# HEATHKIT® MANUAL

*for the*

## 5 MHz OSCILLOSCOPE

Model IO-4560

I-595-1728-04

HEATH COMPANY • BENTON HARBOR, MICHIGAN

## HEATH COMPANY PHONE DIRECTORY

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

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

*Technical Assistance Phone Numbers*
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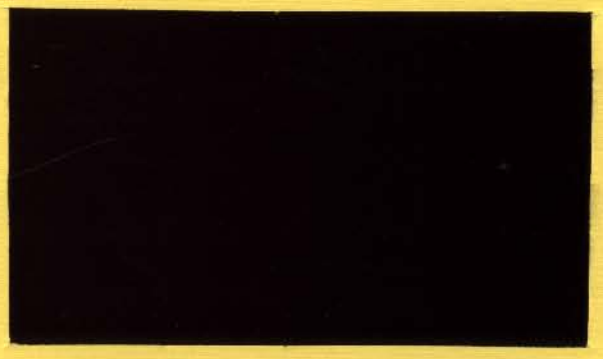


## YOUR HEATHKIT 90 DAY LIMITED WARRANTY

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

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

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

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

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

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

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

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

HEATH COMPANY
BENTON HARBOR, MI. 49022

Prices and specifications subject to change without notice.

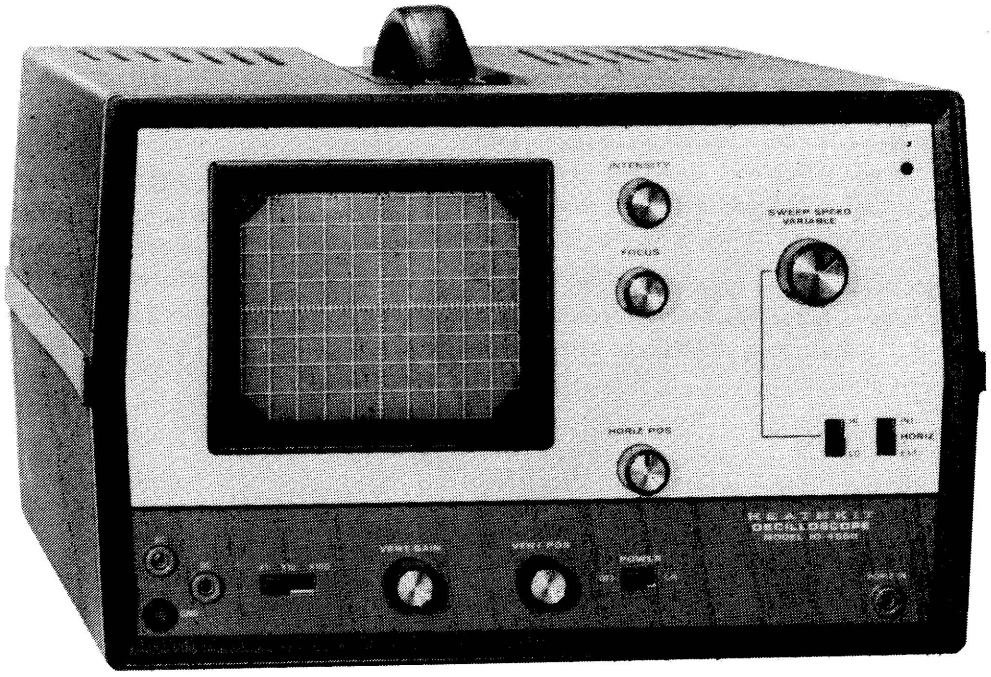
# Heathkit® Manual

*for the*

## 5 MHz OSCILLOSCOPE

Model IO-4560

I-595-1728-04



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

# TABLE OF CONTENTS

# INTRODUCTION

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

The Heathkit Model IO-4560 5 MHz Oscilloscope is an economical and rugged instrument that includes some of the features of more expensive oscilloscopes. The DC to 5 megahertz vertical amplifier bandwidth allows you to use this Oscilloscope for nearly all types of waveform display applications.

The transformer-operated, silicon rectifier power supplies can be wired to operate from either 110-130 volt, or 220-260 volt AC power. This Oscilloscope has excellent display stability because the low voltage power supplies for the amplifiers and the sweep circuit are zener regulated. The primary circuit of the power transformer is fused for protection from overload.

Other features include: an all solid-state circuit (except for the CRT), triggered horizontal sweep circuit, modern styling, low price, and versatility. Its rugged plastic cabinet and ease of operation add to its usefulness and long life.

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

# SWEEP CIRCUIT BOARD

## PARTS LIST

Locate and open pack #1. Check each part against the following list. The key numbers correspond to the numbers in the Parts Pictorial. Make a check (√) in the space provided as you identify each part. Any part that is packed in an individual envelope with the part number on it should be placed back into the envelope after you identify it until it is called for in a step, Do not discard any packing materials until all parts are accounted for. The remaining parts in the shipping carton will be considered as parts in the "final pack."

Each circuit component in this kit has a Circuit Component Number (R2, C4, L1, etc.). This is a specific number for only that one part in the kit. The purpose of these numbers, which are especially useful if a part ever has to be replaced; is to help you easily identify the same part in each section of the Manual. These numbers will appear:

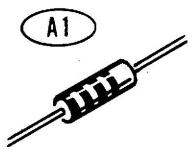
- In the Parts List,
- At the beginning of each step where a circuit component is installed in the Assembly Manual,
- In some illustrations,
- On the Schematic Diagram,
- In the various sections in the rear of this Manual.

| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|

### RESISTORS, 1/2-Watt

NOTE: All resistors are 10% (fourth band silver) unless specified 5% (fourth band gold).

| | | | | | |
|---|---|---|---|---|---|
| A1 | ( ) | 2 | 2.7 Ω, 5% (red-violet-gold) | 1-143 | R314, R316 |
| A1 | ( ) | 1 | 100 Ω (brown-black-brown) | 1-3 | R311 |
| A1 | ( ) | 1 | 200 Ω, 5% (red-black-brown) | 1-137 | R312 |
| A1 | ( ) | 3 | 1000 Ω (brown-black-red) | 1-9 | R307, R309, R315 |
| A1 | ( ) | 4 | 4700 Ω (yellow-violet-red) | 1-16 | R302, R303, R305, R306 |
| A1 | ( ) | 1 | 12 kΩ, 5% (brown-red-orange) | 1-109 | R317 |

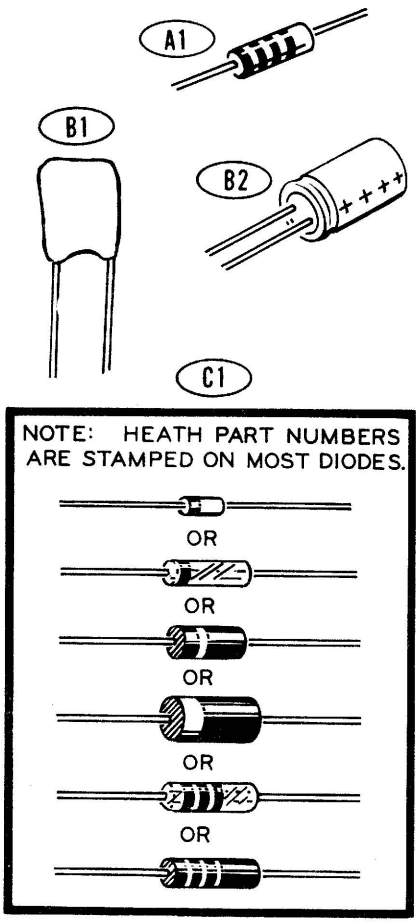


| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|
| **Resistors (cont'd.)** | | | | |
| A1 | ( ) 1 | 27 kΩ (red-violet-orange) | 1-23 | R313 |
| A1 | ( ) 1 | 47 kΩ (yellow-violet-orange) | 1-25 | R308 |
| A1 | ( ) 1 | 1 MΩ (brown-black-green) | 1-35 | R301 |
| **CAPACITORS** | | | | |
| B1 | ( ) 1 | .1 μF Mylar* | 27-47 | C301 |
| B2 | ( ) 1 | 10 μF electrolytic | 25-115 | C302 |
| B2 | ( ) 2 | 100 μF electrolytic | 25-117 | C303, C304 |
| **DIODES-TRANSISTORS-INTEGRATED CIRCUITS (IC's)** | | | | |
| C1 | ( ) 3 | Germanium diode | 56-602 | D302, D303, D304 |
| C1 | ( ) 2 | 1N4149 diode | 56-56 | D301, D305 |
| C2 | ( ) 1 | 2N4304 transistor | 417-140 | Q301 |
| C3 | ( ) 1 | EL131 transistor | 417-241 | Q306 |
| C3 | ( ) 5 | MPSA20 transistor | 417-801 | Q302, Q303, Q304, Q305, Q307 |
| C4 | ( ) 1 | SN7472 IC | 443-4 | IC303 |
| C4 | ( ) 1 | SN74121 IC | 443-22 | IC304 |
| C4 | ( ) 1 | SN74122 IC | 443-23 | IC302 |
| C4 | ( ) 1 | SN74132 IC | 443-625 | IC301 |
| **MISCELLANEOUS** | | | | |
| D1 | ( ) 1 | 10 kΩ control | 10-386 | R304 |
| D2 | ( ) 4 | IC socket | 434-298 | |

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

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

*Mylar, DuPont Registered Trademark



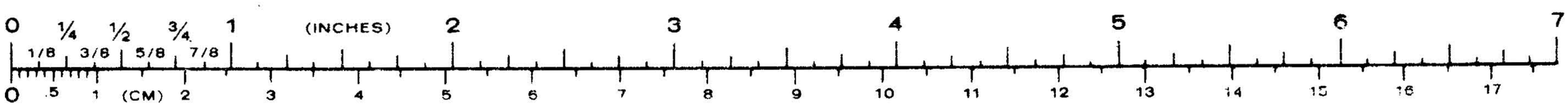
| QTY. | | DESCRIPTION | PART No. |
|---|---|---|---|

## PARTS FROM FINAL PACK

| | | | |
|---|---|---|---|
| ( ) | 3′ | Black stranded wire | 341-1 |
| ( ) | 3′ | Red stranded wire | 341-2 |
| ( ) | 2′-0″ | Shielded cable | 343-15 |
| ( ) | 9′-0″ | Blue wire | 344-13 |
| ( ) | 3′-0″ | Brown stranded wire | 344-31 |
| ( ) | 3′-6″ | Black | 344-50 |
| ( ) | 4′-0″ | Orange | 344-53 |
| ( ) | 4′-6″ | Green | 344-55 |
| ( ) | 3′-6″ | Violet | 344-57 |
| ( ) | 5′-6″ | Gray | 344-58 |
| ( ) | 11′-0″ | White | 344-59 |
| ( ) | 2′ | 300 Ω twin lead | 347-2 |
| ( ) | 1 | Sweep circuit board | 85-1534-3 |
| ( ) | 1 | Kit Builders Guide | 597-308 |
| ( ) | 1 | Parts Order Form | 597-260 |
| | | Solder | |
| | | Illustration Book | |
| | | Manual (See front cover for part number.) | |

NOTE: The prices shown on the separate "Heath Parts Price List" 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 (Michigan residents add 4% sales tax) to cover insurance, 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.

To order a replacement part, refer to "Replacement Parts" inside the rear cover of the Manual.



# STEP-BY-STEP ASSEMBLY

## CIRCUIT BOARD ASSEMBLY

Before you start to assemble this Kit, read the "Kit Builders Guide" for complete information on wiring, soldering, and step-by-step assembly procedures.

During assembly, position all parts as shown in the Pictorials. Follow the instructions carefully, and read the entire step before you perform the operation. Solder a part or a group of parts only when instructed.

Do not create solder bridges between adjacent circuit board foils. A solder bridge usually occurs when you use too much solder and then drag the soldering iron across the board when you remove it from the connection. Always use just enough solder to make a good connection, and lift the soldering iron straight up from the circuit board. If a solder bridge should develop, turn the circuit board foil side down and heat the solder between connections. The excess solder will run onto the tip of the soldering iron, and this will remove the solder bridge. See Figure 1-1. If you suspect a solder bridge exists, but are not sure, compare the foil side of the circuit board with the "X-Ray View" of the circuit board at the rear of the Manual.

Use 1/2-watt resistors unless directed otherwise in a step. All resistors will be called out by the resistance value (in Ω, kΩ, or MΩ); the color code will also be given for color-coded resistors. Capacitors will be called out by the capacitance value and type. After you solder, always cut off any excess lead or lug length from the foil side of the circuit board, unless instructed not to do so.

NOTE: When you are instructed to cut something to a particular length, use the scales (ruler) provided at the bottom of the Manual pages.

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

## CIRCUIT BOARD COMPONENT MOUNTING

Components will be installed on the circuit board in the following Pictorials. Position each component within its outline on the lettered side of the circuit board. Push each component down (as close as possible) to the circuit before you solder its leads to the opposite (foil) side.

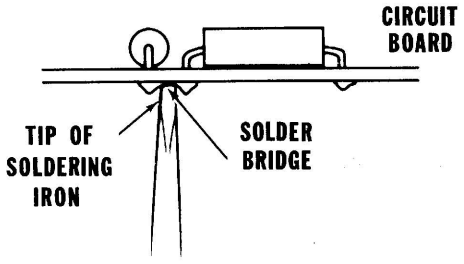



Figure 1-1

**START**

NOTE: When a bare wire is called for in a step, prepare it from the white wire furnished in the kit. Remove all the insulation from the specified length of wire first. Then cut the bare wire off the white wire.

( ) 1" bare wire.

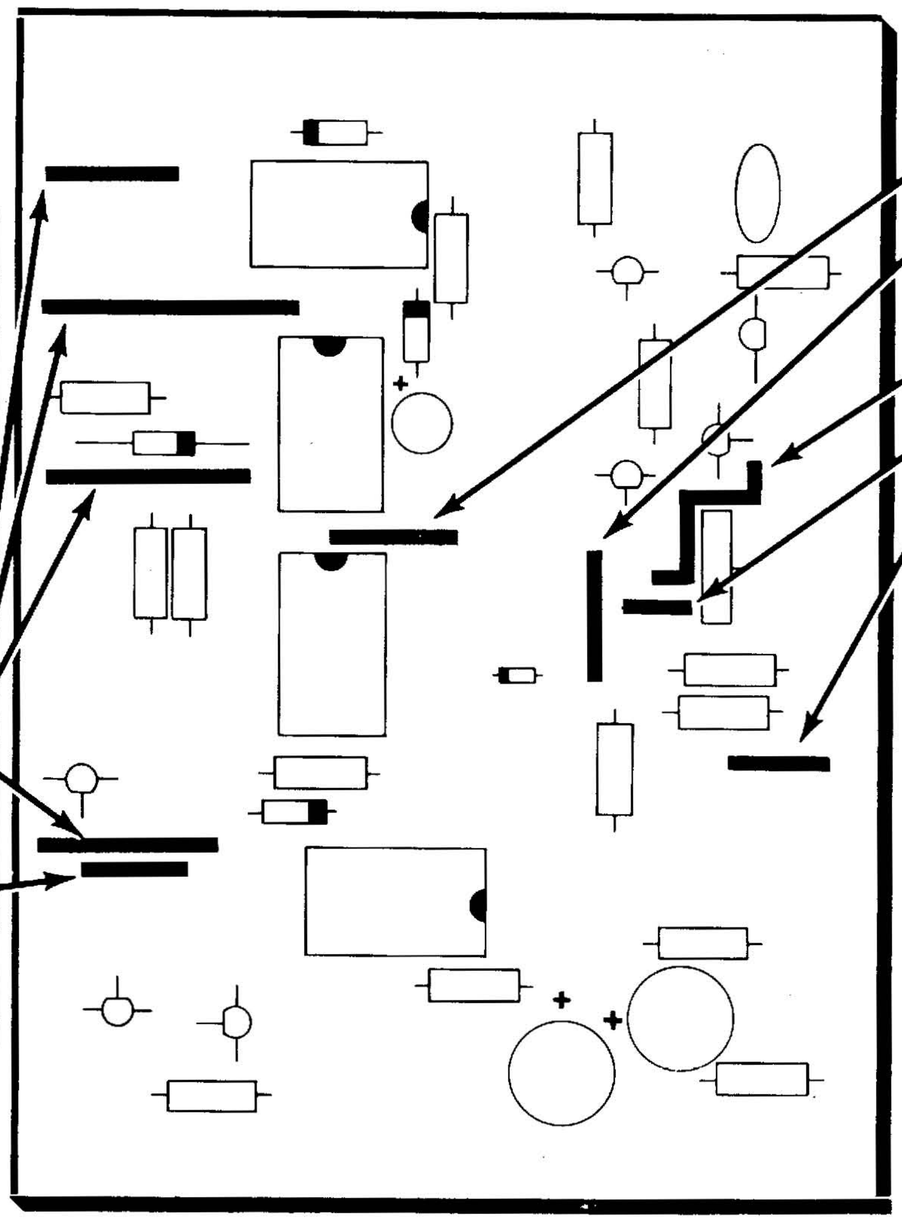
( ) 1-1/2" bare wire.

( ) 1-1/2" bare wire.

( ) 1-1/4" white wire. Remove 1/4" of insulation from each end.

( ) 1" bare wire.

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



**CONTINUE**

( ) 1" bare wire.

( ) 1" bare wire.

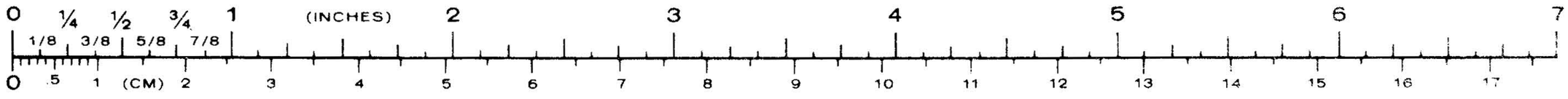
( ) 1-1/4" white wire. Remove 1/4" of insulation from each end.

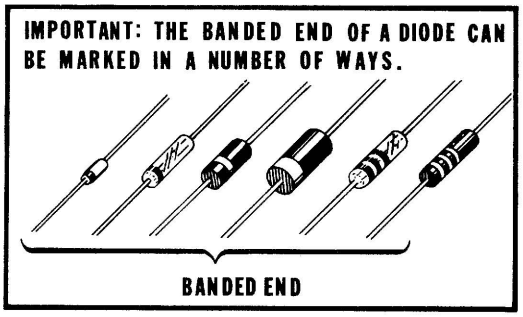
( ) 1" bare wire.

( ) 1" bare wire.

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

## PICTORIAL 1-1

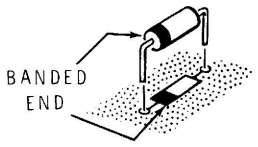





Detail 1-2A

**START**

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




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

( ) D302 : Germanium diode (#56-602).

( ) R312: 200 Ω (red-black-brown).

( ) D303 : Germanium diode (#56-602).

( ) R309: 1000 Ω (brown-black-red).

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

( ) R311: 100 Ω (brown-black-brown).

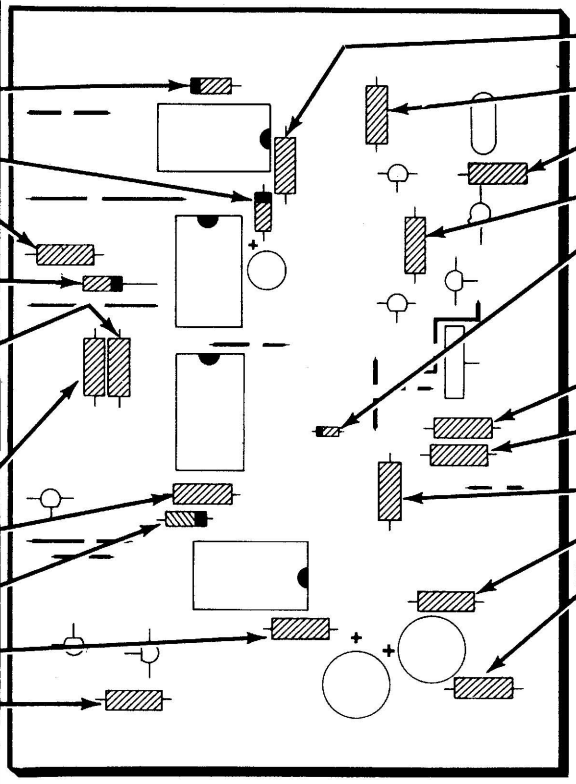
( ) R315: 1000 Ω (brown-black-red).

( ) D304 : Germanium diode (#56-602).

( ) R313: 27 kΩ (red-violet-orange).

( ) R317: 12 kΩ (brown-red-orange).

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



**CONTINUE**

( ) R308: 47 kΩ (yellow-violet-orange).

( ) R307: 1000 Ω (brown-black-red).

( ) R301: 1 MΩ (brown-black-green).

( ) R305: 4700 Ω (yellow-violet-red).

( ) D301: 1N4149 diode (#56-56).

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

( ) R306: 4700 Ω (yellow-violet-red).

( ) R302: 4700 Ω (yellow-violet-red).

( ) R303: 4700 Ω (yellow-violet-red).

( ) R314: 2.7 Ω (red-violet-gold).

( ) R316: 2.7 Ω (red-violet-gold).

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

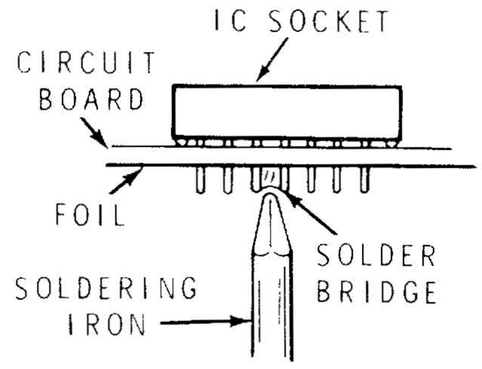
PICTORIAL 1-2

## START

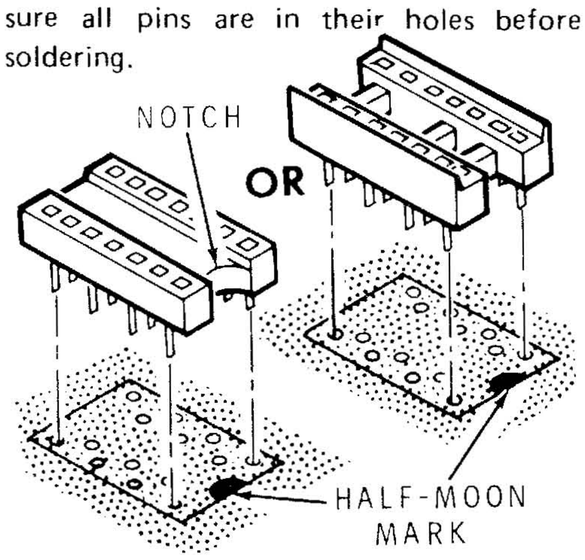
NOTE: Read this information carefully before you install the IC (integrated circuit) sockets in the following steps. First, be sure to position each socket as shown, so its arrow points at the dot on the circuit board. If you received IC sockets without arrows, you can install the sockets either way. Solder the pins of each socket when you install it.

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

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




NOTE: Be sure to position the socket so the half-moon mark on the circuit board is still visible after it is installed. Solder the pins of each socket as you install it. Make sure all pins are in their holes before soldering.

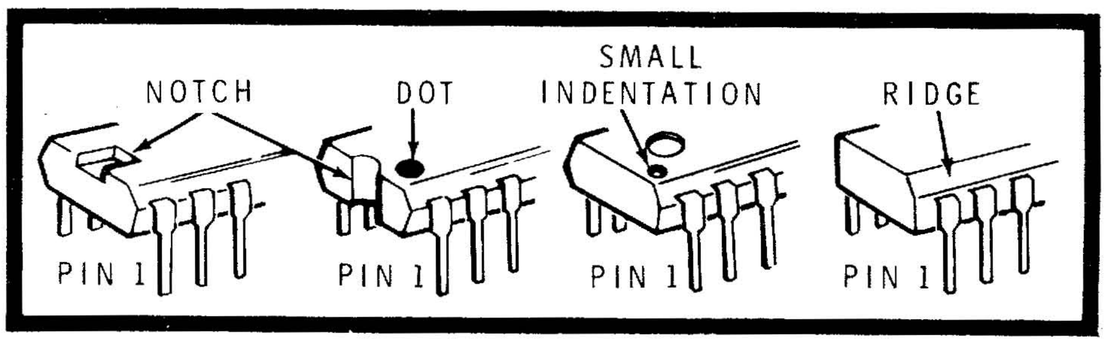



( ) 14-pin IC socket at IC301.

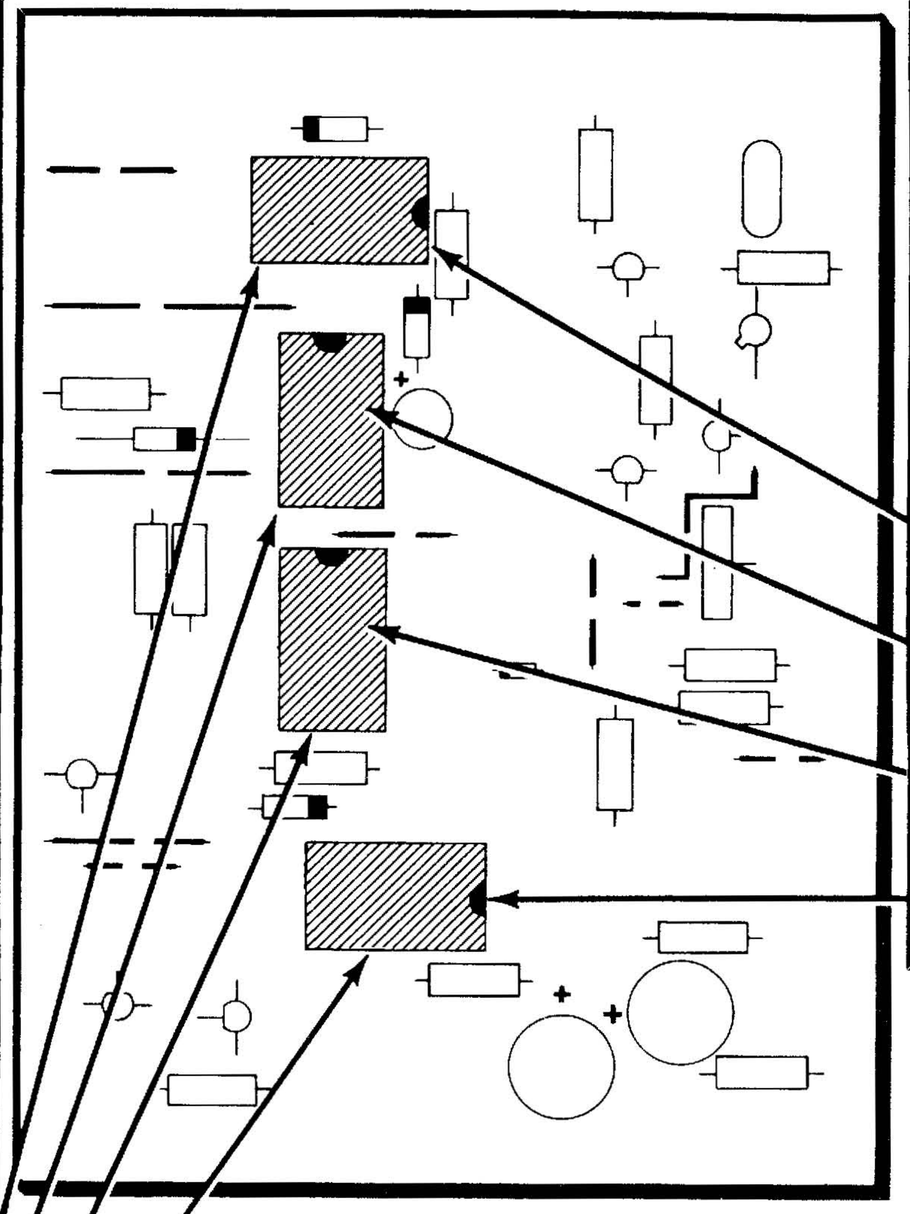
( ) 14-pin IC socket at IC302.

( ) 14-pin IC socket at IC303.

( ) 14-pin IC socket at IC304.




**Detail 1-3A**

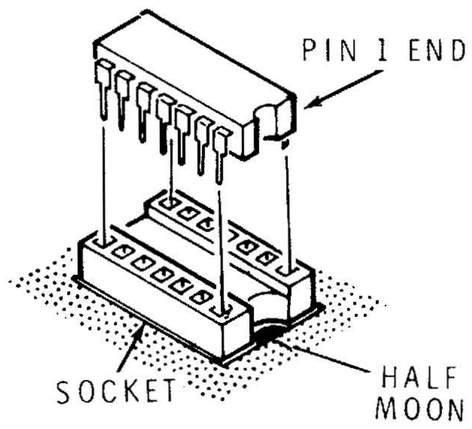


**PICTORIAL 1-3**

## CONTINUE

NOTE: Integrated circuits may be marked with a notch, dot, dimple, or beveled edge. See Detail 1-3A.

When you install each integrated circuit in the following steps, position the pin 1 end (see Detail 1-3A) at the half moon on the circuit board; then carefully insert the leads into the socket.




( ) IC301: SN74132N integrated circuit (#443-625).

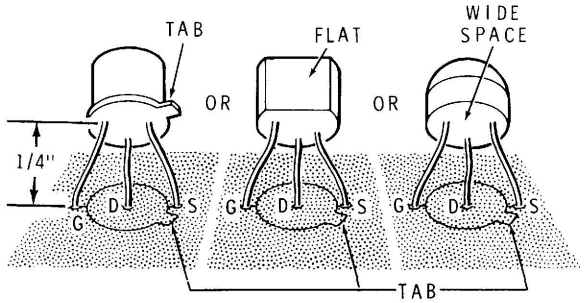
( ) IC302: SN74122N integrated circuit (#443-23).

( ) IC303: SN7472N integrated circuit (#443-4).

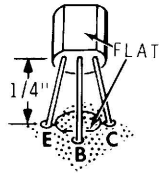
( ) IC304: SN74121N integrated circuit (#443-22).

**START**

( ) Q301: 2N4304 transistor (#417-140). Position the locating tab, the flat, or the wide space of the transistor as shown with respect to the tab outline on the circuit board. Solder the leads to the foil and cut off the excess lead lengths.




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




( ) Q304: MPSA20 transistor (#417-801).

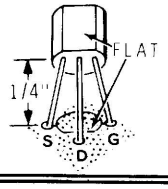
( ) Q302: MPSA20 transistor (#417-801).

( ) Q303: MPSA20 transistor (#417-801).

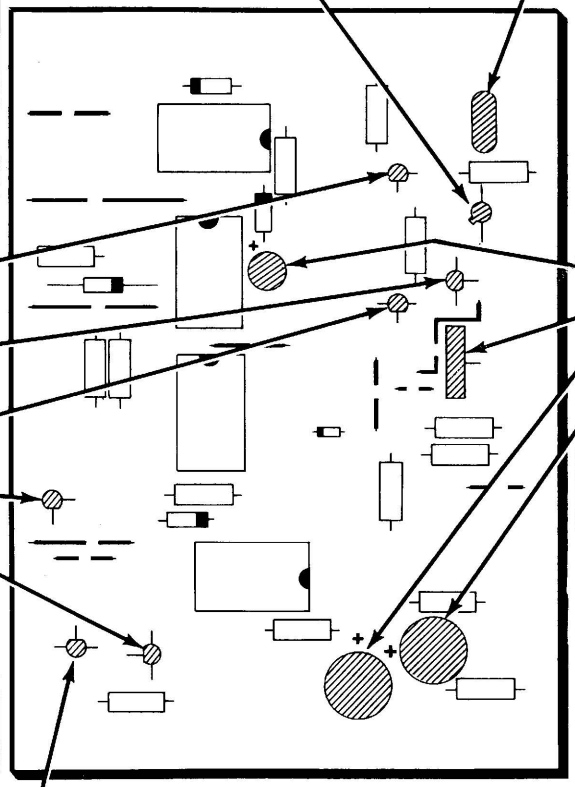
( ) Q305: MPSA20 transistor (#417-801).

( ) Q307: MPSA20 transistor (#417-801).

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




( ) Q306: EL131 transistor (#417-241).

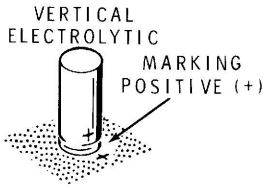


**PICTORIAL 1-4**

**CONTINUE**

( ) C301: .1 µF Mylar.

NOTE: When you install an electrolytic capacitor, always connect the lead at the positive (+) end of the capacitor to the positive (+) marked point on the circuit board.




( ) C302: 10 µF electrolytic.

( ) R304: 10 kΩ control (#10-386).

( ) C304: 100 µF electrolytic.

( ) C303: 100 µF electrolytic.

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

**START**

NOTE: When wiring this kit, you will be instructed to prepare wires ahead of time, as in the following step. Cut the indicated color wire to the length specified. Then remove 1/4" of insulation from each end of the wire. The wires are listed in the order they will be used. Solder each wire as it is installed.

( ) Prepare the following wires:

2" white
6" orange
5-1/2" gray
6" white

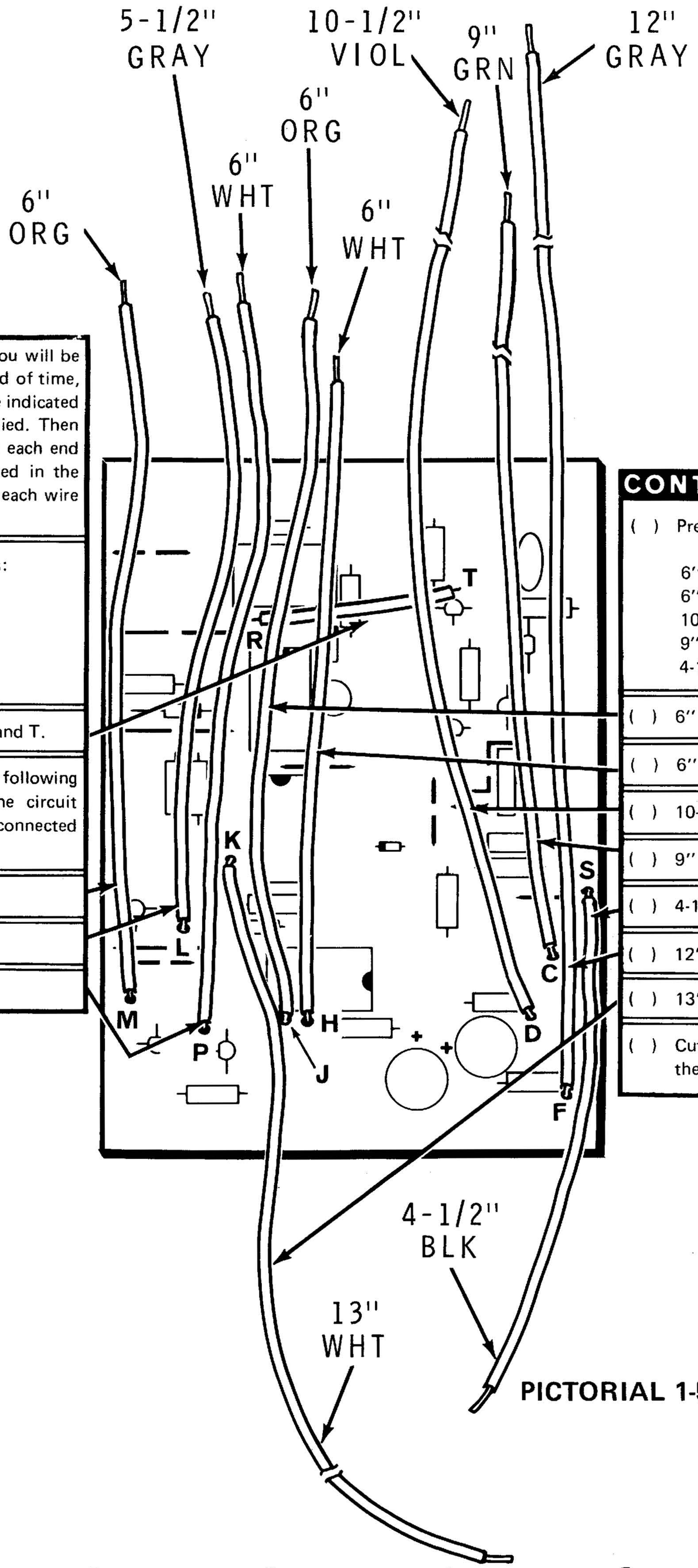
( ) 2" white between holes R and T.

