeters.

Connect the amplifier output to the FRONT LEFT input.

Set the FUNCTION switch to FL and adjust the VERTICAL GAIN control for a trace 4 centimeters high.

Set the FUNCTION switch to 2 CH and observe the Lissajous pattern on the screen.

Obtain the phase angle as follows:

Sine $\theta$ = B/A

A = Length of initial horizontal trace (4 cm).

B = Distance between the two points where the Lissajous pattern crosses the horizontal axis.

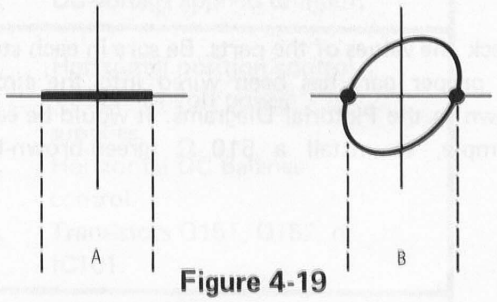



**Figure 4-19**

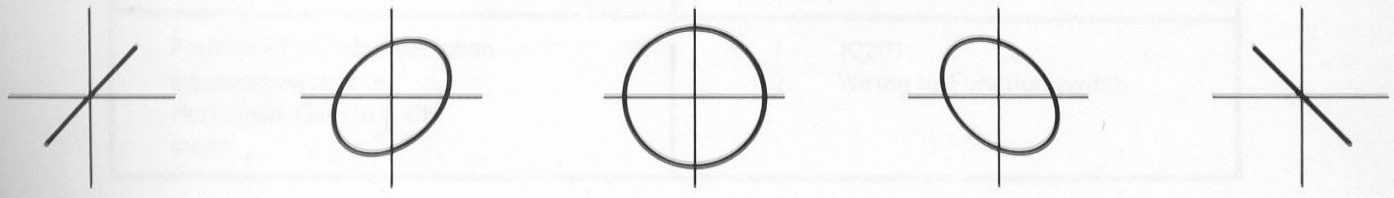



**Figure 4-20**

# IN CASE OF DIFFICULTY

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

NOTE: Refer to the "Circuit Board X-Ray Views" on Page 70 for the physical location of parts on the circuit boards.

## VISUAL TESTS

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

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure they are soldered as described in the "Soldering" section of the "Kit Builders Guide." Be sure there are no solder bridges.

3. Check to be sure that all transistors and diodes are in their proper locations. Make sure each lead is connected to the proper point.

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

5. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial Diagrams. It would be easy, for example, to install a 510 Ω (green-brown-brown) resistor where a 150 Ω (brown-green-brown) resistor should have been installed.

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

7. Look between each circuit board and the chassis to be sure all leads have been cut off.

8. A review of the "Circuit Description" may also help you to determine where the trouble is.

If the trouble is still not located after the "Visual Tests" are completed, and a voltmeter is available, check voltage readings against those shown on the "Schematic Diagram" (fold-out from Page 75). Read the "Precautions for Troubleshooting" below before taking any measurements. NOTE: All voltage readings are taken with a high-impedance voltmeter. Voltages may vary as much as ±20%.

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

## PRECAUTIONS FOR TROUBLESHOOTING

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

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

# Troubleshooting Charts

The following chart lists the "Condition" and the "Possible Cause" of a number of malfunctions. If a particular part or parts are mentioned (transistor Q201, for example, or resistor R104) as a possible cause, check these parts to see if they are incorrectly installed or wired. Also check to see if an improper part was installed at that location. It is also possible, on rare occasions, for a part to be faulty.

| CONDITION | POSSIBLE CAUSE |
|---|---|
| No visible sign of operation. | 1. Fuse.<br>2. On-off switch.<br>3. No AC power from source. |
| Function lamps lit, CRT filament not lit. | 1. Wiring to CRT.<br>2. Power transformer.<br>3. CRT. |
| No dot or trace on face of CRT. | 1. Intensity or positioning control improperly adjusted.<br>2. High voltage power supply.<br>3. CRT. |
| CRT dot cannot be vertically centered in either Stereo or Multipath modes (inputs not connected). | 1. Vertical position control.<br>2. +14 or -14-volt power supplies.<br>3. Vertical DC Balance control.<br>4. Transistors Q101, Q102, or IC101. |
| (Inputs connected.) | 1. DC voltage applied to input. |
| CRT dot cannot be horizontally centered in either Stereo or Multipath modes (inputs not connected). | 1. Horizontal position control.<br>2. +14 or -14-volt power supplies.<br>3. Horizontal DC Balance control.<br>4. Transistors Q151, Q152, or IC101. |
| (Inputs connected.) | 1. DC voltage applied to input. |
| Position of dot changes when adjusting vertical or Horizontal Gain in 4 CH mode. | 1. IC201.<br>2. Wiring to Function switch. |

| CONDITION | POSSIBLE CAUSE |
|---|---|
| No vertical deflection. | 1. Vertical gain control.<br>2. Function selector wiring.<br>3. No input signal.<br>4. 200-volt power supply. |
| No horizontal deflection. | 1. Horizontal gain control.<br>2. Function selector wiring.<br>3. No input signal.<br>4. 200-volt power supply. |
| Poor focus. | 1. CRT.<br>2. Focus control.<br>3. Astigmatism control.<br>4. Resistors R302, R303, R304, or R305. |
| No retrace blanking. | 1. Transistor Q407.<br>2. Capacitors C406 or C407. |
| Function indicator lamps change intensity. | This is a normal condition. |

## OSCILLATOR SECTION

| CONDITION | POSSIBLE CAUSE |
|---|---|
| Oscillator does not run when Frequency control is in counterclockwise position. | This is a normal condition. |
| Oscillator stops running when Frequency control is set at "20." | 1. Symmetry control R7 misadjusted. |
| Small irregularities in sine wave peaks. | This is a normal condition. |

| CONDITION | POSSIBLE CAUSE |
|---|---|
| Sine wave appears to be tilted. | 1. Symmetry control R7 misadjusted. |
| Sine wave is unsymmetrical from top to bottom. | 1. Controls R17 or R44 misadjusted.<br>2. A diode in shaper circuit installed backward.<br>3. Transistors Q3 through Q6.<br>4. Output level set too high. |

## SWEEP CIRCUITS

| CONDITION | POSSIBLE CAUSE |
|---|---|
| No sweep; Left Front, Right Front, Left Back, Right Back, and Scope modes. | 1. Function switch wiring.<br>2. Controls R427 and R428 misadjusted.<br>3. +14, -14, or +5-volt power supplies. |
| Sweep not synchronized with input signal. | 1. Transistors Q401, Q402.<br>2. Integrated circuit IC401, IC402, IC403.<br>3. Diode D401. |
| No base line when no signal is applied to scope. Sweep appears when signal is applied. | 1. Transistors Q401, Q402.<br>2. Integrated circuit IC401.<br>3. Diode D401. |
| Sweep does not go across entire face of CRT. | 1. Controls R427 and R428 misadjusted. |

