PRICE $2.00

HEATH COMPANY, BENTON HARBOR, MICHIGAN

HEATHKIT®
ASSEMBLY MANUAL

HEATHKIT

LABORATORY 5" OSCILLOSCOPE

MODEL IO-12

RESISTOR AND CAPACITOR COLOR CODES

RESISTORS

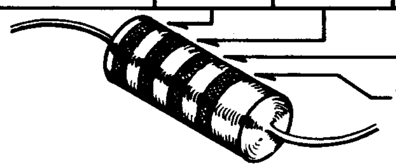
The colored bands around the body of a color coded resistor represent its value in ohms. These colored bands are grouped toward one end of the resistor body. Starting with this end of the resistor, the first band represents the first digit of the resistance value; the second band represents the second digit; the third band represents the number by which the first two digits are multiplied. A fourth band of gold or silver represents a tolerance of ±5% or ±10% respectively. The absence of a fourth band indicates a tolerance of ±20%.

The physical size of a composition resistor is related to its wattage rating. Size increases progressively as the wattage rating is increased. The diameters of 1/2 watt, 1 watt and 2 watt resistors are approximately 1/8", 1/4" and 5/16", respectively.

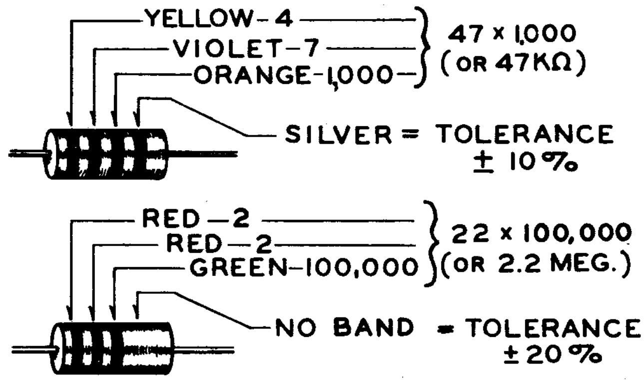
The color code chart and examples which follow provide the information required to identify color coded resistors.

CODE

COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	1,000,000,000
GOLD	-	-	.1
SILVER	-	-	.01



EXAMPLES



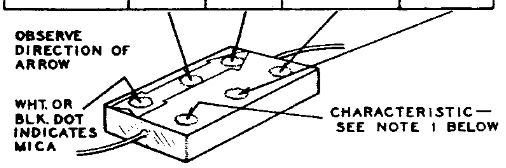
CAPACITORS

Generally, only mica and tubular ceramic capacitors, used in modern equipment, are color coded. The color codes differ somewhat among capacitor manufacturers, however the codes shown below apply to practically all of the mica and tubular ceramic capacitors that are in common use. These codes comply with EIA (Electronics Industries Association) Standards.

MICA

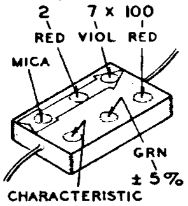
CODE

COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLER.%
BLACK	0	0	1	±20
BROWN	1	1	10	—
RED	2	2	100	± 2
ORANGE	3	3	1,000	± 3
YELLOW	4	4	10,000	—
GREEN	5	5	—	± 5
BLUE	6	6	—	—
VIOLET	7	7	—	—
GRAY	8	8	—	—
WHITE	9	9	—	—
GOLD	-	-	.1	—
SILVER	-	-	.01	± 10



(VALUE IN μμf—SEE NOTE 3 BELOW)

EXAMPLE



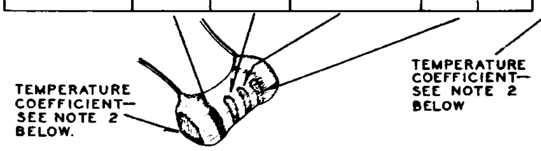
2,700μμf ±5%
OR .0027μfd

TUBULAR CERAMIC

Place the group of rings or dots to the left and read from left to right.

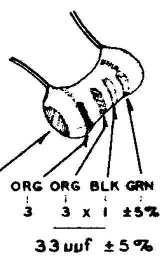
CODE

COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLER.% 10 OR LESS	TOLER.% OVER 10
BLACK	0	0	1	±20	±20
BROWN	1	1	10	±0.1	±1
RED	2	2	100	—	±2
ORANGE	3	3	1,000	—	±2.5
YELLOW	4	4	10,000	—	—
GREEN	5	5	—	±0.5	±5
BLUE	6	6	—	—	—
VIOLET	7	7	—	—	—
GRAY	8	8	—	±0.25	—
WHITE	9	9	—	±1.0	±10



(VALUE IN μμf—SEE NOTE 3 BELOW)

EXAMPLE



33μμf ±5%

NOTES:

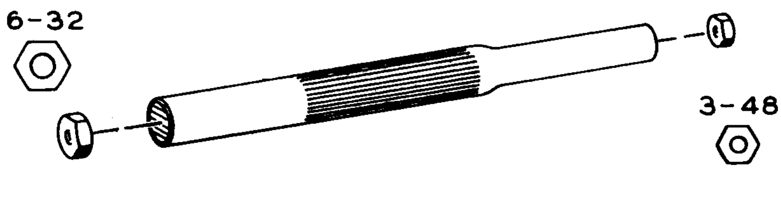
1. The characteristic of a mica capacitor is the temperature coefficient, drift capacitance and insulation resistance. This information is not usually needed to identify a capacitor but, if desired, it can be obtained by referring to EIA Standard, RS-153 (a Standard of Electronic Industries Association.)

2. The temperature coefficient of a capacitor is the predictable change in capacitance with temperature change and is expressed in parts per million per degree centigrade. Refer to EIA Standard, RS-198 (a Standard of Electronic Industries Association.)

3. The farad is the basic unit of capacitance, however capacitor values are generally expressed in terms of μfd (micro-farad, .000001 farad) and μμf (micro-micro-farad, .000001 μfd); therefore, 1,000 μμf = .001 μfd, 1,000,000 μμf = 1μfd.

USING A PLASTIC NUT STARTER

A plastic nut starter offers a convenient method of starting the most used sizes: 3/16" and 1/4" (3-48 and 6-32). When the correct end is pushed down over a nut, the pliable tool conforms to the shape of the nut and the nut is gently held while it is being picked up and started on the screw. The tool should only be used to start the nut.



Assembly

and

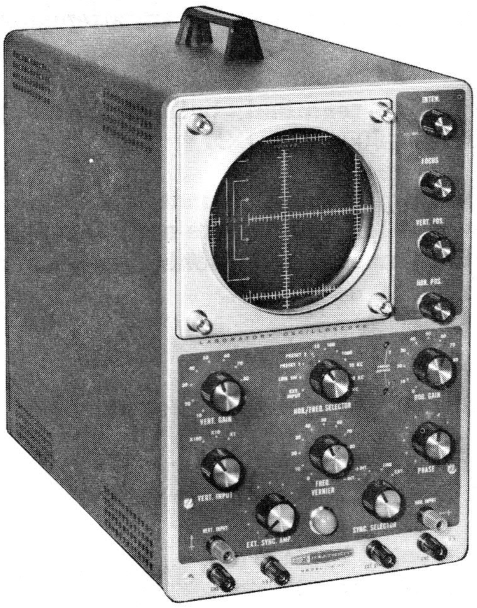
Operation

of the

HEATHKIT

LABORATORY 5" OSCILLOSCOPE

MODEL IO-12



HEATH COMPANY,

BENTON HARBOR,

MICHIGAN

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All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

2/19/65

SPECIFICATIONS

VERTICAL CHANNEL:

Sensitivity:	0.025 volts (rms) per inch at 1 kc.
Frequency Response:	±1 db from 8 cps to 2.5 mc. +1.5 to -5 db from 3 cps to 5 mc. Response at 3.58 mc: - 2.2 db. (All response measurements referred to 1 kc.)
Rise Time:	0.08 microseconds or less.
Overshoot:	10% or less.
Input Impedance:	In X1 attenuator position, 2.9 megohms shunted by 21 $\mu\mu$f. (1 kc impedance: 2.7 megohms). In X10 and X100 positions, 3.4 megohms shunted by 12 $\mu\mu$f. (1 kc impedance: 3.3 megohms).
Attenuator:	Three-position, switch-type, fully compensated; no visible change in wave shape at any attenuator setting.
Input Characteristics:	Low-capacity input terminal; built-in blocking capacitor rated at 600 volts DC.
Vertical Positioning:	DC type; permits placement of undeflected trace at any horizontal level on usable area (±1-1/2" from center) of screen; positioning is almost instantaneous and free of drift.

HORIZONTAL CHANNEL:

Sensitivity:	0.3 volts (rms) per inch at 1 kc.
Frequency Response:	±1 db from 1 cps to 200 kc. ±3 db from 1 cps to 400 kc.
Input Impedance:	30 megohms shunted by 31 $\mu\mu$f. (1 kc impedance: 4.9 megohms).
Attenuator:	Low-impedance type in cathode follower output.
Input Characteristics:	Selector switch permits use of external input through panel terminal, line-frequency sweep of variable phase, either of two preset sweep frequencies, or variable internal sweep from the sweep generator.
Horizontal Positioning:	DC type; permits wide range of positioning to examine any part of trace even with full horizontal gain.

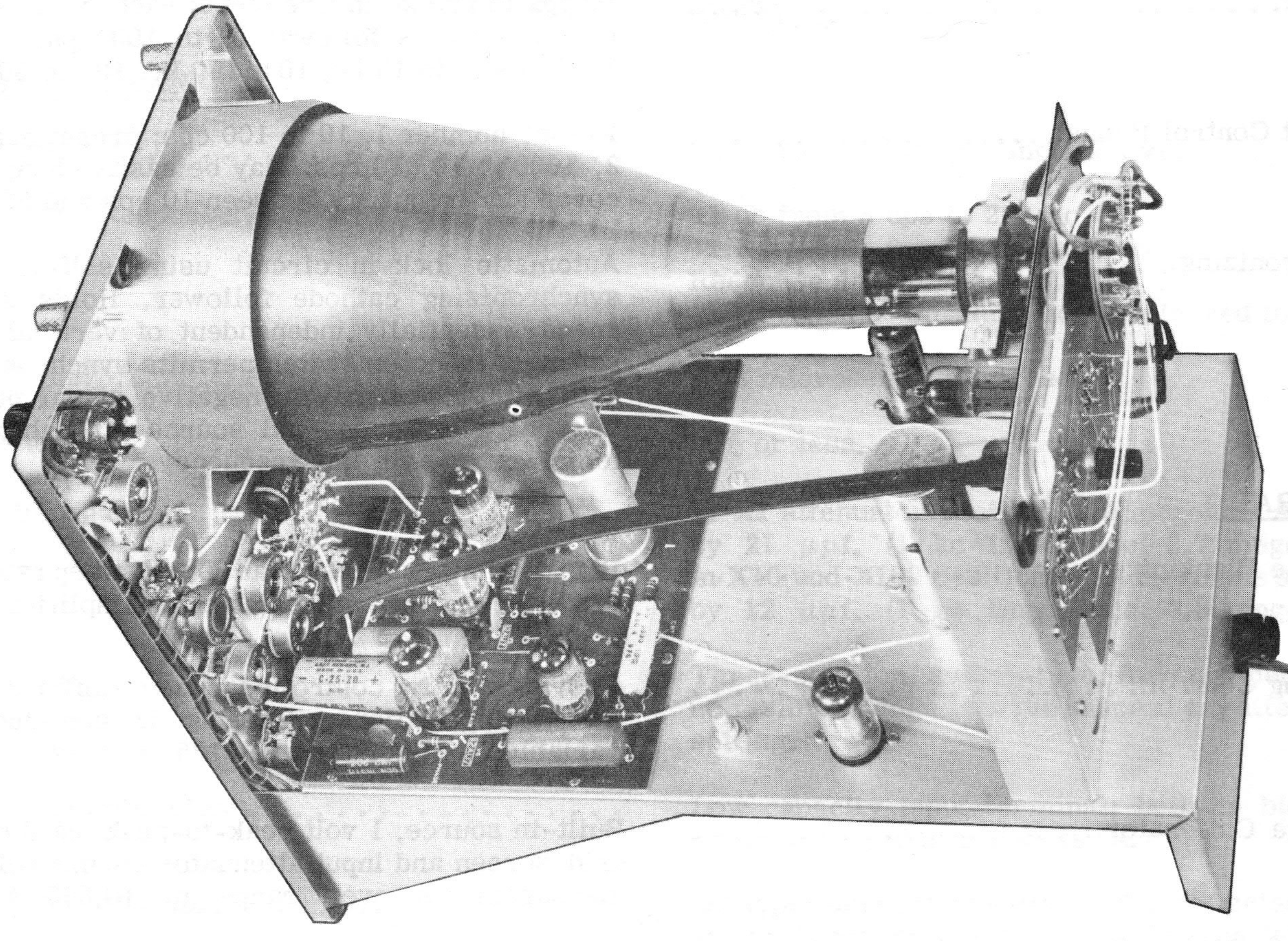
SWEEP GENERATOR:

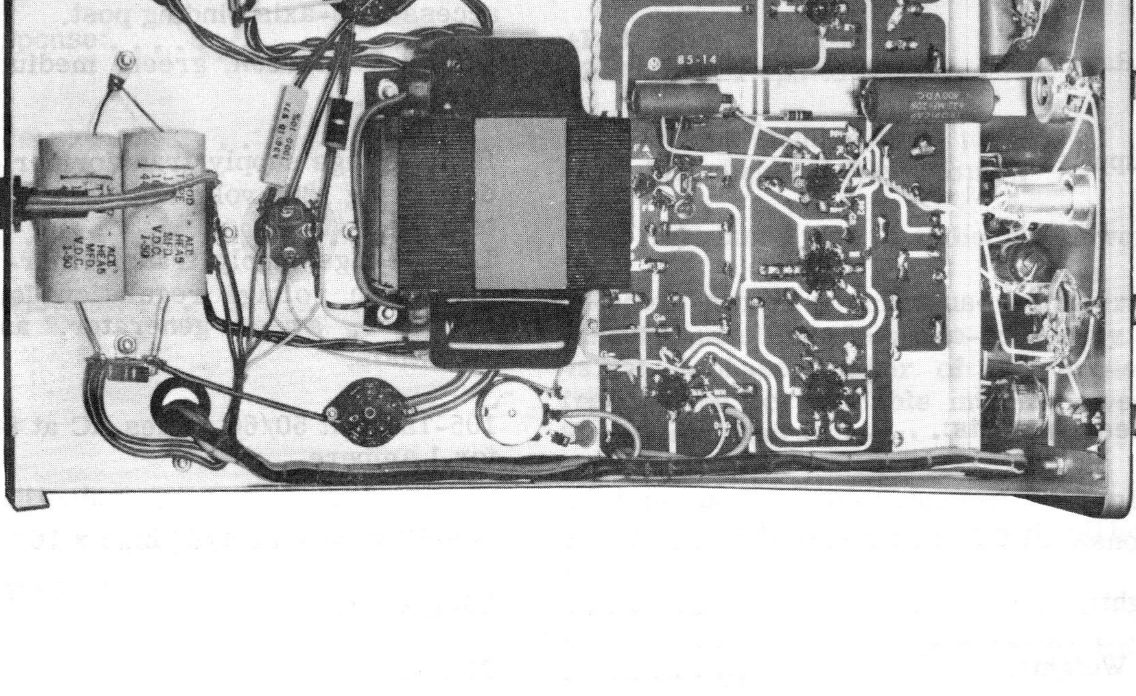
Type:	Recurrent type, utilizing patented HEATHKIT sweep circuit.