NOTE: Only one end of the following wires will be connected to the circuit board. The free ends will. be connected later.

( ) 6" orange to hole M.

( ) 5-1/2" gray to hole L.

( ) 6" white to hole P.




**PICTORIAL 1-5**

**CONTINUE**

( ) Prepare the following wires:

6" orange
6" white
10-1/2" violet
9" green
4-1/2" black
12" gray
13" white

( ) 6" orange to hole J.

( ) 6" white to hole H.

( ) 10-1/2" violet to hole D.

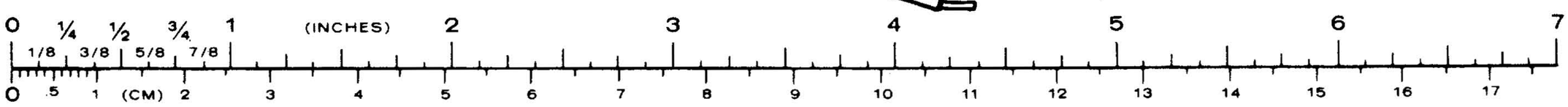
( ) 9" green to hole C.

( ) 4-1/2" black to hole S.

( ) 12" gray to hole F.

( ) 13" white to hole K.

( ) Cut off any excess lead lengths on the foil side of the circuit board.

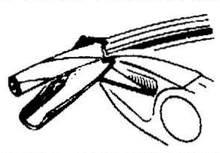


**START**

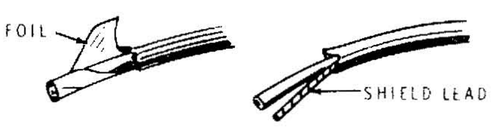
( ) Prepare the ends of a 6" and a 12" length of shielded cable as follows:

PREPARE EACH END AS SHOWN

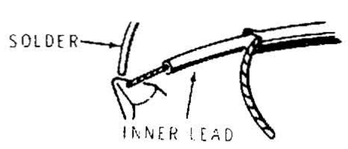

TAKING CARE NOT TO CUT THE SHIELD LEAD, REMOVE THE OUTER INSULATION.



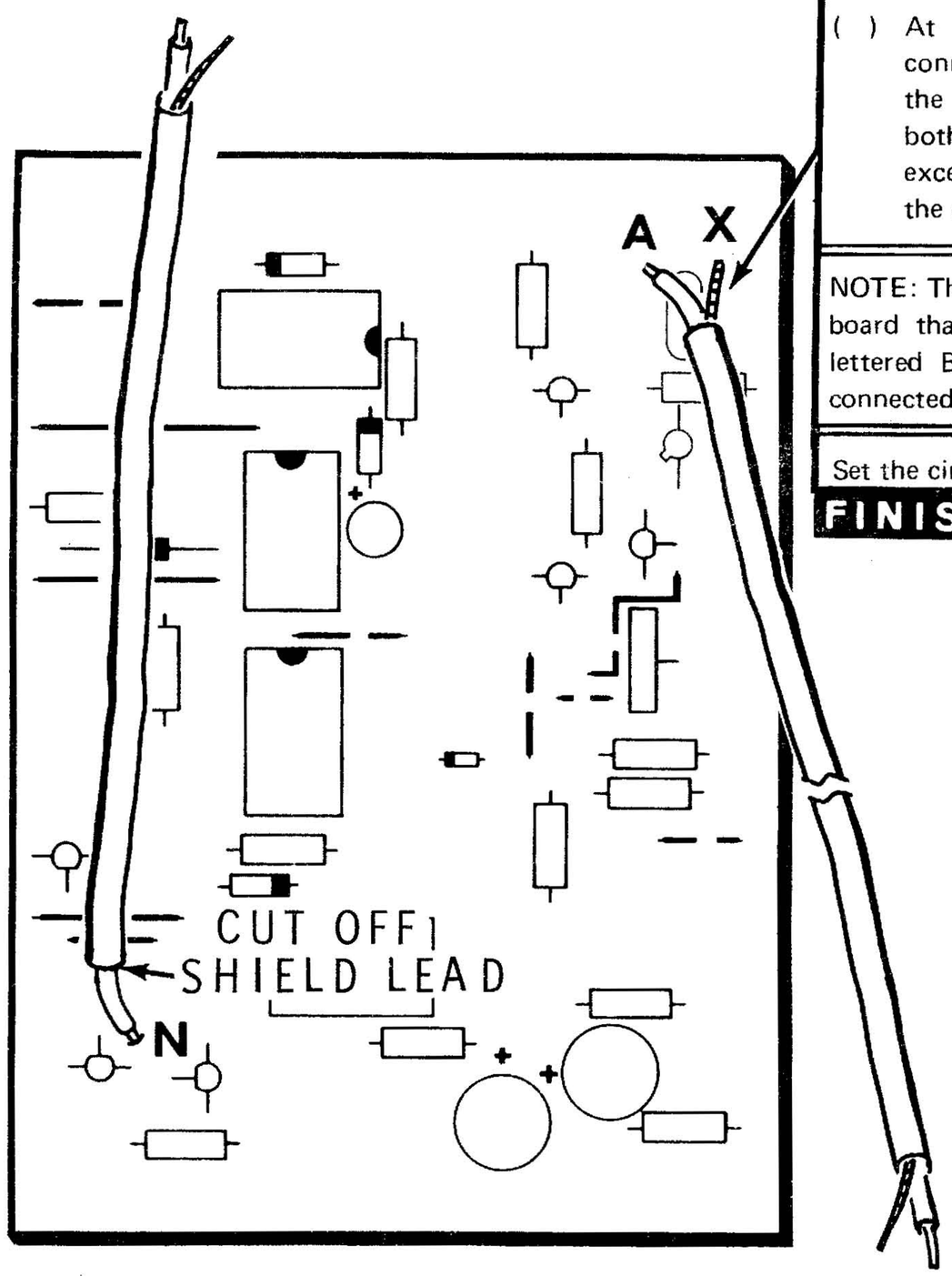
PEEL OFF THE FOIL AND STRAIGHTEN OUT THE SHIELD LEAD




REMOVE THE INNER INSULATION




( ) At one end of the 6" cable, connect the inner lead to hole N. Solder the lead to the foil and cut off the excess lead length. Now cut off the shield lead at the circuit board end of the cable. The other end of this cable will be connected later.




**CONTINUE**

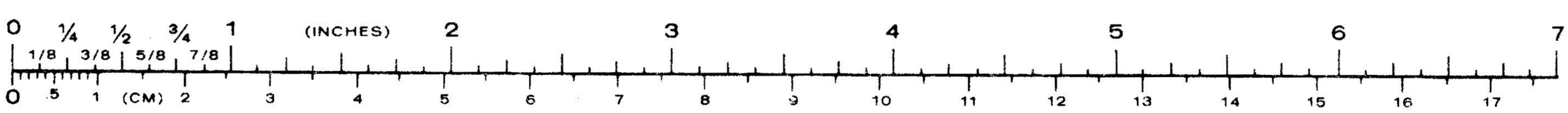
( ) At one end of the 12" cable, connect the inner lead to hole A and the shield lead to hole X. Solder both leads to the foil and cut off the excess lead lengths. The other end of the cable will be connected later.

NOTE: There are many holes in the circuit board that are not used. Also, the holes lettered B, E, and G do not have wires connected to them and are not used.

Set the circuit board aside temporarily.

**FINISH**

## PICTORIAL 1-6



# CHASSIS

## PARTS LIST

Check the remaining parts against the following list. The key numbers correspond to the numbers in the Parts Pictorial. Make a check (✓) in the space provided as you identify each part.

| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|

### RESISTORS

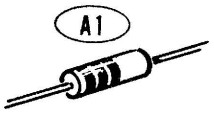
#### 1/2-Watt

NOTES:

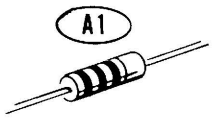
1. All resistors are 10% (fourth band silver) unless specified 5% (fourth band gold).

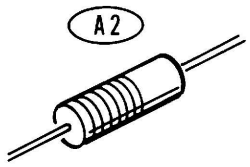
2. The resistors may be packed in more than one envelope. Open all resistor envelopes (marked with an "R") before you check the resistors against the following list.

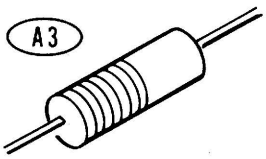
| | | | | | |
|---|---|---|---|---|---|
| A1 | ( ) | 4 | 100 Ω (brown-black-brown) | 1-3 | R111, R118, R205, R357 |
| A1 | ( ) | 4 | 220 Ω (red-red-brown) | 1-45 | R18, R105, R211, R212 |
| A1 | ( ) | 2 | 330 Ω (orange-orange-brown) | 1-4 | R114, R115 |
| A1 | ( ) | 2 | 390 Ω (orange-white-brown) | 1-48 | R121, R122 |
| A1 | ( ) | 1 | 470 Ω (yellow-violet-brown) | 1-6 | R349 |
| A1 | ( ) | 2 | 680 Ω (blue-gray-brown) | 1-7 | R113, R116 |
| A1 | ( ) | 2 | 820 Ω (gray-red-brown) | 1-8 | R215, R216 |
| A1 | ( ) | 6 | 1000 Ω (brown-black-red) | 1-9 | R107, R108, R203, R209, R213, R352 |

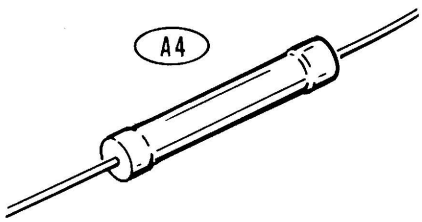


| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|
| **Resistors (cont'd.)** | | | | |
| A1 | ( ) 4 | 1500 Ω (brown-green-red) | 1-11 | R202, R208, R124, R126 |
| A1 | ( ) 1 | 1800 Ω (brown-gray-red) | 1-93 | R206 |
| A1 | ( ) 1 | 2200 Ω (red-red-red) | 1-44 | R351 |
| A1 | ( ) 1 | 4700 Ω (yellow-violet-red) | 1-16 | R201 |
| A1 | ( ) 2 | 10 kΩ, 5% (brown-black-orange) | 1-105 | R103, R218 |
| A1 | ( ) 1 | 47 kΩ (yellow-violet-orange) | 1-25 | R11 |
| A1 | ( ) 1 | 82 kΩ (gray-red-orange) | 1-102 | R1 |
| A1 | ( ) 1 | 91 kΩ, 5% (white-brown-orange) | 1-127 | R102, |
| A1 | ( ) 4 | 100 kΩ (brown-black-yellow) | 1-26 | R2, R104 R354, R355 |
| A1 | ( ) 2 | 820 kΩ (gray-red-yellow) | 1-68 | R8, R9 |
| A1 | ( ) 1 | 910 kΩ, 5% (white-brown-yellow) | 1-176 | R101 |
| A1 | ( ) 1 | 1 MΩ (brown-black-green) | 1-35 | R19 |
| A1 | ( ) 1 | 10 MΩ (brown-black-blue) | 1-40 | R3 |
| **1-Watt** | | | | |
| A2 | ( ) 1 | 33 Ω (orange-orange-black) | 1-14-1 | R16 |
| A2 | ( ) 2 | 68 Ω (blue-gray-black) | 1-16-1 | R14, R15 |
| A2 | ( ) 1 | 470 kΩ (yellow-violet-yellow) | 1-32-1 | R6 |
| A2 | ( ) 1 | 3.3 MΩ (orange-orange-green) | 1-37-1 | R4 |
| **2-Watt** | | | | |
| A3 | ( ) 1 | 100 Ω (brown-black-brown) | 1-20-2 | R17 |
| A3 | ( ) 1 | 1500 Ω (brown-green-red) | 1-14-2 | R12 |
| A3 | ( ) 1 | 2700 Ω (red-violet-red) | 1-1-2 | R13 |
| A3 | ( ) 1 | 10 kΩ (brown-black-orange) | 1-3-2 | R356 |
| A3 | ( ) 2 | 15 kΩ (brown-green-orange) | 1-4-2 | R214, R217 |
| **4-Watt** | | | | |
| A4 | ( ) 2 | 5600 Ω (5.6k) film | 5-1-4 | R119, R123 |



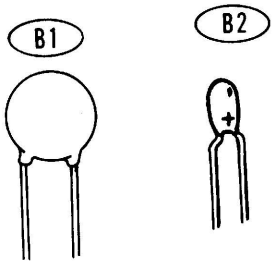



| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|

## CAPACITORS

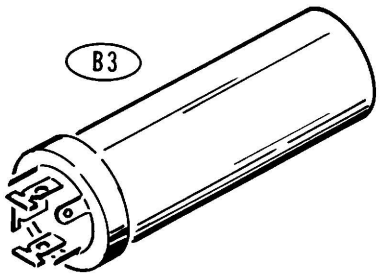
### Ceramic

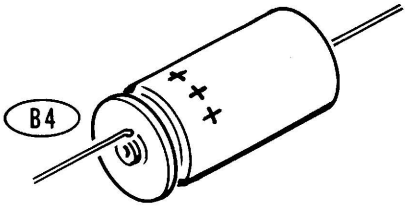
| | | | | |
|---|---|---|---|---|
| B1 | ( ) 1 | 5 pF | 21-78 | C102 |
| B1 | ( ) 1 | 56 pF | 21-121 | C103 |
| B1 | ( ) 1 | 100 pF | 21-9 | C355 |
| B1 | ( ) 2 | 150 pF | 21-11 | C106, C107 |
| B1 | ( ) 1 | 220 pF | 21-22 | C201 |
| B1 | ( ) 1 | 680 pF | 21-171 | C104 |
| B1 | ( ) 1 | .003 μF | 21-26 | C356 |
| B1 | ( ) 1 | .005 μF, 1.6kv | 21-35 | C357 |
| B1 | ( ) 2 | .01 μF, 500V | 21-16 | C105, C353 |
| B1 | ( ) 1 | .01 μF, 100V | 21-176 | C351 |




### Electrolytic

| | | | | |
|---|---|---|---|---|
| B2 | ( ) 1 | 2.2 μF (tantalum) | 25-221 | C352 |
| B3 | ( ) 1 | 100-100-300 μF | 25-228 | C4—A,B,C |
| B4 | ( ) 2 | 1200 μF | 25-241 | C8, C9 |
| B4 | ( ) 3 | 2000 μF | 25-230 | C5, C6, C7 |



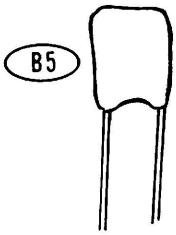



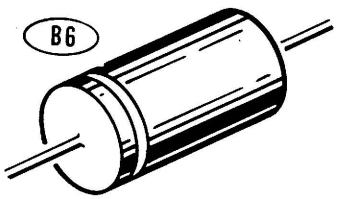

### Mylar

| | | | | |
|---|---|---|---|---|
| B5 | ( ) 1 | .1 μF | 27-47 | C354 |
| B5 | ( ) 1 | .1 μF, 400V | 27-28 | C101 |
| B5 | ( ) 1 | .47 μF, 200V | 27-61 | C11 |

### Other Capacitors

| | | | | |
|---|---|---|---|---|
| B6 | ( ) 3 | .1 μF paper, 1600V | 23-62 | C1, C2, C3 |



| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|

NOTE: Diodes and 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.

## DIODES

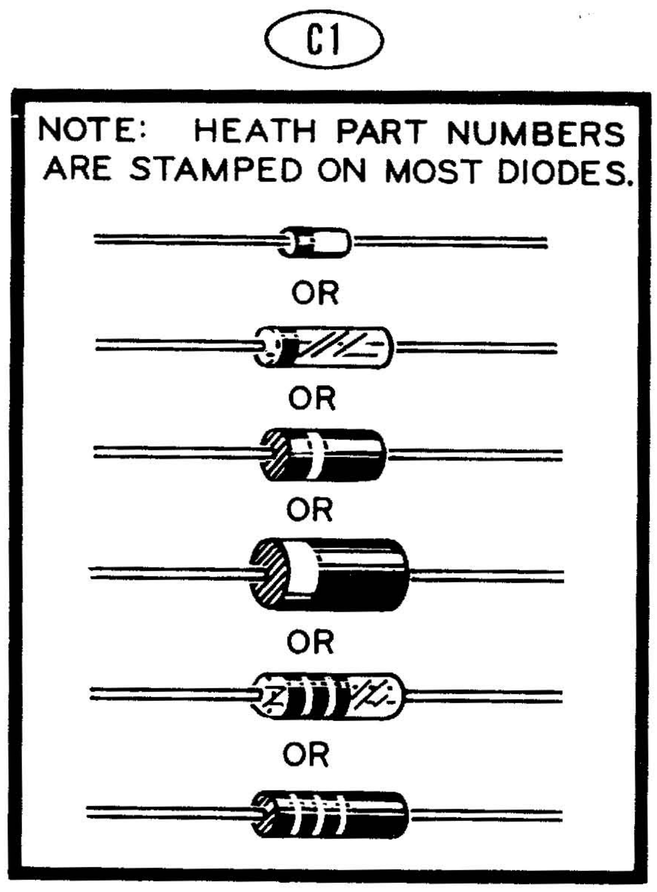
| | | | | | |
|---|---|---|---|---|---|
| C1 | ( ) | 1 | 1N751 (zener) | 56-16 | ZD8 |
| C1 | ( ) | 2 | VR 9.1 (zener) | 56-19 | ZD7, ZD9 |
| C1 | ( ) | 1 | ZVR68 (zener) | 56-68 | ZD353 |
| C1 | ( ) | 8 | 1N2071 | 57-27 | D3, D4, D5, D6, D11, D12, D13, D14 |
| C1 | ( ) | 2 | 5D20 | 57-52 | D1, D2 |

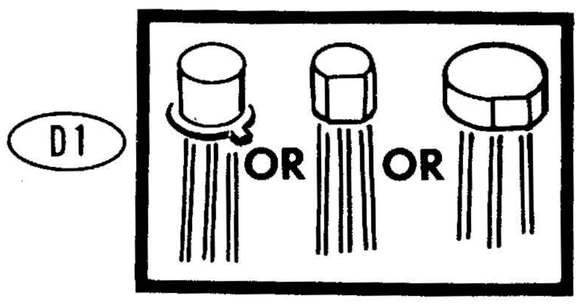
## TRANSISTORS

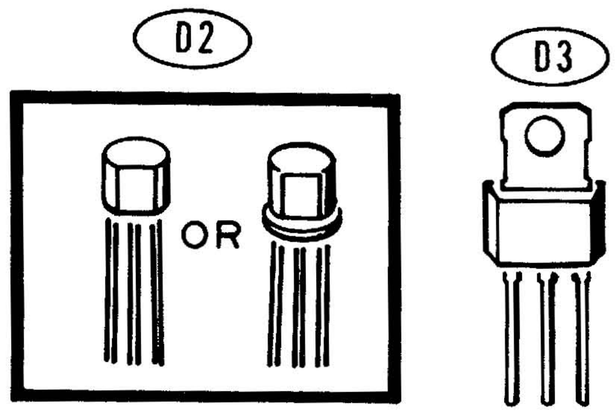
| | | | | | |
|---|---|---|---|---|---|
| D1 | ( ) | 1 | 2N4304 | 417-140 | Q101 |
| D2 | ( ) | 1 | X29A829 | 417-201 | Q351 |
| D2 | ( ) | 2 | 2N5770 | 417-293 | Q104, Q105 |
| D2 | ( ) | 3 | MPSA42 | 417-294 | Q205, Q206, Q352 |
| D2 | ( ) | 10 | MPSA20 | 417-801 | Q102, Q103, Q201, Q202, Q203, Q204, ZD101, ZD102, ZD351, ZD352 |
| D3 | ( ) | 2 | MPSU10 | 417-834 | Q106, Q107 |

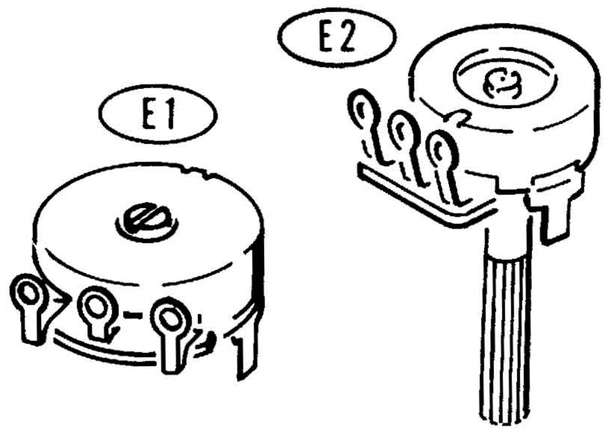
## CONTROLS-SWITCHES

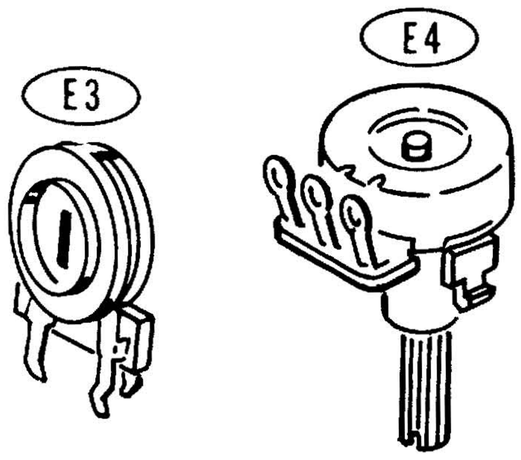
| | | | | | |
|---|---|---|---|---|---|
| E1 | ( ) | 2 | 1000 Ω (1K) control | 10-329 | R109, R204 |
| E2 | ( ) | 2 | 1000 Ω (1K) control | 10-1017 | R106, R207 |
| E2 | ( ) | 1 | 5000 Ω (5K) control | 10-1016 | R117 |
| E3 | ( ) | 1 | 10 kΩ control | 10-386 | R125 |
| E4 | ( ) | 1 | 250 kΩ control | 10-1042 | R353 |
| E4 | ( ) | 1 | 500 kΩ control | 10-1052 | R7 |
| E2 | ( ) | 1 | 1 MΩ control | 10-334 | R5 |



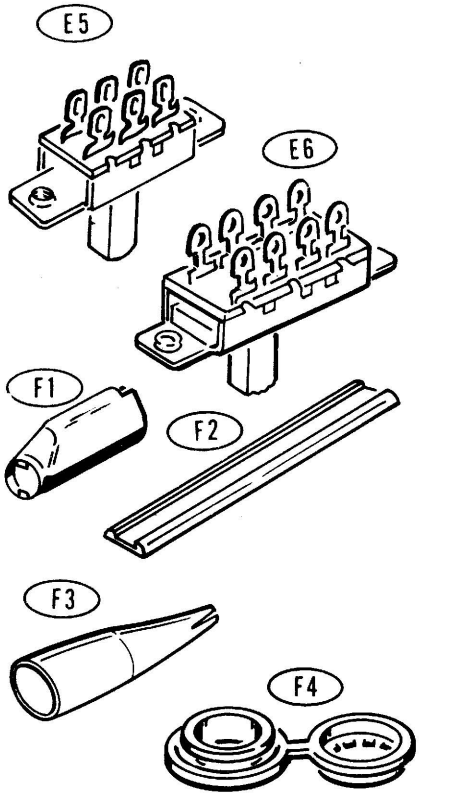



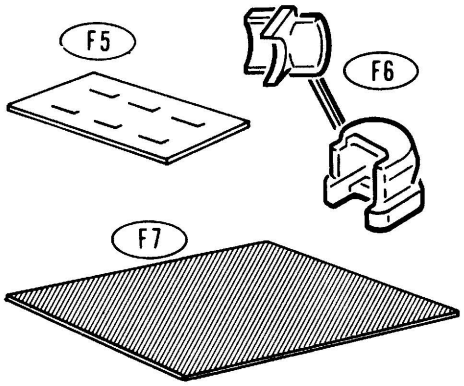



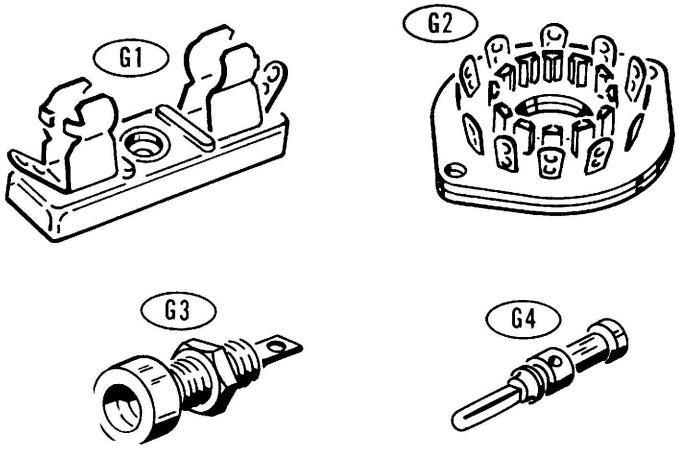



| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|
| **Controls-Switches (cont'd.)** | | | | |
| E5 | ( ) 3 | 6-lug switch | 60-2 | SW1, SW301, SW302 |
| E6 | ( ) 1 | 8-lug switch | 60-73 | SW101 |
| **INSULATORS-STRAIN RELIEF** | | | | |
| F1 | ( ) 1 | Black banana plug insulator | 70-10 | |
| F1 | ( ) 1 | Red banana plug insulator | 70-11 | |
| F2 | ( ) 1 | Rubber strip insulator | 73-5 | |
| F3 | ( ) 2 | Red alligator clip insulator | 73-34 | |
| F4 | ( ) 13 | Plastic grommet insulator | 73-45 | |
| F5 | ( ) 1 | Switch insulator | 75-52 | |
| F6 | ( ) 1 | Line cord strain relief | 75-736 | |
| F7 | ( ) 1 | Fish paper | 75-108 | |
| **FUSEHOLDER-SOCKETS-PLUG** | | | | |
| G1 | ( ) 1 | Fuseholder | 422-1 | |
| G2 | ( ) 1 | Tube socket | 434-41 | |
| G3 | ( ) 3 | Red banana socket | 436-11 | S1, S2, S4 |
| G3 | ( ) 1 | Black banana socket | 436-22 | S3 |
| G4 | ( ) 2 | Banana plug | 438-47 | |



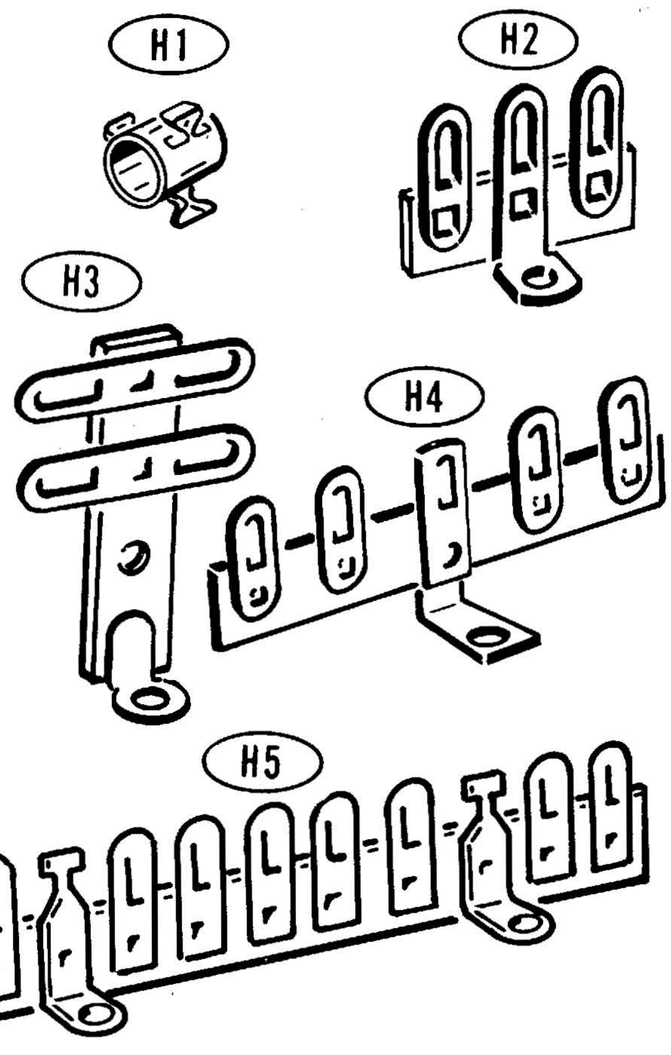



| KEY No. | QTY. | DESCRIPTION | PART No. |
|---|---|---|---|

## TERMINAL COLLAR-TERMINAL STRIPS

| | | | |
|---|---|---|---|
| H1 | ( ) 1 | 3-lug terminal collar | 431-82 |
| H2 | ( ) 1 | 3-lug terminal strip | 431-10 |
| H3 | ( ) 1 | 4-lug terminal strip | 431-28 |
| H4 | ( ) 6 | 5-lug terminal strip | 431-42 |
| H5 | ( ) 9 | 11-lug terminal strip | 431-49 |

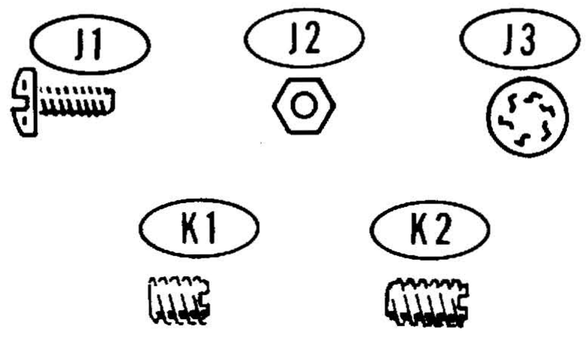



NOTE: The hardware of a particular size (stamped "#4 HDW" for example) may be in more than one packet. Open all the hardware packets of the same size hardware before you check the hardware against the Parts List.