# SPECIFICATIONS

## FRONT PANEL

| | |
|---|---|
| **Scope Input** | |
| Vertical Sensitivity | 25 millivolts P-P/cm. |
| Input Impedance | 100 kΩ. |
| Frequency Response | 5 Hz to 200 kHz ±3 dB.<br>20 Hz to 20 kHz ±.5 dB or less. |
| **Audio Oscillator Output** | |
| Range | 20 Hz to 20 kHz. |
| Voltage Level | 2 mV to 3 volts (rms), variable |
| Output Variation | .25 dB, 20 Hz to 20 kHz. |
| Output Impedance (front panel jack) | Approximately 600 Ω. |
| Calibrator Voltage | 1.0 volt P-P ±5%. |
| Total Harmonic Distortion | 1% or less. |

## REAR PANEL

| | |
|---|---|
| Oscillator Output Impedance | 6000 Ω. |
| **Multipath Input (Scope Horizontal and Scope Vertical)** | |
| Sensitivity | 25 mV P-P/cm. |
| Input Impedance | 100 kΩ. |
| **Left Front, Right Front, Left Back, and Right Back Inputs** | |
| Sensitivity | 25 mV P-P/cm. |
| Input Impedance | 100 kΩ. |
| Frequency Response | 5 Hz to 200 kHz, ±3 dB. |
| **4-Channel Input** | |
| Sensitivity | 1 volt P-P/cm. |
| Input Impedance | 5000 Ω. |

## GENERAL

| | |
|---|---|
| **Triggered Sweep Generator** | |
| Range | 10 Hz to 100 kHz. |
| Power Requirement | 120 or 240 volts AC, 50/60 Hz, 15 watts with no accessory load. |
| AC Outlet (on rear panel) | Unswitched. |
| Dimensions (overall) | 18-1/2" wide x 5-1/8" high x 13-1/2" deep. |

| | |
|---|---|
| Mounting | Heathkit ARA-1500-1 Cabinet or Custom Installation. |
| Net Weight | 15 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.

# CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 75) while you read this "Circuit Description."

To help you locate specific parts in the Oscilloscope, or on the Schematic, the circuit part numbers (R1, C101, D201, etc.) are in the following groups.

| | |
|---|---|
| 1-99 | Audio oscillator parts. |
| 100-149 | Vertical amplifier parts. |
| 150-199 | Horizontal amplifier parts. |
| 200-299 | 4-channel decoder parts. |
| 300-399 | Parts associated with the CRT. |
| 400-499 | Sweep generator parts. |
| 500-599 | Power supply parts. |
| 600-699 | Parts on the chassis. |

Because the horizontal amplifier is nearly identical to the vertical amplifier, only the vertical amplifier will be described.

## VERTICAL AMPLIFIER

A signal from the desired input, as determined by the position of the Function switch, is connected to control R101. The signal is then coupled through resistor R102, capacitor C101, and input transistor Q101, is amplified by IC101, and is then further amplified by the cascoded differential amplifier (Q103 through Q107) to drive the vertical plates of the CRT.

Diodes D101 and D102 are transistors connected as zener diodes that limit the input signal to ±9 volts. This protects Q101 from excessive voltage.

Transistor Q101 has a high input impedance to prevent loading of the input signal, and transistor Q102 is a constant current source for Q101. Diodes D104 and D103 keep the base of Q102 at a constant potential. The emitter of Q102 follows this unchanging voltage and is therefore also held constant. Because these voltages are constant, the current through Q102 is also constant. Resistor R103 is adjusted so the source voltage of Q101 is zero volts with no input signal. Therefore, the input signal appears to IC101 as only a voltage change (at the source of Q101), referenced at zero volts.

The gain of IC101 is set by resistors R105 and R106, and capacitor C102. Capacitor C102 improves the high frequency response, and resistor R107 and capacitor C103 provide frequency compensation for the IC.

Transistor Q103 is a constant current source for the cascode differential amplifier (Q104, Q105, Q106, and Q107). As the signal at the base of Q104 goes negative, the current through that transistor decreases. As a result, the current through Q105 increases because the constant current source demands that the total current through these transistors be constant. The signals at the collectors of Q104 and Q105 are 180° out of phase, and are amplified further by transistors Q106 and Q107. Resistor R116 and zener diode ZD106 establish the base reference potential.

The Vertical Position control, R118, controls the operating point of transistor Q105. When the voltages at the bases of Q104 and Q105 are equal, the trace will be centered on the CRT. Therefore, by varying the control, the trace position moves. Control R108 further controls the operating point of the amplifier.

## SWEEP GENERATOR

A trigger signal (from IC101 of the vertical amplifier) is coupled through C401 and R401 to IC401. IC401 compares the voltages at its inputs (pins 2 and 3) and produces a corresponding rectangular wave at its output, pin 7. This drives the narrow-pulse generator (gates A, D, and B of IC402), whose output is a narrow pulse that corresponds to the leading edge of the rectangular wave from IC401. With no trigger signal to IC401, the base-line generator (Q401, Q402, Q403, and Q404) is activated and pulses are applied to pin 8, gate C, of IC402 to produce a base line on the CRT.

The output from gate C of IC402 is applied to IC403 and latches it on. The output of IC403 (pin 6) then turns off Q405 and starts the ramp generator (C408 through C412 and Q406). Transistor Q408 is also turned off at this time and Q409 follows the ramp. This ramp is coupled through controls R427, R428, and the Function switch to the horizontal amplifier. The ramp also turns on Q411 and Q412, which turns off transistor Q413. This sets monostable IC404, which clears IC403. During the time monostable IC404 holds IC403 clear, Q405 and Q408 are turned on to stop the ramp, and Q407 is turned on to blank the CRT during retrace. IC404, at the end of its pulse, readies IC403 for the next pulse from IC402.

The base-line generator, with an input signal, had been held off because Q401 had been pulsed on to charge C403 through D401. The charge on C403 then held Q402 on. With no input signal, Q401 is held off and C403 discharges through Q402. Then Q403 and Q404, which function as a unijunction transistor, oscillate and drive IC402. This activates the sweep circuit and provides a base line on the CRT. The frequency of oscillation is set by R412 and C404.

The sweep ramp is linear because the selected capacitor charges through constant current source Q406.

Transistors Q411 and Q412 are referenced by voltage divider R429 and R431. When the ramp at the emitter of Q411 equals the reference voltage, Q411 and Q412 conduct and turn off transistor Q413 until the ramp drops when IC404 and IC403 change state.

## 4-CHANNEL DECODER

The signal from the FL, FR, BL, and BR rear panel connectors are switched by the Function switch to input level controls R213, R214, R205, and R211. The back channels can be inverted by transistors Q201 and Q202 if the 4-channel system to which the Audio Oscilloscope is connected has an inherent 180° phase shift between the front and back channels.

The matrix; diodes D201, D202, D203, and D204, and associated resistors; detects the phase and amplitude relations of the four input signals and drives dual differential amplifier IC201. The plus and minus vertical information is applied to part A of IC201, and the plus and minus horizontal information is applied to part B of IC201. The outputs from these amplifiers are switched by the Function switch and applied to the vertical and horizontal amplifiers. C205, C206, R239 and C207, C208, and R242 provide frequency compensation for IC201.

