

# HEATHKIT<sup>®</sup> MANUAL

*for the*

## 5 MEGAHERTZ OSCILLOSCOPE

Model IO-4105

595-2074-03



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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Home Clocks ..... (616) 982-3315  
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## YOUR HEATHKIT 90-DAY LIMITED WARRANTY

### Consumer Protection Plan for Heathkit Consumer Products

Welcome to the Heath family. We believe you will enjoy assembling your kit and will be pleased with its performance. Please read this Consumer Protection Plan carefully. It is a "LIMITED WARRANTY" as defined in the U.S. Consumer Product Warranty and Federal Trade Commission Improvement Act. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

#### Heath's Responsibility

**PARTS** — Replacements for factory defective parts will be supplied free for 90 days from date of purchase. Replacement parts are warranted for the remaining portion of the original warranty period. You can obtain warranty parts direct from Heath Company by writing or telephoning us at (616) 982-3571. And we will pay shipping charges to get those parts to you . . . anywhere in the world.

**SERVICE LABOR** — For a period of 90 days from the date of purchase, any malfunction caused by defective parts or error in design will be corrected at no charge to you. You must deliver the unit at your expense to the Heath factory, any Heathkit Electronic Center (units of Veritechnology Electronics Corporation), or any of our authorized overseas distributors.

**TECHNICAL CONSULTATION** — 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.

**NOT COVERED** — The correction of assembly errors, adjustments, calibration, and damage due to misuse, abuse, or negligence are not covered by the warranty. Use of corrosive solder and/or the unauthorized modification of the product or of any furnished component will void this warranty in its entirety. This warranty does not include reimbursement for inconvenience, loss of use, customer assembly, set-up time, or unauthorized service.

This warranty covers only Heath products and is not extended to other equipment or components that a customer uses in conjunction with our products.

SUCH REPAIR AND REPLACEMENT SHALL BE THE SOLE REMEDY OF THE CUSTOMER AND THERE SHALL BE NO LIABILITY ON THE PART OF HEATH FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO ANY LOSS OF BUSINESS OR PROFITS, WHETHER OR NOT FORSEEABLE.

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.

#### Owner's Responsibility

**EFFECTIVE WARRANTY DATE** — Warranty begins on the date of first consumer purchase. You must supply a copy of your proof of purchase when you request warranty service or parts.

**ASSEMBLY** — Before seeking warranty service, you should complete the assembly by carefully following the manual instructions. Heathkit service agencies cannot complete assembly and adjustments that are customer's responsibility.

**ACCESSORY EQUIPMENT** — Performance malfunctions involving other non-Heath accessory equipment, (antennas, audio components, computer peripherals and software, etc.) are not covered by this warranty and are the owner's responsibility.

**SHIPPING UNITS** — Follow the packing instructions published in the assembly manuals. Damage due to inadequate packing cannot be repaired under warranty.

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

# Heathkit<sup>®</sup> Manual

*for the*

## **5 MEGAHERTZ OSCILLOSCOPE**

Model IO-4105

595-2074-03

### **WARNING**

**Do not expose this  
oscilloscope  
to rain or moisture.**

**HEATH COMPANY**  
BENTON HARBOR, MICHIGAN 49022

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## TABLE OF CONTENTS

|                             |    |   |                                   |
|-----------------------------|----|---|-----------------------------------|
| INTRODUCTION .....          | 3  | OPERATION .....                             | 79                                |
| UNPACKING .....             | 4  | IN CASE OF DIFFICULTY .....                 | 86                                |
| ASSEMBLY NOTES .....        | 5  | General Troubleshooting Information .....   | 86                                |
| VERTICAL CIRCUIT BOARD      |    | Troubleshooting Precautions and Notes ..... | 87                                |
| Parts List .....            | 8  | Troubleshooting Charts .....                | 88                                |
| Step-by-Step Assembly ..... | 11 | Trouble Locator Chart .....                 | 89                                |
| HORIZONTAL CIRCUIT BOARD    |    | Checking Components .....                   | 90                                |
| Parts List .....            | 24 | SPECIFICATIONS .....                        | 95                                |
| Step-by-Step Assembly ..... | 27 | THEORY OF OPERATION .....                   | 97                                |
| POWER SUPPLY CIRCUIT BOARD  |    | CIRCUIT DESCRIPTION .....                   | 98                                |
| Parts List .....            | 40 | SEMICONDUCTOR IDENTIFICATION                |                                   |
| Step-by-Step Assembly ..... | 42 | CHART .....                                 | 104                               |
| CHASSIS                     |    | CIRCUIT BOARD X-RAY                         |                                   |
| Parts List .....            | 49 | VIEWS .....                                 | Illustration Booklet, Pages 34-36 |
| Step-by-Step Assembly ..... | 51 | SCHEMATIC DIAGRAM .....                     | (Fold-in)                         |
| INITIAL TESTS .....         | 71 | WARRANTY .....                              | Inside front cover                |
| CALIBRATION .....           | 73 | CUSTOMER SERVICE .....                      | Inside rear cover                 |
| FINAL ASSEMBLY .....        | 78 |   |                                   |



## INTRODUCTION

The Heathkit Model IO-4105, 5 MHz Oscilloscope is a compact, versatile, easy-to-build, electronic instrument that you can use to study the waveforms in electronic circuits. You can also use it to measure frequency, and AC or DC voltages. The DC to 5 MHz bandwidth and the excellent input sensitivity of the vertical amplifier allows you to use this Oscilloscope for nearly all types of waveform applications. The triggered horizontal sweep circuit and the many other outstanding features provide accuracy and capabilities that are usually found only in higher priced oscilloscopes.

Among the many other features this Oscilloscope offers are:

- A special TV position on the trigger selector. This allows low frequencies to pass while rejecting high frequencies, thus making it

easier to trigger on the vertical frequency of a TV set.

- A 10 to 1 attenuation circuit that can be used for signals applied to the external, horizontal input jack.
- Calibrated vertical attenuator with variable control.
- A calibrated time base (seven time base selections, variable within each selection).
- Regulated power supplies for the vertical, horizontal, and sweep circuits.

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

# UNPACKING

Inside the shipping carton is the box stamped PACK 1 which contained this Assembly Manual. With this box removed from the shipping carton, you will find bags stamped PACK 2 through PACK 4. The Manual will refer to these as "packs." You will be directed to open each of these "packs" as it is needed. All other parts in the shipping carton will be considered the "final pack." Caution: Do not remove any parts from their bags or the "final pack" until they are specifically called for in a Parts List in the Manual.

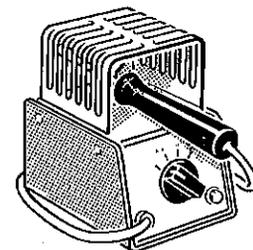
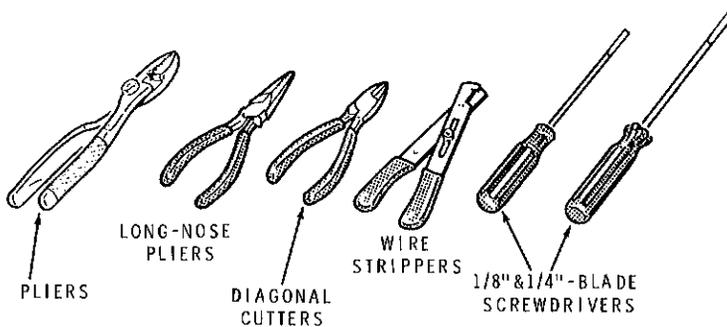
Each assembly section of the Manual contains its own "Parts List" and "Step-by-Step Assembly" instructions. At the beginning of each "Parts List," you will be instructed to open one of the packs. You will also be directed, in some Parts Lists, to remove certain parts from the final pack.



# ASSEMBLY NOTES

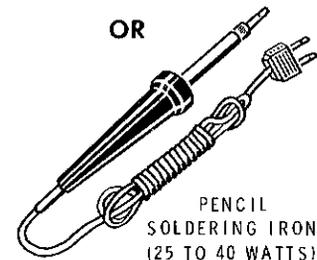
## TOOLS

You will need these tools to assemble your kit.



HEATHKIT  
SOLDERING  
IRON

OR

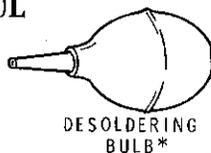


PENCIL  
SOLDERING IRON  
(25 TO 40 WATTS)

### OTHER HELPFUL TOOLS



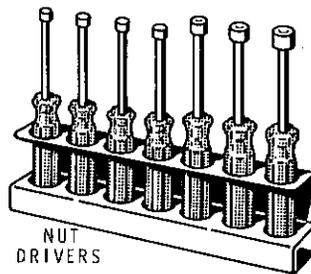
NUT STARTER  
(MAY BE SUPPLIED  
WITH KIT)



DESOLDERING  
BULB\*



DESOLDERING  
BRAID\*



NUT  
DRIVERS

\*TO REMOVE SOLDER FROM CIRCUIT CONNECTIONS.

## ASSEMBLY

1. Follow the instructions carefully. Read the entire step before you perform each operation.
2. The illustrations in the Manual are called Pictorials and Details. Pictorials show the overall operation for a group of assembly steps; Details generally illustrate a single step. When you are directed to refer to a certain Pictorial "for the following steps," continue using that Pictorial until you are referred to another Pictorial for another group of steps.
3. Most kits use a separate "Illustration Booklet" that contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. Keep the "Illustration Booklet" with the Assembly Manual. The illustrations in it are arranged in Pictorial number sequence.
4. Position all parts as shown in the Pictorials.
5. Solder a part or a group of parts only when you are instructed to do so.

6. Each circuit part in an electronic kit has its own component number (R2, C4, etc.). Use these numbers when you want to identify the same part in the various sections of the Manual. These numbers, which are especially useful if a part has to be replaced, appear:
- In the Parts List,
  - At the beginning of each step where a component is installed,
  - In some illustrations,
  - In the Schematic,
  - In the section at the rear of the Manual.
7. When you are instructed to cut something to a particular length, use the scales (rulers) provided at the bottom of the Manual pages.

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

## SOLDERING

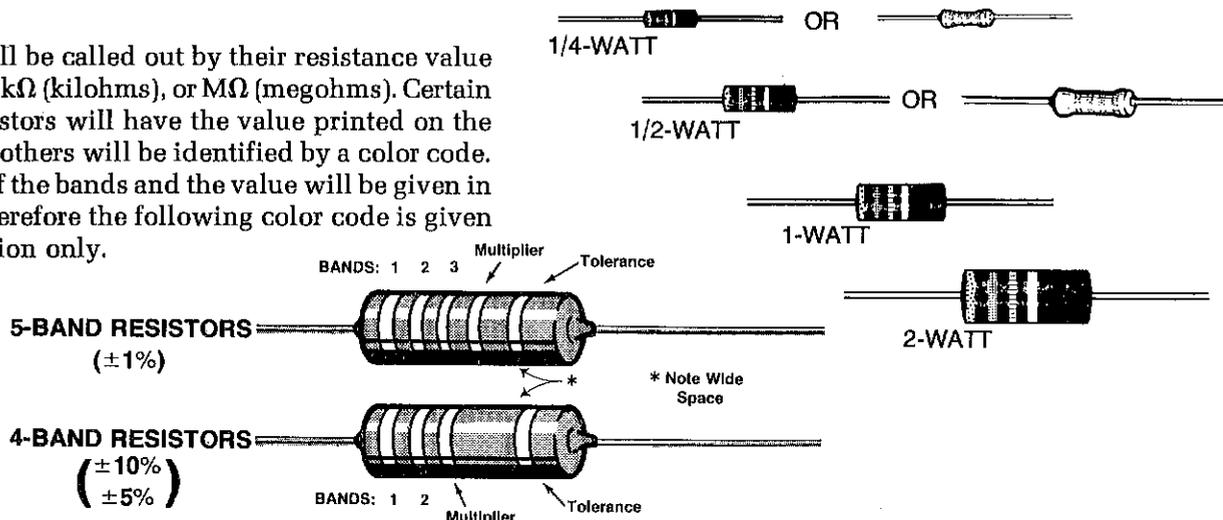
Soldering is one of the most important operations you will perform while assembling your kit. A good solder connection will form an electrical connection between two parts, such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well-assembled kit from operating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

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

1. Use the right type of soldering iron. A 25 to 40-watt pencil soldering iron with a 1/8" or 3/16" chisel or pyramid tip works best.
2. Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned.

## PARTS

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



| Band 1<br>1st Digit |       | Band 2<br>2nd Digit |       | Band 3 (if used)<br>3rd Digit |       | Multiplier |            | Resistance<br>Tolerance |           |
|---------------------|-------|---------------------|-------|-------------------------------|-------|------------|------------|-------------------------|-----------|
| Color               | Digit | Color               | Digit | Color                         | Digit | Color      | Multiplier | Color                   | Tolerance |
| Black               | 0     | Black               | 0     | Black                         | 0     | Black      | 1          | Silver                  | ±10%      |
| Brown               | 1     | Brown               | 1     | Brown                         | 1     | Brown      | 10         | Gold                    | ±5%       |
| Red                 | 2     | Red                 | 2     | Red                           | 2     | Red        | 100        | Brown                   | ±1%       |
| Orange              | 3     | Orange              | 3     | Orange                        | 3     | Orange     | 1,000      |                         |           |
| Yellow              | 4     | Yellow              | 4     | Yellow                        | 4     | Yellow     | 10,000     |                         |           |
| Green               | 5     | Green               | 5     | Green                         | 5     | Green      | 100,000    |                         |           |
| Blue                | 6     | Blue                | 6     | Blue                          | 6     | Blue       | 1,000,000  |                         |           |
| Violet              | 7     | Violet              | 7     | Violet                        | 7     | Silver     | 0.01       |                         |           |
| Gray                | 8     | Gray                | 8     | Gray                          | 8     | Gold       | 0.1        |                         |           |
| White               | 9     | White               | 9     | White                         | 9     |            |            |                         |           |

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

### EXAMPLES:

$$151K = 15 \times 10 = 150 \text{ pF}$$

$$759 = 75 \times 0.1 = 7.5 \text{ pF}$$

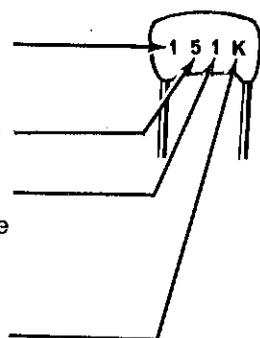
NOTE: The letter "R" may be used at times to signify a decimal point: as in: 2R2 = 2.2 ( $pF$  or  $\mu F$ ).

First digit of capacitor's value: 1

Second digit of capacitor's value: 5

Multiplier: Multiply the first & second digits by the proper value from the Multiplier Chart.

To find the tolerance of the capacitor, look up this letter in the Tolerance columns.



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

\*DuPont Registered Trademark

# VERTICAL CIRCUIT BOARD

## PARTS LIST

Remove the parts from the pack marked #1. Check each part against the following list. The key numbers correspond to the numbers on the Vertical Circuit Board Parts Pictorial (Illustration Booklet, Page 1). Any part that is in an individual envelope with the part number on it should be placed back into the envelope after you identify it until it is called for in a step. Do not discard any packing materials until all parts are accounted for.

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

To order a replacement part, always include the PART NUMBER. Use the Parts Order Form furnished with the kit. If one is not available, see "Replacement Parts" inside the rear cover. For prices, refer to the separate "Heath Parts Price List."

| KEY No.  | HEATH Part No. | QTY. | DESCRIPTION                 | CIRCUIT Comp. No.  | KEY No.                    | HEATH Part No. | QTY. | DESCRIPTION                 | CIRCUIT Comp. No.        |
|--|----------------|------|-----------------------------|--|----------------------------|----------------|------|-----------------------------|--------------------------|
| <b>RESISTORS</b>   |                |      |                             |  | <b>Resistors (Cont'd.)</b> |                |      |                             |                          |
| All resistors are 5% (fourth band gold) unless designated 10% (fourth band silver).  |                |      |                             |  |                            |                |      |                             |                          |
| NOTE: The resistors may be packed in more than one envelope (stamped RES). Open all the resistor envelopes in this pack before you check the resistors against the Parts List. |                |      |                             |  |                            |                |      |                             |                          |
| <b>1/2-Watt</b>  |                |      |                             |  |                            |                |      |                             |                          |
| A1   | 6-159          | 1    | 1.5 $\Omega$ (brn-grn-gld)  | R105 ✓   | A1                         | 6-330          | 2    | 33 $\Omega$ (org-org-blk)   | R2, R106 ✓               |
| A1   | 6-279          | 2    | 2.7 $\Omega$ (red-viol-gld) | R179, R181 ✓   | A1                         | 6-390          | 1    | 39 $\Omega$ (org-wht-blk)   | R151 ✓                   |
| A1   | 6-100          | 12   | 10 $\Omega$ (brn-blk-blk)   | R124, R131, R142, R145, R157, R158, R159, R164, R166, R168, R174, R175, R147, R148 ✓ | A1                         | 6-470          | 1    | 47 $\Omega$ (yel-viol-blk)  | R134 ✓                   |
| A1   | 6-220          | 2    | 22 $\Omega$ (red-red-blk)   |  | A1                         | 6-820          | 1    | 82 $\Omega$ (gry-red-blk)   | R144 ✓                   |
|  |                |      |                             |  | A1                         | 6-101          | 4    | 100 $\Omega$ (brn-blk-brn)  | R161, R162, R171, R172 ✓ |
|  |                |      |                             |  | A1                         | 6-201          | 1    | 200 $\Omega$ (red-blk-brn)  | R117 ✓                   |
|  |                |      |                             |  | A1                         | 6-221          | 3    | 220 $\Omega$ (red-red-brn)  | R111, R113, R114 ✓       |
|  |                |      |                             |  | A1                         | 6-271          | 1    | 270 $\Omega$ (red-viol-brn) | R108 ✓                   |
|  |                |      |                             |  | A1                         | 6-331          | 1    | 330 $\Omega$ (org-org-brn)  | R116 ✓                   |
|  |                |      |                             |  | A1                         | 6-391          | 3    | 390 $\Omega$ (org-wht-brn)  | R135, R139, R153 ✓       |
|  |                |      |                             |  | A1                         | 6-471          | 1    | 470 $\Omega$ (yel-viol-brn) | R136 ✓                   |
|  |                |      |                             |  | A1                         | 6-511          | 1    | 510 $\Omega$ (grn-brn-brn)  | R115 ✓                   |
|  |                |      |                             |  | A1                         | 6-751          | 1    | 750 $\Omega$ (viol-grn-brn) | R163 ✓                   |

| KEY No.                   | HEATH Part No. | QTY. | DESCRIPTION           | CIRCUIT Comp. No.                                |
|---------------------------|----------------|------|-----------------------|--|
| <b>Resistors (Contd.)</b> |                |      |                       |  |
| A1                        | 6-102          | 8    | 1000 Ω (brn-blk-red)  | R104, R133, R141, R146, R149, R156, R165, R167 ✓ |
| A1                        | 6-122          | 1    | 1200 Ω (brn-red-red)  | R155 ✓   |
| A1                        | 6-182          | 1    | 1800 Ω (brn-gry-red)  | R137 ✓   |
| A1                        | 6-272          | 2    | 2700 Ω (red-viol-red) | R118, R122 ✓                                     |
| A1                        | 6-332          | 2    | 3300 Ω (org-org-red)  | R119, R121 ✓                                     |
| A1                        | 6-912          | 1    | 9100 Ω (wht-brn-red)  | R103 ✓   |
| A1                        | 6-103          | 2    | 10 kΩ (brn-blk-org)   | R109, R154 ✓                                     |
| A1                        | 6-153          | 1    | 15 kΩ (brn-grn-org)   | R132 ✓   |
| A1                        | 6-223          | 1    | 22 kΩ (red-red-org)   | R169 ✓   |
| A1                        | 6-913          | 1    | 91 kΩ (wht-brn-org)   | R102 ✓   |
| A1                        | 6-104          | 1    | 100 kΩ (brn-blk-yel)  | R107 ✓   |
| A1                        | 6-914          | 1    | 910 kΩ (wht-brn-yel)  | R101 ✓   |

### Other Resistors

|    |           |   |  |              |
|----|-----------|---|--|--------------|
| A2 | 6-1801-12 | 2 | 1800 Ω (1.8k) 1/4-watt, 1% (brn-gry-blk-brn) | R123, R127 ✓ |
| A2 | 6-4320-12 | 2 | 432 Ω, 1/4-watt, 1% (yel-org-red-blk)        | R125, R126 ✓ |
| A3 | 1-19-1    | 1 | 220 Ω, 1-watt, 10% (red-red-brn)             | R173 ✓       |
| A4 | 5-11-2    | 1 | 15 kΩ 2-watt, 10%                            | R176 ✓       |
| A5 | 3-55-5    | 2 | 2000 Ω, (2k) 5-watt                          | R177, R178 ✓ |

### CAPACITORS

#### Ceramic

|    |        |   |         |              |
|----|--------|---|---------|--------------|
| B1 | 21-121 | 2 | 56 pF   | ✓ C112, C116 |
| B1 | 21-148 | 1 | 75 pF   | C117 ✓       |
| B1 | 21-22  | 1 | 220 pF  | C121 ✓       |
| B1 | 21-722 | 1 | 330 pF  | C105 ✓       |
| B1 | 21-36  | 1 | .002 μF | C108 ✓       |
| B1 | 21-27  | 1 | .005 μF | C107 ✓       |
| B1 | 21-47  | 2 | .01 μF  | C109, C122 ✓ |
| B1 | 21-31  | 1 | .02 μF  | C124 ✓       |
| B1 | 21-199 | 1 | .1 μF   | C114 ✓       |

#### Electrolytic

|    |        |   |        |                    |
|----|--------|---|--------|--------------------|
| B2 | 25-115 | 3 | 10 μF  | ✓ C111, C113, C123 |
| B3 | 25-117 | 2 | 100 μF | ✓ C118, C119       |
| B3 | 25-160 | 2 | 250 μF | ✓ C125, C126       |

| KEY No.        | HEATH Part No. | QTY. | DESCRIPTION | CIRCUIT Comp. No. |
|----------------|----------------|------|-------------|-------------------|
| <b>Trimmer</b> |                |      |             |                   |
| B4             | 31-56          | 2    | 1.5-20 pF   | C101, C103 ✓      |
| B4             | 31-54          | 1    | 4-40 pF     | C102 ✓            |
| B4             | 31-52          | 2    | 8-60 pF     | C104, C115 ✓      |
| B5             | 31-77          | 1    | 80-400 pF   | C106 ✓            |

### Other Capacitors

|    |       |   |             |      |
|----|-------|---|-------------|------|
| B6 | 27-28 | 1 | .1 μF Mylar | C1 ✓ |
|----|-------|---|-------------|------|

### DIODES

|    |       |   |        |                          |
|----|-------|---|--------|--------------------------|
| C1 | 56-56 | 4 | 1N4149 | D103, D104, D105, D106 ✓ |
| C1 | 56-67 | 1 | VR10A  | D107 ✓                   |

### TRANSISTORS-INTEGRATED CIRCUITS (IC's)

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

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

|    |         |   |                    |                                      |
|----|---------|---|--------------------|--------------------------------------|
| D1 | 417-134 | 2 | MPS6520 transistor | ✓ Q111, Q112                         |
| D1 | 417-235 | 6 | 2N4121 transistor  | ✓ Q104, Q105, Q106, Q107, Q108, Q109 |
| D1 | 417-237 | 2 | SE6020 transistor  | ✓ Q113, Q114                         |
| D1 | 417-801 | 1 | MPSA20 transistor  | ✓ Q103                               |
| D2 | 417-834 | 2 | MPSU10 transistor  | ✓ Q115, Q116                         |
| D4 | 417-854 | 2 | FET                | ✓ D101, D102                         |
| D3 | 417-902 | 2 | 5566 transistor    | ✓ Q101, Q102                         |

### OTHER CIRCUIT COMPONENTS

|    |         |   |  |          |
|----|---------|---|--|----------|
| E1 | 10-357  | 1 | 100 Ω control                          | ✓ R112   |
| E2 | 10-917  | 1 | 200 Ω control                          | ✓ R152   |
| E2 | 10-918  | 1 | 500 Ω control                          | ✓ R143   |
| E2 | 10-936  | 1 | 1000 Ω (1k) control                    | ✓ R138   |
| E3 | 10-1118 | 1 | 1000 Ω (1k) control                    | ✓ R4     |
| E4 | 60-73   | 1 | DP3T 3-position slide switch           | SW2 ✓    |
| E5 | 63-1316 | 1 | Rotary switch with 5000 Ω (5k) control | SW1-R3 ✓ |
| E6 | 475-16  | 2 | Ferrite bead                           | ✓        |



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

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

**HARDWARE**

**#4 Hardware**

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

**#6 Hardware**

|    |         |   |                             |   |
|----|---------|---|-----------------------------|---|
| G1 | 250-416 | 2 | 6-32 × 1/4" flat head screw | ✓ |
|----|---------|---|-----------------------------|---|

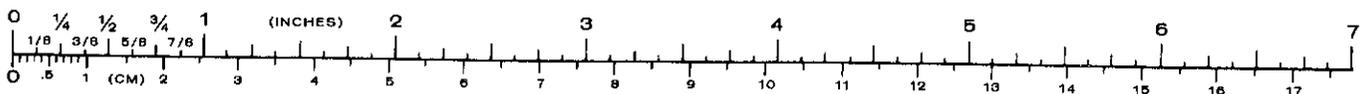
**Other Hardware**

|    |         |   |                     |   |
|----|---------|---|---------------------|---|
| H1 | 253-50  | 1 | 1/4" plastic spacer | ✓ |
| H2 | 252-7   | 2 | 3/8-32 nut          | ✓ |
| H3 | 254-4   | 1 | 3/8" lockwasher     | ✓ |
| H4 | 255-145 | 1 | 3/8" spacer         | ✓ |

**MISCELLANEOUS**

|    |           |    |                                |   |
|----|-----------|----|--------------------------------|---|
|    | 85-2357-1 | 1  | Vertical circuit board         | ✓ |
| J1 | 204-2315  | 1  | Switch bracket                 | ✓ |
| J2 | 215-95    | 2  | Heat sink                      | ✓ |
|    | 343-15    | 2' | Shielded cable                 | ✓ |
|    | 344-51    | 3' | Brown wire                     | ✓ |
|    | 344-54    | 1' | Yellow wire                    | ✓ |
|    | 344-56    | 1' | Blue wire                      | ✓ |
|    | 346-1     | 6" | Sleeving                       | ✓ |
|    | 390-1438  | 1  | Metal front panel              | ✓ |
| J3 | 432-892   | 1  | BNC connector                  | ✓ |
| J4 | 434-230   | 2  | 8-pin IC socket                | ✓ |
| J5 | 462-1059  | 1  | Small black knob<br>with skirt | ✓ |
| L1 | 490-5     | 1  | Plastic nut starter            | ✓ |
|    | 390-147   | 1  | Danger label                   | ✓ |
|    | 390-1255  | 1  | Fuse label                     | ✓ |
|    | 390-1483  | 1  | Power consumption label        | ✓ |
|    | 391-34    | 1  | Blue and white label           | ✓ |
|    | 597-260   | 1  | Parts Order Form               | ✓ |

Solder ✓  
 ✓ Assembly Manual (See Page 1  
 for Part Number)



# STEP-BY-STEP ASSEMBLY

## START

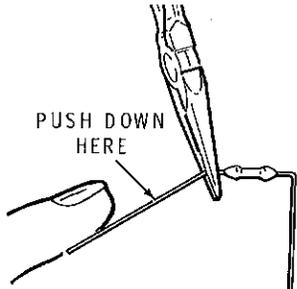
In the following steps, you will be given detailed instructions on how to install and solder the first part on the circuit board. Read and perform each step carefully. Then use the same procedure whenever you install parts on a circuit board.

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

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

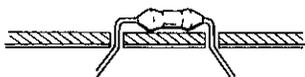
**NOTE:** When you install a component that has its value printed on it, position the value marking up, so it can be easily read. Diodes should be mounted with their type or part number up, if possible.

(✓) Hold a 1.5 Ω (brn-grn-gld) resistor with long-nose pliers and bend the leads straight down to fit the hole spacing on the circuit board.

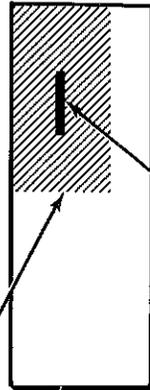


(✓) R105: Push the leads through the holes at the indicated location on the circuit board. The end with color bands may be positioned either way. **NOTE:** Your circuit board may be screened 33 at this location.

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

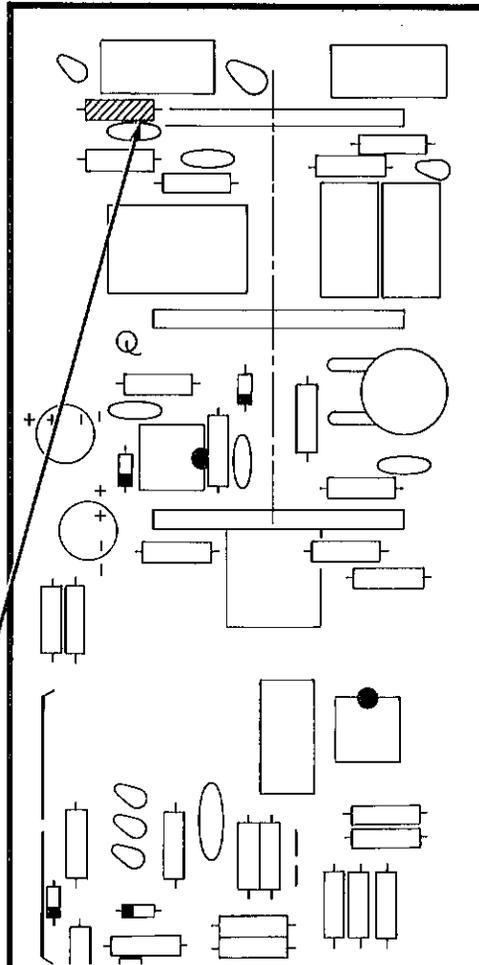


IDENTIFICATION DRAWING



PART NUMBER

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

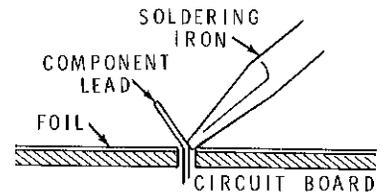


PICTORIAL 1-1

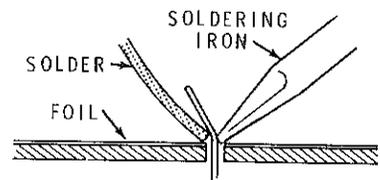
## CONTINUE

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

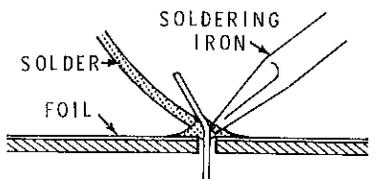
1. Push the soldering iron tip against both the lead and the circuit board foil. Heat both for two or three seconds.



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



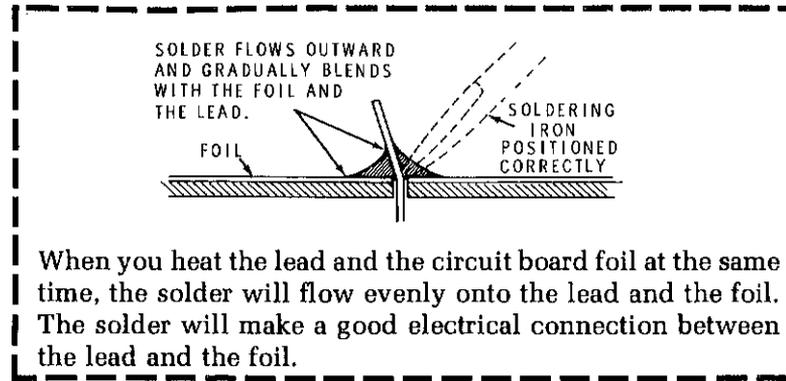
3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



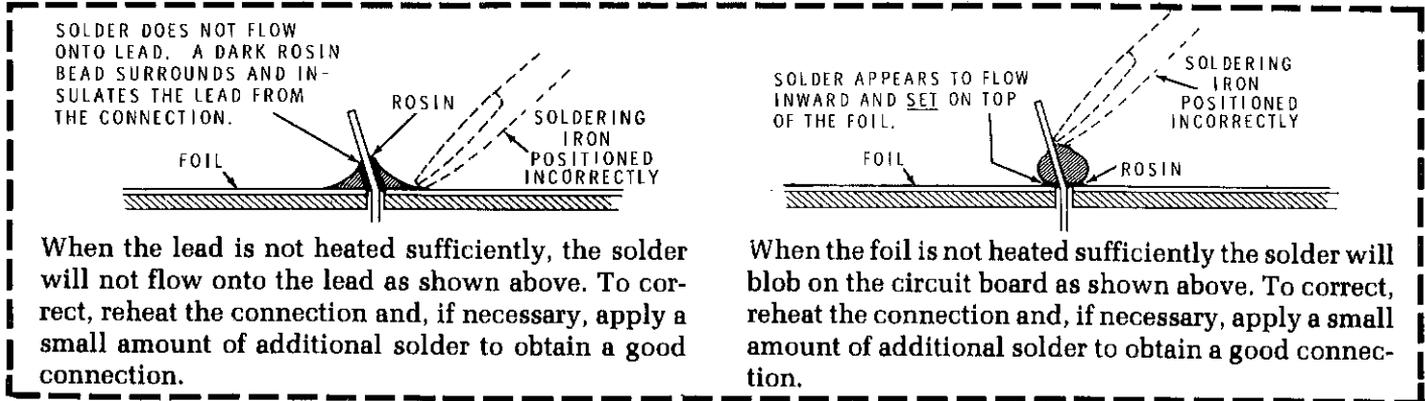
(✓) Cut off the excess lead lengths close to the connection. **WARNING:** Clip the leads so the ends will not fly toward your eyes.

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

## A GOOD SOLDER CONNECTION



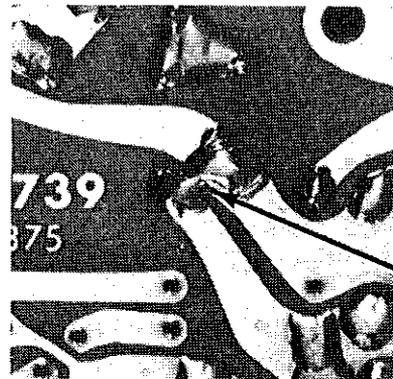
## POOR SOLDER CONNECTIONS

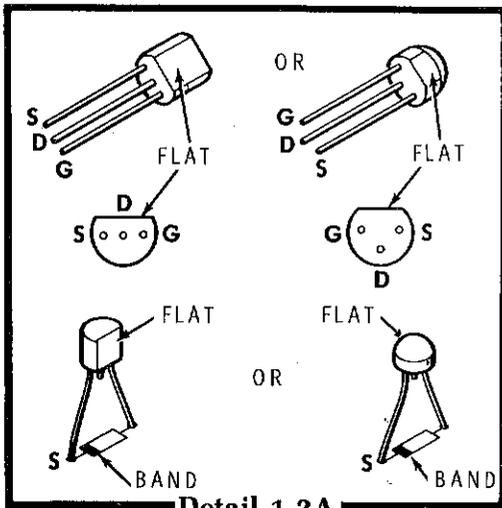


## SOLDER BRIDGES

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

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





Detail 1-2A

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

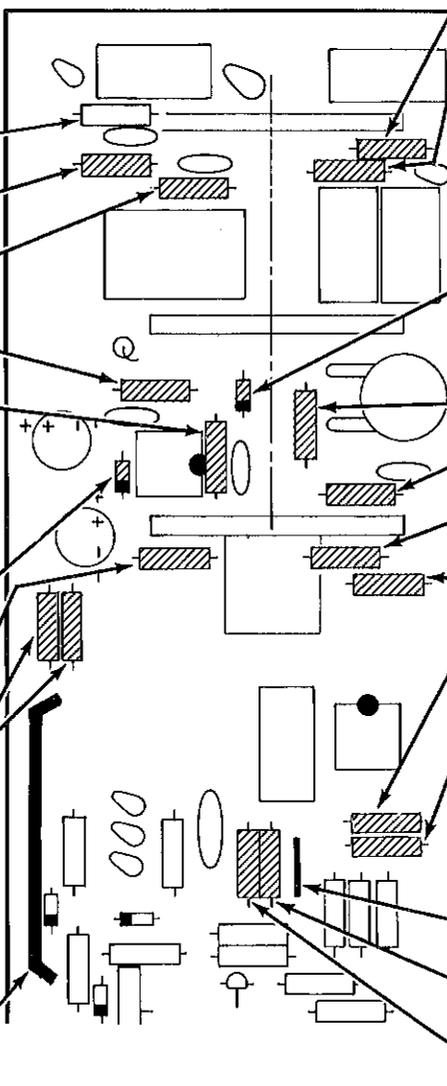
IDENTIFICATION DRAWING

PART NUMBER

**CONTINUE** →

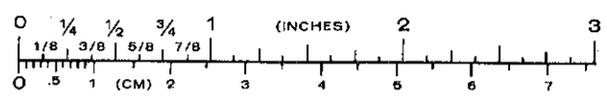
**START** →

- NOTE: Be sure you installed resistor R105 in Pictorial 1-1 on Page 11.
- (✓) R104: 1000 Ω (brn-blk-red).
  - (✓) R103: 9100 Ω (wht-brn-red).
  - (✓) R107: 100 kΩ (brn-blk-yel).
  - (✓) R108: 270 Ω (red-viol-brn).
  - (✓) Refer to Detail 1-2A and identify which type of #417-854 transistor you have.
  - (✓) Locate and cut off the lead labeled "D" in the Detail.
  - (✓) D101: (#417-854). Install the diode with the source (S) lead at the banded end of the diode symbol on the circuit board.
  - (✓) R115: 510 Ω (grn-brn-brn).
  - (✓) R113: 220 Ω (red-red-brn).
  - (✓) R114: 220 Ω (red-red-brn).
- NOTE: When a wire is called for in a step, cut the brown wire to the specified length. Then remove 1/4" of insulation from each end.
- (✓) 2-3/8" brown wire.
  - (✓) Solder the leads to the foil and cut off the excess lead lengths.



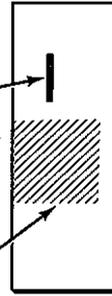
- (✓) R101: 910 kΩ (wht-brn-yel).
  - (✓) R102: 91 kΩ (wht-brn-org).
  - (✓) Refer again to Detail 1-2A and identify which type of #417-854 transistor you have.
  - (✓) Locate and cut off the "D" lead.
  - (✓) D102: (#417-854). Install the diode with the source (S) lead at the banded end of the diode symbol on the circuit board.
  - (✓) R111: 220 Ω (red-red-brn).
  - (✓) R109: 10 kΩ (brn-blk-org).
  - (✓) R116: 330 Ω (org-org-brn).
  - (✓) R117: 200 Ω (red-blk-brn).
  - (✓) R127: 1800 Ω, 1% (brn-gry-blk-brn).
  - (✓) R123: 1800 Ω, 1% (brn-gry-blk-brn).
- NOTE: When a bare wire is called for in a step, remove all the insulation from the specified length of brown wire.
- (✓) 1" bare wire.
  - (✓) R125: 432 Ω, 1% (yel-org-red-blk).
  - (✓) R126: 432 Ω, 1% (yel-org-red-blk).
  - (✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-2

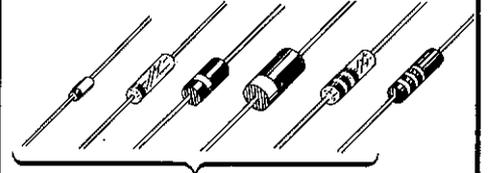


IDENTIFICATION  
DRAWING

PART  
NUMBER



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

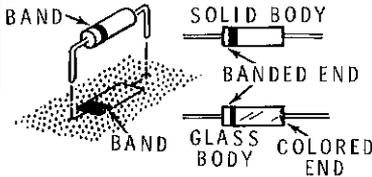


**BANDED END  
Detail 1-3A**

(✓) R121: 3300 Ω (org-org-red).

(✓) R119: 3300 Ω (org-org-red).

NOTE: When you install a diode, always match the band on the diode with the band mark on the circuit board. A DIODE WILL NOT WORK PROPERLY IF IT IS INSTALLED BACKWARDS. See Detail 1-3A.



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

(✓) D103: 1N4149 diode (#56-56).

(✓) D104: 1N4149 diode (#56-56).

(✓) R118: 2700 Ω (red-viol-red).

(✓) D105: 1N4149 diode (#56-56).

(✓) R136: 470 Ω (yel-viol-brn).

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

(✓) R137: 1800 Ω (brn-gry-red).

(✓) R147: 22 Ω (red-red-blk).

(✓) R148: 22 Ω (red-red-blk).

(✓) R145: 10 Ω (brn-blk-blk).

(✓) R142: 10 Ω (brn-blk-blk).