## HARDWARE

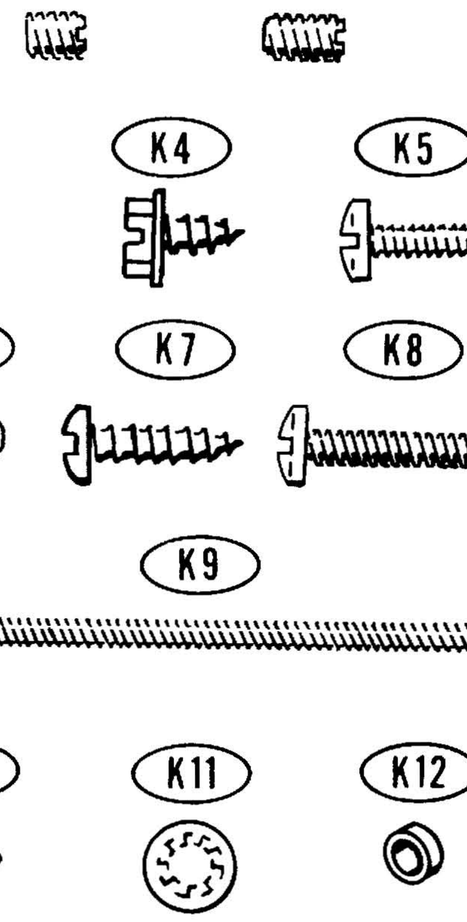
### #4 Hardware

| | | | |
|---|---|---|---|
| J1 | ( ) 18 | 4-40 x 1/4" screw | 250-52 |
| J2 | ( ) 18 | 4-40 nut | 252-15 |
| J3 | ( ) 36 | #4 lockwasher | 254-9 |




### #6 Hardware

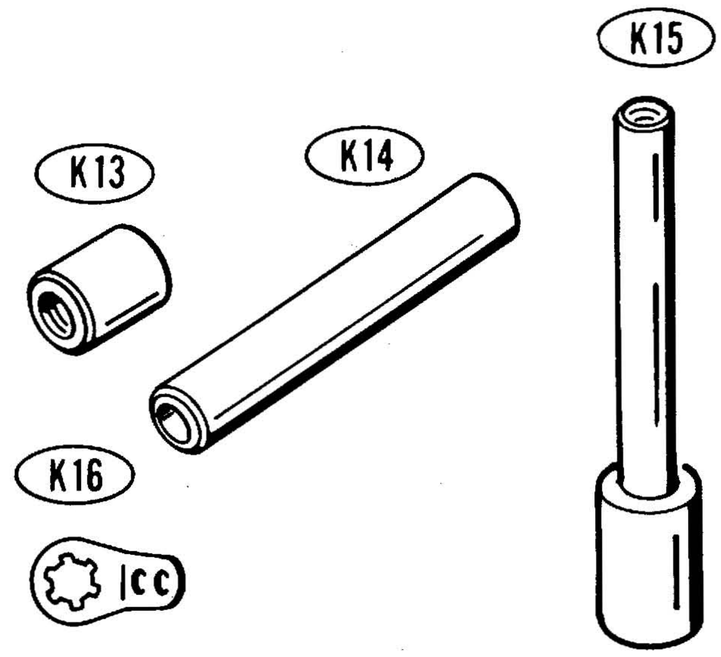
| | | | |
|---|---|---|---|
| K1 | ( ) 5 | 6-32 x 3/16" setscrew | 250-16 |
| K2 | ( ) 1 | 6-32 x 1/4" setscrew | 250-43 |
| K3 | ( ) 6 | 6-32 x 3/16" screw | 250-7 |
| K4 | ( ) 13 | #6 x 1/4" hex head screw | 250-365 |
| K5 | ( ) 15 | 6-32 x 3/8" screw | 250-89 |
| K6 | ( ) 2 | 6-32 x 3/8" flat head screw | 250-32 |
| K7 | ( ) 1 | #6 x 1/2" screw | 250-591 |
| K8 | ( ) 6 | 6-32 x 5/8" screw | 250-26 |
| K9 | ( ) 1 | 6-32 x 2" screw | 250-27 |
| K10 | ( ) 18 | 6-32 nut | 252-3 |
| K11 | ( ) 22 | #6 lockwasher | 254-1 |
| K12 | ( ) 6 | #6 x 1/16" long spacer | 255-74 |



| KEY No. | QTY. | DESCRIPTION | PART No. |
|---|---|---|---|

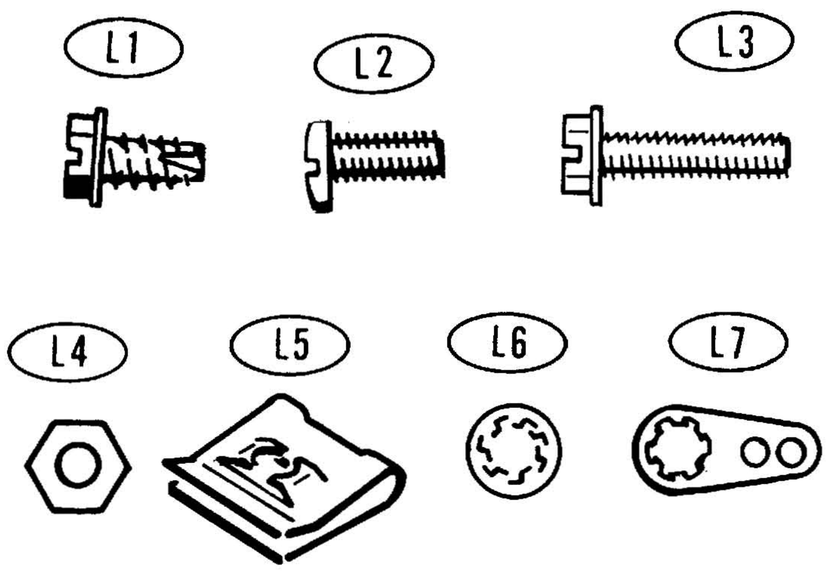
## #6 Hardware (cont'd.)

| | | | | |
|---|---|---|---|---|
| K13 | ( ) | 4 | 6-32 x 11/32" spacer | 255-103 |
| K14 | ( ) | 1 | #6 x 1-1/2" spacer | 255-10 |
| K15 | ( ) | 2 | 6-32 x 2-13/16" spacer | 255-117 |
| K16 | ( ) | 3 | #6 solder lug | 259-1 |



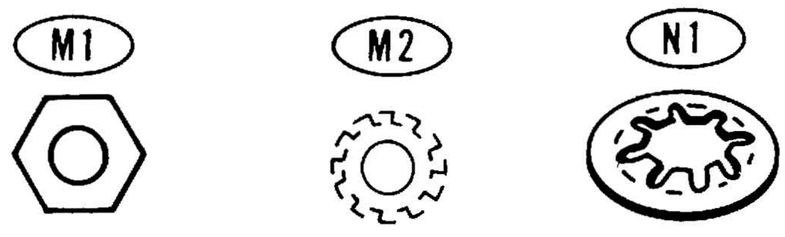

## #8 Hardware

| | | | | |
|---|---|---|---|---|
| L1 | ( ) | 4 | #8 x 5/16" hex head screw | 250-1232 |
| L2 | ( ) | 9 | 8-32 x 3/8" screw | 250-137 |
| L3 | ( ) | 8 | #8 x 5/8" screw | 250-1138 |
| L4 | ( ) | 5 | 8-32 nut | 252-4 |
| L5 | ( ) | 8 | 8-32 push-on nut | 252-68 |
| L6 | ( ) | 4 | #8 lockwasher | 254-2 |
| L7 | ( ) | 1 | #8 solder lug | 259-2 |




## #10 Hardware

| | | | | |
|---|---|---|---|---|
| M1 | ( ) | 2 | 10-32 nut | 252-5 |
| M2 | ( ) | 2 | #10 lockwasher | 254-37 |



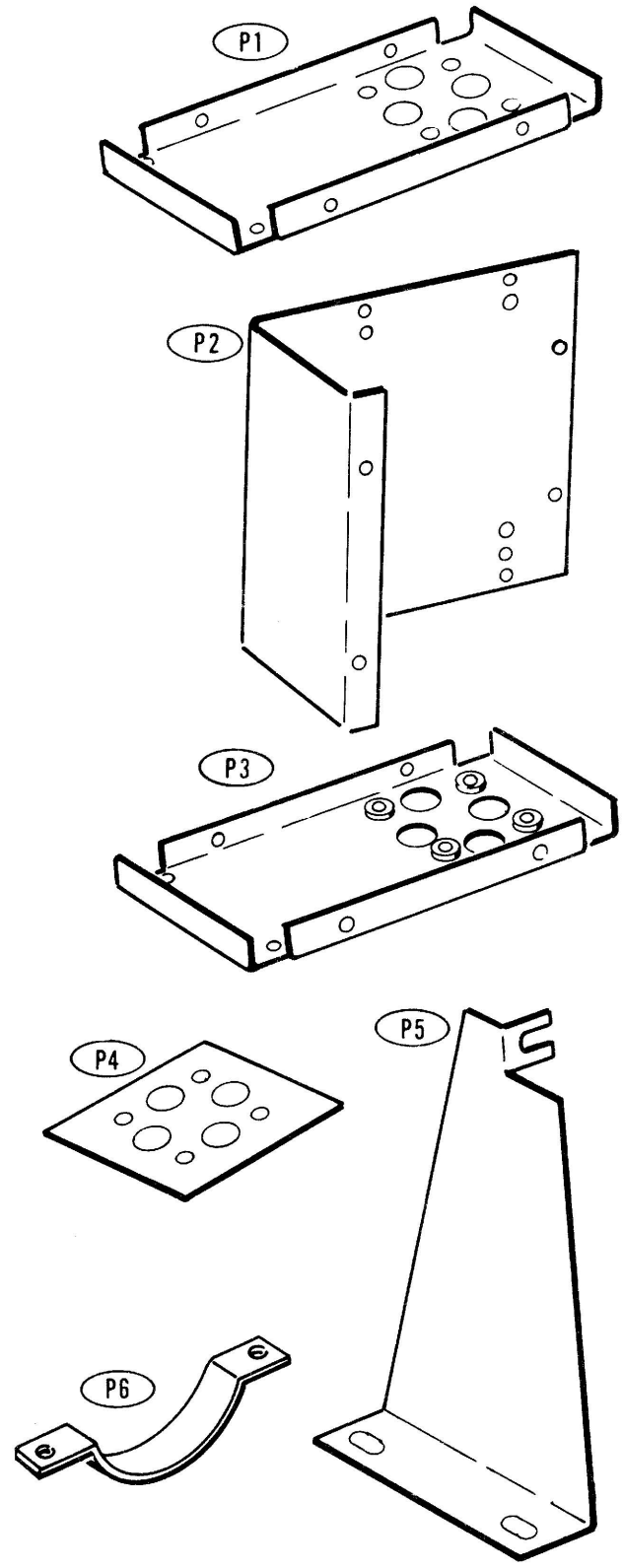

## Other Hardware

| | | | | |
|---|---|---|---|---|
| N1 | ( ) | 1 | Spring nut | 252-73 |

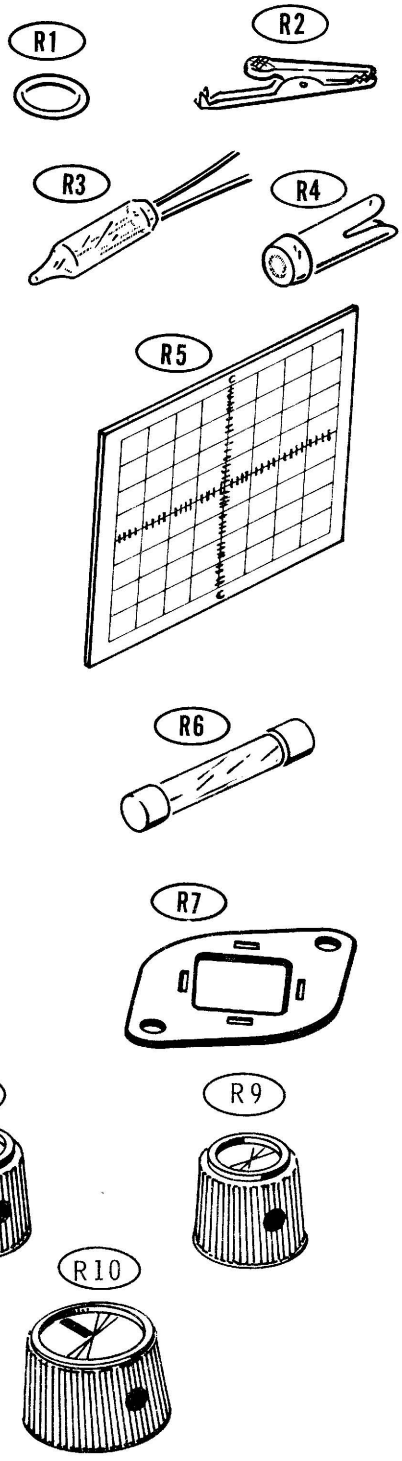
| KEY No. | QTY. | DESCRIPTION | PART No. |
|---|---|---|---|

## METAL PARTS

| | | | | |
|---|---|---|---|---|
| P1 | ( ) | 1 | Transformer cage top | 206-1171 |
| P2 | ( ) | 2 | Transformer cage side | 206-1161 |
| P3 | ( ) | 1 | Transformer cage bottom (with press-in nuts) | 206-1162 |
| P4 | ( ) | 1 | Transformer shield plate | 206-1163 |
| P5 | ( ) | 1 | Front support bracket | 204-2141 |
| P6 | ( ) | 2 | Tube clamp | 207-1 |
| | ( ) | 1 | Chassis | 200-1293 |
| | ( ) | 1 | Metal front panel | 390-1201 |



| KEY No. | QTY. | DESCRIPTION | PART No. | CIRCUIT Component No. |
|---|---|---|---|---|
| **MISCELLANEOUS** | | | | |
| | ( ) 1 | Power transformer | 54-282 | T1 |
| | ( ) 1 | Power transformer | 54-880 | T2 |
| | ( ) 1 | Line cord | 89-54 | |
| | ( ) 1 | Plastic front panel | 92-608 | |
| | ( ) 1 | Cabinet | 92-609 | |
| | ( ) 1 | Handle | 211-49 | |
| R1 | ( ) 1 | "O" ring | 253-115 | |
| R2 | ( ) 2 | Alligator clip | 260-16 | |
| | ( ) 1 | Felt strip | 330-18 | |
| | ( ) 1 | Danger label | 390-147 | |
| | ( ) 1 | Fuse replacement label | 390-1255 | |
| | ( ) 1 | Caution label | 390-1185 | |
| | ( ) 1 | Blue and white label | 391-34 | |
| | ( ) 1 | Cathode ray tube | 411-815 | V1 |
| R3 | ( ) 1 | Pilot lamp | 412-15 | PL1 |
| R4 | ( ) 1 | Pilot lamp lens | 413-10 | |
| R5 | ( ) 1 | Graticule | 414-36 | |
| R6 | ( ) 1 | 1/8 ampere, 3AG fuse | 421-26 | F1 |
| R6 | ( ) 1 | 1/4 ampere, 3AG fuse | 421-33 | F1 |
| R7 | ( ) 1 | Capacitor mounting plate | 481-1 | |
| R8 | ( ) 1 | Small knob (with pointer) | 462-159 | |
| R9 | ( ) 4 | Small knob | 462-138 | |
| R10 | ( ) 1 | Large knob | 462-187 | |
| | ( ) 1 | Plastic nut starter | 490-5 | |




NOTE: The prices shown on the separate "Heath Parts Price List" 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 (Michigan residents add 4% sales tax) to cover insurance, 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.

To order a replacement part, refer to "Replacement Parts" inside the rear cover of the Manual.

# STEP-BY-STEP ASSEMBLY

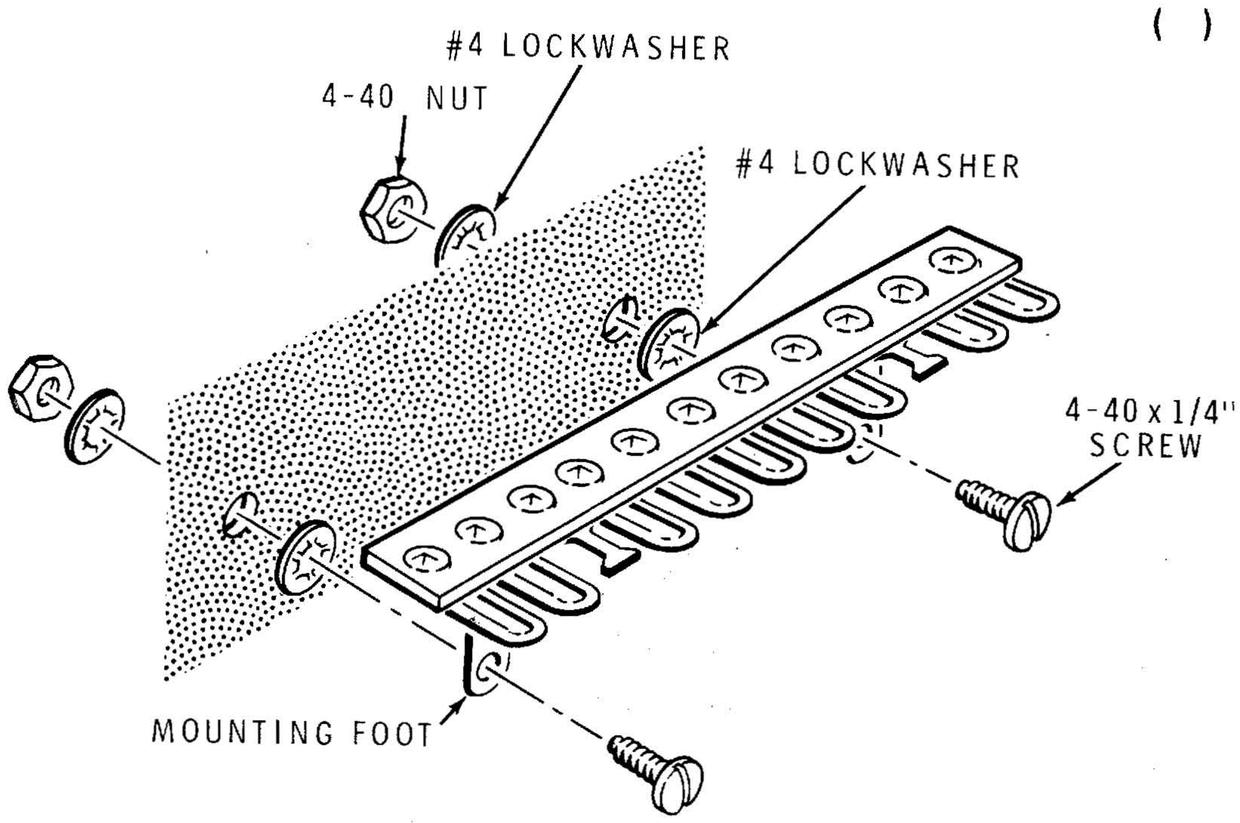
## CHASSIS TOP PARTS MOUNTING

NOTE: A separate Illustration Book contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. The illustrations are arranged in Pictorial number sequence. Place the Book in a convenient location and keep it with the Assembly Manual.

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

( ) Position the chassis as shown in the Pictorial.

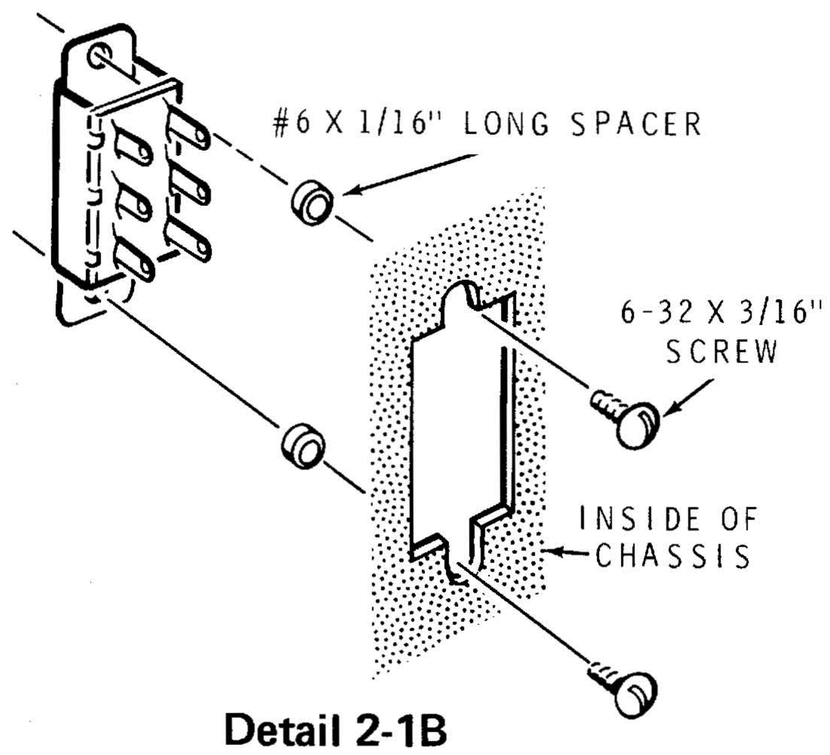
NOTE: The term "hardware" refers to the screws, nuts, and lockwashers when you mount parts in some of the following steps. The phrase "Use 4-40 x 1/4" hardware," for example, means to use a 4-40 x 1/4" screw, one or more #4 lockwashers, and a 4-40 nut. Refer to the Detail called out in the step for the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




**Detail 2-1A**

CAUTION: When you install terminal strips, pay particular attention to the position of the mounting feet. If the terminal strips are mounted incorrectly, the circuit components that you mount later may not fit properly.

( ) Refer to Detail 2-1A and install an 11-lug terminal strip at A. Use 4-40 x 1/4" hardware in both mounting feet of the terminal strip.

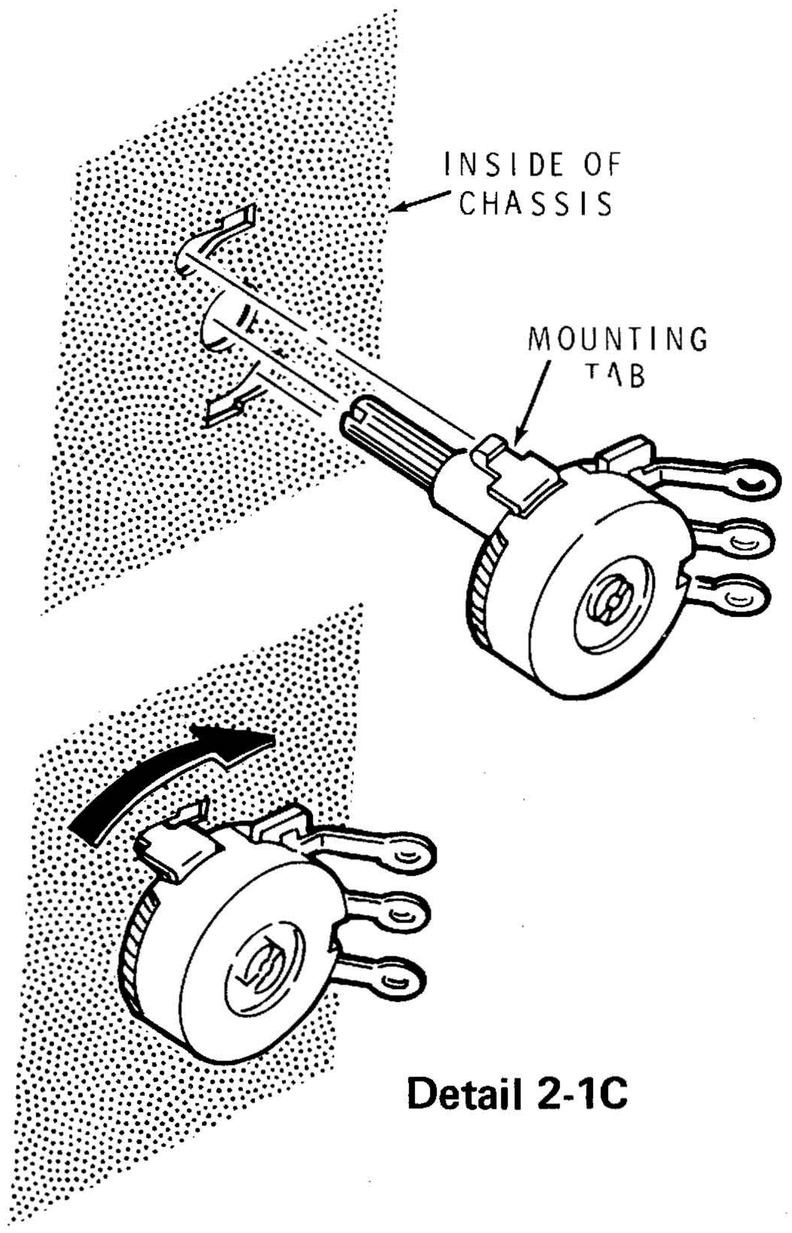



**Detail 2-1B**

( ) In the same manner, install 11-lug terminal strips at locations C, D, E, F, G, H, J, and K.

( ) SW301: Refer to Detail 2-1B and install a 6-lug switch. Use 6-32 x 3/16" screws and #6 x 1/16" long spacers.

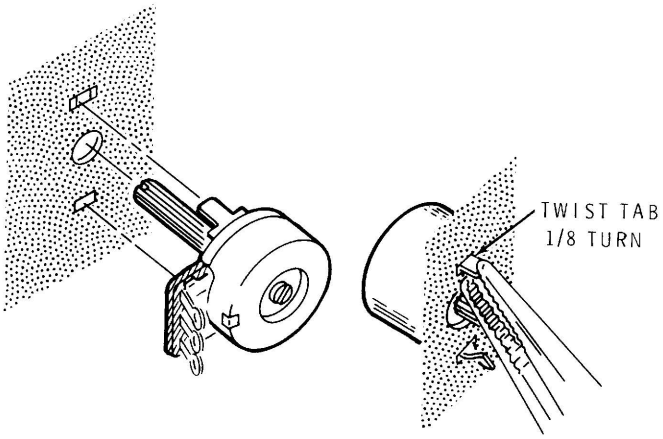
( ) SW302: In the same manner, install a 6-lug switch.




**Detail 2-1C**

( ) R353: Refer to Detail 2-1C and install a 250 kΩ control (#10-1042). Rotate the control clockwise until the plastic mounting tabs lock into place.

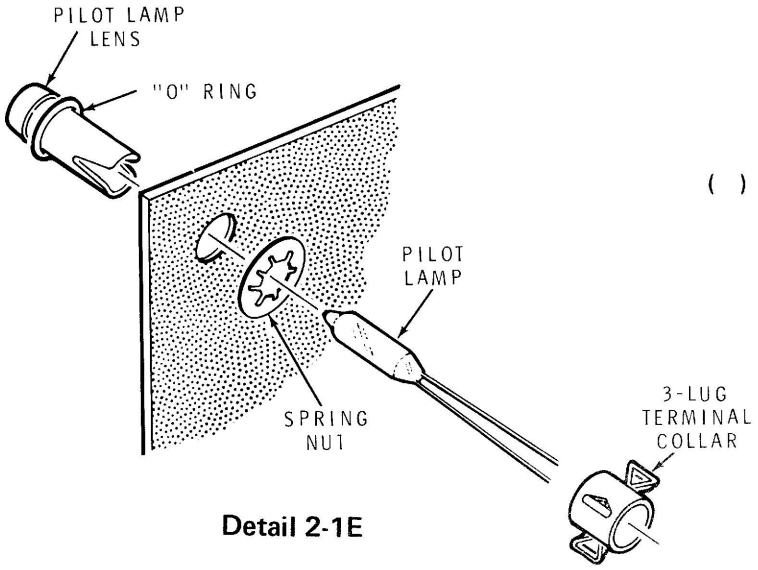
( ) R7: In the same manner, install a 500 kΩ control (#10-1052).




**Detail 2-1D**

( ) R5: Refer to Detail 2-1D and install a 1 MΩ control (#10-334). Twist the metal tabs 1/8 turn.

( ) R207: In the same manner, install a 1000 Ω (1K) control (#10-1017).

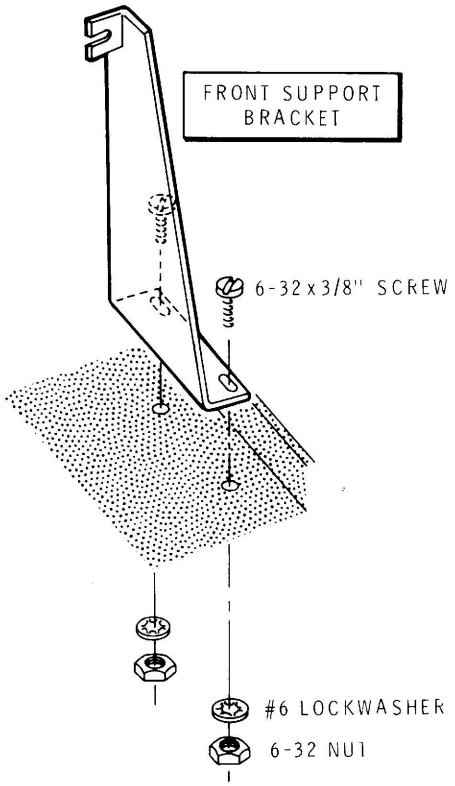



**Detail 2-1E**

( ) Refer to Detail 2-1E and install the pilot lamp lens at PL1. Use the "O" ring and a spring nut.

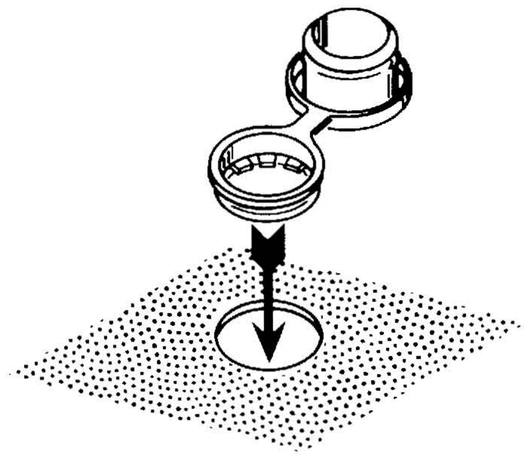
( ) PL1: Refer to Detail 2-1E and push the pilot lamp into the lamp lens until the end of the lamp is even with the end of the lens.

( ) Refer to Detail 2-1E and push the 3-lug terminal collar onto the lamp lens. The collar should be even with the end of the lens as shown in Pictorial 2-1.

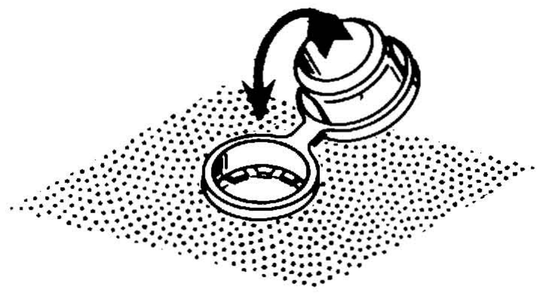



**Detail 2-1F**

( ) Refer to Detail 2-1F and mount the front support bracket at BA with 6-32 x 3/8" hardware. Do not tighten the hardware at this time.



POSITION THE SMALL PORTION OF THE GROMMET INTO THE CHASSIS HOLE.

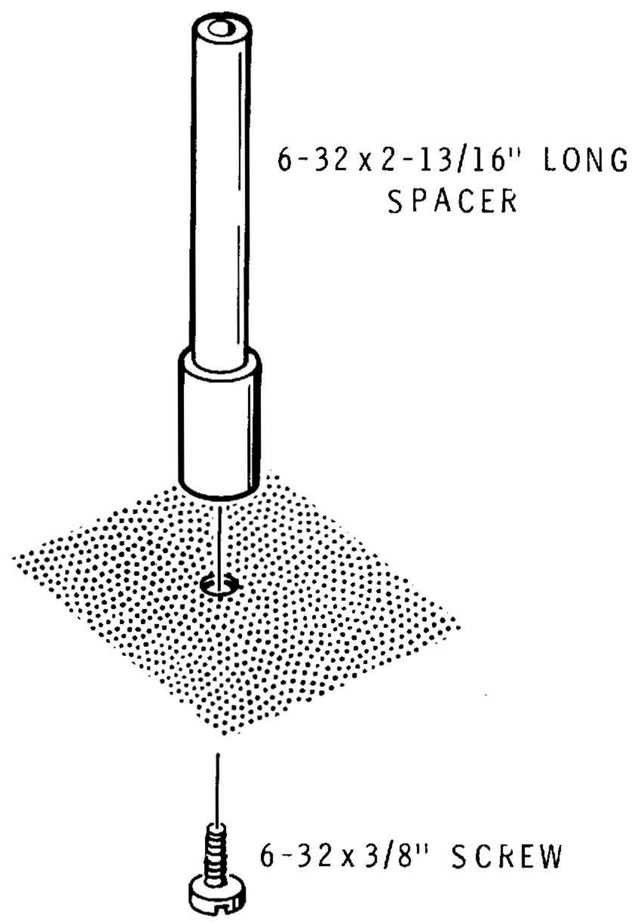


BEND THE LARGE PORTION OF THE GROMMET OVER AND INTO THE SMALL PORTION. PRESS IT FIRMLY INTO PLACE.

### Detail 2-1G

( ) Refer to Detail 2-1G and install a plastic grommet in hole AA.

( ) In the same manner, install plastic grommets in holes AB, AC, AD, AE, AF, AG, AH, AJ, and AK.




### Detail 2-1H

( ) Refer to Detail 2-1H and install a 6-32 x 2-13/16" spacer at BB with a 6-32 x 3/8" screw.

( ) In the same manner, install the remaining 6-32 x 2-13/16" spacer at BC.

## CHASSIS BOTTOM PARTS MOUNTING

Refer to Pictorial 2-2 (in the Illustration Book) for the following steps.

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

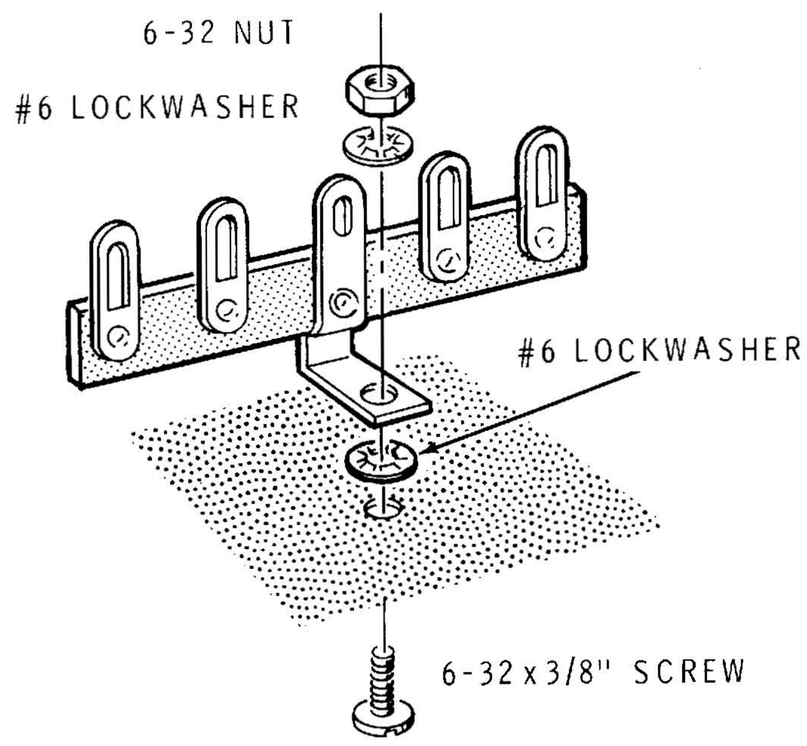
( ) SW101: Install the 8-lug switch with 6-32 x 3/16" screws and #6 x 1/16" spacers. (See Detail 2-1B on Page 24.)

( ) R106: Install a 1000 Ω (1K) control (#10-1017).

( ) R117: Install a 5000 Ω (5K) control (#10-1016).

( ) R204: Install a 1000 Ω (1K) control (#10-329).

( ) R109: Install a 1000 Ω (1K) control (#10-329).

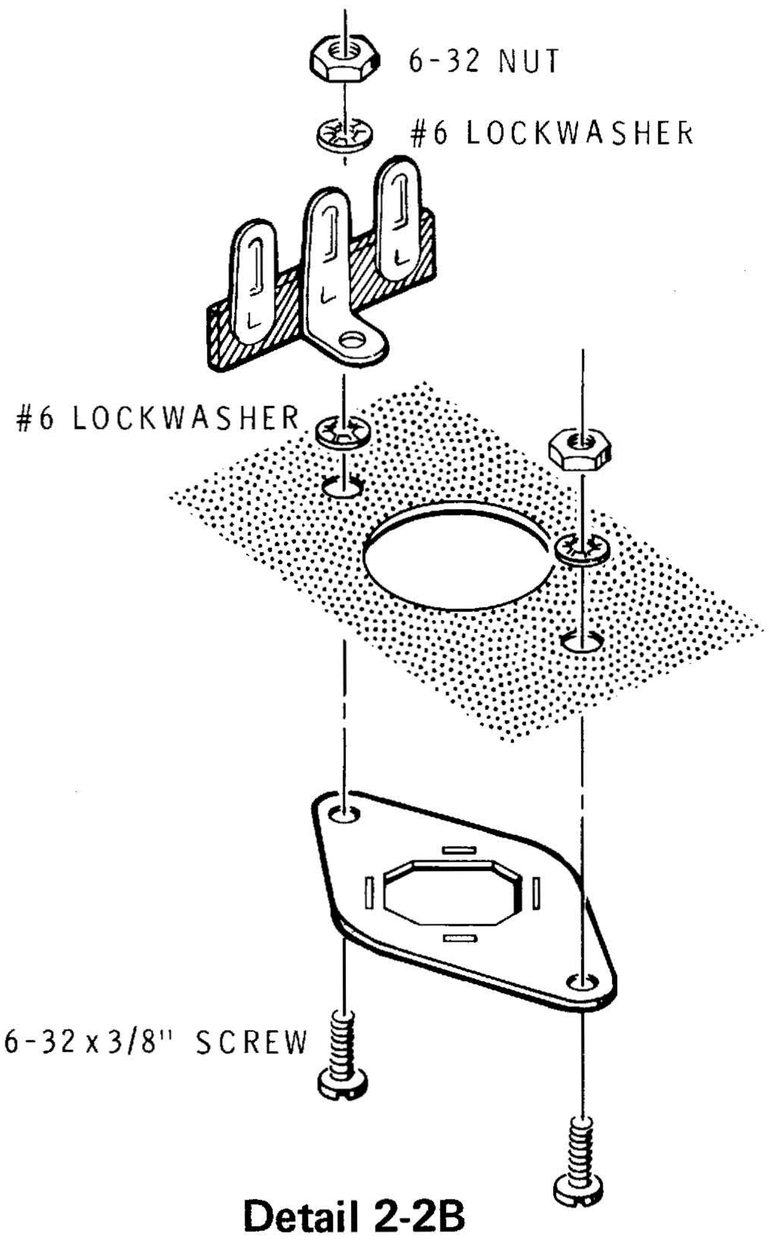



### Detail 2-2A

( ) Refer to Detail 2-2A and install a 5-lug terminal strip at N. Use 6-32 x 3/8" hardware.