Range:.	10 cps to 500 kc in five steps; each range is approximately as follows: 10 to 100 cps, 100 to 1000 cps, 1 to 10 kc, 10 to 100 kc, 100 to 500 kc.
Preset Control Range:.	Preset number 1, 10 to 100 cps; preset number 2, 1000 to 10,000 cps. May be easily changed to cover any frequency between 10 cps and 500 kc.
Synchronizing:.	Automatic lock-in circuit using self-limiting synchronizing cathode follower. Holds sweep speed essentially independent of vertical gain settings. Selector switch permits synchronizing with either positive or negative signal pulses internally, with external source through panel terminal, or with line frequency.

GENERAL:

Retrace Blanking:.	Blanking interval less than 30% of sweep rate regardless of sweep speed. Blanking amplifier provided.
Phasing Control:.	Provides fully controlled phase shift for line sweep applications. Phasing is continuously variable from zero to over 135 degrees.
Voltage Calibrator:.	Built-in source, 1 volt peak-to-peak; calibrated grid screen and input attenuator permit voltage measurements over range of 10,000 to 1.
Z-Axis Modulation:.	Provision for intensity modulation of electron stream through high-voltage isolation capacitor; 8 to 20 volts (rms) required for complete blanking of trace.
Access Panel:.	Removable panel at rear of cabinet for easy access to Z-axis binding post.
Cathode Ray Tube:.	5UP1, 5" screen, green, medium-persistence phosphor.
Power Supplies:.	High-voltage supply: transformer-rectifier type, developing 1200 volts at output of RC filter system. Low-voltage supply: transformer-rectifier type, electronic voltage regulation for all critical amplifier, sweep generator, and positioning potentials.
Power Requirements:.	105-125 volt 50/60 cycles AC at 80 watts; fused for 1 ampere.
Dimensions:.	8-5/8" wide x 14-1/8" high x 16" deep.
Net Weight:.	20-1/2 lbs.
Shipping Weight:.	21 lbs.





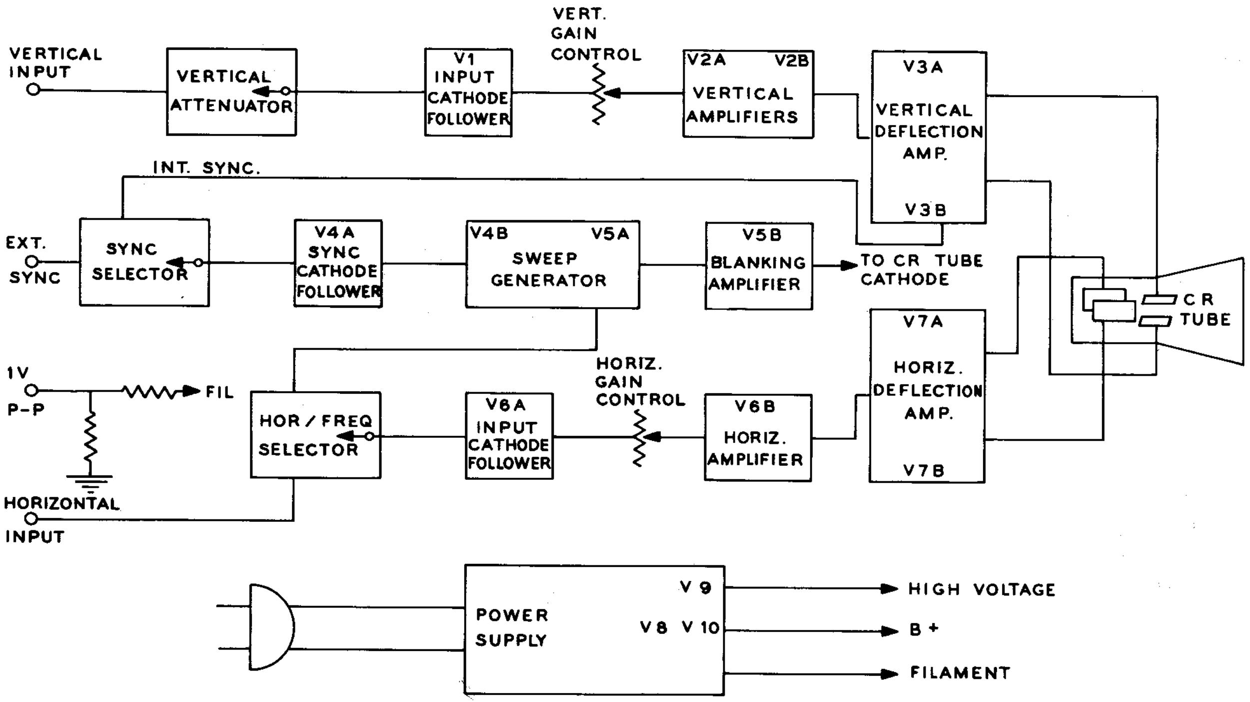
INTRODUCTION

The HEATHKIT Model IO-12 Oscilloscope is a wide-range, general-purpose oscilloscope, designed to satisfy the needs of both the electronic serviceman and the ham operator, or hobbyist. Many years of refinements on earlier models have culminated in this troublefree performer.

The use of two preset adjustments in the horizontal oscillator circuit facilitate instantaneous horizontal lock-in for often-used sweep frequencies. This is especially handy in servicing the vertical and horizontal circuits of television receivers.

CIRCUIT DESCRIPTION

Reference to the fold-out Schematic at the rear of the manual, and to the Block Diagram which follows, will prove helpful in thoroughly understanding this description.



VERTICAL AMPLIFIER

A signal applied to the VERT. INPUT terminals is coupled through the frequency-compensated vertical attenuator to V1. From input cathode follower V1, the signal is coupled through VERT. GAIN control R8 to amplifiers V2A and V2B.

From V2B, the signal is applied through the series peaking coil to the push-pull vertical deflection amplifier. Positioning of the trace is accomplished by adjusting VERT. POS. control R18, which changes the relative DC grid voltages between the halves of the push-pull amplifier. The fixed tap of control R18 provides the reference voltage for V3A.

Push-pull output stage V3A and V3B drives the vertical plates of the CR tube to provide balanced deflection of the electron beam. (Common cathode coupling applies the signal from V3A to V3B.) A small portion of the signal is coupled from the plate circuits of the push-pull stage to the SYNC. SELECTOR switch to facilitate positive or negative internal sweep synchronization.

SWEEP GENERATOR

The SYNC SELECTOR switch is used to select the desired sweep synchronizing signal. This signal is applied to the sweep generator by means of the common cathode resistor, R38, of V4A and V4B. V4A is the sync cathode follower. V4B and V5A, the sweep multivibrator, with their associated circuit components, create the horizontal sweep waveform. The sweep timing capacitor that is switched into the cathode circuit of V5A, determines the coarse horizontal sweep frequency as it discharges through R47 and FREQ. VERNIER control R48. Fine frequency adjustment of this sawtooth waveform is obtained by varying the FREQ. VERNIER control (or the PRESET ADJUST controls).

A retrace blanking signal is coupled to the CR tube through blanking amplifier V5B from the sweep generator. The positive going portion of the sweep waveform is used for this purpose.

HORIZONTAL AMPLIFIER

The HOR./FREQ. SELECTOR is used to select the desired sweep signal and apply it to input cathode follower V6A. This sweep signal may be from the sweep generator, 60 cycle line sweep, or an external sweep signal from the HOR. INPUT.

The sweep signal is coupled from V6A through the HOR. GAIN control and through amplifier V6B to the push-pull horizontal deflection amplifier, V7A and V7B. The HOR. POS. control is used to position the trace by changing the relative DC grid voltages of the push-pull amplifier.

The push-pull horizontal deflection amplifier drives the horizontal plates of the CR tube to provide balanced horizontal deflection of the electron beam.

CATHODE RAY TUBE

Operating and accelerating voltages are supplied to the cathode ray tube (CR tube) by a bleeder network connected from the high voltage power supply to ground. This network contains the FOCUS and INTEN. controls, and supplies bias voltage to regulator tube V10. Intensity modulation of the electron beam may be accomplished by connecting an external signal to the Z-AXIS input of the CR tube.

POWER SUPPLY

High voltage for the CR tube is supplied by V9, the high-voltage rectifier. B+ is supplied by full-wave rectifier V8 and its associated circuitry. V10 is used to prevent power line surges from appearing on the B+ voltages. Two separate filament windings are used on the power transformer, one for the CR tube alone. The other winding supplies filament voltage to all other tubes, and supplies AC voltage to the HOR./FREQ. switch for line sweep, to the PHASE control, and to the 1-V, P-P binding post.

CONSTRUCTION NOTES

This manual is supplied to assist you in every way to complete your kit with the least possible chance for error. The arrangement shown is the result of extensive experimentation and trial. If followed carefully, the result will be a stable instrument, operating at a high degree of dependability. We suggest that you retain the manual in your files for future reference, both in the use of the instrument and for its maintenance.

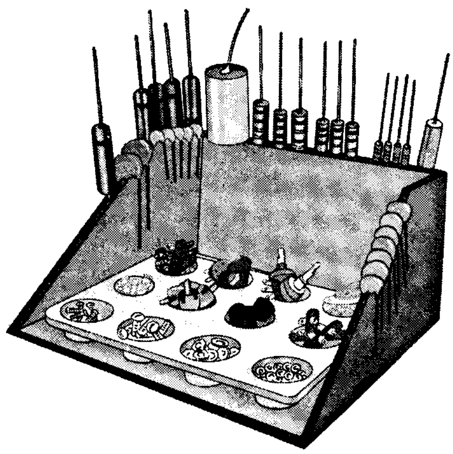
UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with the parts. Refer to the charts and other information on the inside covers of the manual to help you identify the components. If some shortage or parts damage is found in checking the Parts List, please read the REPLACEMENT section and supply the information called for therein.

Resistors generally have a tolerance rating of 10% unless otherwise stated in the Parts List. Tolerances on capacitors are generally even greater. Limits of +100% and -20% are common for electrolytic capacitors.

We suggest that you do the following before work is started:

1. Lay out all parts so that they are readily available.
2. Provide yourself with good quality tools. Basic tool requirements consist of a screwdriver with a 1/4" blade; a small screwdriver with a 1/8" blade: long-nose pliers; wire cutters, preferably separate diagonal cutters; a pen knife or a tool for stripping insulation from wires; a soldering iron (or gun) and rosin core solder. A set of nut drivers and a nut starter, while not necessary, will aid extensively in construction of the kit.

Most kit builders find it helpful to separate the various parts into convenient categories. Muffin tins or molded egg cartons make convenient trays for small parts. Resistors and capacitors may be placed with their lead ends inserted in the edge of a piece of corrugated cardboard until they are needed. Values can be written on the cardboard next to each component. The illustration shows one method that may be used.



PARTS LIST

Refer to the fold-out Parts Pictorial on page 13 of this manual.

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-84	1	62 Ω 1/2 watt (blue-red-black)
1-3	5	100 Ω 1/2 watt (brown-black-brown)
1-45	3	220 Ω 1/2 watt (red-red-brown)
1-6	1	470 Ω 1/2 watt (yellow-violet-brown)
1-8	1	820 Ω 1/2 watt (gray-red-brown)
1-9	1	1 KΩ 1/2 watt (brown-black-red)
1-90	2	2 KΩ 1/2 watt (red-black-red)
1-57	3	2.2 KΩ 1/2 watt (red-red-red)
1-13	1	2.7 KΩ 1/2 watt (red-violet-red)
1-14	3	3.3 KΩ 1/2 watt (orange-orange-red)
1-46	2	3.9 KΩ 1/2 watt (orange-white-red)
1-19	1	6.8 KΩ 1/2 watt (blue-gray-red)
1-20	3	10 KΩ 1/2 watt (brown-black-orange)
1-21	1	15 KΩ 1/2 watt (brown-green-orange)
1-22	2	22 KΩ 1/2 watt (red-red-orange)
1-24	2	33 KΩ 1/2 watt (orange-orange-orange)
1-88	1	36 KΩ 1/2 watt (orange-blue-orange)
1-25	1	47 KΩ 1/2 watt (yellow-violet-orange)
1-26	2	100 KΩ 1/2 watt (brown-black-yellow)
1-27	4	150 KΩ 1/2 watt (brown-green-yellow)
1-87	1	330 KΩ 1/2 watt (orange-orange-yellow)
1-33	3	470 KΩ 1/2 watt (yellow-violet-yellow)
1-35	3	1 megohm 1/2 watt (brown-black-green)
1-38	2	3.3 megohm 1/2 watt (orange-orange-green)