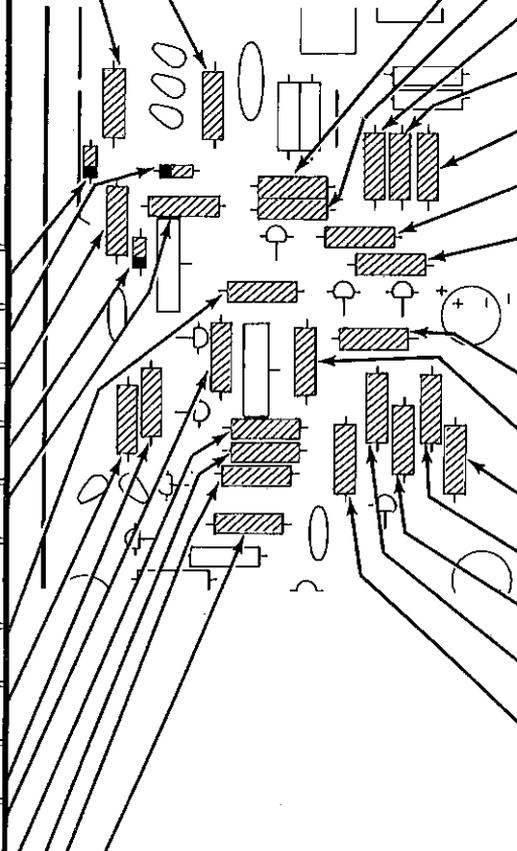
(✓) R146: 1000 Ω (brn-blk-red).

(✓) R149: 1000 Ω (brn-blk-red).

(✓) R155: 1200 Ω (brn-red-red).

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

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



**CONTINUE**

(✓) R122: 2700 Ω (red-viol-red).

(✓) R132: 15 kΩ (brn-grn-org).

(✓) R124: 10 Ω (brn-blk-blk).

(✓) R131: 10 Ω (brn-blk-blk).

(✓) R134: 47 Ω (yel-viol-blk).

(✓) R139: 390 Ω (org-wht-brn).

(✓) R135: 390 Ω (org-wht-brn).

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

(✓) R156: 1000 Ω (brn-blk-red).

(✓) R144: 82 Ω (gry-red-blk).

(✓) R159: 10 Ω (brn-blk-blk).

(✓) R133: 1000 Ω (brn-blk-red).

(✓) R157: 10 Ω (brn-blk-blk).

(✓) R141: 1000 Ω (brn-blk-red).

(✓) R158: 10 Ω (brn-blk-blk).

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

**PICTORIAL 1-3**

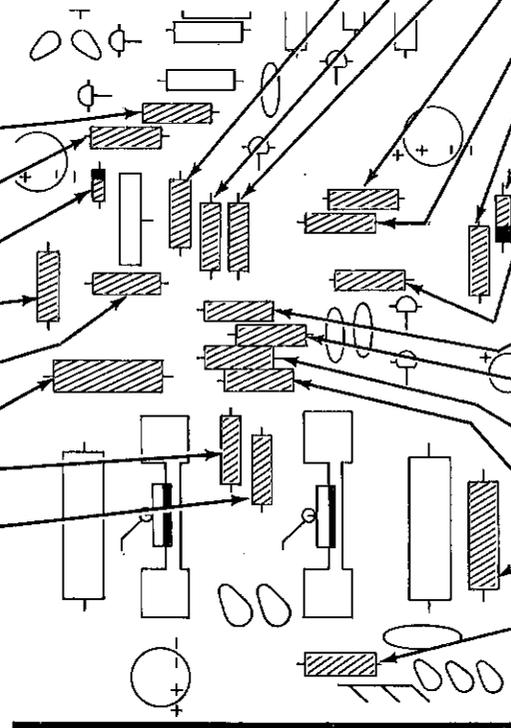
IDENTIFICATION  
DRAWING

PART  
NUMBER

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

**START** →

- (✓) R151: 39 Ω (org-wht-blk).
- (✓) R154: 10 kΩ (brn-blk-org).
- (✓) D106: 1N4149 diode (#56-56).
- (✓) R164: 10 Ω (brn-blk-blk).
- (✓) R163: 750 Ω (viol-grn-brn).
- (✓) R173: 220 Ω, 1-watt (red-red-brn).
- (✓) R175: 10 Ω (brn-blk-blk).
- (✓) R174: 10 Ω (brn-blk-blk).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



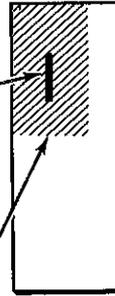
**CONTINUE** →

- (✓) R153: 390 Ω (org-wht-brn).
- (✓) R161: 100 Ω (brn-blk-brn).
- (✓) R162: 100 Ω (brn-blk-brn).
- (✓) R165: 1000 Ω (brn-blk-red).
- (✓) R167: 1000 Ω (brn-blk-red).
- (✓) R179: 2.7 Ω (red-viol-gld).
- (✓) D107: VR10A diode (#56-67).
- (✓) R166: 10 Ω (brn-blk-blk).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) R171: 100 Ω (brn-blk-brn).
- (✓) R169: 22 kΩ (red-red-org).
- (✓) R172: 100 Ω (brn-blk-brn).
- (✓) R168: 10 Ω (brn-blk-blk).
- (✓) R176: 15 kΩ, 2-watt.
- (✓) R181: 2.7 Ω (red-viol-gld).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-4

IDENTIFICATION  
DRAWING

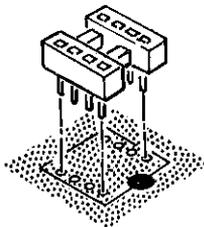
PART  
NUMBER



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

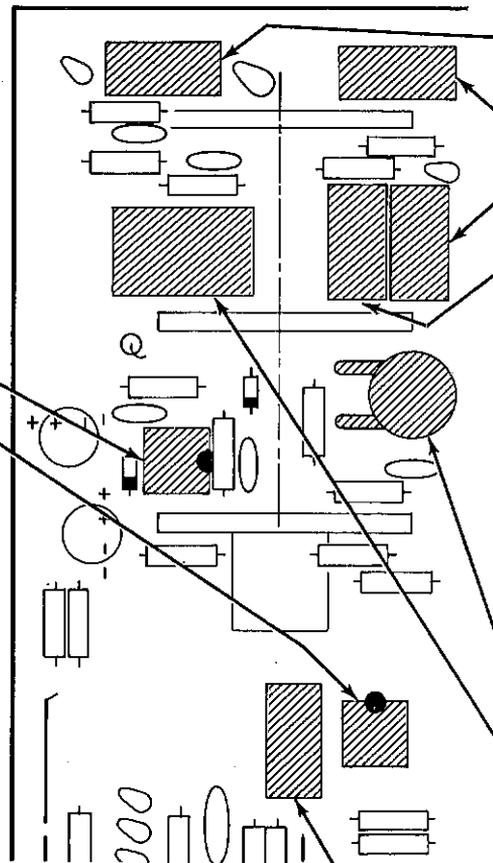
**START** →

NOTE: When you install an IC socket, insert the pins into the circuit board holes and solder them to the foil. The socket can be installed either way.



(✓) 8-pin IC socket at Q101.

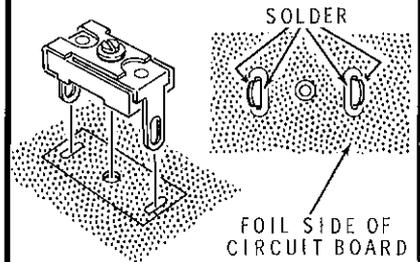
(✓) 8-pin IC socket at Q102.



PICTORIAL 1-5

**CONTINUE** →

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



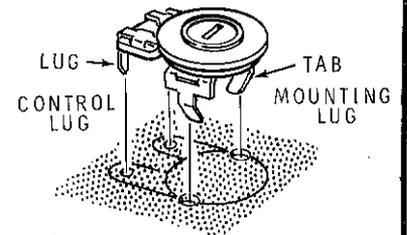
(✓) C101: 1.5-20 pF trimmer (#31-56).

(✓) C102: 4-40 pF trimmer (#31-54).

(✓) C103: 1.5-20 pF trimmer (#31-56).

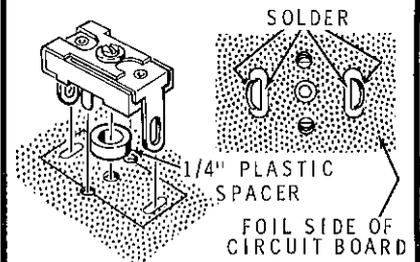
(✓) C104: 8-60 pF trimmer (#31-52).

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



(✓) R112: 100 Ω control (#10-357).

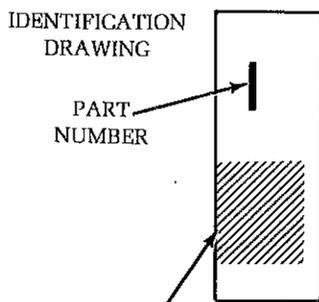
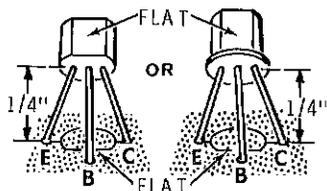
(✓) C106: 80-400 pF trimmer (#31-77). Use a 1/4" plastic spacer around the screw. Do not cut off the leaves.



(✓) C115: 8-60 pF trimmer (#31-52).

**START** 

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



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

(✓) Q103: MPSA20 transistor (#417-801).

(✓) Q105: 2N4121 transistor (#417-235).

(✓) Q104: 2N4121 transistor (#417-235).

(✓) Q107: 2N4121 transistor (#417-235).

(✓) Q106: 2N4121 transistor (#417-235).

(✓) Q109: 2N4121 transistor (#417-235).

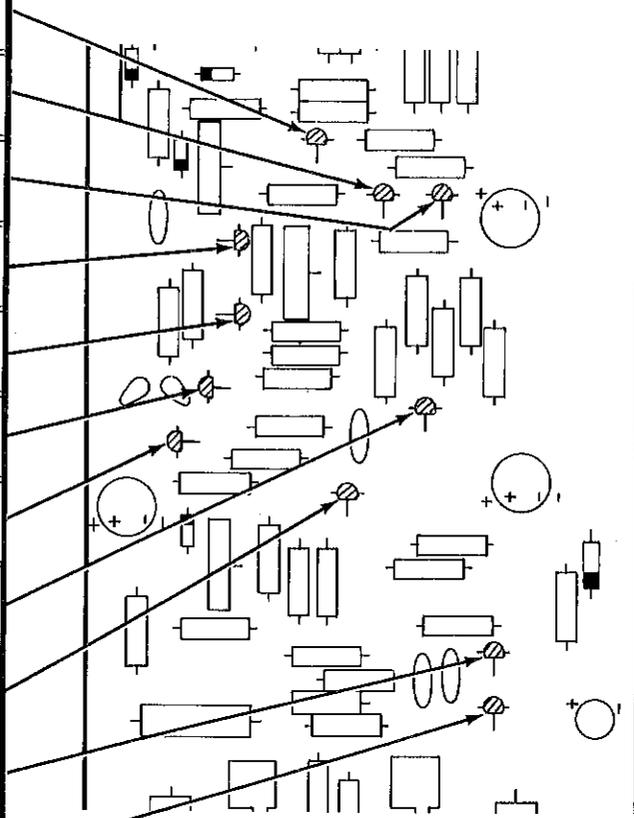
(✓) Q108: 2N4121 transistor (#417-235).

(✓) Q111: MPS6520 transistor (#417-134).

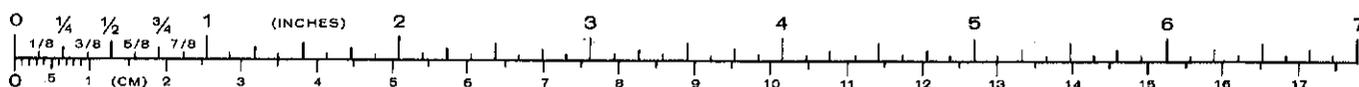
(✓) Q112: MPS6520 transistor (#417-134).

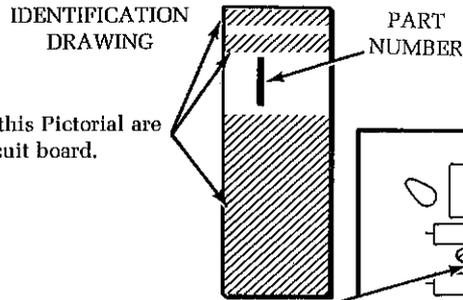
(✓) Q113: SE6020 transistor (#417-237).

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



**PICTORIAL 1-6**

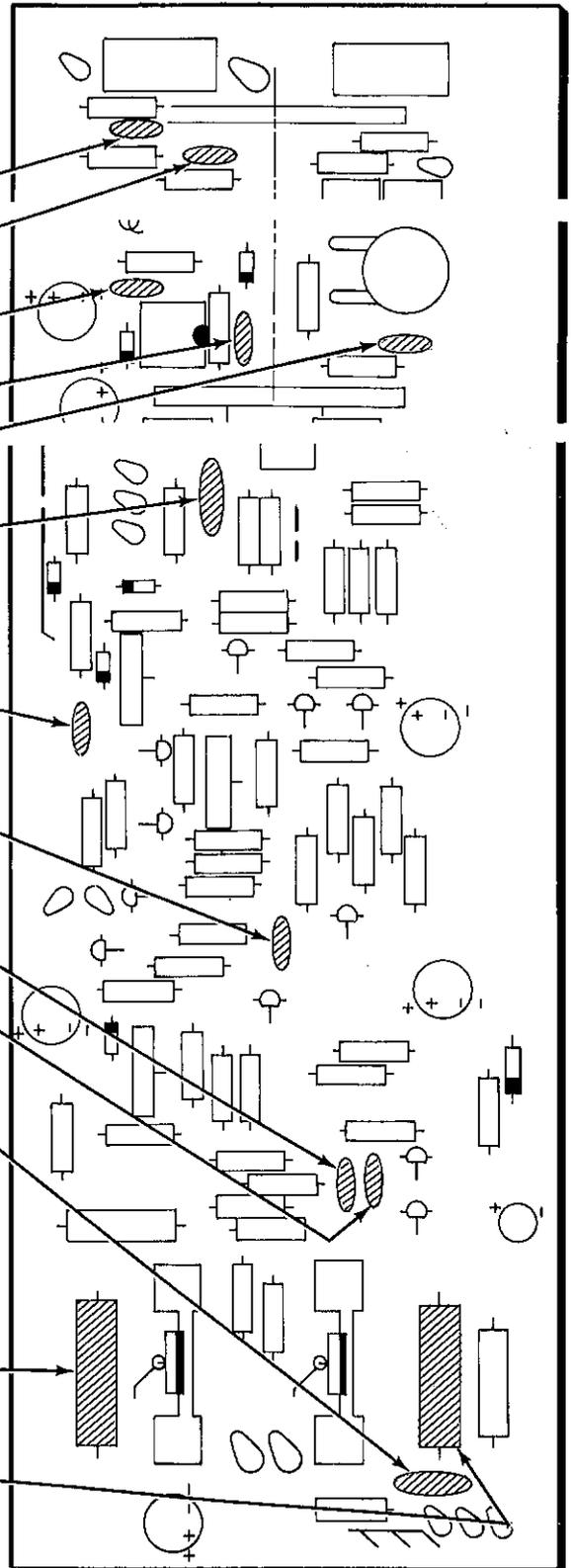




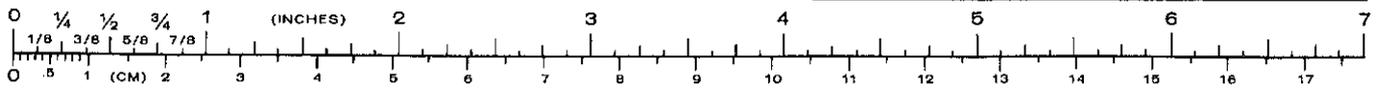
The steps performed in this Pictorial are in these areas of the circuit board.

**START**

- (✓) C107: .005  $\mu$ F ceramic.
  - (✓) C105: 330 pF ceramic.
  - (✓) C108: .002  $\mu$ F ceramic.
  - (✓) C112: 56 pF ceramic.
  - (✓) C109: .01  $\mu$ F ceramic.
  - (✓) C114: .1  $\mu$ F ceramic.
  - (✓) C116: 56 pF ceramic.
  - (✓) C117: 75 pF ceramic.
  - (✓) C122: .01  $\mu$ F ceramic.
  - (✓) C121: 220 pF ceramic. Note: The board may be lettered 100.
  - (✓) C124: .02  $\mu$ F ceramic.
- NOTE:** When you are instructed to mount a resistor  $3/16"$  above the circuit board as shown, use a  $1" \times 1"$  piece of  $3/16"$  cardboard (from shipping carton) for a spacer. After the leads are soldered, remove the cardboard spacer.
- 
- (✓) R178: 2000  $\Omega$ , 5-watt ( $3/16"$  above board).
  - (✓) R177: 2000  $\Omega$ , 5-watt ( $3/16"$  above board).
  - (✓) Solder the leads to the foil and cut off the excess lead lengths.



**PICTORIAL 1-7**



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

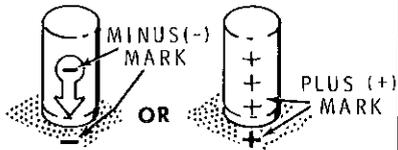


IDENTIFICATION DRAWING

PART NUMBER

**START** →

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

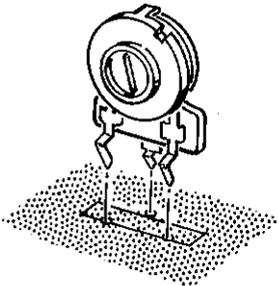


(✓) C113: 10  $\mu$ F electrolytic.

(✓) C111: 10  $\mu$ F electrolytic.

(✓) C118: 100  $\mu$ F electrolytic.

When you install a control, be sure it is tight against and perpendicular to the circuit board. Then solder the pins to the foil and cut off the excess pin lengths.



(✓) R138: 1000  $\Omega$  (1k) control (#10-936).

(✓) R143: 500  $\Omega$  control (#10-918).

(✓) R152: 200  $\Omega$  control (#10-917).

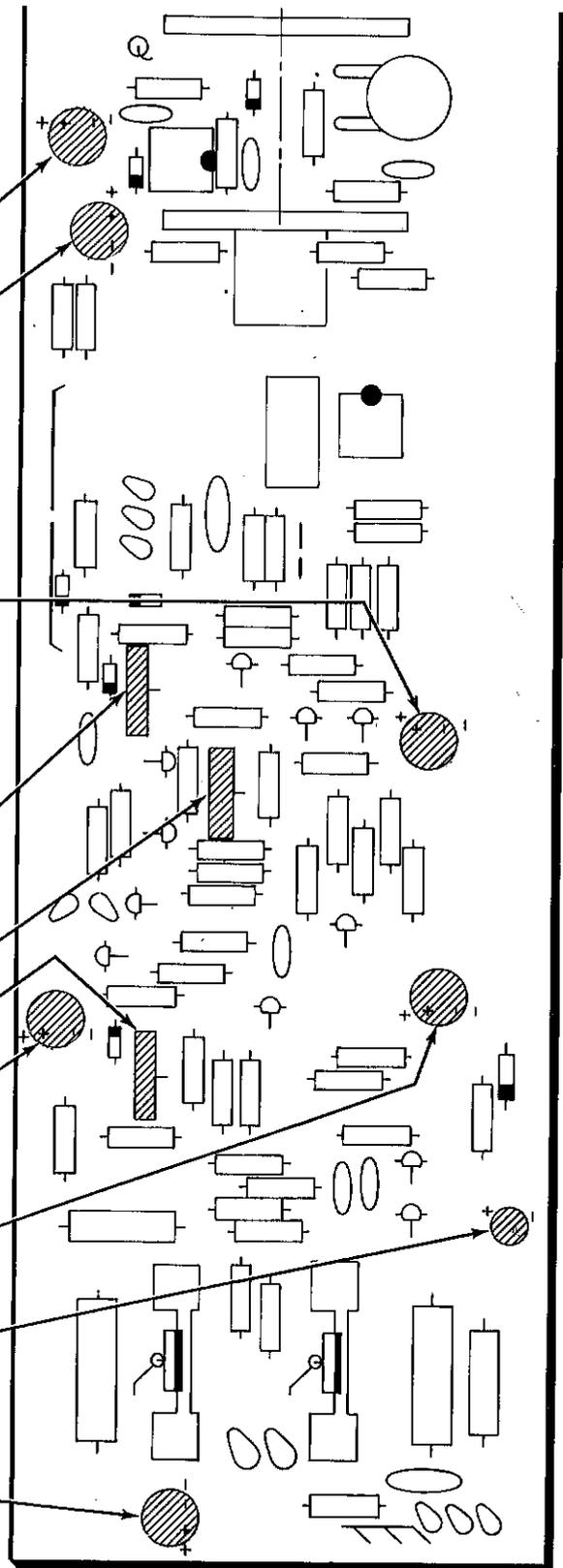
(✓) C119: 100  $\mu$ F electrolytic.

(✓) C215: 250  $\mu$ F electrolytic.

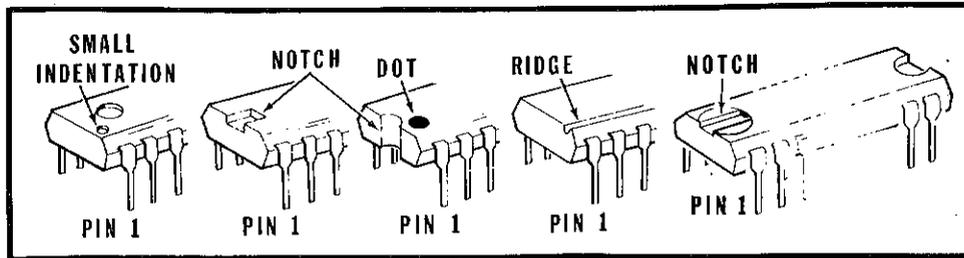
(✓) C123: 10  $\mu$ F electrolytic.

(✓) C126: 250  $\mu$ F electrolytic.

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



PICTORIAL 1-8



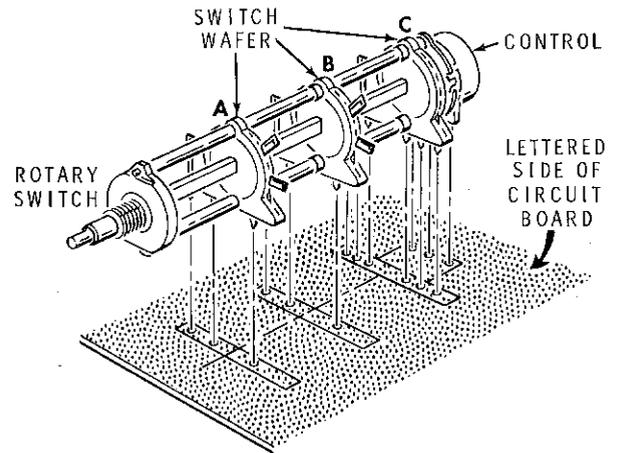
Detail 1-9A

Refer to Pictorial 1-9 (Illustration Booklet, Page 2) for the following steps.

NOTE: When you install a transistor in the following steps, be sure to match the pin 1 end of the transistor to the index mark on the circuit board. See Detail 1-9A.

- (✓) Q101: Install a 5566 transistor (#417-902) at location Q101.
- (✓) Q102: Install a 5566 transistor (#417-902) at location Q102.
- (✓) SW1-R3: Refer to Detail 1-9B and mount the rotary switch with 5000  $\Omega$  (5 k) control (#63-1316) at its location on the printed side of the circuit board as follows:

1. Carefully align the pins of the front wafer (A) with their holes in the circuit board.
2. Fit the pins of each switch wafer, one wafer at a time, into their board holes until all the switch and control pins are in place. Then push the switch down tight against the circuit board.
3. Carefully turn the circuit board over and solder **only** the end pins of each wafer to the foil. Inspect these switch pins to make sure all the pins are tight against the printed side of the circuit board. If they are not, reheat the connection and push the switch tight against the board. Then solder all the remaining switch and control pins to the foil.



Detail 1-9B

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

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

3"

2"

## NOTES:

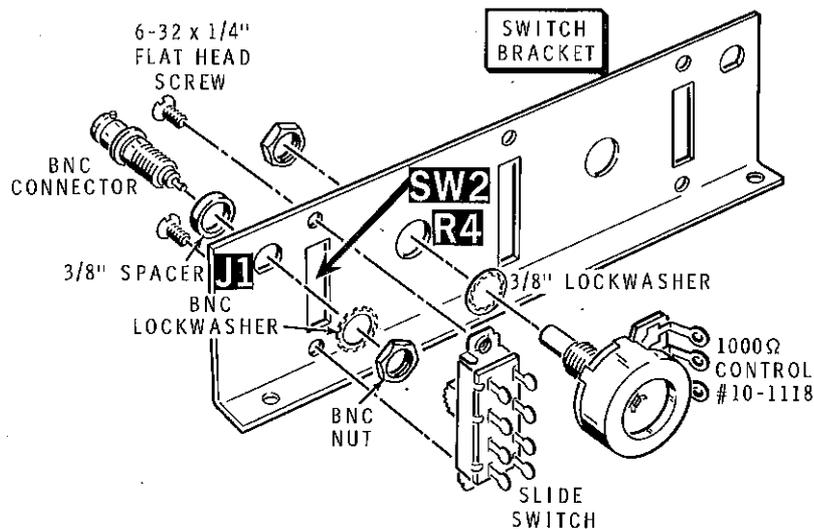
1. When you connect a wire to the circuit board, always cut off the excess lead length after the connection is soldered.



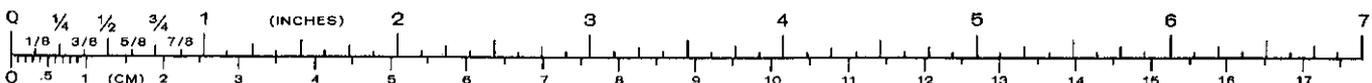
2. In the following steps, (NS) means not to solder because other wires will be added later. "S-" with a number, such as (S-3), means to solder the connection. The number following the "S" tells how many wires are at the connection.
  3. When you wire to the rotary switches, be sure **no** wires or components are positioned directly above the screws in the trimmer capacitors, as these trimmers must be adjusted later.
- (✓) Connect a 3" brown wire from circuit board hole A (S-1) to switch SW1 wafer A lug 9 (NS). Position the wire between the shaft and indicated spacer on the switch.
  - (✓) Connect a 2" brown wire from circuit board hole A2 (S-1) to switch SW1 wafer A lug 8 (S-1).
  - (✓) Place a 1/2" length of sleeving on each lead of a 33  $\Omega$ , 1/2-watt (org-org-blk) 5% resistor.
  - (✓) R2: Connect this resistor to switch SW1 between wafer A lug 9 (NS) and wafer B lug 8 (S-1).
  - (✓) R106: Connect a 33  $\Omega$ , 1/2-watt (org-org-blk) 5% resistor from the indicated resistor outline in the circuit board (S-1) to switch SW1 wafer B lug 9 (S-1).
  - (✓) Set the circuit board aside temporarily.

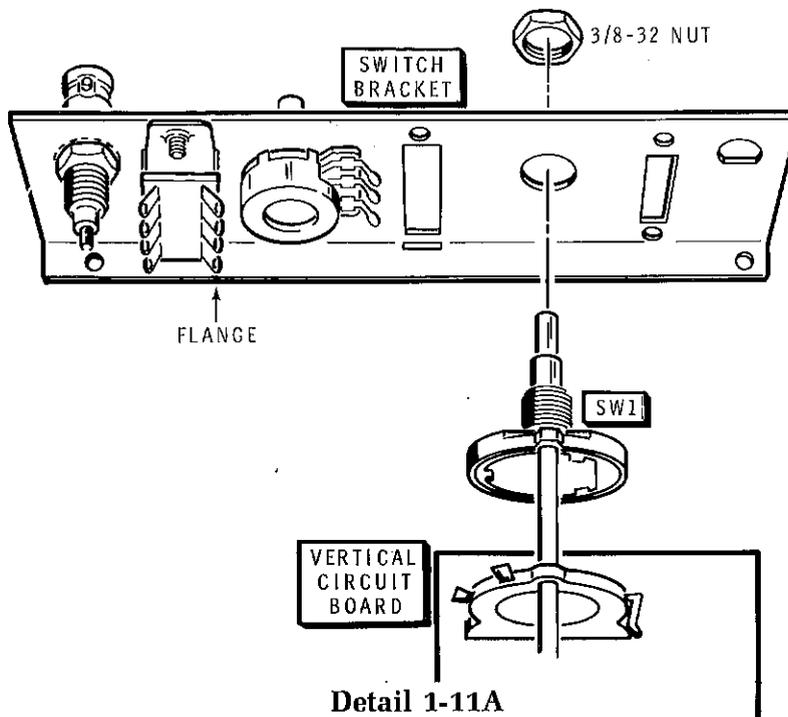
Refer to Pictorial 1-10 for the following steps.

- (✓) SW2: Install a DP3T 3-position slide switch at location SW2 in the switch bracket. Use 6-32  $\times$  1/4" **flat head** screws. The switch can be installed either way.
- (✓) J1: Install a BNC connector at location J1 in the switch bracket. Use the lockwasher and nut furnished with the connector and a 3/8" spacer.
- (✓) R4: Install a 1000  $\Omega$  (1k) control (#10-1118) at location R4 with a 3/8" lockwasher and a 3/8-32 nut. Position the control so its lugs are located as shown.



PICTORIAL 1-10





Detail 1-11A

Refer to Pictorial 1-11 (Illustration Booklet, Page 2) for the following steps.

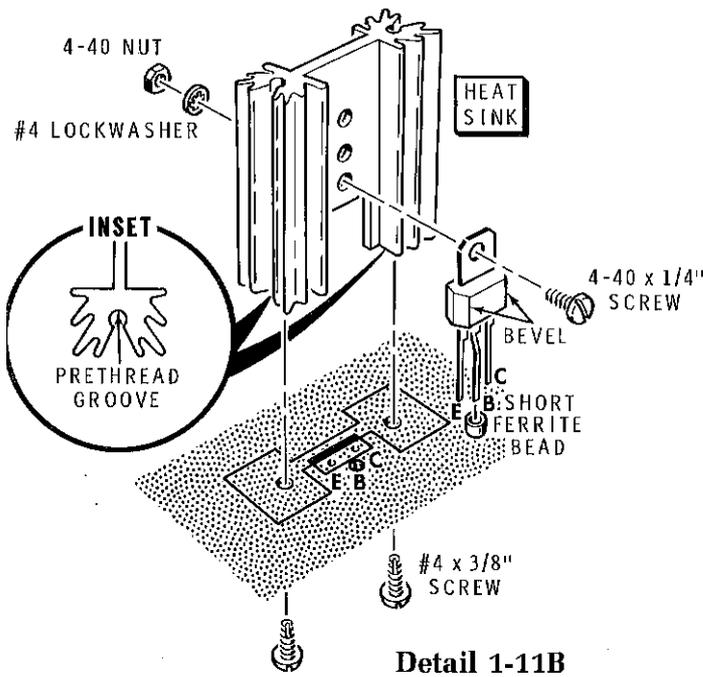
- (✓) Refer to Detail 1-11A and mount the switch bracket onto switch SW1 (mounted on the vertical circuit board) with a 3/8-32 nut. Be sure to position the flange of the switch bracket as shown and keep the circuit board parallel to this flange.
- (✓) Prepare the following wires.
  - 2-1/2" brown    7-1/4" yellow
  - 4" brown        7" blue
  - 7-1/2" brown
- (✓) Connect a 2-1/2" brown wire from switch SW2 lug 7 (S-1) to circuit board hole B (S-1).
- (✓) Remove an extra 1/2" of insulation (total 3/4") from one end of a 4" brown wire.

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

- (✓) Connect the longer bared end of this wire to switch SW2 through lug 6 (S-2) to lug 3 (S-1). Connect the other end of this wire to switch SW1 lug 9 (S-3).
- (✓) Connect a 7-1/2" brown wire from control R4 lug 3 (S-1) to circuit board E (S-1).
- (✓) Connect a 7-1/4" yellow wire from control R4 lug 2 (S-1) to circuit board hole F (S-1).
- (✓) Connect a 7" blue wire from control R4 lug 1 (S-1) to circuit board hole G (S-1).

NOTE: Be sure to position the capacitor, installed in the next step, **exactly** as shown.

- (✓) C1: Connect one lead of .1  $\mu$ F Mylar capacitor through connector J1 (S-2) to switch SW2 through lug 1 (S-2) to lug 5 (S-1). Connect the other lead to switch SW2 lug 4 (S-1). Disregard the band on the capacitor.



- (✓) Refer to Detail 1-11B and prethread the two grooves in the bottom of both heat sinks. Use a #4 x 3/8" screw.

NOTE: The term "hardware" in the following steps refers to the screws, nuts, and lockwashers you will use to mount parts. The phrase "Use 4-40 x 1/4" hardware," for example, means to use 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.

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

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

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

### CIRCUIT BOARD CHECKOUT

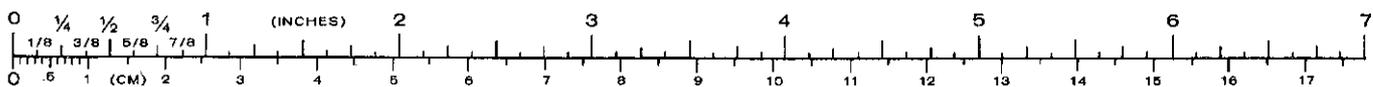
Carefully inspect the circuit board for the following conditions.

- (✓) Unsoldered connections.
- (✓) Poor solder connections.
- (✓) Solder bridges between foil patterns.
- (✓) Protruding leads which could touch together.
- (✓) Transistors for the proper type and installation.
- (✓) Electrolytic capacitors for the correct position of the positive (+) or negative (-) end.
- (✓) Diodes for the proper type and the correct position of the banded end.

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

Save the remaining parts for use later.

- 2' shielded cable
- 5" sleeving
- Metal front panel
- Black knob
- Danger label
- Fuse label
- Power consumption label
- Blue and white label
- All wire



# HORIZONTAL CIRCUIT BOARD

## PARTS LIST

Open the pack marked #2 and check each part against the following list. The key numbers correspond to the numbers on the Horizontal Circuit Board Parts Pictorial (Illustration Booklet, Page 3).

To order a replacement part, always include the PART NUMBER. Use the Parts Order Form furnished with the kit. If one is not available, see "Replacement Parts" inside the rear cover. For prices, refer to the separate "Heath Parts Price List."

| KEY No.  | HEATH Part No. | QTY. | DESCRIPTION                   | CIRCUIT Comp. No.            | KEY No.                    | HEATH Part No. | QTY. | DESCRIPTION                  | CIRCUIT Comp. No.   |
|--|----------------|------|-------------------------------|------------------------------|----------------------------|----------------|------|------------------------------|---|
| <b>RESISTORS</b>   |                |      |                               |                              | <b>Resistors (Cont'd.)</b> |                |      |                              |   |
| All resistors are 5% (fourth band gold) unless designated 10% (fourth band silver).  |                |      |                               |                              |                            |                |      |                              |   |
| NOTE: The resistors may be packed in more than one envelope (stamped RES). Open all the resistor envelopes in this pack before you check the resistors against the Parts List. |                |      |                               |                              |                            |                |      |                              |   |
| <b>1/2-Watt</b>  |                |      |                               |                              |                            |                |      |                              |   |
| A1   | 6-279          | 1    | 2.7 $\Omega$ (red-viol-gld)   | ✓ R277                       | A1                         | 6-102          | ✓ 13 | 1000 $\Omega$ (brn-blk-red)  | R12, R202, R204, R218, R219, R221, R227, R245, R262, R268, R273, R278, R282 |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-152          | 1 ✓  | 1500 $\Omega$ (brn-grn-red)  | R248  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-182          | 5 ✓  | 1800 $\Omega$ (brn-gry-red)  | R205, R208, R213, R216, R250  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-222          | 1 ✓  | 2200 $\Omega$ (red-red-red)  | R272  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-682          | 1 ✓  | 6800 $\Omega$ (blu-gry-red)  | R226  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-103          | 1 ✓  | 10 k $\Omega$ (brn-blk-org)  | R256  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-153          | 1 ✓  | 15 k $\Omega$ (brn-grn-org)  | R210  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-473          | 2 ✓  | 47 k $\Omega$ (yel-viol-org) | R220, R222  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-683          | 1 ✓  | 68 k $\Omega$ (blu-gry-org)  | R225  |
| A1   | 6-100          | 5    | 10 $\Omega$ (brn-blk-blk) ✓   | R244, R269, R270, R275, R276 | A1                         | 6-104          | 5 ✓  | 100 k $\Omega$ (brn-blk-yel) | R201, R239, R243, R252, R274  |
| A1   | 6-271          | 2    | 270 $\Omega$ (red-viol-brn) ✓ | R259, R260, R212, R255       | A1                         | 6-684          | 1 ✓  | 680 k $\Omega$ (blu-gry-yel) | R224  |
| A1   | 6-331          | 2    | 330 $\Omega$ (org-org-brn) ✓  | R209, R228                   | A1                         | 6-914          | 1 ✓  | 910 k $\Omega$ (wht-brn-yel) | R242  |
| A1   | 6-391          | 1    | 390 $\Omega$ (org-wht-brn) ✓  | R229                         | A1                         | 6-105          | 1 ✓  | 1 M $\Omega$ (brn-blk-grn)   | R280  |
| A1   | 6-511          | 2    | 510 $\Omega$ (grn-brn-brn) ✓  | R206, R207                   | A1                         | 1-163          | 1 ✓  | 6.8 M $\Omega$ (blu-gry-grn) | R223  |
| A1   | 6-561          | 2    | 560 $\Omega$ (grn-blu-brn) ✓  | R235, R258                   | A1                         | 1-166          | 1 ✓  | 10 M $\Omega$ (brn-blk-blu)  | R240  |
| A1   | 6-821          | 1    | 820 $\Omega$ (gry-red-brn) ✓  | R217                         |                            |                |      |                              |   |



| KEY No. | HEATH Part No. | QTY. | DESCRIPTION |
|---------|----------------|------|-------------|
|---------|----------------|------|-------------|

| CIRCUIT Comp. No. |
|-------------------|
|-------------------|

### Other Resistors

|    |         |     |                                 |            |
|----|---------|-----|---------------------------------|------------|
| A2 | 6-681-1 | ✓ 1 | 680 Ω, 1-watt, 5% (blu-gry-brn) | R232       |
| A3 | 1-23-2  | ✓ 2 | 5600 Ω, 2-watt (grn-blu-red)    | R236, R265 |
| A4 | 5-2-2   | ✓ 2 | 22 kΩ, 2-watt                   | R233, R264 |

### CAPACITORS

#### Ceramic

|    |        |     |            |                  |
|----|--------|-----|------------|------------------|
| B1 | 21-157 | 1 ✓ | 5 pF       | C219             |
| B1 | 21-7   | 1 ✓ | 33 pF      | C204             |
| B1 | 21-32  | 2 ✓ | 47 pF      | C220, C235       |
| B1 | 21-121 | 2 ✓ | 56 pF      | C205, C213       |
| B1 | 21-75  | 1 ✓ | 100 pF     | C212             |
| B1 | 21-21  | 1 ✓ | 200 pF     | C222             |
| B1 | 21-56  | 1 ✓ | 470 pF     | C214             |
| B1 | 21-36  | 3 ✓ | .002 μF    | C211, C218, C229 |
| B1 | 21-16  | 2 ✓ | .01 μF + 1 | C202, C224       |
| B1 | 21-82  | 1 ✓ | .02 μF     | C210             |
| B1 | 21-199 | 3 ✓ | .1 μF      | C209, C228, C232 |

#### Tantalum—Electrolytic

|    |        |     |                                       |  |
|----|--------|-----|---------------------------------------|--|
| C1 | 25-224 | 1 ✓ | 2.2 μF electrolytic (M) tantalum      | C208   |
| C2 | 25-820 | 2 ✓ | 10 μF NP (non-polarized) electrolytic | C203, C221   |
| C2 | 25-115 | 9 ✓ | 10 μF electrolytic                    | C206, C217, C223, C225, C226, C227, C230, C231, C234 |
| C2 | 25-233 | 1 ✓ | 22 μF electrolytic                    | C207   |

#### Other Capacitors

|    |       |     |                     |      |
|----|-------|-----|---------------------|------|
| C3 | 29-5  | 1 ✓ | 1000 pF polystyrene | C216 |
| C4 | 27-47 | 1 ✓ | .1 μF Mylar         | C201 |
| C5 | 27-2  | 1 ✓ | 1 μF film           | C215 |

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

### DIODES

|    |       |     |        |  |
|----|-------|-----|--------|--|
| D1 | 56-56 | 8 ✓ | 1N4149 | D201, D204, D207, D208, D209, D210, D213, D214 |
| D1 | 56-59 | ✓ 1 | 1N750A | D206   |
| D1 | 56-67 | ✓ 2 | VR10A  | D205, D211                                     |

### TRANSISTORS — INTEGRATED CIRCUITS (IC's)

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

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

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



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

**CONTROLS**

|    |        |   |                       |            |
|----|--------|---|-----------------------|------------|
| F1 | 10-918 | 2 | ✓ 500 Ω control       | R231, R247 |
| F2 | 10-391 | 1 | ✓ 1000 Ω (1k) control | R236       |
| F1 | 10-936 | 1 | ✓ 1000 Ω (1k) control | R257       |
| F1 | 10-398 | 1 | ✓ 2000 Ω (2k) control | R251       |
| F1 | 10-904 | 1 | ✓ 5000 Ω (5k) control | R211       |

**HARDWARE**

|    |         |   |                     |
|----|---------|---|---------------------|
| G1 | 250-52  | 2 | ✓ 4-40 × 1/4" screw |
| G2 | 250-186 | 4 | ✓ #4 × 3/8" screw   |
| G3 | 252-15  | 2 | ✓ 4-40 nut          |
| G4 | 254-9   | 2 | ✓ #4 lockwasher     |

**MISCELLANEOUS**

|    |         |   |                      |    |
|----|---------|---|----------------------|----|
| H1 | 434-230 | 3 | ✓ 8-pin IC socket    |    |
| H2 | 434-298 | 5 | ✓ 14-pin IC socket   |    |
| H3 | 475-16  | 2 | ✓ Short ferrite bead | FB |
| H4 | 475-10  | 2 | ✓ Long ferrite bead  | FB |

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

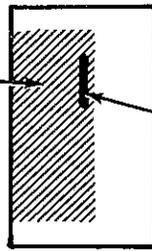
**PARTS FROM FINAL PACK**

|    |         |       |  |             |
|----|---------|-------|--|-------------|
| J1 | 63-1315 | 1     | ✓ Rotary switch with 5 kΩ and 10 kΩ controls | SW5-R10-R11 |
| H2 | 215-95  | 2     | ✓ Heat sink                                  |             |
|    | 85-2044 | 1     | ✓ Horizontal circuit board                   |             |
|    | 344-163 | 2'    | Black wire ✓                                 |             |
|    | 344-51  | 6'-8" | Brown wire ✓                                 |             |
|    | 344-165 | 1'    | Red wire ✓                                   |             |
|    | 344-166 | 1'    | Orange wire ✓                                |             |
|    | 344-167 | 1'    | Yellow wire ✓                                |             |
|    | 344-168 | 1'    | Green wire ✓                                 |             |
|    | 344-56  | 2'    | Blue wire ✓                                  |             |
|    | 344-170 | 1'    | Violet wire ✓                                |             |
|    | 344-58  | 2'    | Gray wire ✓                                  |             |
|    | 344-172 | 1'    | White wire ✓                                 |             |
|    | 344-173 | 1'    | White-black wire ✓                           |             |
|    | 344-174 | 1'    | White-brown wire ✓                           |             |
|    | 344-175 | 1'    | White-red wire ✓                             |             |
|    | 344-176 | 1'    | White-orange wire ✓                          |             |
|    | 344-177 | 1'    | White-yellow wire ✓                          |             |
|    | 344-178 | 1'    | White-green wire ✓                           |             |
|    | 344-179 | 1'    | White-blue wire ✓                            |             |
|    | 344-180 | 1'    | White-violet wire ✓                          |             |
|    | 344-181 | 1'    | White-gray wire ✓                            |             |



# STEP-BY-STEP ASSEMBLY

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



IDENTIFICATION DRAWING

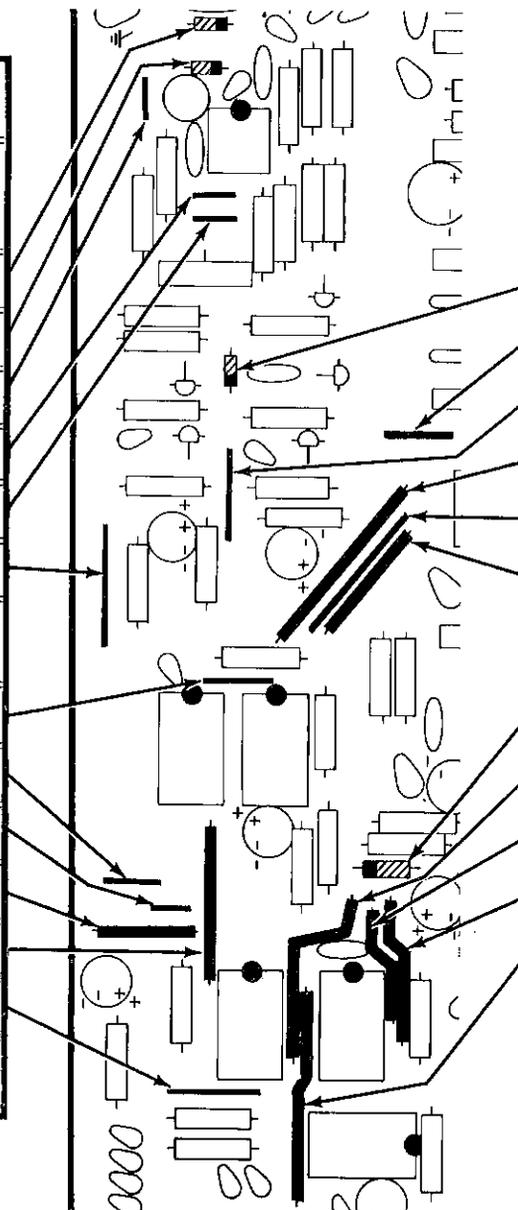
PART NUMBER

## START

Position the circuit board printed side up as shown.