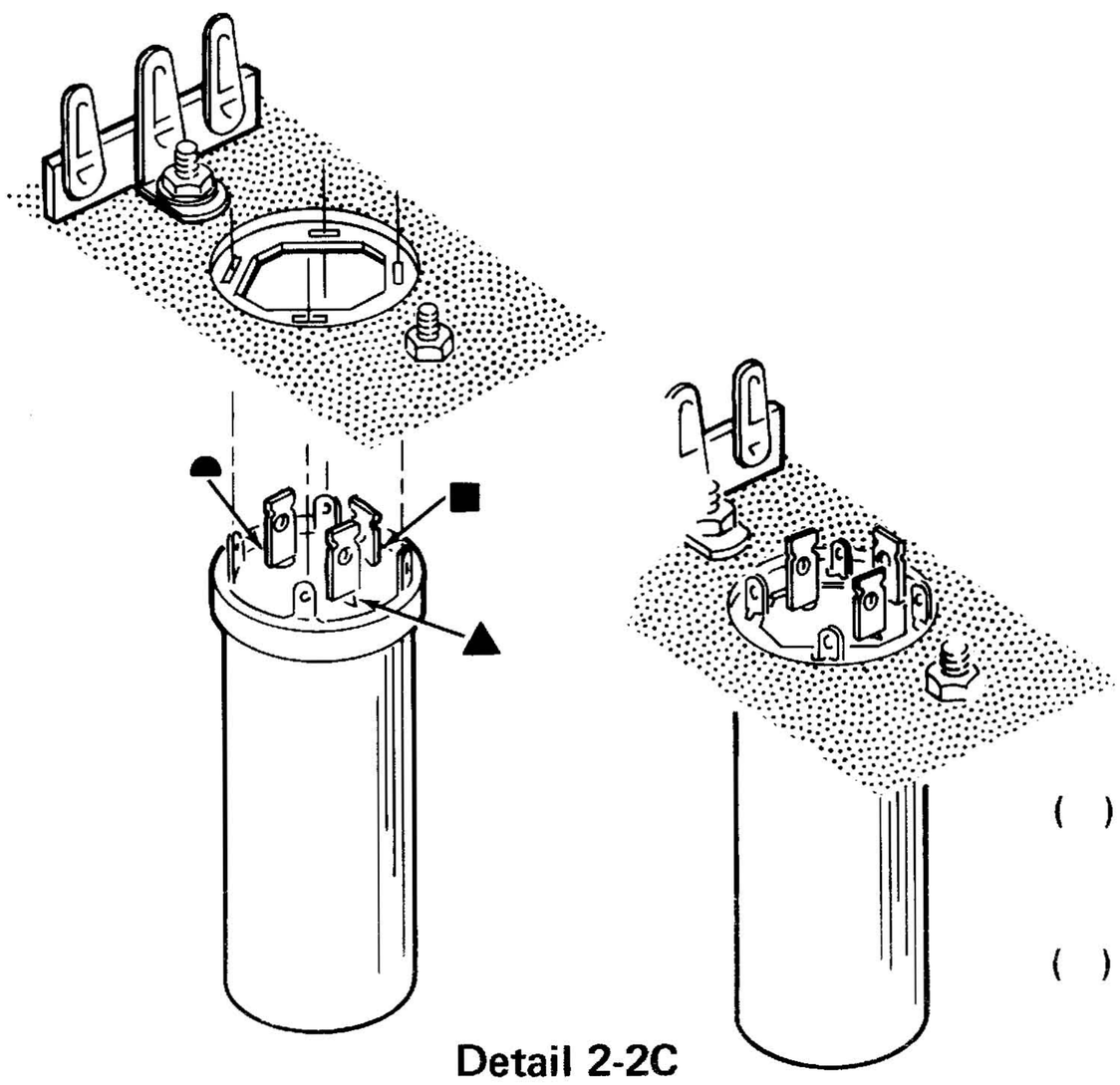
( ) In a like manner, install 5-lug terminal strips at P, R, U, W, and Y.

( ) In a like manner, install a 4-lug terminal strip at V.



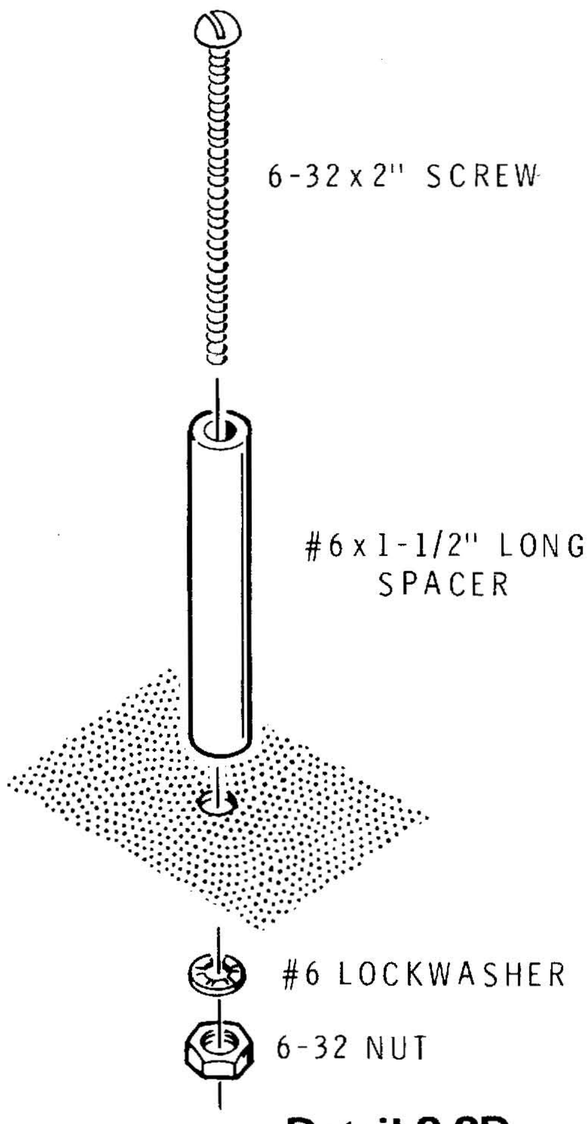

**Detail 2-2B**

( ) Refer to Detail 2-2B and mount the capacitor mounting plate on the top of the chassis at C4 with a 3-lug terminal strip at X on the bottom of the chassis. Use 6-32 x 3/8" hardware.



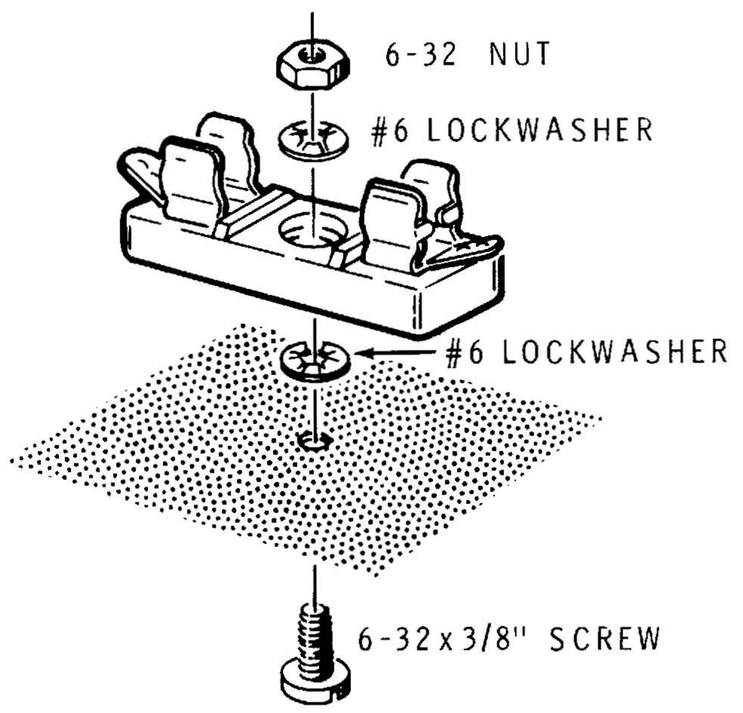
**Detail 2-2C**

( ) C4: Refer to Detail 2-2C and mount the 100-100-300 $\mu$F electrolytic capacitor to the capacitor mounting plate. Twist each tab 1/8 turn. Be sure to position the capacitor lugs as shown in Pictorial 2-2.




**Detail 2-2D**

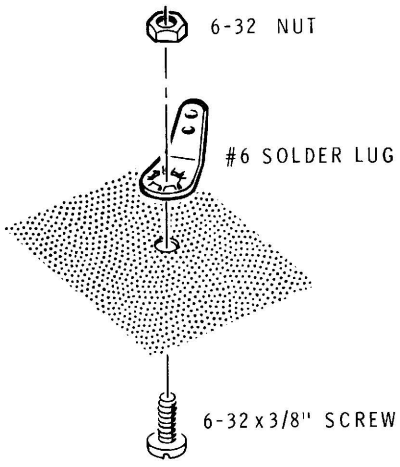
( ) Refer to Detail 2-2D and install a #6 x 1-1/2" spacer at BT. Use 6-32 x 2" hardware.




**Detail 2-2E**

( ) Refer to Detail 2-2E and install the fuseholder at F1 with 6-32 x 3/8" hardware.

( ) Refer to the inset drawing on Pictorial 2-2 and install an 8-32 push-on nut at BG. Be sure to position the flat side of the nut as shown.




**Detail 2-2F**

( ) In the same manner, install 8-32 push-on nuts at locations BH, BJ, BK, BL, BN, BP, and BR with their flat sides as shown.

( ) Refer to Detail 2-2F and install a #6 solder lug at location L. Use 6-32 x 3/8" hardware.

( ) In the same manner, install a #8 solder lug at Z with 8-32 x 3/8" hardware. Bend the solder lug up as shown.

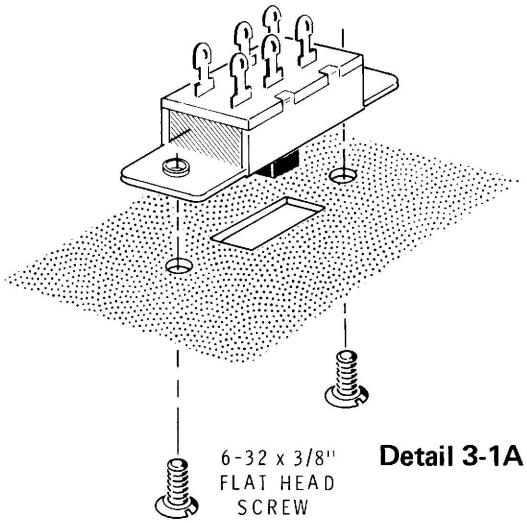
( ) Set the chassis aside temporarily.

## FRONT PANEL PARTS MOUNTING

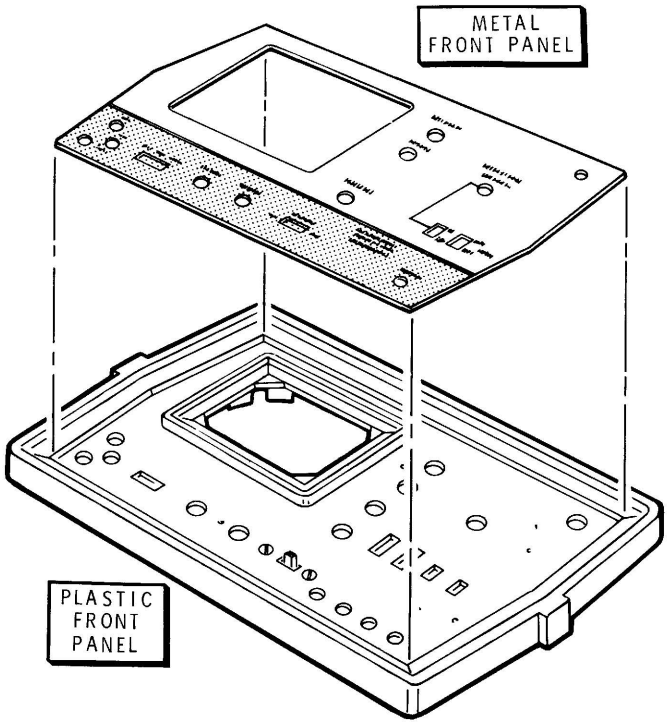
Refer to Pictorial 3-1 (in the Illustration Book) for the following steps.

( ) Place the plastic front panel on a soft cloth on your work area. The soft cloth will keep the front panel from getting scratched.

( ) SW1: Refer to Detail 3-1A and install a 6-lug switch with 6-32 x 3/8" flat head screws.




**Detail 3-1A**




**Detail 3-1B**

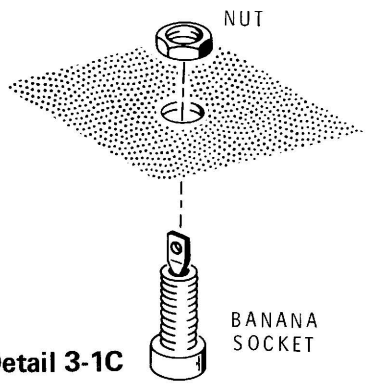
( ) Turn the plastic front panel over as shown in Detail 3-1B.

( ) Locate the metal front panel and carefully remove the paper backing.

( ) Position the metal front panel, sticky side down, over the front panel. Lower the metal front panel slowly onto the plastic front panel as shown in Detail 3-1B. Center all holes carefully; then press the metal front panel firmly onto the plastic front panel.

( ) Turn the front panel assembly over as shown in Pictorial 3-1.

( ) S4: Refer to Detail 3-1C and install a red banana socket with the nut supplied with the socket.




**Detail 3-1C**

( ) Locate the graticule and remove the protective paper from both sides. Clean it with a solution of mild soap and warm water. Then dry.

( ) Position the graticule into the rectangular opening in the front panel. The side of the graticule with the white lines must be down.

( ) Locate the felt strip and cut it to 14-3/4" long. Discard the short piece.

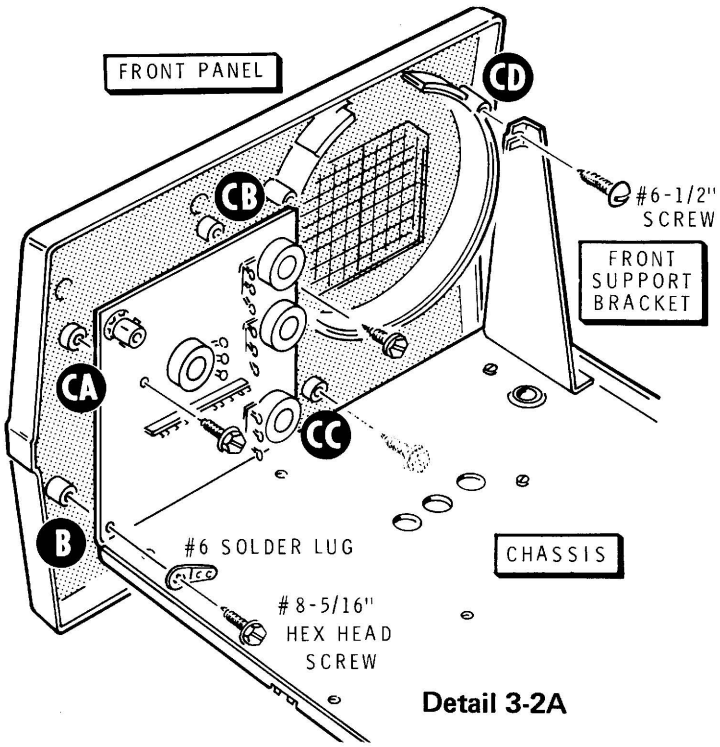
( ) Remove the paper backing from the felt strip. Press the felt strip around the inside of the curved raised portion of the front panel. Be sure the felt strip is down against the front panel so it will hold the graticule in place.

Refer to Pictorial 3-2 (in the Illustration Book) for the following steps.

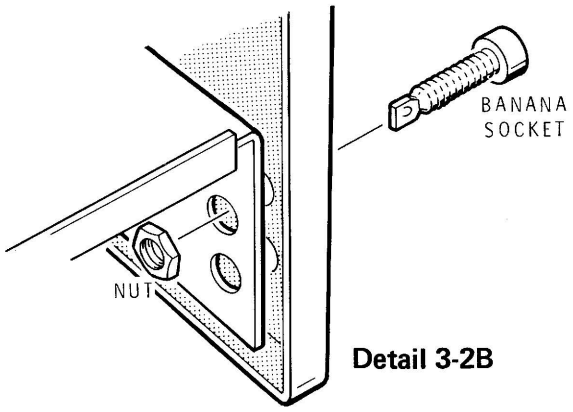
( ) Locate the chassis and fit the shafts of the controls on the chassis through the indicated holes in the front panel.

( ) Refer to Detail 3-2A and secure the chassis to the front panel with #8 x 5/16" hex head screws in chassis holes CA, CB, and CC. Do not tighten the screws at this time.

( ) Install a #6 x 1/2" screw in hole CD at the top of the front support bracket.




**Detail 3-2A**




**Detail 3-2B**

( ) Install a #6 solder lug at B with #8 x 5/16" hex head screw. See Detail 3-2A.

( ) S2: Refer to Detail 3-2B and install a red banana socket. Use the nut furnished with the socket.

( ) S1: In the same manner, install a red banana socket.

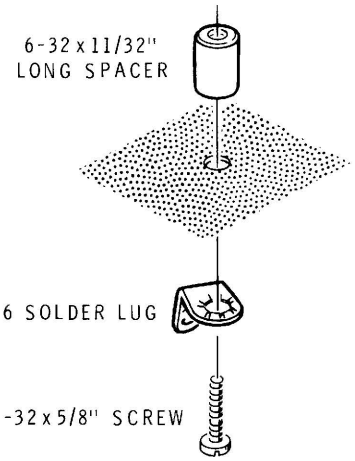
( ) S3: In the same manner, install a black banana socket.

( ) Now tighten the hex head screws that secure the chassis to the front panel. Do not overtighten the screws as the threads will be stripped from the front panel.

( ) Refer to Detail 3-2C and install a #6 solder lug at M on the bottom of the chassis with a 6-32 x 5/8" screw and a 6-32 x 11/32" spacer.

( ) In a similar manner, install 6-32 x 11/32" spacers on the top of the chassis at locations BD, BE, and BF. Use 6-32 x 5/8" screws, but do not use solder lugs.

( ) Check to see that the chassis is perpendicular to the front panel and then tighten the screws that secure the front support bracket to the chassis.




**Detail 3-2C**

## WIRING

### Wiring Notes:

1. Use solid wire unless the step specifically calls for stranded wire.

2. To prepare solid wire, remove 1/4" of insulation from each end.

3. To prepare stranded wire, remove 1/4" of insulation from the ends, twist the fine strands of wire, and melt a small amount of solder on the exposed wire end.

4. The wires are listed in the order they will be used. Use the scale at the bottom of the page to measure the wire lengths.

5. When you connect several wires to the lug of a terminal strip, make sure you solder all of them properly. It is possible to overlook a connection near the bottom of the lug.

6. Some of the wire lengths may seem too long. However, do not shorten them. All wires should be positioned neatly and down against the chassis. Some Pictorials are distorted to show parts more clearly.

7. In the steps, (NS) means not to solder because other wires or components 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.

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

( ) Position the chassis as shown. Be sure the soft cloth is under the front panel.

( ) Connect one of the pilot lamp leads to PL1 lug 1 (NS) and the other pilot lamp lead to PL1 lug 2 (NS). Be sure these leads do not touch each other.

( ) R11: Connect a 47 kΩ (yellow-violet-orange) resistor between pilot lamp PL1 lug 2 (S-2) and PL1 lug 3 (NS).

( ) Prepare the following wires:

| | |
|---|---|
| 4-3/4" black | 2-1/2" white |
| 9-1/2" white | 8-1/2" green |
| 1-3/4" gray | 25" blue |
| 3-1/2" violet | 18-1/2" blue |

( ) Connect a 4-3/4" black wire from pilot lamp PL1 lug 1 (S-2) to terminal strip A lug 3 (NS).

( ) Connect a 9-1/2" white wire to pilot lamp PL1 lug 3 (S-2). Pass the other end of this wire through grommet AB for connection later.

( ) Connect a 1-3/4" gray wire from control R353 lug 3 (S-1) to terminal strip A lug 6 (NS).

( ) Connect a 3-1/2" violet wire from terminal strip A lug 8 (NS) to switch SW302 lug 1 (NS).

( ) Remove an extra 1/2" (total 3/4") of insulation from one end of a 2-1/2" white wire. Pass this end of the wire through switch SW301 lug 2 (NS) to switch SW302 lug 4 (NS). Connect the other end of the wire to terminal strip A lug 5 (NS).

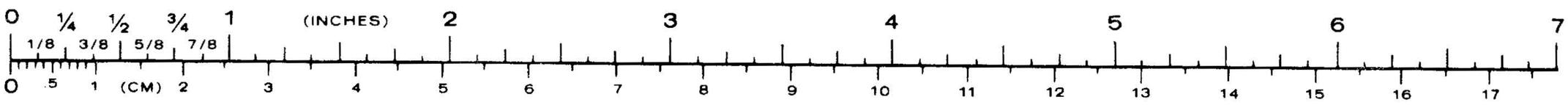
( ) Connect one end of an 8-1/2" green wire to terminal strip A lug 7 (NS). Pass the other end through grommet AB for connection later.

( ) Connect one end of a 25" blue wire to control R5 lug 2 (S-1). Pass the other end through grommet AB for connection later.

( ) Connect one end of an 18-1/2" blue wire to control R7 lug 1 (S-1). Pass the other end through grommet AB for connection later.

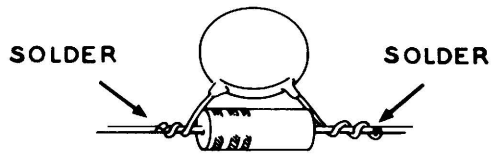
( ) Prepare a 26-1/2" blue wire by removing 1/4" of insulation from only one end. Connect this end of the wire to control R7 lug 2 (S-1). Pass the other end through grommet AB for connection later.

( ) R354: Connect a 100 kΩ (brown-black-yellow) resistor from solder lug B (NS) to socket S4 (NS). The resistor lead to the solder lug must pass up through grommet AA.



( ) Locate a 100 kΩ (brown-black-yellow) resistor and a .01 μF, 500V ceramic capacitor. Refer to Detail 4-1A and prepare a resistor-capacitor combination by wrapping the capacitor leads around the resistor leads as shown. Then solder the capacitor leads to the resistor leads and cut off the excess capacitor leads.

( ) Place a 1" length of insulation (remove from the brown stranded wire) on one of the leads of the resistor-capacitor combination.




**Detail 4-2A**

( ) R355/C353: Pass the insulated lead of the resistor-capacitor combination through grommet AA and connect the lead to switch SW302 lug 6 (NS). Connect the other lead of the resistor-capacitor combination to socket S4 (S-2).

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

( ) C352: Connect the positive (+) marked lead of a 2.2 μF tantalum capacitor to switch SW301 lug 3 (S-1). Pass the other lead through solder lug B (S-3) to switch SW302 lug 3 (NS). See the inset drawing.

( ) R6: Connect a 470 kΩ, 1-watt (yellow-violet-yellow) resistor from control R7 lug 3 (S-1) to control R5 lug 1 (S-1).

Refer to Pictorial 4-2 (in the Illustration Book) for the following steps.

( ) Prepare the following wires:

9-1/2" black
10" orange
10-1/2" green

( ) Connect a 9-1/2" black wire from control R207 lug 2 (S-1) to terminal strip F lug 5 (NS).

( ) Connect a 10" orange wire from terminal strip A lug 11 (NS) to terminal strip D lug 2 (NS).

( ) Connect a 10-1/2" green wire from terminal strip A lug 10 (NS) to terminal strip D lug 5 (NS).

( ) Locate two MPSA20 transistors (#417-801) and cut off the center lead of each transistor as shown in the inset drawing on Pictorial 4-2. These transistors will be used as zener diodes.

NOTE: When you install the transistors (zener diodes) in the next two steps, be sure to position their flat sides against each other.

( ) ZD352: Connect this transistor to switch SW302; collector (C) lead to lug 3 (NS) and the emitter (E) lead to lug 6 (NS). See inset drawing for the proper lead identification with respect to the flat on the transistor.

( ) ZD351: Refer to the inset drawing and connect this transistor to switch SW302, emitter (E) lead to lug 3 (NS) and the collector (C) lead to lug 6 (S-3).

( ) C351: Pass one lead of a .01 μF, 100V ceramic capacitor through switch SW301 lug 1 (S-2) to lug 2 (S-3). Connect the other lead to terminal strip A lug 3 (NS).

( ) R352: Connect a 1000 Ω (brown-black-red) resistor to terminal strip A between lugs 3 (S-3) and 4 (NS).

( ) R351: Connect a 2200 Ω (red-red-red) resistor to terminal strip A between lugs 4 (NS) and 7 (NS).

( ) R349: Connect a 470 Ω (yellow-violet-brown) resistor from control R353 lug 2 (S-1) to terminal strip A lug 7 (NS).

NOTE: When you solder, be careful not to burn the insulation from nearby wires.

( ) R206: Connect an 1800 Ω (brown-gray-red) resistor from terminal strip A lug 7 (NS) to control R207 lug 3 (S-1).

( ) R201: Connect a 4700 Ω (yellow-violet-red) resistor to terminal strip A between lugs 10 (NS) and 11 (NS).

( ) R208: Connect a 1500 Ω (brown-green-red) resistor from terminal strip A lug 11 (S-3) to control R207 lug 1 (S-1).

Refer to Pictorial 4-3 (in the Illustration Book) for the following steps.

**CAUTION: WHEN YOU INSTALL COMPONENTS, BE SURE THEIR LEADS DO NOT TOUCH LEADS OF OTHER PARTS OR LUGS THAT THE COMPONENT IS NOT CONNECTED TO.**

( ) C355: Connect a 100 pF ceramic capacitor from terminal strip A lug 2 (NS) to switch SW301 lug 4 (S-1).

( ) C354: Connect a .1 $\mu$F 100V Mylar capacitor from terminal strip A lug 2 (NS) to switch SW301 lug 6 (S-1).

( ) R4: Connect a 3.3 MΩ, 1-watt (orange-orange-green) resistor from control R5 lug 3 (S-1) to terminal strip A lug 9 (S-1).

( ) Q351: Refer to inset drawing #1 and connect an X29A829 transistor (#417-201) to terminal strip A as follows:

Base (B) lead to lug 4 (S-3).
Collector (C) lead to lug 5 (S-2).
Emitter (E) lead to lug 6 (S-2).

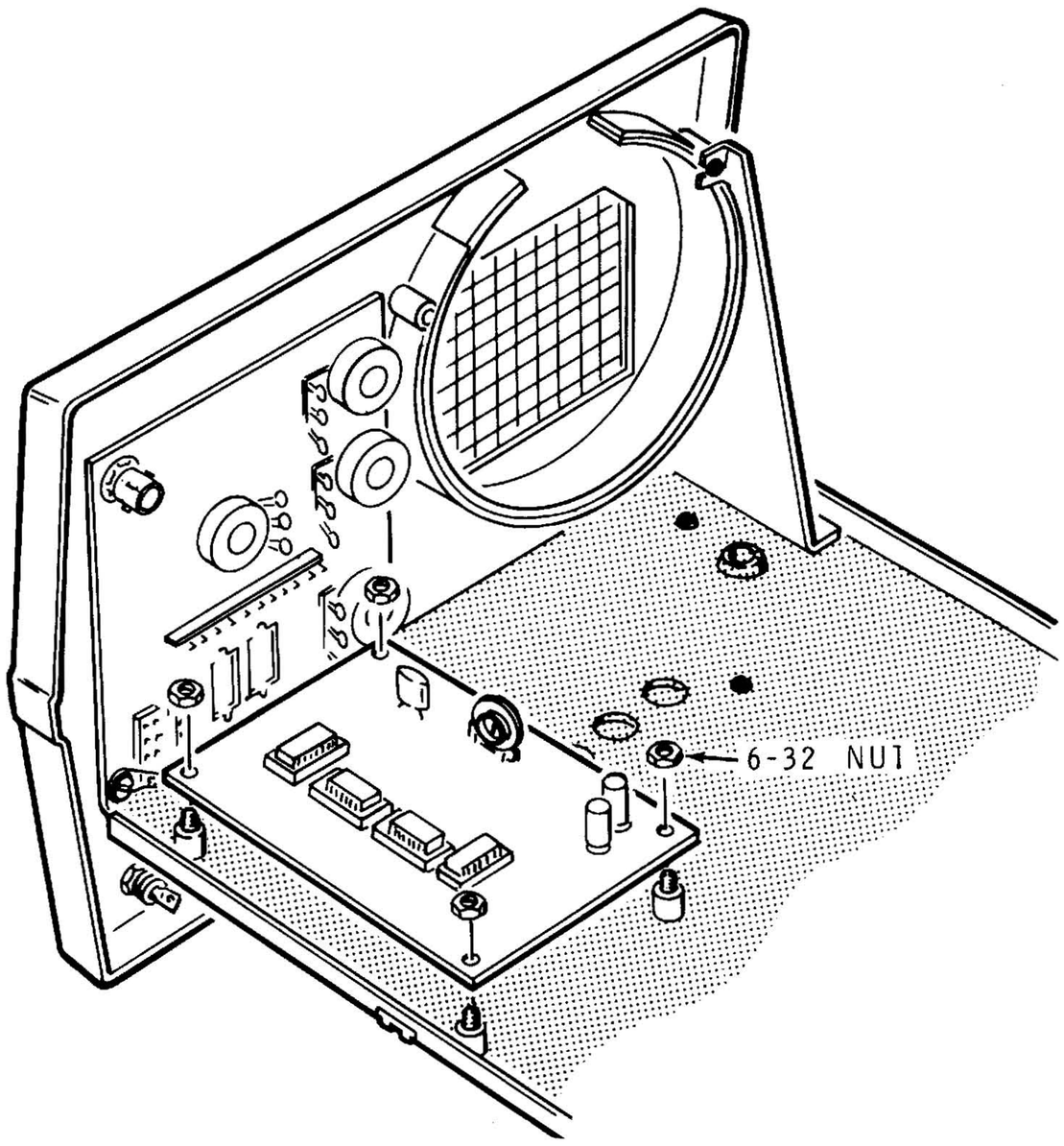
( ) Q201: Refer to inset drawing #2 and connect an MPSA20 transistor (#417-801) to terminal strip A as follows:

Collector (C) lead to lug 7 (S-5).
Base (B) lead to lug 8 (S-2).
Emitter (E) lead to lug 10 (S-3).

Refer to Pictorial 4-4 (in the Illustration Book) for the following steps.

( ) Refer to Detail 4-4A and install the sweep/trigger circuit board on the chassis with four 6-32 nuts. Be sure to position the circuit board part number as shown in Pictorial 4-4.

( ) Position the free end of the long shielded cable coming from the circuit board towards the right side of the chassis for connection later.




**Detail 4-4A**

( ) Pass the free ends of the green, violet, and gray wires, coming from circuit board holes C, D, and F respectively, through grommet AB for connection later.

Connect the free ends of the wires coming from the circuit board holes to switch SW302 as follows:

( ) Orange from hole M to lug 5 (S-1).

( ) Gray from hole L to lug 4 (S-2).

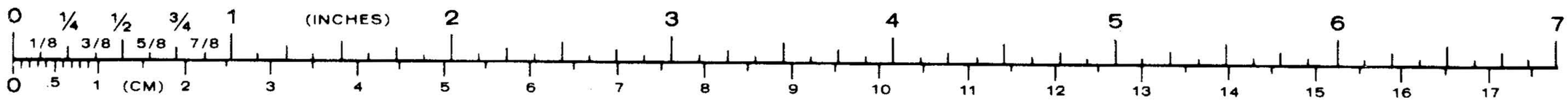
( ) White from hole P to lug 2 (S-1).

( ) Shielded cable from hole N inner lead to lug 1 (S-2) and the shield to lug 3 (S-4).

( ) Now position these wires down next to the circuit board.

( ) Connect the free end of the white wire coming from circuit board hole H to switch SW301 lug 5 (S-1).

( ) Connect the free end of the orange wire coming from circuit board hole J to terminal strip A lug 2 (S-3).



Refer to Pictorial 4-5 (in the Illustration Book) for the following steps.

( ) Connect the free end of the black wire coming from circuit board hole S to terminal strip D lug 3 (S-1).

NOTE: The white wire from circuit board hole K will be connected later.

( ) Prepare the following wires:

| | |
|---|---|
| 3-1/2" white | 9" violet |
| 3-1/2" orange | 11-1/2" white |
| 8" orange | 8-1/2" black |
| 2-1/4" white | 2-1/4" white |

( ) Connect one end of a 3-1/2" white wire to terminal strip D lug 1 (NS). Pass the other end through grommet AD for connection later.

( ) Connect one end of a 3-1/2" orange wire to terminal strip D lug 2 (NS). Pass the other end through grommet AD for connection later.

( ) Connect one end of an 8" orange wire to terminal strip D lug 2 (NS). Pass the other end through grommet AE for connection later.

( ) Connect a 2-1/4" white wire to terminal strip D between lugs 6 (NS) and 10 (NS).

( ) Connect one end of a 9" violet wire to terminal strip E lug 6 (NS). Pass the other end through grommet AE for connection later.