PART No.	PARTS Per Kit	DESCRIPTION
Resistors (cont'd.)		
1-71	2	4.7 megohm 1/2 watt (yellow-violet-green)
1-40	3	10 megohm 1/2 watt (brown-black-blue)
1-70	1	22 megohm 1/2 watt (red-red-blue)
1A-2	2	1 KΩ 1 watt (brown-black-red)
1A-22	1	1.5 KΩ 1 watt (brown-green-red)
1A-27	2	33 KΩ 1 watt (orange-orange-orange)
1A-28	1	100 KΩ 1 watt (brown-black-yellow)
1A-32	1	470 KΩ 1 watt (yellow-violet-yellow)
1A-34	1	1 megohm 1 watt (brown-black-green)
1A-37	1	3.3 megohm 1 watt (orange-orange-green)
1B-19	1	1.2 KΩ 2 watt (brown-red-red)
1B-1	2	2.7 KΩ 2 watt (red-violet-red)
1B-2	1	4.7 KΩ 2 watt (yellow-violet-red)
1B-22	1	12 KΩ 2 watt (brown-red-orange)
2-129	1	3.3 megohm 1/2 watt 5% precision
3G-15	1	1000 Ω 7 watt wire-wound
3G-4	1	5000 Ω 7 watt wire-wound
Controls-Switches		
10-65	1	2000 Ω linear control with dummy lug
10-31	1	10 KΩ linear control
10-41	1	20 KΩ control, center-tapped
10-13	1	200 KΩ control, center-tapped
10-26	1	500 KΩ linear control
10-32	1	1 megohm linear control
10-39	2	2 megohm linear control
10-45	1	7.5 megohm linear control
10-115	2	7.5 megohm linear control, tab-mounting
19-40	1	500 KΩ control with SPST switch and dummy lug
63-47	1	3-position switch
63-88	1	4-position switch
63-237	1	9-position switch

Capacitors

PART No.	PARTS Per Kit	DESCRIPTION
21-3	1	10 $\mu\mu$f ceramic
21-5	1	20 $\mu\mu$f ceramic
20-1	1	47 $\mu\mu$f mica (yellow-violet-black)
21-9	1	100 $\mu\mu$f ceramic
21-21	1	200 $\mu\mu$f ceramic
20-43	1	390 $\mu\mu$f mica (orange-white brown)
21-13	1	500 $\mu\mu$f ceramic
21-36	2	.002 μfd ceramic
21-16	1	.01 μfd ceramic
23-3	1	.01 μfd paper tubular, 400 V
21-31	2	.02 μfd ceramic, 500 V
21-38	2	.02 μfd ceramic, 1600 V
23-59	2	.05 μfd plastic molded tubular, 200 V
23-11	1	.1 μfd paper tubular, 600 V
23-28	6	.1 μfd plastic molded tubular, 200 V
23-62	2	.1 μfd paper tubular, 1600 V
23-58	2	.2 μfd plastic molded tubular, 200 V
23-63	3	.25 μfd plastic molded tubular, 400 V
25-20	2	40 μfd electrolytic, 150 V
25-28	1	100 μfd electrolytic, 50 V
25-31	1	20-20-20 μfd at 250 V-250 V-250 V electrolytic
25-32	1	40-20-20-50 μfd at 450 V-450 V-450 V-300 V electrolytic
31-12	1	Dual trimmer

Chokes-Transformer

PART No.	PARTS Per Kit	DESCRIPTION
45-25	1	30 μh (green band)
45-12	2	33 μh on 3300 Ω 1 watt resistor
45-23	2	61 μh (red band)
45-24	2	90 μh (blue-band)
54-103	1	Power transformer

Insulators-Wire

PART No.	PARTS Per Kit	DESCRIPTION
73-1	2	3/8" grommet
73-2	2	3/4" grommet
73-3	4	1/2" grommet
73-5	1	Cushion strip
75-24	1	Line cord strain relief
89-1	1	Line cord
134-19	1	Cable assembly
340-8	1	Length bare wire
341-1	1	Length black test lead
341-2	1	Length red test lead
344-59	1	Length hookup wire
346-1	1	Length 1/16" sleeving
347-2	1	Length 300 Ω twin lead

Connectors-Terminal Strips-Sockets

PART No.	PARTS Per Kit	DESCRIPTION
70-5	1	Banana plug sleeve, black
70-6	1	Banana plug sleeve, red
75-17	12	Binding post insulator
100-M16B	5	Binding post cap, black
100-M16R	2	Binding post cap, red
260-1	2	Alligator clip
427-2	11	Binding post base
431-1	1	Dual-lug terminal strip
431-2	3	2-lug terminal strip
431-12	3	4-lug terminal strip
434-16	2	9-pin socket
434-22	1	Pilot lamp socket
434-41	1	12-pin socket
434-45	3	7-pin socket - circuit board type
434-46	5	9-pin socket - circuit board type
438-13	2	Banana plug
481-1	1	Capacitor mounting wafer, metal

Sheet Metal Parts

PART No.	PARTS Per Kit	DESCRIPTION
90-234	1	Cabinet
100-M294	1	Chassis
100-M296	1	Panel ring
203-219F752, 753, 754	1	Front panel
204-M361	1	Rear support bracket
204-M362	1	Control mounting bracket
204-M363	2	CR tube mounting bracket
206-M144	1	Top shield plate
206-M145	1	Bottom shield plate
207-M1	2	CR tube clamp
210-21F	1	Bezel

Hardware

PART No.	PARTS Per Kit	DESCRIPTION
250-8	3	#6 sheet metal screw
250-29	2	6-32 x 3/4" screw
250-48	4	6-32 x 1/2" screw
250-49	18	3-48 x 1/4" screw
250-83	2	#10 sheet metal screw
250-89	20	6-32 x 3/8" screw
250-137	4	8-32 x 3/8" screw
252-1	18	3-48 nut
252-3	37	6-32 nut
252-4	4	8-32 nut
252-7	13	3/8"-32 control nut
252-35	4	Thumbnut
253-9	4	#8 flat washer
253-10	13	Steel flat washer, 5/8" OD (control)
253-39	4	Steel flat washer, 9/16" OD
254-1	33	#6 lockwasher
254-2	4	#8 lockwasher
254-4	9	Control lockwasher
259-1	10	#6 solder lug
259-10	4	Control solder lug

PART No.	PARTS Per Kit	DESCRIPTION
Tubes*-Lamp		
411-4	1	6C4 tube
411-153	3	12AU7/ECC82 tube
411-49	1	5UP1 cathode ray tube (CR tube)
411-58	1	6AB4 tube
411-65	1	1V2 tube
411-68	1	6AN8 tube
411-73	1	12BH7 tube
411-79	1	6J6 tube
411-110	1	EZ81/6CA4 tube
412-1	1	#47 lamp

*The type markings on the tubes furnished with this kit may or may not be followed by the letter "A."

PART No.	PARTS Per Kit	DESCRIPTION
Miscellaneous		
85-12F179	1	Small circuit board
85-14F178	1	Large circuit board
211-15	1	Handle
261-9	4	Rubber feet
414-11	1	Green grid screen
414-10	1	Grid screen window
421-23	1	1 ampere slow-blow fuse
423-1	1	Fuseholder
462-138	4	Small knob
462-187	8	Large knob
331-6		Solder
595-561	1	Manual

PROPER SOLDERING TECHNIQUES

Only a small percentage of HEATHKIT equipment purchasers find it necessary to return an instrument for factory service. Of these instruments, by far the largest portion malfunction due to poor or improper soldering.

If terminals are bright and clean and free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Correctly soldered connections are essential if the performance engineered into a kit is to be fully realized. If you are a beginner with no experience in soldering, a half hour's practice with some odd lengths of wire may be a worthwhile investment.

For most wiring, a 25 to 100 watt iron or its equivalent in a soldering gun is very satisfactory. A lower wattage iron than this may not heat the connection enough to flow the solder smoothly over the joint. Keep the iron tip clean and bright by wiping it from time to time with a cloth.

CHASSIS WIRING AND SOLDERING

1. Unless otherwise indicated, all wire used is the type with colored insulation (hookup wire); the size of the conductor is the same for all colors of hookup wires furnished with this kit. In preparing a length of hookup wire, 1/4" of insulation should be removed from each end unless directed otherwise in the construction step.

2. To avoid breaking internal connections when stripping insulation from the leads of transformers or similar components, care should be taken not to pull directly on the lead. Instead, hold the lead with pliers while it is being stripped.

3. Leads on resistors, capacitors and similar components are generally much longer than they need to be to make the required connections. In these cases, the leads should be cut to proper length before the part is added to the chassis. In general, the leads should be just long enough to reach their terminating points.

4. Wherever there is a possibility of bare leads shorting to other parts or to the chassis, the leads should be covered with insulating sleeving. Where the use of sleeving is specifically intended, the phrase "use sleeving" is included in the associated construction step. In any case where there is the possibility of an unintentional short circuit, sleeving should be used. Extra sleeving is provided for this purpose.

5. Crimp or bend the lead (or leads) around the terminal to form a good joint without relying on solder for physical strength. If the wire is too large to allow bending or if the step states that the wire is not to be crimped, position the wire so that a good solder connection can still be made.

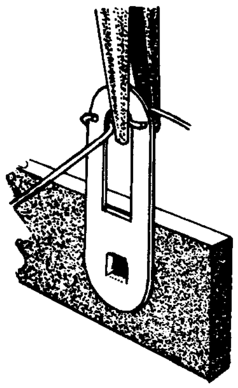
6. Position the work, if possible, so that gravity will help to keep the solder where you want it.

7. Place a flat side of the soldering iron tip against the joint to be soldered until it is heated sufficiently to melt the solder.

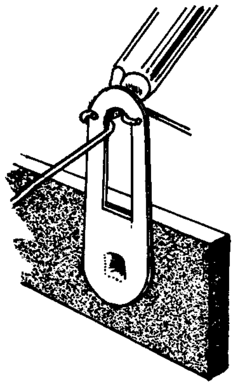
8. Then place the solder against the heated terminal and it will immediately flow over the joint; use only enough solder to thoroughly wet the junction. It is usually not necessary to fill the entire hole in the terminal with solder.

9. Remove the solder and then the iron from the completed junction. Use care not to move the leads until the solder is solidified.

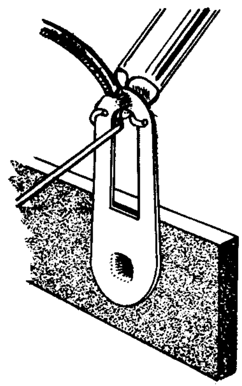
A poor or cold solder joint will usually look crystalline and have a grainy texture, or the solder will stand up in a blob and will not have adhered to the joint. Such joints should be reheated until the solder flows smoothly over the entire junction. In some cases, it may be necessary to add a little more solder to achieve a smooth bright appearance.



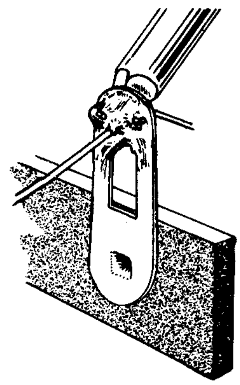
CRIMP WIRES



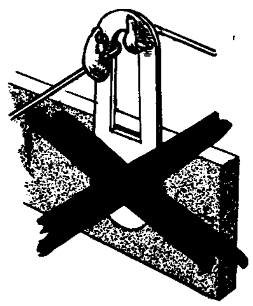
HEAT CONNECTION



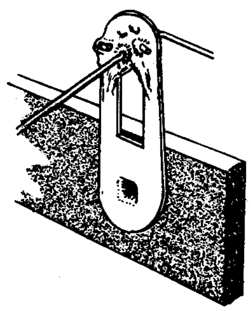
APPLY SOLDER



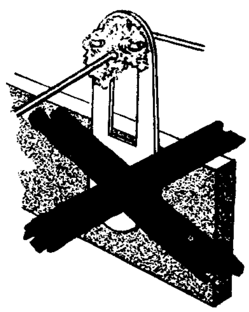
ALLOW SOLDER TO FLOW



COLD SOLDER JOINT CONNECTION INSUFFICIENTLY HEATED



PROPER SOLDER CONNECTION



COLD SOLDER JOINT CONNECTION MOVED WHILE COOLING

ROSIN CORE SOLDER HAS BEEN SUPPLIED WITH THIS KIT. THIS TYPE OF SOLDER MUST BE USED FOR ALL SOLDERING IN THIS KIT. ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE EQUIPMENT IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. IF ADDITIONAL SOLDER IS NEEDED, BE SURE TO PURCHASE ROSIN CORE (60:40 or 50:50 TIN-LEAD CONTENT) RADIO TYPE SOLDER.

CIRCUIT BOARD WIRING AND SOLDERING

Before attempting any work on the circuit boards, read the following instructions carefully and study the Figures. It is only necessary to observe the following basic precautions to insure proper operation of the unit the first time it is turned on.

Proper mounting of components on the board is essential for good performance. A good general rule to follow is that all components on the board should be mounted tightly to the board, unless instructions state otherwise. All leads should be kept as short as possible to minimize the effects of stray capacity in the wiring. Proper methods of mounting are illustrated in the accompanying Figures.

NOTE: Exercise care not to damage resistors or capacitors when bending the leads as shown.