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

- (✓) D201: 1N4149 diode (#56-56).
- (✓) D214: 1N4149 diode (#56-56).
- (✓) 1" bare wire.
- (✓) 1-3/8" bare wire.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) 1" bare wire.
- (✓) 1" bare wire.
- (✓) 1" bare wire.
- (✓) 1-1/8" brown wire.
- (✓) 1-5/8" brown wire.
- (✓) 1-1/8" bare wire.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



## CONTINUE

- (i) ✓ D204: 1N4149 diode (#56-56).
- (✓) 1" bare wire.
- (✓) 1-1/8" bare wire.
- (✓) 1-3/4" brown wire.
- (✓) 1-5/8" bare wire.
- (✓) 1-3/8" brown wire.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) D206: 1N750 diode (#56-59).
- (✓) 1-7/8" brown wire.
- (✓) 1-1/4" brown wire.
- (✓) 1-1/2" brown wire.
- (✓) 2" brown wire.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

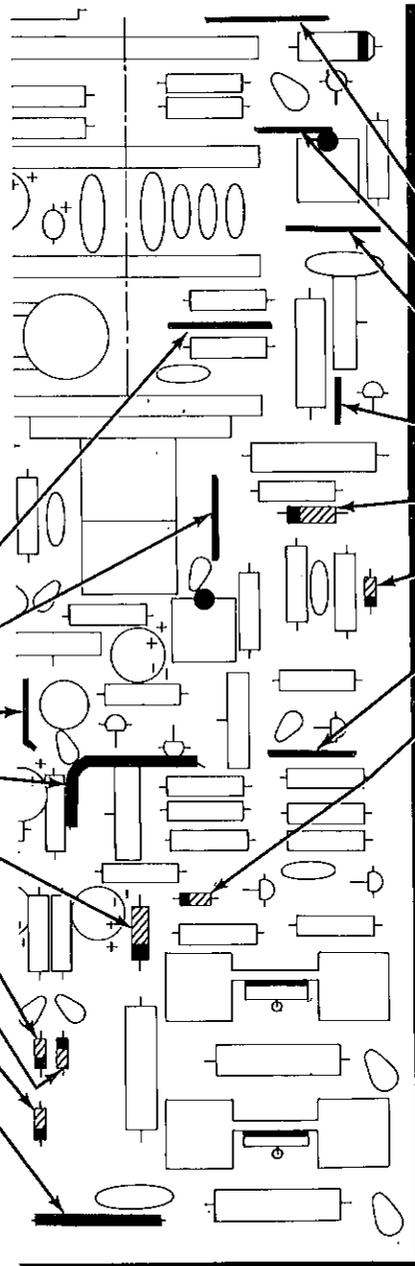
PICTORIAL 2-1

IDENTIFICATION  
DRAWING

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



PART  
NUMBER



**START** ↓

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

**CONTINUE** ↓

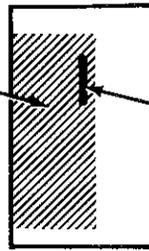
- (✓) 1-3/8" bare wire.
- (✓) 1" bare wire.
- (✓) 1-1/8" bare wire.
- (✓) 1" bare wire.
- (✓) D205: VR10 diode (#56-67).
- (✓) D209: 1N4149 diode (#56-56).
- (✓) 1-1/8" bare wire.
- (✓) D210: 1N4149 diode (#56-56).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-2



IDENTIFICATION  
DRAWING

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



PART  
NUMBER

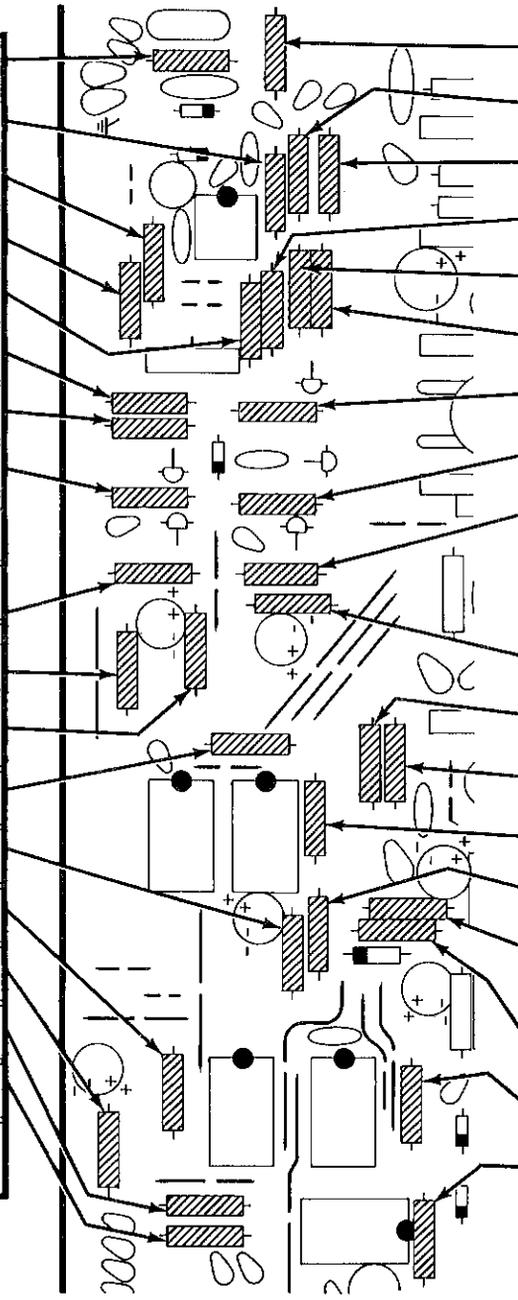
**START** →

- (✓) R201: 100 kΩ (brn-blk-yel).
- (✓) R204: 100 kΩ (brn-blk-yel).
- (✓) R207: 510 Ω (grn-brn-brn).
- (✓) R208: 1800 Ω (brn-gry-red).
- (✓) R206: 510 Ω (grn-brn-brn).
- (✓) R212: 270 Ω (red-viol-brn).
- (✓) R215: 47 Ω (yel-viol-blk).
- (✓) R216: 1800 Ω (brn-gry-red).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) R219: 1000 Ω (brn-blk-red).
- (✓) R241: 100 Ω (brn-blk-brn)\*.
- (✓) R281: 100 Ω (brn-blk-brn)\*.
- (✓) R229: 390 Ω (org-wht-brn).
- (✓) R228: 330 Ω (org-org-brn).
- (✓) R268: 1000 Ω (brn-blk-red).
- (✓) R277: 2.7 Ω (red-viol-gld).
- (✓) R278: 1000 Ω (brn-blk-red).
- (✓) R227: 1000 Ω (brn-blk-red).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

**CONTINUE** ↘

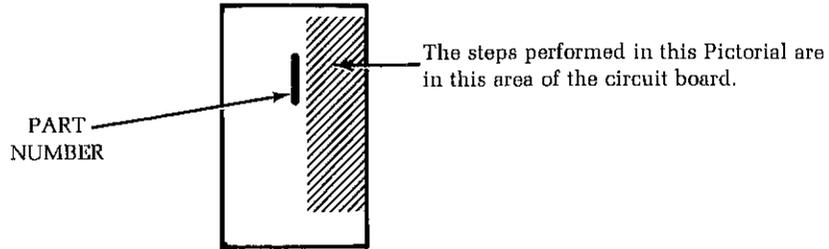
- (✓) R280: 1 MΩ (brn-blk-grn).
- (✓) R203: 1000 Ω (brn-blk-red).
- (✓) R202: 1000 Ω (brn-blk-red).
- (✓) R205: 1800 Ω (brn-gry-red).
- (✓) R210: 15 kΩ (brn-grn-org).
- (✓) R209: 330 Ω (org-org-brn).
- (✓) R214: 47 Ω (yel-viol-blk).
- (✓) R213: 1800 Ω (brn-gry-red).
- (✓) R218: 1000 Ω (brn-blk-red).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) R217: 820 Ω (gry-red-brn).
- (✓) R242: 910 kΩ (wht-brn-yel).
- (✓) R244: 10 Ω (brn-blk-blk).
- (✓) R237: 220 Ω (red-red-brn).
- (✓) R238: 220 Ω (red-red-brn).
- (✓) R276: 10 Ω (brn-blk-blk)\*.
- (✓) R275: 10 Ω (brn-blk-blk)\*.
- (✓) R222: 47 kΩ (yel-viol-org).
- (✓) R220: 47 kΩ (yel-viol-org).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

\*NOTE: The board may be lettered 2.7.



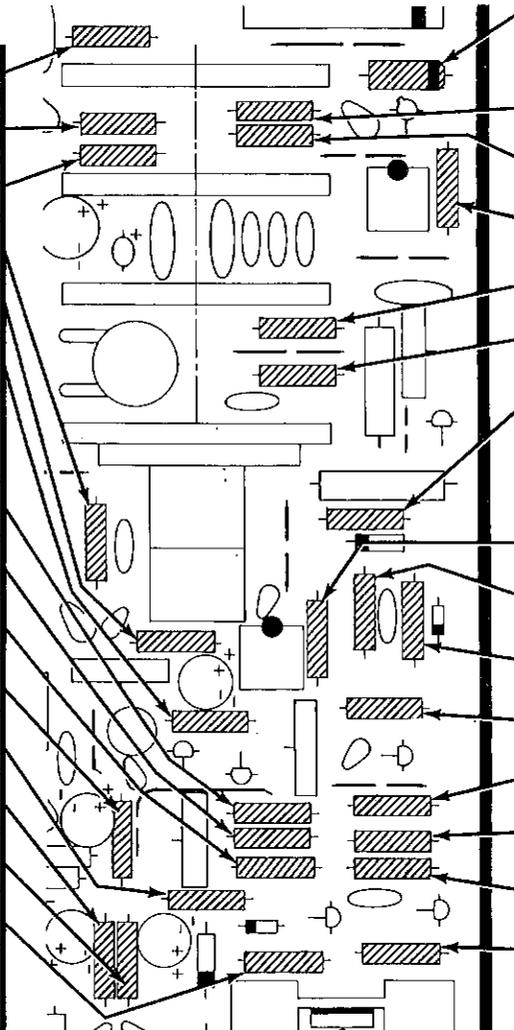
PICTORIAL 2-3

IDENTIFICATION  
DRAWING



**START** ↘

- (✓) R221: 1000 Ω (brn-blk-red).
- (✓) R223: 6.8 MΩ (blu-gry-grn).
- (✓) R224: 680 kΩ (blu-gry-yel).
- (✓) R243: 100 kΩ (brn-blk-yel).
- (✓) R274: 100 kΩ (brn-blk-yel).
- (✓) R254: 220 Ω (red-red-brn).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) R262: 1000 Ω (brn-blk-red).
- (✓) R256: 10 kΩ (brn-blk-org).
- (✓) R260: 220 Ω (red-red-brn).
- (✓) R255: 270 Ω (red-viol-brn).
- (✓) R282: 1000 Ω (brn-blk-red).
- (✓) R250: 1800 Ω (brn-gry-red).
- (✓) R248: 1500 Ω (brn-grn-red).
- (✓) R270: 10 Ω (brn-blk-blk).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



**CONTINUE** ↘

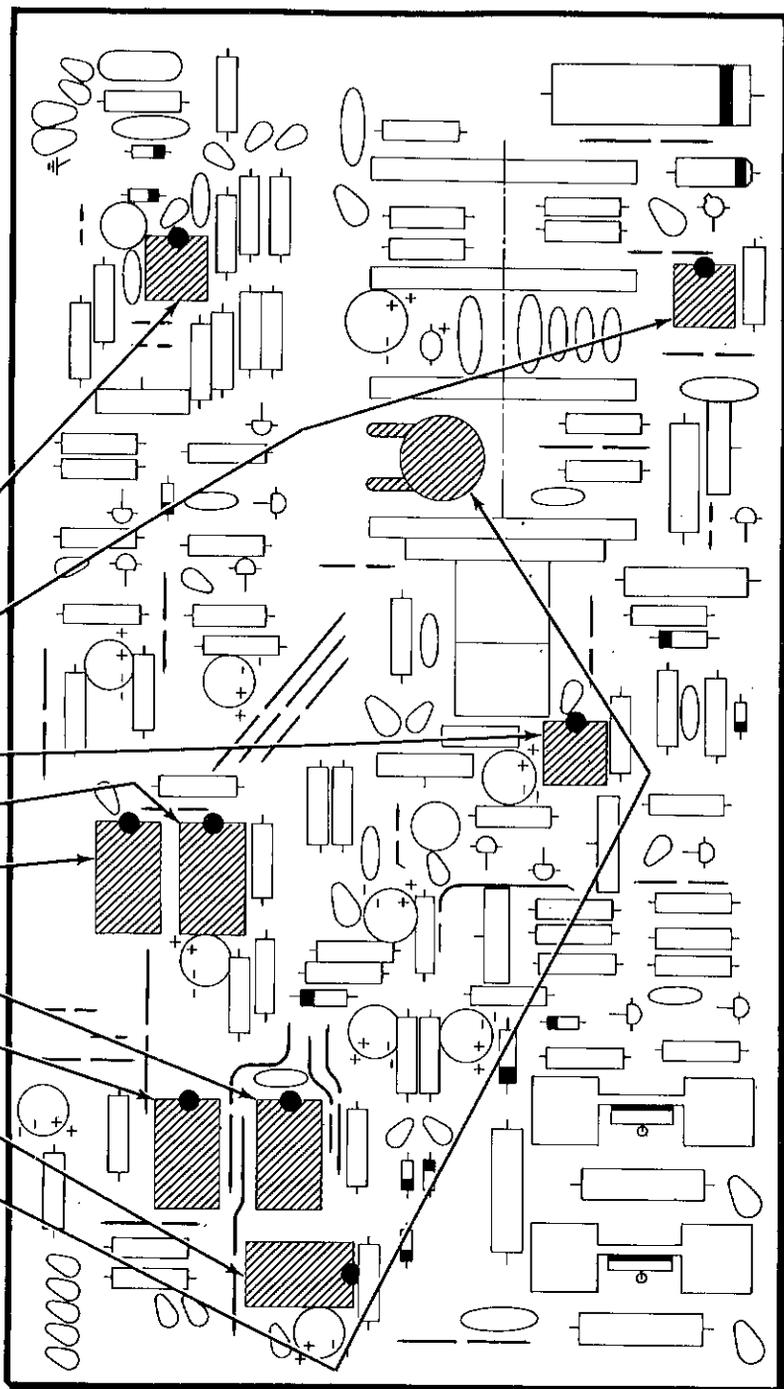
- (✓) C216: 1000 pF polystyrene. Match the band (colored end) on the capacitor with the band on the circuit board.
- (✓) R225: 68 kΩ (blu-gry-org).
- (✓) R226: 6800 Ω (blu-gry-red).
- (✓) R230: 220 Ω (red-red-brn).
- (✓) R273: 1000 Ω (brn-blk-red).
- (✓) R272: 2200 Ω (red-red-red).
- (✓) R235: 560 Ω (grn-blu-brn).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) R246: 220 Ω (red-red-brn).
- (✓) R240: 10 MΩ (brn-blk-blu).
- (✓) R239: 100 kΩ (brn-blk-yel).
- (✓) R253: 220 Ω (red-red-brn).
- (✓) R245: 1000 Ω (brn-blk-red).
- (✓) R258: 560 Ω (grn-blu-brn).
- (✓) R259: 220 Ω (red-red-brn).
- (✓) R269: 10 Ω (brn-blk-blk).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-4

**START** →

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

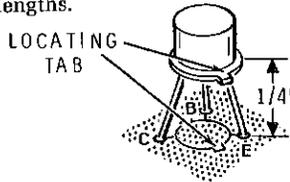
- ( / ) 8-pin IC socket at Q201.
- ( / ) 8-pin IC socket at Q207.
- ( / ) 8-pin IC socket at Q208.
- ( / ) 14-pin IC socket at U204.
- ( / ) 14-pin IC socket at U202.
- ( / ) 14-pin IC socket at U205.
- ( / ) 14-pin IC socket at U201.
- ( / ) 14-pin IC socket at U203.
- ( / ) R236: 1000  $\Omega$  (1k) control (#10-391).



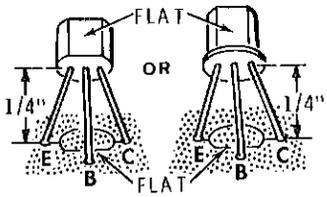
PICTORIAL 2-5

**START** →

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



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



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

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

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

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

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

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

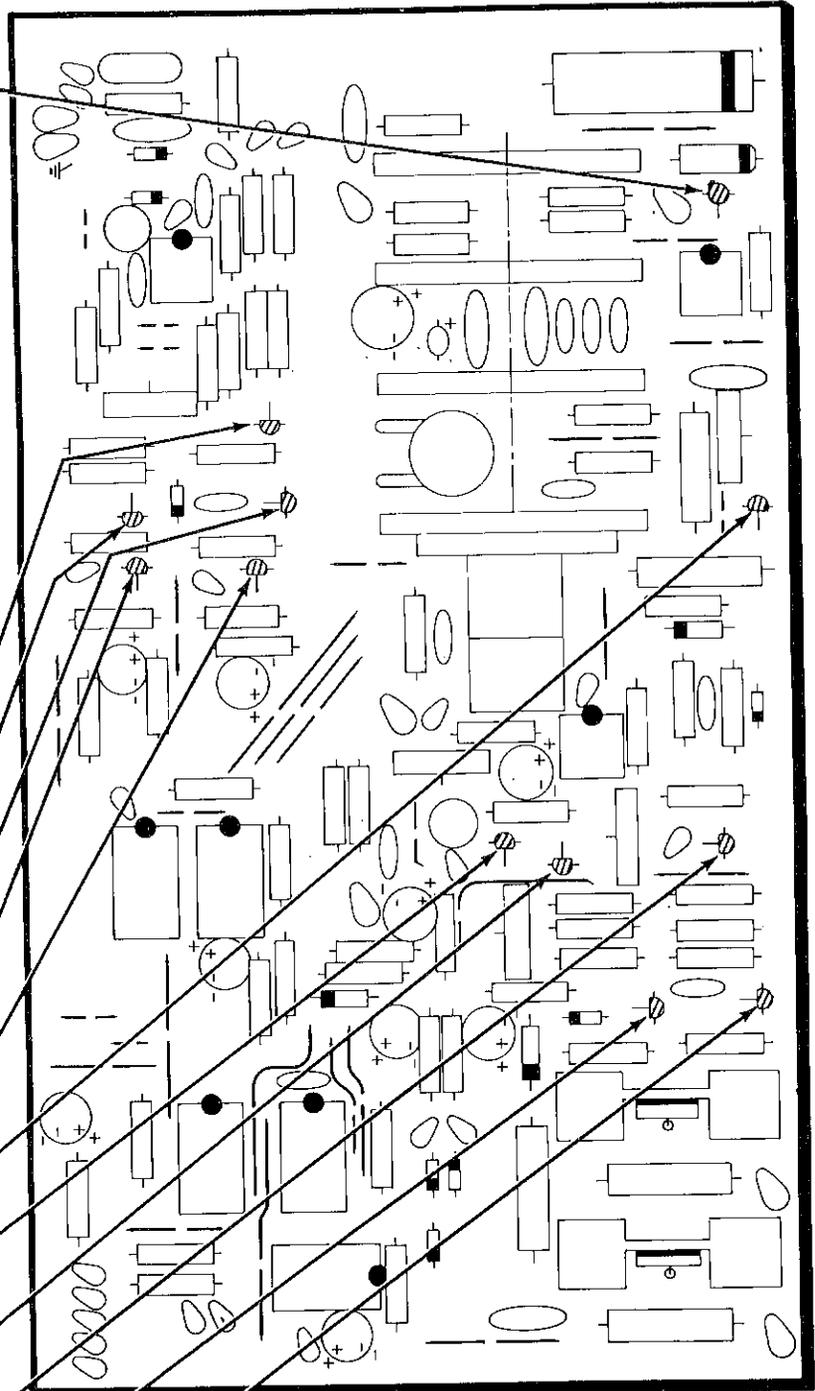
(✓) Q211: MPSA20 transistor (#417-801).

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

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

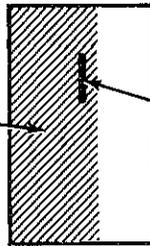
(✓) Q213: MPS6520 transistor (#417-134).

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



**PICTORIAL 2-6**

IDENTIFICATION  
DRAWING



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

PART  
NUMBER

**START** ▾

C201: .1  $\mu$ F Mylar.

C202: .01  $\mu$ F ceramic.

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

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

C203: 10  $\mu$ F NP electrolytic.

C204: 33 pF ceramic.

C205: 56 pF ceramic.

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

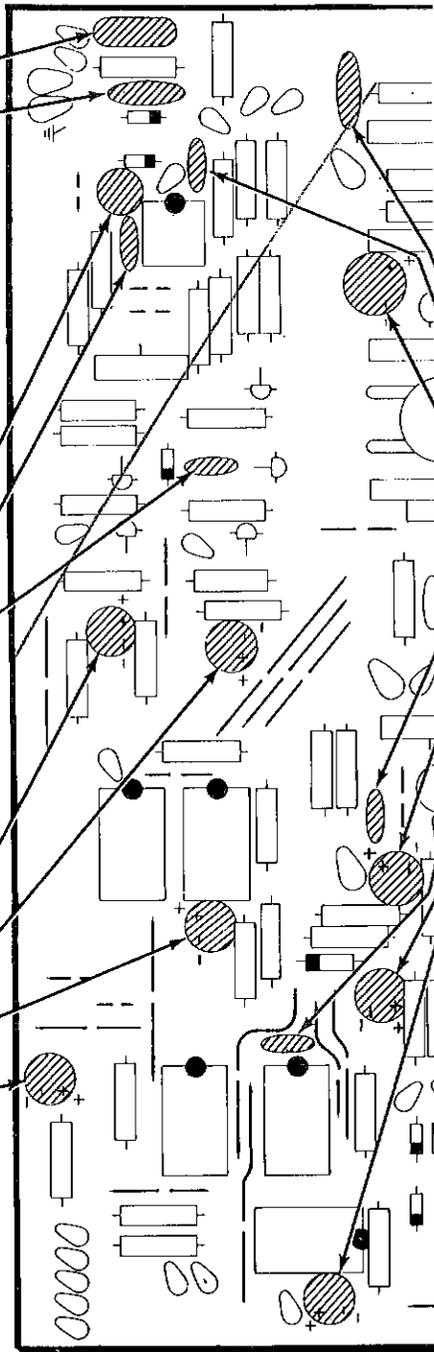
C225: 10  $\mu$ F electrolytic.

C234: 10  $\mu$ F electrolytic.

C217: 10  $\mu$ F electrolytic.

C227: 10  $\mu$ F electrolytic.

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



**CONTINUE** ▾

C228: .1  $\mu$ F ceramic.

C229: .002  $\mu$ F ceramic.

C207: 22  $\mu$ F electrolytic.

C219: 5 pF ceramic.

C231: 10  $\mu$ F electrolytic.

C214: 470 pF ceramic.

C230: 10  $\mu$ F electrolytic.

C206: 10  $\mu$ F electrolytic.

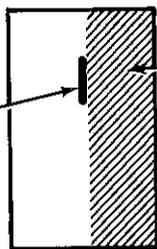
Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-7

IDENTIFICATION  
DRAWING

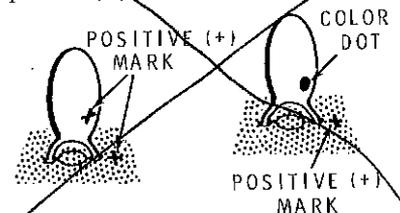
PART  
NUMBER

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



**START**

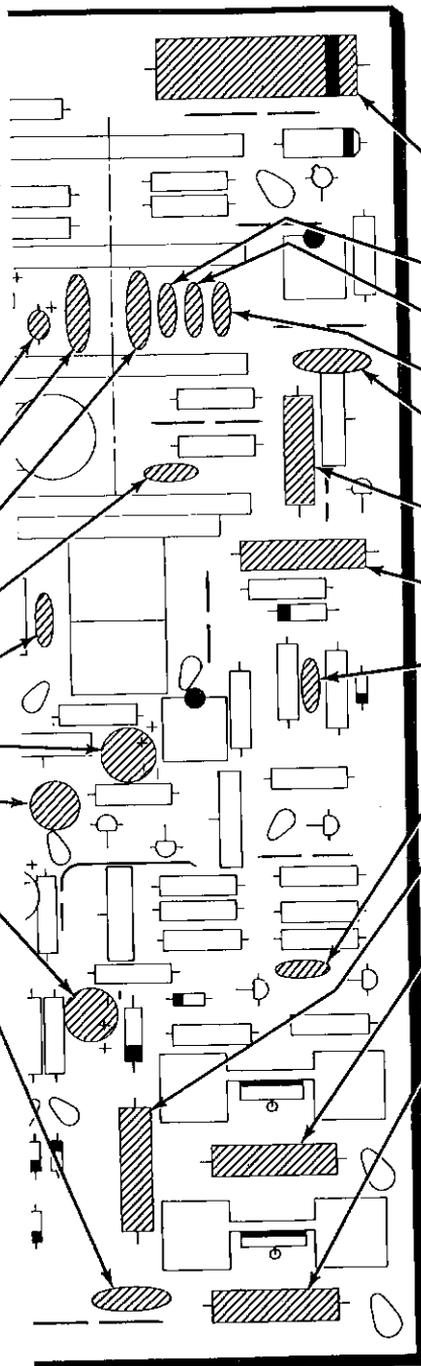
NOTE: When you install a tantalum capacitor, match the positive (+) mark, or color dot on the capacitor with the positive (+) mark on the board.



- (✓) C208: 2.2  $\mu$ F tantalum electrolytic
- (✓) C209: .1  $\mu$ F ceramic.
- (✓) C210: .02  $\mu$ F ceramic.
- (✓) C235: 47 pF ceramic.
- (✓) C220: 47 pF ceramic.
- (✓) C226: 10  $\mu$ F electrolytic.
- (✓) C221: 10  $\mu$ F NP electrolytic.
- (✓) C223: 10  $\mu$ F electrolytic.
- (✓) C224: .01  $\mu$ F ceramic.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

**CONTINUE**

- ( ) C215: 1  $\mu$ F film. Match the band on the capacitor with the band on the circuit board.
- (✓) C211: .002  $\mu$ F ceramic.
- (✓) C212: 100 pF ceramic.
- (✓) C213: 56 pF ceramic.
- (✓) C232: .1  $\mu$ F ceramic.
- (✓) R232: 680  $\Omega$ , 1-watt (blu-gry-brn).
- (✓) R233: 22 k $\Omega$ , 2-watt.
- (✓) C218: .002  $\mu$ F ceramic.
- (✓) C222: 200 pF ceramic.
- (✓) R264: 22 k $\Omega$ , 2-watt.
- (✓) R265: 5600  $\Omega$ , 2-watt (grn-blur-red).
- (✓) R263: 5600  $\Omega$ , 2-watt (grn-blur-red).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 2-8

**START** →

NOTE: Solder the pins to the foil as each part is installed.

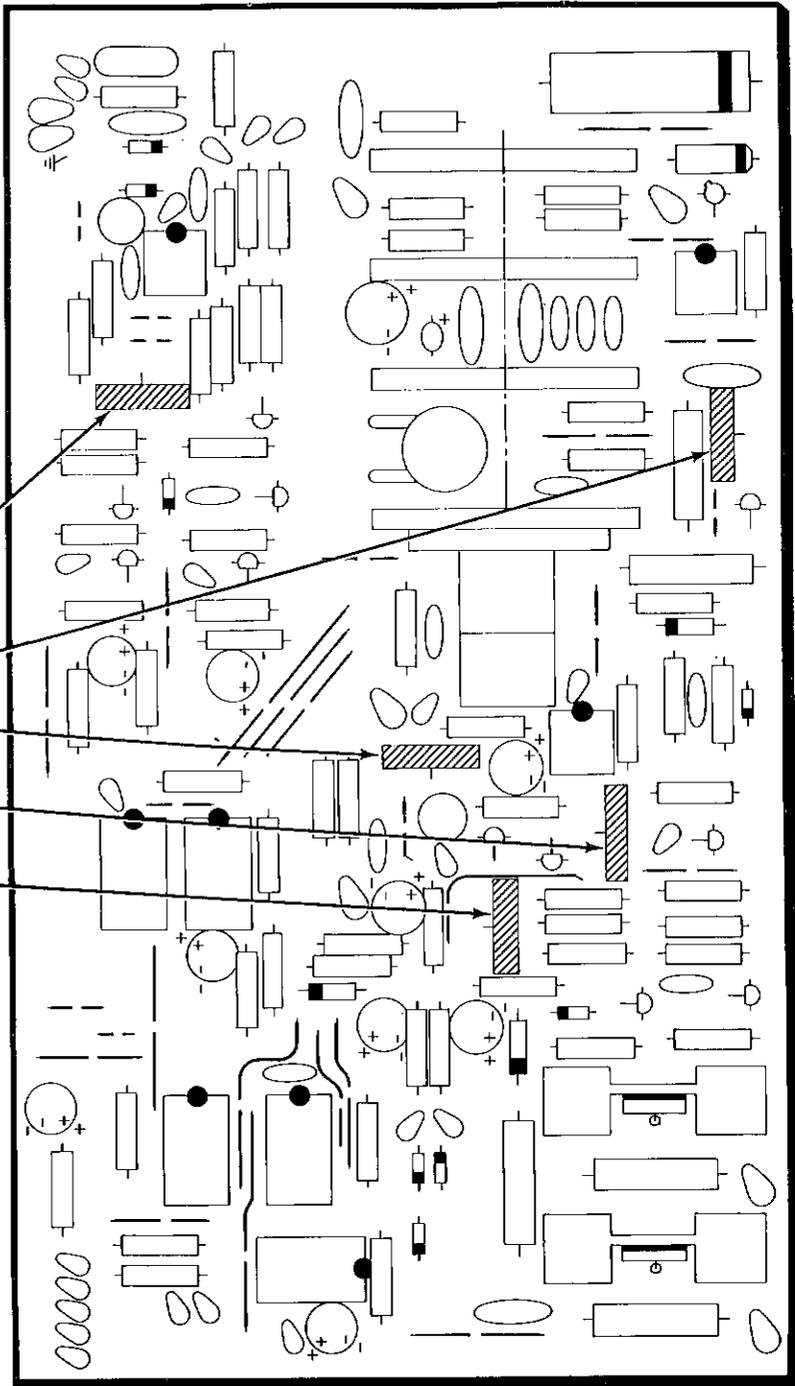
( / R211: 5000  $\Omega$  (5k) control (#10-904).

( / R231: 500  $\Omega$  control (#10-918).

( / R247: 500  $\Omega$  control (#10-918).

( / R251: 2000  $\Omega$  (2k) control (#10-398).

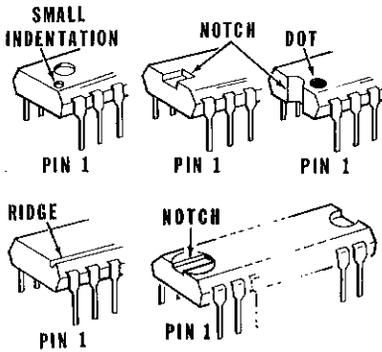
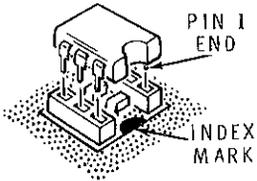
( / R257: 1000  $\Omega$  (1k) control (#10-936).



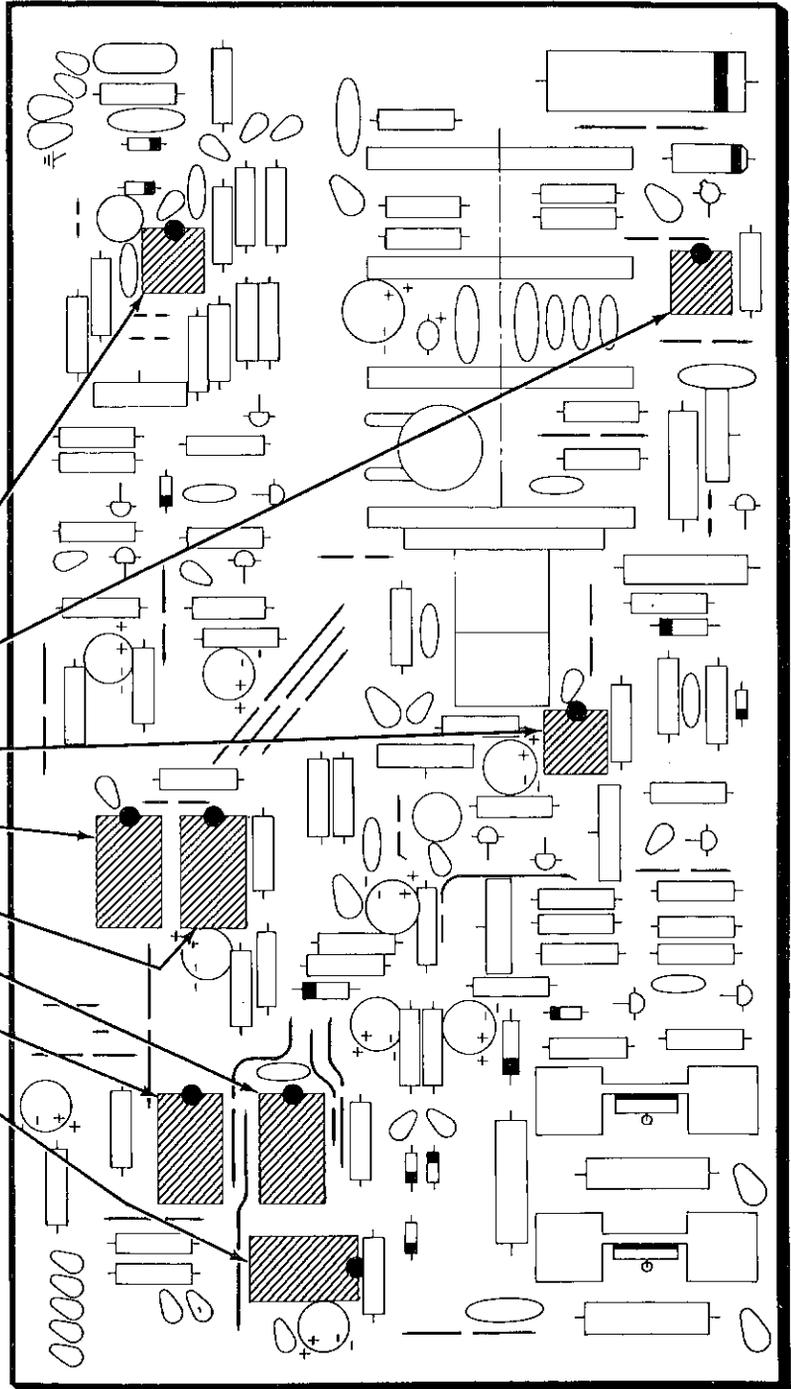
PICTORIAL 2-9

**START**

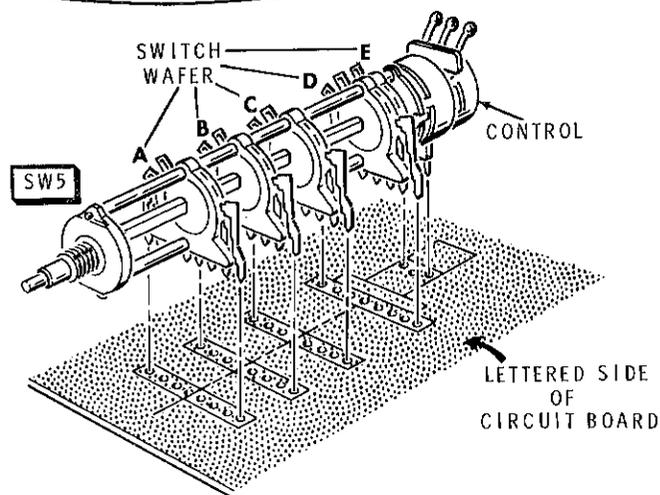
Align the pin 1 end of the IC with the index mark on the circuit board as you install each integrated circuit or transistor.



- (✓) Q201: 5566 transistor (#417-902).
- (✓) Q207: 5566 transistor (#417-902).
- (✓) Q208: 5566 transistor (#417-902).
- (✓) U202: 74132 IC (#443-625).
- (✓) U204: 7413 IC (#443-44).
- (✓) U205: 74121 IC (#443-22).
- (✓) U201: 7474 IC (#443-6).
- (✓) U203: 74122 IC (#443-23).



PICTORIAL 2-10



Detail 2-11A

Refer to Pictorial 2-11 (Illustration Booklet, Page 4) for the following steps.