## AUDIO OSCILLATOR

Transistors Q1 and Q2, and integrated circuits IC1 and IC2 (with their associated components), make up a voltage-controlled triangle-wave generator. These triangle waves are then applied to the nonlinear load (transistors Q3, Q4, Q5, and Q6, and associated components), which shapes the triangle waves into sine waves. The sine waves are applied to the Level control and amplified by complementary amplifier transistors Q7 and Q8. This signal is then coupled to the front and rear panel connectors. When the Level control is turned fully counterclockwise, the audio signal is disconnected and the calibrator output of the power transformer is connected to the front and rear panel connectors.

IC1 operates as an integrator. The voltage at pin 2 and the value of C7 determine the rate of integration.

When the oscillator starts, the voltage from the Oscillator Frequency control is connected to pin 2 of IC1 because transistor Q1 is biased on by resistor R5. This causes IC1 to integrate in the negative direction and generate a linear ramp at pin 6. This ramp is coupled by diodes ZD3 and ZD4 to the input of comparator IC2. The output of IC2 is high at this time until the ramp becomes negative enough to cause ZD3 and ZD4 to conduct and overcome the reference set by R12, R13, and the positive output of IC2.

The output of IC2 then goes low and forward biases D1 and reverse biases D2. This turns Q1 off and Q2 on. The voltage at pin 2 of IC1 is now zero volts and IC1 integrates in the positive direction. It will integrate until it overcomes the negative reference on pin 2 of IC2. Then the output of IC2 goes positive and the procedure starts over. The rate of integration, and thus the frequency, can be controlled by control R2. The amplitude is constant because the switching points of IC2 remain constant.

Capacitors C4 and C6 provide frequency compensation for IC1 while resistor R9 and control R7 balance the integrator to give a symmetrical triangle waveform.

The nonlinear load changes the triangular waves into sine waves. With no signal input, all the diodes are reverse biased. As the signal goes positive, diode D11 turns on – then D9, D8, D7, D6, and D5 turn on – and load the signal. As the signal becomes less positive, the diodes (in turn) turn off. Then, as the signal goes negative, the remaining diodes turn on and off as before. Emitter follower transistors Q3 and Q5 permit you to set the positive voltage level on the nonlinear load. The voltage ratio between them is set by divider R29 and R34. Transistors Q4 and Q6, with divider R39 and R41, set the negative level.

## POWER SUPPLY

Line voltage is connected through the fuse and the On-Off switch to the primary windings of the power transformer, and also to the unswitched AC outlet.

The dual-primary transformer windings may be connected in parallel for 120-volt operation, or in series for 240-volt operation.

A high voltage secondary winding is connected to the voltage doubler circuit consisting of D501, D502, and C501. Capacitors C502 and C503, and resistor R501 filter this negative high voltage.

A tap from the high voltage secondary winding is connected to half-wave rectifier D503. The rectified voltage is filtered by capacitor C504.

Full-wave rectifier diodes D504, D505, D506, and D507 rectify the voltage from the center-tapped low voltage winding. D504 and D506 provide positive voltage, which is filtered by C505. D505 and D507 provide negative voltage, which is filtered by C508.

The positive voltage is coupled to the collector of the series regulator transistor Q501. A voltage divider, consisting of resistors R507 and R508, provides base bias for transistor Q503. This transistor is operated as a DC coupled voltage amplifier with the emitter held constant by diode ZD508 and resistor R506. Resistors R500 and R504, and the base of transistor Q502, provide the collector load for transistor Q503. Capacitor C507 provides filtering for the emitter reference voltage of Q503. Capacitor C506 provides filtering for the voltage at the collector of Q503.

When the voltage decreases at the emitter of Q501, the voltage at the base of Q503 also decreases. This causes the collector voltage of Q503 to rise. Since the base of Q502 is connected to the collector of Q503, its emitter voltage, and consequently the emitter voltage of Q501, increases. This increase compensates for the original decrease that appeared at the emitter of Q501.

The negative regulator operates in a similar manner except the voltage at the emitter of Q504 is negative and the emitter reference of Q506 is ground.

A third voltage is obtained by dropping voltage across pass transistor Q508. Transistors Q507 and Q508 are connected in a Darlington configuration, and the voltage at the emitter is determined by the voltage established at the base of Q507 by voltage divider R509 and R511.

A fourth winding provides a calibrated 60 Hz signal at the oscillator output terminals when the oscillator output control, R45, is in the Calibrate position.

# CIRCUIT BOARD X-RAY VIEWS

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

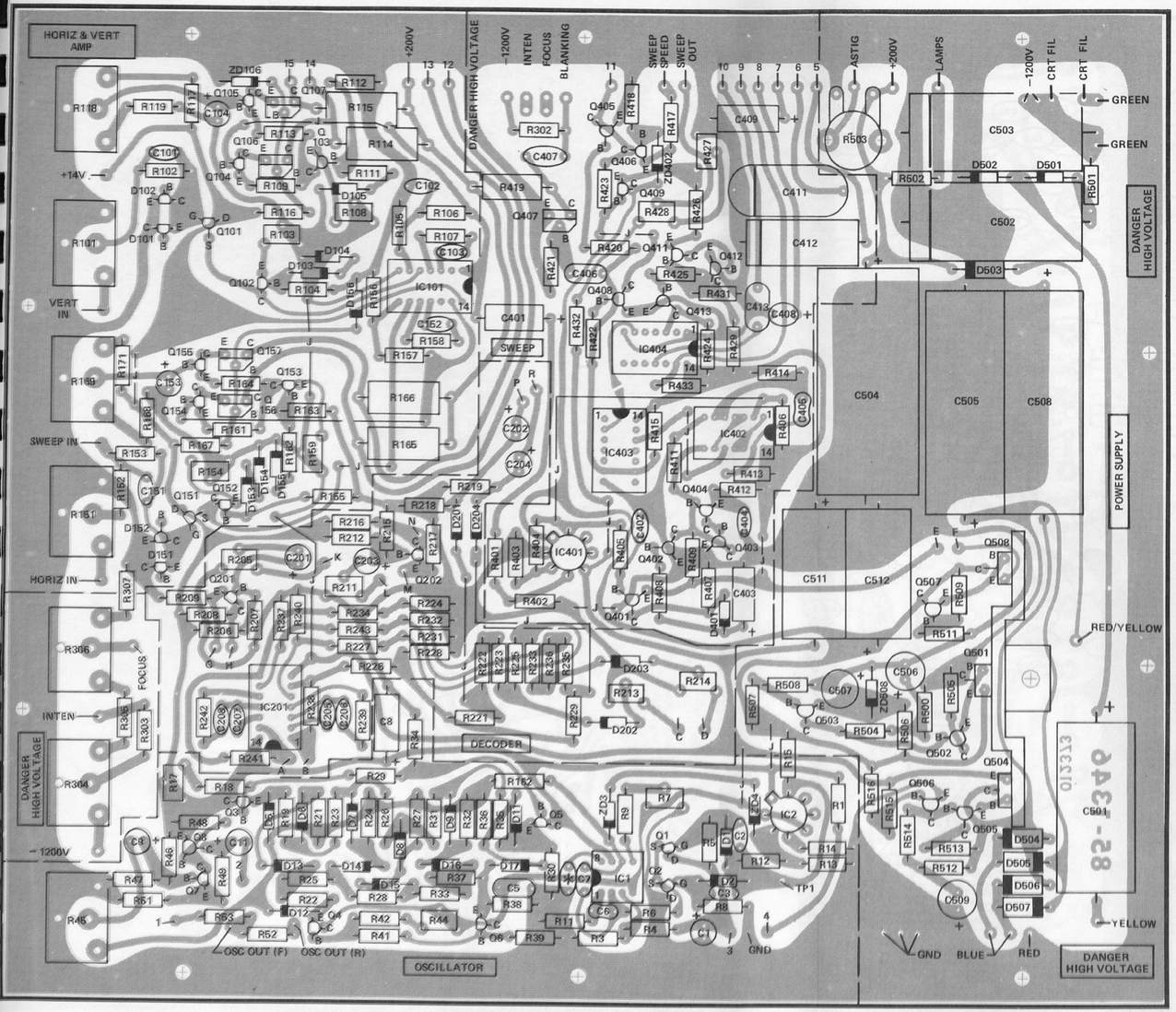
1. A. Refer to the place where the part is installed in the Step-by-Step instructions and note the "Description" of the part (for example: 22 kΩ, .05 μF, or 2N2712).