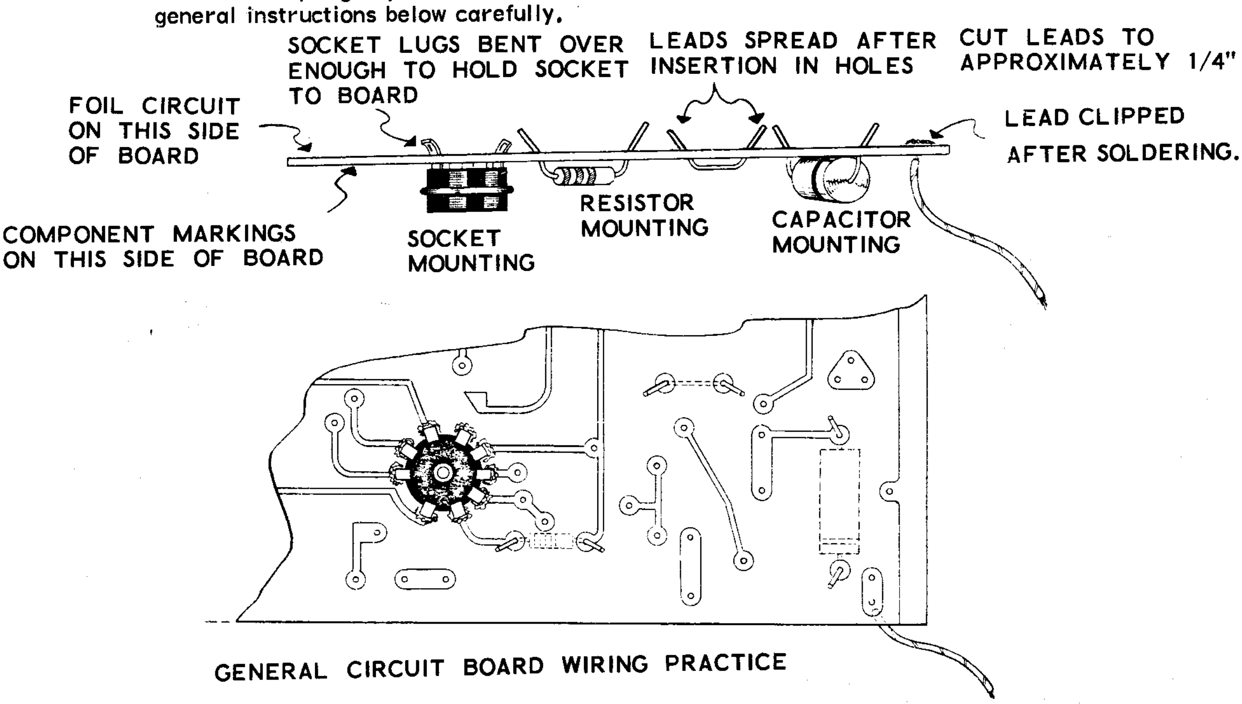
Tubular capacitors and resistors will fit properly if the leads are bent as shown. Disc capacitors will generally fit in place with no lead preparation other than determining that the leads are straight. Components with lugs normally require no preparation unless the lugs appear to be bent, in which case they can be straightened with pliers.

Parts should be inserted as instructed, and the leads bent outward, as illustrated, to lock them in place. After the part is in position, cut the leads off about 1/4" from the board. When all the parts have been installed on a circuit board, solder each lead to the foil pattern and clip off the excess wire.

The actual technique of soldering leads to a circuit board is quite simple. Position the tip of the soldering iron so that it firmly contacts both the circuit board foil and the wire or lug to be soldered, as shown. The iron should be held so that solder is not likely to flow to adjacent foil conductors or connections. The solder should immediately be placed between the iron and the joint to be soldered. Remove the length of solder as soon as its end begins to melt and

CIRCUIT BOARD WIRING

Before attempting any work on the circuit boards, study the illustration and read the general instructions below carefully.



GENERAL CIRCUIT BOARD WIRING PRACTICE

flow onto the lead and foil. Hold the tip of the iron in place only until the solder begins to flow outward over the foil; then remove the iron quickly.

Avoid overheating the connection. A soldering pencil or small iron (approximately 25 watts) is ideal for use in circuit board work. If only a high wattage iron or soldering gun is available, precautions must be taken to avoid circuit board damage due to overheating and excess solder.

The use of excessive amounts of solder will increase the possibility of bridging between foil conductors or plugging holes which are to be left open for wires which may be added later on. If solder is accidentally bridged across insulating areas between conductors, it can be cleaned off by heating the connection carefully and quickly wiping or brushing the solder away with a soft cloth or clean brush. Holes which become plugged can be cleared by heating the area immediately over the hole while gently pushing the lead of a resistor through the hole from the opposite side, and withdrawing the lead before the solder rehardens. Do not force the lead through; too much pressure before the solder has time to soften may separate the foil from the board.

In cases where foil does become damaged, repairs can usually be made with little difficulty. A break in the foil can be rejoined with a small piece of bare wire soldered across the gap, or between the foil and the lead of a component. "Hairline" breaks can usually be repaired by bridging them with a small amount of solder.

STEP-BY-STEP PROCEDURE

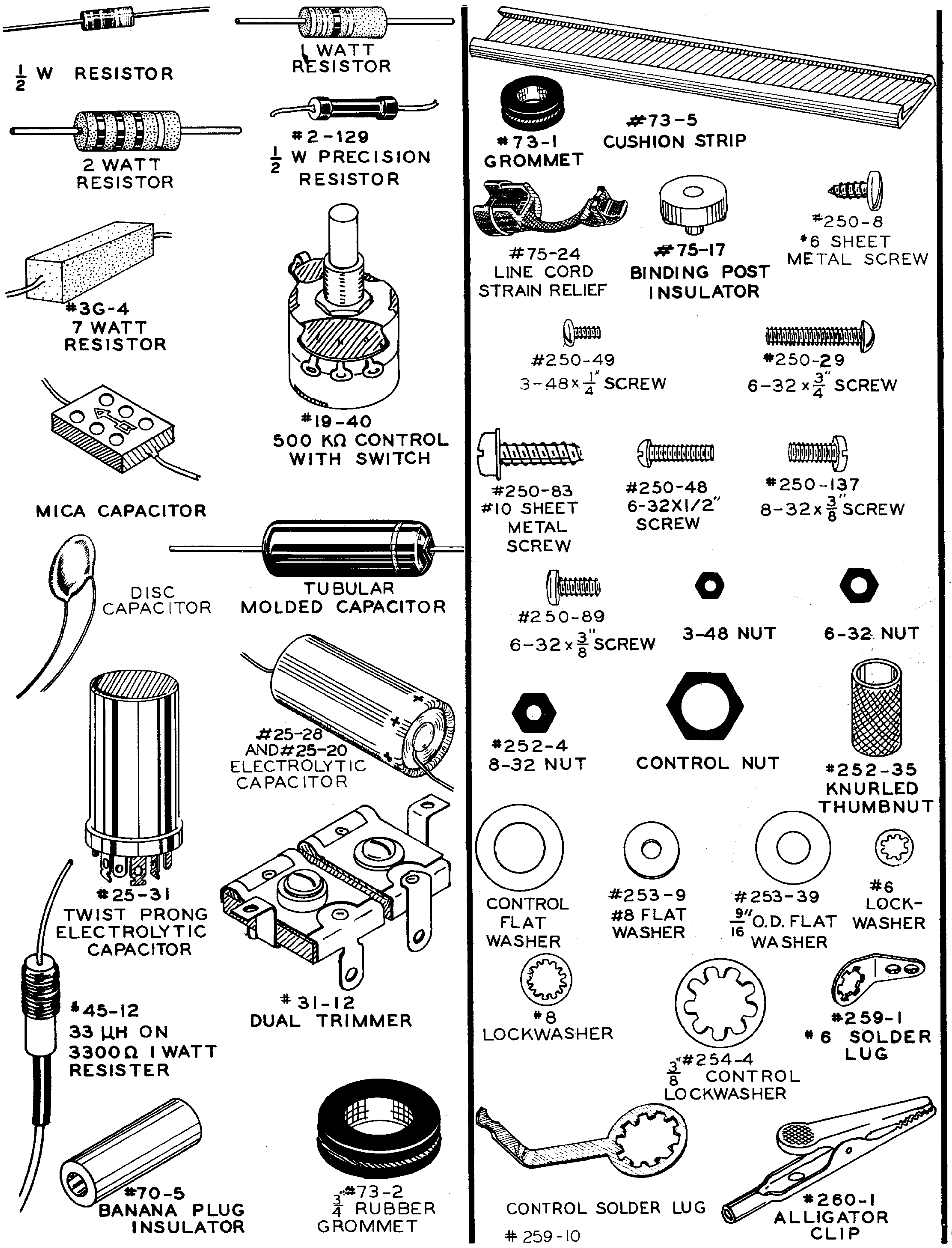
The following instructions are presented in a logical step-by-step sequence to enable you to complete your kit with the least possible confusion. Be sure to read each step all the way through before beginning the specified operation. Also read several steps ahead of the actual step being performed. This will familiarize you with the relationship of the subsequent operations. When the step is completed, check it off in the space provided. This is particularly important as it may prevent errors or omissions, especially if your work is interrupted. Some kit builders have also found it helpful to mark each lead in colored pencil on the Pictorial as it is added.

The fold-out diagrams in this manual may be removed and attached to the wall above your working area; but, because they are an integral part of the instructions, they should be returned to the manual after the kit is completed.

In general, the illustrations in this manual correspond to the actual configuration of the kit; however, in some instances the illustrations may be slightly distorted to facilitate clearly showing all of the parts.

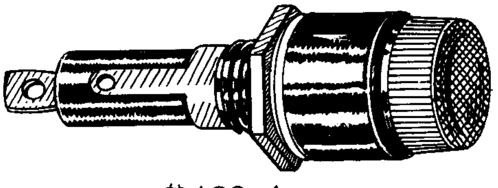
The abbreviation "NS" indicates that a connection should not be soldered yet as other wires will be added. When the last wire is installed, the terminal should be soldered and the abbreviation "S" is used to indicate this. Note that a number will appear after each solder instruction. This number indicates the number of leads that are supposed to be connected to the terminal in point before it is soldered. For example, if the instruction reads, "Connect a lead to lug 1 (S-2)," it will be understood that there will be two leads connected to the terminal at the time it is soldered. (In cases where a lead passes through a terminal or lug and then connects to another point, it will count as two leads, one entering and one leaving the terminal.)

The steps directing the installation of resistors include color codes to help identify the parts. Also, if a part is identified by a letter-number designation on the Schematic, its designation will appear in the construction step which directs its installation.

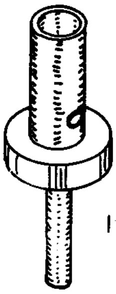


1/2 W RESISTOR
1 WATT RESISTOR
2 WATT RESISTOR
#2-129
1/2 W PRECISION RESISTOR
#3G-4
7 WATT RESISTOR
#19-40
500 KΩ CONTROL WITH SWITCH
MICA CAPACITOR
DISC CAPACITOR
TUBULAR MOLDED CAPACITOR
#25-28 AND #25-20 ELECTROLYTIC CAPACITOR
#25-31
TWIST PRONG ELECTROLYTIC CAPACITOR
#31-12
DUAL TRIMMER
#45-12
33 µH ON 3300Ω 1 WATT RESISTER
#70-5
BANANA PLUG INSULATOR
3/4" #73-2
RUBBER GROMMET
#73-1
GROMMET
#73-5
CUSHION STRIP
#75-24
LINE CORD STRAIN RELIEF
#75-17
BINDING POST INSULATOR
#250-8
#6 SHEET METAL SCREW
#250-49
3-48 x 1/4" SCREW
#250-29
6-32 x 3/4" SCREW
#250-83
#10 SHEET METAL SCREW
#250-48
6-32X1/2" SCREW
#250-137
8-32 x 3/8" SCREW
#250-89
6-32 x 3/8" SCREW
3-48 NUT
6-32 NUT
#252-4
8-32 NUT
CONTROL NUT
#252-35
KNURLED THUMBNUT
CONTROL FLAT WASHER
#253-9
#8 FLAT WASHER
#253-39
9/16" O.D. FLAT WASHER
#6 LOCK-WASHER
#8 LOCKWASHER
3/8" #254-4
CONTROL LOCKWASHER
#259-1
#6 SOLDER LUG
CONTROL SOLDER LUG
259-10
#260-1
ALLIGATOR CLIP

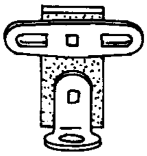
#261-9
RUBBER
FOOT



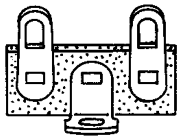
#423-1
FUSE HOLDER



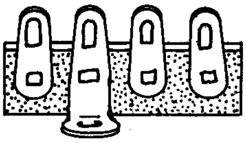
#427-2
BINDING POST
BASE



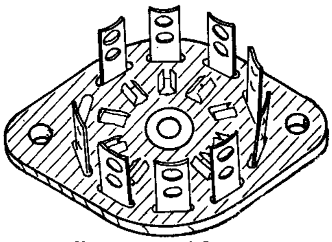
#431-1
1-LUG TERMINAL
STRIP (DUAL)



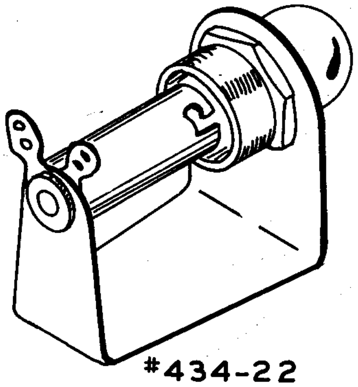
#431-2
2-LUG
TERMINAL STRIP



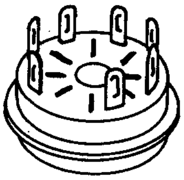
#431-12
4-LUG
TERMINAL STRIP



#434-16
9-PIN
SOCKET

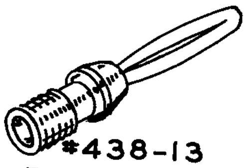


#434-22
PILOT
LAMP SOCKET

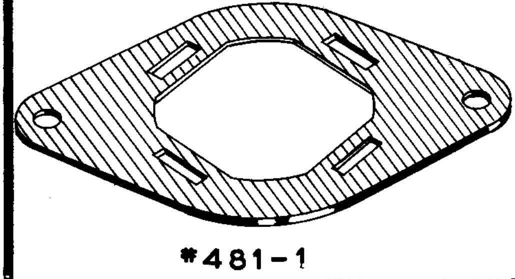


#434-45
7-PIN SOCKET
(CIRCUIT BOARD
TYPE)

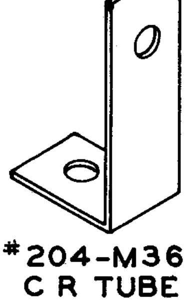
#434-46
9-PIN SOCKET
(CIRCUIT BOARD
TYPE)