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

1. Carefully align the pins of the front wafer (A) with their holes in the circuit board.
2. Fit the pins of each switch wafer, one wafer at a time, into their board holes until all the switch pins and the pins of control R11 are in place. Then push the switch down tight against the circuit board.
3. Carefully turn the circuit board over and solder **only** the end pins in each wafer to the foil. Inspect these switch pins to make sure all the pins are tight against the printed side of the circuit board. If they are not, reheat the connection and push the switch tight against the board. Then solder all the remaining switch and control pins to the foil.

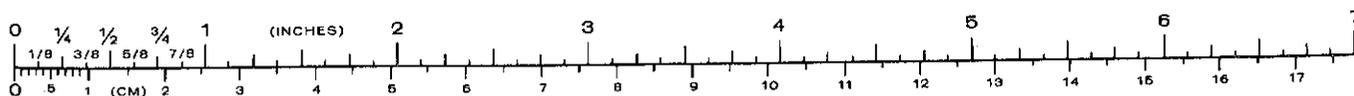
(✓) Prepare the following brown wires.

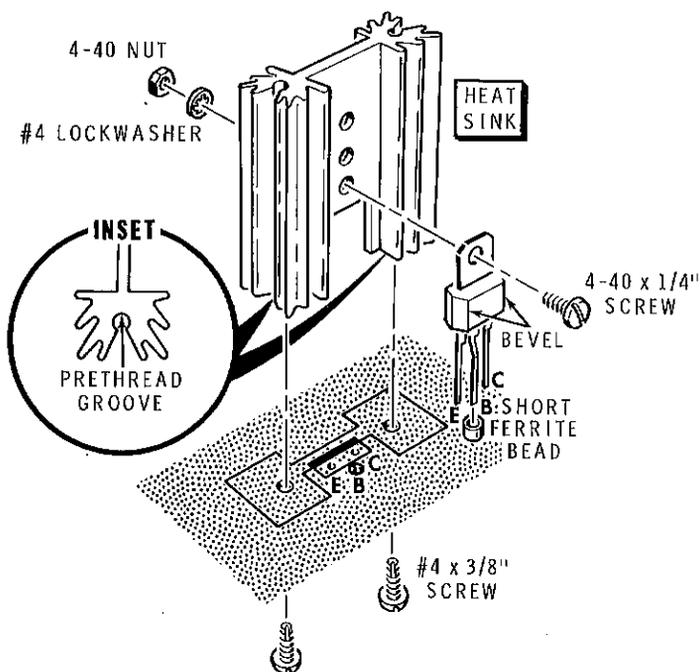
|        |        |
|--------|--------|
| 3-1/4" | 3-1/4" |
| 2"     | 3-1/4" |
| 2-1/4" | 4-1/4" |
| 2"     |        |

- (✓) Remove an extra 1/2" of insulation (total 3/4") from one end of a 3-1/4" brown wire.
- (✓) Connect the longer bared end of this wire to switch SW5 wafer A through lug 5 (S-2) to lug 4 (S-1). Connect the other end of this wire in circuit board hole B9 (S-1).
- (✓) Remove an extra 1/2" of insulation (total 3/4") from one end of a 2" brown wire.
- (✓) Connect the longer bared end of this wire to switch SW5 wafer B through lug 4 (S-2) to lug 5 (S-1). Connect the other end of this wire in circuit board hole A9 (S-1).
- (✓) Connect a 2-1/4" brown wire from switch SW5 wafer E lug 9.(S-1) to control R11 lug 3 (NS).
- (✓) Connect a 2" brown wire from switch SW5 wafer E lug 8 (S-1) to control R11 lug 2 (NS).
- (✓) Connect a 3-1/4" brown wire from circuit board hole D9 (S-1) to switch SW5 wafer D lug 5 (S-1).
- (✓) Connect a 3-1/4" brown wire from circuit board hole M (S-1) to switch SW5 wafer E lug 4 (S-1).
- (✓) Connect a 4-1/4" brown wire from circuit board hole D8 (S-1) to switch SW5 wafer D lug 4 (S-1).

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

- (✓) Prepare a 3" and a 2" brown wire.
- (✓) Connect a 3" brown wire from circuit board hole J (S-1) to control R11 lug 2 (S-2).
- (✓) Connect a 2" brown wire from circuit board hole I (S-1) to control R11 lug 3 (S-2).
- (✓) R12: Connect a 1000  $\Omega$ , 1/2-watt (brn-blk-red) resistor from switch SW5 wafer E lug 5 (S-1) to control R11 lug 1 (S-1). Use a 1/2" length of sleeving on each lead.





Detail 2-11B

- (✓) Refer to Detail 2-11B and prethread the two grooves in the bottom of both heat sinks. Use a #4 × 3/8" screw.
- (✓) Refer to Detail 2-11B and install an MPSU10 transistor (#417-834) on a heat sink with 4-40 × 1/4" hardware. Be sure the beveled edges of the transistor are positioned as shown.
- (✓) In the same manner, install another MPSU10 transistor (#417-834) on a heat sink.
- (✓) Q215: Place a **short** ferrite bead on the center lead of one of these transistors. Insert the E, B, and C leads of the transistor into their corresponding holes in the circuit board at location Q215. Secure the heat sink to the circuit board with two #4 × 3/8" screws. Then solder the transistor leads to the foil and cut off the excess lead lengths.
- (✓) Q214: In the same manner, install the other transistor and a **short** ferrite bead at location Q214 on the circuit board.

Refer to Pictorial 2-12 (Illustration Booklet, Page 5) for the following steps.

( ) Prepare the following wires.

|                    |                     |
|--------------------|---------------------|
| 8" orange          | 8" red              |
| 6-1/2" white-black | 7-1/2" white-violet |
| 6-1/2" violet      | 9-1/2" white-yellow |
| 6-1/2" white-blue  | 9-1/2" white-gray   |
| 4-1/2" black       |                     |

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

- (✓) 8" orange wire to hole K (S-1).
- (✓) 6-1/2" white-black wire to hole L (S-1).
- (✓) 6-1/2" violet wire to hole AA (S-1).
- (✓) 6-1/2" white-blue wire to hole BB (S-1).
- (✓) 4-1/2" black wire to hole (⊥) ground (S-1).
- (✓) 8" red wire to hole B (S-1).
- (✓) 7-1/2" white-violet wire to hole N (S-1).
- (✓) 9-1/2" white-yellow wire to hole C (S-1).
- (✓) 9-1/2" white-gray wire to hole A (S-1).
- ( ) Prepare the following wires.

|                |                  |
|----------------|------------------|
| 7" white-brown | 12" white-orange |
| 8" white-green | 12" white-red    |
| 9" brown       | 12" white        |
| 8-1/2" yellow  | 10" blue         |
| 12" green      | 9-1/2" gray      |

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

- (✓) 7" white-brown wire to hole Q (S-1).



- ( / ) 8" white-green wire to hole P (S-1).
- ( / ) 9" brown wire to hole EXT (S-1).
- ( / ) 8-1/2" yellow wire to hole R (S-1).
- ( / ) 12" green wire to hole E (S-1).
- ( / ) 12" white-orange wire to hole F (S-1).
- ( / ) 12" white-red wire to hole D (S-1).
- ( / ) 12" white wire to hole G (S-1).
- ( / ) Remove an extra 1/2" (total 3/4") of insulation from only one end of the remaining blue and gray wires. Pass the longer bared end of each wire through the ferrite bead in the next two steps.

Refer to the inset drawing on Pictorial 2-12 and connect only one end of the two following wires to the **foil** side of the horizontal circuit board. Their free ends will be connected later.

- ( / ) 10" blue wire with a long ferrite bead to hole X2 (S-1).
- ( / ) 9-1/2" gray wire with a long ferrite bead to hole X1 (S-1).

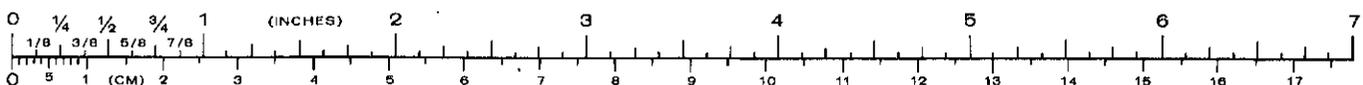
## CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

- ( / ) Unsoldered connections.
- ( / ) Poor solder connections.
- ( / ) Solder bridges between foil patterns.
- ( / ) Protruding leads which could touch together.
- ( / ) Transistors for the proper type and installation.
- ( / ) Electrolytic capacitors for the correct position of the positive (+) end.
- ( / ) Diodes for the proper type and the correct position of the banded end.
- ( / ) IC's for the proper type and installation.

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

Save the remaining parts and wire for use later.



# POWER SUPPLY CIRCUIT BOARD

## PARTS LIST

Open the pack marked #3 and check each part against the following list. The key numbers correspond to the numbers on the Power Supply Circuit Board Parts Pictorial (Illustration Booklet, Page 6).

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

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

### RESISTORS

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

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

#### 1/2-Watt

|    |       |   |   |                       |                     |
|----|-------|---|---|-----------------------|---------------------|
| A1 | 6-510 | ✓ | 1 | 51 Ω (grn-brn-blk)    | R322                |
| A1 | 6-471 | ✓ | 1 | 470 Ω (yel-viol-brn)  | R332                |
| A1 | 6-511 | ✓ | 1 | 510 Ω (grn-brn-brn)   | R325                |
| A1 | 6-561 | ✓ | 1 | 560 Ω (grn-blu-brn)   | R307                |
| A1 | 6-102 | ✓ | 3 | 1000 Ω (brn-blk-red)  | R311, R314,<br>R320 |
| A1 | 6-152 | ✓ | 1 | 1500 Ω (brn-grn-red)  | R341                |
| A1 | 6-182 | ✓ | 3 | 1800 Ω (brn-gry-red)  | R312, R313,<br>R342 |
| A1 | 6-222 | ✓ | 1 | 2200 Ω (red-red-red)  | R317                |
| A1 | 6-432 | ✓ | 1 | 4300 Ω (yel-org-red)  | R334                |
| A1 | 6-472 | ✓ | 1 | 4700 Ω (yel-viol-red) | R315                |
| A1 | 6-752 | ✓ | 1 | 7500 Ω (viol-grn-red) | R316                |
| A1 | 6-682 | ✓ | 2 | 6800 Ω (blu-gry-red)  | R335, R336          |
| A1 | 6-103 | ✓ | 1 | 10 kΩ (brn-blk-org)   | R331                |
| A1 | 6-123 | ✓ | 1 | 12 kΩ (brn-red-org)   | R326                |

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

### Resistors (Cont'd.)

|    |       |   |   |                       |                     |
|----|-------|---|---|-----------------------|---------------------|
| A1 | 6-153 | ✓ | 2 | 15 kΩ (brn-grn-org)   | R328, R329          |
| A1 | 6-183 | ✓ | 1 | 18 kΩ (brn-gry-org)   | R321                |
| A1 | 6-273 | ✓ | 1 | 27 kΩ (red-viol-org)  | R327                |
| A1 | 6-473 | ✓ | 2 | 47 kΩ (yel-viol-org)  | R318, R338          |
| A1 | 6-104 | ✓ | 3 | 100 kΩ (brn-blk-yel)  | R319, R333,<br>R339 |
| A1 | 6-474 | ✓ | 1 | 470 kΩ (yel-viol-yel) | R324                |
| A1 | 6-105 | ✓ | 1 | 1 MΩ (brn-blk-grn)    | R323                |

### Other Resistors

|    |         |   |   |                                    |                     |
|----|---------|---|---|------------------------------------|---------------------|
| A2 | 6-224-1 | ✓ | 1 | 220 kΩ, 1-watt, 10% (red-red-yel)  | R308                |
| A2 | 6-474-1 | ✓ | 3 | 470 kΩ, 1-watt, 10% (yel-viol-yel) | R301, R309,<br>R310 |
| A2 | 3-5-2   | ✓ | 1 | 2.2 Ω, 2-watt, 10% (red-red-gld)   | R302                |
| A2 | 3-11-2  | ✓ | 1 | 3.9 Ω, 2-watt, 10% (org-wht-gld)   | R303                |
| A3 | 5-1-3   | ✓ | 1 | 2700 Ω (2.7 kΩ) 3-watt, 10%        | R306                |

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

### CAPACITORS

#### Ceramic

|    |        |     |               |            |
|----|--------|-----|---------------|------------|
| B1 | 21-33  | / 1 | 3.3 pF        | C317       |
| B1 | 21-120 | / 2 | 500 pF        | C314, C315 |
| B1 | 21-141 | / 1 | .0033 $\mu$ F | C319       |
| B1 | 21-16  | / 1 | .01 $\mu$ F † | C318       |

#### Other Capacitors

|    |               |     |                                      |                        |
|----|---------------|-----|--------------------------------------|------------------------|
| B2 | 28-2          | / 1 | 1 pF phenolic (brn-blk-wht)          | C312                   |
| B3 | 27-47         | / 1 | .1 $\mu$ F Mylar                     | C316                   |
| B4 | 23-115        | / 3 | .1 $\mu$ F paper                     | C301, C302, C303       |
| B6 | 25-897<br>923 | / 3 | 1.5 $\mu$ F Tantalum<br>ELECTROLYTIC | C309, C310, C311       |
| B6 | 25-288        | / 1 | 25 $\mu$ F electrolytic              | C320                   |
| B7 | 25-241        | / 4 | 1200 $\mu$ F electrolytic            | C304, C305, C306, C307 |

### DIODES

|    |        |     |                     |  |
|----|--------|-----|---------------------|--|
| C1 | 56-26  | / 1 | 1N191 (brn-wht-brn) | D314   |
| C1 | 56-56  | / 7 | 1N4149              | D312, D315, D316, D318, D319, D320, D321       |
| C1 | 56-89  | / 1 | GD510               | D313   |
| C1 | 56-634 | / 2 | 2EZ82D5             | D311, D317                                     |
| C1 | 57-27  | / 8 | 1N2071              | D303, D304, D305, D306, D307, D308, D309, D310 |
| C1 | 57-52  | / 2 | DO7                 | D301, D302                                     |

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

### TRANSISTORS—INTEGRATED CIRCUITS (IC's)

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

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

|    |         |     |                   |                        |
|----|---------|-----|-------------------|------------------------|
| D1 | 417-237 | / 2 | SE6020 transistor | Q301, Q302             |
| D1 | 417-295 | / 1 | MPSL51 transistor | Q305                   |
| D1 | 417-811 | / 4 | MPSL01 transistor | Q303, Q304, Q306, Q307 |
| D2 | 442-617 | / 2 | UA78              | U301, U302             |
| D2 | 442-618 | / 1 | UA79              | U303                   |

### MISCELLANEOUS

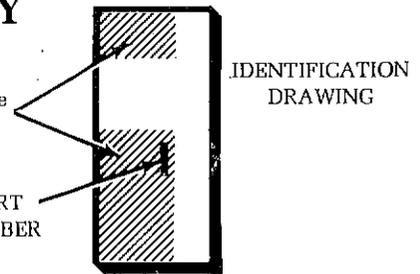
|    |         |     |                          |      |
|----|---------|-----|--------------------------|------|
| E1 | 10-312  | / 1 | 10 k $\Omega$ control    | R340 |
| E1 | 10-941  | / 1 | 100 k $\Omega$ control   | R330 |
| E2 | 215-629 | / 3 | Heat sink                |      |
| E3 | 250-49  | / 6 | 3-48 $\times$ 1/4" screw |      |
| E4 | 252-1   | / 6 | 3-48 nut                 |      |
| E5 | 254-7   | / 6 | #3 lockwasher            |      |

### PARTS FROM FINAL PACK

|    |           |     |                            |  |
|----|-----------|-----|----------------------------|--|
| E6 | 85-2045-2 | / 1 | Power supply circuit board |  |
| E6 | 354-7     | / 6 | Cable tie                  |  |

# STEP-BY-STEP ASSEMBLY

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

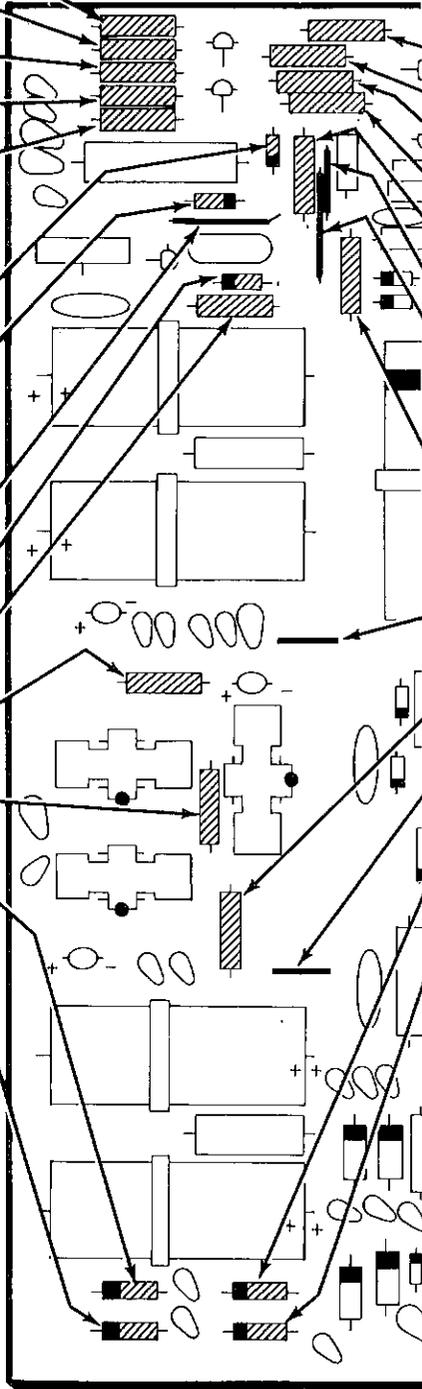


## START

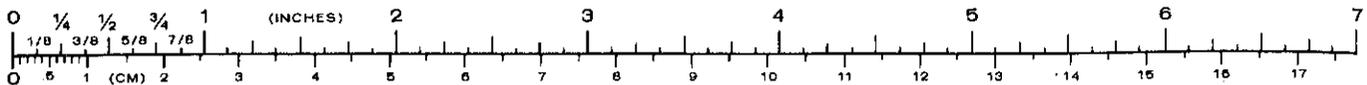
- ( / ) R311: 1000  $\Omega$  (brn-blk-red).
- ( ) R314: 1000  $\Omega$  (brn-blk-red).
- ( / ) R313: 1800  $\Omega$  (brn-gry-red).
- ( / ) R312: 1800  $\Omega$  (brn-gry-red).
- ( / ) R315: 4700  $\Omega$  (yel-viol-red).
- NOTE: When you install a diode, always match the band on the diode with the band on the circuit board.
- ( / ) D315: 1N4149 diode (#56-56).
- ( / ) D314: 1N191 diode (brn-wht-brn, #56-26).
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.
- ( / ) 1-1/4" brown wire.
- ( / ) D311: 2EZ82D5 zener diode (#56-634).
- ( / ) R339: 100 k $\Omega$  (brn-blk-yel).
- ( / ) R336: 6800  $\Omega$  (blu-gry-red).
- ( / ) R335: 6800  $\Omega$  (blu-gry-red).
- ( / ) D304: 1N2071 diode (#57-27).
- ( / ) D303: 1N2071 diode (#57-27).
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.

## CONTINUE

- ( / ) R320: 1000  $\Omega$  (brn-blk-red).
- ( / ) R319: 100 k $\Omega$  (brn-blk-yel).
- ( / ) R316: 7500  $\Omega$  (viol-grn-red).
- ( / ) R317: 2200  $\Omega$  (red-red-red).
- ( / ) R318: 47 k $\Omega$  (yel-viol-org).
- ( / ) 1" brown wire.
- ( / ) 1-1/4" brown wire.
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.
- ( / ) R328: 15 k $\Omega$  (brn-grn-org).
- ( / ) 1" bare wire.
- ( / ) R334: 4300  $\Omega$  (yel-org-red).
- ( / ) 1" bare wire.
- ( / ) D306: 1N2071 diode (#57-27).
- ( / ) D305: 1N2071 diode (#57-27).
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 3-1





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

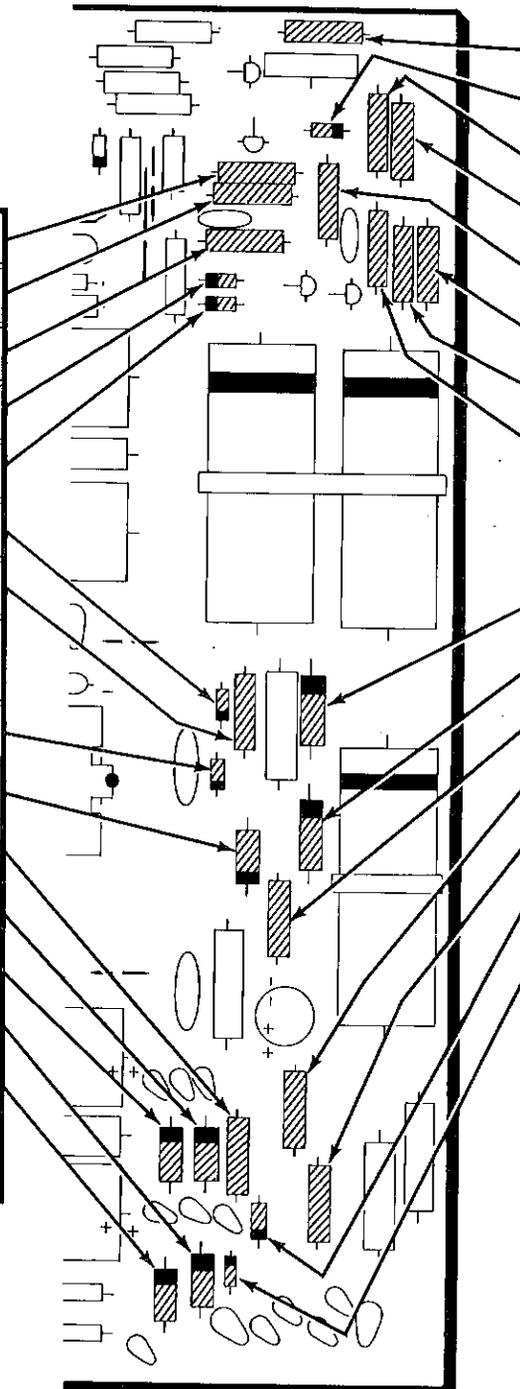


IDENTIFICATION DRAWING

PART NUMBER

**START** →

- ( / ) R321: 18 kΩ (brn-gry-org).
- ( / ) R326: 12 kΩ (brn-red-org).
- ( / ) R327: 27 kΩ (red-viol-org).
- ( / ) D318: 1N4149 diode (#56-56).
- ( / ) D319: 1N4149 diode (#56-56).
- ( / ) D316: 1N4149 diode (#56-56).
- ( / ) R323: 1 MΩ (brn-blk-grn).
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.
- ( / ) D320: 1N4149 diode (#56-56).
- ( / ) D317: 2EZ82D5 zener diode (#56-634).
- ( / ) R307: 560 Ω (grn-blu-brn).
- ( / ) D310: 1N2071 diode (#57-27).
- ( / ) D309: 1N2071 diode (#57-27).
- ( / ) D308: 1N2071 diode (#57-27).
- ( / ) D307: 1N2071 diode (#57-27).
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.



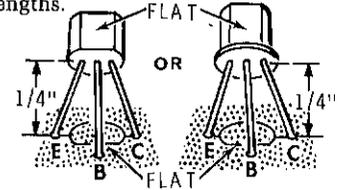
**CONTINUE** →

- ( / ) R322: 51 Ω (grn-brn-blk).
- ( / ) D321: 1N4149 diode (#56-56).
- ( / ) R341: 1500 Ω (brn-grn-red).
- ( / ) R342: 1800 Ω (brn-gry-red).
- ( / ) R329: 15 kΩ (brn-grn-org).
- ( / ) R332: 470 Ω (yel-viol-brn).
- ( / ) R331: 10 kΩ (brn-blk-org).
- ( / ) R333: 100 kΩ (brn-blk-yel).
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.
- ( / ) D301: DO7 diode (#57-52).
- ( / ) D302: DO7 diode (#57-52).
- ( / ) R338: 47 kΩ (yel-viol-org).
- ( / ) R324: 470 kΩ (yel-viol-yel).
- ( / ) R325: 510 Ω (grn-brn-brn).
- ( / ) D313: GD510 diode (#56-89).
- ( / ) D312: 1N4149 diode (#56-56).
- ( / ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 3-2

**START**

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



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

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

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

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

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

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

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

(✓) R306: 2700  $\Omega$  (2.7k) 3-watt.

(✓) R303: 3.9  $\Omega$ , 2-watt (org-wht-gld).

(✓) R301: 470 k $\Omega$ , 1-watt (yel-viol-yel).

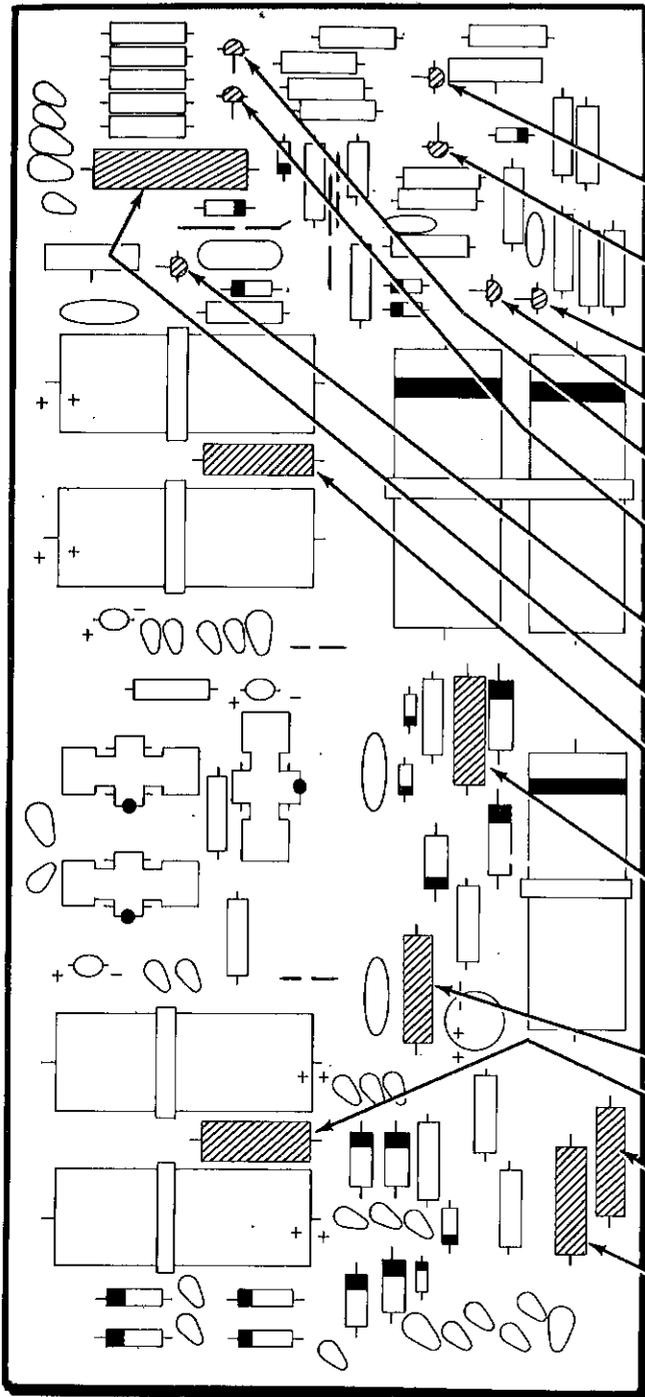
(✓) R308: 220 k $\Omega$ , 1-watt (red-red-yel).

(✓) R302: 2.2  $\Omega$ , 2-watt (red-red-gld).

(✓) R310: 470 k $\Omega$ , 1-watt (yel-viol-yel).

(✓) R309: 470 k $\Omega$ , 1-watt (yel-viol-yel).

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



PICTORIAL 3-3

**START** 

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

(✓) R340: 10 kΩ control (#10-312).

(✓) R330: 100 kΩ control (#10-941).

(✓) C318: .01 μF ceramic.

(✓) C316: .1 μF Mylar.

(✓) C312: 1 pF phenolic (brn-blk-wht).

(✓) C317: 3.3 pF ceramic.

(✓) C319: .0033 μF ceramic.

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

(✓) C311: 1.5 μF tantalum.

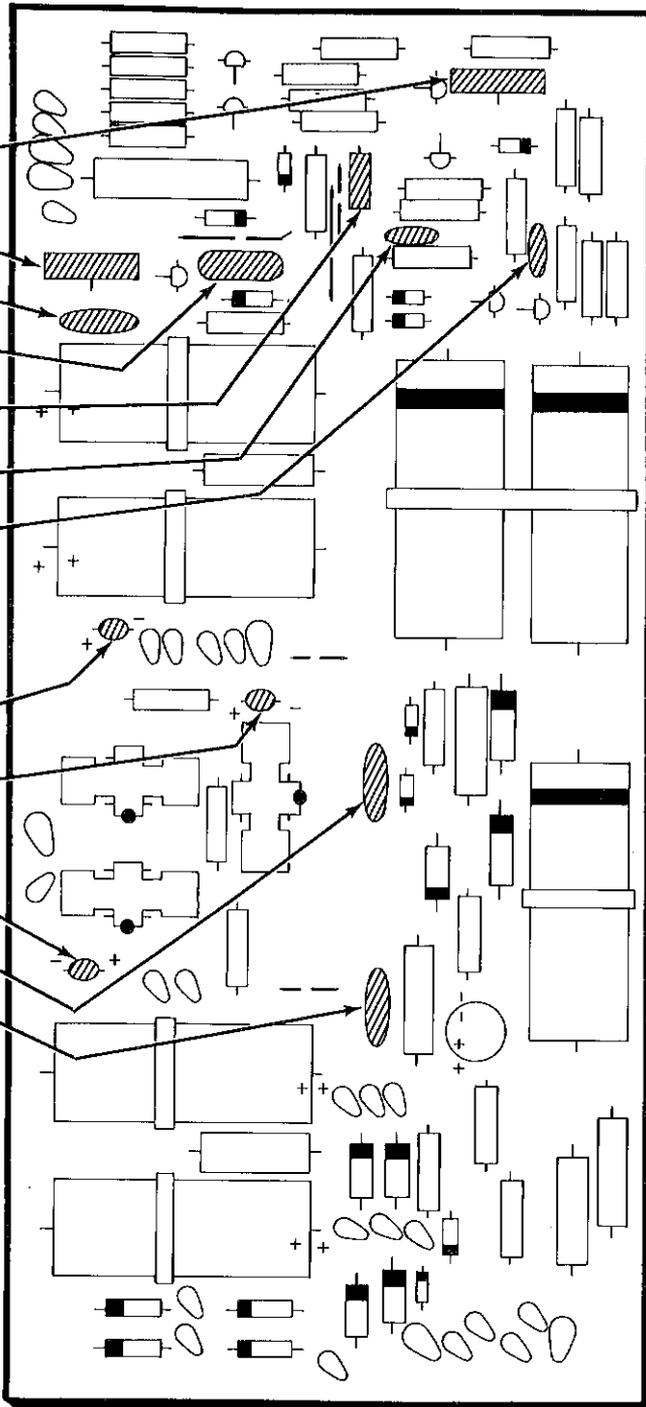
(✓) C309: 1.5 μF tantalum.

(✓) C310: 1.5 μF tantalum.

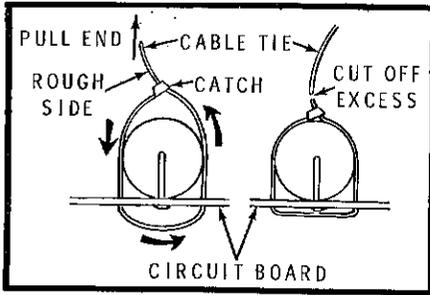
(✓) C314: 500 pF ceramic.

(✓) C315: 500 pF ceramic.

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



PICTORIAL 3-4



Detail 3-5A

**START** →

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

(✓) C305: 1200  $\mu$ F electrolytic.

(✓) C307: 1200  $\mu$ F electrolytic.

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

(✓) C303: .1  $\mu$ F paper.

(✓) C302: .1  $\mu$ F paper.

(✓) C301: .1  $\mu$ F paper.

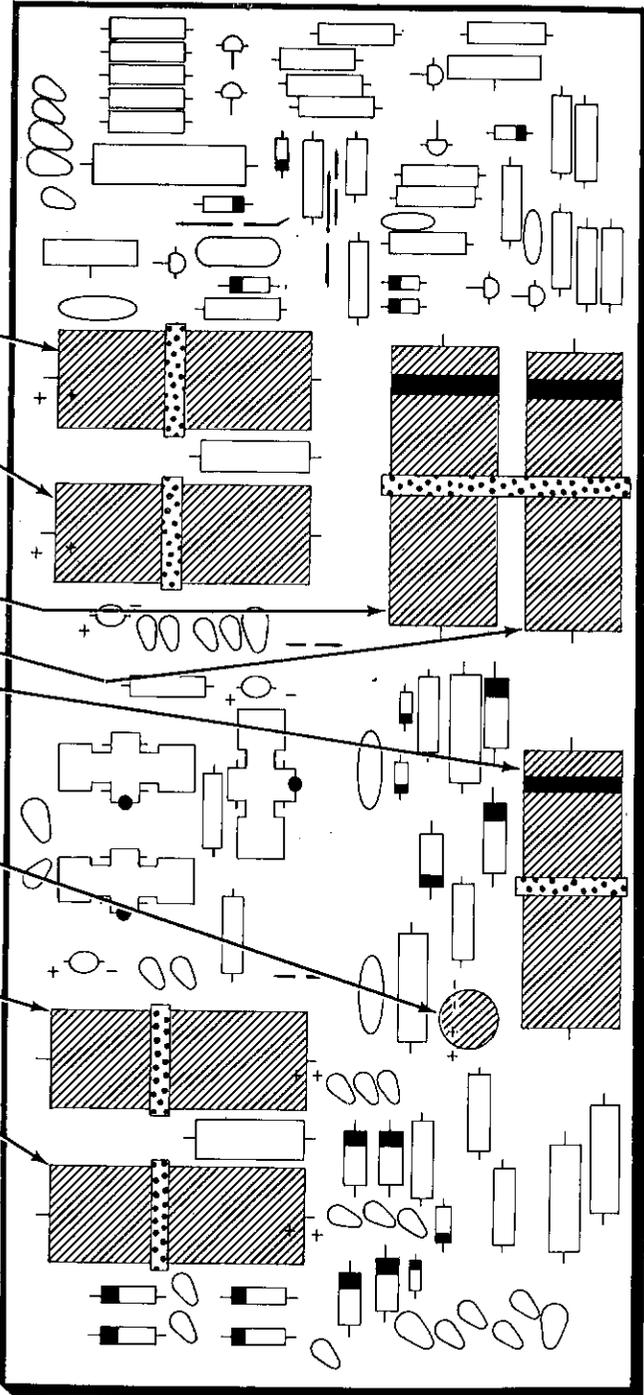
(✓) C320: 25  $\mu$ F electrolytic. Match the positive (+) mark on the capacitor with the positive (+) mark on the board **or** match the negative (-) mark on the capacitor with the negative (-) mark on the board.

(✓) C306: 1200  $\mu$ F electrolytic.

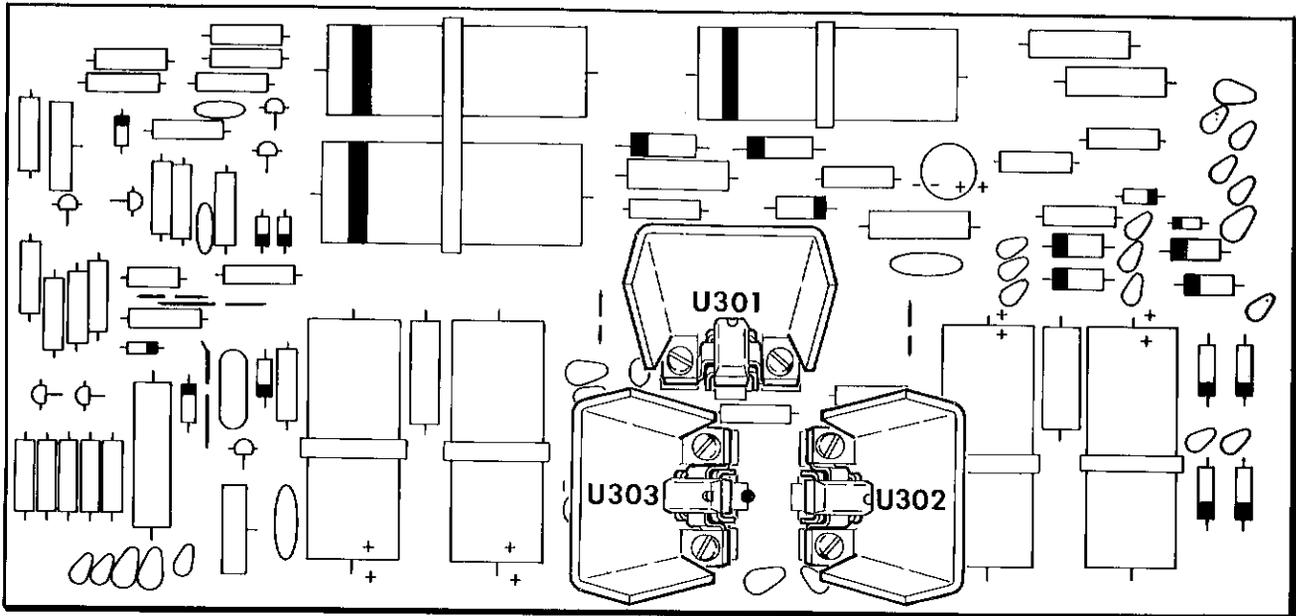
(✓) C304: 1200  $\mu$ F electrolytic.

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

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



PICTORIAL 3-5

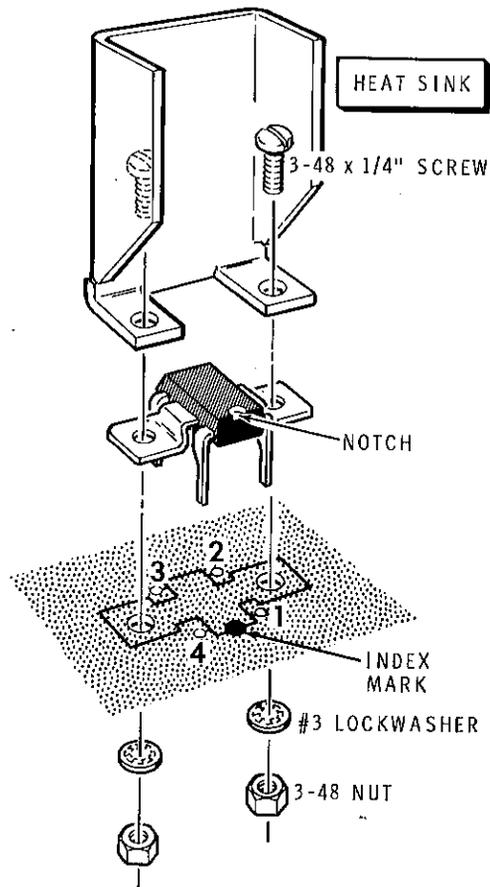


POWER SUPPLY  
CIRCUIT BOARD

PICTORIAL 3-6

Refer to Pictorial 3-6 for the following steps.

- (✓) U303: Refer to Detail 3-6A and install a UA79IC (#442-618) at location U303 on the circuit board. Match the notch in the IC with the index mark on the circuit board and insert the IC pins in their holes in the circuit board. Then press the IC tight against the board but do not solder its pins at this time.
- (✓) Refer to Detail 3-6A and mount a heat sink at location U303 with 3-48 × 1/4" hardware. Be sure to position the heat sink as shown in Pictorial 3-6.
- (✓) Now solder the pins of the IC to the foil and cut off the excess pin lengths.
- (/) U301: In the same manner, install a UA78 IC (#442-617) and a heat sink at location U301. Position the heat sink as shown.
- (/) U302: In the same manner, install a UA78 IC (#442-617) and a heat sink at location U302. Position the heat sink as shown.



Detail 3-6A

## CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

- Unsoldered connections.
- Poor solder connections.
- Solder bridges between the foil patterns.
- Protruding leads which could touch together.

- Transistors for proper type and installation.
- Electrolytic capacitors for the correct position of the positive (+) end.
- Diodes for the proper type and the correct position of the banded end.
- IC's for proper type and installation.

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



# CHASSIS

## PARTS LIST

Open the pack marked #4 and check these and the remaining parts in the final pack against the following list. The key numbers correspond to the numbers on the Chassis and Final Pack Parts Pictorial (Illustration Booklet, Pages 7 and 8).