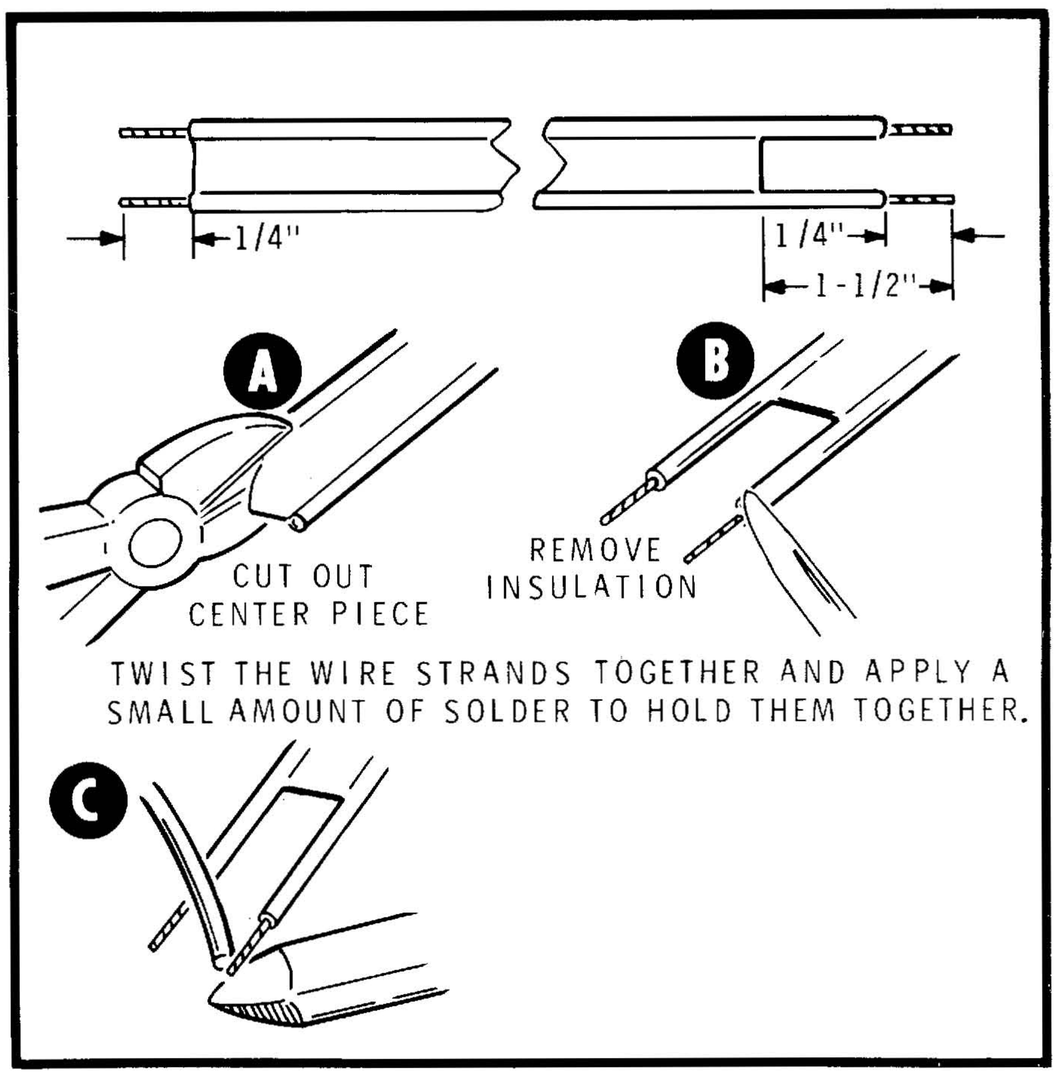
( ) Connect one end of an 11-1/2" white wire to terminal strip E lug 11 (NS). Pass the other end through grommet AE for connection later.

( ) Connect one end of an 8-1/2" black wire to terminal strip E lug 11 (NS). Pass the other end through grommet AE for connection later.

( ) Connect a 2-1/4" white wire to terminal strip F between lugs 6 (NS) and 10 (NS).

( ) Refer to Detail 4-5A and prepare the ends of a 10" length of 300 Ω twin lead.

( ) At the end of this twin lead with the longest separation, connect either lead to terminal strip D lug 11 (NS) and the other lead to terminal strip F lug 11 (NS). The other end will be connected later.




**Detail 4-5A**

Refer to Pictorial 4-6 (in the Illustration Book) for the following steps.

( ) R205: Connect a 100 Ω (brown-black-brown) resistor from terminal strip D lug 1 (S-2) to terminal strip E lug 1 (NS).

( ) R203. Connect a 1000 Ω (brown-black-red) resistor from terminal strip D lug 2 (S-4) to terminal strip E lug 2 (NS).

( ) R211: Connect a 220 Ω (red-red-brown) resistor from terminal strip D lug 4 (NS) to terminal strip E lug 4 (NS).

( ) R209: Connect a 1000 Ω (brown-black-red) resistor from terminal strip D lug 6 (NS) to terminal strip E lug 6 (NS).

( ) R215: Pass one lead of an 820 Ω (gray-red-brown) resistor through terminal strip D lug 8 (NS) to lug 7 (NS). Connect the other lead to terminal strip E lug 8 (NS).

( ) R214: Connect a 15 kΩ, 2-watt (brown-green-orange) resistor from terminal strip D lug 11 (NS) to terminal strip E lug 11 (NS).

( ) R202: Pass one lead of a 1500 Ω (brown-green-red) resistor through terminal strip F lug 2 (S-2) to lug 3 (S-1). Connect the other lead to terminal strip E lug 2 (NS).

( ) R212: Connect a 220 Ω (red-red-brown) resistor from terminal strip E lug 4 (NS) to terminal strip F lug 4 (NS).

( ) R213: Connect a 1000 Ω (brown-black-red) resistor from terminal strip E lug 6 (S-3) to terminal strip F lug 6 (NS).

( ) R218: Pass one lead of a 10 kΩ (brown-black-orange) resistor through terminal strip F lug 7 (NS) to lug 8 (NS). Connect the other lead to terminal strip E lug 7 (NS).

( ) R216: Pass one lead of an 820 Ω (gray-red-brown) resistor through terminal strip E lug 8 (S-3) to lug 9 (S-1). Connect the other lead to terminal strip F lug 8 (NS).

( ) R217: Connect a 15 kΩ, 2-watt (brown-green-orange) resistor from terminal strip E lug 11 (S-4) to terminal strip F lug 11 (NS).

Refer to Pictorial 4-7 for the following steps.

( ) C201: Pass one lead of a 220 pF ceramic capacitor through terminal strip E lug 7 (S-3) to terminal strip D lug 7 (S-2). Connect the other lead to terminal strip F lug 7 (S-3).

NOTE: Refer to inset drawing for proper lead identification when you install the following transistors.

( ) Q203: Connect an MPSA20 transistor (#417-801) to terminal strip D as follows:

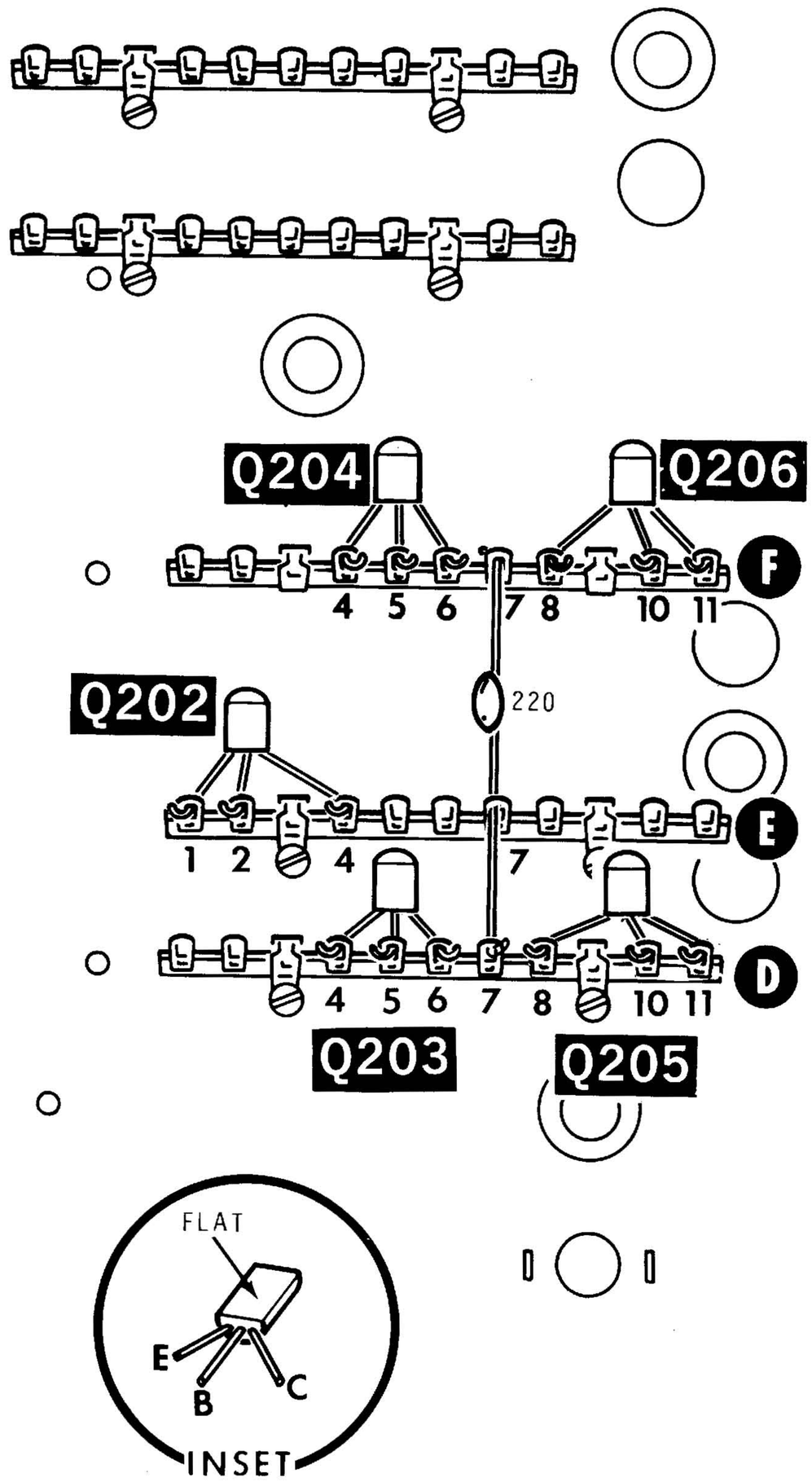
Emitter (E) lead to lug 4 (S-2).
Base (B) lead to lug 5 (S-2).
Collector (C) lead to lug 6 (S-3).

( ) Q205: Connect an MPSA42 transistor (#417-294) to terminal strip D as follows:

Emitter (E) lead to lug 8 (S-3).
Base (B) lead to lug 10 (S-2).
Collector (C) lead to lug 11 (S-3).

( ) Q202: Connect an MPSA20 transistor (#417-801) to terminal strip E as follows:

Emitter (E) lead to lug 1 (S-2).
Base (B) lead to lug 2 (S-3).
Collector (C) lead to lug 4 (S-3).




**PICTORIAL 4-7**

( ) Q204: Connect an MPSA20 transistor (#417-801) to terminal strip F as follows:

Emitter (E) lead to lug 4 (S-2).
Base (B) lead to lug 5 (S-2).
Collector (C) lead to lug 6 (S-3).

( ) Q206: Connect an MPSA42 transistor (#417-294) to terminal strip F as follows:

Emitter (E) lead to lug 8 (S-3).
Base (B) lead to lug 10 (S-2).
Collector (C) lead to lug 11 (S-3).

Refer to Pictorial 4-8 (in the Illustration Book) for the following steps.

( ) Connect the free end of the shielded cable coming from the sweep/trigger circuit board to terminal strip J, inner lead to lug 8 (NS) and the shield lead to lug 9 (S-1).

( ) Prepare the following wires:

| | |
|---|---|
| 5" orange | 8" black |
| 6" green | 9-1/2" gray |
| | 8-1/2" white |

NOTE: Only one end of each of the following wires will be connected at this time. Pass their free ends through grommet AC for connection later.

( ) Connect a 5" orange wire to terminal strip C lug 2 (NS).

( ) Connect a 6" green wire to terminal strip C lug 5 (NS).

( ) Connect an 8" black wire to terminal strip J lug 1 (NS).

( ) Connect a 9-1/2" gray wire to terminal strip G lug 2 (NS).

( ) Connect an 8-1/2" white wire to terminal strip G lug 4 (NS).

( ) Prepare the following wires:

| | |
|---|---|
| 4-3/4" green | 7-1/2" white |
| 4" white | 7-1/2" gray |
| 3-1/4" gray | 11-1/2" gray |
| 3-1/2" gray | 10" violet |
| 2-1/4" green | 2-1/4" green |
| 8-1/2" white | |

( ) Connect a 4-3/4" green wire from terminal strip C lug 5 (NS) to terminal strip H lug 6 (NS).

( ) Connect a 4" white wire from terminal strip C lug 6 (NS) to terminal strip J lug 5 (NS).

( ) Connect a 3-1/4" gray wire from terminal strip C lug 7 (NS) to terminal strip H lug 2 (NS).

( ) Connect a 3-1/2" gray wire from terminal strip C lug 11 (NS) to terminal strip G lug 2 (NS).

( ) Connect a 2-1/4" green wire to terminal strip J between lugs 6 (NS) and 10 (NS).

( ) Connect one end of an 8-1/2" white wire to terminal strip H lug 11 (NS). Pass the other end through grommet AG for connection later.

( ) Connect one end of a 7-1/2" white wire to terminal strip G lug 1 (NS). Pass the other end through grommet AF for connection later.

( ) Connect one end of a 7-1/2" gray wire to terminal strip G lug 2 (NS). Pass the other end through grommet AF for connection later.

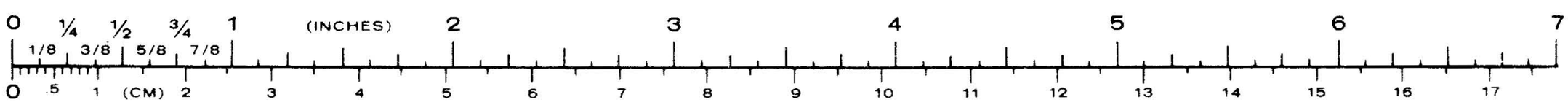
( ) Connect one end of an 11-1/2" gray wire to terminal strip G lug 2 (NS). Pass the other end through grommet AG for connection later.

( ) Connect one end of a 10" violet wire to terminal strip G lug 5 (NS). Pass the other end through grommet AF for connection later.

( ) Connect a 2-1/4" green wire to terminal strip G between lugs 6 (NS) and 10 (NS).

( ) Refer to Detail 4-8A (in the Illustration Book) and prepare the ends of a 10" length of 300 Ω twin lead.

( ) At the end of this twin lead with the longest separation, connect either lead to terminal strip G lug 11 (NS) and the other lead to terminal strip J lug 11 (NS). The other end will be connected later.



Refer to Pictorial 4-9 (in the Illustration Book) for the following steps.

( ) C105: Connect a .01 μF, 500V ceramic capacitor to terminal strip C between lugs 2 (NS) and 4 (NS).

( ) R104: Connect a 100 kΩ (brown-black-yellow) resistor to terminal strip C between lugs 2 (S-3) and 4 (NS).

( ) R105: Connect a 220 Ω (red-red-brown) resistor to terminal strip C between lugs 8 (NS) and 10 (NS).

( ) R125: Connect a 10 kΩ control (#10-386) lug 1 to terminal strip C lug 10 (S-2). Connect control lug 2 to terminal strip C lug 11 (S-2). Lug 3 of this control does not get connected.

( ) R111: Connect a 100 Ω (brown-black-brown) resistor from terminal strip G lug 1 (S-2) to terminal strip H lug 1 (NS).

( ) R108: Connect a 1000 Ω (brown-black-red) resistor from terminal strip G lug 2 (S-5) to terminal strip H lug 2 (NS).

( ) C107: Connect a 150 pF ceramic capacitor to terminal strip G between lugs 3 (S-1) and 5 (NS).

( ) R115: Connect a 330 Ω (orange-orange-brown) resistor from terminal strip G lug 4 (NS) to terminal strip H lug 4 (NS).

( ) R116: Connect a 680 Ω (blue-gray-brown) resistor from terminal strip G lug 6 (NS) to terminal strip H lug 6 (NS).

( ) R122: Pass one lead of a 390 Ω (orange-white-brown) resistor through terminal strip G lug 8 (NS) to lug 7 (NS). Connect the other lead to terminal strip H lug 8 (NS).

( ) R123: Connect a 5600 Ω (5.6k) 4-watt film resistor from terminal strip G lug 11 (NS) to terminal strip H lug 11 (NS).

( ) R107: Connect one lead of a 1000 Ω (brown-black-red) resistor to terminal strip H lug 2 (NS). Pass the other lead through terminal strip J lug 2 (S-2) to lug 3 (S-1).

( ) R114: Connect a 330 Ω (orange-orange-brown) resistor from terminal strip H lug 4 (NS) to terminal strip J lug 4 (NS).

( ) R118: Connect a 100 Ω (brown-black-brown) resistor to terminal strip J between lugs 1 (S-2) and 4 (NS).

( ) R113: Connect a 680 Ω (blue-gray-brown) resistor from terminal strip H lug 6 (S-3) to terminal strip J lug 6 (NS).

( ) R121: Pass one lead of a 390 Ω (orange-white-brown) resistor through terminal strip H lug 8 (S-3) to lug 9 (S-1). Connect the other lead to terminal strip J lug 8 (NS).

( ) R119: Connect a 5600 Ω (5.6k) 4-watt film resistor from terminal strip H lug 11 (S-3) to terminal strip J lug 11 (NS).

Refer to Pictorial 4-10 for the following steps.

( ) Locate an MPSA20 transistor (#417-801) and cut off the center lead as shown in inset drawing #1. This transistor is used as a zener diode.

( ) ZD101: Refer to inset drawing #1 and connect this transistor to terminal strip C, emitter (E) lead to lug 3 (NS) and the collector (C) lead to lug 4 (NS).

( ) Locate an MPSA20 transistor (#417-801) and cut off its center lead. This transistor is used as a zener diode.

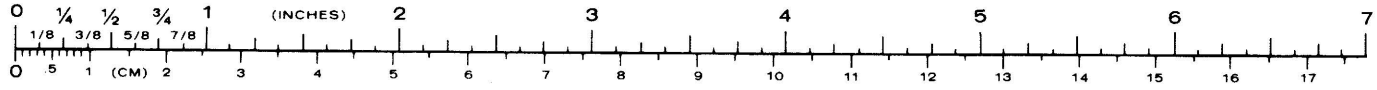
( ) ZD102: Refer to inset drawing #1 and connect this transistor to terminal strip C, collector (C) lead to lug 3 (S-2) and the emitter (E) lead to lug 4 (NS).

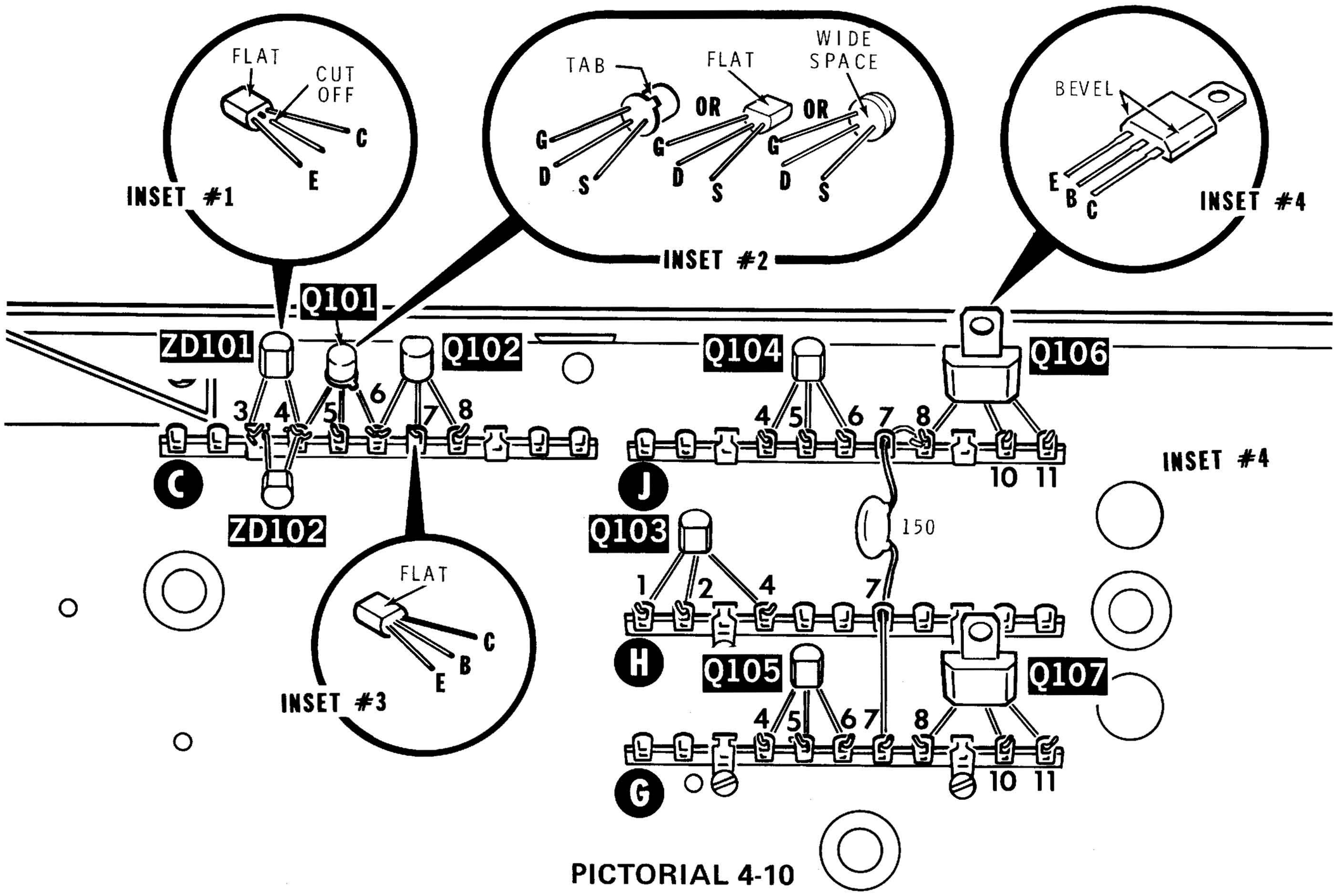
( ) Q101: Refer to inset drawing #2 and connect a 2N4304 transistor (#417-140) to terminal strip C as follows:

Gate (G) lead to lug 4 (S-5).
Drain (D) lead to lug 5 (S-3).
Source (S) lead to lug 6 (NS).

( ) Q102: Refer to inset drawing #3 and connect an MPSA20 transistor (#417-801) to terminal strip C as follows:

Collector (C) lead to lug 6 (S-3).
Base (B) lead to lug 7 (S-2).
Emitter (E) lead to lug 8 (S-2).






PICTORIAL 4-10

( ) Q103: Refer to inset drawing #3 and connect an MPSA20 transistor (#417-801) to terminal strip H as follows:

Emitter (E) lead to lug 1 (S-2).
Base (B) lead to lug 2 (S-4).
Collector (C) lead to lug 4 (S-3).

( ) Q105: Refer to inset drawing #3 and connect a 2N5770 transistor (#417-293) to terminal strip G as follows:

Emitter (E) lead to lug 4 (S-3).
Base (B) lead to lug 5 (S-3).
Collector (C) lead to lug 6 (S-3).

( ) Q104: Refer to inset drawing #3 and connect a 2N5770 transistor (#417-293) to terminal strip J as follows:

Emitter (E) lead to lug 4 (S-3).
Base (B) lead to lug 5 (S-2).
Collector (C) lead to lug 6 (S-3).

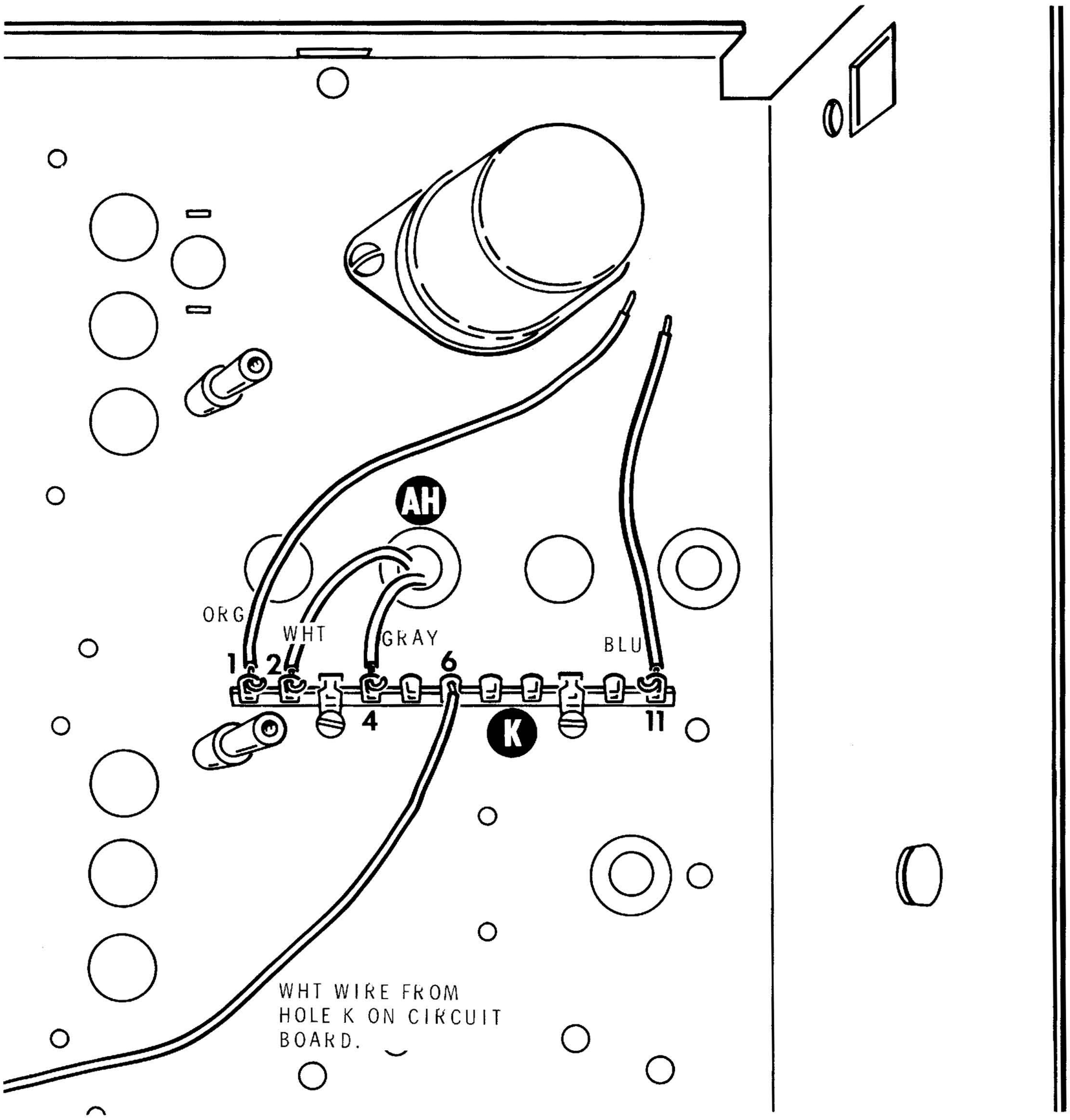
( ) C106: Pass one lead of a 150 pF ceramic capacitor through terminal strip H lug 7 (S-2) to terminal strip G lug 7 (S-2). Pass the other lead through terminal strip J lug 7 (S-2) to lug 8 (NS).

( ) Q107: Refer to inset drawing #4 and connect an MPSU10 transistor (#417-834) to terminal strip G as follows:

Emitter (E) lead to lug 8 (S-3).
Base (B) lead to lug 10 (S-2).
Collector (C) lead to lug 11 (S-3).

( ) Q106: Refer to inset drawing #4 and connect an MPSU10 transistor (#417-834) to terminal strip J as follows:

Emitter (E) lead to lug 8 (S-4).
Base (B) lead to lug 10 (S-2).
Collector (C) lead to lug 11 (S-3).




**PICTORIAL 4-11**

Refer to Pictorial 4-11 for the following steps.

( ) Connect the free end of the white wire coming from hole K on the sweep/trigger circuit board to terminal strip K lug 6 (NS).

( ) Prepare the following wires:

| | |
|---|---|
| 4"orange | 4" gray |
| 5" white | 5-1/2" blue |

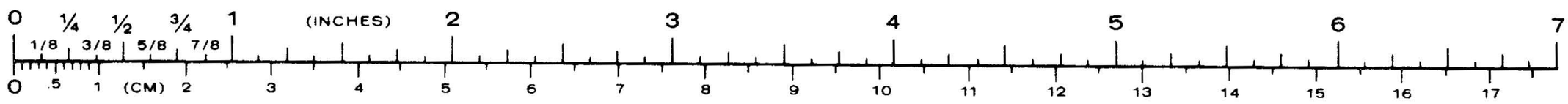
NOTE: Only one end of each of the following wires will be connected to terminal strip K at this time. Their free ends will be connected later.

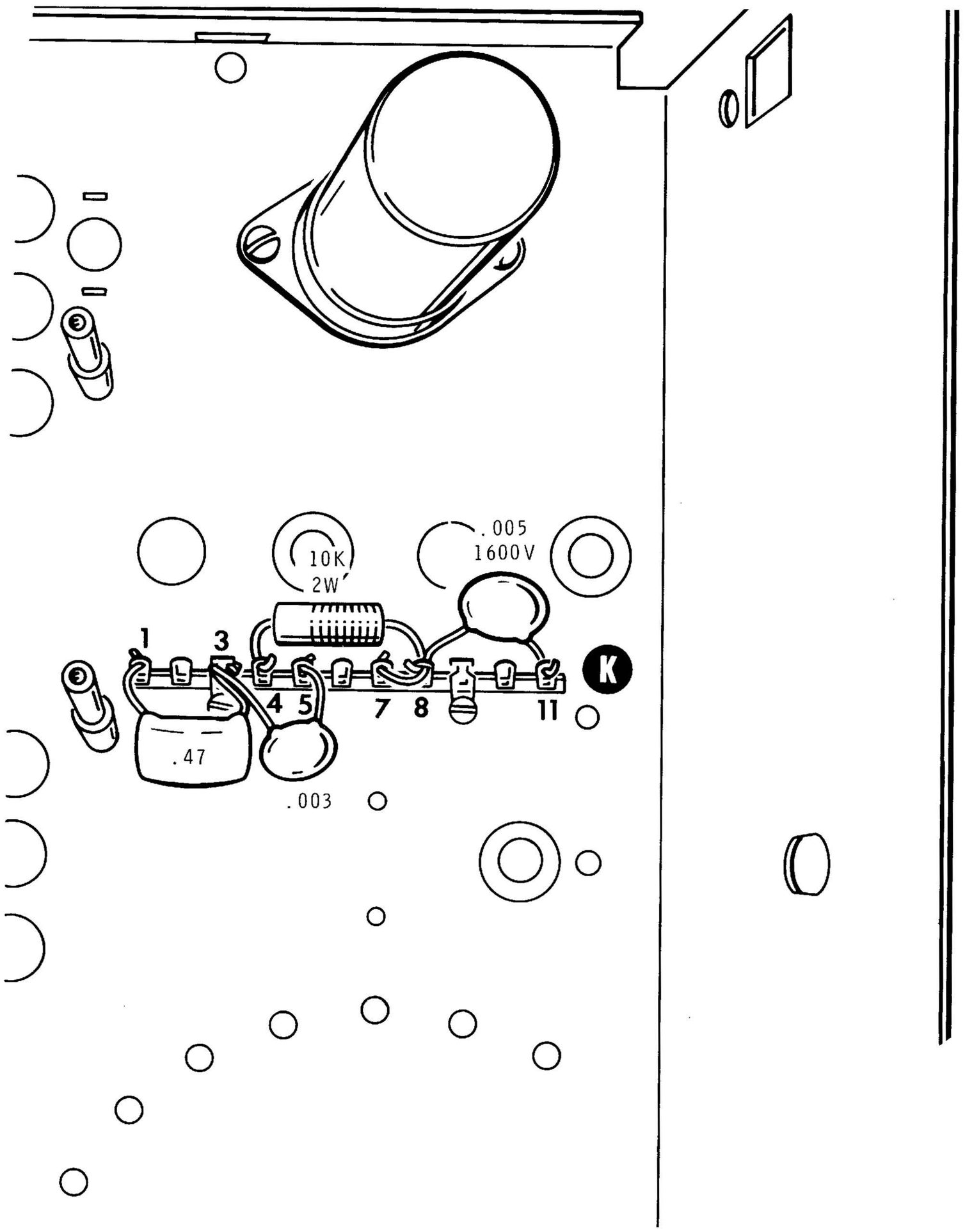
( ) Connect a 4" orange wire to lug 1 (NS).

( ) Connect a 5" white wire to lug 2 (NS). Pass the other end through grommet AH.

( ) Connect a 4" gray wire to lug 4 (NS). Pass the other end through grommet AH.

( ) Connect a 5-1/2" blue wire to lug 11 (NS).






## PICTORIAL 4-12

Refer to Pictorial 4-12 for the following steps.

NOTE: All the following parts will be connected to terminal strip K.

( ) C11: Connect a .47 μF Mylar capacitor between lugs 1 (NS) and 3 (NS).

( ) C356: Connect a .003 μF ceramic capacitor between lugs 3 (NS) and 5 (NS).

( ) R356: Connect a 10 kΩ, 2-watt (brown-black-orange) resistor between lugs 4 (S-2) and 8 (NS).

( ) C357: Connect one lead of a .005 μF 1600V (1.6KV) ceramic capacitor through lug 8 (S-3) to lug 7 (NS). Connect the other lead to lug 11 (S-2).

Refer to Pictorial 4-13 (in the Illustration Book) for the following steps.

NOTE: All the following parts will be connected to terminal strip K.

( ) R1: Connect an 82 kΩ (gray-red-orange) resistor between lugs 1 (NS) and 2 (S-2).

( ) R2: Connect a 100 kΩ (brown-black-yellow) resistor between lugs 1 (S-4) and 3 (NS).

( ) R357: Connect a 100 Ω (brown-black-brown) resistor between lugs 3 (S-4) and 5 (NS).

( ) ZD353: Connect a ZVR68 diode (#56-68), banded end to lug 7 (NS) and the other end to lug 9 (S-1).

( ) Q352: Refer to the inset drawing and connect an MPSA42 transistor (#417-294) as follows:

Emitter (E) lead to lug 5 (S-3).
Base (B) lead to lug 6 (S-2).
Collector (C) lead to lug 7 (S-3).

Set the chassis aside until it is called for in a step.

Refer to Pictorial 4-14 for the following steps.