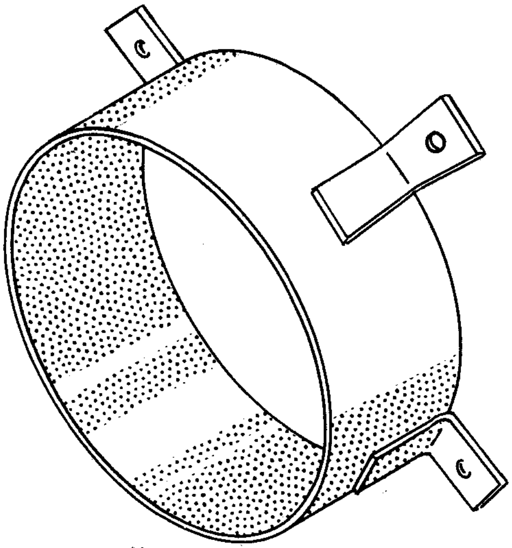
#438-13
BANANA PLUG



#481-1
CAPACITOR MOUNTING WAFER

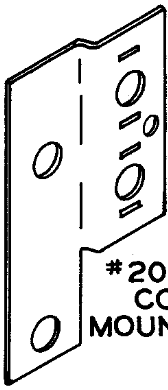


#204-M363
C R TUBE
MOUNTING
BRACKET

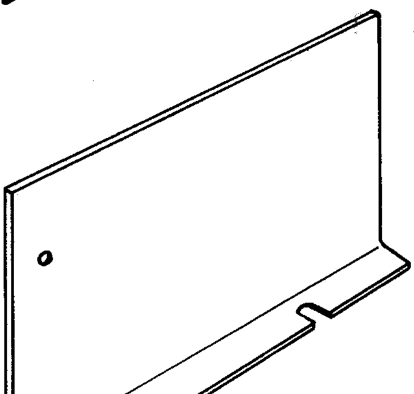


100-M296
PANEL RING

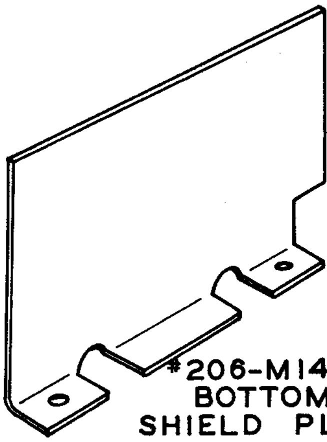
#207-M1
CR TUBE CLAMP



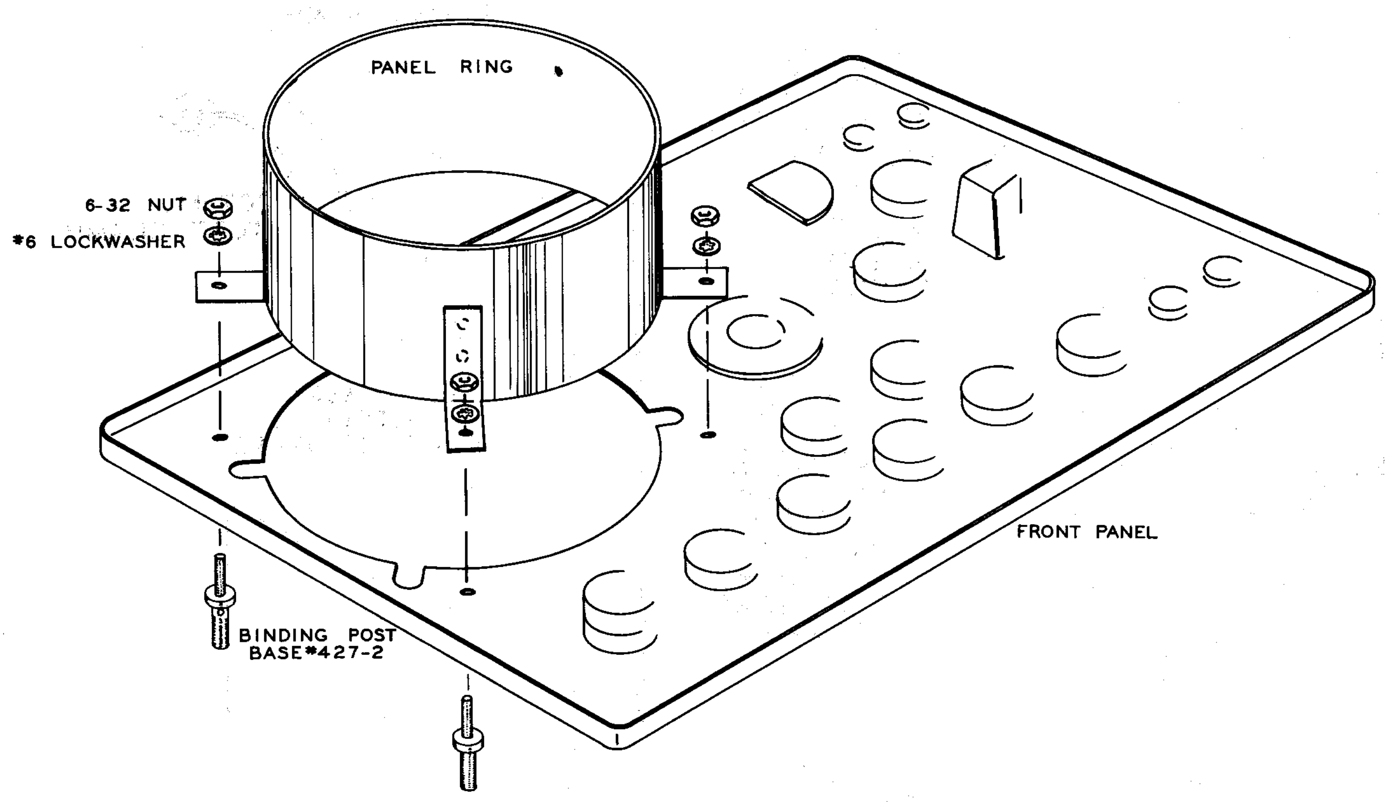
#204-M362
CONTROL
MOUNTING BRKT.



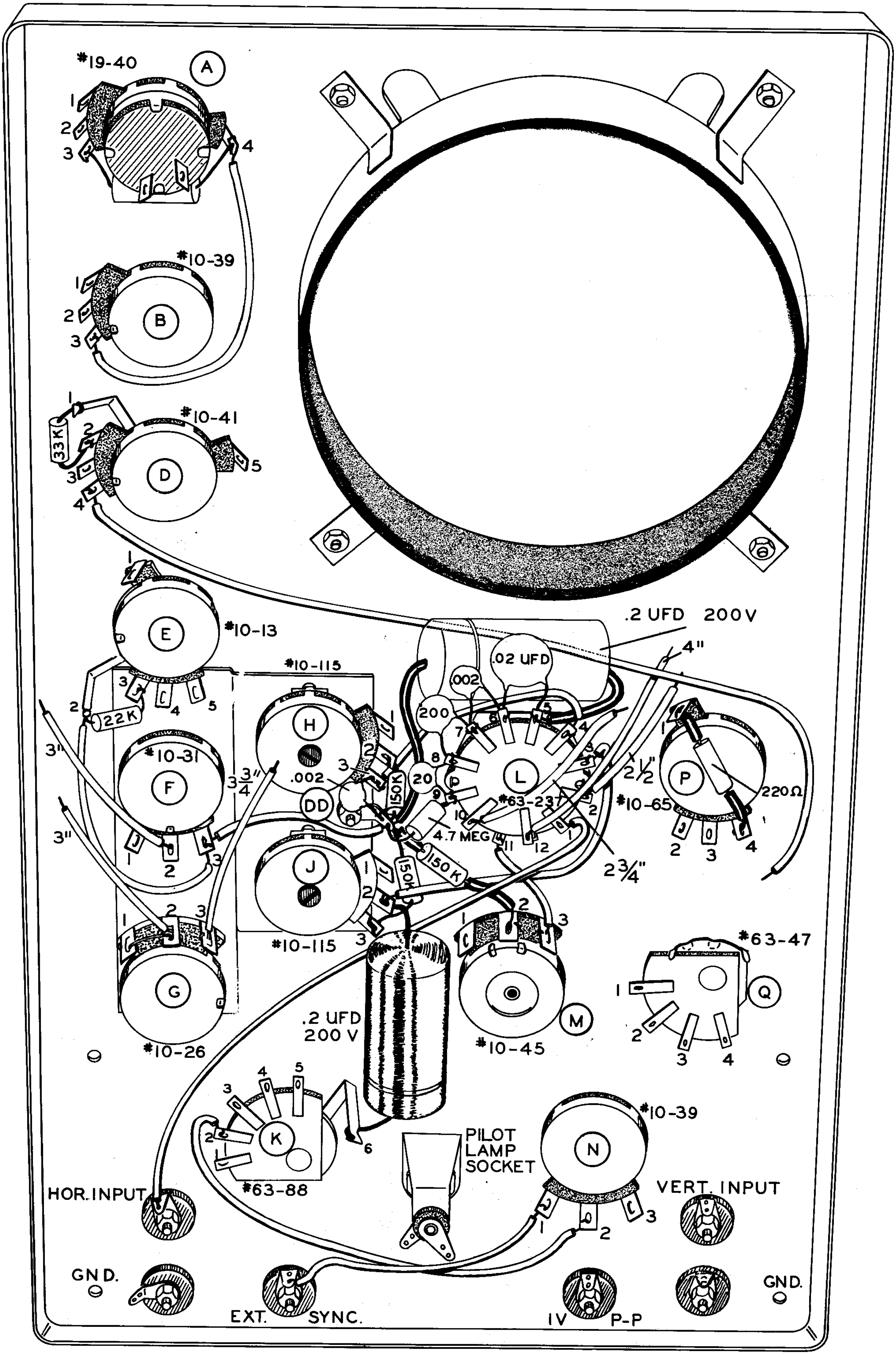
#206-M144
TOP
SHIELD PLATE



#206-M145
BOTTOM
SHIELD PLATE


PANEL RING
6-32 NUT
#6 LOCKWASHER
FRONT PANEL
BINDING POST
BASE #427-2

Detail 1E



#19-40
A
#10-39
B
#10-41
33K
D
#10-13
E
22K
#10-31
F
3"
3 3/4"
#10-115
H
.002
DD
150K
20
200
.002
.02 UFD
.2 UFD 200V
4"
L
#63-237
4.7 MEG
150K
150 K
2 1/2"
2 3/4"
P
220Ω
#10-65
J
#10-115
G
#10-26
.2 UFD
200 V
M
#10-45
#63-47
Q
K
#63-88
PILOT
LAMP
SOCKET
#10-39
N
HOR. INPUT
VERT. INPUT
GND.
EXT.
SYNC.
1V
P-P
GND.

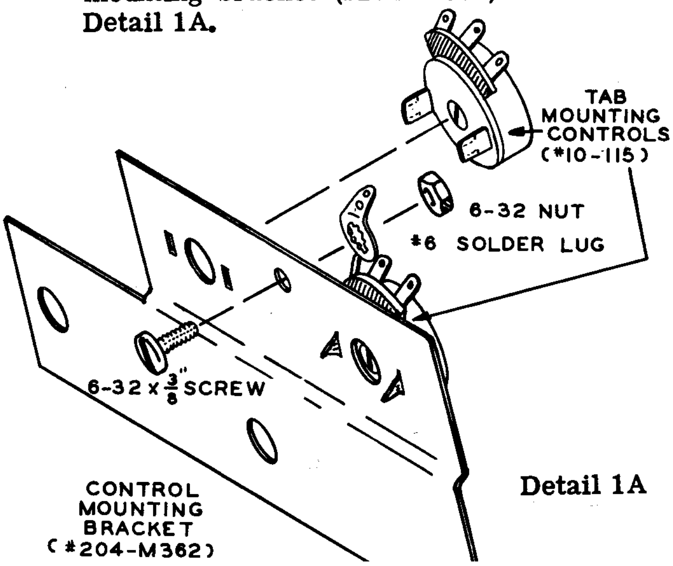
Pictorial 1

STEP-BY-STEP ASSEMBLY

FRONT PANEL ASSEMBLY

Mount each of the following components as they appear in Pictorial 1. Place a soft cloth over your work area to keep from scratching the front panel.

(✓) R45, R46. Mount the two 7.5 megohm twist-tab controls (#10-115) on the control mounting bracket (#204-M362) as shown in Detail 1A.



Detail 1A

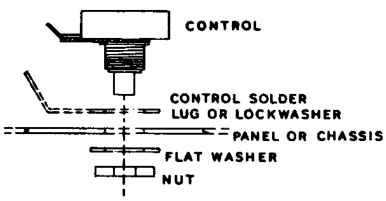
(✓) Mount a #6 solder lug on the control mounting bracket with a 6-32 x 3/8" screw and a 6-32 nut.

(✓) R52. Fasten the control mounting bracket to the front panel by installing 10 KΩ control F (#10-31) but do not tighten yet. Place the control lockwasher between the control and the mounting bracket. See Detail 1B.

(✓) R72. Similarly install 500 KΩ control G (#10-26) through the bracket. Now tighten the control nuts.

(✓) R78. Mount 500 KΩ control and switch A (#19-40) with a control lockwasher, flat control washer, and a control nut as shown in Detail 1B.

Detail 1B



CONTROL MOUNTING WITH GROUND LUG

(✓) R80. Mount 2 megohm control B (#10-39) in the same manner.

(✓) R18. Mount 20 KΩ control D (#10-41) using a control solder lug in place of the control lockwasher.

(✓) R55. Install 200 KΩ control E (#10-13) using a control solder lug in place of the control lockwasher.

(✓) Install switch L (#63-237), making sure that it is oriented properly by checking the position of lug 11.

(✓) Install switch K (#63-88), using a control solder lug in place of the control lockwasher.

In the same manner, but using control lockwashers, mount:

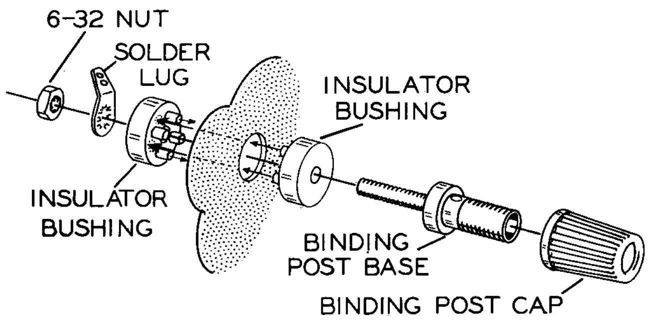
(✓) Switch Q (#63-47).

(✓) R8. 2000 Ω control P (#10-65).

(✓) R48. 7.5 megohm control M (#10-45).

(✓) R31. 2 megohm control N (#10-39).

(✓) Install the six binding posts at the bottom of the panel in the manner shown in Detail 1C. Face each solder lug as shown in Pictorial 1. Orient the holes in the binding post base parallel to the bottom of the panel.