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

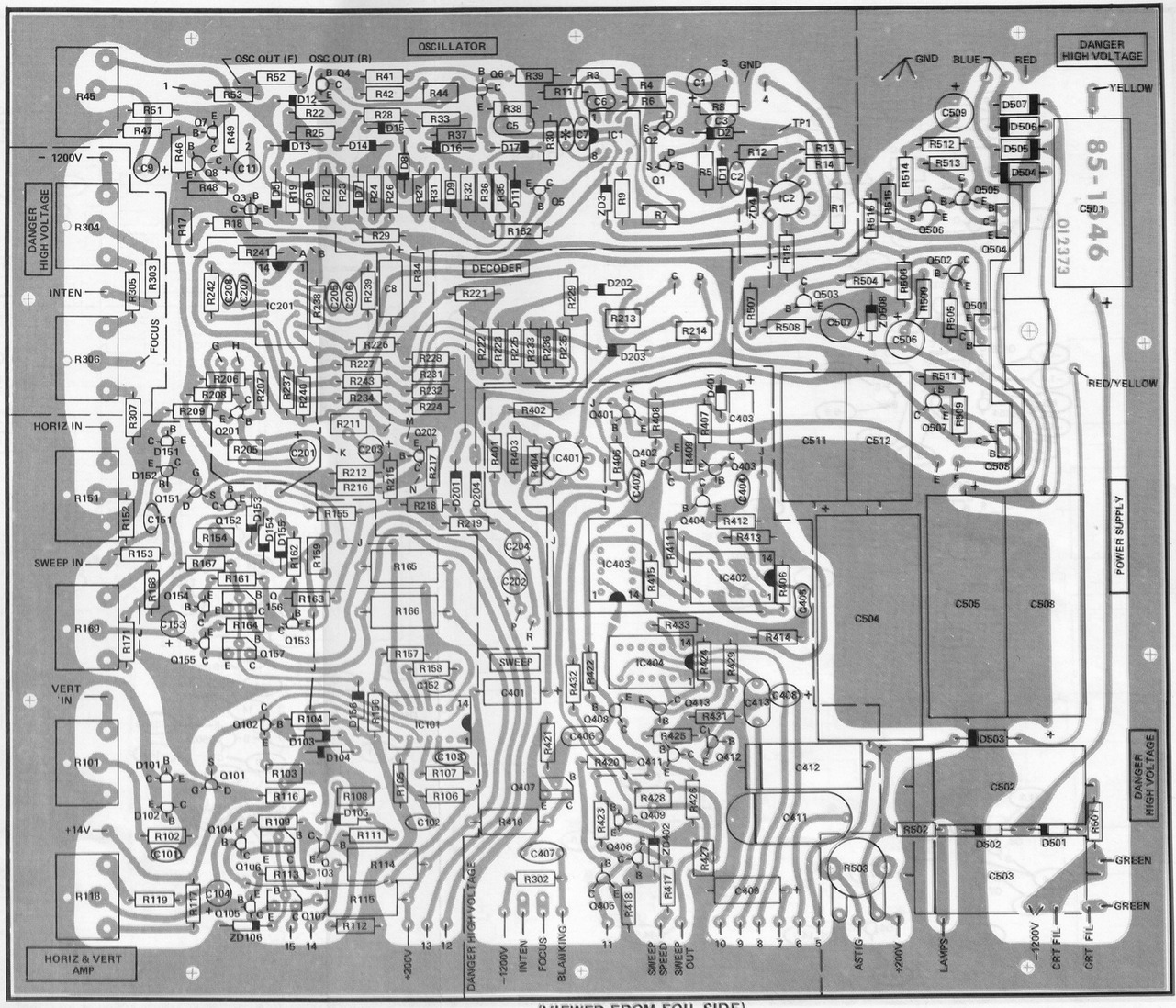
2. A. Note the identification number of the part (R-number, C-number, etc.).