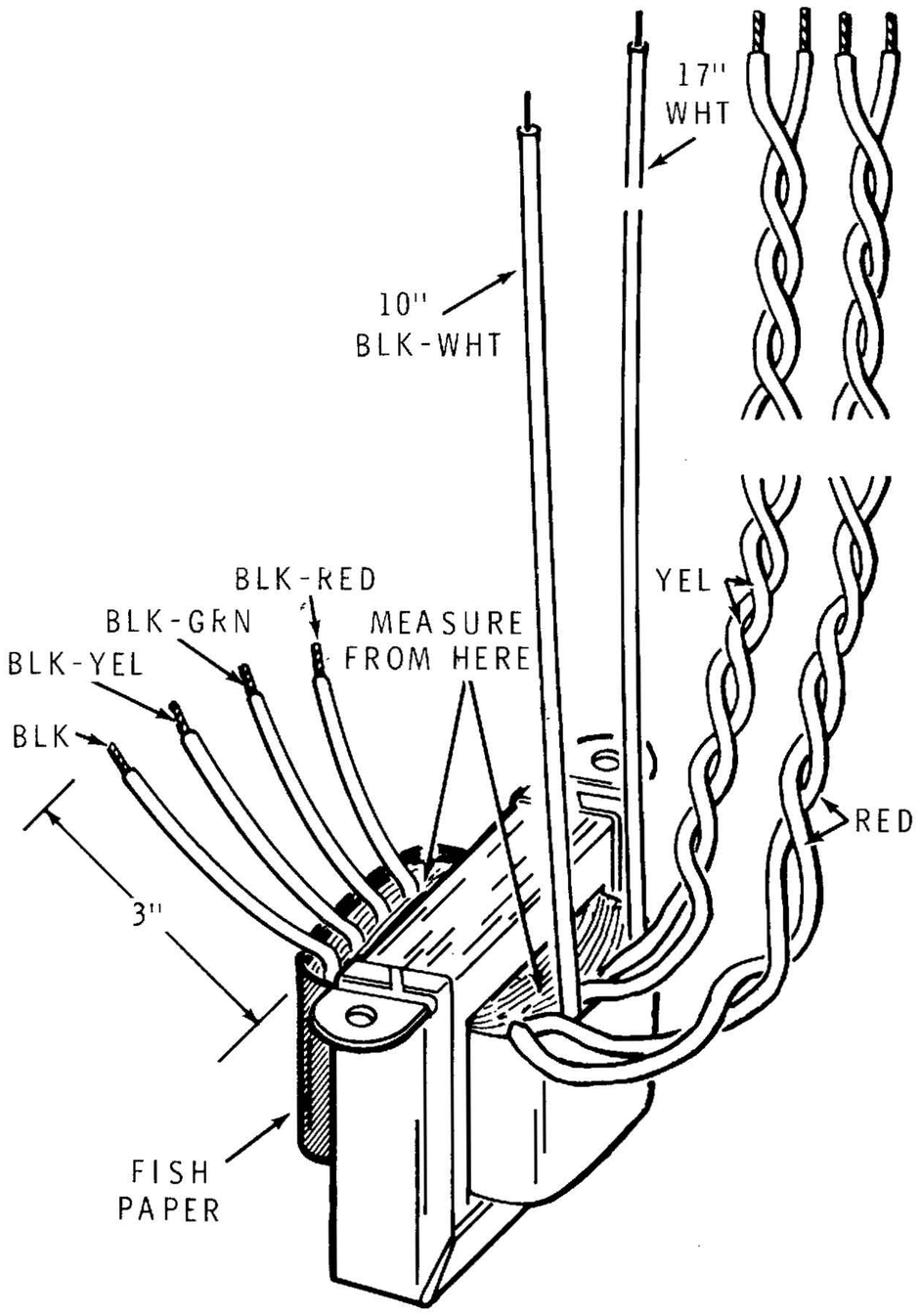
( ) Locate power transformer #54-880 and cut the specified color leads to the indicated lengths. Then remove 1/4" of insulation from each lead end and melt a small amount of solder on the bare lead ends. Save only the cut-off black, black-green, black-yellow, and black-red leads for later use.

( ) Twist together the two red leads to form a twisted pair.

( ) In the same manner, twist the two yellow leads together.

( ) Locate the piece of fishpaper and remove the paper backing. Then press the fish paper onto the indicated side of the transformer.

( ) Set this transformer aside temporarily.




**PICTORIAL 4-14**

Refer to Pictorial 4-15 for the following steps.

( ) Locate power transformer #54-282 and twist together the two red leads to form a twisted pair.

( ) In the same manner, twist together the two green leads.

( ) Cut the four cut-off leads saved from transformer #54-880 to 8" and prepare their ends.

( ) Position power transformer #54-282 as shown.

NOTE: When you are instructed to make a "mechanically secure connection," do this by inserting the lead through and wrapping it around the lug. See the inset drawing on Pictorial 4-15.

One end only of the four prepared cut-off transformer leads will be connected in the following steps. Their free ends will be connected later. Make "mechancially secure connections."

( ) Black to lug 4 (NS).

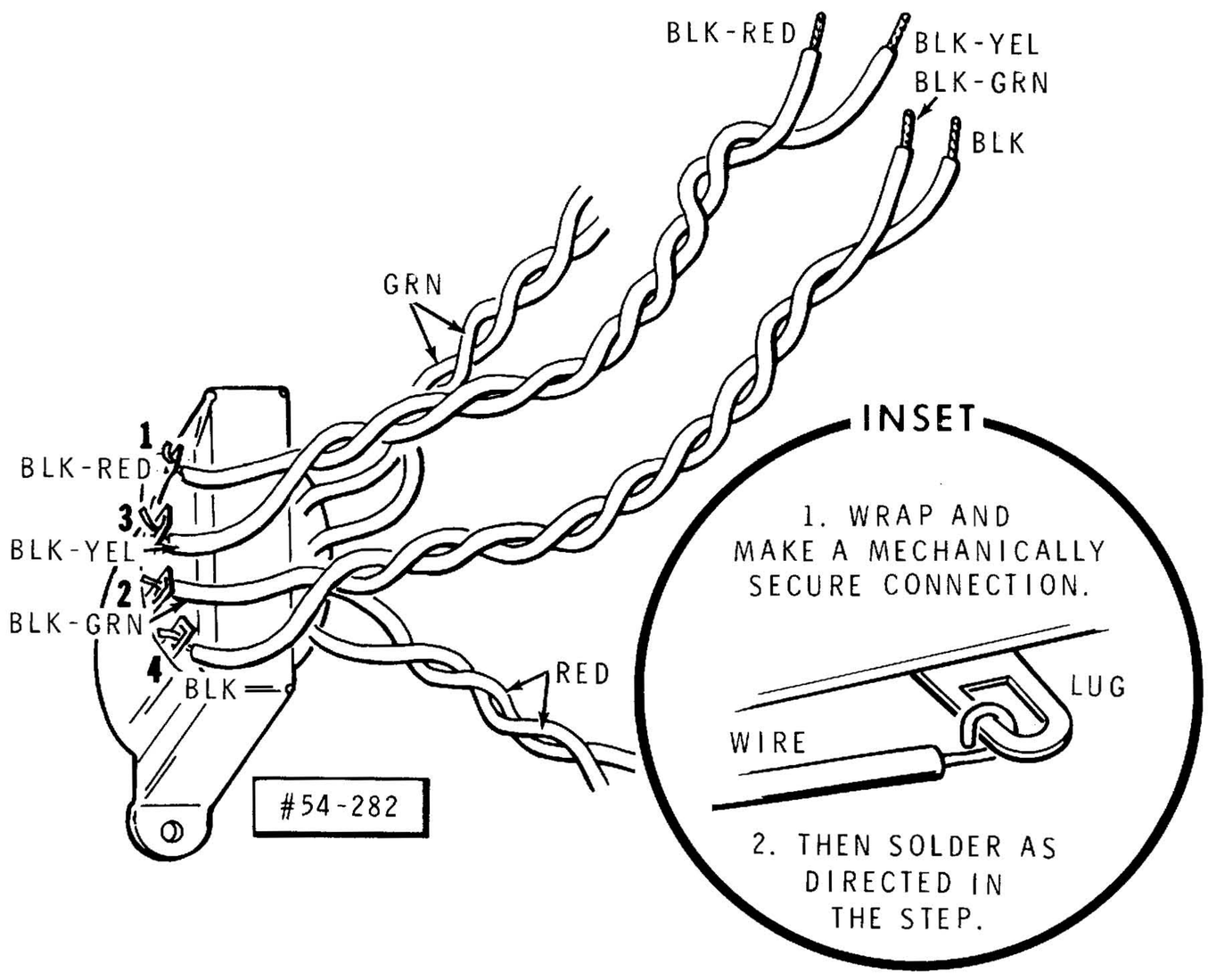
( ) Black-green to lug 2 (NS).

( ) Black-yellow to lug 3 (NS).

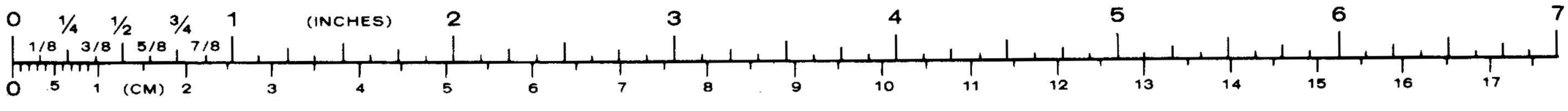
( ) Black-red to lug 1 (NS).

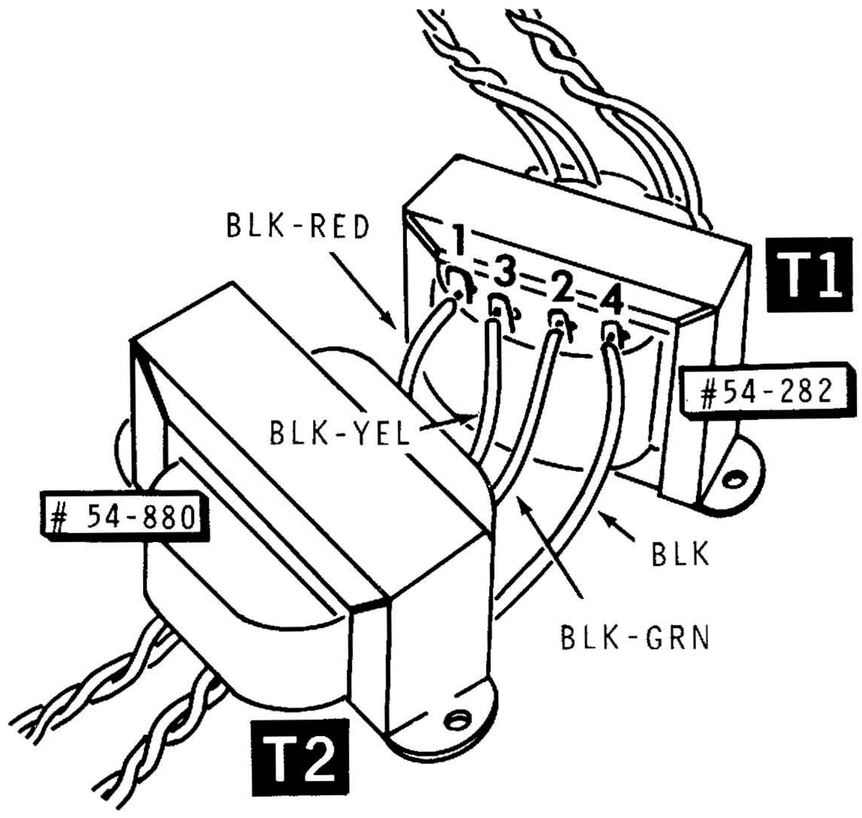
( ) Twist together the black and black-green leads to form a twisted pair.

( ) In the same manner, twist together the black-yellow and the black-red leads.




**PICTORIAL 4-15**






**PICTORIAL 4-16**

Refer to Pictorial 4-16 for the following steps.

Make "mechanically secure connections" when you connect the short leads coming from transformer #54-880 to the lugs of transformer #54-282 in the following steps. The transformer lug numbers are on the transformer.

( ) Black-red to lug 1 (S-2).

( ) Black-yellow to lug 3 (S-2).

( ) Black-green to lug 2 (S-2).

( ) Black to lug 4 (S-2).

Refer to Pictorial 4-17 (in the Illustration Book) for the following steps.

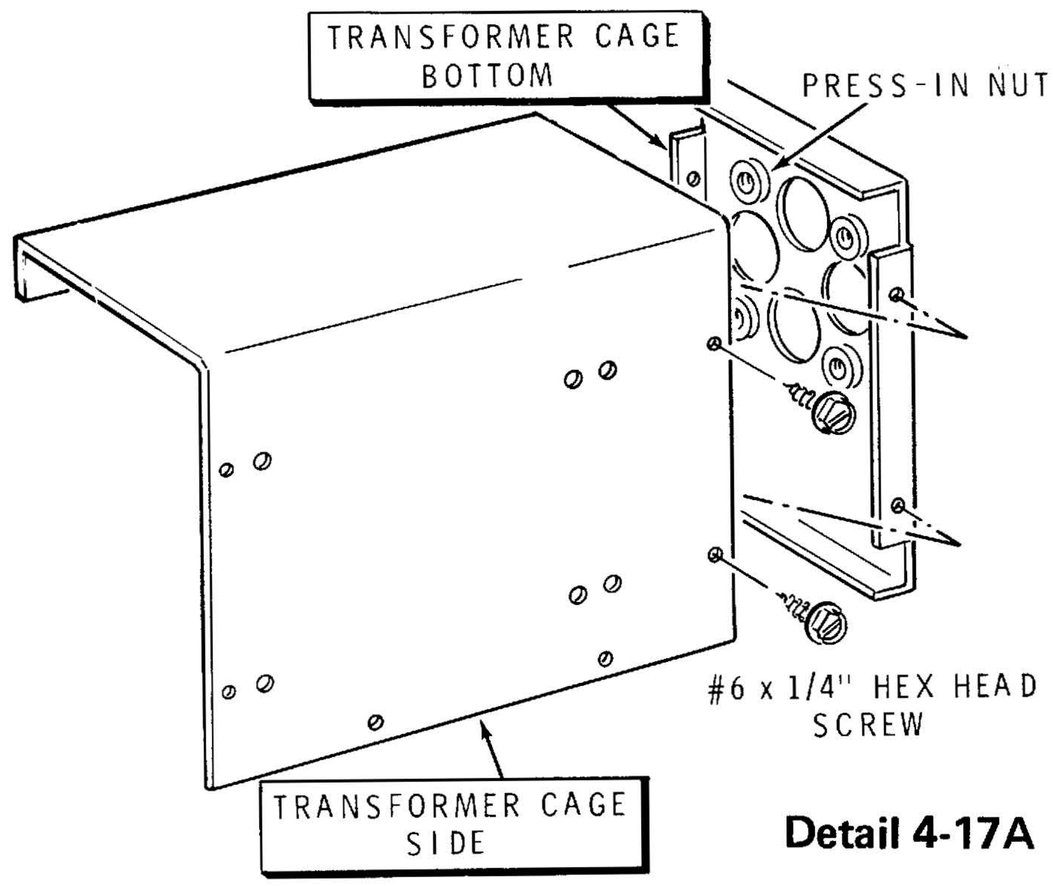
( ) Locate one of the (identical) transformer cage sides and the transformer cage bottom (with press-in nuts).

( ) Refer to Detail 4-17A and secure the transformer cage side to the transformer cage bottom with two #6 x 1/4" hex head screws.

( ) Pass the red and green twisted pairs of wires from transformer T1 through hole BY in the transformer cage bottom.

( ) Pass the black and black-green and the black-red and black-yellow twisted pairs of wires of transformer T1 (#54-282) through hole BZ in the transformer cage bottom.

( ) T1: Mount transformer #54-282 to the transformer cage side with 8-32 x 3/8" hardware.




**Detail 4-17A**

( ) Pass the red twisted pair, the yellow twisted pair, and the white and black-white wires coming from transformer T2 (#54-880) through hole BX in the transformer cage bottom.

( ) T2: Secure transformer #54-880 on the transformer cage side at the location shown. Use 8-32 x 3/8" hardware.

Refer to Pictorial 4-18 (in the Illustration Book) for the following steps.

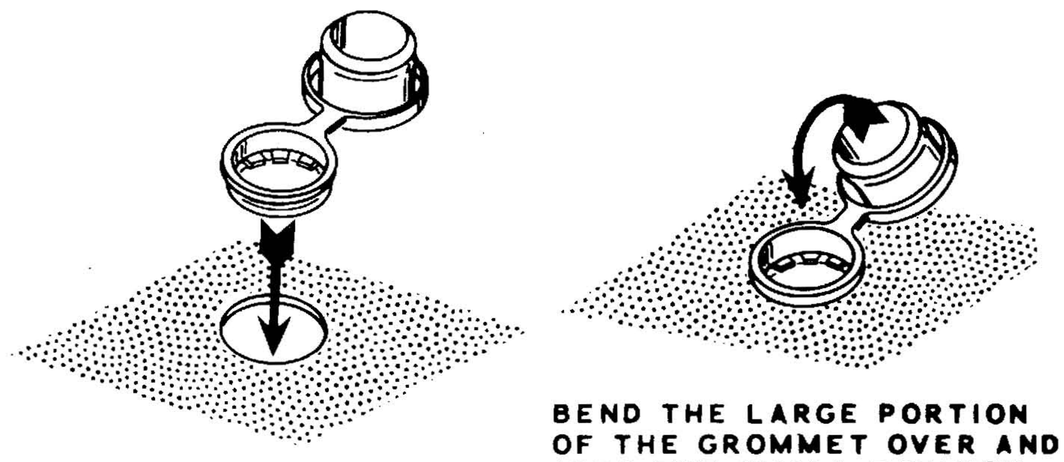
( ) Mount the transformer cage top (#206-1171) to the transformer assembly with two #6 x 1/4" hex head screws.

( ) Mount the other transformer cage side to the transformer assembly with eight #6 x 1/4" hex head screws.

Refer to Pictorial 4-19 (in the Illustration Book) for the following steps.

( ) Refer to Detail 4-19A and install plastic grommets in holes BX, BY, BZ of the transformer cage plate (#206-1163).

( ) Locate and position the chassis upside down as shown.




**Detail 4-19A**

( ) Pass all the transformer leads coming from the transformer cage assembly through the indicated hole in the chassis.

( ) Pass the proper transformer leads through the indicated holes (with grommets) in the transformer cage plate.

( ) Secure the transformer cage plate to the bottom of the transformer cage assembly with 8-32 x 3/8" screws. Tighten only one screw at this time.

Refer to Pictorial 5-1 (in the Illustration Book) for the following steps.

( ) Reposition the chassis as shown.

( ) Pass the shortest blue wire coming from grommet AB under terminal strip P and connect it to terminal strip U lug 5 (NS).

( ) Pass the free ends of the two longest blue wires coming from grommet AB under terminal strip P and then through grommet AK for connection later.

( ) Push the switch insulator over the lugs on switch SW1.

( ) Connect the free end of the white wire coming from grommet AB to switch SW1 lug 1 (NS).

( ) Connect the free end of the white wire from grommet AE to switch SW1 lug 1 (S-2).

Connect the transformer leads from grommet BZ to terminal strip Y in the following steps. Make mechanically secure connections.

( ) Black-red to lug 1 (NS).

( ) Black-yellow to lug 2 (NS).

( ) Black-green to lug 4 (NS).

( ) Black to lug 5 (NS).

Connect the transformer leads from grommet BY in the following steps. Make mechanically secure connections.

( ) Either red to terminal strip W lug 1 (NS).

( ) Other red to terminal strip W lug 2 (NS).

( ) Either green to terminal strip W lug 4 (NS).

( ) Other green to terminal strip U lug 5 (NS).

Connect the transformer leads from grommet BX in the following steps. Make mechanically secure connections.

( ) White-black to terminal strip Y lug 3 (S-1).

( ) Either red to terminal strip X lug 1 (NS).

( ) Other red to terminal strip X lug 3 (NS).

( ) Either yellow to terminal strip P lug 4 (NS).

( ) Other yellow to terminal strip P lug 5 (NS).

( ) Pass the white lead through grommet AF for connection later. Pass this lead under the other wires as shown.

( ) Prepare the ends of two 15" brown stranded wires.

( ) Twist these two brown wires together to form a twisted pair.

( ) At one end of the twisted brown wires, connect the wires to switch SW1, either wire to lug 5 (S-1) and the other wire to lug 6 (S-1). Make mechanically secure connections.

( ) Pass the other end of the twisted brown wires under terminal strip R and connect either wire to fuseholder F1 lug 1 (S-1). Connect the other wire to terminal strip Y lug 1 (NS). Make mechanically secure connections.

( ) Prepare a 3-1/2" white wire. Connect this wire from socket S3 (S-1) to solder lug L (NS).

Connect the free ends of the wires from grommet AC as follows:

( ) Remove an extra 1/2" (total 3/4") of insulation from the orange wire. Pass this end through switch SW101 lug 7 (S-2) to lug 2 (S-1).

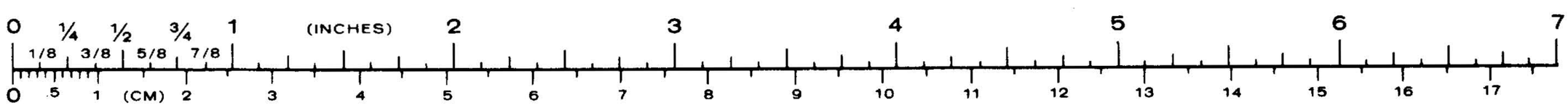
( ) White wire to control R117 lug 2 (S-1).

( ) Black wire to control R117 lug 1 (S-1).

( ) Gray wire to terminal strip V lug 4 (S-1).

( ) Green wire to terminal strip V lug 2 (NS).

( ) Prepare a 4" green wire. Connect this wire from terminal strip V lug 2 (S-2) to terminal strip N lug 5 (NS).



Connect the free ends of the wires from grommet AF as follows:

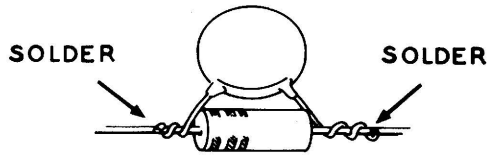
( ) Violet to control R106 lug 2 (S-1).

( ) Gray to control R109 lug 2 (S-1).

( ) White to control R109 lug 3 (S-1).

Refer to Pictorial 5-2 (in the Illustration Book) for the following steps.

( ) C101: Pass one lead of a .1 μF 400V Mylar capacitor through socket S1 (S-2) to switch SW101 lug 1 (NS). Connect the other lead to socket S2 (S-1). Disregard the band on the capacitor.




**Detail 5-2A**

( ) Locate a 10 kΩ, 5% (brown-black-orange) resistor and a 680 pF ceramic capacitor. Refer to Detail 5-2A and prepare a resistor-capacitor combination with these parts.

( ) R103/C104: Connect this resistor-capacitor combination from switch SW101 lug 8 (NS) to solder lug L (S-2).

( ) In the same way, prepare a resistor-capacitor combination using a 91 kΩ, 5% (white-brown-orange) resistor and a 56 pF ceramic capacitor.

( ) R102/C103: Connect this resistor-capacitor combination to switch SW101 between lugs 3 (NS) and 8 (S-2).

( ) Prepare a resistor-capacitor combination using a 910 kΩ, 5% (white-brown-yellow) resistor and a 5 pF ceramic capacitor.

( ) R101/C102: Connect this resistor-capacitor combination to switch SW101 between lugs 1 (S-2) and 3 (S-2).

Connect the free ends of the wires coming from grommet AB to terminal strip N as follows:

( ) Violet to lug 4 (NS).

( ) Both green to lug 5 (NS).

The remaining gray wire coming from grommet AB will be connected later.

( ) R18: Connect a 220 Ω (red-red-brown) resistor from switch SW1 lug 2 (S-1) to solder lug M (S-1). Be sure the wires connected to this switch do not touch the resistor lead when they are soldered, otherwise the insulation will melt and cause a short circuit.

( ) C5: Connect the lead at the positive (+) end of a 2000 μF electrolytic capacitor to terminal strip N lug 5 (NS). Pass the other lead through terminal strip N lug 2 (NS) to lug 3 (NS).

( ) C6: Connect the lead at the positive (+) end of a 2000 μF electrolytic capacitor to terminal strip N lug 4 (NS). Pass the other lead through terminal strip N lug 1 (S-2) to lug 2 (S-3).

Refer to Pictorial 5-3 (in the Illustration Book) for the following steps.

( ) Connect the free end of the gray wire from grommet AB to terminal strip R lug 4 (NS).

( ) Connect the free end of the orange wire coming from grommet AE to terminal strip R lug 4 (NS).

( ) Connect the free end of the gray wire coming from grommet AG to terminal strip R lug 4 (NS).

( ) Connect the free end of the violet wire coming from grommet AE to terminal strip N lug 5 (NS).

( ) Prepare two 2-1/4" white wires.

( ) Connect a 2-1/4" white wire to terminal strip R between lugs 3 (NS) and 5 (NS).

( ) Connect a 2-1/4" white wire to terminal strip R between lugs 2 (NS) and 4 (NS).

( ) R126: Connect a 1500 Ω (brown-green-red) resistor from control R106 lug 3 (S-1) to terminal strip V lug 3 (S-1).

( ) R124: Connect a 1500 Ω (brown-green-red) resistor from control R106 lug 1 (S-1) to terminal strip V lug 1 (S-1).

( ) ZD8: Connect a 1N171 zener diode (#56-16) to terminal strip N, the lead from the banded end to lug 4 (NS) and the other lead to lug 3 (NS).

( ) ZD7: Connect a VR9.1 zener diode (#56-19) to terminal strip N, the lead from the banded end to lug 5 (NS) and the other lead to lug 3 (S-3).

( ) C8: Connect the lead from the positive (+) end of a 1200 μF electrolytic capacitor to terminal strip P lug 1 (NS). Pass the other lead through terminal strip R lug 1 (NS) to lug 2 (NS).

( ) R15: Connect a 68 Ω, 1-watt (blue-gray-black) resistor from terminal strip N lug 4 (S-4) to terminal strip P lug 1 (NS).

( ) R14: Connect a 68 Ω, 1-watt (blue-gray-black) resistor from terminal strip N lug 5 (S-7) to terminal strip P lug 1 (NS). Be sure all the wires get soldered.

( ) C9: Connect the lead from the positive (+) end of a 1200 μF electrolytic capacitor to terminal strip P lug 2 (NS). Connect the other lead to terminal strip R lug 1 (NS).

( ) C7: Connect a 2000 μF electrolytic capacitor to terminal strip R, the lead at the positive (+) end to lug 5 (S-2) and the other lead to lug 2 (NS).

Connect the free ends of the wires coming from grommet AD to control R204 as follows:

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

( ) White to lug 2 (S-1).

Refer to Pictorial 5-4 for the following steps.

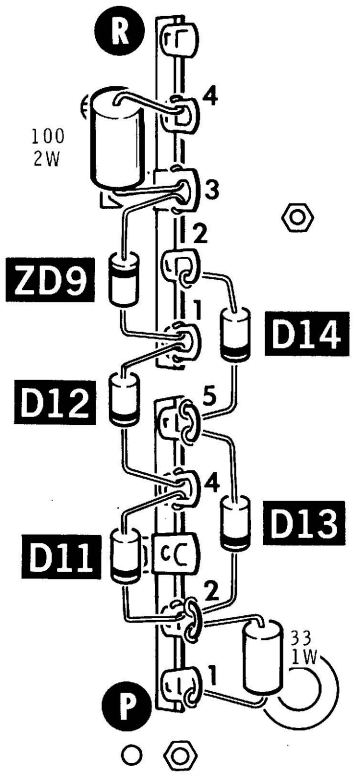
( ) R16: Connect a 33 Ω, 1-watt (orange-orange-black) resistor to terminal strip P between lugs 1 (S-4) and 2 (NS).

( ) D11: Connect a 1N2071 diode (#57-27) to terminal strip P, the lead at the banded end to lug 2 (NS) and the other lead to lug 4 (NS).

( ) D13: Connect a 1N2071 diode (#57-27) to terminal strip P, the lead at the banded end to lug 2 (S-4) and the other lead to lug 5 (NS).

( ) D12: Connect the lead at the banded end of a 1N2071 diode (#57-27) to terminal strip P lug 4 (S-3). Connect the other lead to terminal strip R lug 1 (NS).

( ) D14: Connect the lead at the banded end of a 1N2071 diode (#57-27) to terminal strip P lug 5 (S-3), and connect the other lead to terminal strip R lug 2 (S-4).




**PICTORIAL 5-4**

( ) ZD9: Connect a VR9.1 zener diode (#56-19) to terminal strip R, the lead at the banded end to lug 3 (NS) and the other lead to lug 1 (S-5).

( ) R17: Connect a 100 Ω, 2-watt resistor (brown-black-brown) to terminal strip R between lugs 3 (S-3) and 4 (S-5).

Refer to Pictorial 5-5 (in the Illustration Book) for the following steps.

( ) Connect the free end of the white wire coming from grommet AG to capacitor C4 lug C (NS).

( ) Connect the free end of the black wire coming from grommet AE to capacitor C4 lug B (NS).

Connect the free ends of the wires coming from grommet AH to capacitor C4 as follows:

( ) Gray to lug B (NS).

( ) White to lug C (NS).

( ) Prepare the following wires:

4-1/2" white
2" white
11" blue

( ) Connect a 4-1/2" white wire from terminal strip U lug 2 (NS) to terminal strip W lug 2 (S-2).

( ) Connect a 2" white wire from terminal strip X lug 2 (NS) to capacitor C4 lug 1 (S-1).

( ) Connect one end of an 11" blue wire to terminal strip U lug 5 (NS). The other end will be connected later.

( ) Prepare one end only of a 12" blue wire. Connect the prepared end to terminal strip W lug 4 (S-2). The other end will be connected later.

Refer to Pictorial 5-6 (in the Illustration Book) for the following steps.

( ) D1: Connect a 5D20 diode (#57-52) to terminal strip U, the lead from the banded end to lug 2 (NS) and the other lead to lug 1 (NS).

( ) D2: Connect a 5D20 diode (#57-52) to terminal strip U, the lead from the banded end to lug 3 (S-1) and the other lead to lug 2 (S-3).

( ) C2: Connect the lead from the banded end of a .1 μF (1.6KV) paper capacitor to terminal strip W lug 1 (NS), and connect the other lead to terminal strip U lug 1 (NS).

( ) C1: Connect the lead from the banded end of a .1 μF (1.6KV) paper capacitor to terminal strip W through lug 5 (NS) to lug 3 (S-1). Connect the other lead to terminal strip U lug 5 (NS).

( ) C3: Connect a .1 μF (1.6KV) paper capacitor to terminal strip W, the lead from the banded end to lug 5 (S-3) and the other lead to lug 1 (S-3).

( ) R9: Connect an 820 kΩ (gray-red-yellow) resistor to terminal strip U between lugs 1 (S-3) and 4 (NS).

( ) R8: Connect an 820 kΩ (gray-red-yellow) resistor to terminal strip U between lugs 4 (S-2) and 5 (S-5).

( ) D6: Connect a 1N2071 diode (#57-27) to terminal strip X, the lead at the banded end to lug 1 (NS) and the other lead to lug 2 (NS).

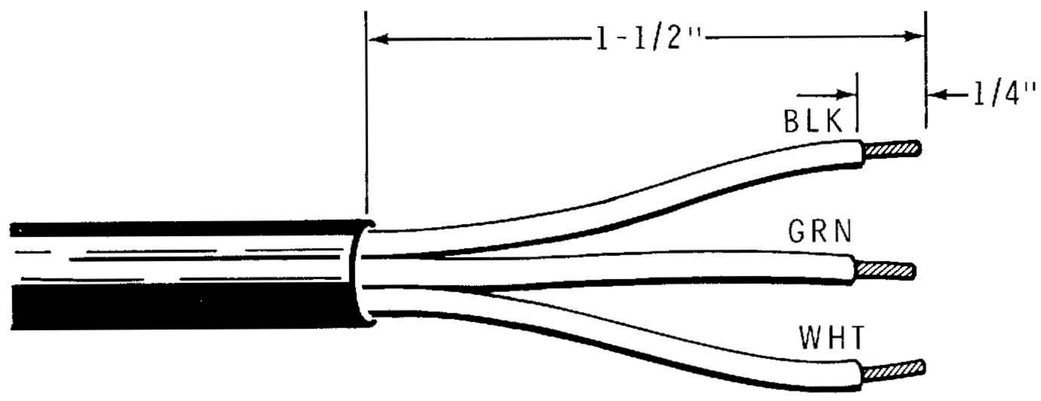
( ) D4: Connect a 1N2071 diode (#57-27) to terminal strip X, the lead at the banded end to lug 3 (NS) and the other lead to lug 2 (S-3).

( ) D5: Connect the lead at the banded end of a 1N2071 diode (#57-27) to capacitor C4 lug A (NS), and connect the other lead to terminal strip X lug 1 (S-3).

( ) D3: Connect the lead at the banded end of a 1N2071 diode (#57-27to capacitor C4 lug A (NS). Connect the other lead to terminal strip X lug 3 (S-3).

( ) R13: Connect a 2700 Ω, 2-watt (red-violet-red) resistor to capacitor C4 between lugs A (NS) and C (S-3).

( ) R12: Connect a 1500 Ω, 2-watt (brown-green-red) resistor to capacitor C4 between lugs A (S-4) and B (S-3).




**Detail 5-6A**

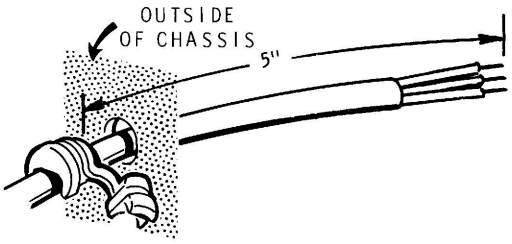
( ) Refer to Detail 5-6A and prepare the line cord as follows:

1. Remove the outer insulation of the line cord for 1-1/2".

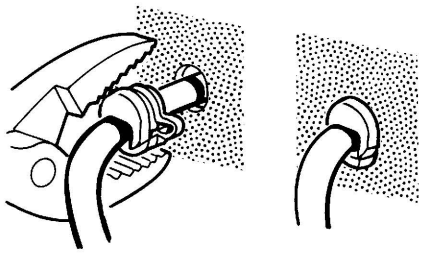
2. Twist together the fine wire strands at the end of each lead and apply a small amount of solder to hold them in place.

( ) Refer to Detail 5-6B and place the line cord strain relief on the line cord 5" from its prepared end. Then install the line cord strain relief in hole AL.

( ) Pass the prepared end of the line cord up through grommet AJ.




PLACE THE LINE CORD
STRAIN RELIEF
OVER THE CABLE.



SQUEEZE THE TWO SEGMENTS TOGETHER.

INSERT THE REAR HALF INTO THE CHASSIS HOLE.

**Detail 5-6B**

Connect the line cord wires as follows. Make mechanically secure connections.