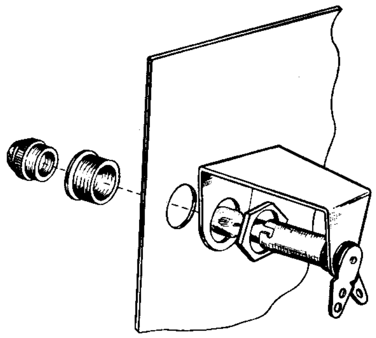


Detail 1C

(✓) Install a red binding post cap on the VERT. INPUT and HOR. INPUT binding posts.

(✓) Install a black binding post cap on each of the four binding posts at the bottom of the panel.

( ) Install the pilot lamp socket as shown in Detail 1D, and install the #47 lamp in the socket.



Detail 1D

( ) Install the panel ring on the front panel with four binding post bases, #6 lockwashers, and 6-32 nuts as shown in Detail 1E. (see fold-out from page 14)

( ) R79. Connect a 1 megohm (brown-black-green) 1 watt resistor from lug 3 (S-1) to lug 4 (NS) of control A.

( ) Connect a 3-1/2" length of hookup wire from lug 4 of control A (S-2) to lug 3 of control B (S-1).

( ) R19. Connect a 33 KΩ (orange-orange-orange) 1/2 watt resistor from lug 1 (S-1) to lug 2 (S-1) of control D.

( ) R56. Connect a 22 KΩ (red-red-orange) 1/2 watt resistor from lug 2 (NS) to lug 3 (S-1) of control E.

( ) Connect a 2-1/4" length of hookup wire from lug 3 of control F (NS) to solder lug DD (NS).

( ) Connect a 3" length of hookup wire from lug 3 of control F (S-2) to lug 2 of control E (S-2).

( ) Connect a 2-3/4" length of hookup wire from lug 3 of control H (NS) to lug 4 of switch L (S-1).

( ) R84. Connect a 150 KΩ (brown-green-yellow) 1/2 watt resistor from lug 2 of control H (S-1) to ground lug DD (lower hole) (NS).

( ) Connect a 3-1/2" length of hookup wire from lug 2 of control J (NS) to lug 3 of switch L (S-1).

( ) R83. Connect a 150 KΩ (brown-green-yellow) 1/2 watt resistor from lug 3 of control J (S-1) to the lower hole of ground lug DD (NS).

( ) Connect a 1-1/2" length of hookup wire from lug 3 of control M (S-1) to lug 11 of switch L (S-1).

( ) Connect a 5-3/4" length of hookup wire from lug 1 of switch L (S-1) to the HOR. INPUT solder lug (S-1).

( ) R47. Connect a 150 KΩ (brown-green-yellow) 1/2 watt resistor from solder lug DD (NS) to lug 2 of control M (S-1). Use sleeving on both leads.

( ) Strip both ends of an 11-1/2" length of hookup wire and connect one to lug 4 of control D (S-1). Route the other end of the wire across the panel as shown. It will be connected later.

( ) Connect a 5" length of hookup wire from lug 2 of switch K (S-1) to lug 2 of control N (S-1).

( ) Connect a 3-1/2" length of hookup wire from lug 1 of control N (S-1) to the EXT. SYNC. solder lug (S-1).

( ) C23. Connect a .2 μfd 200 V capacitor from lug 2 of control J (S-2) to lug 6 of switch K (S-1).

( ) C21. Connect a .2 μfd 200 V capacitor from lug 5 of switch L (NS) to solder lug DD (NS). Use sleeving on both leads and place the capacitor as shown.

( ) R43. Connect a 4.7 megohm (yellow-violet-green) 1/2 watt resistor from ground lug DD (NS) to lug 9 of switch L (NS).

( ) C22. Connect a .002 μfd ceramic capacitor from lug 3 of control H (S-2) to ground lug DD (S-7).

( ) C17. Connect a 20 μμf ceramic capacitor from lug 9 (S-2) to lug 8 (NS) of switch L.

( ) C18. Connect a 200 μμf ceramic capacitor from lug 8 (S-2) to lug 7 (NS) of switch L.

( ) C19. Connect a .002 μfd ceramic capacitor from lug 7 (S-2) to lug 6 (NS) of switch L.

( ) C20. Connect a .02 μfd ceramic 500 V capacitor from lug 6 (S-2) to lug 5 (S-2) of switch L.

( ) R9. Connect a 220 Ω (red-red-brown) 1/2 watt resistor from lug 1 (NS) to lug 4 (S-1) of control P. Use sleeving on both leads.

Note: The other end of each of the following wires will be connected later.

( ) Connect a 2-1/2" length of hookup wire to lug 2 of switch L (S-1).

( ) Connect a 3-3/4" length of hookup wire to lug 3 of control G (NS).

( ) Connect a 4" length of hookup wire to lug 12 (both the front and rear lugs) of switch L (S-1).

( ) Connect a 2-3/4" length of hookup wire to lug 10 of switch L (S-1).

( ) Strip 3/4" of insulation from one end and 1/4" of insulation from the other end of a 3" length of hookup wire. Insert the 3/4" stripped end through lug 2 (NS) to lug 1 (S-1) of control G. Now solder lug 2 (S-2).

( ) Connect a 3" length of hookup wire to lug 2 of control F (S-1).

This completes the preliminary panel wiring.

LARGE CIRCUIT BOARD WIRING

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

( ) Before working on the circuit board, refer to the Circuit Board Wiring and Soldering section on Page 12 of this manual.

Insert 7-pin molded sockets in the holes marked V1, V4 and V10, in the large circuit board as follows:

( ) Place the body of each socket on the phenolic side of the board, with the contacts extending through to the pattern or foil side. Align the blank space of the socket with the arrow printed on the circuit board. Fan out the socket contacts enough to prevent the socket from falling out.

( ) Rotate the socket slightly to obtain exact alignment between socket contacts and circuit pattern. BE SURE that no socket contact falls in the blank area of the circuit pattern.

( ) Now, carefully solder each contact to the adjacent foil pattern. Do not attempt to cut off the tip of the contact after soldering.

( ) Install the 9-pin sockets V5 and V6 in the same manner.

Pictorial 2 shows the wiring sequence for the large circuit board. Start with Step 1, in the upper left corner and follow the numbered operations around the board in clockwise order.

Observe the special instructions for mounting the 5000 Ω 7 watt resistor in Step 7. This part is mounted above the circuit board to provide better heat dissipation.

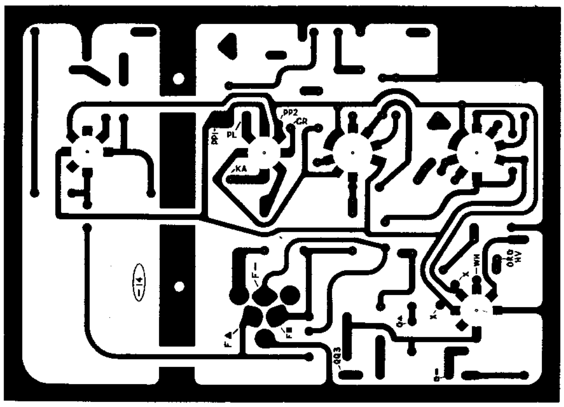
DO NOT CONFUSE 1/2 WATT AND 1 WATT RESISTORS. Be sure to use the part called out. In most cases, the lead holes are spaced precisely to accept the leads of the component, when they are bent down near the body of the component.

IF THE PART DOES NOT SEEM TO MATCH THE HOLES, RECHECK YOUR WORK. It is possible that the part is not the proper one.

To mount parts on the circuit board properly, Refer to the CIRCUIT BOARD WIRING section on Page 12 of this manual.

Observe the polarity markings of the capacitor installed in Step 37.

Use bare wire in steps 1, 15, 23, and 36.



Detail 2A

When all parts have been mounted, go back and recheck your work thoroughly. An error found now will save much difficulty later. When you are satisfied that the parts are correctly wired, carefully solder each lead to the circuit foil pattern, using the technique outlined previously. Then cut off the excess leads neatly, close to the soldered point.

AFTER the operations outlined in Pictorial 2 have been completed:

( ) Mount the 3-prong filter capacitor can at F. Match the markings stamped in the insulator at the base of the capacitor, with those printed on the phenolic side of the board. DO NOT attempt to mount this capacitor by twisting the mounting lugs in conventional fashion; instead, solder the mounting lugs to the circuit pattern surrounding the slots. Then solder the capacitor terminals in the same way. Do not attempt to cut off the tips of the lugs or terminals.

SMALL CIRCUIT BOARD WIRING

Refer to Pictorial 3 and Detail 3A for the following steps.

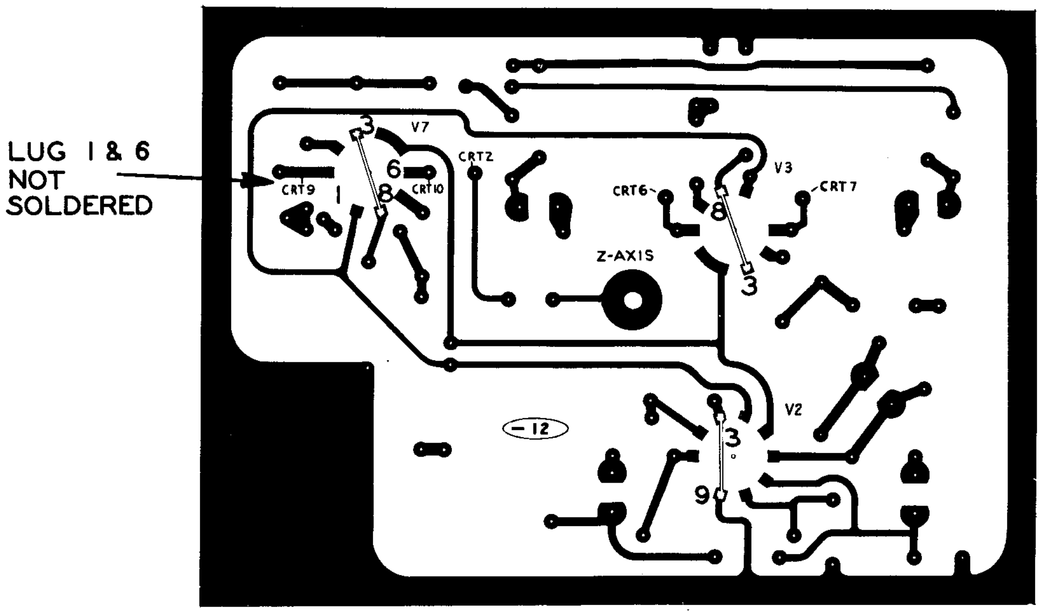
( ) Mount the three 9-pin sockets and fan out the lugs. However, before soldering the sockets to the circuit pattern, connect a short bare wire from pin 3 to pin 8 of sockets V3 and V7, and between pins 3 and 9 on V2. See Detail 3A. Then solder all socket lugs in place except for lug 1 and lug 6 of tube socket V7. Be sure that the short jumper is well soldered to the lugs, since the lugs are soldered to the pattern.

Now wire the circuit board as directed in Pictorial 3. Start at Step 1 at the top of the board and progress clockwise. When mounting the five peaking coils, hold the coil form tightly against the circuit board while spreading the terminals slightly. This will insure that the coil form is perpendicular to the circuit board when the connections are soldered.

When all parts have been mounted, go back and recheck your work thoroughly. An error found now will save much difficulty later. When you are satisfied that the parts are correctly wired, carefully solder each lead to the circuit foil pattern, using the technique outlined previously. Then cut off the excess leads neatly, close to the soldered point.

AFTER the operations outlined in Pictorial 3 are completed:

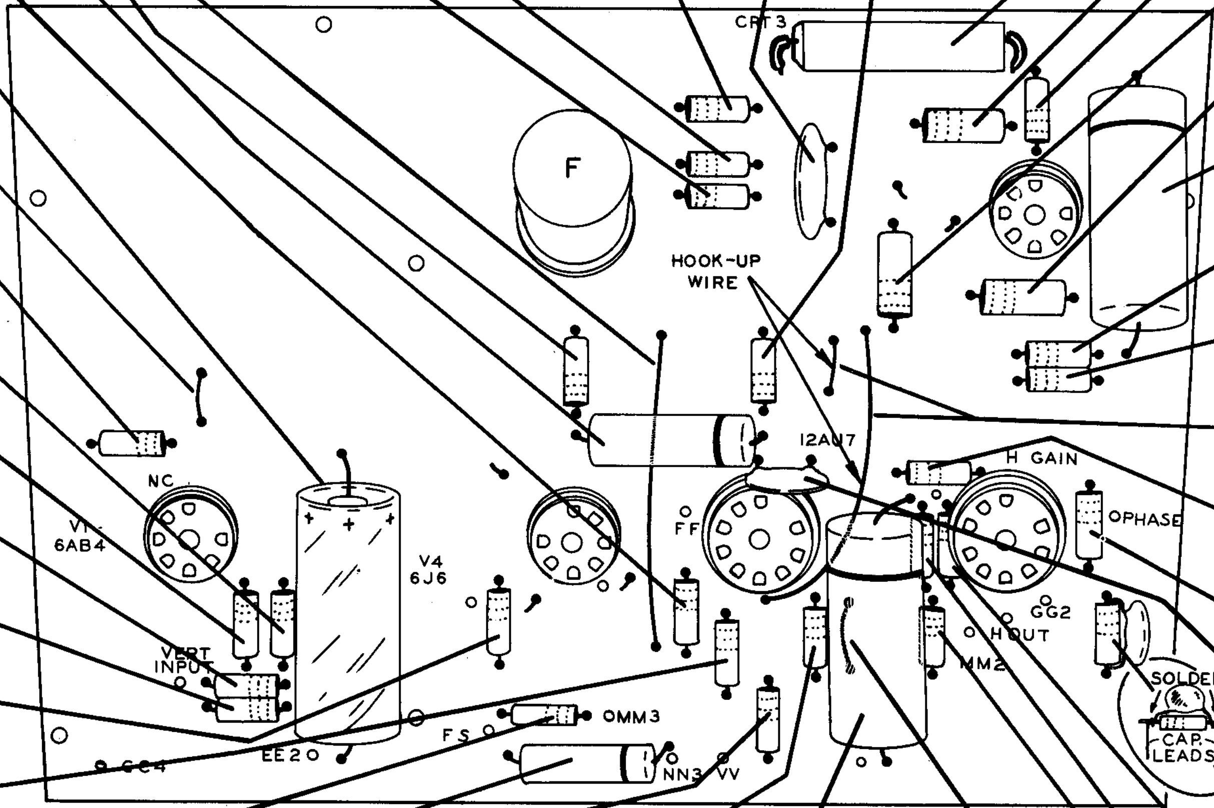
( ) Assemble the Z-axis binding post to the circuit board using the 5/32" hole provided. The binding post base goes on the foil side of the circuit board. Use a 6-32 nut and lockwasher on the phenolic side. (See Detail 3A.) Install the black cap on the binding post base.