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

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



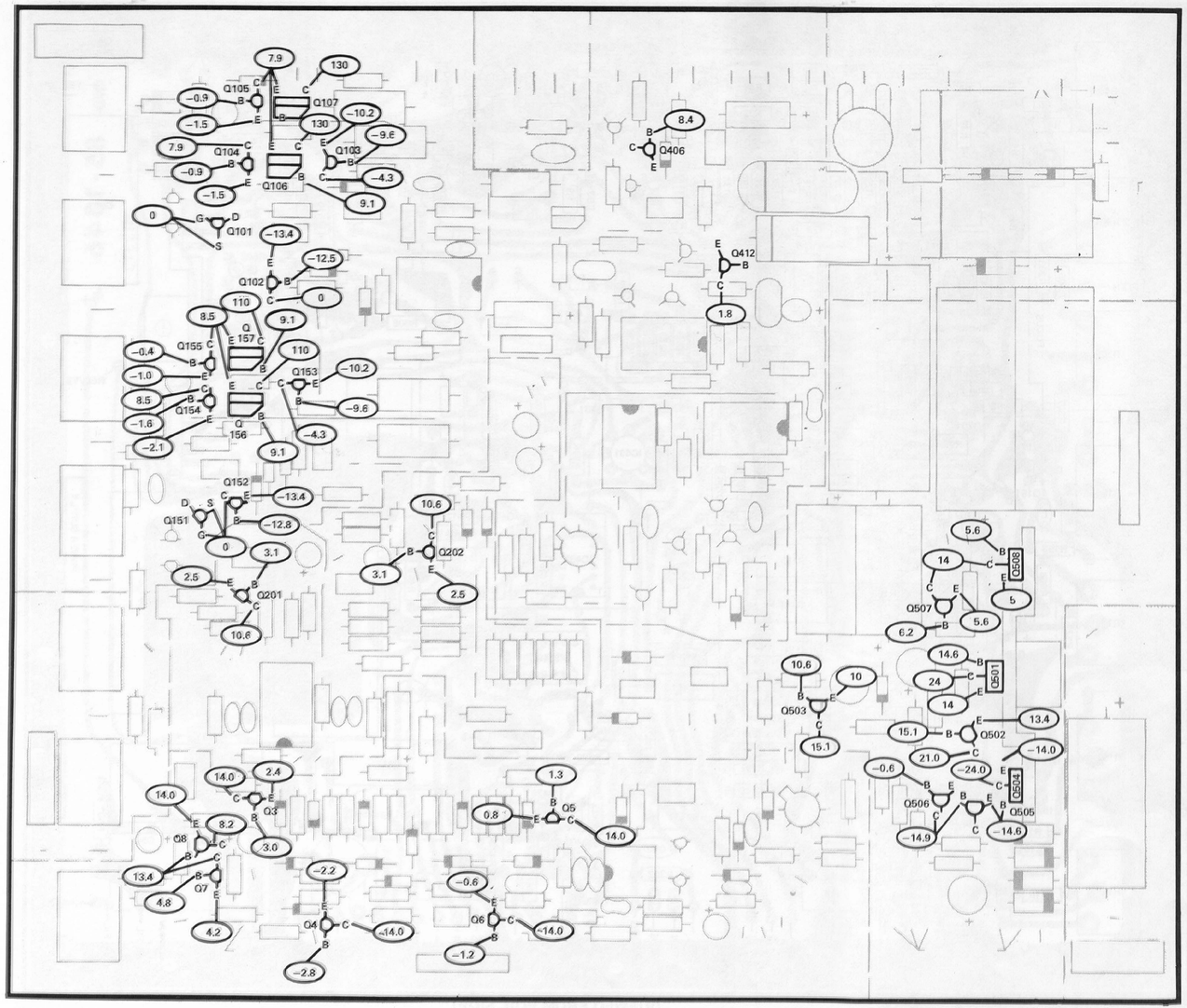

(VIEWED FROM COMPONENT SIDE)



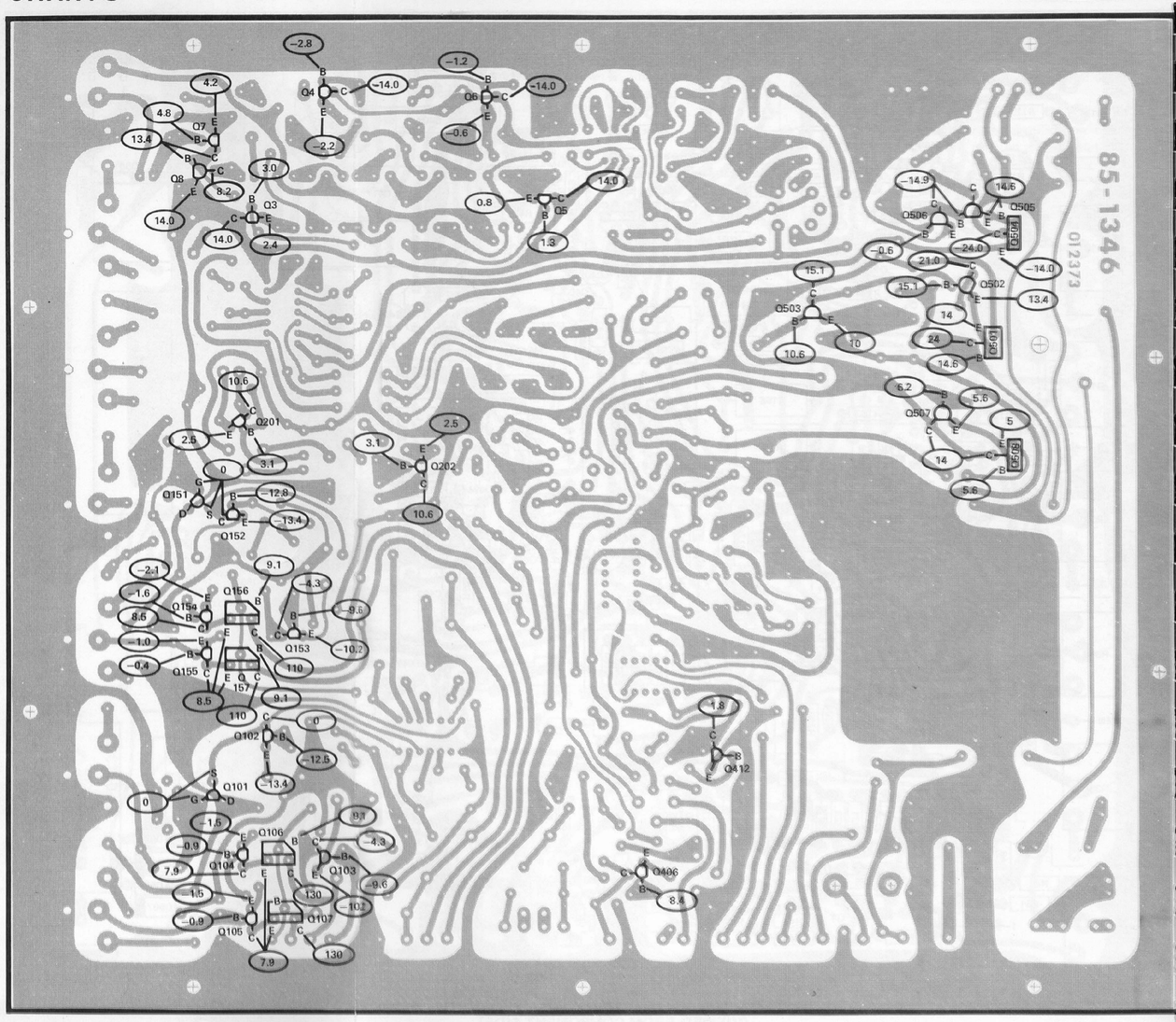

(VIEWED FROM FOIL SIDE)

*NO PART INSTALLED HERE.