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

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

| KEY No.                             | HEATH Part No. | QTY. | DESCRIPTION                     | CIRCUIT Comp. No. |
|-------------------------------------|----------------|------|---------------------------------|-------------------|
| <b>Circuit Components (Cont'd.)</b> |                |      |                                 |                   |
| A13                                 | 412-15         | 1    | NE2H pilot lamp                 | PL1               |
| A14                                 | 421-20         | 1    | 1/2-ampere, 3AG, slow-blow fuse | F1                |

### HARDWARE

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

### #4 Hardware

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



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

**#6 Hardware**

|     |          |    |                                 |  |
|-----|----------|----|---------------------------------|--|
| C1  | 250-1282 | 9  | 6-32 x 1/8" black setscrew      |  |
| C2  | 250-1164 | 6  | 6-32 x 3/16" flat head screw    |  |
| C3  | 250-138  | 17 | 6-32 x 3/16" screw              |  |
| C4  | 250-365  | 2  | #6 x 1/4" hex washer head screw |  |
| C5  | 250-1157 | 12 | 6-32 x 1/4" hex stud            |  |
| C6  | 250-32   | 2  | 6-32 x 3/8" flat head screw     |  |
| C7  | 250-89   | 12 | 6-32 x 3/8" screw               |  |
| C8  | 250-1101 | 1  | 6-32 x 3/8" T-bolt              |  |
| C9  | 250-591  | 5  | #6 x 1/2" screw                 |  |
| C10 | 250-1203 | 1  | #6 x 9/16" screw                |  |
| C11 | 250-29   | 2  | 6-32 x 3/4" screw               |  |
| C12 | 252-3    | 25 | 6-32 nut                        |  |
| C13 | 252-22   | 2  | 6-32 push-on nut                |  |
| C14 | 254-1    | 26 | #6 lockwasher                   |  |
| C15 | 255-63   | 3  | 6-32 x 2" threaded spacer       |  |
| C16 | 259-1    | 3  | #6 solder lug                   |  |

**#8 Hardware**

|    |          |   |                                 |  |
|----|----------|---|---------------------------------|--|
| D1 | 250-1138 | 8 | #8 x 5/8" hex washer head screw |  |
| D2 | 254-4    | 4 | 8-32 nut                        |  |
| D3 | 252-68   | 8 | 8-32 push-on nut                |  |
| D4 | 254-2    | 4 | #8 lockwasher                   |  |

**Other Hardware**

|    |        |   |                   |  |
|----|--------|---|-------------------|--|
| E1 | 252-5  | 2 | 10-32 nut         |  |
| E2 | 254-37 | 2 | #10 lockwasher    |  |
| E3 | 252-73 | 1 | 5/16" push-on nut |  |
| E4 | 252-7  | 5 | 3/8" nut          |  |
| E5 | 253-10 | 7 | 3/8" flat washer  |  |
| E6 | 254-4  | 4 | 3/8" lockwasher   |  |

**LINE CORD—HARNESS—CABLE**

|          |   |                      |  |
|----------|---|----------------------|--|
| 89-54    | 1 | Line cord            |  |
| 134-237  | 1 | Cable with connector |  |
| 134-1021 | 1 | Harness              |  |

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

**METAL PARTS**

|    |          |   |                       |  |
|----|----------|---|-----------------------|--|
| F1 | 200-1348 | 1 | Chassis               |  |
| F2 | 204-2141 | 1 | Front panel bracket   |  |
| F3 | 204-2313 | 2 | CRT bracket           |  |
| F4 | 204-2314 | 1 | Circuit board bracket |  |
| F5 | 206-1216 | 1 | CRT shield            |  |
| F6 | 206-1274 | 1 | Input shield          |  |
| F7 | 207-1    | 2 | CRT clamp             |  |

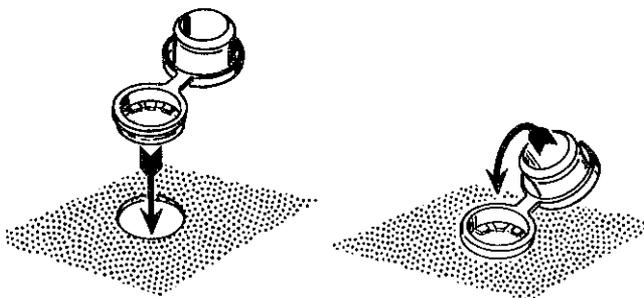
**MISCELLANEOUS**

|     |          |   |                              |            |
|-----|----------|---|------------------------------|------------|
| G1  | 73-5     | 1 | 3/4" x 5" rubber strip       |            |
| G2  | 73-34    | 2 | Red alligator clip insulator |            |
| G3  | 73-45    | 7 | Plastic grommet              |            |
| G4  | 75-52    | 1 | Slide switch insulator       |            |
| G5  | 75-754   | 1 | Line cord strain relief      |            |
| G6  | 75-771   | 4 | Slide switch cover (2-1/2")  |            |
|     | 92-609   | 1 | Cabinet shell                |            |
| G7  | 92-679   | 1 | Cabinet front                |            |
|     | 211-49   | 1 | Handle                       |            |
| G8  | 260-16   | 2 | Alligator clip               |            |
| G9  | 261-1    | 3 | Foot                         |            |
| G10 | 266-991  | 4 | Plastic spacer               |            |
|     | 300-18   | 1 | Felt strip                   |            |
|     | 351-9    | 1 | Epoxy glue packet            |            |
| G11 | 354-5    | 2 | Cable tie                    |            |
| G12 | 413-10   | 1 | Red lens                     |            |
| G13 | 414-36   | 1 | Graticule                    |            |
| G14 | 422-1    | 1 | Fuse block                   |            |
| G15 | 431-82   | 1 | Terminal collar              |            |
| G16 | 434-41   | 1 | CRT socket                   |            |
| G17 | 436-11   | 3 | Red socket                   | J3, J4, J6 |
| G17 | 436-22   | 1 | Black socket                 | J5         |
| G18 | 462-1049 | 2 | Red knob                     |            |
| G19 | 462-1055 | 2 | Large black knob             |            |
| G20 | 462-1059 | 4 | Small black knob with skirt  |            |
| G21 | 490-14   | 1 | Allen wrench                 |            |
| G22 | 205-778  | 1 | Alignment tool blade         |            |

## STEP-BY-STEP ASSEMBLY

Refer to Pictorial 4-1 (Illustration Booklet, Page 9) for the following steps.

- (✓) Position the chassis as shown. This is the top side of the chassis. The front of the chassis is to your left.
- (✓) Refer to Detail 4-1A and install a plastic grommet in hole BA from the top of the chassis.



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

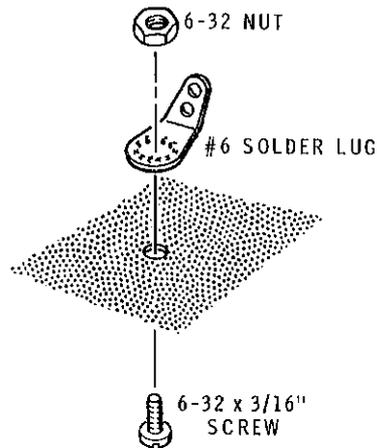
BEND THE LARGE PORTION OF THE GROMMET OVER AND INTO THE SMALL PORTION. PRESS IT FIRMLY INTO PLACE.

**Detail 4-1A**

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

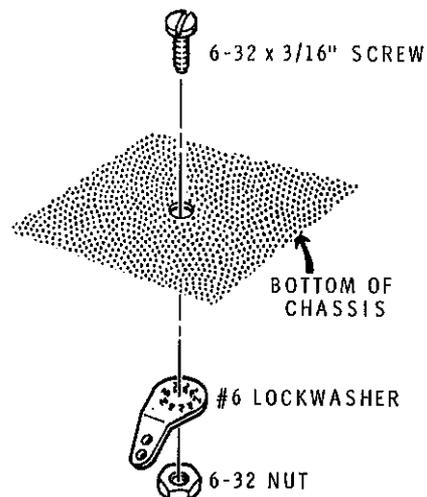
- (✓) BB
- (✓) BC
- (✓) BD
- (✓) BE
- (✓) BF
- (✓) BG

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



**Detail 4-1B**

- (✓) Refer to Detail 4-1B and mount a #6 solder lug on top of the chassis at location K with a 6-32 x 3/16" screw and a 6-32 nut. Position the solder lug as shown.
- (✓) Refer to Detail 4-1C and mount a #6 solder lug on the bottom of the chassis at location N with a 6-32 x 3/16" screw and a 6-32 nut. Position the solder lug as shown.
- (✓) In the same manner, install a #6 solder lug at location P.

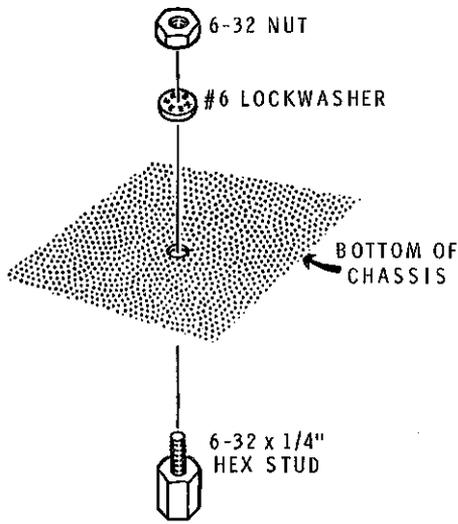


**Detail 4-1C**

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

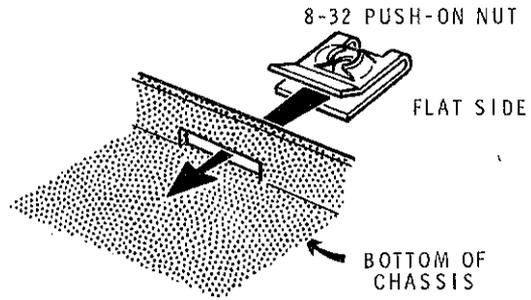
In the same manner, loosely mount 6-32 × 1/4" hex studs at the following chassis holes.

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



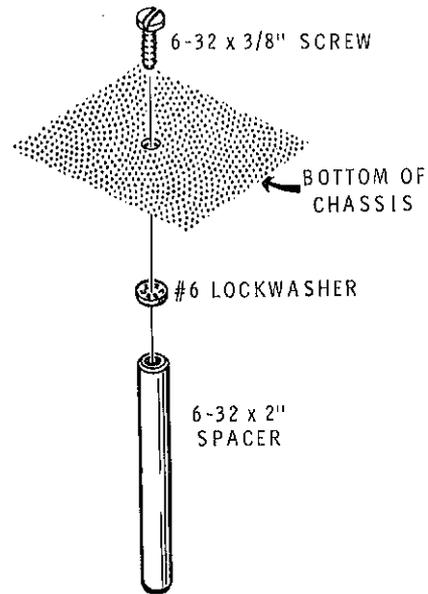
**Detail 4-1D**

- (✓) Refer to Detail 4-1E and install an 8-32 push-on nut in the slot at location H. Be sure the flat side of the nut is on the bottom of the chassis. Do not use the two 6-32 push-on nuts at this time.
- (✓) In the same manner, install 8-32 push-on nuts at locations J, L, and M.
- (✓) Install an 8-32 push-on nut at location T with the flat side of the nut on the rear (outside) of the chassis.



**Detail 4-1E**

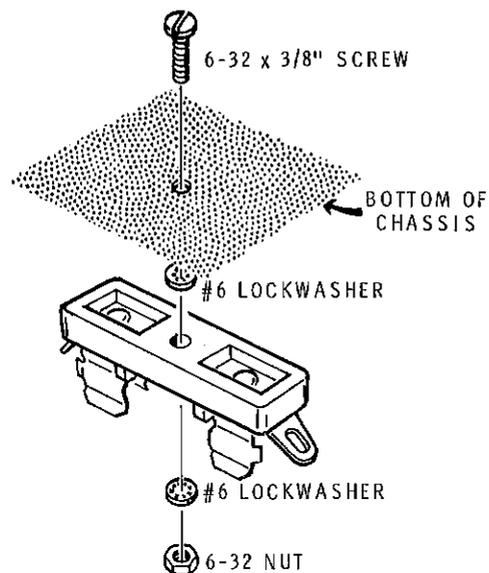
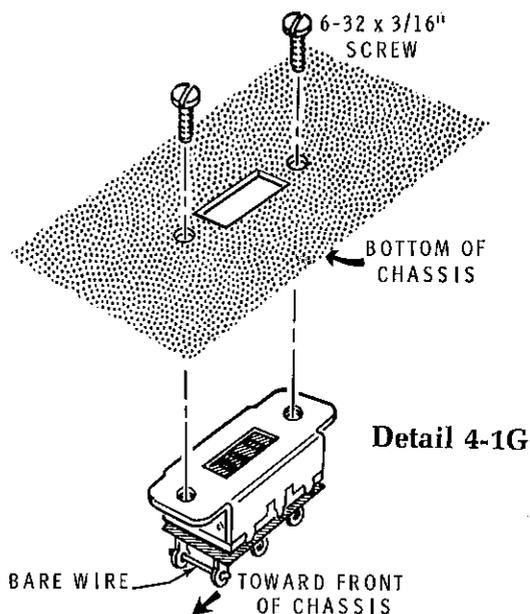
- (✓) In the same manner, install 8-32 push-on nuts at locations U, X, and Y on the rear of the chassis.
- (✓) Refer to Detail 4-1F and install a 6-32 × 2" threaded spacer on the bottom of the chassis at location Q. Use a 6-32 × 3/8" screw and a #6 lockwasher.
- (✓) In the same manner, install 6-32 × 2" threaded spacers at locations R and S.



**Detail 4-1F**

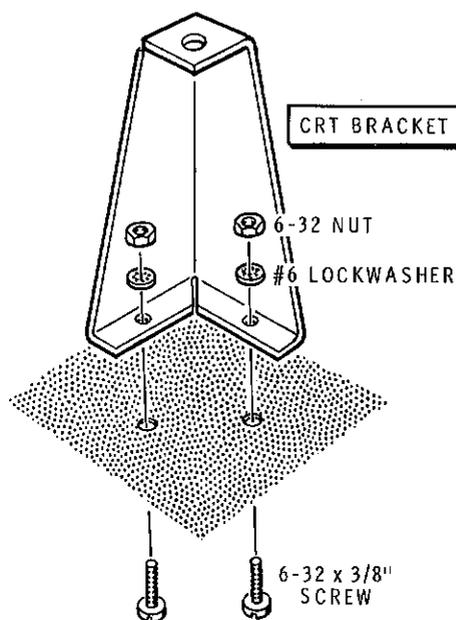


- (✓) SW10: Refer to Detail 4-1G and mount the DPDT 120V-240V slide switch on the bottom of the chassis at location SW10 with 6-32 × 3/16" screws. Be sure the switch is positioned so the lugs with the bare wire between them is toward the front of the chassis.

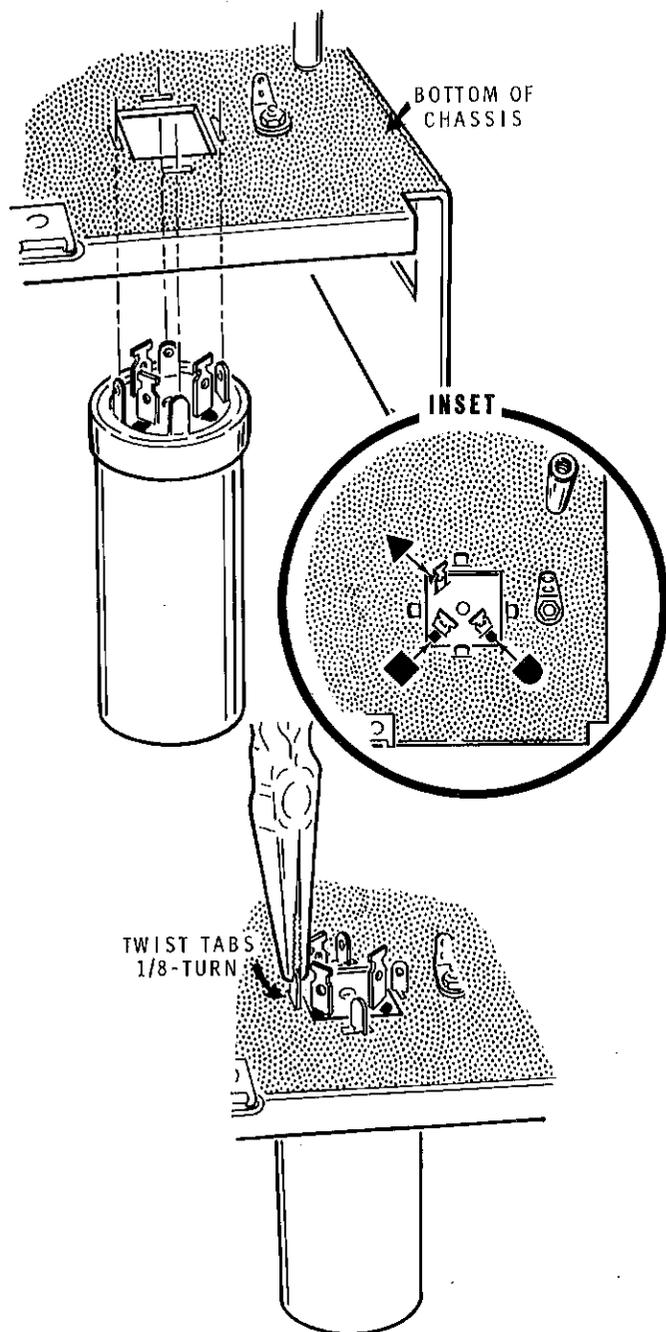


Detail 4-1H

- (✓) Refer to Detail 4-1H and mount the fuse block on the bottom of the chassis at location F1 with 6-32 × 3/8" hardware.
- (✓) Refer to Detail 4-1J and mount a CRT (cathode ray tube) bracket on top of the chassis at either of the V1 locations. Use 6-32 × 3/8" hardware.
- (✓) In the same manner, install the other CRT bracket at the remaining V1 location.
- (✓) Install a 6-32 push-on nut on the top of each CRT bracket. Be sure the flat side of each nut is up and that each nut is positioned as shown on Pictorial 4-1.

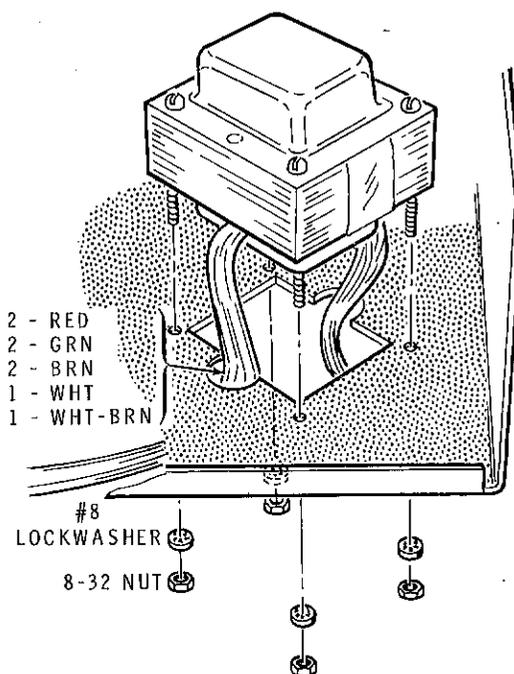


Detail 4-1J



Detail 4-1K

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

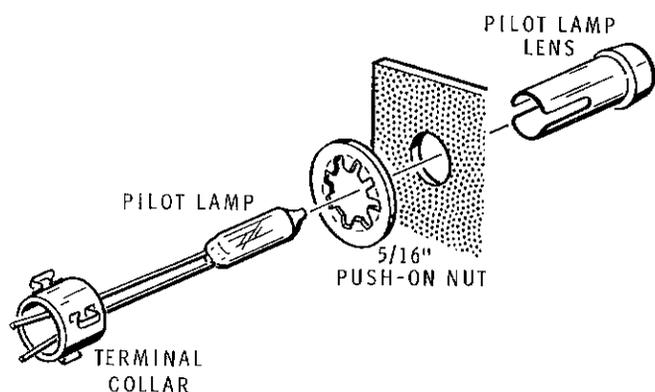


Detail 4-1L

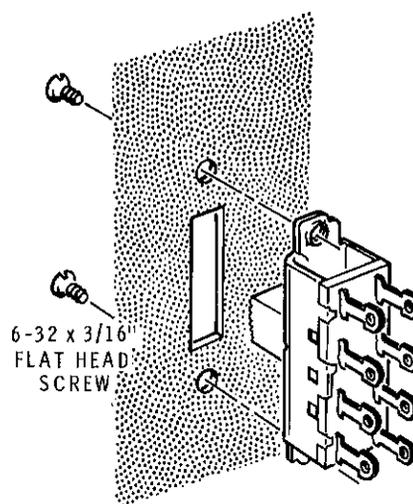
- (✓) T1: Refer to Detail 4-1L and mount the power transformer (#54-953) at location T1 with #8 lockwashers and 8-32 nuts. Be sure to position the transformer so the proper color wires are located as shown.

Refer to Pictorial 4-2 (Illustration Booklet, Page 10) for the following steps.

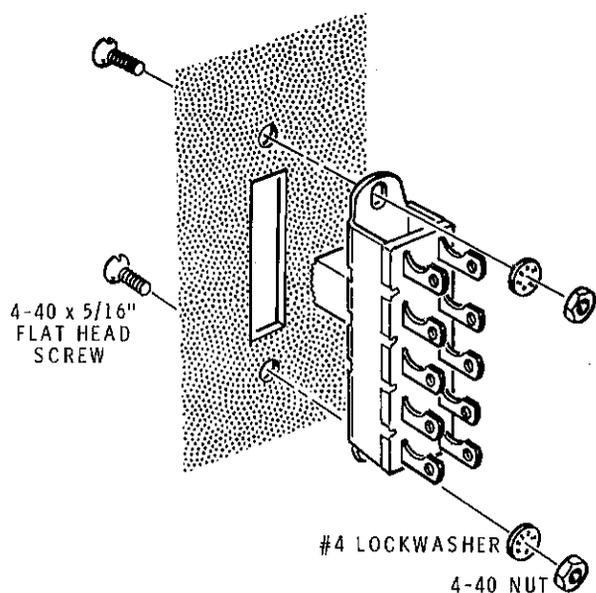
- (✓) Refer to Detail 4-2A and install the pilot lamp lens in hole PL1 in the chassis with a 5/16" push-on nut. Be sure the slot in the lens is positioned as shown before you push the nut tight against the chassis.
- (✓) PL1: Push the pilot lamp all the way into the pilot lamp lens.
- (✓) Refer to Detail 4-2A and push the terminal collar onto the pilot lamp lens. Position the terminal collar so its lugs are located as shown.



Detail 4-2A



Detail 4-2C



Detail 4-2B

- (✓) SW4: Refer to Detail 4-2B and mount the DP4T 4-position slide switch at location SW4 with 4-40 x 5/16" flat head hardware. The switch can be mounted either way.
- (✓) SW6: Refer to Detail 4-2C and install a DP3T 3-position slide switch at location SW6 with 6-32 x 3/16" flat head screws.

- (✓) SW7: In the same manner, install an SPDT 2-position slide switch at location SW7. Position the switch so its lugs are located as shown.
- (✓) SW8: In the same manner, install another SPDT 2-position slide switch at location SW8.

Refer to Pictorial 4-3 (Illustration Booklet, Page 11) for the following steps.

- (✓) Turn the chassis over and position it as shown.
- (✓) Locate the harness and position it on the chassis with the wires from the various breakouts (BO) as shown.
- (✓) Pass the wires from BO#1 through grommet BA for connection later.
- (✓) Pass the wires from BO#8 through grommet BF for connection later.
- (✓) Pass the large brown, large red, large orange, and the small gray-white wires from BO#9 through grommet BE for connection later.
- (✓) Twist together the two green leads coming from transformer T1. Pass these leads under the harness and through grommet BE for connection later.

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

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

- (↖) Black-green lead to lug 5 (S-1).
- (↗) Black lead to lug 6 (NS).
- (↗) Black-yellow lead to lug 2 (S-1).
- (↗) Black-red lead to lug 3 (NS).

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

- (↗) Either large brown wire to fuse block F1 lug 2 (S-1).
- (↗) Other large brown wire to switch SW10 lug 3 (S-2).
- (↗) Connect a 1" bare wire (remove all the insulation from a 1" length of brown wire) from capacitor C3 lug 4 (S-1) to solder lug N (NS).

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

- (↗) All five black wires to solder lug N (S-6). Be sure all wires, especially the lower ones, get soldered.
- (↗) Both violet wires to capacitor C3 lug 1 (NS).
- (↗) Both white-red wires to capacitor C3 lug 2 (NS).
- (↗) Red wire to capacitor C3 lug 3 (NS).
- (↗) Place a 1" length of sleeving on each lead of a 500  $\Omega$ , 10-watt resistor.
- (↗) R14: Connect this resistor to capacitor C3 between lugs 1 (S-3) and 2 (NS). Position this resistor directly above the capacitor lugs.
- (↗) Place a 5/8" length of sleeving on each lead of a 270  $\Omega$ , 3-watt resistor.

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

Refer to Pictorial 4-5 (Illustration Booklet, Page 12) for the following steps.

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

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

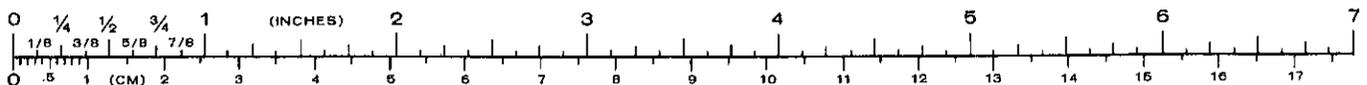
- (↗) White-green wire to hole S (S-1).
- (↗) White wire to hole R (S-1).
- (↗) Green wire to hole AA (S-1).
- (↗) Violet wire to hole AD (S-1).
- (↗) White-gray to hole Y (S-1).

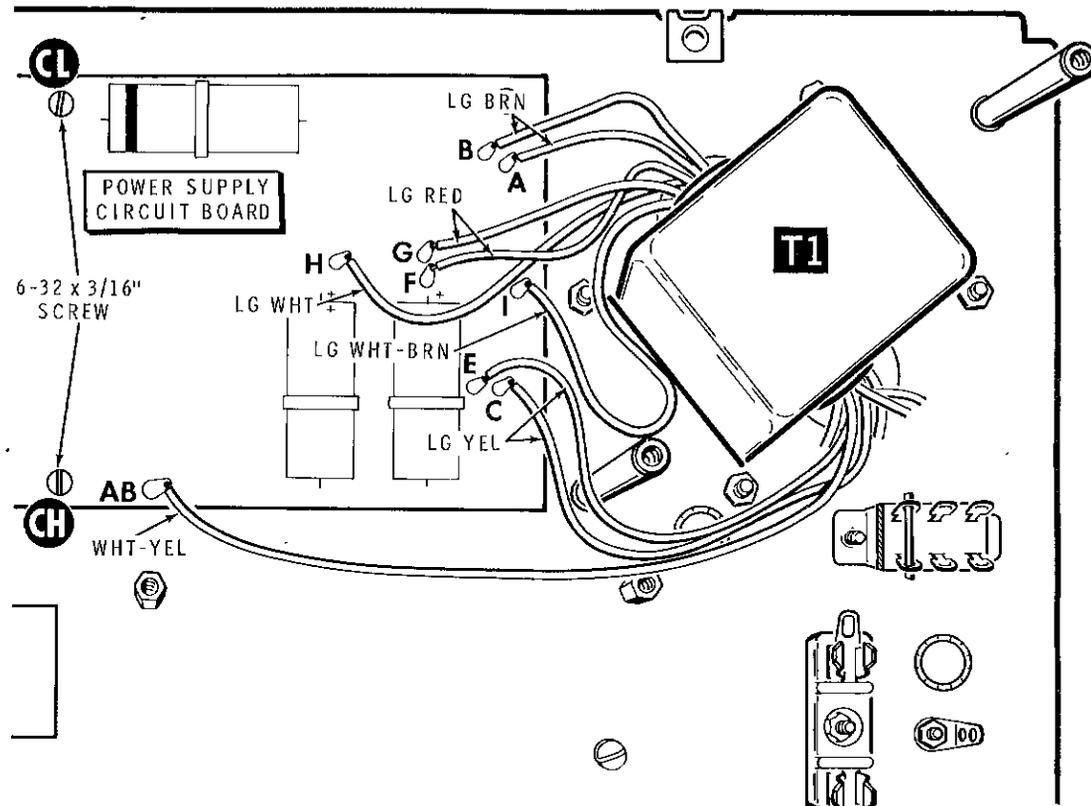
Connect the wires coming from BO#4 of the harness to the power supply circuit board as follows:

- (↗) Either gray wire to hole Q (S-1).
- (↗) Other gray wire to hole V (S-1).
- (↗) Any of the three yellow wires to hole N (S-1).
- (↗) Either of the remaining yellow wires to hole T (S-1).
- (↗) Remaining yellow wire to hole AH (S-1).

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

- (↗) Black wire to hole D (S-1).
- (↗) Either orange wire to hole P (S-1).
- (↗) Other orange wire to hole U (S-1).
- (↗) White-red wire to hole J (S-1).
- (↗) White-yellow wire to hole L (S-1).
- (↗) White-brown wire to hole K (S-1).





PICTORIAL 4-6

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

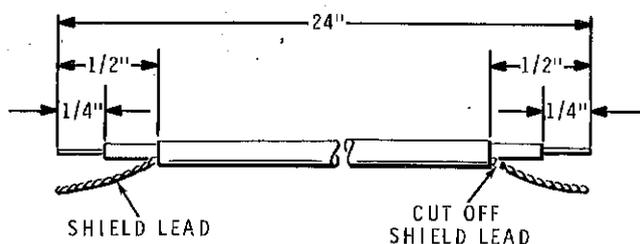
- (✓) Large black wire to hole AE (S-1).
- (✓) Large orange wire to hole X (S-1).
- (✓) Large red wire to hole W (S-1).
- (✓) Large yellow wire to hole AF (S-1).
- (✓) Large white-brown lead to hole I (S-1).
- (✓) Large white lead to hole H (S-1).
- (✓) Either large red lead to hole F (S-1).
- (✓) Other large red lead to hole G (S-1).
- (✓) Either large brown lead to hole A (S-1).
- (✓) Other large brown lead to hole B (S-1).

Refer to Pictorial 4-6 for the following steps.

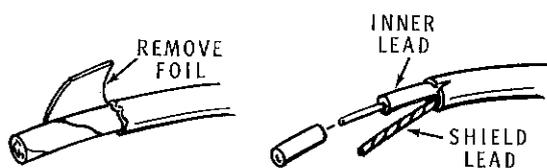
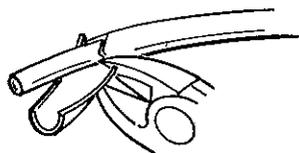
Connect the leads coming from the transformer T1 to the power supply circuit board as follows:

- (✓) Large white-yellow lead to hole AB (S-1).
- (✓) Either large yellow lead to hole E (S-1).
- (✓) Other large yellow lead to hole C (S-1).
- (✓) Temporarily mount the power supply circuit board at hex studs CH and CL with 6-32 x 3/16" screws.

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



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



REMOVE THE FOIL AND REMOVE 1/4" OF INSULATION FROM THE END OF THE INNER LEAD.

**Detail 4-7A**

Refer to Pictorial 4-7 (Illustration Booklet, Page 13) for the following steps.

- (✓) Refer to Detail 4-7A and prepare both ends of a 24" length of shielded cable (furnished with the vertical circuit board parts).

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

- (✓) Inner lead in hole H (S-1).
- (✓) Shield lead in hole K (S-1). The other end will be connected later.
- (✓) Prepare the ends of an 8" gray wire and an 8" blue wire.
- (✓) Connect one end of an 8" gray wire in hole Y2 in the vertical circuit board (S-1). The other end will be connected later.
- (✓) Connect one end of an 8" blue wire in hole Y1 in the vertical circuit board (S-1). The other end will be connected later.
- (✓) Position the vertical circuit board on the chassis as shown in Pictorial 4-7.

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

- (✓) Orange wire to hole U (S-1).
- (✓) Violet wire to hole N (S-1).
- (✓) Gray wire to hole V (S-1).
- (✓) White-green wire to one (GND) hole (S-1).
- (✓) Black wire to another of the (GND) holes (S-1).
- (✓) At BO#10 on the harness, cut off the green and yellow wires as close as possible to the end tie in the string. Be sure the ends of these wires can not touch each other or the chassis.





This completes the wiring of the vertical circuit board. Check to see that all connections are soldered, and cut off all excess lead lengths as close to the foil as possible. There is one GND hole in the circuit board that is not used.

Refer to Pictorial 4-8 (Illustration Booklet, Page 14) for the following steps.

- (✓) Secure the vertical circuit board to the chassis with two #6 × 1/4" hex washer head screws through the switch bracket and into chassis holes B and C and 6-32 × 3/16" screws through the circuit board and into hex studs CA, CB, CC, CD, CE, and CF. Then tighten the nuts on the hex studs.
- (✓) Position the free end of the shielded cable coming from the vertical circuit board under the harness and then through grommet BF for connection later.
- (✓) Pass the free end of the gray wire coming from the vertical circuit board through grommet BD for connection later.
- (✓) Pass the free end of the blue wire coming from the vertical circuit board through grommet BC for connection later.
- (✓) Position the power transformer (T1) leads on top of the harness near the corner of the vertical circuit board and install a cable tie around all these wires. See the inset drawing on Pictorial 4-8. Pull the cable tie tight and cut off its excess.

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

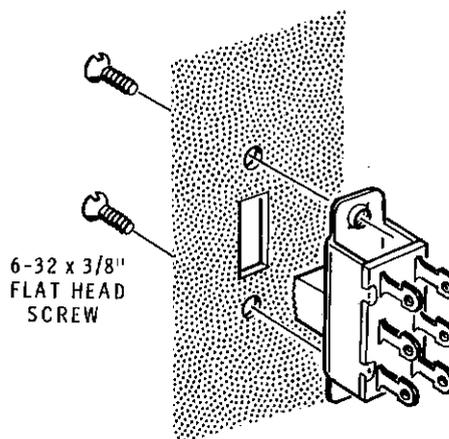
Set the chassis aside temporarily.

Refer to Pictorial 4-9 (Illustration Booklet, Page 15) for the following steps.

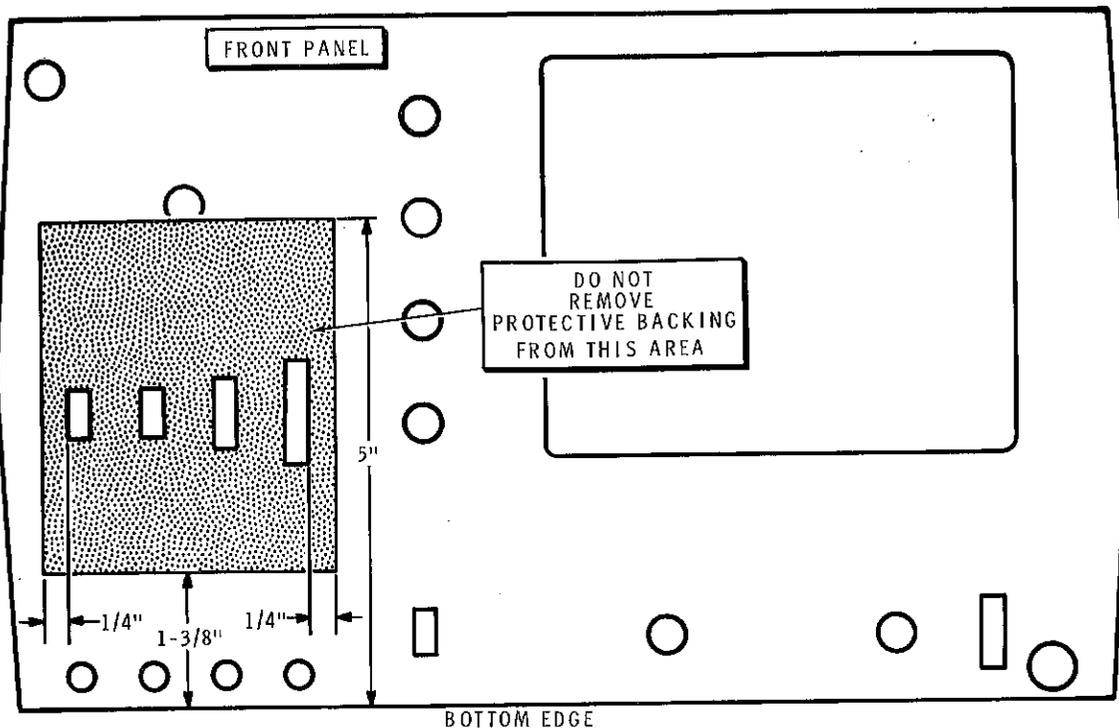
**CAUTION:** Place a large soft cloth on your work area to protect the cabinet front from being scratched as you work with the Oscilloscope.

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

Set the cabinet front aside temporarily.



**Detail 4-9A**



Detail 4-9B

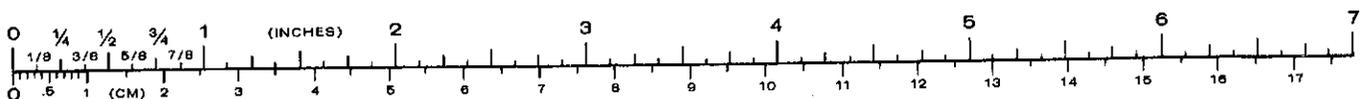
NOTE: In the next step, you will be instructed to remove the protective backing from the back (unprinted) side of the front panel. The protective backing **must not** be removed from the shaded area, otherwise, the switch covers, positioned in the four recessed areas of the cabinet front, will stick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

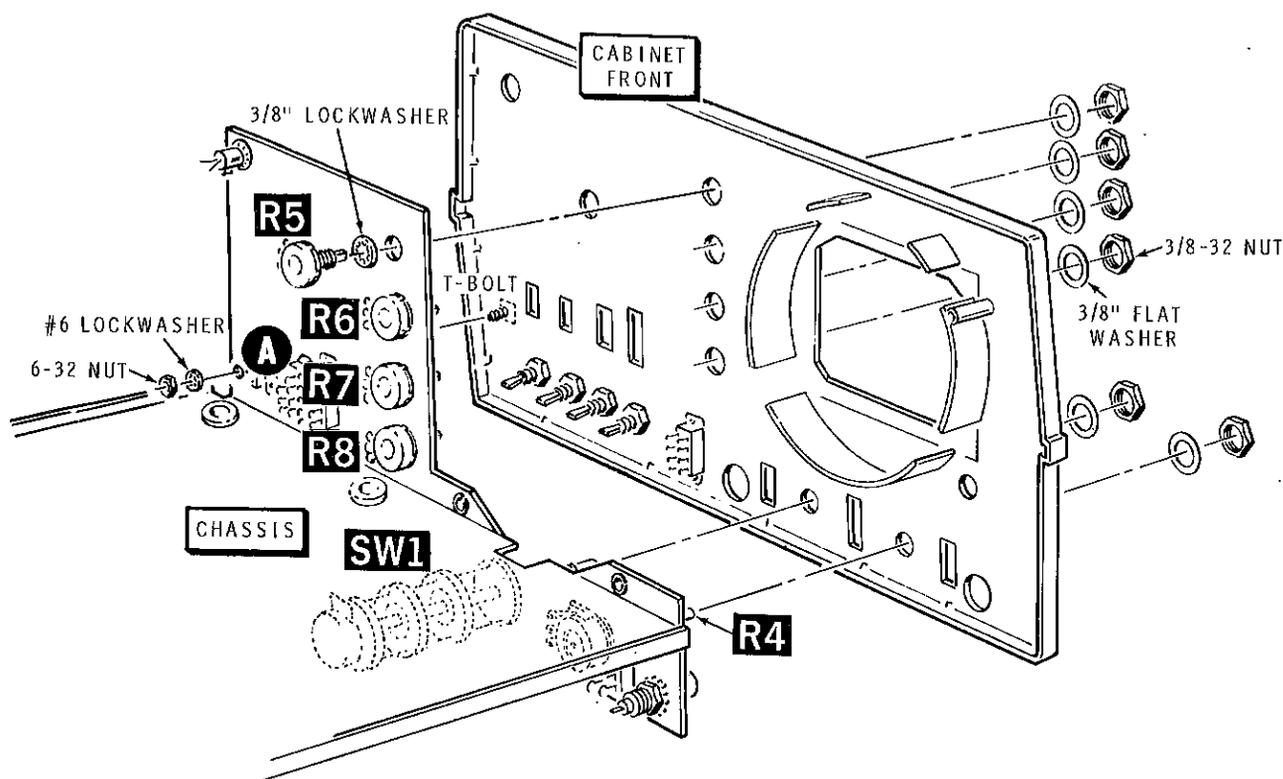
- (✓) Refer to Detail 4-9B and remove the protective backing from the back of the front panel except for the shaded area mentioned in the previous note.
- (✓) Temporarily lay the front panel **adhesive side up** on your work area.
- (✓) Position the cabinet front as shown in Pictorial 4-9.

- (✓) Fit the 6-32 × 3/8" T-bolt into the indicated square recess in the cabinet front.
- (✓) Place a 2-1/2" slide switch cover in each of the recessed areas at switch locations SW4, SW6, SW7, and SW8 in the cabinet front.

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

- (✓) Carefully fit the front panel (adhesive side down) into the recessed area of the cabinet front. Press the front panel down into place.
- (✓) J3: Install a red socket at location J3 in the front panel. Use the nut furnished with the socket.
- (✓) J4: In the same manner, install a red socket at location J4.
- (✓) J5: Install a **black** socket at location J5.
- (✓) J6: Install the remaining red socket at location J6.





PICTORIAL 4-10

Refer to Pictorial 4-10 for the following steps.

- (✓) Temporarily remove the 3/8-32 nuts from rotary switch SW1 and control R4.

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

- (✓) Fit the cabinet front onto the front of the chassis. Be sure all the switches and the T-bolt fit properly into their slots and holes. Do not pinch any wires between the chassis and cabinet front.