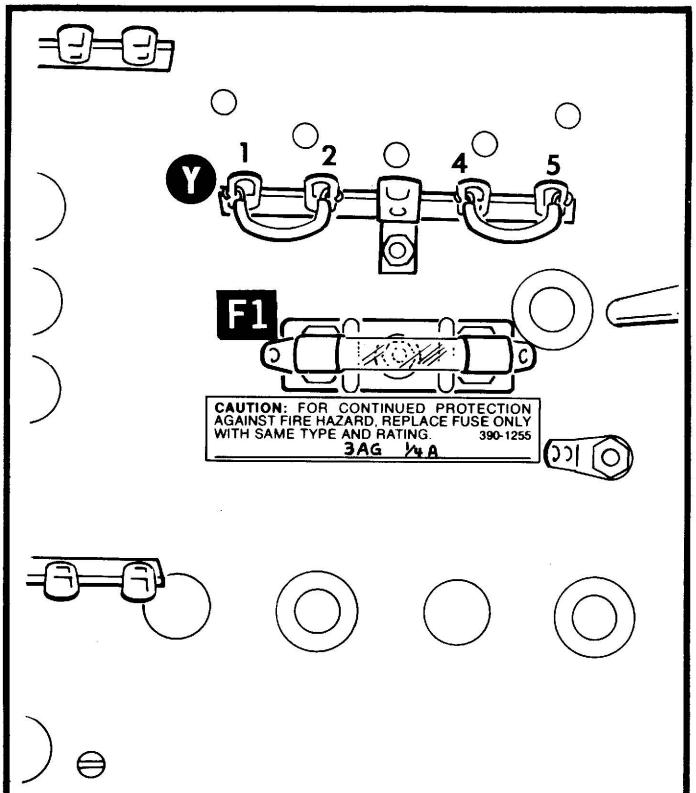
( ) Green to solder lug Z (S-1).

( ) Black to fuse socket F1 lug 2 (S-1).

( ) White to terminal strip Y lug 5 (NS).

NOTE: Two sets of line voltage instructions are given below, one for 120 VAC line voltage and the other for 240 VAC line voltage. In the U.S.A., 120 VAC is most often used, while in other countries 240 VAC is more common. USE ONLY THE INSTRUCTIONS THAT AGREE WITH THE LINE VOLTAGE IN YOUR AREA.

All the following connections will be made to terminal strip Y. Make mechanically secure connections.




**Detail 5-6C**

## 120 VAC Wiring

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

( ) Prepare two 2" brown stranded wires.

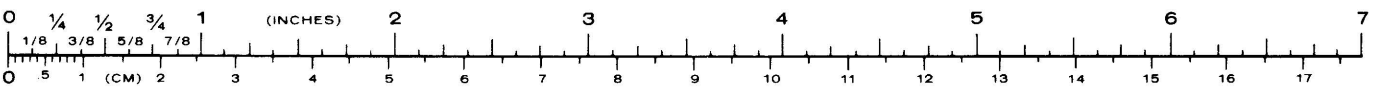
( ) Connect one of these wires between lugs 1 (S-3) and 2 (S-2). Make mechanically secure connections.

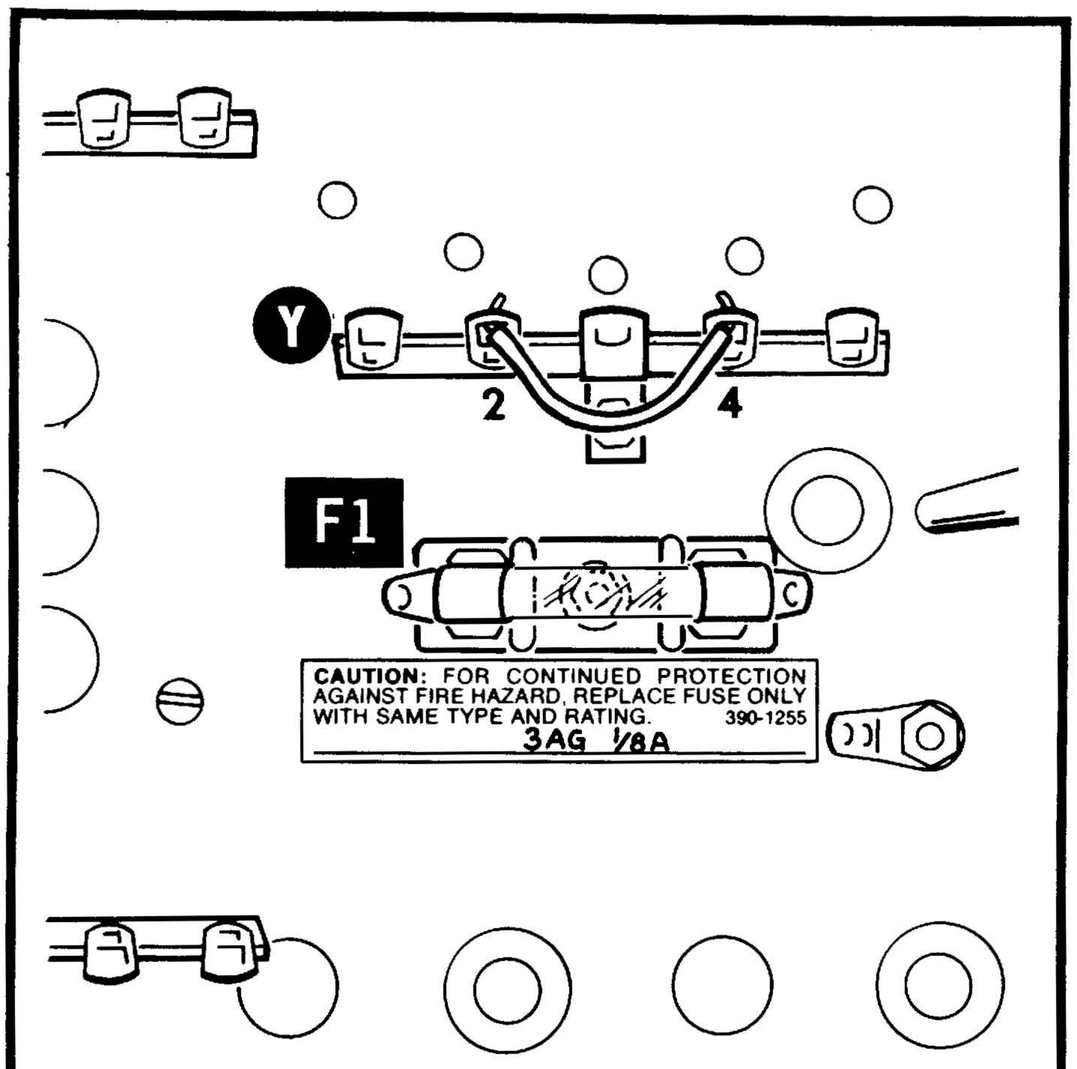
( ) Connect the other wire between lugs 4 (S-2) and 5 (S-3). Make mechanically secure connections.

( ) Mark the fuse label 3AG 1/4A as shown.

( ) Remove the paper backing from the fuse label and press the label into place near fuse socket F1.

( ) F1: Install the 1/4 ampere fuse in fuseholder F1.






**Detail 5-6D**

## 240 VAC Wiring

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

( ) Solder the wires at lug 1 (S-2).

( ) Prepare a 2" brown stranded wire.

( ) Connect this 2" wire between lugs 2 (S-2) and 4 (S-2). Make mechanically secure connections.

( ) Solder the wires at lug 5 (S-2).

( ) Mark the fuse label 3AG 1/8A as shown.

( ) Remove the paper backing from the fuse label and press the label into place near fuse socket F1.

( ) F1: Install the 1/8 ampere fuse in fuseholder F1.

Refer to Pictorial 5-7 and Detail 5-7A (in the Illustration Book) for the following steps.

( ) Turn the chassis over as shown.

( ) Connect the free end of the white lead extending from grommet AF to terminal strip F lug 1 (S-1).

( ) Locate the rubber strip insulator and cut it in half.

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.

( ) Position the large end of the CRT into the ring on the front panel so the CRT is against the graticule.

( ) Secure the CRT with the two tube clamps and the rubber strip insulator. Use 6-32 x 5/8" screws into spacers BB and BC. Position the "key" on the CRT as shown. Tighten the screws only enough to keep the CRT from turning.

( ) Push the tube socket onto the CRT. Align the keyway of the socket with the key on the CRT. Push the socket on as far as possible with moderate pressure. It will not go on all-the-way.

Refer to Pictorial 5-7 for the following steps.

( ) Connect the free end of the orange wire from terminal strip K to CRT socket lug 8 (S-1).

NOTE: When you connect the free ends of the twin lead to the CRT socket, make sure you connect the leads from the proper terminal strip to the correct lug of the CRT socket. Otherwise the Oscilloscope will not function properly.

Connect the twin lead from terminal strips D and F to the CRT socket as follows:

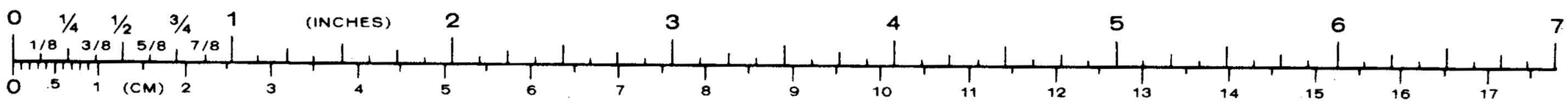
( ) Lead from terminal strip D to lug 9 (S-1).

( ) Lead from terminal strip F to lug 10 (S-1).

Connect the other twin lead to the CRT socket as follows:

( ) Lead from terminal strip G to lug 7 (S-1).

( ) Lead from terminal strip J to lug 6 (S-1).



( ) R19: Connect a 1 MΩ (brown-black-green) resistor to the CRT socket between lugs 3 (S-1) and 5 (NS).

( ) R3: Connect a 10 MΩ (brown-black-blue) resistor to the CRT socket between lugs 1 (NS) and 2 (NS).

( ) Connect the free end of the blue wire coming from terminal strip K to CRT socket lug 2 (S-2).

Refer to the inset drawing on Pictorial 5-7 for the following steps.

( ) Remove 1/4" of insulation from the free end of the blue wire from grommet AK that does not have the insulation removed. Connect this wire to CRT socket lug 5 (S-2).

( ) Connect the free end of the other blue wire from grommet AK (with insulation removed) to CRT socket lug 4 (S-1).

( ) Locate and pass the free ends of the two blue wires from under the chassis up through grommet AK.

( ) Connect the free end of the blue wire just passed through grommet AK (with insulation removed) to CRT socket lug 1 (S-2).

( ) Remove 1/4" of insulation from the other blue wire just passed through grommet AK. Connect this wire to CRT socket lug 12 (S-1).

( ) Turn the Oscilloscope upside down to remove any wire clippings or solder splashes.

( ) Carefully peel the backing paper from the blue and white identification label and press the label onto the rear of the chassis. Be sure to refer to the numbers on this label in any communications you have with the Heath Company about this kit.

( ) Peel the backing paper from the DANGER label and press the label onto the rear of the chassis.

This completes the chassis wiring. Make the following checks to insure proper chassis wiring. Look for:

1. Unsoldered connections.
2. A wire or component connected to the wrong place. Check the wiring against the Pictorials.
3. Electrolytic capacitors installed backwards. Be sure their positive (+) marked ends are connected as directed.
4. Transistors and diodes installed incorrectly. Check the wiring instruction for each transistor and diode.
5. Wire ends touching lugs other than the one to which they are connected.

( ) Refer to Pictorial 5-8 (in the Illustration Book) and prepare two test leads. Use the black and red stranded wire.

Refer to Figure 2-1 (in the Illustration Book) for the following steps.

( ) Start a 6-32 x 3/16" setscrew in each of the five small knobs.

( ) Start a 6-32 x 1/4" setscrew in the large knob.

( ) Turn the shaft of the Vert Gain and Sweep Speed Variable controls fully counterclockwise.

( ) Install the small knob (with pointer) on the shaft of the Vert Gain control. Position the knob pointer at the 7 o'clock position.

( ) In the same manner, install the large knob on the shaft of the Sweep Speed Variable control.

( ) Install small knobs on the four remaining control shafts.

Proceed to the "Test and Adjustment" section of the Manual.

# TESTS AND ADJUSTMENTS

This section of the Manual is divided into three main sections consisting of: "Resistance Measurements," "Voltage Measurements," and "Adjustments." Each section consists of charts which list meter connecting points, the results to be obtained, and the area of the kit to be checked if proper results are not obtained.

The following "Troubleshooting Hints" deal with the types of difficulties that may show up right after a kit is assembled, before you can put it into operation. These difficulties are most likely to be caused by assembly errors or faulty soldering.

## TROUBLESHOOTING HINTS

The following checks will help you locate problems that can exist right after the kit is completed.

1. First, make a good visual check of the whole unit to make sure there are no obvious difficulties, such as unsoldered connections, burned or overheated parts, bare wires touching each other, obviously faulty solder connections, etc. Make sure there are no bits of solder, wire ends or other foreign matter lodged in the wiring. Carefully check all terminals that have several wires attached to make sure that all wires, especially the lower ones, are soldered.

2. Then check all wires to make sure they are connected to the right places. Usually, it is quite helpful to have a friend help you check your work. Often, someone not familiar with the unit will notice an error that you have overlooked consistently.

3. Check to make sure that each transistor, diode, tantalum and electrolytic capacitor, and IC is installed properly and is in the proper location.

4. Check all solder connections to make sure they are bright and shiny. About 90% of the kits that are returned to the Heath Company for repair do not operate properly due to poor solder connections. Reheat and, if necessary, melt a little more solder to all questionable connections to make sure they are soldered as described in the Soldering section of the "Kit Builders Guide."

5. Check the values of resistors and capacitors to make sure the proper part is wired into the circuit in each position. It is sometimes easy to misread the third color band on a resistor. For example, if a 22 kΩ (red-red-orange) resistor were installed instead of a 220 kΩ (red-red-yellow) resistor, the circuit would not operate properly.

6. Before you try to locate the cause of a difficulty, be sure to check the operation of the controls. Difficulties may also be due to improper adjustments of the front panel and circuit controls. A recheck of these adjustments as outlined in the "Adjustments" section may help you locate the source of trouble.

7. When you are instructed to check a specific component, Q103 for example, also check any associated components to Q103 to be sure they are the proper value and installed correctly.

8. In the event you cannot correct a malfunction in your kit, use the information in the "Test and Adjustments" and the "In Case of Difficulty" sections of this Manual.

WARNING: Since high voltages are present at many points throughout the kit, caution should be taken to avoid personal shock.

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

# RESISTANCE MEASUREMENTS

If an ohmmeter is available, perform the following resistance measurements. The purpose of these measurements is to make sure your oscilloscope will not be damaged by wiring errors or incorrectly installed components.

NOTES:

1. All ohmmeters do not read the same. Therefore, the following meter readings are approximate.

2. Some of the circuits being tested have large value capacitors in them. In these cases, the ohmmeter will start at or near zero and then climb slowly. When this happens, keep the ohmmeter lead connected until the meter stops moving and then check the meter reading.

3. In a number of steps, you will be instructed to connect one of the ohmmeter leads to ground. This ground is the chassis.

4. Not all ohmmeters have the positive battery terminal connected to the red meter lead. Therefore, you may find that your ohmmeter leads will have to be connected in reverse to the chart directions in order to obtain the correct readings.

5. All resistance readings were taken with an ohmmeter having a single 1-1/2V battery. CAUTION: When you make resistance measurements, always make sure the kit is unplugged.

Refer to Figure 2-1 (in the Illustration Book) for the test point locations.

( ) Tip the chassis up so it is sitting on its side with the bottom facing you.

( ) Place the ohmmeter switch in the "X10 Ohms" position.

| | METER CONNECTIONS | | METER READING | POSSIBLE CAUSE OF TROUBLE |
|---|---|---|---|---|
| | RED LEAD | BLACK LEAD | | |
| 1. | Either flat prong of line plug. | Round prong of line plug. | INFINITE with Power switch ON or OFF. | A. Terminal strip Y wiring.<br>B. T1. |
| 2. | Other flat prong of line plug. | Round prong of line plug. | INFINITE with Power switch ON or OFF. | A. Terminal strip Y wiring.<br>B. T1. |
| 3. | TP1 | Ground. | INFINITE Power switch ON. | A. C4A, C4B, or C4C.<br>B. R11, R12, or R13.<br>C. 150 volt line.<br>D. 180 volt line. |
| 4. | TP2 | Ground. | INFINITE Power switch ON. | A. C4A, C4B, or C4C.<br>B. R11, R12, or R13.<br>C. 150 volt line.<br>D. 180 volt line. |
| 5. | TP3 | Ground. | Greater than 200 Ω | A. ZD7.<br>B. C5.<br>C. +9 volt line. |
| 6. | TP4 | Ground. | Greater than 250 Ω | A. ZD8.<br>B. C6.<br>C. +5 volt line. |
| 7. | TP5 | Ground. | Greater than 80 Ω | A. R17.<br>B. ZD9.<br>C. C7.<br>D. −9 volt line. |

This completes the "Resistance Measurements." If all tests were satisfactory, proceed to the "Voltage Measurements" section. If any of the tests were not correct, you must make any corrections necessary to obtain the correct readings before you continue.

# VOLTAGE MEASUREMENTS

In this section of the Manual you will make voltage measurements to check the power supplies to see that they are working properly.

Refer to Figure 2-1 (in the Illustration Book) for control and test point locations.

In the following steps you will be instructed to preset the various controls and switches. Once set, they should not be changed unless you are instructed to do so in a step.

Set the front panel controls and switches as follows:

( ) SW203: POWER – OFF.

( ) R7: INTENSITY – Fully clockwise.

( ) R5: FOCUS – Center of rotation.

( ) R207: Horizontal Position (HORIZ POS) – Center of rotation.

( ) R106: Vertical Position (VERT POS) – Center of rotation.

( ) R117: Vertical Gain (VERT GAIN) – Fully clockwise.

( ) SW101: Vertical Attenuator Switch – X1.

( ) SW302: HORIZONTAL – EXTERNAL.

( ) SW301: SWEEP SPEED switch – LO.

( ) R353: SWEEP SPEED control – Center of rotation.

( ) R109: VERTICAL PLATE VOLTS ADJUST (on chassis) – Center of rotation.

( ) R204: HORIZONTAL PLATE VOLTS ADJUST (on chassis) – Center of rotation.

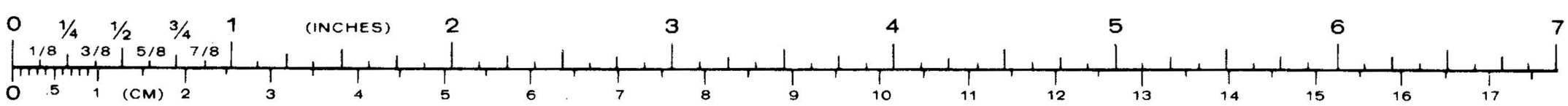
( ) R125: DC Balance (on chassis) – Center of rotation.

( ) R304: LEVEL SET (on circuit board) – Center of rotation.

( ) Plug the line cord into an AC receptacle.

| POWER SWITCH | RED LEAD | BLACK LEAD | METER READING | POSSIBLE CAUSE OF TROUBLE |
|---|---|---|---|---|
| ( ) ON | TP1 | Ground | +154 VDC | A. D3, D4, D5, or D6.<br>B. C4.<br>C. +180 volt line. |
| ( ) ON | TP2 | Ground | +110 VDC | A. D3, D4, D5, or D6.<br>B. C4.<br>C. +150 volt line. |
| ( ) ON | TP4 | Ground | +9.3 VDC | A. D11, D12, D13, or D14.<br>B. C5, C8, or C9.<br>C. R14 or R16.<br>D. ZD7.<br>E. +9 volt line. |
| ( ) ON | TP3 | Ground | +5.3 VDC | A. D11, D12, D13, or D14.<br>B. C6, C8, or C9.<br>C. R15 or R16.<br>D. ZD8.<br>E. +5 volt line. |
| ( ) ON | TP5 | Ground | –9.5 VDC | A. D11, D12, D13, or D14.<br>B. C7.<br>C. R17.<br>D. ZD9.<br>E. –9 volt line. |
| ( ) OFF | | | | |

This completes the "Voltage Measurements." If all tests were satisfactory, proceed to the "Adjustments" section. If any of the tests were not correct, you must make any corrections necessary to obtain the correct readings before you continue.



# ADJUSTMENTS

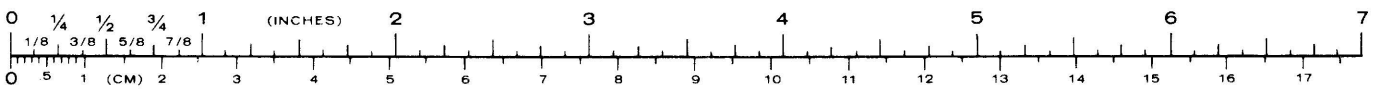
In this section of the Manual, you will be instructed to make a number of adjustments. Always allow the Oscilloscope to warm up for a few minutes before making the adjustments.

Refer to Figure 2-1 in the Illustration Book for the control and test point locations. Be sure the control settings have not been changed from the settings listed in the "Voltage Measurements" section of the Manual.

Perform the operation described in the "Instructions-Results" column of the chart. The results will be a meter reading or a particular display on the face of the CRT. If an inaccurate result is obtained, turn the Power switch to OFF.

Refer to the "Possible Cause of Trouble" column and check the components or area described for a possible assembly error.

| INSTRUCTION-RESULT | POSSIBLE CAUSE OF TROUBLE |
|---|---|
| ( ) Short both the vertical (DC) and the horizontal (HORIZ IN) inputs (connect a jumper wire from each of the inputs to ground). | |
| ( ) Power switch to ON. | |
| ( ) Adjust DC balance for zero volts at source ("S") of Q101. | |
| (4) Alternately measure the voltage at TP6 and TP7 and adjust the VERT POS (vertical position) until these voltages are equal. | A. Q106 or Q107.<br>B. Q104 or Q105.<br>C. Q102.<br>D. R106. |
| (5) Adjust the VERTICAL PLATE VOLTS ADJUST control for an 80-volt meter indication at TP6. | A. Q103.<br>B. R109.<br>C. Q102.<br>D. Q101. |
| (6) Repeat the two previous steps until the voltage at both TP6 and TP7 is 80 volts. | |
| (7) Alternately measure the voltage at TP8 and TP9 and adjust the HORIZ POS (horizontal position) until these voltages are equal. | A. Q205 or Q206.<br>B. Q203 or Q204.<br>C. R207. |
| (8) Adjust the HORIZONTAL PLATE VOLTS ADJUST control for a 90-volt meter indication at TP8. | A. Q202.<br>B. R204.<br>C. Q201. |
| (9) Repeat the two previous steps until the voltage at both TP8 and TP9 is 90 volts. | |



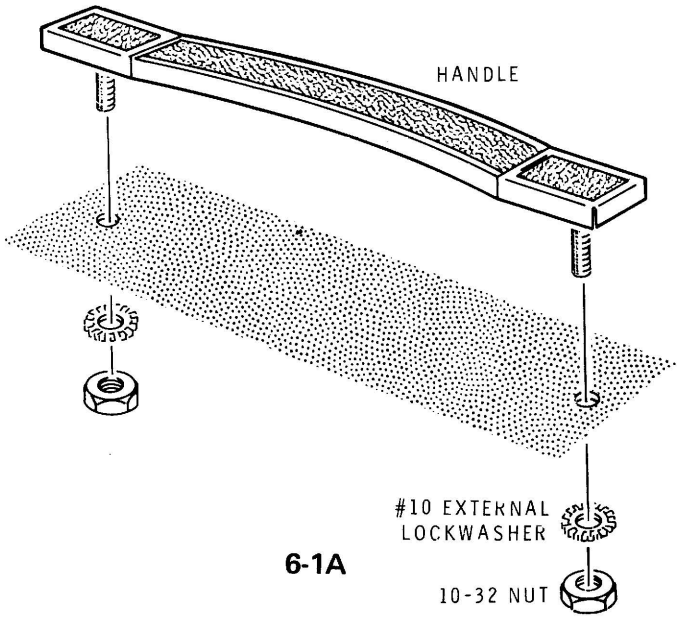
| INSTRUCTION-RESULT | POSSIBLE CAUSE OF TROUBLE |
|---|---|
| (10) HORIZONTAL switch to INT (internal) and SWEEP SPEED to HI. | |
| (11) Loosen the CRT mounting clamp and rotate the CRT until the line on the CRT is perfectly horizontal. Then retighten the CRT clamp. NOTE: The two rear corners of the chassis must be propped so they are the same distance from the work surface. Otherwise, the extra transformer weight will twist the chassis and the line on the CRT will no longer be perfectly horizontal when the Oscilloscope is installed in the cabinet. | |
| (12) Remove shorts from both inputs. | |
| (13) SWEEP SPEED to LO and connect the AC input to TP10. | A. C101.<br>B. See 4, 5, 6, or 7, 8 and 9 on preceeding page. |
| (14) Increase VERT (vertical) GAIN control until the waveform is 3 to 4 centimeters high. | |
| (15) Adjust the LEVEL SET control until the waveform "locks in." | A. See "In Case of Difficulty" section of Manual. |
| (16) Slowly reduce the amplitude of the input signal until the waveform loses sync. | |
| (17) Repeat the two previous steps to obtain sync with the smallest possible waveform. | |
| (18) Position the Oscilloscope in the location where it will be used. | |
| (19) Loosen the transformer cage assembly mounting screws. Increase the amplitude of the trace to approximately 4 centimeters. Rotate the transformer shield assembly until you notice minimum hum on the trace. | |
| (20) POWER switch to OFF and unplug the line cord. | |
| (21) Tighten the four mounting screws on the transformer cage assembly. | |
| (22) ( ) Install a #6 x 1/4" hex head screw in the hole in the bottom of the chassis that lines up closest with the hole in the bottom of the transformer cage. | |

Proceed to the "Final Assembly" section of this Manual.

# FINAL ASSEMBLY

Refer to Pictorial 6-1 (in the Illustration Book) for the following steps.

( ) Refer to Detail 6-1A and mount the handle in the holes provided in the cabinet. Use 10-32 nuts and #10 lockwashers.




**6-1A**

( ) Place a soft cloth on your work surface. Then position the Oscilloscope face down on the cloth as shown.

( ) Pass the line cord out through the hole in the rear of the cabinet.

( ) Carefully slide the cabinet down over the chassis. Be sure the front edge of the cabinet is inside the lip around the outer edge of the front panel.

( ) Secure the cabinet to the chassis with eight #8 x 5/8" hex head screws. Tighten the four rear screws first. Then tighten the remaining screws.

( ) Remove the paper backing from the caution label and press the label onto the rear of the cabinet at the location shown.

This completes the "Final Assembly." Proceed to the "Operation and Applications" section of the Manual.

# OPERATION AND APPLICATIONS

Refer to Figure 3-1 (in the Illustration Book) for an explanation of the control functions. This section of the Manual will help you obtain the greatest use from your applications for it.

NOTE: Your Oscilloscope has sensitive DC amplifiers. It is therefore normal for the trace to drift vertically somewhat during the first half hour or so after it is turned on.

The Oscilloscope's ability to display many types of voltage waveforms permits you to study complex signals, such as found in audio devices, television receivers, transmitters, and in other electronic equipment. Voltage,frequency, and phase can also be measured with an oscilloscope.

This section of the Manual presents some fundamental oscilloscope applications. These will help you to become familiar with the instrument to achieve the greatest use of it.

## WAVEFORM DISPLAY

Lines or waveforms appear on the face of a cathode ray tube (CRT) when its electron beam is deflected by varying charges on its deflection plates. Generally, an internal sweep generator in the oscilloscope varies the charge on the horizontal deflection plates and moves the beam rapidly from side to side. Horizontal sweep can also be produced by applying an external sweep signal to the Horizontal Input of the oscilloscope.

Vertical deflection results from a signal applied to the Vertical Input of the oscilloscope. This signal is amplified and applied to the vertical deflection plates in the CRT.

When the frequency of the vertical input signal is equal to the horizontal sweep frequency, one complete cycle will be displayed on the screen. If the signal frequency is higher than the sweep frequency, more than one cycle will be displayed. The height of the waveform on the screen will be proportional to the amplitude of the vertical input signal, although it is affected by the setting of the Vertical Gain control and Attenuator switch.

With this very brief theory of operation, you can see that an oscilloscope will display the waveform of the signal voltage that is fed to its vertical input. The signal voltage may be taken from an audio amplifier, a television receiver, a transmitter, or almost any electronic circuit. Some of the more common oscilloscope applications are described in the following paragraphs.

## AUDIO AMPLIFIER CIRCUITS

You can observe frequency response, distortion, and gain in an audio amplifier by making connections as shown in Figure 3-2. The audio generator injects either a sine wave or square wave signal into the input of the amplifier. The amplifier's output terminates in a proper load impedance, and the Oscilloscope is connected across the load.

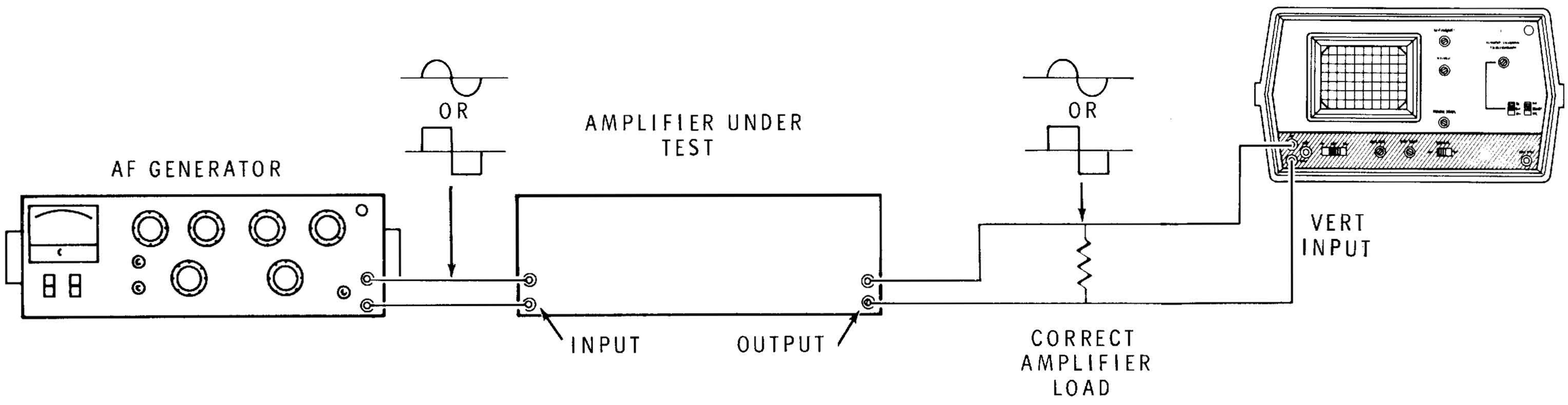



**Figure 3-2**

Normal input and output waveforms are also shown in Figure 3-2.

The waveform produced by the audio generator will not be changed as it passes through properly operating circuits of a high fidelity amplifier. However, if any circuit is not operating properly, the output waveform will be distorted.

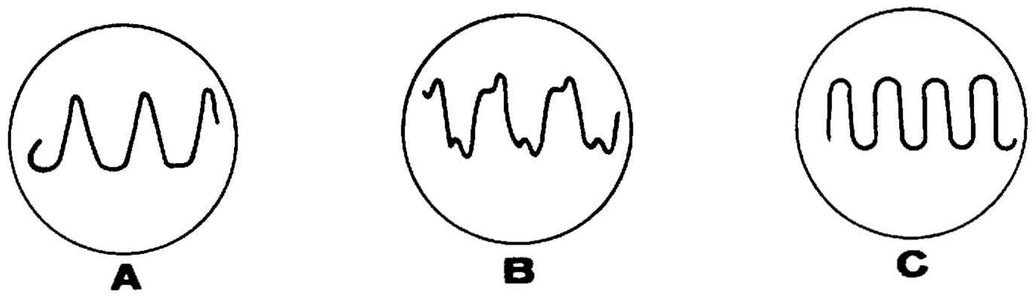



**Figure 3-3**

Figure 3-3A shows a sine wave with a serious flattening of one peak. This represents about 10% harmonic distortion, which could be caused by an improperly biased stage, or a defective tube or transistor in a push-pull stage.

Figure 3-3B indicates third harmonic distortion, which is a particularly objectionable amplifier fault. Figure 3-3C shows a flattening of both peaks, which usually indicates an overdriven stage somewhere in the amplifier.

While a sine wave signal will tell much about an amplifier, a square wave signal gives a very accurate indication of amplifier performance with respect to frequency response, amplitude distortion, and phase shift. The square wave generator must produce a clean waveform with straight sides, sharp corners, and flat horizontal lines, as shown in Figure 3-4A.

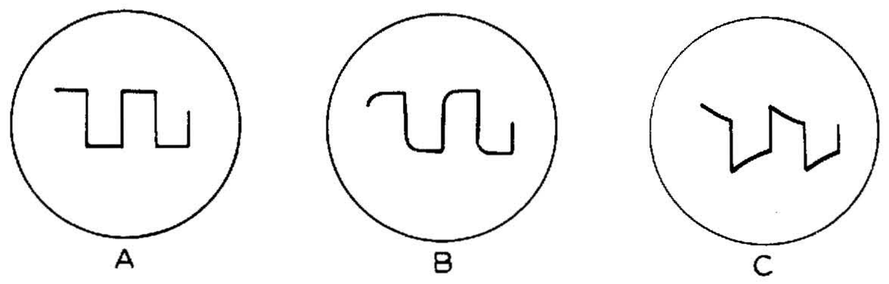



**Figure 3-4**

When a midfrequency square wave signal is fed into the input of an amplifier, its output waveform will be a faithfully reproduced sqaure wave if the frequency response of the amplifier is good and if there is little amplitude or phase distortion. The shape of the leading edge of an output waveform, as shown in Figure 3-4B, indicates poor high frequency response. This may be caused by amplitude distortion or phase shift, or both.

The slope of the flat portion of the waveform, as shown in Figure 3-4C, indicates poor low frequency response.

When making square wave tests of an amplifier, be sure the generator you use produces clean waveforms and has good voltage regulation.

## TELEVISION RECEIVER CIRCUITS

Another application of the cathode ray oscilloscope is the servicing of television receivers. There are two methods of using the oscilloscope in TV service work. One is the point-to-point probing to study components of a

transmitted television signal and their effect on receiver circuits. The other method uses the signal from a sweep generator and is used primarily for the alignment of a receiver. These two methods will be treated separately in the following paragraphs.

## Point-to-Point Signal Tracing

Most television manufacturers supply service information that shows correct oscilloscope patterns at various points in the receiver. These patterns are generally of the composite video signal or synchronizing signals that are received from a television transmitter, or generated within the receiver. Some of these patterns are shown in Figure 3-5, with the signal frequency indicated for each pattern. No special equipment is required for observing these patterns on your Oscilloscope, except a demodulator probe to detect modulation envelopes in the IF or RF amplifier sections.