# VOLTAGE CHARTS



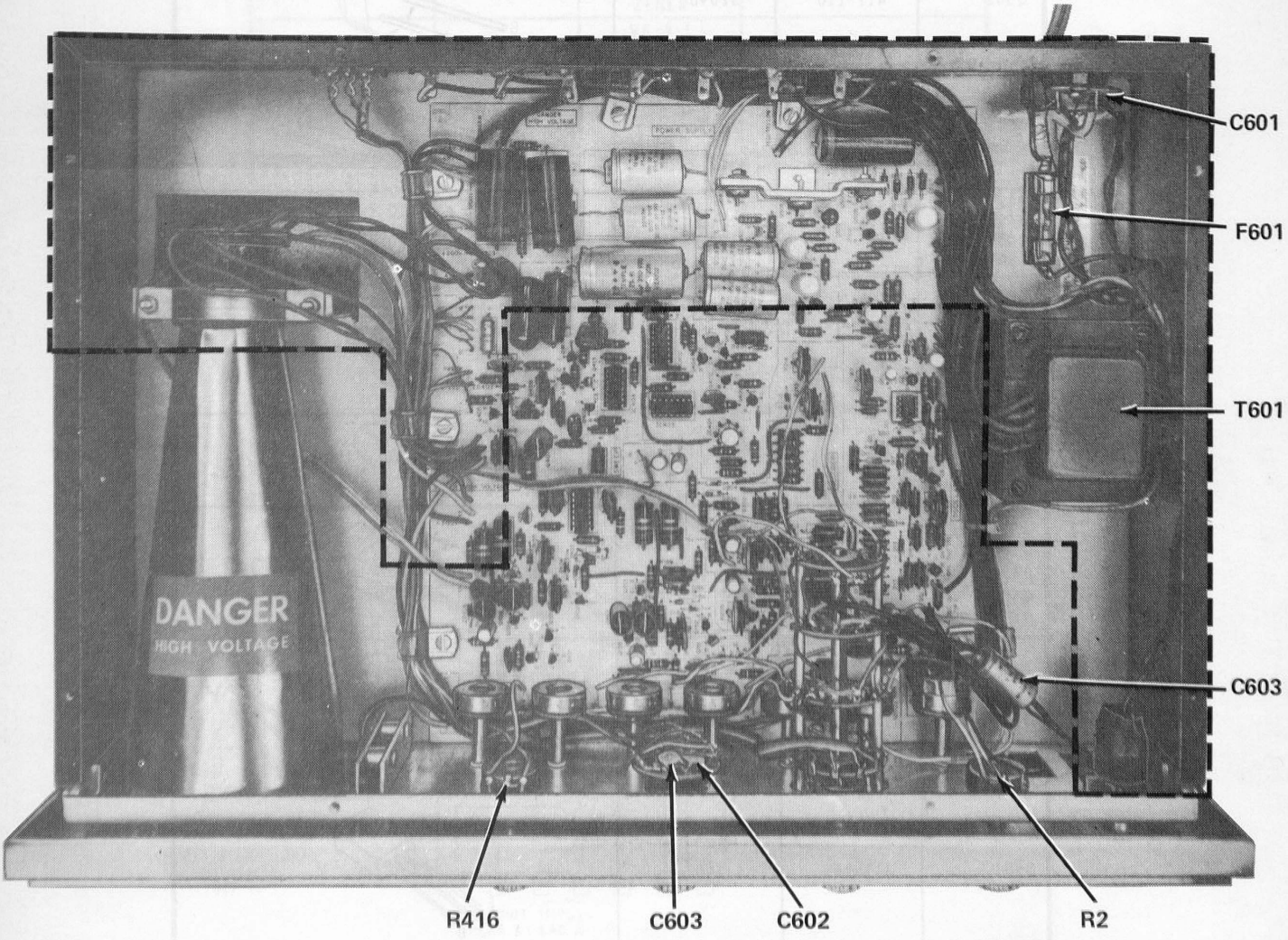

(VIEWED FROM COMPONENT SIDE)




(VIEWED FROM FOIL SIDE)

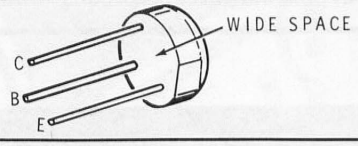
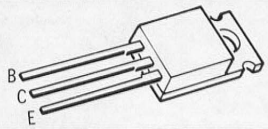
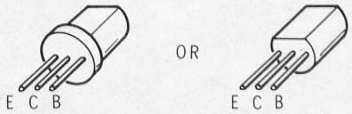
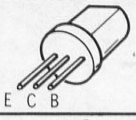
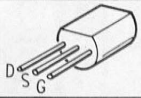
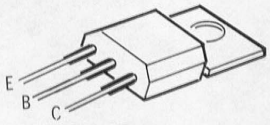
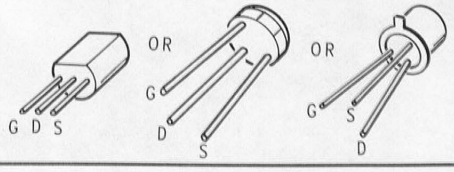
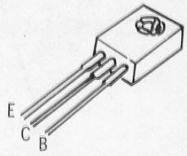
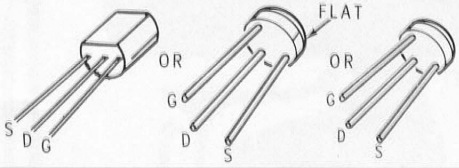
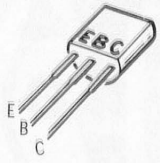
# CHASSIS PHOTOGRAPHS

WARNING: Boxed in area indicates hazardous voltage locations.

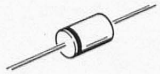


# IDENTIFICATION CHARTS

## TRANSISTORS

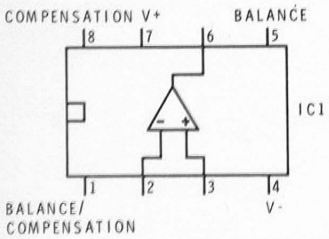
| COMPONENT | HEATH PART NUMBER | MAY BE REPLACED WITH | BASE DIAGRAM |
|---|---|---|---|
| Q502 | 417-110 | S2090 |   |
| Q501, Q508 | 417-175 | 2N5294 |   |
| Q4, Q6, Q8, Q401, Q404, Q406, Q411, Q505, Q506 | 417-201 | X29A829 |   |
| Q409, | 417-222 | 2N5308 | |
| Q503 | 417-213 | 2N5249A |   |
| Q101, Q151 | 417-241 | EL131 |   |
| Q106, Q107, Q156, Q157, Q407 | 417-834 | MPSU10 |   |
| Q1 | 417-140 | 2N4304 |   |
| Q504 | 417-263 | SJE607 |   |
| Q2 | 417-265 | 2N5033 |   |
| Q3, Q5, Q7, Q102, Q103, Q104, Q105, Q152, Q153, Q154, Q155, Q201, Q202, Q402, Q403, Q405, Q408, Q412, Q413, Q507, D101, D102, D151, D152 | 417-801 | MPSA20 |   |

## DIODES

| COMPONENT | HEATH PART NUMBER | MAY BE REPLACED WITH | LEAD DIAGRAM |
|---|---|---|---|
| ZD3, ZD4 | 56-16 | 1N751 5.1 VOLT, 20mA ZENER |  |
| ZD402 | 56-63 | MZ500-10 5.6VOLT, 1mA ZENER | |
| ZD106, ZD156 | 56-19 | VR-9-1 9.1VOLT, 25mA ZENER |  |
| ZD508 | 56-67 | VR-10A 10VOLT, 10mA ZENER | |
| D1, D2, D5, D6, D7, D8, D9, D11, D12, D13, D14, D15, D16, D17, D103, D104, D105, D153, D154, D155, D201, D202, D203, D204, D401 | 56-56 | 1N4149 75VOLT, 10mA |  |
| D503, D504, D505, D506, D507 | 57-27 | 1N2071 600VOLT, 1AMP |  |
| D501, D502 | 57-52 | DO-7 2000VOLT, 5mA |  |