Detail 3A

START

BEFORE INSTALLING, SLIP 1/2" LENGTHS OF SLEEVING OVER BOTH LEADS TO LIFT RESISTOR BODY OFF CIRCUIT BOARD.



1. ( ) Wire Jumper. (hookup wire)
2. ( ) R167. 10 KΩ resistor (brown-black-orange).
3. ( ) R166. 3.9 KΩ resistor (orange-white-red).
4. ( ) R165. 3.9 KΩ resistor (orange-white-red).
5. ( ) C124. 0.02 1.6 KV capacitor (ceramic disc).
6. ( ) R141. 10 KΩ resistor (brown-black-orange).
7. ( ) R162. 5000 Ω 7 watt resistor (marked numerically).
8. ( ) R164. 1.5 KΩ 1 watt resistor (brown-green-red).
9. ( ) R163. 220 Ω resistor (red-red-brown).
10. ( ) R144. 100 KΩ 1 watt resistor (brown-black-yellow).
11. ( ) R181. 3.3 megohm 1 watt resistor (orange-orange-green).
12. ( ) C135. 0.25 400 V capacitor (molded tubular).
13. ( ) R170. 1 megohm resistor (brown-black-green).
14. ( ) R182. 15 KΩ resistor (brown-green-orange).
15. ( ) TWO wire jumpers.
16. ( ) R147. 2.2 KΩ resistor (red-red-red).
17. ( ) R151. 22 KΩ resistor (red-red-orange).
18. ( ) C116. 100 μμf capacitor (ceramic disc).
19. ( ) R153 and C129. 1 KΩ resistor (brown-black-red) and 500 μμf capacitor.
20. ( ) R149. 2.2 KΩ resistor (red-red-red).
21. ( ) R142. 4.7 megohm resistor (yellow-violet-green).
22. ( ) R150. 47 KΩ resistor (yellow-violet-orange).
23. ( ) Wire Jumper.
24. ( ) C126. *0.25 400 V capacitor (molded tubular).
25. ( ) R142. 22 megohm resistor (red-red-blue).
26. ( ) R133. 62 Ω resistor (blue-red-black).
27. ( ) C42. 0.01 400 V capacitor (molded tubular).
28. ( ) R73. 470 KΩ resistor (yellow-violet-yellow).
29. ( ) R132. 470 Ω resistor (yellow-violet-brown).
30. ( ) R74. 10 KΩ resistor (brown-black-orange).
31. ( ) R107. 2.7 KΩ resistor (red-violet-red).
32. ( ) R105. 3.3 megohm resistor (orange-orange-green).
33. ( ) R104. 100 Ω resistor (brown-black-brown).
34. ( ) R106. 220 Ω resistor (red-red-brown).
35. ( ) R117. 100 KΩ resistor (brown-black-yellow).
36. ( ) Wire jumper.
37. ( ) C106. 100 μfd 50 V capacitor **(electrolytic tubular).
38. ( ) R139. 6.8 KΩ resistor (blue-gray-red).
39. ( ) C115. 0.05 200 V capacitor (molded tubular).
40. ( ) R140. 470 KΩ resistor (yellow-violet-yellow).

**OBSERVE POLARITY MARKINGS

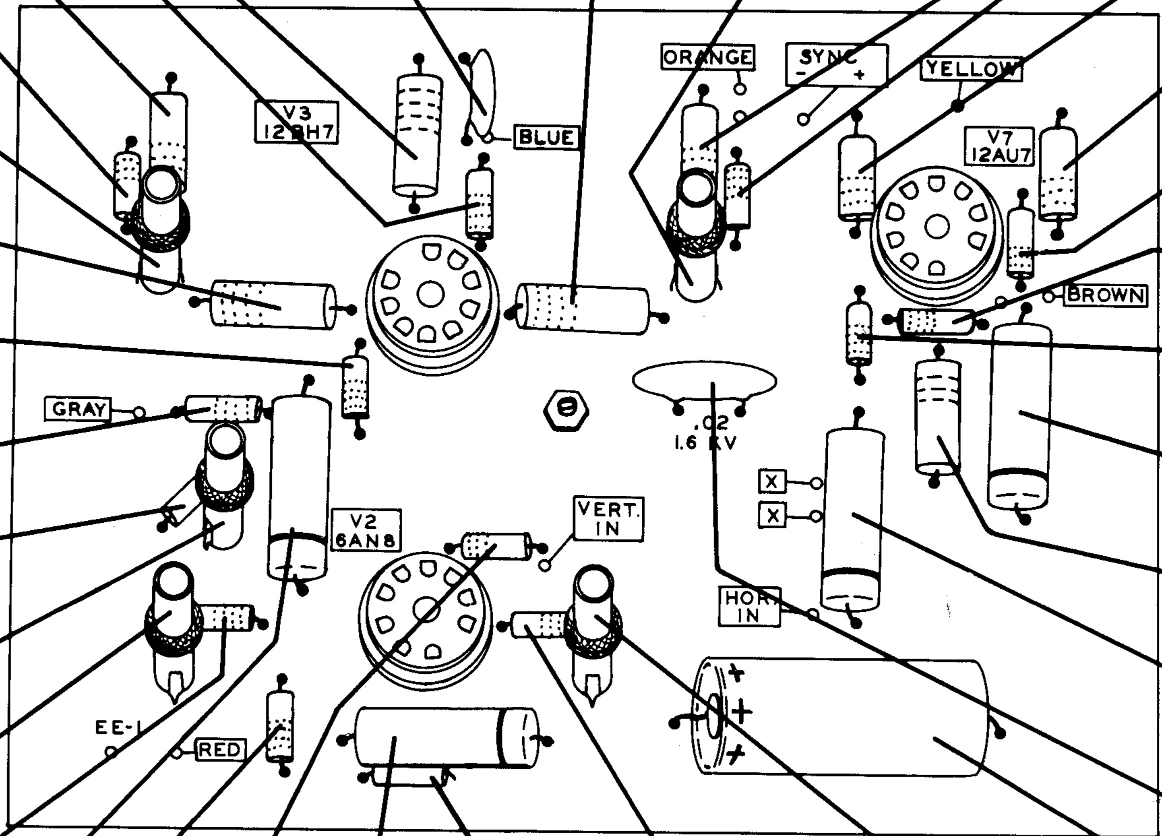
*In Step 24 position capacitor body snugly against circuit board between 4.7 megohm resistor (see Step 21) and wire jumper (see Step 23). Pull leads taut, then spread on foil side of board.

Pictorial 2

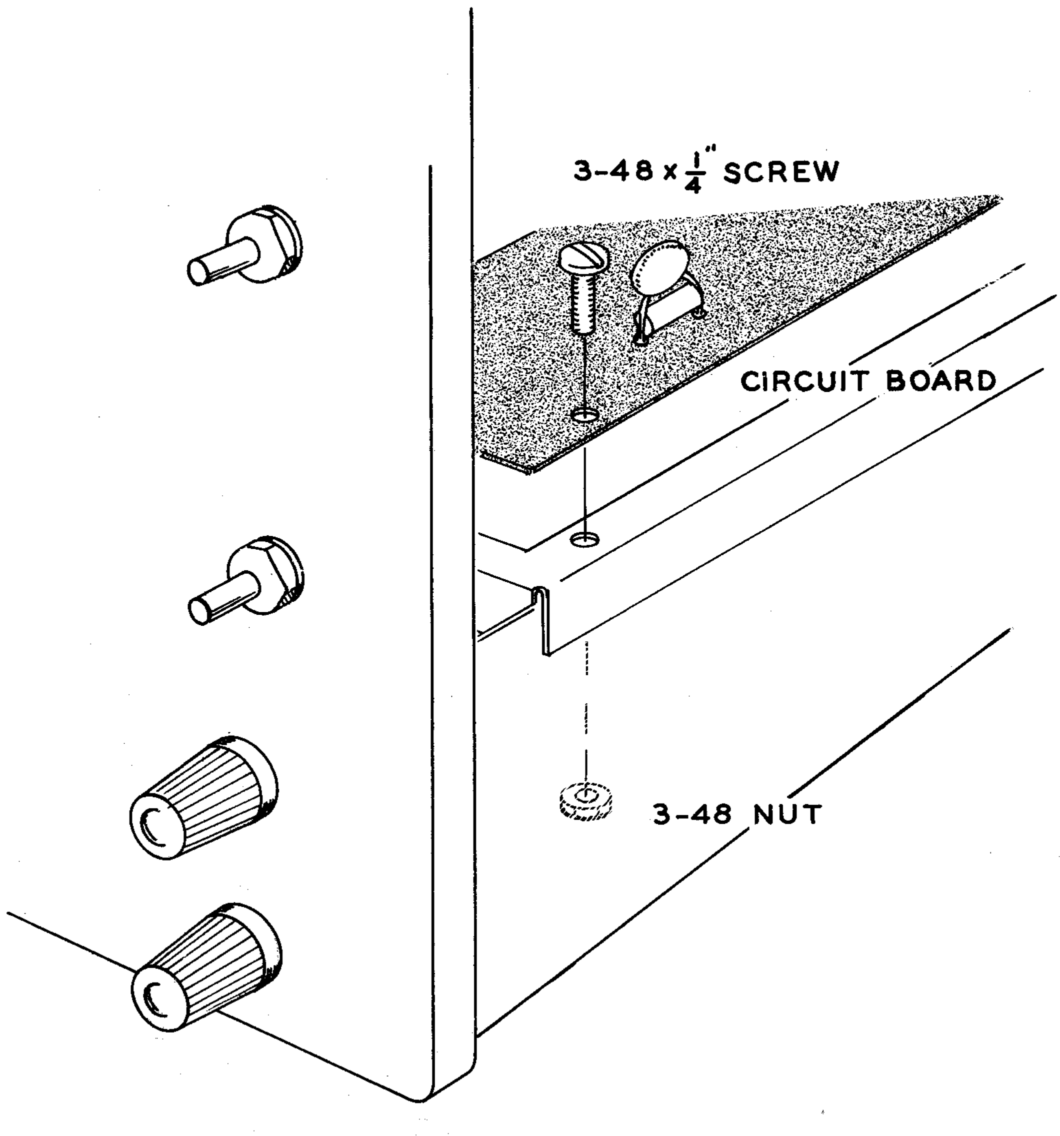
START

✱ Before installing, slip 3/8" lengths of sleeving over both leads to lift resistor body off circuit board.

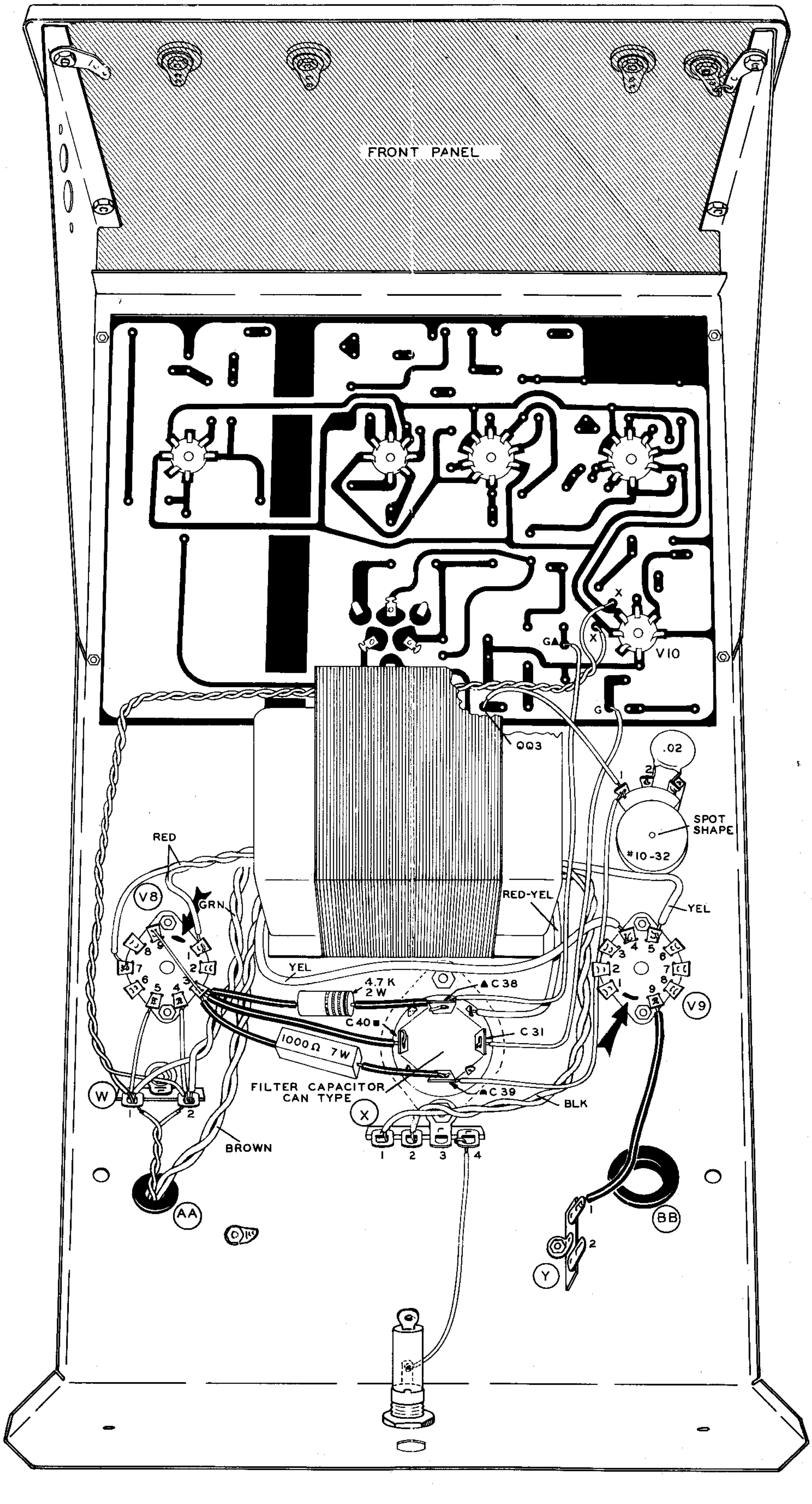
1. ( ) R221. 1.2 KΩ 2 watt resistor (brown-red-red). ✱
2. ( ) C211. 0.01 500 V capacitor (ceramic disc).
3. ( ) R229. 2.7 KΩ 2 watt resistor (red-violet-red). ✱
4. ( ) 90 μh coil (blue band).
5. ( ) R227. 1 KΩ 1 watt resistor (brown-black-red).
6. ( ) R228. 3.3 KΩ resistor (orange-orange-red).
7. ( ) R260. 33 KΩ 1 watt resistor (orange-orange-orange).
8. ( ) R261. 33 KΩ 1 watt resistor (orange-orange-orange).
9. ( ) R259. 100 Ω resistor (brown-black-brown).
10. ( ) R254. 10 megohm resistor (brown-black-blue).
11. ( ) R257. 100 Ω resistor (brown-black-brown).
12. ( ) C230. 0.1 200 V capacitor (molded tubular).
13. ( ) R258. 12 KΩ 2 watt resistor (brown-red-orange).
14. ( ) C128. 0.1 200 V capacitor (molded tubular).
15. ( ) C225. 0.02 1.6 KV capacitor (ceramic disc).
16. ( ) C208. 40 μfd 150 V capacitor *(electrolytic tubular).
    * OBSERVE POLARITY.
17. ( ) 61 μh coil (red band)
18. ( ) R211. 2.2 KΩ resistor (red-red-red).
19. ( ) R212. 3.3 KΩ resistor (orange-orange-red).
20. ( ) C209. 0.1 200 V capacitor (molded tubular).
21. ( ) R210. 10 megohm resistor (brown-black-blue).
22. ( ) R213. 10 megohm resistor (brown-black-blue).
23. ( ) C210. 0.1 200 V capacitor (molded tubular).
24. ( ) R214. 2 KΩ resistor (red-black-red).
25. ( ) 61 μh coil (red band).
26. ( ) 30 μh coil (green band).
27. ( ) R215. 2 KΩ resistor (red-black-red).
28. ( ) R216. 3.3 megohm resistor (orange-orange-green).
29. ( ) R220. 100 Ω resistor (brown-black-brown).
30. ( ) R224. 2.7 KΩ 2 watt resistor (red-violet-red). ✱
31. ( ) 90 μh coil (blue-band).
32. ( ) R225. 3.3 KΩ resistor (orange-orange-red).
33. ( ) R226. 1 KΩ 1 watt resistor (brown-black-red).
34. ( ) R222. 100 Ω resistor (brown-black-brown).