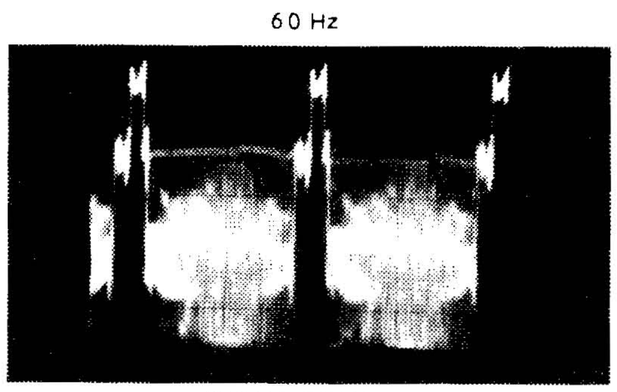



**Figure 3-5**

Figure 3-6 (in the Illustration Book) is a simplified block diagram of a typical receiver. It shows various stages and points for connection of the oscilloscope probe. The letters at each test point indicate the type of probe to use and the setting of the Oscilloscope's sweep frequency. These letters are defined in the following chart.

| PROBE | | SWEEP FREQUENCY | |
|---|---|---|---|
| R | Direct | H | 7,875 or 15,750 Hz |
| D | Demodulator | V | 20, 30, or 60 Hz |
| | | A | Audio test frequency |

NOTE: For simplicity, all amplifier stages are shown within one block in the diagram in Figure 3-6. Tests may be made at the input or output of individual amplifier stages using the indicated probe and sweep frequency.

At any point up to the video detector, the voltages will be quite small and considerable vertical gain will be required. Within the sync circuits and deflection circuits, however, these voltages are larger and very little amplification is required.

In checking the waveforms, remember that two basic frequencies are involved in the television signal. The vertical or field frequency is 60 Hz. Any investigation of the circuit except within the horizontal oscillator, its differentiator network, and the horizontal amplifier stages, can generally be made using a sweep frequency of 20 or 30 Hz; thus showing two or three complete fields of the signal. In order to study the horizontal pulse shape or the operation of the horizontal deflection system, it is generally necessary to operate the sweep generator at 15,750 or 7,875 Hz. This sweep rate will show the waveform of one or two complete lines of the signal.

The point-to-point signal tracing method of analysis is most helpful in troubleshooting a receiver, since faulty receiver operation is generally caused by the loss of all or a significant portion of the picture information and pulses at some stage within the receiver. With a basic understanding of the function of each part of the signal and with a knowledge of what the signal actually looks like at any part of the receiver, it is a comparatively simple matter to isolate the defective portion and the particular component causing the failure.

Since a phase shift of 180 degrees takes place in some circuits of a receiver, the pattern displayed on the Oscilloscope screen may be inverted in some cases. The pattern or form of the wave should not be changed however.

You can measure video amplifier response in exactly the same way you test an audio amplifier (see Page 59); and again, a square wave signal is the most efficient method to use. Because a video amplifier must pass signals as low as 20 Hz and as high as 4 or 5 megahertz, a more comprehensive test is required. Usually a 60 Hz check is made to cover low and medium frequency characteristics. A second check at 25 kHz covers the high frequency portion of the response curve. Again such tests require accuracy on the part of the Oscilloscope.

The signal tracing technique can be used in these tests also. The square wave generator is fed directly into the first video amplifier stage. Very low signal input will be required. Then, the Oscilloscope is connected to various stages, starting near the output end and working back until you isolate any distortion. Patterns such as Figure 3-4B (on Page 60) are responsible for poor picture detail or fuzziness, while distortion of the waveform shown in Figure 3-4C can cause shading of the picture from top to bottom.

## Receiver Alignment

Alignment of television RF and IF circuits requires the use of an alignment sweep generator as well as the oscilloscope. The sweep generator supplies an RF signal that sweeps across all the frequencies of a television channel or IF amplifier 60 times per second. The sweep generator also supplies the 60 Hz sweep voltage to the horizontal input of the oscilloscope. Figure 3-7 (in the Illustration Book) shows a typical setup for the alignment of a television receiver.

The exact procedure for alignment differs with various receivers and with different sweep generators. Manufacturer's service data usually includes alignment procedure and correct response waveforms.

Figure 3-8A shows a typical response curve for a properly aligned receiver.

Notice that the top part of the waveform is essentially flat, and tapers sharply at both ends. The waveform shown in Figure 3-8B might result if the IF stages of the receiver were aligned too sharply or all at the same frequency. This would produce a narrow bandwidth and seriously affect picture quality. A misalignment of one or more IF stages would produce a waveform like that shown in Figure 3-8C, which would also reduce picture quality.

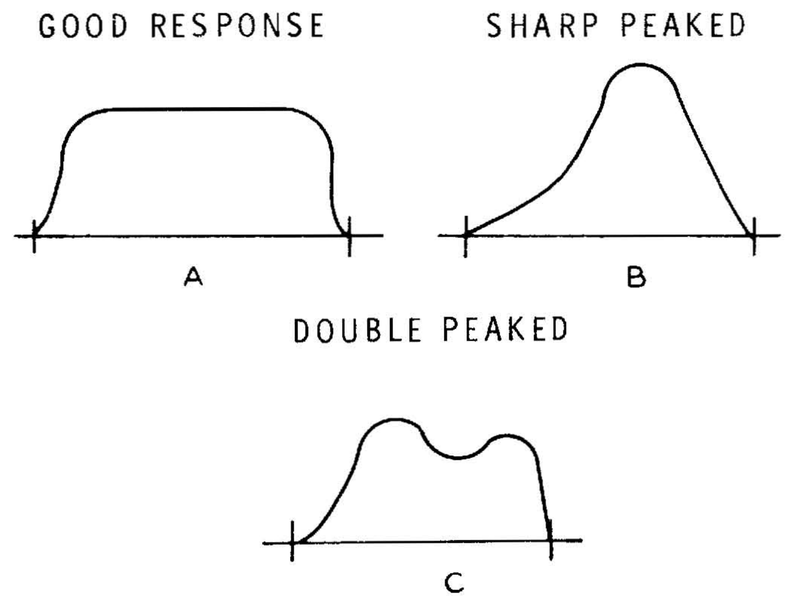



**Figure 3-8**

## AC VOLTAGE MEASUREMENTS

The oscilloscope is particulary suited for measuring AC voltages. In some television circuits it is imperative that AC voltage measurements be made accurately without respect to wave shape. Therefore, the conventional rms-indicating AC voltmeter is no longer adequate. Most television service bulletins specify peak-to-peak voltages which appear at various points in the circuit.

The Oscilloscope can be used to display and accurately measure these voltages. It can be easily calibrated for this purpose by using a known accurate external AC voltage source. Connect the Vertical Input lead to a reference voltage source (.1 VP-P for example). Adjust the Vertical GAIN control until the waveform on the screen reaches the height on one division line. Now, as long as the Vertical GAIN control remains unchanged, the pattern height of any vertical input signal up to .8 volts peak-to-peak can be read in relation to the .1 volt reference line on the graticule. By switching the VERTICAL attenuator switch to the X10 position, voltages up to 8.0 volts peak-to-peak can be measured. Switching the attenuator to the X100 position will change the sensitivity to 10.0 volts per centimeter.

The following relationships exist for sine wave AC voltages:

rms x 1.414 = Peak Voltage

rms x 2.828 = Peak-to-Peak Voltage.

Peak Voltage x 0.707 = rms Voltage

Peak-to-Peak Voltage x 0.3535 = rms Voltage.

## DC VOLTAGE MEASUREMENTS

Often it is important that a DC voltage be measured or that an AC signal be observed on a certain DC level. To check either of these conditions, connect the DC INPUT to GND. Then, with the VERTICAL position control, position the trace to the center division line on the screen. Turn the VERTICAL attenuator switch to the appropriate position and apply a known DC voltage to the vertical input. Adjust the Vertical GAIN control until the trace is at a convenient position on the screen. Then, when the Oscilloscope is connected to an unknown DC voltage, the trace will rise or drop to a position that is a function of the known voltage.

Example: If 9 volts DC was used to cause the trace to rise one division, then 18 volts will cause the trace to rise two divisions, and 4-1/2 volts will cause the trace to rise 1/2 division above the center line on the screen.

## FREQUENCY MEASUREMENTS

Frequency measurements can be made with an accuracy limited only by the reference source available. At times, this can be the 60 Hz line frequency which is usually controlled very closely. The unknown frequency is applied to the vertical input and the reference frequency to the horizontal input. The internal sweep generator is not used. The resultant pattern may take on any one of a number of shapes. Typical patterns are shown in Figure 3-9. These patterns are called Lissajous figures. They are obtained when sinusoidal AC voltages are applied simultaneously to the two sets of Oscilloscope deflection plates. The resultant pattern depends upon the relative amplitudes, frequencies, and phase of the two voltages.

The frequency ratio can be calculated from the formula:

$$fx = \frac{Th \times f}{Tv}$$

Where fx is the unknown frequency, Th is the number of loops which touch the horizontal tangent line, Tv is the number of loops which touch the vertical tangent line, and f is the known frequency.

When using Lissajous figures, it is good practice to have the figure rotating slowly rather than stationary. This eliminates the possibility of an error in counting the tangent points. If the pattern is stationary, a double image may be formed. In such cases, the end of the trace should be counted as one-half of a tangent point rather than a full point. This condition may occur when neither frequency can be varied.

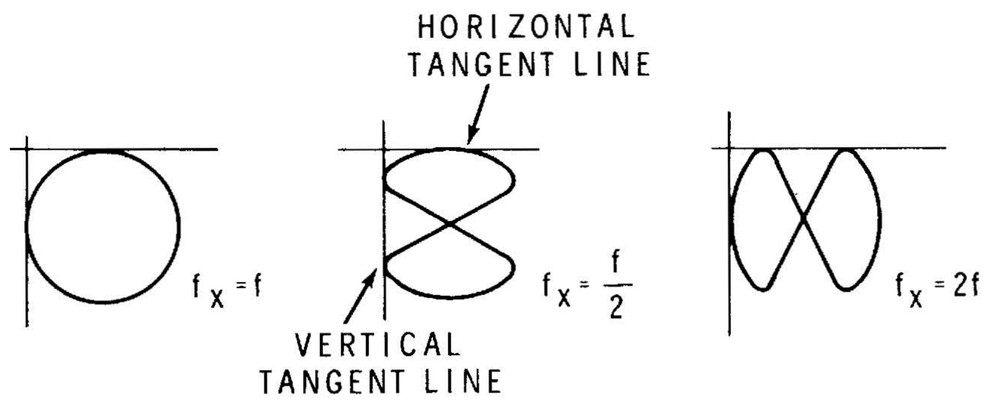



**Figure 3-9**

## PHASE MEASUREMENTS

It is sometimes necessary to determine the phase relationship between two AC voltages of the same frequency. You can do this by applying one of the voltages to the horizontal input and the other voltage to the vertical input. You can estimate the phase relationship from Figure 3-10 (in the Illustration Book).

NOTE: For proper displays the horizontal trace length must be set equal to the vertical trace height.

To calculate the phase relationship, use the following formula:

$$\text{Sin} = \frac{A}{B}$$

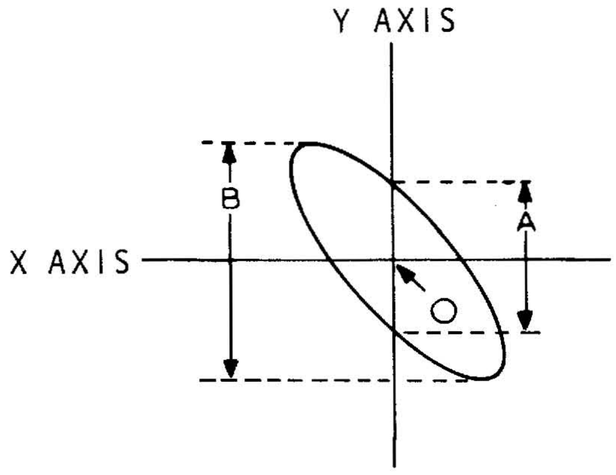



**Figure 3-11**

As shown in Figure 3-11, the distance A is measured from the X axis to the intercept point of the trace and the Y axis. The distance B represents the heights of the pattern above the X axis. The axis of the ellipse must pass through the point 0.

# IN CASE OF DIFFICULTY

This section of the Manual is divided into three parts. The first part, titled "General Troubleshooting Information," describes what to do about difficulties that may occur right after the kit is assembled.

The second part, titled "Finding the Area of Trouble," describes a method for locating trouble in differential amplifiers.

The third part, a "Troubleshooting Chart," is provided to assist in servicing if the general information does not clear up the problem, or if difficulties occur after the Instrument has been in operation for some time. This chart lists a number of possible difficulties that could arise, and lists several possible causes.

Before starting any troubleshooting procedure, try to narrow the problem down to a specific area by trying the various functions of the Instrument.

## GENERAL TROUBLESHOOTING INFORMATION

The following paragraphs deal with the types of difficulties that may show up right after a kit is assembled. These difficulties are most likely to be caused by assembly errors or faulty soldering. These checks will help you locate any error of this type that might have been made.

1. Recheck the wiring. Trace each 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 constructor.

2. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the "Soldering" section of the "Kit Builders Guide."

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

4. Check the values of the parts. Be sure that the proper part has been wired into the circuit as shown in the pictorial diagrams and called out in the wiring instructions.

5. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring. Check for solder bridges between circuit board foils. Compare your foil pattern against the "X-Ray View" on Page 71.

## FINDING THE AREA OF TROUBLE

A review of the "Circuit Description" and "Block Diagram" will prove helpful in locating the trouble.

If after careful checks, the trouble is still not located and a voltmeter is available, check the voltage readings against those shown on the Schematic Diagram. NOTE: All voltage readings were taken with an 11 megohm input voltmeter. Voltages may vary as much as ±20%.

Because most of the circuits are DC coupled, it is almost impossible to list troubles in a "cause and effect" type of chart. For example, a saturated transistor on one side of a differential amplifier may appear as a trouble on the other side. However, a "Troubleshooting Chart" is provided to help you isolate the problem to a particular area of the Oscilloscope.

Since the Position controls are at the front of each differential amplifier and affect each succeeding stage, they serve as troubleshooting aids. When you are troubleshooting the vertical amplifier, for instance, first check the associated power supply voltages. Then check the collector voltage of transistors Q106 and Q107. These voltages should vary as the Vertical position control is turned. If these voltages change accordingly, the trouble may be in the CRT circuit. If the voltages do not change, the problem is in either Q106 or Q107, or the preceding stages. Move the voltmeter to the preceding state (Q104 and Q105) and repeat the procedure until you locate the trouble.

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

# Troubleshooting Chart

| Difficulty | Possible Area of Trouble |
|---|---|
| Neither pilot lamp nor CRT filament lights. | 1. Fuse blown.<br>2. On-Off switch.<br>3. No AC power from outlet. |
| Pilot lamp lights, CRT filament does not light. | 1. Power transformer.<br>2. CRT. |
| No spot or trace on CRT. | 1. Positioning or intensity controls improperly adjusted.<br>2. High voltage power supply.<br>3. CRT. |
| Dot cannot be centered vertically. | 1. Vertical Position control and associated circuit. |
| Dot cannot be centered horizontally. | 1. Horizontal Position control and associated circuit. |
| No vertical deflection. | 1. Vertical amplifier. |
| No horizontal deflection. | 1. Horizontal amplifier. |
| Poor focus. | 1. CRT.<br>2. Focus control.<br>3. Astigmatism (voltage divider R1, R2).<br>4. Resistors R7, R6, R5, and R4.<br>5. Protective covering on graticule not removed. |
| Trace acts erratic when the window is touched. | 1. Clean the window with detergent to eliminate static charge. |
| Cannot synchronize input signal with sweep generator frequency. | 1. Control R304 misadjusted. |
| No triggering or sweep. | 1. Refer to Tests #1 and #2 in the Illustration Booklet. |
| No retrace blanking or poor retrace blanking. | 1. Transistor Q352.<br>2. Diode ZD353. |
| Pilot lamp changes intensity from bright to dim. | 1. This is normal. |

# SPECIFICATIONS

## VERTICAL CHANNEL

| | |
|---|---|
| Input Impedance | 1 megohm. |
| Sensitivity | 100 mv/centimeter. |
| Maximum Input Voltage | 400 volts DC. |
| Frequency Response | DC to 5 MHz ±3 dB. |
| Attenuator | X1, X10, X100, AC or DC. |

## HORIZONTAL CHANNEL

| | |
|---|---|
| Input Impedance | 100 kΩ. |
| Sensitivity | 0.25 volt/cm (uncalibrated). |
| Frequency Response | DC to 100 kHz. |

## TIME BASE

| | |
|---|---|
| Sweep | 20 ms to 200 ns/cm (uncalibrated). |
| Trigger Mode | Automatic. |

## GENERAL

| | |
|---|---|
| CRT | 5 DEP 31, 8X10 cm viewing area.<br>Blue-green, medium persistance phosphor. |
| Graticule | 8X10 cm. |
| Power Requirements | 110-130 or 220-260 VAC.<br>50/60 Hz 35 watts. |
| Overall Dimensions | 12-7/8" wide x 8-7/16" high x 17-3/4" long. |
| Net Weight | 13 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 and the Block Diagram (in the Illustration Book) while you read this Circuit Description.

## VERTICAL AMPLIFIER

A signal to a VERT IN (Vertical Input) connector is coupled through the frequency compensated attenuator network. Capacitor C101 blocks any DC voltage when the AC input is used. From the attenuator circuit, a portion of the input signal is coupled through resistor R104 and capacitor C105 to the gate of transistor Q101. Resistor R104 protects Q101 from being damaged in case a high potential is applied to the VERT IN connector. Diodes ZD102 are transistors connected to provide a zener action. These diodes limit the input voltage to approximately ±9 volts, which further protect Q101 from excess gate voltage. Capacitor C105 improves high frequency response by forming a high frequency path around R104.

Transistor Q101 is a field-effect transistor (FET) connected as a source follower to provide the high impedance input necessary to prevent loading the attenuator.

Transistor Q102 is a constant current source for input transistor Q101. Resistors R107 and R108 hold the base of Q102 at constant voltage. Since the emitter voltage is dependent upon the base voltage, the emitter voltage will also remain constant. This constant emitter voltage is across emitter resistors R105 and R125; therefore, the current through R105 and R125 is constant. Resistor R125 is adjusted so the source voltage of Q101 is zero when the input is shorted.

A signal applied to the gate of Q101 will cause voltage changes at the source because the current through Q101 is constant. These voltage variations are applied to the base of transistor Q104.

Transistor Q103 forms a constant current source for transistors Q104 and Q105. Since the emitters of both transistors are connected to this constant current source, the current source serves as a common emitter resistance and sets the operating point for the following stages.

The output from source follower transistor Q101 is amplified by Q104. A portion of the signal applied to the base of Q104 appears at its emitter. Because transistors Q104 and Q105 have a common emitter resistance, the signal present at the emitter of Q104 is effectively coupled to the emitter of Q105.

The base of transistor Q105 is held constant by resistors R124, R126, and control 106. When the collector output voltage of Q104 decreases, its emitter voltage will increase. An increased emitter voltage at Q105 reduces its forward bias and increases its collector output voltage. The signal at the collector of transistor Q105 is 180 degrees out of phase with the signal at the collector of Q104, forming a "push-pull" type of amplifier required to drive the CRT deflection plates. Emitter resistors R114 and R115 and collector resistors R113 and R116 establish the DC gain of the vertical amplifier.

Output amplifiers Q106 and Q107 again amplify the differential signal and drive the vertical plates of the CRT. Capacitor C106 improves the high frequency response.

## SWEEP AND TRIGGER CIRCUITS

Internal triggering is accomplished by coupling a signal from the vertical amplifier, through capacitor C301, to the trigger amplifier circuit. The trigger amplifier circuit consists of FET follower Q301, current source Q302, and transistors Q303 and Q304. The Level Set control, R304 adjusts the DC level at the emitter of Q304 to give optimum trigger sensitivity.

The signal from the emitter of transistor Q304 is direct coupled to IC301C, which generates a pulse that is fed to IC303. This pulse causes the output pins (pins 6 and 8) of IC303 to change state. The pulse from pin 6 drives the blanking circuit. The pulse from pin 8 is inverted by IC301D and applied to the sweep latch transistor, Q305. This pulse causes Q305 to turn off, allowing the sweep generator to generate a ramp (sawtooth) voltage.

The sweep circuit consists of current source Q351, timing capacitors C351 and/or C352, and timing resistors R353, R349, R352, and R351 form a voltage divider to provide bias for Q351.

The ramp voltage from Q351 is monitored by IC304 through transistors Q306 and Q307. When the ramp voltage reaches approximately 1.2 volts, IC304 generates a pulse whose duration is determined by capacitor C354 or C355 and resistor R313. This pulse is applied to pin 2 of IC303, causes the outputs of IC303 to change state, turning on Q305, shorting out the sweep generator. Simultaneously, pin 6 of IC303 goes high and Q352 is turned on. This applies a negative pulse through C357 to the grid of the CRT, thus blanking the tube. As soon as the pulse from IC304 is ended, IC303 is in a set condition to "trip" on the next pulse from IC301C or from the auto base line generator, IC302.

Pulses are applied to IC302 at the same time they are applied to IC303. As long as pulses are received by IC302, its output will stay low. When pulses are no longer received by IC302, its output will "time out" and go high. The "time out" is determined by resistor R308 and capacitor C302. This pulse is inverted by IC301A and applied to pin 13 of IC303, which presets IC303 and causes its output to change state the same as if a pulse had been applied to pin 12 of IC303.

IC301B is used as an anti-latch-up monitor. If IC303 or IC304 misses the end of the sweep pulse, the ramp voltage will go to maximum and "trip" IC301B. The pulse generated by IC301B will clear IC303 and reset the trigger circuit so they will assume normal operation.

## HORIZONTAL AMPLIFIER

Operation of the horizontal amplifier is similar to that of the vertical amplifier. The positive-going ramp voltage (sawtooth) from the sweep generator is amplified and applied to the horizontal plates of the CRT. The increasing voltage causes the electron beam to sweep across the face of the CRT producing a visible trace.

### Power Supply

Line voltage is connected through the slow-blow fuse and the On-Off switch to the primary windings of power transformers T1 and T2. The dual-primary transformer windings may be connected in parallel for 120-volt operation or in series for 240-volt operation.

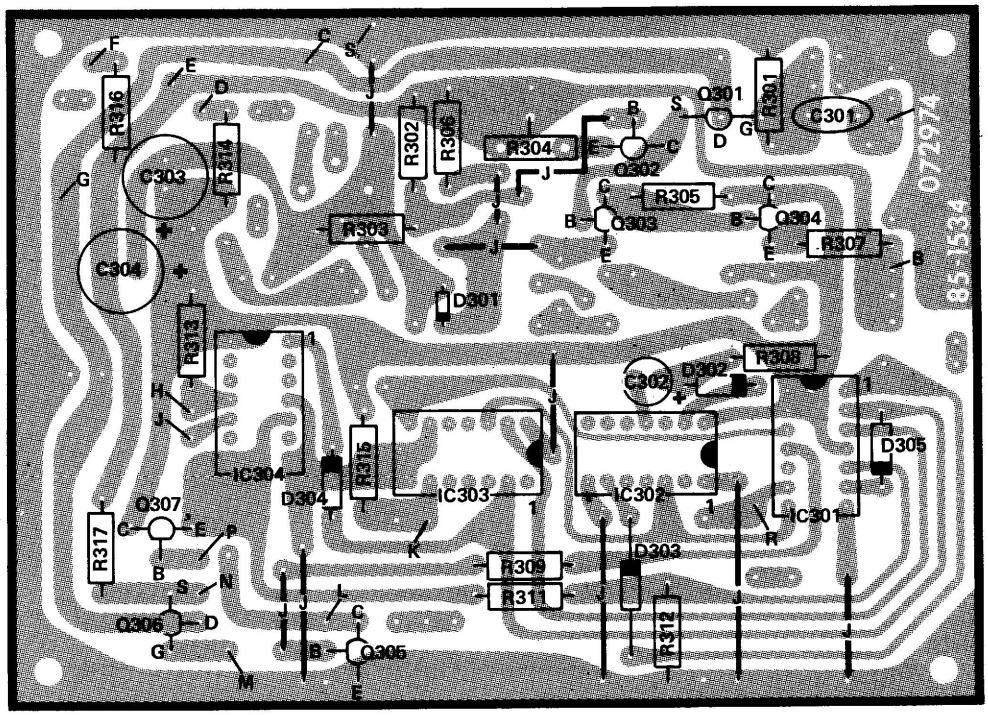
A high voltage secondary winding of the power transformer is connected to the voltage doubler circuit consisting of D1, D2, C2, and C3. Resistors R8, R9, and capacitor C1 filter this negative high voltage, which is fed through resistor R3 to the grid of the CRT. The intensity and focusing voltages are also supplied to the CRT from the voltage divider network consisting of resistors R4, R5, R6, and R7. A separate 6.3-volt winding supplied the CRT filament voltage.

Optimum focus is obtained when the CRT deflection plates and the astigmatism grid are at the same potential. Since the vertical deflection plate voltages (collectors of Q106 and Q107) are adjusted to 80 volts DC by constant current source Q103, the astigmatism voltage is also approximately 80 volts DC.

A low-voltage secondary winding is connected to the full-wave bridge rectifier circuit consisting of diodes D11, D12, D13, and D14 and capacitor C9. By connecting equal loads from each side of the supply to ground, three separate supplies are obtained: +9 volts DC, –9 volts DC, and +5 volts DC.

Another secondary winding is connected to the full-wave rectifier circuit consisting of diodes D3, D4, D5, and D6 and capacitor C4A. Resistor R12 and capacitor C4B form the 180-volt DC supply circuit and resistor R13 and capacitor C4C form the 150-volt DC supply circuit.

# CIRCUIT BOARD X-RAY VIEW



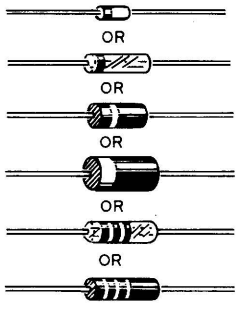

(Shown from foil side)

# SEMICONDUCTOR IDENTIFICATION CHARTS

## DIODES

| HEATH PART NUMBER | MAY BE REPLACED WITH | CIRCUIT COMPONENT NUMBER |
|---|---|---|
| 56-16 | 1N751 | ZD8 |
| 56-19 | VR9.1 | ZD7, ZD9 |
| 56-602 | GERMANIUM 200mA 10V | D302, D303, D304 |
| 56-56 | 1N4149 | D301, D305 |
| 56-68 | ZVR68 | ZD357 |
| 57-27 | 1N2071 | D3, D4, D5, D6, D11, D12, D13, D14 |
| 57-52 | 5D20 | D1, D2 |

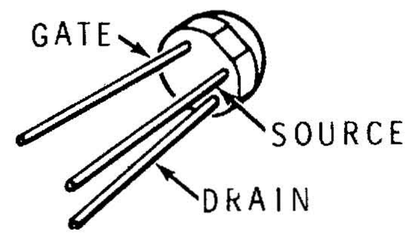
NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.



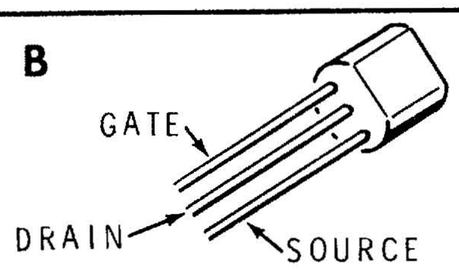
# TRANSISTORS

| HEATH PART NUMBER | MAY BE REPLACED WITH | CIRCUIT COMPONENT NUMBER | BASING DIAGRAM |
|---|---|---|---|
| 417-140 | 2N4304 | Q101, Q301 | A, B, C |
| 417-201 | X29A829 | Q351 | F |
| 417-241 | EL131 | Q306 | D |
| 417-293 | 2N5770 | Q104, Q105, Q205, Q206 | E |
| 417-294 | MPSA42 | Q352 | E |
| 417-801 | MPSA20 | Q102, Q103, Q201, Q202, Q203, Q204, Q302, Q303, Q304, Q305, Q307, ZD101, ZD102, ZD351, ZD352, | E |
| 417-834 | MPSU10 | Q106, Q107 | G |

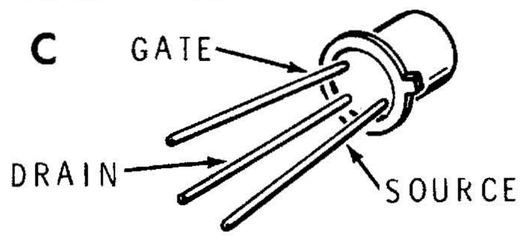
**A**



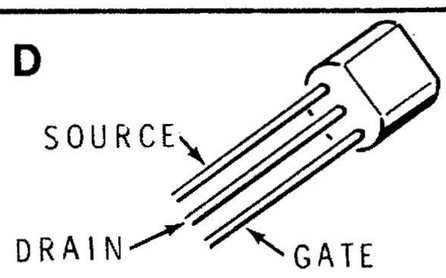

**B**



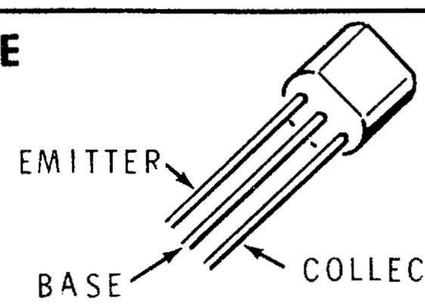

**C**



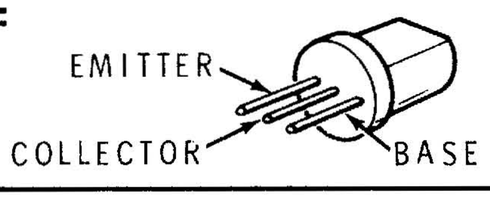

**D**



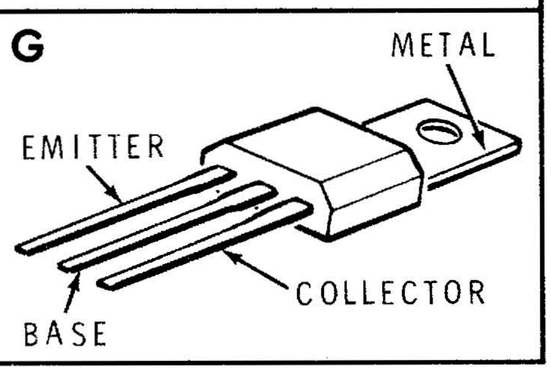

**E**



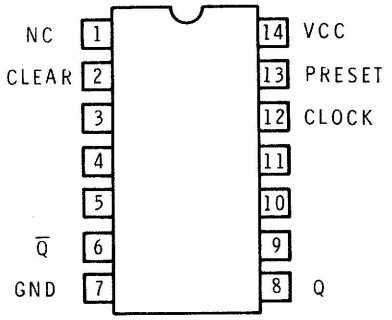
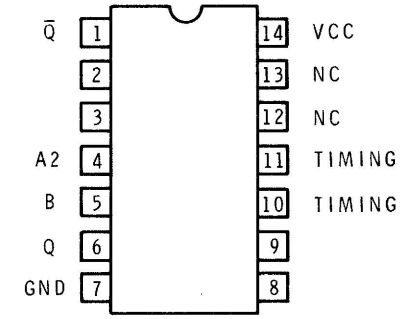
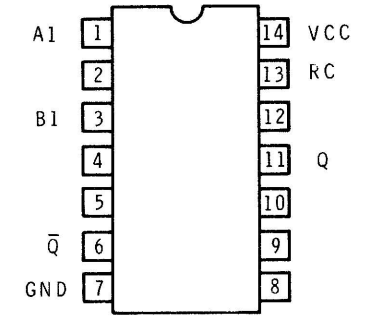
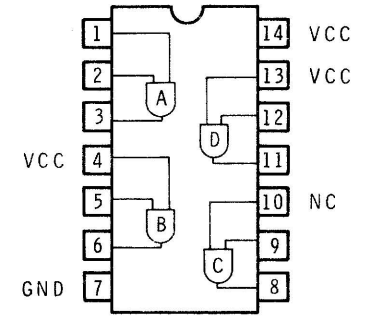

**F**




**G**



# INTEGRATED CIRCUITS

| HEATH PART NUMBER | MAY BE REPLACED WITH | CIRCUIT COMPONENT NUMBER | TOP VIEWS |
|---|---|---|---|
| 443-4 | SN7472 | IC303 |   |
| 443-22 | SN74121 | IC304 |   |
| 443-23 | SN74122 | IC302 |   |
| 443-625 | 74132 | IC301 |   |

## FOR PARTS REQUESTS ONLY

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

**DO NOT WRITE IN THIS SPACE**

## INSTRUCTIONS

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

  Total enclosed $
- If you prefer COD shipment, check the COD box and mail this card. COD ☐

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

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

Model # _____ Invoice # _____

Date Purchased _____ Location Purchased _____

| LIST **HEATH** PART NUMBER | QTY. | PRICE EACH | TOTAL PRICE |
|---|---|---|---|
| | | | |
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| | | | |
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| | | | |
| TOTAL FOR PARTS | | | |
| HANDLING AND SHIPPING | | | |
| MICHIGAN RESIDENTS ADD 4% TAX | | | |
| **TOTAL AMOUNT OF ORDER** | | | |

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

Phone (Replacement parts only): 616 982-3571

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## FOR PARTS REQUESTS ONLY

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| LIST **HEATH** PART NUMBER | QTY. | PRICE EACH | TOTAL PRICE |
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# CUSTOMER SERVICE

## REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

### ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

**Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.**

### OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

## TECHNICAL CONSULTATION

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

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

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

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

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

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

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

## REPAIR SERVICE

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

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

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

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

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

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

Heath Company
Service Department
Benton Harbor, Michigan 49022

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# SCHEMATIC OF THE HEATHKIT®
# 5MHz OSCILLOSCOPE MODEL IO-4560

NOTES:

1. ALL RESISTORS ARE 1/2-WATT UNLESS SPECIFIED OTHERWISE.
2. ALL CAPACITORS LESS THAN 1 ARE IN µF. ALL CAPACITORS GREATER THAN 1 ARE IN pF UNLESS MARKED OTHERWISE.
3. ▽ DENOTES A DC VOLTAGE FROM THAT POINT TO GROUND.
4. ⏚ DENOTES CHASSIS GROUND.
5. ▽ DENOTES A CIRCUIT BOARD GROUND.
6. ⬭ DENOTES A DC VOLTAGE BETWEEN THE POINT INDICATED AND CHASSIS GROUND. ALL VOLTAGES WERE MEASURED WITH A HIGH IMPEDANCE INPUT VOLTMETER WITH THE HORIZ SWITCH ON EXT AND THE DOT CENTERED ON THE CRT.
7. CIRCUIT COMPONENT NUMBERS HAVE BEEN PLACED IN THE FOLLOWING GROUPS:

   1- 99 POWER SUPPLY CIRCUITS
   101-199 VERTICAL AMPLIFIER CIRCUITS
   201-299 HORIZONTAL AMPLIFIER CIRCUITS
   301-339 CIRCUIT BOARD SWEEP / TRIGGER CIRCUITS
   341-399 CHASSIS SWEEP / TRIGGER CIRCUITS

VERTICAL AMPLIFIER

SWEEP / TRIGGER CIRCUIT BOARD

HORIZONTAL AMPLIFIER

5DEP31F CRT

POWER TRANSFORMER SHIELD ASSEMBLY