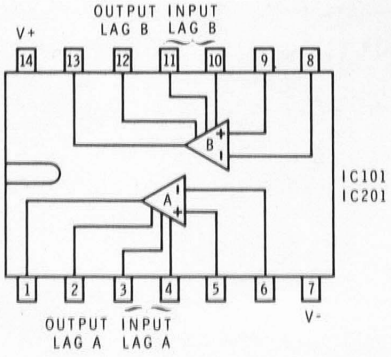
## INTEGRATED CIRCUIT BASING DIAGRAMS

TOP VIEW



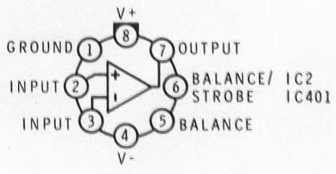

LM301A OPERATIONAL AMPLIFIER
442-39

TOP VIEW




μA739C DUAL LOW-NOISE OPERATIONAL AMPLIFIER
442-41

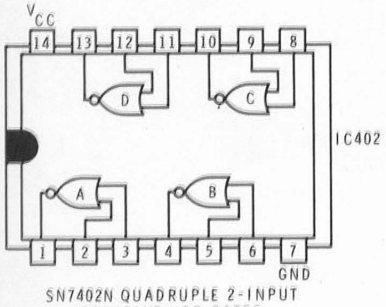
TOP VIEW




NOTE: PIN 4 CONNECTED TO CASE

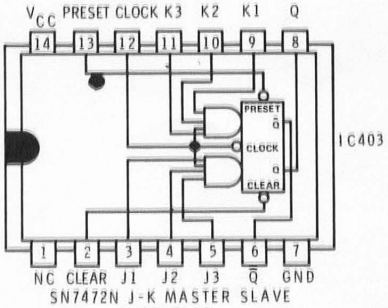
LM311 VOLTAGE COMPARATOR/BUFFER
442-36

TOP VIEW



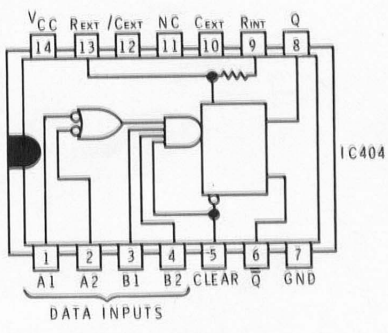

SN7402N QUADRUPLE 2-INPUT POSITIVE NOR GATES
443-46

TOP VIEW

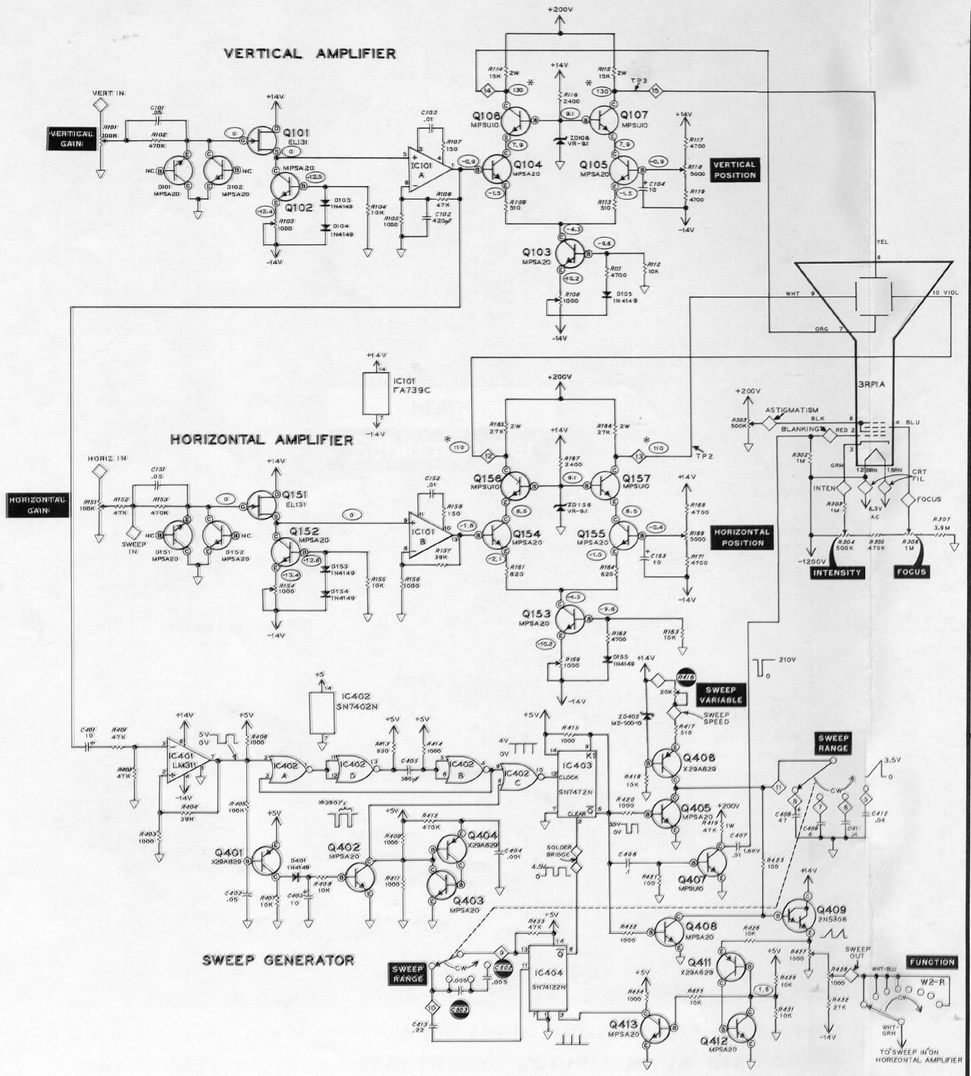


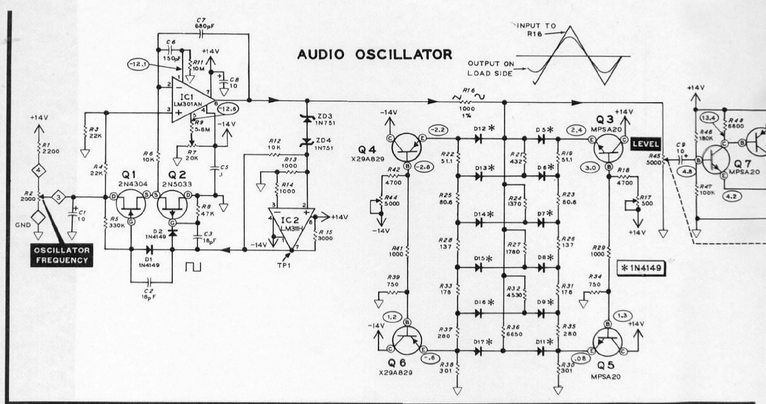

SN7472N J-K MASTER SLAVE FLIP-FLOP
443-4

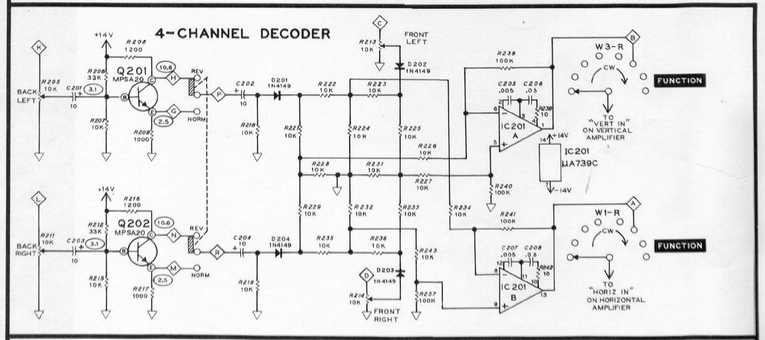
TOP VIEW

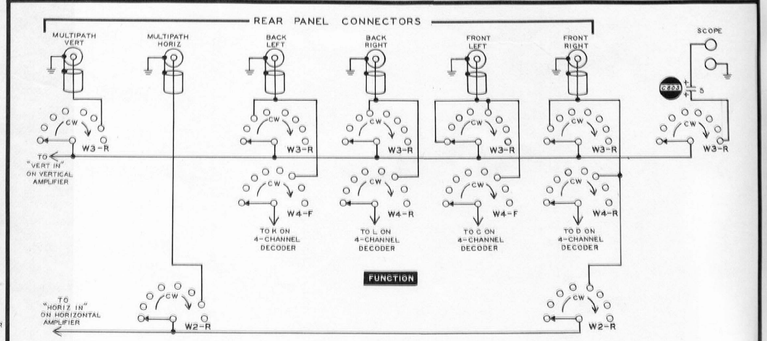



SN74122N RETRIGGERABLE MONOSTABLE MULTIVIBRATOR WITH CLEAR
443-23




SCHEMATIC OF THE
HEATHKIT®
AUDIO OSCILLOSCOPE
MODEL AD-1013

NOTES:

1. PARTS ARE NUMBERED IN THE FOLLOWING GROUPS:

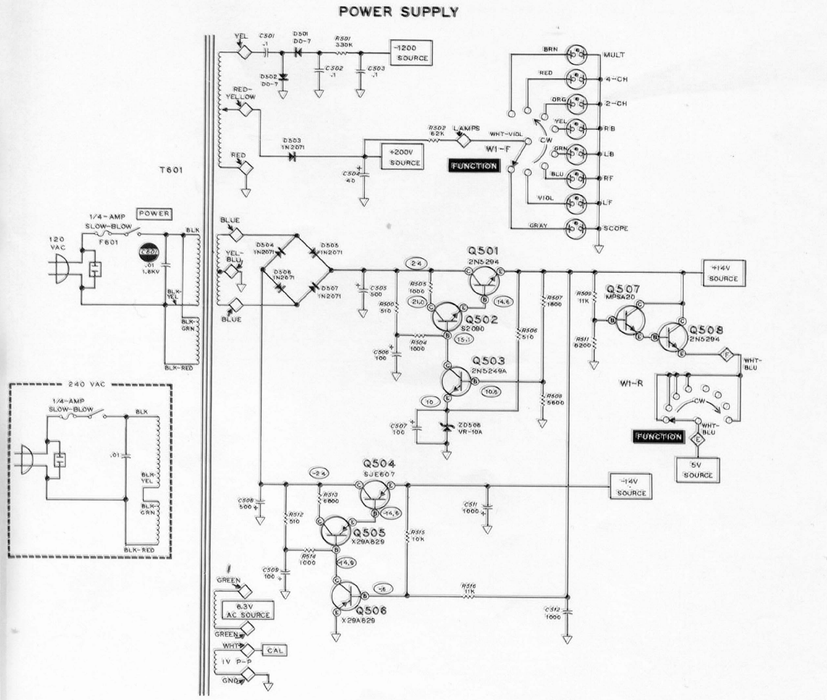
   1- 99 PARTS IN THE AUDIO OSCILLATOR.
   100-149 PARTS IN THE VERTICAL AMPLIFIER.
   150-199 PARTS IN THE HORIZONTAL AMPLIFIER.
   200-299 PARTS IN THE 4-CHANNEL DECODER.
   300-399 PARTS ASSOCIATED WITH THE CRT.
   400-499 PARTS IN THE SWEEP GENERATOR.
   500-599 PARTS IN THE POWER SUPPLY.
   600-699 PARTS ON THE CHASSIS.

2. RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K=1000, M=1,000,000).
3. CAPACITORS ARE IN µF UNLESS MARKED OTHERWISE.
4. SWITCHES ARE SHOWN IN THEIR COUNTERCLOCKWISE POSITION.
5. DC VOLTAGE MEASUREMENTS WERE TAKEN WITH A HIGH IMPEDANCE INPUT VOLTMETER FROM THE POINT INDICATED TO THE CHASSIS GROUND. VOLTAGES MAY VARY ±20%.
6. ▽ THIS SYMBOL INDICATES CIRCUIT BOARD GROUND.
7. ⏚ THIS SYMBOL INDICATES CHASSIS GROUND.
8. ◇ THIS SYMBOL INDICATES A CIRCUIT BOARD CONNECTION.
9. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE TAKEN FROM THE POINT INDICATED TO CHASSIS GROUND.

* ⬭ THIS VOLTAGE MAY VARY ±30%.

NOTE: ALL VOLTAGES WERE TAKEN UNDER THE FOLLOWING CONDITIONS:

| FUNCTION | SCOPE |
|---|---|