- (✓) Install 3/8" flat washers and 3/8-32 nuts on rotary switch SW1 and control R4.

- (✓) Install 1 #6 lockwasher and a 6-32 nut on the T-bolt at hole A in the chassis front.

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

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

- (✓) R6: Install a 1 M $\Omega$  control (#10-1119) at location R6.

- (✓) R5: Install a 1000  $\Omega$  (1 k) control (#10-1118) at location R5.

Refer to Pictorial 4-11 (Illustration Booklet, Page 15) for the following steps.

- (✓) Position the chassis upside down as shown.
- (✓) Push the slide switch insulator onto the rear of switch SW9.

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

- ( ✓ ) Either large brown wire to switch SW9 lug 6 (S-1). Make a mechanically secure connection.
- ( ✓ ) Other large brown wire to switch SW9 lug 5 (S-1). Make a mechanically secure connection.
- ( ✓ ) White-brown wire to socket J3 (S-1).
- ( ✓ ) Black wire to socket J5 (NS).
- ( ✓ ) Pass the white-red wire coming from BO#2 through grommet BB for connection later.
- ( ✓ ) Prepare a 5-1/2" white-blue wire and a 3" black wire.
- ( ✓ ) Connect one end of a 5-1/2" white-blue wire to socket J4 (S-1). Pass the other end of this wire through grommet BA for connection later.
- ( ✓ ) Connect one end of the 3" black wire to socket J5 (S-2). Pass the other end of this wire through grommet BB for connection later.

Refer to Pictorial 4-12 for the following steps.

- ( ✓ ) Turn the chassis around as shown.
- ( ) Refer to Detail 4-12A and prepare the end of the line cord.
- ( ✓ ) Refer to Detail 4-12B and pass the prepared end of the line cord through hole W in the rear of the chassis.
- ( ✓ ) Refer to Detail 4-12B and install the line cord in the line cord strain relief. Install the line cord strain relief at location W with a #6 × 9/16" screw.

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

- ( ✓ ) Green to solder lug P (S-1).
- ( ✓ ) Black lead to fuse block F1 lug 1 (S-1).
- ( ✓ ) White lead to switch SW10 lug 6 (S-2).

## ALTERNATE LINE VOLTAGE OPERATION

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

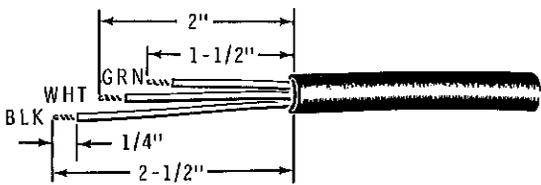
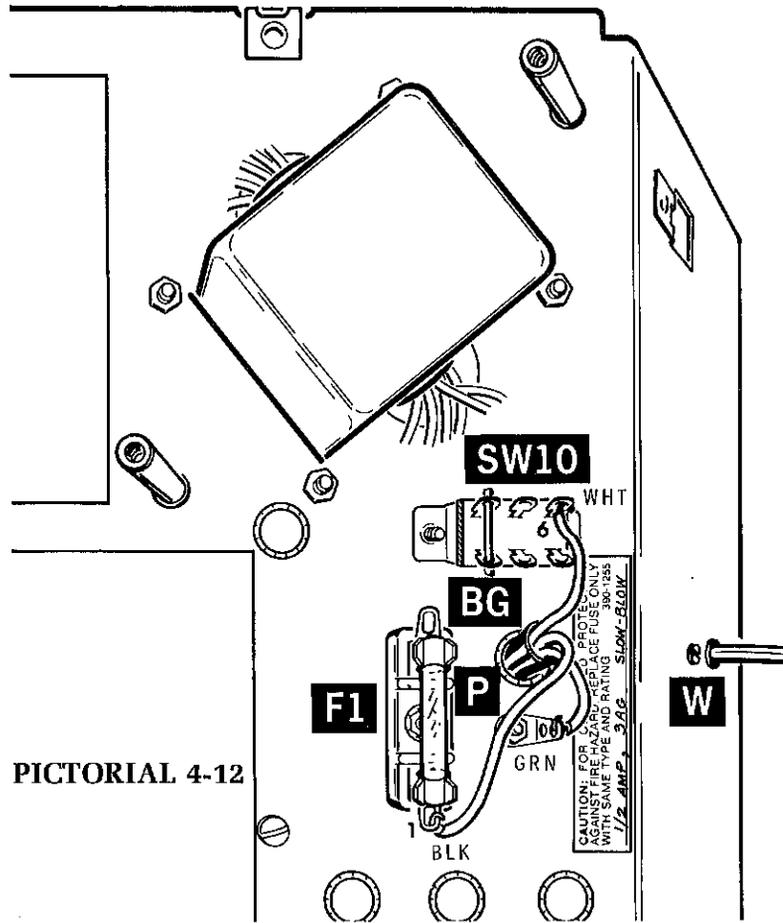
### 120 VAC LINE VOLTAGE

- ( ) Move slide switch SW10, if necessary, so the **120** is visible on the top of the switch. Use a screwdriver blade to move the switch slider.
- ( ) F1: Install the 1/2-ampere, 3 AG, slow-blow fuse in the fuse block at location F1.
- ( ) Remove the protective backing from the fuse label and press the label onto the bottom of the chassis at the indicated location.
- ( ) Write "1/2-ampere, 3 AG, Slow-blow" on the line on the fuse label.

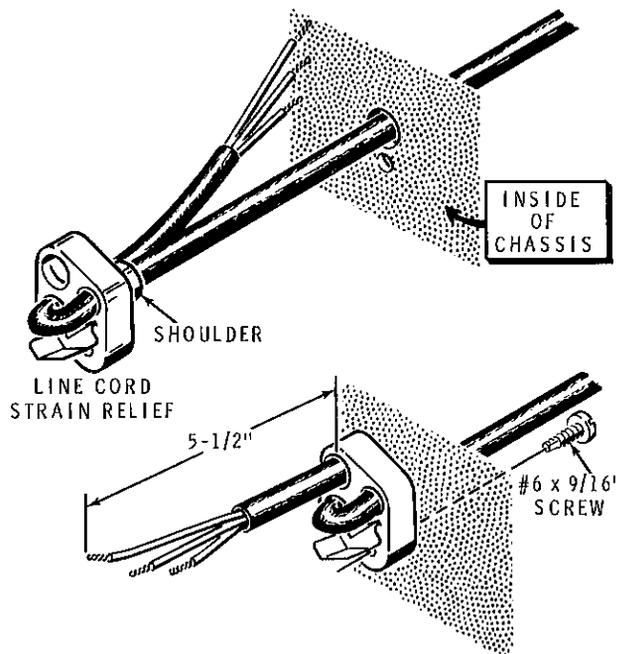
### 240 VAC LINE VOLTAGE

- ( ✓ ) Move slide switch SW10, if necessary, so the **240** is visible on the top of the switch. Use a screwdriver blade to move the switch slider.
- ( ✓ ) F1: Install a 1/4-ampere, 3 AG, slow-blow fuse (not supplied) in the fuse block at location F1.
- ( ✓ ) Remove the protective backing from the fuse label and press the label onto the bottom of the chassis at the indicated location.
- ( ✓ ) Write "1/4-ampere, 3 AG, Slow-blow" on the line on the fuse label.





**Detail 4-12A**



**Detail 4-12B**



Refer to Pictorial 4-13 (Illustration Booklet, Page 16) for the following steps.

(✓) Position the chassis top side up as shown.

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

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

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

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

(✓) **Yellow wire** to control R5 lug 3 (S-1).

(✓) **Green wire** to control R5 lug 2 (S-1).

(✓) **Black wire** to control R5 lug 1 (S-1).

(✓) **White-yellow wire** to switch SW4 lug 5 (S-1).

(✓) **R17:** Connect a 330 k $\Omega$ , 1-watt (org-org-yel) resistor to control R6 between lugs 1 (S-2) and 3 (S-2).

(✓) Prepare a 1" brown wire and connect it to switch SW4 between lugs 4 (NS) and 7 (S-1).

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

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

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

(✓) Connect the free end of the white-red wire coming from grommet BB to pilot lamp PL-1 lug 3 (NS).

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

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

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

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

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

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

(✓) **R13:** Connect a 47 k $\Omega$  (yel-viol-org) resistor to PL1 between lugs 2 (S-2) and 3 (S-2).

Refer to Pictorial 4-14 (Illustration Booklet, Page 17) for the following steps.

(✓) Locate the horizontal circuit board and position it as shown.

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

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



- ( ✓ ) White-orange wire to control R8 lug 3 (S-1).
- ( ✓ ) Green wire to control R8 lug 2 (S-1).
- ( ✓ ) White-red to control R8 lug 1 (S-1).
- ( ✓ ) White-gray to control R7 lug 3 (S-1).
- ( ✓ ) Red wire to control R7 lug 2 (S-1).
- ( ✓ ) White-yellow to control R7 lug 1 (S-1).

- ( ✓ ) Remove an additional 3/4" of insulation (total 1") from the free end of the orange wire. Pass the end of this wire through switch SW4 lug 4 (S-3) to switch SW6 lug 6 (S-1).
- ( ✓ ) White-blue wire to switch SW6 lug 8 (S-1).
- ( ✓ ) Remove an additional 1/2" of insulation (total 3/4") from the free end of the white-violet wire. Connect the free end of this wire to switch SW6 through lug 7 (S-2) to lug 1 (S-1).

Refer to Pictorial 4-15 (Illustration Booklet, Page 18) for the following steps.

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

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

- ( ✓ ) White-green wire to switch SW7 lug 3 (S-1).
- ( ✓ ) Yellow wire to switch SW7 lug 2 (S-1).
- ( ✓ ) White-brown wire to switch SW7 lug 1 (S-1).
- ( ✓ ) White wire to switch SW8 lug 2 (S-1).

Refer to Pictorial 4-16 (Illustration Booklet, Page 19) for the following steps.

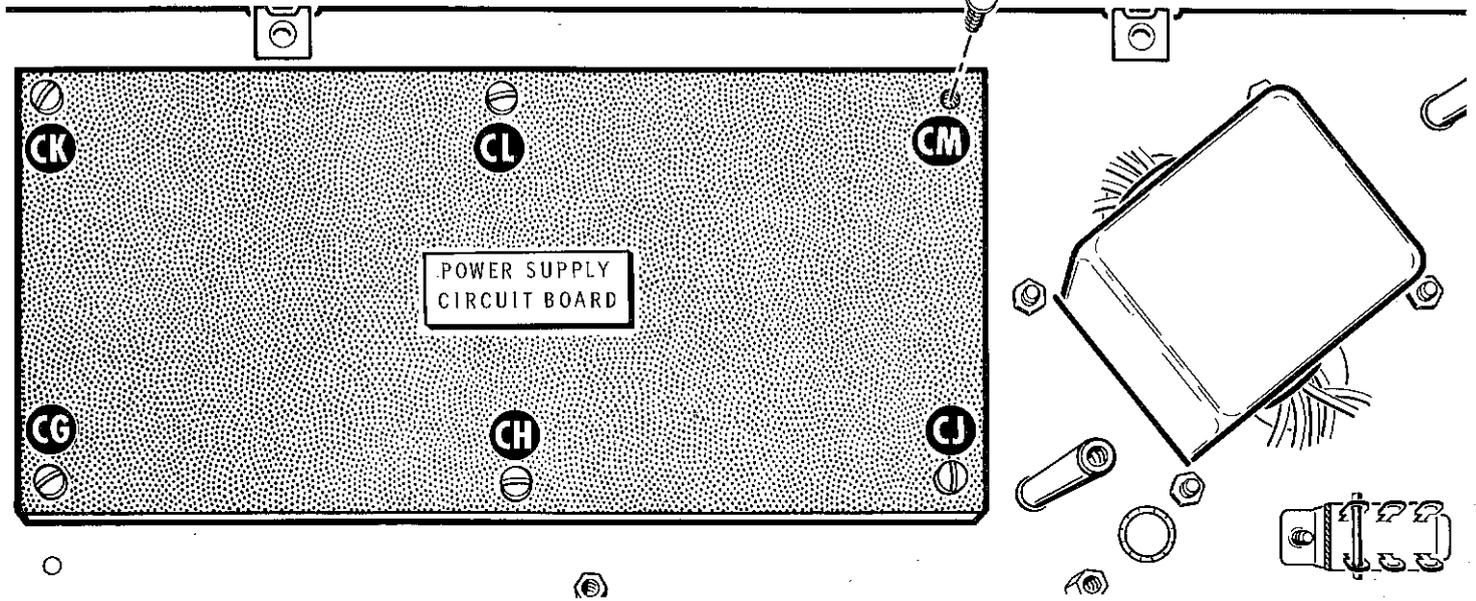
Connect the harness wires from BO#8 coming from grommet BF to the horizontal circuit board as follows:

- ( ✓ ) Yellow wire to hole W (S-1).
- ( ✓ ) Gray wire to hole V (S-1).
- ( ✓ ) Orange wire to hole U (S-1).
- ( ✓ ) Red wire to hole X (S-1).
- ( ✓ ) Black wire to hole H (S-1).
- ( ✓ ) White wire to hole S (S-1).
- ( ✓ ) Green wire to hole T (S-1).

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

- ( ✓ ) Black wire to solder lug K (S-4).
- ( ✓ ) Brown wire through grommet BB to socket J6 (S-1).



6-32 x 3/16"  
SCREW

Detail 4-16A

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

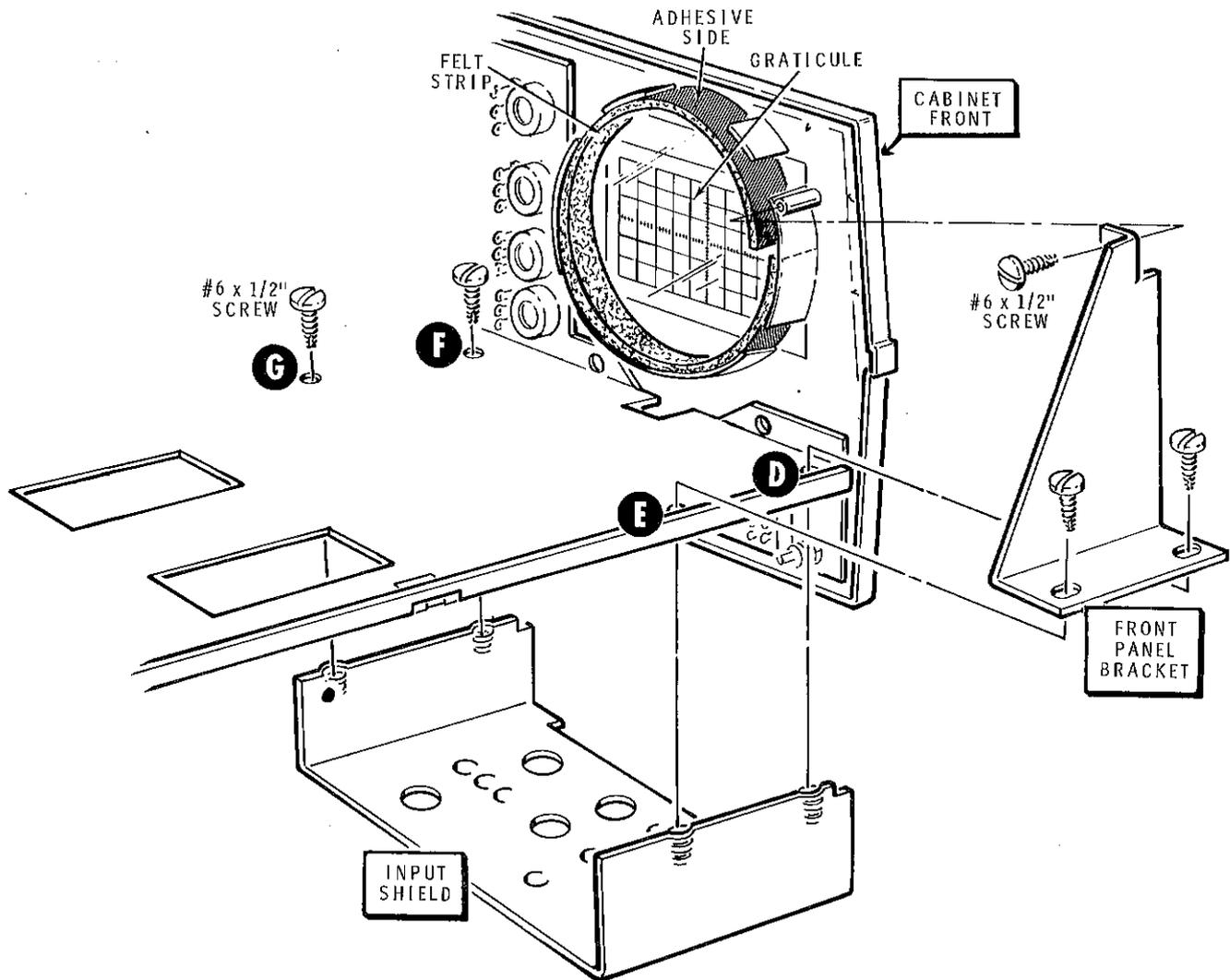
- (✓) Carefully position all the wires connected to the horizontal circuit board and harness as shown.
- (✓) Pass the shaft of the rotary switch through the chassis at location SW5. Install the switch with a 3/8" flat washer and a 3/8-32 nut. Do not tighten the nut at this time.
- (✓) Refer to Detail 4-16A and remove the power supply circuit board screws from holes CL and CH.
- (✓) Refer to the inset drawing on Pictorial 4-16 and mount the circuit board bracket at location Z on the chassis with 6-32 x 3/8" hardware.
- (✓) Remount the power supply circuit board with 6-32 x 3/16" screws at hex studs CG, CH, CJ, CK, CL, and CM. Then tighten the nuts on the hex studs.

- (✓) Secure the end of the horizontal circuit board to the circuit board bracket with 6-32 x 3/8" hardware.
- (✓) Now tighten the nut on switch SW5.
- (✓) Position all the wires connected between the horizontal circuit board and the chassis as shown. Then install a cable tie through the two indicated chassis holes and around these wires. Pull the cable tie tight and cut off its excess end.

Refer to Pictorial 4-17 for the following steps.

Reposition the chassis as shown.

- (✓) Locate the graticule and remove the protective backing. (There may also be a protective film on the face of the graticule which must be removed at this time.)
- (✓) Place the graticule in the large rectangular opening in the cabinet front from the inside. Position the printed side of the graticule to the front.



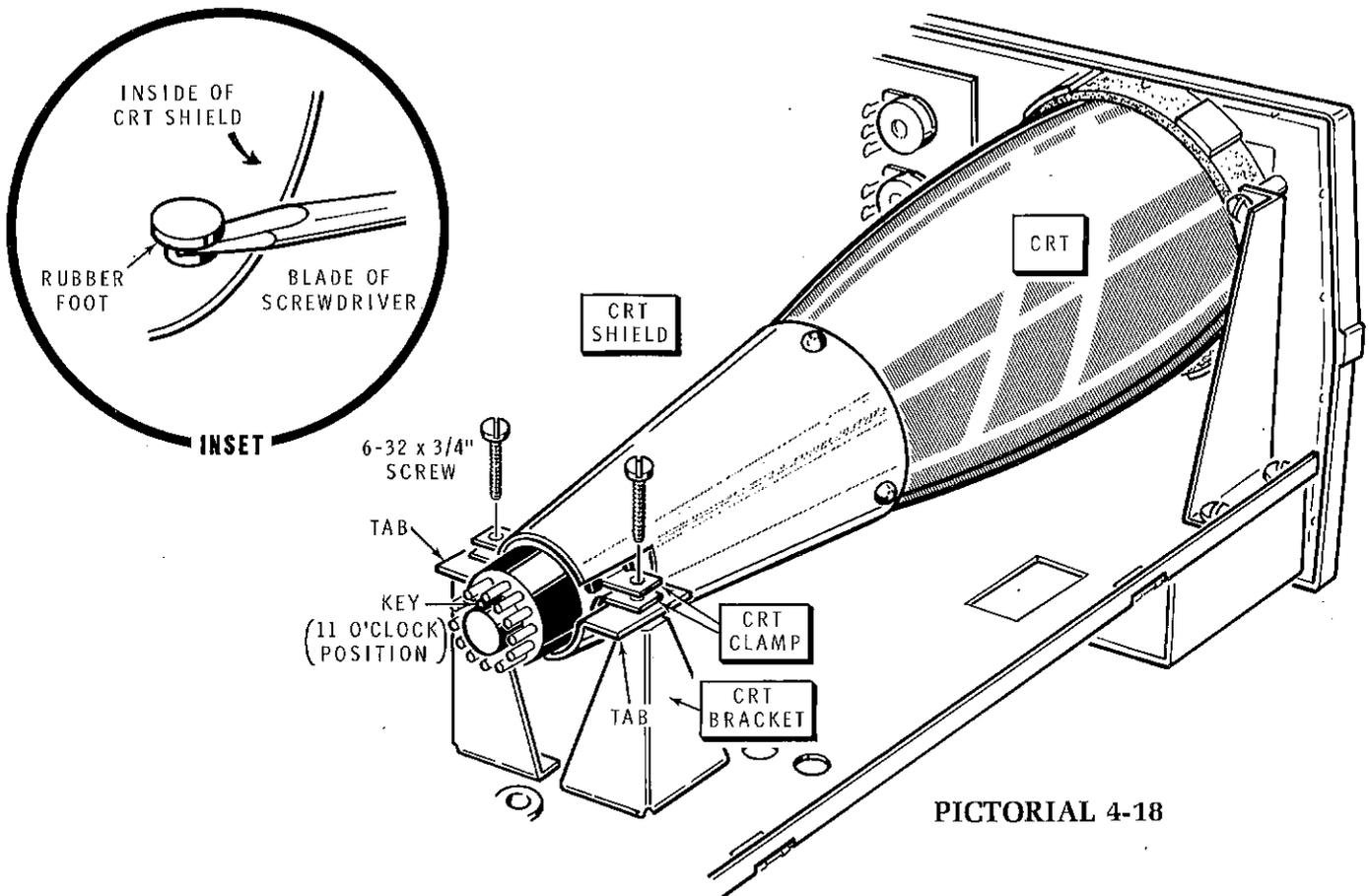
PICTORIAL 4-17

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

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

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

- (✓) Install the input shield with #6 × 1/2" screws in chassis holes F and G. Be sure not to pinch any wires between the shield and the chassis.
- (✓) Install the front panel bracket with #6 × 1/2" screws into chassis holes D and E and into the input shield. Do not tighten the screws.
- ( ) Install another #6 × 1/2" screw through the top slot in the front panel bracket and into the cabinet front.
- (✓) If necessary, reposition the front panel bracket so the front panel is perpendicular to the top of the chassis. Then tighten the screws at holes D and E and the hex studs.

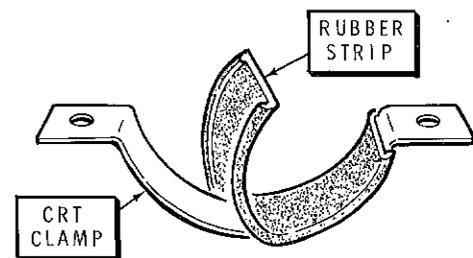


PICTORIAL 4-18

Refer to Pictorial 4-18 for the following steps.

- ( J ) Refer to the inset drawing on Pictorial 4-18 and install a rubber foot in each of the three indicated holes in the CRT shield. Use a small screwdriver to force the feet into the holes.
- ( J ) Cut the  $3/4" \times 5"$  rubber strip into two equal lengths.
- ( J ) Refer to Detail 4-18A and place a length of rubber strip onto each CRT clamp.

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



Detail 4-18A



- ( T ) Carefully unpack the CRT.
- ( T ) Slide the CRT shield over the neck of the CRT. Note the position of the tabs on the CRT shield with reference to the key on the CRT plug.
- ( → ) Push the face of the CRT into the ring in the cabinet front. Note the position of the key on the CRT plug.
- ( ✓ ) Install the two CRT clamps around the neck of the CRT but inside the CRT shield.
- ( ✓ ) Secure the CRT clamps and the CRT shield to the tops of the CRT brackets with two 6-32 × 3/4" screws. Tighten these screws only enough to hold the CRT in place. The CRT may have to be repositioned later.

Refer to Pictorial 4-19 (Illustration Booklet, Page 20) for the following steps.

- ( ✓ ) Align the keyway of the CRT socket with the key on the CRT plug and push the socket onto the CRT plug. It is alright if the socket does not go all the way onto the CRT plug.
- ( ✓ ) Connect the blue wire coming from grommet BC to the CRT socket lug 6 (S-1).
- ( ✓ ) Connect the gray wire coming from grommet BD to the CRT socket lug 7 (S-1).

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

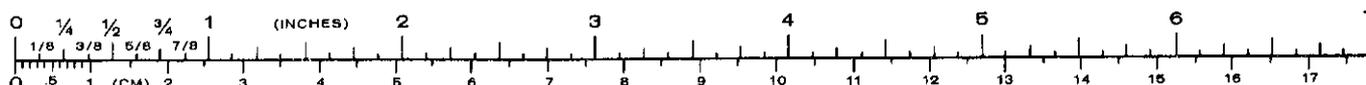
- ( T ) White-gray wire to lug 8 (S-1).
- ( T ) Large brown wire to lug 4 (S-1).
- ( T ) Large red wire to lug 3 (NS).
- ( → ) Large orange wire to lug 2 (S-1).
- ( T ) Either large green wire to lug 1 (NS).
- ( ✓ ) Other large green wire to lug 12 (S-1).

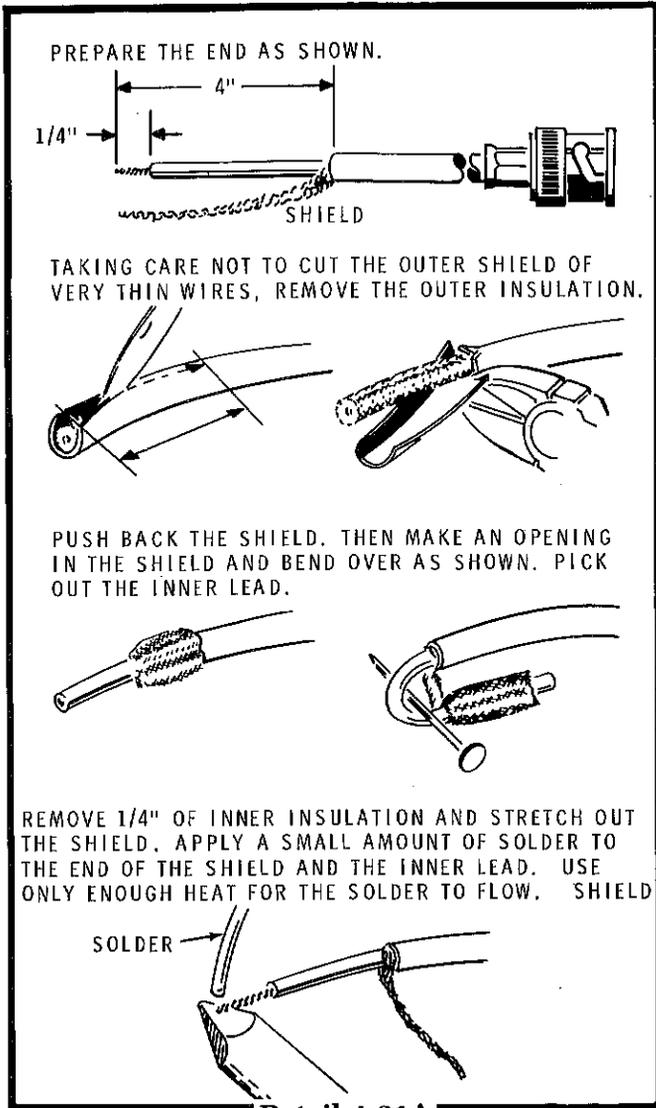
- ( ✓ ) R16: Connect a 100 kΩ (brn-blk-yel) resistor to the CRT socket between lugs 1 (S-2) and 3 (S-2).
- ( T ) Connect the gray wire coming from the horizontal circuit board to the CRT socket lug 9 (S-1).
- ( → ) Connect the blue wire coming from the horizontal circuit board to the CRT socket lug 10 (S-1).

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

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

- ( T ) Start a 6-32 × 1/8" black setscrew in each of the 9 knobs. Use the allen wrench furnished with the kit. NOTE: One of the knobs was packed with the vertical circuit board parts.
- ( T ) Turn the VERT POS, INTENSITY, FOCUS, TRIG LEVEL, and HORIZ POS controls to the center of their rotation.
- ( T ) Install a small black knob with a skirt on each of these controls with their pointers positioned straight up.
- ( T ) Turn the two rotary switches (large outer shafts) fully counterclockwise.
- ( T ) Install a large black knob on the 0 VOLTS/CM switch shaft with the pointer at the "20" position.
- ( T ) Install a large black knob on the 0 TIME/CM switch shaft with its pointer at the "200" position.
- ( T ) Turn the remaining two small inner control shafts to their fully **clockwise** positions.
- ( → ) Install a red knob on each of these control shafts with each knob pointer at the CAL position.





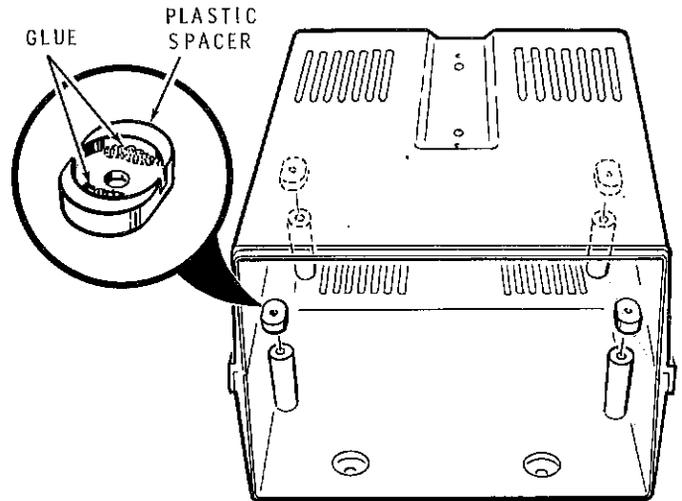
Detail 4-21A

Refer to Pictorial 4-21 (Illustration Booklet, Page 20) for the following steps.

- ( ↗ ) Locate the shield cable with a connector on one end. Refer to Detail 4-21A and prepare the free end of this cable.
- ( ) Slide a red alligator clip insulator over the end of the inner lead.

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

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



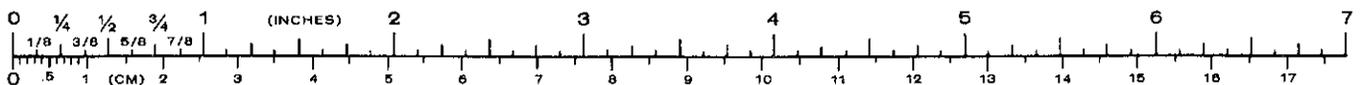
PICTORIAL 4-22

Refer to Pictorial 4-22 for the following steps.

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

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

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





# INITIAL TESTS

## RESISTANCE MEASUREMENTS

Be sure the power switch is in its OFF position.

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

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

Use an ohmmeter to make the following resistance measurements before you apply power to the Oscilloscope. This will insure that the power supply will not be damaged due to a wiring error or some incorrectly installed or faulty part. If you do not get the proper indication in a step, check the wiring and installation of the parts listed in the "Possible Cause" column for that step. You may also refer to the "In Case of Difficulty" section of the Manual (Page 86). Be sure you obtain the correct resistance reading before proceeding.

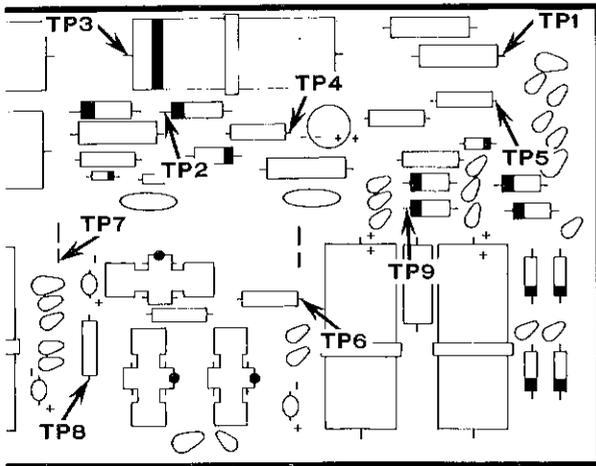
Refer to Pictorial 5-1 (on Page 72) for the following steps.

- (✓) Position the Oscilloscope bottom side up.
- (✓) Connect the negative ohmmeter lead to the chassis of the Oscilloscope. Then touch the positive meter lead to the points indicated in the chart on Page 72.

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

NOTE: The ohmmeter that was used to make the following measurements was powered by a 1.5 volt battery and set on the R×1000 range.

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



PICTORIAL 5-1

| POSITIVE METER LEAD TO: | APPROXIMATE METER READING      | POSSIBLE CAUSE  |
|-------------------------|--------------------------------|---|
| (✓) TP1                 | 600 k $\Omega$ -1 M $\Omega$   | <ol style="list-style-type: none"> <li>1. Resistors R310, R309</li> <li>2. Focus control R2 and resistor R3.</li> <li>3. Diodes D317, D302, and D301.</li> <li>4. Capacitors C301, C302, and C303.</li> <li>5. Power Transformer</li> </ol> |
| (✓) TP2 and TP3         | 20 k $\Omega$ -1 M $\Omega$    | <ol style="list-style-type: none"> <li>1. Power transformer</li> <li>2. Diodes D301 and D302.</li> <li>3. Capacitors C301, C302, and C303.</li> </ol>   |
| (✓) TP4                 | 900 k $\Omega$ -1.5 M $\Omega$ | <ol style="list-style-type: none"> <li>1. Power transformer.</li> <li>2. Diodes D301 and D302.</li> <li>3. Capacitors C301, C302, and C303.</li> </ol>  |
| (✓) TP5                 | 600 k $\Omega$ -1.5 M $\Omega$ | <ol style="list-style-type: none"> <li>1. Power transformer.</li> <li>2. Diodes D301 and D302.</li> <li>3. Capacitors C301, C302, C303, C314, and C315.</li> </ol>  |
| (✓) TP6                 | 400 $\Omega$ -1000 $\Omega$    | <ol style="list-style-type: none"> <li>1. Capacitor C310.</li> <li>2. IC 302.</li> <li>3. Resistors R334, R335, and R336.</li> </ol>  |
| (✓) TP7                 | 300 $\Omega$ -800 $\Omega$     | <ol style="list-style-type: none"> <li>1. Capacitor C309.</li> <li>2. IC U301.</li> <li>3. Connections to other circuit boards.</li> </ol>  |
| (✓) TP8                 | 400 $\Omega$ -1000 $\Omega$    | <ol style="list-style-type: none"> <li>1. Capacitor at C311.</li> <li>2. IC U303.</li> <li>3. Resistors R334, R335, and R336.</li> <li>4. Connections to other circuit boards.</li> </ol>   |
| (✓) TP9                 | 9000 $\Omega$ -20 k $\Omega$   | <ol style="list-style-type: none"> <li>1. Diodes D307, D308, D309, and D310.</li> <li>2. All sections of capacitor C308.</li> <li>3. Connections to other circuit boards.</li> </ol>  |

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

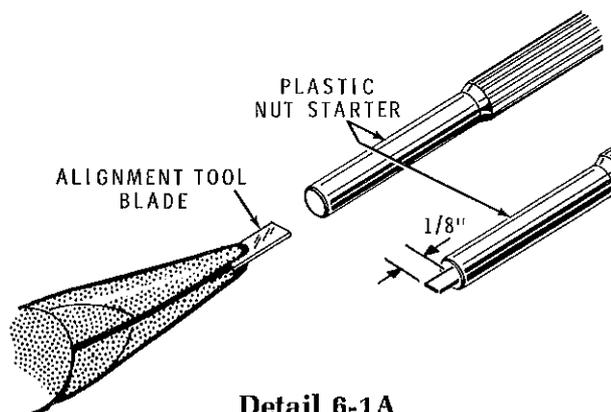
# CALIBRATION

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

Refer to Pictorials 6-1 and 6-2 through 6-5 (Illustration Booklet, Pages 21 and 22) for the following steps.

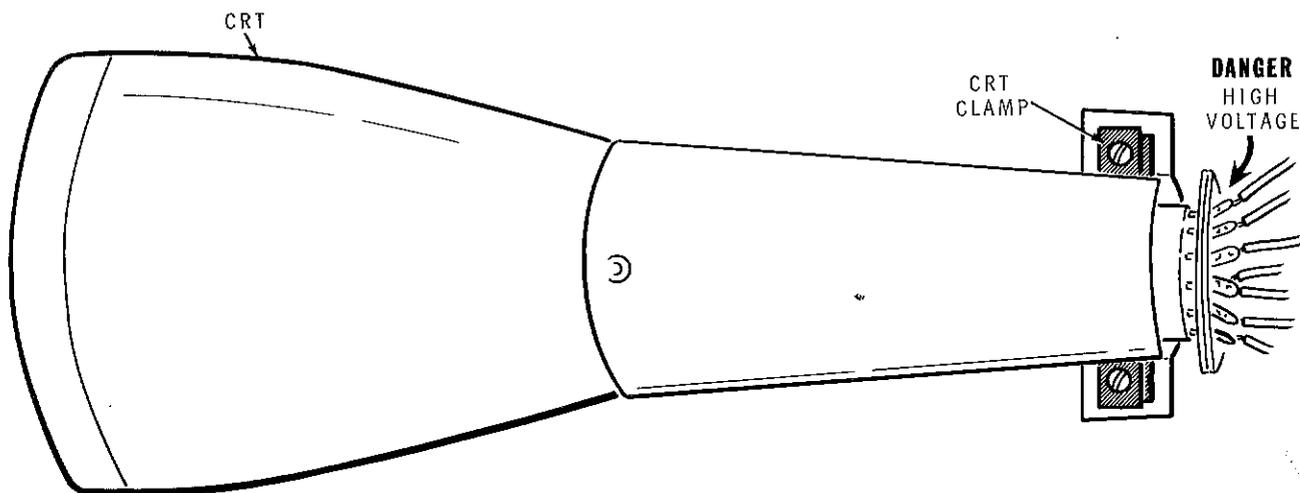
Set the front panel controls as follows:

- (✓) AC-GND-DC: GND.
- (✓) VERT POS: Center of rotation.
- (✓) VOLTS/CM: 0.01.
- (✓) VARIABLE: Full clockwise.
- (✓) POWER: OFF.
- (✓) INTENSITY: Full clockwise.
- (✓) FOCUS: Center of rotation.
- (✓) TRIG LEVEL: Center of rotation.
- (✓) HORIZ POS: Center of rotation.
- (✓) TIME/CM: 200  $\mu$ S.
- (✓) SWEEP VAR/HORIZ GAIN: Full clockwise.
- (✓) INT-EXT-LINE: INT.
- (✓) AC-DC-TV: AC.



- (✓) +/-: +.
- (✓) AUTO-NORMAL: AUTO.
- (✓) Refer to Detail 6-1A and push the alignment tool blade into the end of the plastic nut starter. Always use this tool to adjust the trimmer capacitors and controls in the following steps.
- (✓) Set all circuit board controls to their centers of rotation.
- (✓) On the vertical circuit board, turn all six trimmer capacitors clockwise until they are snug. Then turn them counterclockwise 1/2 turn.

**CAUTION:** AC and DC voltages in some areas of the Oscilloscope may exceed 1600 volts. Be very careful when you make the following adjustments. Make sure the Oscilloscope is setting on a nonmetallic surface and is not within reach of a water pipe or other ground conductor. The "Dangerous Voltage Areas" are shown on Page 24 in the Illustration Booklet.



PICTORIAL 6-2

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

NOTE: If you do not get the proper results in the following steps, recheck the steps to make sure you have adjusted the correct controls. If you still do not get the indicated results, turn the Oscilloscope off and refer to the "In Case of Difficulty" section on Page 86.

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

NOTE: It may be necessary to adjust the VERT POS and HORIZ POS controls to center the line in the next step.

- (✓) Check to see if the CRT trace is parallel with the horizontal graticule lines. If it is not parallel,

perform the following numbered steps. ✓

1. Note the position of the trace and turn off the power. ✓
2. Refer to Pictorial 6-2 and loosen the CRT clamp.
3. Rotate the CRT to align the trace.
4. Turn the power on and check the position of the trace.
5. Repeat steps 1, 3, and 4 as necessary to align the trace to the horizontal graticule lines.
6. After the correct results have been obtained, turn the power off and tighten the CRT clamp. ✓



## DC CALIBRATION

### POWER SUPPLY CIRCUIT BOARD

- ( ) Place the POWER switch in the ON position.
- ( ) Turn the front panel INTENSITY control fully counterclockwise.

Refer to Pictorial 6-3 (Illustration Booklet, Page 22) for the following steps.

- ( / ) Adjust the INTEN BIAS control clockwise (as viewed from the front panel) until the trace is visible (the trace may already be visible). Then adjust the control back counterclockwise until the trace disappears.
- ( / ) Adjust the ASTIG control:
  - / Turn the INTENSITY control clockwise until the trace appears.
  - / Turn the TIME/CM switch to the EXT IN  $\times 10$  position.
  - / Center the spot with the HORIZ POS control
  - / Adjust the ASTIG control and front panel FOCUS control until the dot is small, round, and as clear as possible.

### HORIZONTAL CIRCUIT BOARD

- ( / ) Use the front panel HORIZ POS control and center the spot on the screen.
- ( ) Connect the negative voltmeter lead to the chassis of the Oscilloscope.
- ( ) Set the voltmeter to measure 1.5 volts DC.

Refer to Pictorial 6-4 (Illustration Booklet, Page 22) for the following steps.

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

- ( / ) Touch the voltmeter probe to TP1 and adjust the ZERO ADJ control for zero volts.
- ( / ) Measure the voltage at TP2 and adjust the INPUT ZERO control for zero volts.
- ( ) Set the voltmeter to measure 5 volts DC.
- ( ) Measure the voltage at TP3 and record the reading beside this step. It should be approximately 5 volts (4.8 to 5.2).
- ( / ) Measure the voltages at TP4 and TP5. Adjust the front panel HORIZ POS control until both test points are equal. Then adjust the BIAS ADJ control until the test point voltages equal the meter reading you recorded in the previous step.

### VERTICAL CIRCUIT BOARD

- ( / ) Set the voltmeter to measure 1.5 volts DC.

Refer to Pictorial 6-5 (Illustration Booklet, Page 22) for the following steps.

- ( / ) Measure the voltage at TP6. Then adjust the DC BAL control for zero volts.
- ( / ) Center the trace with the VERT POS control.
- ( / ) Rotate VARIABLE control from one end to the other and check to see if the trace moves up or down. If the trace moves, adjust the DC BAL control so it does not move when you rotate the control.

NOTE: Because of the normal aging of your Oscilloscope, you may have to repeat the previous adjustment periodically. To determine if the adjustment is necessary, turn the VARIABLE control from one end to the other and see if the dot or trace moves up or down. The trace should remain in the same place.

( / ) Set the voltmeter to measure 5 volts DC.

( / ) Measure the voltages at TP7 and TP8. Adjust the front panel VERT POS control until both readings are the same. Then adjust the BIAS ADJ control until the reading is the same as the one you recorded earlier in the Manual (4.8 to 5.2 volts).

( / ) Measure the voltage at TP9 and adjust the TRIG ZERO control for zero volts.

## AC CALIBRATION

Set the front panel controls as follows:

( / ) VOLTS/CM: 0.05

( / ) VARIABLE: Full clockwise.

( / ) INT-EXT-LINE: INT

( / ) TIME/CM: 200  $\mu$ S

( / ) Use the VERT POS and HORIZ POS controls and center the trace on the screen.

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

Refer to Pictorial 6-6 (Illustration Booklet, Page 22) and connect a 1 kHz square wave signal to the INPUT connector. Adjust the generator output to produce a display that is 4 to 5 cm high. Adjust the TRIG LEVEL as necessary.

### VERTICAL CALIBRATION AND ATTENUATOR COMPENSATION

Refer to Pictorial 6-5 (Illustration Booklet, Page 22) for the following steps.

1. ( / ) Set the VOLTS/CM switch to the 0.1 position. Use a nonmetallic screwdriver to adjust the  $\times 100$  trimmer capacitor for a proper display like the one labeled RIGHT in Pictorial 6-7. If it will not adjust, then adjust the  $\times 10$  trimmer capacitor.

2. ( / ) Set the VOLTS/CM switch to the 1 position, readjust the generator output as necessary, and adjust the  $\times 1000$  trimmer capacitor for a proper display. If it will not adjust, then adjust the  $\times 100$  trimmer capacitor.

3. ( / ) Set the VOLTS/CM switch to the 10 position, readjust the generator output as necessary, and adjust the  $\times 10$  trimmer capacitor for a proper display.

4. ( / ) Repeat the above three steps until the compensation is correct.

NOTE: If you do not have a calibrated voltage source, disregard the next three steps and use the 1 V (P-P) 60 Hz signal that is available at the front panel. Connect the signal to the INPUT connector, set the TIME/CM switch to 2 mS, set the VOLTS/CM switch to 0.2, and adjust the CAL control for a display that is 4.5 cm high.

1. ( / ) Set the generator output to .1 V.

2. ( / ) Set the VOLTS/CM switch to .02. Be sure the VARIABLE control is fully clockwise.

3. ( / ) Adjust the CAL control for a display 5 cm high.

( / ) Set the TIME/CM switch to 0.2  $\mu$ S.

( / ) Set the generator frequency to 1 MHz and adjust its output to produce a display that is four or five cm high.

( / ) Adjust the H.F.COMP trimmer capacitor for a square wave with a smooth leading edge as shown in Pictorial 6-8 (Illustration Booklet, Page 22).



## HORIZONTAL AMPLIFIER ADJUSTMENTS

Refer to Pictorial 6-4 (Illustration Booklet, Page 22) for the following steps.

- ( ✓ ) Set the generator frequency to 5 kHz.
- ( ✓ ) Set the TIME/CM switch to 200  $\mu$ s.
- ( ✓ ) Set the AC-GND-DC switch to GND.
- ( ✓ ) Adjust the SWEEP LENGTH control for a trace that is 10 cm long (just fills the screen).
- ( ✓ ) Set the AC-GND-DC switch to AC.
- ( ✓ ) Adjust the horizontal circuit board CAL control and the HORIZ POS control so there are ten complete waveforms in 10 cm as shown in Pictorial 6-9 (Illustration Booklet, Page 22).

NOTE: If a calibrated signal source is not available, use the 1 V (P-P) 60 Hz output. Set the TIME/CM switch to 2 ms and adjust the HORIZ CAL control for a waveform that is 8.3 cm long. The 1 V (P-P) 60 Hz output can be used for remaining Horizontal Amplifier adjustments.

- ( ✓ ) Set the AC-GND-DC switch to GND.
- ( ✓ ) Readjust the SWEEP LENGTH control for a trace that is 10 cm long (just fills the screen).
- ( ✓ ) Move the trace one division to the left with the HORIZ POS control and again adjust the SWEEP LENGTH control until the trace again fills the screen. The trace is now 11 cm long.
- ( ✓ ) Set the generator frequency to produce a sine wave approximately 500 Hz.
- ( ✓ ) Set the AC-GND-DC switch to AC.
- ( ✓ ) Set the TIME/CM switch to 2 ms.
- ( ✓ ) Adjust the VERT POS control to center the trace vertically on the screen.
- ( ✓ ) Adjust the HORIZ POS control so the left end of the trace is on the screen.
- ( ✓ ) Adjust the TRIG LEVEL control so the trace starts on the zero base line (center of the graticule). Then move the +/- switch to the "-" position. Adjust the TRIG BAL control so the trace starts on the zero base line. Move the +/- switch back and forth to make this final adjustment.

- ( ✓ ) Move the TRIGGER COUPLING switch to DC. If the trace starting point moves, adjust the TRIG ZERO control (on the vertical board) until there is no movement when you switch the coupling switch back and forth between the AC and DC positions. Use the TRIG LEVEL control to keep the trace starting on the zero base line.

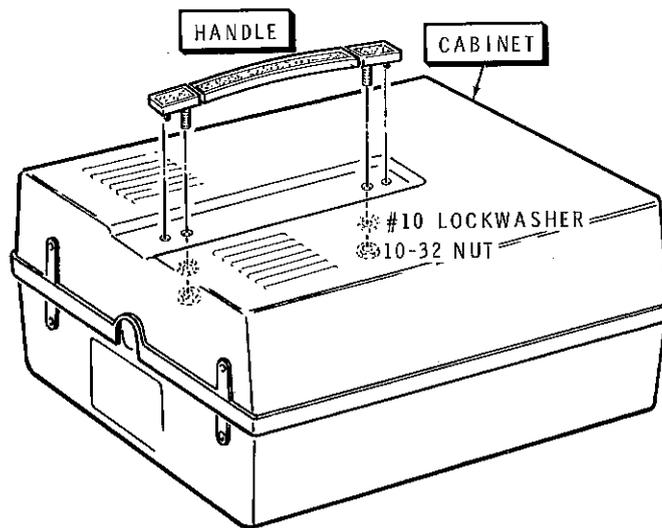
## LOW-CAPACITY PROBE

NOTE: If you do not have a low capacity probe, disregard the following steps and proceed to "Final Assembly."

- ( ✓ ) Set the TRIGGERING switches to INT, AC, +, and AUTO.
- ( ✓ ) Set the TIME/CM switch to 200  $\mu$ s.
- ( ✓ ) Set the VOLTS/CM switch to 0.05 and the VARIABLE control fully clockwise.
- ( ✓ ) Connect a low-capacity probe to the INPUT connector.
- ( ✓ ) Connect the probe to a 1 kHz square wave signal.
- ( ✓ ) Adjust the output of the generator to produce a display that is 4 cm high.
- ( ✓ ) Adjust the compensation capacitor on the probe for a proper square wave with no overshoot as shown in Pictorial 6-7.
- ( ✓ ) Set the VOLTS/CM switch to 0.5.
- ( ) Readjust the generator output for a 4 cm display.
- ( ) Adjust the trimmer capacitor #1 for a proper square wave. If you cannot make this adjustment, readjust the probe capacitor and capacitor #1 until the correct waveform is displayed.
- ( ) Set the VOLTS/CM switch to 0.05 and readjust the generator output for a 4 cm display again.
- ( ✓ ) Adjust trimmer capacitor #2 for a proper square wave.

NOTE: If necessary, repeat the previous steps until a proper square wave is displayed.

## FINAL ASSEMBLY



Detail 7-1A

Refer to Pictorial 7-1 (Illustration Booklet, Page 23) for the following steps.

- ( / ) Refer to Detail 7-1A and mount the handle in the holes provided in the cabinet. Use #10 lockwashers and 10-32 nuts.
- ( / ) Place a soft cloth on your work surface. Then position the Oscilloscope face down on the cloth.
- ( ) Remove the protective backing from the blue and white label and press the label in place on the rear of the chassis. Always mention the numbers on this label in any communications you have with the Heath Company about this kit.

- ( ) Carefully slide the cabinet down over the chassis. Be sure the front edge of the cabinet is inside the lip around the outer edge of the cabinet front.
- ( ) Secure the cabinet to the chassis with eight #8  $\times$  5/8" hex washer head screws. Tighten the four rear screws first.
- ( ) Remove the protective backing from the power consumption label and press the label in place on the rear of the cabinet.

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



# OPERATION

## WARNING

The danger of an electrical shock or equipment damage, or both, exist if you use this instrument with any electronic device that does not have a transformer to isolate it from the AC line (AC-DC equipment). Always use a line isolation transformer if you want to make any connections to AC-DC equipment. Also use an isolation transformer, between the test leads and the AC line, if you want to measure the AC line directly.

This section of the Manual explains the function of each control, switch, and connector; describes how to

correlate between time/cm and frequency; and provides operational examples.

## NORMAL OPERATING CHARACTERISTICS

The following information is provided to help answer possible questions you may have about the operation of your Oscilloscope.

- Several minutes may be required for the trace to stabilize when the Oscilloscope is first turned on, especially on the more sensitive voltage ranges.
- Random noise on the input signal may cause false triggering, especially on the most sensitive voltage ranges.
- A baseline will automatically appear after a short pause when the TRIGGERING AUTO/NORMAL switch is placed in the AUTO position or when the input signal is disconnected when automatic triggering is used.
- Placement of the ground clip may be critical if the signal source ground carries an appreciable current. Voltage differences of several millivolts from one side of a chassis or ground foil to the other are common. Place the ground clip at the point that gives the least error. This is usually nearest the signal source. You may have to move the ground clip when you measure different points.
- Stray 60 Hz pickup may be hard to eliminate, especially in high impedance circuits. Be sure to use shielded test cables. Shield the signal source if necessary.
- Wideband measurements in the millivolt region are more difficult because of the inherent noise (shot noise and thermal noise) generated by electronic components. This may appear as a widening of the baseline or the baseline appearing out of focus. Noise on the baseline that appears as "hash" or "spikes" may be caused by the electromagnetic pickup of man-made noise such as ignition noise, appliance noise, etc. Noise of any kind may cause erratic triggering.

## USING A 10-MILLIVOLT OSCILLOSCOPE

When you use an Oscilloscope as sensitive as this, you must use special care to make reliable measurements. Keep the following points in mind when you measure very low level signals.

## ALTERNATE PRIMARY VOLTAGES

In the United States 120 VAC line voltage is most often used, while in other countries 240 VAC line voltage is more common. If you intend to operate the Oscilloscope on 240 volts, perform the following steps. Otherwise, proceed to "Operation and Applications." NOTE: Electrical regulations in some areas require a special line cord and/or plug for 240-volt operation. Replace them if necessary.

- ( ) Make sure the line cord is unplugged.
- ( ) Remove the cabinet from the Oscilloscope.

- ( ) Shift the 120/240 slide switch to the 240 position. This switch is located near the rear of the chassis, between the CRT and power transformer.
- ( ) Remove the 1/2-ampere slow-blow fuse and install a 3/8-ampere slow-blow fuse (not supplied). The fuse block is located on the bottom side of the chassis.
- ( ) Reinstall the cabinet.

## OPERATION AND APPLICATIONS

Refer to Pictorial 6-1 (Illustration Booklet, Page 21) for the location and explanation of the front panel controls and switches.

### OPERATIONAL EXAMPLE

The following example will help you become more familiar with the control functions, especially the sweep and trigger controls.

Connect a 1 kHz sine wave source to the vertical INPUT connector. Set the TRIGGERING switches to INT, AC, (+), and NORMAL. Set the INPUT switch to AC.

Turn the TRIG LEVEL control to its center of rotation. Adjust the VOLTS/CM switch to obtain a trace 3 or 4 centimeters high. Adjust the HORIZ POS control so the left edge of the trace is just inside the left margin of the graticule. Set the TIME/CM switch to display a few cycles of the waveform. Adjust the VERT POS control to center the trace vertically.

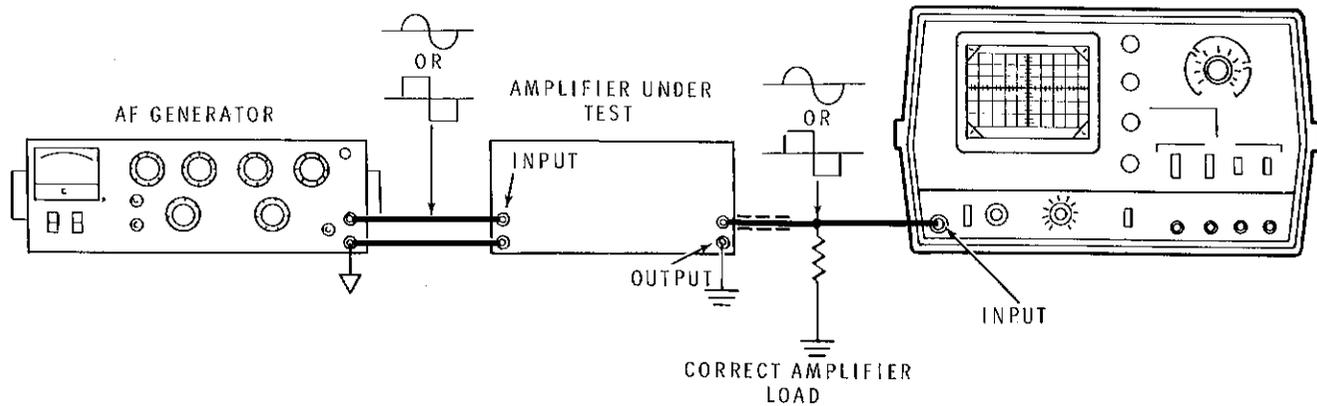
Now carefully readjust the TRIG LEVEL control and observe how the left edge (starting point) of the sweep moves upward as the control is turned clockwise, and downward as the control is turned counterclockwise. See A on Pictorial 8-1 (Illustration Booklet, Page 23).

Switch the TRIGGERING +/- switch to the "-" position, and note that the TRIG LEVEL control has the same effect except that the sweep start point is on the negative slope of the waveform.

There is no fixed rule for setting the TRIG LEVEL control, as no two waveforms are alike. For example, assume that you want to examine the "spike" on waveform B of Pictorial 8-1. By adjusting the TRIG LEVEL control so the sweep starts just before the spike, as in C in Pictorial 8-1, and decreasing the time required for one complete sweep by changing the position of the TIME/CM switch, the spike can be spread out across a large area of the screen for closer observation, as shown in D of Pictorial 8-1.

By reading the TIME/CM switch, and measuring the spike on the graticule, you can determine the duration of the spike. This feature is also useful to observe distortion in circuits using square wave signals.

The TIME/CM switch should be set to display the desired waveform or portion of a waveform. Occasionally it may also be necessary to use the VARIABLE. However, the sweep time is not calibrated when the VARIABLE is used. Refer to the formula or the "TIME/CM FREQUENCY Correlation Chart" on Page 85 to determine unknown frequencies or sweep times when you use the calibrated positions of the TIME/CM switch.



PICTORIAL 8-2

The TRIGGERING INT/EXT/LINE switch permits you to choose between internal or external triggering signals. The internal trigger is derived from the vertical input signal. In the LINE position, the trigger comes from the power line signal. The EXT (external) trigger position allows the sweep to be triggered from external sources, such as TV horizontal or vertical sync pulses.

When the TRIGGERING AUTO/NORMAL switch is in the AUTO position, a sweep appears on the screen even in the absence of a signal. The AUTO position is useful for simple waveforms with frequencies from about 40 cycles and upward. This switch position is also useful for signals that are too weak to trigger the sweep circuit in the normal position.

The TRIGGERING AC/DC/TV switch will normally be on the AC position except when you use very low frequency or DC signals as a trigger source, or when you use the TV setting to filter out the horizontal sync signal when viewing a composite waveform.

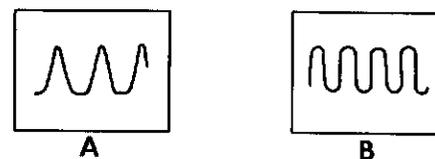
### AUDIO AMPLIFIER CIRCUITS

You can observe frequency response, distortion, and gain in an audio amplifier by observing its output waveform when a sine wave or a square wave is applied to the amplifier input.

Pictorial 8-2 shows a typical setup for checking an audio amplifier. The audio generator injects either a low distortion sine wave or square wave signal into the input of the amplifier. The amplifier's output terminates in the proper load for the amplifier, and the oscilloscope is connected across the load.

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.

Pictorial 8-3, Part A, shows a sine wave with a serious flattening of one peak. This represents about 10% harmonic distortion, which could be caused by an improperly biased stage or a defective tube or transistor, and is a particularly objectionable amplifier fault. Pictorial 8-3, Part B, shows a flattening of both peaks, which usually indicates an overdriven stage somewhere in the amplifier.



PICTORIAL 8-3

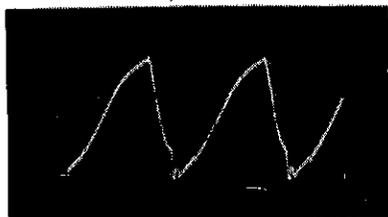
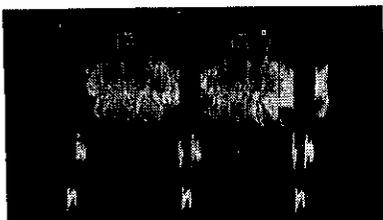
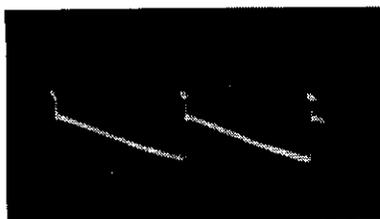
While a sine wave signal will tell a lot about an amplifier, a square wave gives an additional indication of amplifier performance with respect to frequency response, amplitude distortion, and phase shift. The square wave generator must produce a clean waveform with straight sides, sharp corners, and flat horizontal lines, as shown in Pictorial 8-4, (Illustration Booklet, Page 23) Part A.

When a low frequency square wave signal is fed into the input of an amplifier, its output waveform will be a faithfully reproduced square wave if its frequency response is good and if little amplitude or phase distortion occurs in the circuits. The shape of the leading edge of an output waveform, as shown in Pictorial 8-4, Part B, indicates poor high frequency response. This may be caused by amplitude distortion (clipping), or phase shift, or both.

The slope of the flat portion of the waveform, as shown in Pictorial 8-4, Part C, indicates poor low frequency response.

## TELEVISION RECEIVER CIRCUITS

An oscilloscope can also be used to service television receivers. There are two methods of using the oscilloscope in TV service work. One is the point-to-point probing to study components of a transmitted television signal and their effect on receiver circuits. The other method uses the signal from a sweep generator and is used primarily for the alignment of a receiver. These two methods will be treated separately in the following paragraphs.



PICTORIAL 8-5

## 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 Pictorial 8-5. No special equipment is required for observing these patterns on your Oscilloscope, except a demodulator probe to detect modulation envelopes in the IF or RF amplifier sections.

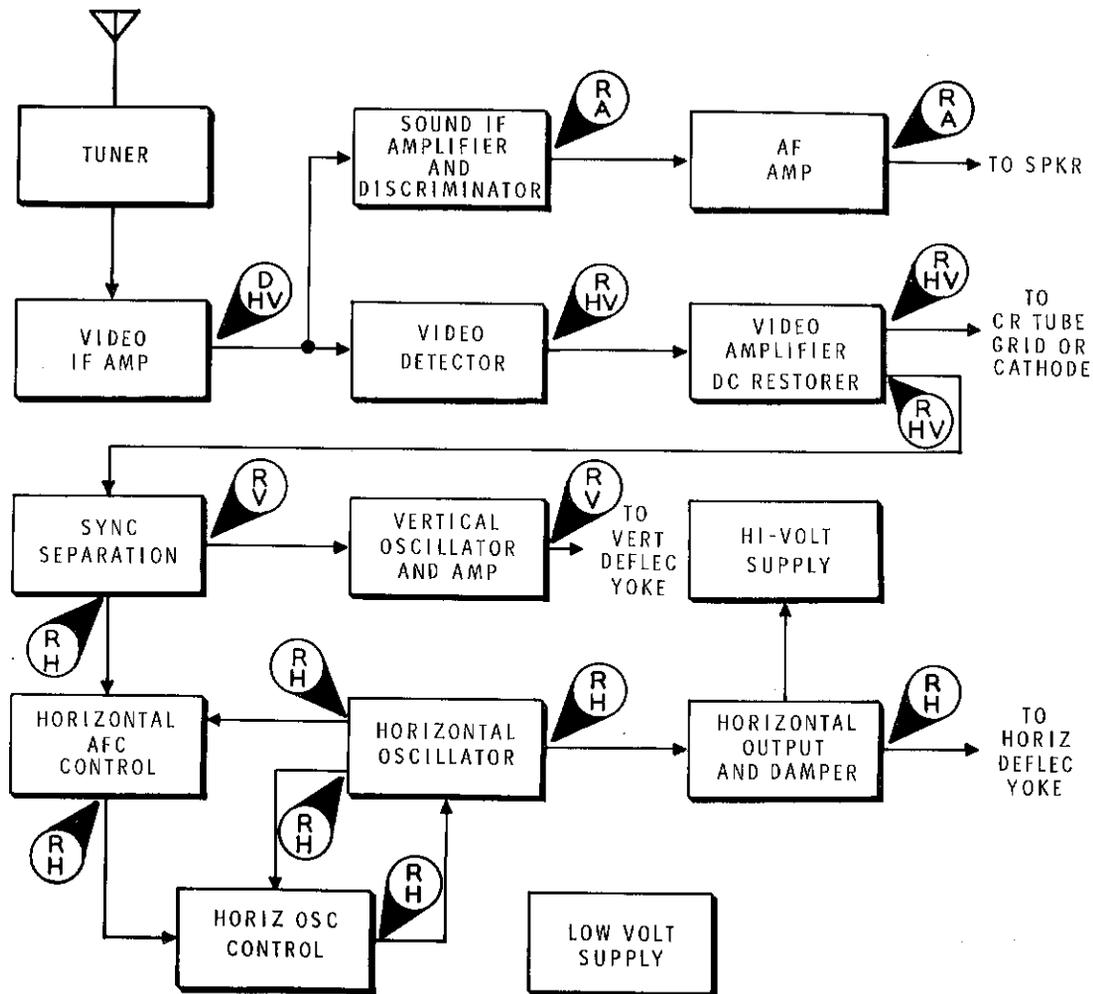
Pictorial 8-6 is a simplified block diagram of a typical television receiver. It shows various stages and points for connecting the Oscilloscope probe. The letters at each test point indicate the type of probe to use, and the setting of the Oscilloscope's sweep speed. These letters are defined in the following chart.

| PROBE         | SWEEP SPEED                |
|---------------|----------------------------|
| R Direct      | H 20 $\mu$ s/cm            |
| D Demodulator | V 2 ms/cm (use TV trigger) |
| A Audio       | Test frequency             |

NOTE: For simplicity, all amplifier stages are shown within one block of the diagram in Pictorial 8-6. 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 circuit, 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 amplifier stages, can generally be made using a sweep speed of 2 ms/cm. In order to study the horizontal pulse shape or the operation of the horizontal deflection system, it is generally necessary to operate the sweep generator at 20  $\mu$ s/cm. This sweep rate will show the waveform of about three lines of the signal.



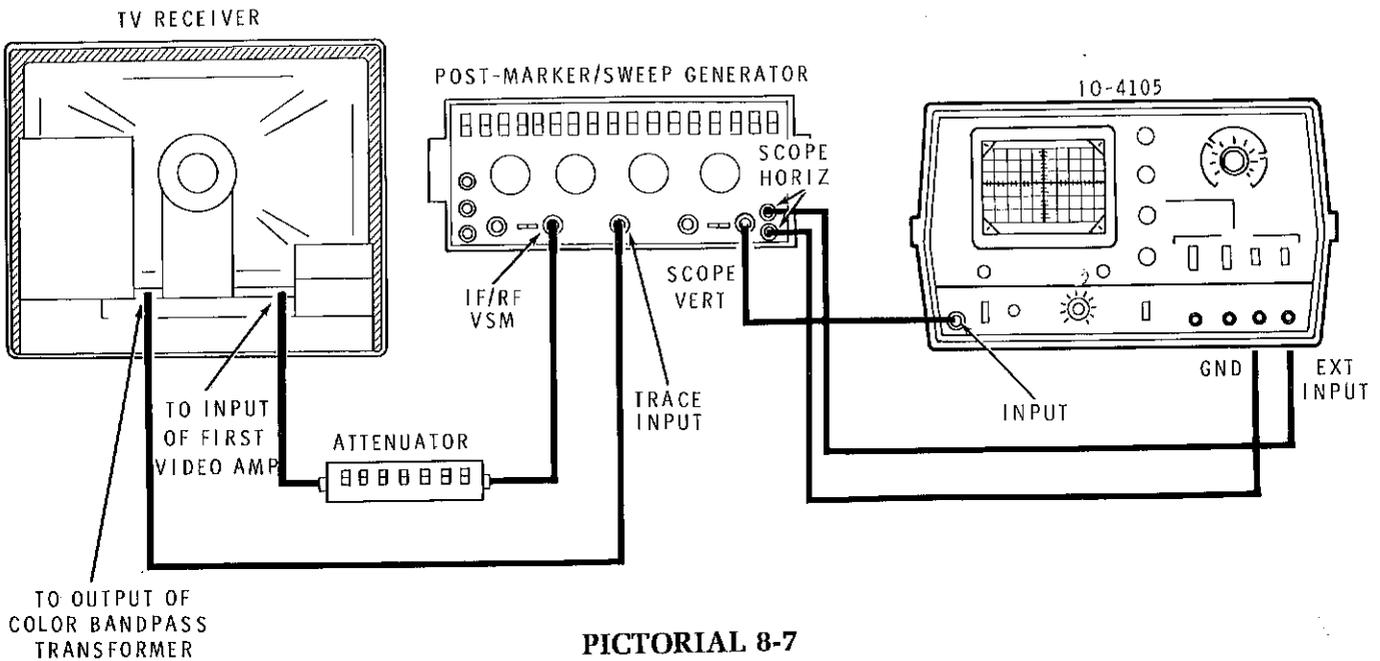
PICTORIAL 8-6

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

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

Video amplifier response can be measured in exactly the same manner described for testing an audio

amplifier, and again a square wave signal is the most efficient method to use. Because a video amplifier must pass signals as low as 20 Hz and as high as 4 or 5 MHz, a more comprehensive test is required. Usually a 60 Hz check is made to cover low and medium frequency characteristics. A second check at 25 kHz covers the high frequency portion of the response curve. Again, such tests require accuracy on the part of the Oscilloscope. The signal tracing technique can be used in these tests also. The square wave generator is fed directly into the first video amplifier stage. Very low signal input will be required. Then the Oscilloscope is connected to various stages, starting near the output end and working back until any distortion is isolated. Patterns such as Pictorial 8-4, Part B, (Illustration Booklet, Page 23) are responsible for poor picture detail or fuzziness, while the distortion of the waveform shown in Pictorial 8-4, Part C, can cause shading of the picture from top to bottom.



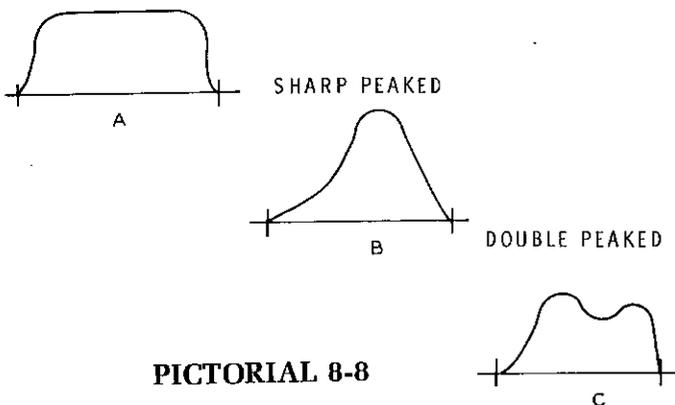
PICTORIAL 8-7

### Receiver Alignment

Alignment of television RF and IF circuits requires the use of an alignment sweep generator as well as the Oscilloscope. This sweep generator supplies an RF signal that sweeps across all the frequencies of a television channel or IF amplifier 60 times a second. The sweep generator also supplies 60 Hz sweep voltage to the Horizontal input of the Oscilloscope. Pictorial 8-7 shows a typical setup for the alignment of a television receiver.

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

GOOD RESPONSE



PICTORIAL 8-8

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

### AC VOLTAGE MEASUREMENTS

Because of its characteristics, the oscilloscope is particularly suited to the measurement of AC voltages. In some television circuits, it is imperative that such measurements be made accurately with respect to wave shape, so that the conventional rms-indicating AC voltmeter is no longer adequate. Most television service bulletins specify peak-to-peak voltages which appear at various points of the circuit.

The following relationships exist for sine wave AC voltages:

- rms  $\times$  1.414 = Peak Voltage
- rms  $\times$  2.828 = Peak-to-Peak Voltage
- Peak Voltage  $\times$  .707 = rms Voltage
- Peak-to-Peak Voltage  $\times$  0.3535 = rms Voltage



## TIME/CM-FREQUENCY CORRELATION

You can determine the frequency of a constant signal with your Oscilloscope by using the following formula.

$$\text{Frequency} = \frac{1}{\text{TIME/CM switch setting multiplied by the number of centimeters on the CRT covered by one cycle of the unknown frequency.}}$$

NOTE: The long vertical and horizontal lines on the graticule are spaced 1 cm (centimeter) apart. The short lines on the center vertical and horizontal lines are 2 mm (millimeters) apart. The usable graticule area is 8 cm high and 10 cm wide.

For example: Assume that one cycle of the unknown frequency covers five centimeters on the CRT (with the VARIABLE control full clockwise). The TIME/CM switch is set at 2  $\mu$ S ( $2 \times 10^{-6}$ ). Using the previous formula.

$$\text{Frequency} = \frac{1}{2 \times 10^{-6} \text{ sec} \times 5 \text{ cm}} \text{ cm}$$

$$\text{Frequency} = 100 \text{ kHz.}$$

NOTE: The VARIABLE control cannot be used when you are computing with this equation, since there are no calibrated values associated with it. This control must be kept in the CAL (full clockwise) position when you are determining an unknown frequency.

## TIME/CM-FREQUENCY CORRELATION CHART

| TIME/CM SWITCH | TIME FOR 1 CM SWEEP | FREQUENCY (Hz) FOR 1 CYCLE/10-CM (full screen width) | FREQUENCY (Hz) FOR 5 CYCLES/10 CM (full screen width) |
|----------------|---------------------|--|---|
| .2 $\mu$ S     | .2 $\mu$ sec        | 500,000  | 2,500,000   |
| 2 $\mu$ S      | 2 $\mu$ sec         | 50,000   | 250,000   |
| 20 $\mu$ S     | 20 $\mu$ sec        | 5,000  | 25,000  |
| 200 $\mu$ S    | 200 $\mu$ sec       | 500  | 2500  |
| 2 mS           | 2 m sec             | 50   | 250   |
| 20 mS          | 20 m sec            | 5  | 25  |
| 200 mS         | 200 m sec           | .5   | 2.5   |

NOTE: When the trigger selector is in the "line" position, a trace may not be visible on the CRT at sweep speeds above 20  $\mu$ sec. The Oscilloscope will still be triggered, but the refresh rate is so low that the trace is dim.

## IN CASE OF DIFFICULTY

This section of the Manual is divided into four parts. The first part, "General Troubleshooting Information," outlines possible causes that are the most often sources of trouble in newly assembled kits. Go through this part very carefully and apply these checks to your kit.

The second part "Troubleshooting Precautions and Notes," outlines precautions you should take when troubleshooting your Oscilloscope. Read this part carefully so you do not damage your oscilloscope while searching for the difficulty.

The third part, the "Troubleshooting Charts," is really two parts. The first part of this section consists of various tests to localize the trouble. You will then be

directed to the second part, where you will pinpoint the trouble within the local area or circuit board.

If the "Troubleshooting Chart" does not help you locate the problem, read the "Circuit Description" and refer to the Schematic Diagram (fold-in) to help you determine where the trouble is.

The fourth part, "Checking Components," shows you how to use an ohmmeter to determine if a suspected component is faulty.

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

## GENERAL TROUBLESHOOTING INFORMATION

The following paragraphs deal with the types of difficulties that may show up right after a kit is assembled. These difficulties are most likely to be caused by assembly errors or poor soldering.

1. Recheck the wiring. Trace each wire lead in colored pencil on the Pictorial where it is installed, as you check it. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something you consistently overlooked.
2. About 90% of the kits that are returned for repair do not work properly due to poor solder connections. Therefore, you can eliminate many troubles by reheating all connections to make sure they are soldered as described in the "Soldering Instructions," at the front of this Manual.
3. Check to make sure that all transistors are in their proper locations. Make sure that each transistor lead is connected to the proper point and that the transistor flats are properly positioned.
4. Check the values of the parts. Be sure that the proper part has been wired into the circuit as shown in the Pictorials and called out in the wiring instructions. For example, it would be easy to install a 200  $\Omega$  (red-black-brown) resistor for a 1000  $\Omega$  (brown-black-red) resistor.
5. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring. Check for solder bridges between circuit board foils. Compare your foil pattern against the "Circuit Board X-Ray Views" (Illustration Booklet, Page 34, 35, and 36).



## TROUBLESHOOTING PRECAUTIONS AND NOTES

**WARNING:** The full AC line voltage and high DC voltage is present at several places in the Oscilloscope. See Pictorial 9-1 and 9-2 (Illustration Booklet, Page 24). Be careful to avoid electrical shock when you work on the Oscilloscope.

1. Be cautious when you test transistors and integrated circuits. Although they have almost unlimited life when used properly, they are easily damaged by excessive voltage and current.
2. Be careful so you do not short any terminals to ground when you make voltage measurements. If the probe should slip, for example, and short out a bias or voltage supply point, it may damage one or more components.
3. **DO NOT** remove any components while the Oscilloscope is turned on.
4. When you make repairs to the Oscilloscope, make sure you eliminate the cause as well as the effect of the trouble. If, for example, you should find a damaged resistor, be sure you find out what caused the resistor to become damaged. If the cause is not eliminated, the replacement resistor may also become damaged when the Oscilloscope is turned on again.
5. Refer to the "Circuit Board X-Ray Views," and the "Schematic Diagram," to locate various components.
6. When the oscilloscope Trigger Selector is in the "LINE" position, a trace may not be visible on the CRT above 20  $\mu$ sec. The oscilloscope will still be triggered, but the writing speed will be too fast to light the CRT.

## TROUBLESHOOTING CHARTS

The "Troubleshooting Charts" are designed to pinpoint a trouble through a series of tests. The following symbols and procedures are used in the charts.



Follow the "YES" arrow when you obtain the correct measurement or condition.



Follow the "NO" arrow when you do not obtain the correct measurement or condition.

Components are listed in the order in which failure or a problem is most likely to occur.

All voltage measurements were made with a high impedance voltmeter, a nominal line voltage of 120 volts AC, and can vary  $\pm 20\%$ .

Set the front panel controls and switches as follows:

INTENSITY: Center of rotation.

FOCUS: Center of rotation.

TRIG LEVEL: Center of rotation.

HORIZ POS: Center of rotation.

TIME/CM:  $\times 10$  (full clockwise).

SWEEP VAR/HORIZ GAIN: CAL (fully clockwise).

INT-EXT-LINE (trigger source switch): INT.

AC-DC-TV (trigger coupling switch): AC.

POSITIVE (+)-NEGATIVE (-) (slope switch): Positive (+).

AUTO-NORMAL (trigger mode switch): AUTO.

AC-GND-DC: GND.

VOLTS/CM: 0.05.

VARIABLE: CAL (fully clockwise).

VERT POS: Center of rotation.

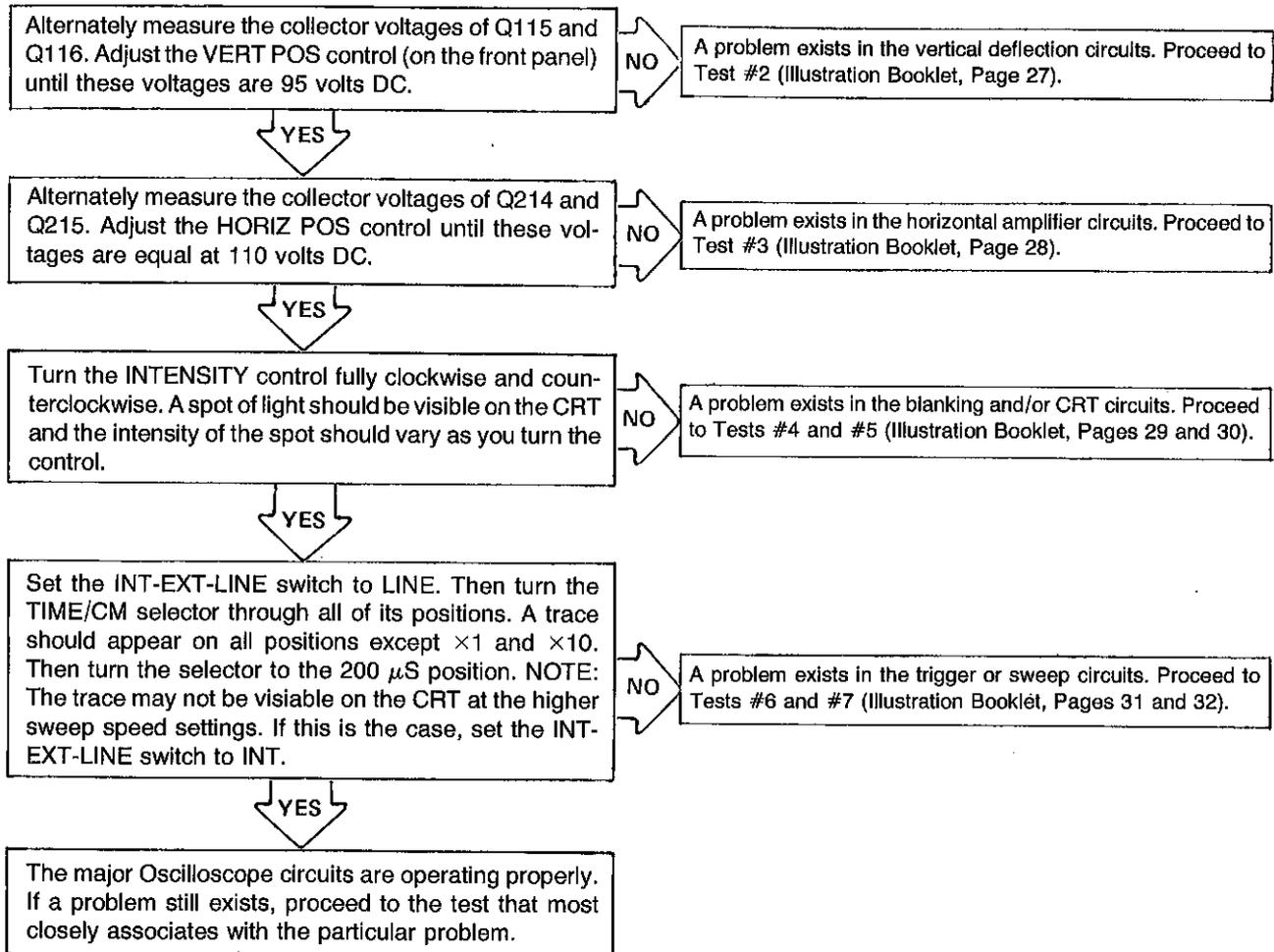
OFF-ON: OFF.

Do not change the position of any control or switch unless you are instructed in a step to do so.

Connect the line cord to an AC outlet and turn the Oscilloscope on.