| HORIZONTAL POSITION | CENTER OF ROTATION |
| VERTICAL POSITION | CENTER OF ROTATION |
| HORIZONTAL GAIN | FULLY CLOCKWISE |
| VERTICAL GAIN | FULLY COUNTERCLOCKWISE |
| SWEEP RANGE | 20K |
| SWEEP VARIABLE | FULLY COUNTERCLOCKWISE |
| OSCILLATOR FREQUENCY | FULLY COUNTERCLOCKWISE |
| OSCILLATOR LEVEL | OFF |
| INTENSITY | CENTER OF ROTATION |
| FOCUS | CENTER OF ROTATION |



# CUSTOMER SERVICE

## REPLACEMENT PARTS

If you need a replacement part, please fill in the Parts Order Form that is furnished and mail it to the Heath Company. Or, if you write a letter, include the:

- **Part number** and **description** as shown in the **Parts List.**
- Model number and Series number from the blue and white label.
- Date of purchase.
- Nature of the defect.

**Please do not return parts** to the factory unless they are requested. Parts that are damaged through carelessness or misuse by the kit builder will not be replaced without cost, and will not be considered in warranty.

Parts are also available at the Heathkit Electronic Centers listed in your catalog. Be sure to provide the Heath part number. Bring in the original part when you request a warranty replacement from a Heathkit Electronic Center.

NOTE: Replacement parts are maintained specifically to repair Heathkit products. Parts sales for other reasons will be declined.

## TECHNICAL CONSULTATION

Need help with your Heathkit? . . . . Self-Service? . . . . Construction? . . . . Operation? . . . . Call or write for assistance. You'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

**Please do not send parts for testing,** unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek. . .please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

## REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

**If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.**

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit C.O.D. for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

HEATH

Schlumberger

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