Perform the  $\pm 9$  and  $+5$  volt power supply test (Test #1) on Page 26 in the Illustration Booklet to verify the operation of the power supplies before you proceed. These power supplies must operate properly before you attempt any further troubleshooting. After you have completed Tests #1, proceed to the "Trouble Locator Chart" on Page 89.

## TROUBLE LOCATOR CHART



## CHECKING COMPONENTS

### INTRODUCTION

To check a transistor accurately, you should use a transistor checker. However, if one is not available, you can use an ohmmeter to determine the general condition of any of the bipolar transistors (or diodes) in this kit. The ohmmeter used must have at least 1 volt DC at the probe tip to exceed the threshold of the diode junctions in the transistor being tested.

Set your ohmmeter to its low range for the following tests.

### HOW TO CHECK TRANSISTORS AND DIODES

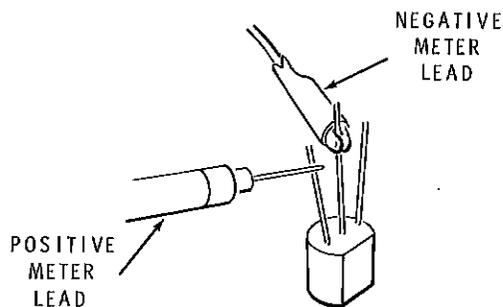
- A. Unsolder and remove the component.
- B. Connect the ohmmeter leads to the component as shown in the example illustration for transistors and diodes.

#### Example:

#### TRANSISTORS

Connect the positive meter lead to one lead as directed in the chart.

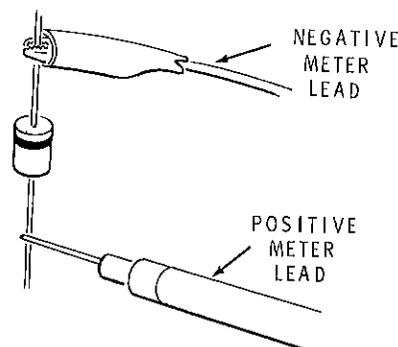
Connect the negative meter lead to another lead, as directed in the chart.



#### DIODES

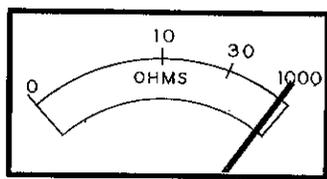
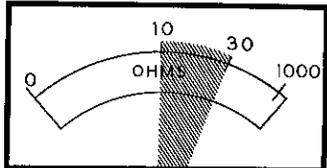
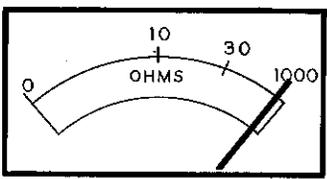
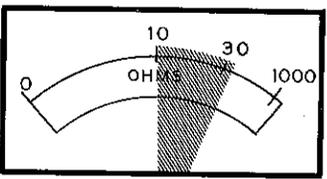
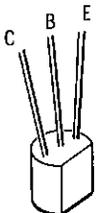
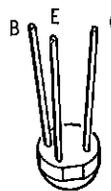
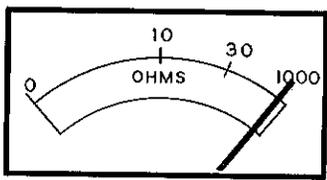
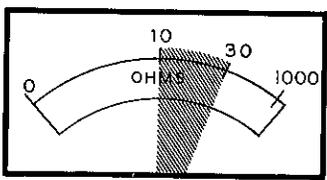
Connect the negative meter lead to one lead as directed in the chart.

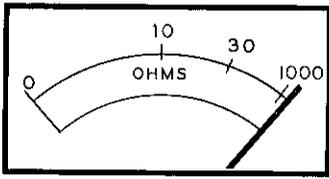
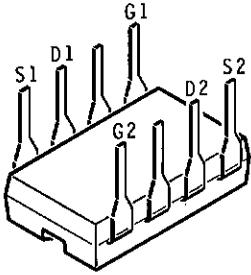
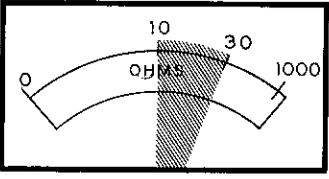
Connect the positive meter lead to the other lead as directed in the chart.

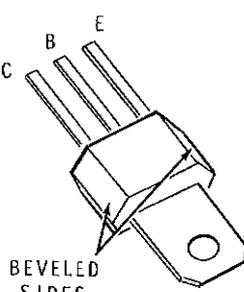
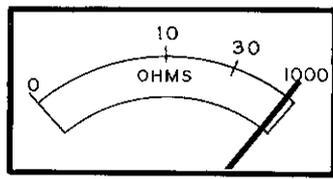
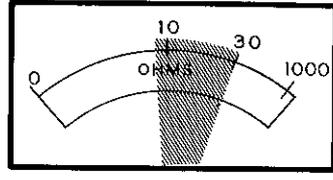
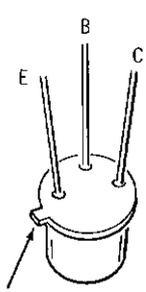
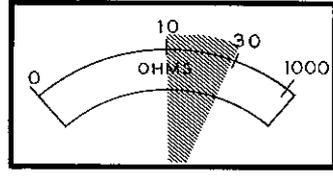
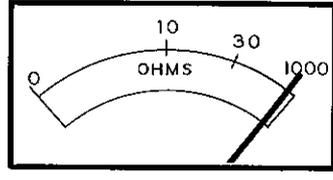
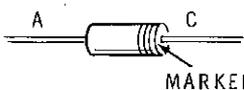
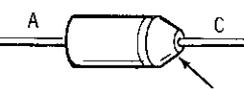
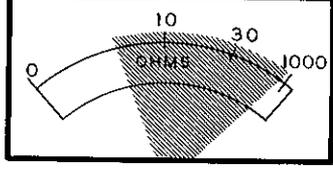
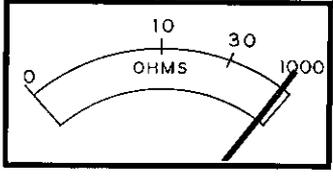


Proceed to the following chart and connect the ohmmeter leads to the component as indicated in the columns titled "Connect Positive Lead To," and "Connect Negative Lead To." The indicated meter reading in the last column is only a nominal reading. Your meter may read slightly different.

**NOTE:** The polarity of all ohmmeters is not the same. Therefore, if you do not get the indicated results, reverse your meter leads and try again. If you do get the correct results now, cross out the word "negative" in the heading in the second column and write in "positive." Also cross out the word "positive" in the heading in the third column and write in "negative."

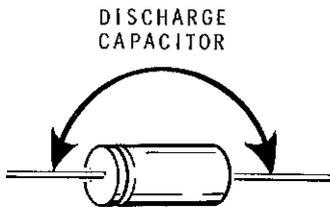
| TRANSISTOR           |   | CONNECT<br>NEGATIVE<br>LEAD TO   | CONNECT<br>POSITIVE<br>LEAD TO | METER READING  |  |
|----------------------|---|--|--------------------------------|--|--|
| MPS6520<br>(417-134) |    | B  | C                              |    |  |
| SE6020<br>(417-237)  |   | B  | E                              |  |  |
| 2N5770<br>(417-293)  |   | E  | C                              |  |  |
| MPSA20<br>(417-801)  |   | C  | B                              |    |  |
| MPSL01<br>(417-811)  |   | E  | B                              |  |  |
| 2N4121<br>(417-235)  | MPSL51<br>(417-295)   |  | C                              | B  |    |
|                      |   |  | E                              | B  |  |
|                      |   |  | C                              | E  |  |
|                      |   |  | B                              | C  |   |
|                      |   |  | B                              | E  |  |
|                      |   |  |                                |  |  |
| 2N4258A<br>(417-260) |  <p>OR</p>  | C  | B                              |  |  |
|                      |   |  | E                              |  | B  |
|                      |   |  | C                              |  | E  |
|                      |   |  | B                              | C  |  |
|                      |   | B  | E                              |  |  |

| TRANSISTOR   | CONNECT<br>NEGATIVE<br>LEAD TO:                            | CONNECT<br>POSITIVE<br>LEAD TO:                            | METER READING  |
|--|--|--|--|
| <p>NOTE: YOU MAY HAVE TO SET YOUR OHMMETER TO A HIGHER RANGE TO MEASURE THIS DUAL TRANSISTOR</p> <p>(417-902)<br/>NDP5566N</p> | <p>G1<br/>G1<br/>G2<br/>G2</p>                             | <p>D1<br/>S1<br/>D2<br/>S2</p>                             |  |
|   | <p>D1<br/>S1<br/>D1<br/>S1<br/>D2<br/>S2<br/>D2<br/>S2</p> | <p>G1<br/>G1<br/>S1<br/>D1<br/>G2<br/>G2<br/>S2<br/>D2</p> |  |

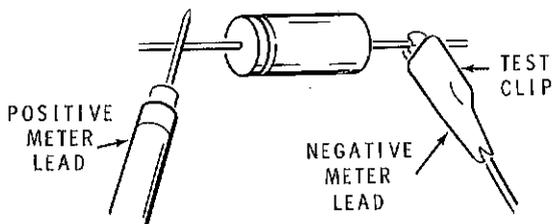
| TRANSISTOR  | CONNECT<br>NEGATIVE<br>LEAD TO | CONNECT<br>POSITIVE<br>LEAD TO | METER READING  |
|---|--------------------------------|--------------------------------|--|
| <p>MPSU10<br/>(417-834)</p>  <p>BEVELED<br/>SIDES</p>  | <p>B<br/>B<br/>E</p>           | <p>E<br/>C<br/>C</p>           |    |
|   | <p>C<br/>E</p>                 | <p>B<br/>B</p>                 |    |
| <p>2N2369<br/>(417-154)</p>  <p>LOCATING<br/>TAB</p>  | <p>C<br/>E</p>                 | <p>B<br/>B</p>                 |    |
|   | <p>B<br/>B<br/>C</p>           | <p>E<br/>C<br/>E</p>           |   |
| <p>DIODES</p> <p>56-26, 56-56<br/>56-59, 56-67<br/>56-89, 56-634<br/>57-27, 57-52</p>  <p>MARKED END</p>  <p>MARKED END</p> | <p>C</p>                       | <p>A</p>                       |  |
|   | <p>A</p>                       | <p>C</p>                       |  |

## HOW TO CHECK CAPACITORS

- A. Unsolder and remove the capacitor.
- B. Discharge the capacitor by touching the leads together.



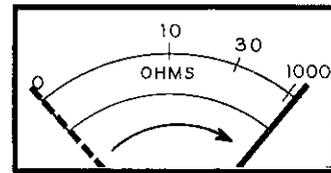
- C. Connect the negative meter lead to one lead. Then, while watching the meter, touch the positive meter lead to the other capacitor lead. (Note the special instructions for the electrolytic capacitors.)



### How to Check Electrolytic Capacitors

Each electrolytic capacitor has a positive (+) mark at one end. When checking one of these capacitors, connect the positive (+) lead to the positive meter lead and the other lead to the negative lead.

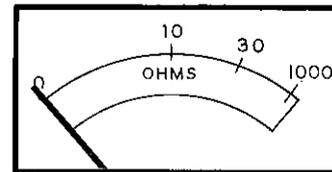
1. If the meter pointer deflects to the low ohms side quickly, and then gradually returns to the high ohms side, the capacitor is not faulty. NOTE: The time it takes for the pointer to return to the high ohms side depends upon the value of the capacitor. A  $50 \mu\text{F}$  capacitor for example, will cause the pointer to return more rapidly than a  $500 \mu\text{F}$  capacitor.



**CAPACITOR OK**  
#4

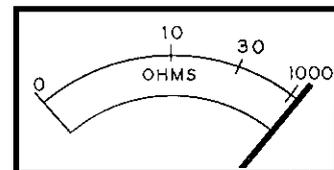
2. If the meter pointer deflects to the low ohms side and stays there, the capacitor is faulty (shorted).

### CAPACITOR FAULTY (Short)



3. If the meter pointer does not deflect at all, but stays at the high ohms side, the capacitor is faulty (open).

### CAPACITOR FAULTY (Open)



4. Recheck the capacitor, BUT FIRST DISCHARGE IT BY TOUCHING THE LEADS TOGETHER.

Because of the small capacitance of capacitors below the value of  $50 \mu\text{F}$ , it is very difficult to determine if the capacitor is faulty (open). If your meter needle does not move at all when you are checking a small value capacitor, it does not mean that the capacitor is open.

# SPECIFICATIONS

## VERTICAL

|                   |  |
|-------------------|--|
| Bandwidth .....   | DC to 5 MHz, $\pm 3$ dB.                   |
| Attenuator .....  | 1, 2, 5 sequence, calibrated and variable. |
| Rise Time .....   | 70 ns.                                     |
| Overshoot .....   | $\leq 5\%$ .                               |
| Impedance .....   | 1 M $\Omega$ /38 pF.                       |
| Sensitivity ..... | 10 mv/cm. To 20 V/cm in 11 ranges.         |

## SWEEP

|                      |   |
|----------------------|---|
| Type .....           | Triggered.                                      |
| Range .....          | 200 ms to .2 $\mu$ S in 7 steps, plus variable. |
| Trigger Source ..... | INT/Ext/Line.                                   |
| Trigger Modes .....  | AC/DC/TV; +/- Slope; Auto/Norm.                 |

## HORIZONTAL

|                       |   |
|-----------------------|---|
| Sensitivity .....     | .1 V/cm.  |
| Bandwidth .....       | DC to 1 MHz.  |
| Impedance .....       | 1 M $\Omega$ /50 pF.                                |
| Ext Horiz Input ..... | $\times 1$ and $\times 10$ attenuator and variable. |



**GENERAL**

|                              |   |
|------------------------------|---|
| CRT .....                    | 5DEP31F. 8 × 10 centimeter viewing area. Blue-green, medium-persistence phosphor. 5" round, flat face tube. |
| Accelerating Potential ..... | Approximately 1.6 kV.   |
| Graticule .....              | Screened, 8 × 10 centimeters.   |
| Power Requirements .....     | 110-130 VAC or 220-260 VAC, 50/60 Hz, 50 watts.   |
| Overall Dimensions .....     | 13" wide, 8" high, 17" deep.  |
| Net Weight .....             | 15 lbs.   |

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

## THEORY OF OPERATION

Refer to the Block Diagram (Illustration Booklet, Page 25) as you read the following material.

The vertical input signal is attenuated by a known factor and amplified to a visible level by the preamplifier section. The preamplifier section consists of three stages of gain and the necessary positioning bias. The amplified signal is applied to the deflection amplifier, which further amplifies the signal. This signal is then applied to the deflection plates of the CRT.

The horizontal portion of the trace displayed on the CRT screen is produced by the sweep and trigger circuits in conjunction with the horizontal deflection amplifier. The sweep circuit produces the linear signal (ramp) used to sweep the electron beam across the CRT screen from left to right at a constant rate. This circuit is switch controlled (by the TIME/CM switch) to provide seven sweep rates. This circuit must be triggered either by a portion of the vertical input signal, by an external signal, or by a portion of the line frequency signal.

In the absence of a trigger signal, an automatic baseline circuit causes the sweep circuits to operate while in the automatic mode. This ensures that, even though no signal is applied, a reference baseline (trace) will appear on the CRT screen. The sweep signal is coupled to the horizontal deflection amplifier where it is amplified before being applied to the horizontal deflection plates of the CRT. Other circuits within the horizontal amplifier also provide the necessary positioning bias.

At the end of each horizontal sweep, the blanking circuits (which are controlled by the sweep circuits) turn the trace off (blank it). This prevents a line (retrace) from being displayed as the electron beam returns to the left side of the CRT screen to start a new trace.

# CIRCUIT DESCRIPTION

Refer to the Block Diagram (Illustration Booklet, Page 25) and the Schematic (fold-in) while you read this "Circuit Description." The part numbers are arranged in the following groups to help you locate specific parts on the Schematic, circuit boards, and chassis.

1-99 Parts on the chassis.  
 100-199 Parts on the vertical circuit board.  
 200-299 Parts on the horizontal circuit board.  
 300-399 Parts on the power supply circuit board.

## VERTICAL CHANNEL

### INPUT CIRCUIT

When input switch SW2 (AC-GND-DC) is in the DC position, a signal applied to the input connector is coupled directly to the input attenuator. When the input switch is in the AC position, the signal is coupled to the attenuator through capacitor C1, which passes only AC signals. This permits an AC signal superimposed on a DC potential to be seen without the DC component being displayed.

The GND position of this switch disconnects the input signal and grounds the attenuator input. This allows the trace to be adjusted to a zero reference without disconnecting the test leads from the circuit under test.

Because the first, second, third and vertical deflection amplifiers operate at a fixed gain, any signal applied to them must be within a usable range (approximately 7 mV/cm). Therefore, the primary function of the vertical input circuit is to reduce the input signal by a known factor to this usable level.

The vertical input circuit basically consists of a high impedance attenuator, an input follower, and a low

impedance attenuator. These circuits function together, through VOLTS/CM switch (SW1), to provide the total desired attenuation. The attenuator obtains its four attenuation factors (1, 10, 100, and 1000) from four divider networks (resistors R101 through R104, and capacitors C103 through C107). At DC and low AC frequencies, the resistive dividers reduce the input signal level. At higher frequencies, however, attenuation is determined by the capacitor dividers.

Trimmer capacitors C103, C104, and C106 are used to adjust the capacitor division ratio to match the resistor ratio. Trimmer capacitors C101 and C102 are adjusted during calibration to make the input capacitance of the Oscilloscope equal in all positions of the VOLTS/CM switch. This is essential when an attenuation probe (usually  $\times 10$ ) is used. Resistors R105, R2, and R106 are used to suppress ringing in the attenuator circuit.

The input follower circuit consists of an FET (field-effect-transistor) source follower and DC current source. The attenuated input signal is coupled through resistors R106 and R107 and capacitor C108 to the gate of FET source follower Q101-1. Capacitor



C108 forms a high frequency path around R107 for improved frequency response. Input protection is provided by the two diodes D101 and D102 and current limiter R107. The diodes are connected to the plus (+) and minus (-) 8-volt supplies. Thus, if the signal at the junction of the two diodes exceeds + or - 8 volts, the appropriate diode becomes forward biased and clamps the signal to a level that is within a diode drop of 8 volts. This prevents damage to Q101 if the VOLTS/CM switch is in a low range, and a high potential is applied to the input.

Transistor Q101-A provides a match between the high impedance of the input attenuator and the low impedance attenuator. Transistor Q101-B is used as a constant current source. DC Balance control R112 sets the current through Q101-B so the voltage at the drain is 0 volt when no signal is present at input J1. Capacitor C112 forms a high frequency path around resistor R108 for improved high frequency response.

The output from Q101-A is coupled to the low impedance attenuator through variable attenuator control R3. The low impedance attenuator attenuates in a 1, 2, 5 sequenc from the three divider resistors (R115, R116, and R117).

The output from the low impedance attenuator is coupled to the gate of transistor Q102-A. Q102-A and Q102-B form the first gain stage with a gain factor of about 3. Vertical Position control R4 is connected to the gate of transistor Q102-B. Transistor Q103, a constant current source for the stage, and Bias Adjust control R138 sets the current through the stage. This in turn sets the bias voltage at the drain of transistors Q102-A and Q102-B.

The output of the first gain stage is direct-coupled to the second gain stage through resistors R124 and R131. The second stage is made up of transistors Q104 and Q105. The gain factor of this stage is about 10. Vertical Calibration control R143 sets the gain of this stage and also of the vertical amplifier.

The output of the second stage is coupled to the third gain stage (Q111 and Q112) through resistors R157 and R158. The gain of the third stage is about 10. The signal at the emitter of the second gain stage is coupled to the trigger amplifier through resistors R142 and R145. The trigger amplifier will be described later.

## VERTICAL DEFLECTION

From the third gain stage, the input signal is direct-coupled to the vertical deflection amplifier through resistors R166 and R168. This amplifier (made up of transistors Q113, Q114, Q115, and Q116) is wired in a differential cascade configuration, with a gain of about 20. Capacitors C121 and C122 between the emitters of Q113 and Q114 provides high-frequency square wave compensation. Ferrite beads on the base leads of common-base amplifier Q115/Q116 prevent oscillations in the amplifier. Circuit loading is provided by resistors R177 and R178. The output of this amplifier is coupled to the vertical deflection plates of the CRT for beam control. Vertical beam deflection requires between 9 and 12 volts/cm, depending on individual CRT characteristics.

## TRIGGER AMPLIFIER

A differential amplifier and follower make up the trigger amplifier circuit. Its output is used to supply a trigger signal to the trigger circuit.

A portion of the input signal is coupled from the emitters of Q104/Q105 to the input of differential amplifier Q106/A107 in the trigger amplifier circuit. Emitter follower Q109 couples the trigger signal from the collector of Q106 to the trigger circuit. Transistor Q108 is a temperature-compensated constant current source for this circuit. Trigger Zero control R152 in the emitter leg adjusts the current so the output of the follower will be zero with no signal to the trigger amplifier. Thus, the circuit performs as a differential to single-ended converter.

## TRIGGER AND SWEEP CIRCUITS

On command from a trigger pulse, the horizontal time base circuits generate a linear ramp signal (sweep) to drive the CRT horizontal deflection plates and move the dot across the screen at a constant rate. In the automatic triggering mode, if no trigger is present, the time base circuits free-run and generate an auto baseline.

When a trigger signal of sufficient amplitude is present, the trigger amplifier amplifies the signal and presents it to the trigger comparator through the slope switch. The output of the comparator changes state and turns on the sweep control and allows the timing capacitor to be charged through the "bootstrap" constant current source. The charging of the capacitor produces a linear ramp signal that is coupled through the voltage followers to the horizontal deflection circuits.

The ramp signal is also coupled to the sweep end circuit. When the ramp reaches a present voltage level, set by the Sweep Length control, the sweep end circuit triggers the blanking flip-flop and ramp hold-off monostable.

### TRIGGER

In the automatic triggering mode, the trigger circuit examines the trigger signal for a proper trigger point. If the signal is large enough, the sweep circuit is activated by the trigger. If the signal is insufficient or absent, the circuits are allowed to free run.

Depending on the desired trigger source, one of three sources can be selected by the Trigger switch: Internal Trigger, External Trigger, or Line Sync. The internal trigger signal is provided by the vertical preamplifier trigger circuits, while the line sync signal is tapped directly off the 1-volt transformer winding. The external trigger input signal is coupled directly to trigger switch SW4. The signal is then coupled to switch SW6. SW6 selects the type of coupling (AC, DC, or TV) that will be used to couple the signal to the trigger circuits. In the AC position, the signal is coupled through capacitor C201 to the trigger circuits. In the DC position, the signal is coupled direct, and in the TV position, the signal is coupled through capacitor C201, and resistor R201. The circuit composed of

capacitor C202, resistor R201, and diode D201 forms a low-pass filter and DC restorer. This circuit allows the trigger circuits to be synchronized to the vertical frame rate of a complex video TV signal.

The trigger signal is coupled to the first gain stage through resistor R204 and capacitor C229. C229 forms a high frequency path around R204 for high frequency response. Resistor R280 sets the input impedance of the amplifier. Diode D214 and the gate-drain junction of Q201A provide input protection.

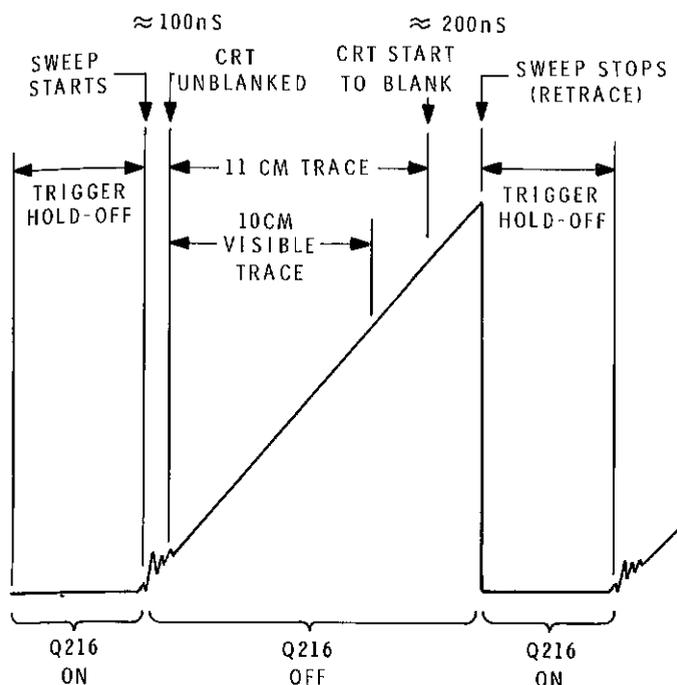
The first gain stage is made up of transistors Q201A and Q201B. Transistor Q202 is a constant current source for the stage. Trigger Balance control R211 adjusts the current through the stage and the bias voltage at the output of the trigger amplifier. Trigger Level control R7 is connected to the gate of transistor Q201B.

The second gain stage is formed by transistors Q203 and Q204 and has a gain of about 30. The output of this stage is coupled to emitter followers Q205 and Q206. The output of the emitter followers is connected to Slope switch SW7.

The amplified signal, with either positive or negative slope as selected by SW7, is coupled to pin 1 of integrated circuit U202A. U202 contains four Schmitt input gates. A trailing edge or low-going pulse applied to pin 1 of U202A causes the output to go high. This high is coupled to pin 11 of U201B and to pin 3 and 4 of U203. U201B controls the sweep circuits and U203 controls the auto baseline portion of the sweep circuits.

### SWEEP

The positive edge of the trigger pulse (pin 11) activates U201B and turns transistor Q216 off. This lets the timing capacitor charge through the bootstrap current source and generates a linear voltage ramp. The ramp (sweep signal) is coupled to the horizontal deflection circuit, and the remaining sweep circuits. When the ramp reaches a pre-determined level, the CRT is blanked, U201B is reset, and Q216 is turned on to provide a discharge path for the timing capacitor (ramp returns to the zero level).



PICTORIAL 10-1

Refer to Pictorial 10-1 for the following discussion.

When transistor Q216 turns off, the timing capacitor begins to charge. After about 100 nS, the CRT unblanks and the trace becomes visible. This short delay hides any switching transients. At a preset ramp level, the CRT is again blanked before the trace is stopped (to give the CRT time to fully blank). After the short delay, transistor Q216 is turned on and the timing capacitor is discharged.

Initially, sweep control U201B is in a reset condition (Q is low and  $\bar{Q}$  is high) and transistor Q216 is turned on. A trigger pulse from  $\bar{U}202A$  will toggle U201B and switch Q high and  $\bar{Q}$  low. The low from  $\bar{Q}$  turns transistor Q216 off and the high Q toggles blanking control U201A. As Q216 turns off, the timing capacitor begins to charge through the "bootstrap" current source. At the same time, U201A switches the CRT blanking circuit and unblanks the CRT.

The bootstrap current source is part of the sweep generator. Field effect transistors Q207A and Q207B and transistor Q217 form a voltage follower with a gain of approximately 1. It has a very high input impedance to prevent circuit loading, which could cause a non-linear voltage ramp (sweep). The junc-

tion of resistors R233 and R10 is held to a level 10 volts above the output of the emitter follower by zener diode D205. Since the follower input voltage equals the output voltage, the voltage across the selected timing resistor (R223, R224, R225, or R226) will always be constant. This will produce a constant current to charge the selected timing capacitor. When variable control R10 is turned from its CAL position this voltage differential is lowered. Thus, the charging current will be reduced and as a result, the sweep speed is reduced. The Variable control is used to provide continuous sweep speeds between the calibrated ranges. Zero adjust control R231 adjusts the follower for the proper voltage offset.

The output of the sweep generator is coupled through resistor divider R272 and R273 to the horizontal deflection amplifier. It is also coupled through Sweep Length control R236 to Schmitt gate U204B. Control R236 is adjusted so the output of the Schmitt trigger-type gate will go low when the ramp voltage exceeds approximately 1.8 volts. (This represents a horizontal sweep of about 11 centimeters.) The low from U204B presets blanking control U201A, which blanks the CRT. Zener diode D206 protects the Schmitt trigger from misalignment or malfunction of the sweep generator. The function of U204A will be described later.

The low from sweep end gate U204B is coupled to hold-off monostable U205. This signal is coupled via resistor R228 and capacitor C214. This RC combination causes a small delay that insures that the retrace will not occur until after the CRT is blanked. The hold-off monostable output goes low and remains in this condition until it "times out." The hold-off time is determined by TIME/CM switch SW5C, and is of sufficient duration to insure complete retrace. With pin 13 of U202D high (from U204A), the low from  $\bar{Q}$  of U205 will force pin 11 of U202D high. Pins 9 and 10 of U202C will go high and pin 8 of U202C is forced low resetting sweep control U201B. This forces the  $\bar{Q}$  output high and turns on Q216 which quickly discharges the sweep timing capacitor (retrace). The low from pin 8 of U202C does not affect gate U202B because pin 5 of U202B is already low (auto-baseline monostable U203 triggered by trigger signal). The low from hold-off monostable U205 "locks up" sweep control U201B, so that it cannot accept a trigger signal until after hold-off. After U205 "times out," U201B can toggle on the next trigger signal and start a new cycle.

If, for any reason the sweep control circuitry should "hang up," such as at initial turn-on, the ramp voltage would continue to increase. A voltage level would be reached where anti-lockup control U204A would activate and (through U202D and U202C) reset (clear) U201B, and discharge the sweep timing capacitor to initiate a new sweep cycle.

Normally, reoccurring trigger pulses hold monostable U203 on. The low at the  $\bar{Q}$  output is coupled

through U202B and holds the output of U202B high for normal sweeps to take place. However, with no input trigger pulses, U203 times out and its Q output goes high. This allows the set and clear inputs of U201B to be in opposite states by U202B, causing U201B to "free run" and produce sweeps for a base line. In "normal" mode operation, the automatic base line feature is overridden by switch SW8.

## HORIZONTAL AMPLIFIER

The sweep signal is coupled to the gate of Q208A by resistor R239 and Capacitor C218. C218 forms a high frequency path around R239 for high frequency improvement. Resistor R240 sets the input impedance to the amplifier. Input protection is provided by diode D209 and the gate-drain junction of Q208A, connected to the  $\pm 9$ -volt sources; thus, clamping the input signal to these potentials. Transistor Q208A is connected as a source follower. Transistor Q208B is connected as a current source for Q208A. Control R247 sets the current through this stage. The signal is connected from the drain of Q208B to the base of Q209. When the horizontal amplifier is used in the external/horizontal mode of operation, the input of the amplifier is connected to the  $\times 1$  and the  $\times 10$  attenuator. The attenuator is formed by resistors R242 and R243. Capacitors C219 and C220 provide frequency compensation. External horizontal variable control R11 and resistor R286 are also switched in at this time.

A reference voltage from the horizontal position control provides offset adjustment at the differential amplifier (base of Q210). Amplifier gain is about 10. Control R251 adjusts the gain of this amplifier, and therefore, the overall gain of the horizontal deflection circuit. This is to compensate for the individual deflection characteristics of the CRT. Transistor Q211 is the constant current source for this amplifier section. Control R257 adjusts the current through this stage and thus the bias voltage at the collectors of Q209 and Q210.

Final amplification occurs in the third deflection amplifier. It is a cascode differential amplifier with a gain of about 25. The output is coupled to the horizontal deflection plates of the CRT for beam control. Horizontal beam deflection requires between 14 and 20 volts/cm, depending on individual CRT characteristics.

## POWER SUPPLIES AND BLANKING

### +130 AND +160 VOLTS

Full-wave bridge rectifier diodes D307, D308, D309, and D310 produce 170 volts, which is reduced by R15 to provide the +160-volt supply used in the horizontal deflection amplifier. A second filter (R14 and C3) divides the 170-volt source down to +130 volts for the vertical deflection amplifier, the blanking amplifier, and the astigmatism control.

### $\pm 9$ AND +5 VOLTS

Diodes D303, D304, D305, and D306 comprise two

full-wave rectifiers that produce positive and negative 15 volts DC from the power transformer. These voltages are filtered and then coupled to voltage regulators U301, U302, and U303. Regulators U303 ( $-9$  V) and U302 (+9 V) are connected in a tracking configuration by resistors R334, R335, and R336. If one regulator shuts down, the other one is also shut down. U301 provides the regulated +5 volts supply.

### HIGH VOLTAGE

Diodes D301, D302 and capacitors C301, C302 make up a voltage doubler that produces approximately

-2000 VDC at nominal line voltage. Resistor R301 and capacitor C303 filter and reduce the voltage to approximately -1650 VDC. Divider string D311, R308, R17, R6, R309, and R310 supply the CRT cathode bias and a reduced voltage for focus control R6. Capacitor C320 bypasses diode D311 and resistor R338. Resistor R338 limits the CRT cathode current. Astigmatism adjust control R330 and emitter follower Q307 control the astigmatism anode voltage.

## CRT BLANKING

The purpose of the CRT blanking circuits is to control the intensity of the trace. The trace has to be turned off after each sweep (for retrace) and has to turn on to a specified level (controlled by the Intensity control) during each sweep. During EXT Horizontal operation, the trace is left on to the level specified by the Intensity control. Since the control grid and cathode voltage of the CRT is about 1650 volts below ground (-1650 VDC), and the other Oscilloscope circuits are near ground, the blanking circuits have to translate the DC voltage coming from the blanking amplifier to the control grid. This is done by amplitude modulating an oscillator (Q305 and Q304) that is capacitor coupled by C314 to demodulator rectifiers D316 and D320. The demodulator is referenced to the -1650-volt supply and the output of the bridge is coupled to the CRT control grid by R324 and R325.

The amplitude of the oscillator output follows the DC output of the blanking amplifier on a one-to-one basis. The output of the demodulator follows the peak value of the oscillator waveform. This means, then, that the DC output of the blanking amplifier is translated to the CRT grid on a one-to-one basis.

An oscillator signal of larger amplitude (as adjusted by the Intensity or CRT Bias controls) will produce a more positive DC voltage on the CRT grid which will make a brighter trace. A retrace pulse will reduce the amplitude of the oscillator signal, and the resulting reduced DC voltage will turn off the CRT during "retrace" or "holdoff."

To fully understand the blanking circuits, keep the following two ideas in mind.

1. The CRT is fully blanked when the control grid is 80 volts **more negative** than the cathode.

2. As the 80-volt difference between the grid and cathode is reduced, the CRT is unblanked and the beam intensity is increased.

The blanking amplifier (Q301, Q302, Q303, Q306) provides the necessary gain to amplify the input blanking pulses and the voltage from the Intensity control. The Intensity control controls the output DC level of the amplifier (emitter of Q306), and the input blanking pulses reduce this DC level for the duration of each pulse. The leading and trailing edges of the amplified blanking pulses are capacitor-coupled to the grid of the CRT by C315 and R325.

The amplitude of the oscillator output follows the DC output of the blanking amplifier on a 1:1 basis. Then the output of the demodulator follows the peak value of the oscillator waveform. This means, then, that the DC output of the blanking amplifier is translated to the CRT grid on a 1:1 basis.

The blanking amplifier has a common base input stage, Q301. Here, the input blanking pulses and the Intensity control voltage are summed at its emitter. Transistors Q302, Q303, and Q306 are current and voltage amplifiers whose gain is determined by the ratio of feedback resistor R318 and the appropriate input resistance. Capacitor C312 is for high frequency compensation.

The blanking amplifier is coupled to the emitter of Q304 by R329. Q304 and Q305 form an emitter-coupled oscillator. Capacitor C319 and emitter resistor R333 determine the frequency of oscillation, which is approximately 200 kHz. Diode D319 protects Q304 from negative spikes during turn-on when C314 charges. D318 is referenced to a maximum voltage that the oscillator is limited to and clamps the output of the oscillator if it tries to exceed this voltage. The reference voltage is set by resistors R326 and R327, and C317 filters this voltage.

## CALIBRATOR

The calibrator section consists of resistor R307 and diodes D312 and D313. The resistor and the diodes clamp the voltage to jack J3 to approximately .94 volts peak to peak.

# SEMICONDUCTOR IDENTIFICATION CHARTS

This section is divided into two parts: "Component Number Index" and "Part Number Index." The Component Number Index provides a cross-reference between Circuit Component Numbers and their respective Heath Part Numbers. The component numbers

are listed in numerical order. The Part Number Index provides a lead configuration detail (basing diagram) for each semiconductor part number. The Heath Part Numbers in this section are also listed in numerical order.

## COMPONENT NUMBER INDEX

This index shows the Heath Part Number for each semiconductor in the IO-4105 Oscilloscope.

### DIODES

| CIRCUIT COMPONENT NUMBER | HEATH PART NUMBER |
|--------------------------|-------------------|
| D101-D106                | 56-56             |
| D107                     | 56-67             |
| D201                     | 56-56             |
| D204                     | 56-56             |
| D205                     | 56-67             |
| D206                     | 56-59             |
| D207-D210                | 56-56             |
| D211                     | 56-67             |

### DIODES (Cont'd.)

| CIRCUIT COMPONENT NUMBER | HEATH PART NUMBER |
|--------------------------|-------------------|
| D213, D214               | 56-56             |
| D301, D302               | 57-52             |
| D303, D310               | 57-27             |
| D311                     | 56-634            |
| D312                     | 56-56             |
| D313                     | 56-89             |
| D314                     | 56-26             |
| D315, D316               | 56-56             |
| D317                     | 56-634            |
| D318, D321               | 56-56             |

**TRANSISTORS**

| CIRCUIT COMPONENT NUMBER | HEATH PART NUMBER |
|--------------------------|-------------------|
| Q101, Q102               | 471-902           |
| Q103                     | 417-801           |
| Q104, Q105               | 417-235           |
| Q106, Q109               | 417-235           |
| Q111, Q112               | 417-134           |
| Q113, Q114               | 417-237           |
| Q115, Q116               | 417-834           |
| Q117, Q118               | 417-801           |
| Q201                     | 417-902           |
| Q202                     | 417-801           |
| Q203, Q204               | 417-235           |
| Q205, Q206               | 417-801           |
| Q207, Q208               | 417-902           |
| Q209, Q210               | 417-134           |
| Q211                     | 417-801           |
| Q212, Q213               | 417-134           |
| Q214, Q215               | 417-834           |
| Q216                     | 417-154           |
| Q217                     | 417-134           |
| Q301, Q302               | 417-237           |
| Q303, Q304               | 417-811           |
| Q305                     | 417-295           |
| Q306, Q307               | 417-811           |

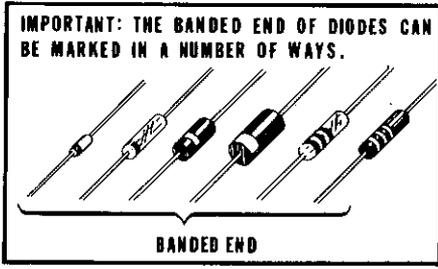
**INTEGRATED CIRCUITS**

| CIRCUIT COMPONENT NUMBER | HEATH PART NUMBER |
|--------------------------|-------------------|
| U201                     | 443-6             |
| U202                     | 443-625           |
| U203                     | 443-23            |
| U204                     | 443-44            |
| U205                     | 443-22            |
| U301, U302               | 442-617           |
| U303                     | 442-618           |

## PART NUMBER INDEX

This index shows a lead configuration detail (basing diagram) for each semiconductor part number.

**DIODES**

| HEATH PART NUMBER | MAY BE REPLACED WITH | IDENTIFICATION   |
|-------------------|----------------------|--|
| 56-26             | 1N191                |  |
| 56-56             | 1N4149               |  |
| 56-59             | 1N750A               |  |
| 56-67             | VR10A                |  |
| 56-89             | GD510                |  |
| 59-634            | 2EZ82D5              |  |
| 57-27             | 1N2071               |  |
| 57-52             | DO-7                 |  |

**TRANSISTORS**

| HEATH PART NUMBER             | MAY BE REPLACED WITH       | IDENTIFICATION  |
|-------------------------------|----------------------------|-----------------|
| 417-134                       | MPS6520                    |                 |
| 417-154                       | 2N2369                     |                 |
| 417-235<br>417-237            | 2N4121<br>SE6020           |                 |
| 417-295<br>417-801<br>417-811 | MPSL51<br>MPSA20<br>MPSL01 |                 |
| 417-834                       | MPSU10                     |                 |
| 417-902                       | NPD5566N                   | <p>TOP VIEW</p> |

## INTEGRATED CIRCUITS

| HEATH PART NUMBER | MAY BE REPLACED WITH | BASING DIAGRAM (TOP VIEW) |
|-------------------|----------------------|---------------------------|
| 442-617           | $\mu$ A78MGT2        |                           |
| 442-618           | $\mu$ A79MGT2        |                           |
| 443-6             | SN7474N              |                           |
| 443-22            | SN74121N             |                           |

Integrated Circuits (Cont'd).

| HEATH PART NUMBER | MAY BE REPLACED WITH | BASING DIAGRAM (TOP VIEW) |
|-------------------|----------------------|---------------------------|
| 443-23            | SN74122N             |                           |
| 443-44            | SN7413N              |                           |
| 443-625           | SN74132N             |                           |

# CUSTOMER SERVICE

## REPLACEMENT PARTS

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

## ORDERING FROM THE FACTORY

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

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

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

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

## OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

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

## TECHNICAL CONSULTATION

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

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

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

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

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

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

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

## REPAIR SERVICE

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

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

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

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

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

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

Heath Company  
Service Department  
Benton Harbor, Michigan 49022



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