Pictorial 3

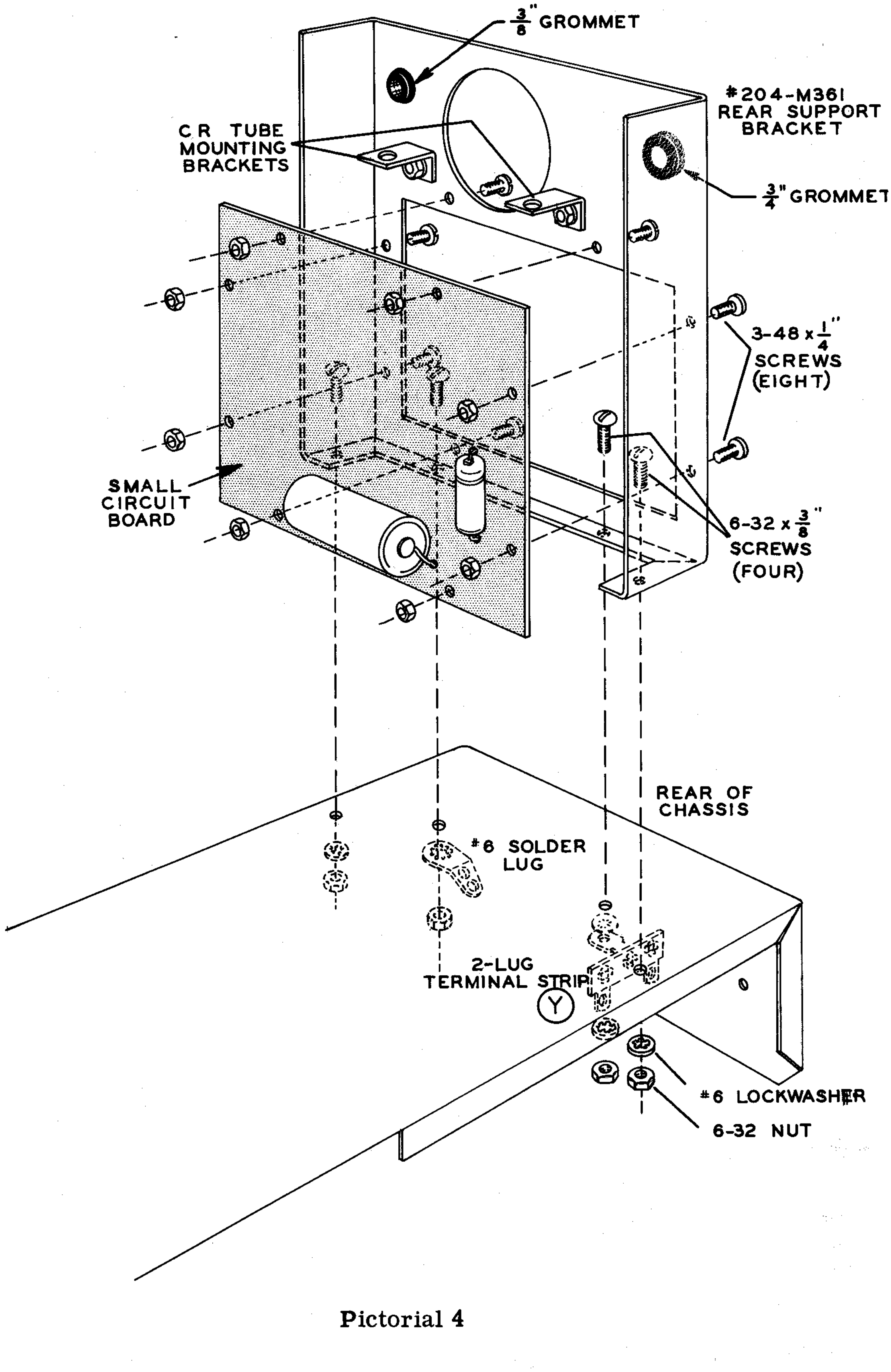


Detail 5A



FRONT PANEL
V10
X
GA
G
QQ3
.02
SPOT SHAPE
#10-32
RED
GRN
V8
RED-YEL
YEL
YEL
4.7 K 2 W
C38
C40
C31
1000Ω 7W
FILTER CAPACITOR CAN TYPE
C39
BLK
V9
W
X
BROWN
AA
BB
Y

Pictorial 5


3/8" GROMMET
#204-M361
REAR SUPPORT
BRACKET
C R TUBE
MOUNTING
BRACKETS
3/4" GROMMET
3-48 x 1/4"
SCREWS
(EIGHT)
SMALL
CIRCUIT
BOARD
6-32 x 3/8"
SCREWS
(FOUR)
REAR OF
CHASSIS
#6 SOLDER
LUG
2-LUG
TERMINAL STRIP
Y
#6 LOCKWASHER
6-32 NUT

Pictorial 4

REAR SUPPORT BRACKET ASSEMBLY

Refer to Pictorial 4 for the following steps.

( ) Install the rear support bracket on the chassis with four 6-32 x 3/8" screws, #6 lockwashers and 6-32 nuts. Install the #6 solder lug and 2-lug terminal strip Y below the chassis as shown.

( ) Install the small circuit board on the rear support bracket with the foil side toward the bracket as shown in Pictorial 4. Use eight 3-48 x 1/4" screws and eight 3-48 nuts.

( ) Install a 3/8" grommet in the small hole near the top of the rear support bracket.

( ) Install a 3/4" grommet in the larger hole near the top of the rear support bracket.

( ) Install the two CR tube mounting brackets (#204-M363) using 6-32 x 3/8" screws, #6 lockwashers and 6-32 nuts.

CHASSIS ASSEMBLY

Refer to Pictorial 5 for the following steps.

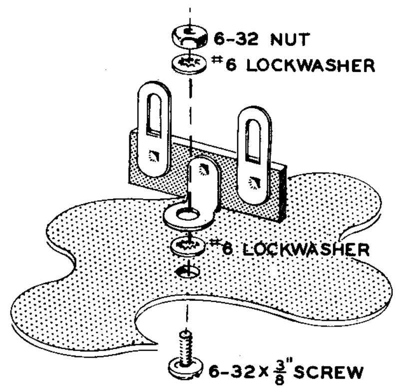
( ) Mount the large circuit board on the top side of the chassis, as shown in Detail 5A, using six 3-48 screws and six 3-48 nuts. (Detail 5A on fold-out from this page).

( ) Install the front panel on the chassis with four 6-32 x 3/8" screws and 6-32 nuts. Place #6 lockwashers under the two upper nuts and place #6 solder lugs, oriented as shown, under the two lower nuts.

( ) Mount 9-pin tube sockets V8 and V9 using 3-48 screws and 3-48 nuts. Be sure to align the blank spaces in the direction shown by the arrows.

( ) R75. Mount the 1 megohm Spot Shape control (#10-32) using a control solder lug in place of the control lockwasher. Position the control solder lug adjacent to lug 3 of the Spot Shape control, but do not solder the lugs until later.

( ) Mount 2-lug terminal strip W using a 6-32 x 3/8" screw, #6 lockwashers, and a 6-32 nut. Use a lockwasher both above and below the mounting foot of the terminal strip as shown in Detail 5B.

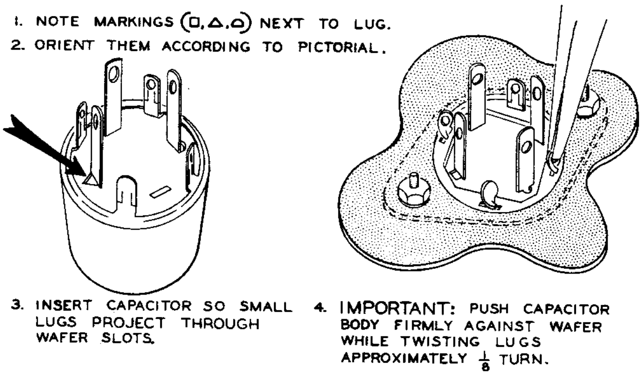


Detail 5B

( ) Install 3/4" grommet BB and 3/8" grommet AA.

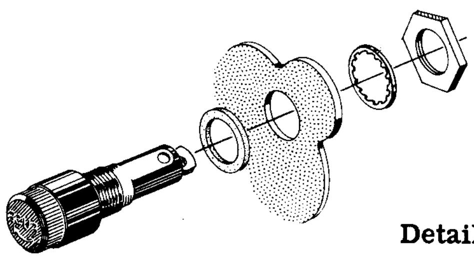
( ) Mount the capacitor mounting wafer on top of the chassis using 6-32 x 3/8" screws, #6 lockwashers, and 6-32 nuts. Install 4-lug terminal strip with two lockwashers on the 6-32 screw closest to the rear of the chassis.

( ) Install the 4-prong filter capacitor in the capacitor mounting wafer by twisting the outer lugs as shown in Detail 5C. Make sure that the lug marked with the triangle, C38, is mounted closest to the front of the chassis.



Detail 5C

( ) Mount the fuse holder on the rear lip of the chassis, as shown in Detail 5D. Now install the fuse in the fuse holder.



Detail 5D

( ) Mount the power transformer using the four 8-32 screws, #8 lockwashers, and 8-32 nuts. Be sure that the leads emerge from the correct sides of the transformer as shown in Pictorial 5.

( ) Twist the two green transformer leads together, then connect one lead to lug 1 (NS) and connect the other lead to lug 2 (NS) of terminal strip W.

( ) Twist the two brown transformer leads together and insert them up through grommet AA to be connected later.

( ) Twist the two red transformer leads together, then connect one lead to lug 1 (S-1) and connect the other lead to lug 7 (S-1) of tube socket V8.

( ) Connect one yellow transformer lead to lug 5 (S-1) and connect the other yellow transformer lead to lug 4 (S-1) of tube socket V9.

( ) Connect the red-yellow transformer lead to the capacitor mounting lug between C31 and C38 (S-1). Now solder this lug to the capacitor mounting wafer.

( ) Twist the two black transformer leads together, then connect one lead to lug 1 (NS) and connect the other lead to lug 2 (NS) of terminal strip X.

( ) Insert a 4" length of bare wire through the top hole of lug 3 (NS) to the top hole of lug 9 (S-1) of tube socket V8.

( ) Place a 2-1/2" length of sleeving over the end of this wire, and connect it to capacitor lug C40 (S-1).

( ) R68. Connect a 4.7 KΩ (yellow-violet-red) 2 watt resistor from lug 3 of tube socket V8 (NS) to capacitor lug C38 (NS). Use sleeving on both leads.

( ) R69. Use sleeving on both leads, and connect a 1000 Ω 7 watt resistor from capacitor lug C39 (NS) to lug 3 of tube socket V8 (S-4). (The bare wire counts for two leads in this solder instruction, one coming and one going, as was stated on Page 13.)

( ) Connect a 6-1/2" length of hookup wire to capacitor lug C38 (NS). Connect the other end of this wire to G ▲ on the large circuit board (S-1).

( ) Connect a 6" length of hookup wire to capacitor lug C39 (NS). Connect the other end of this wire to lug 1 of the Spot Shape control (NS).

( ) Connect a 6" length of hookup wire to capacitor lug C31 (NS). Connect the other end of this wire to G ▬ on the large circuit board (S-1). Make sure that this wire does not short circuit to the chassis.

( ) Connect a 2-3/4" length of hookup wire from lug 1 of the Spot Shape control (S-2) to QQ3 on the large circuit board (S-1).

( ) C43. Connect a .02 μfd ceramic 500 V capacitor from lug 2 (NS) to lug 3 (S-2) of the Spot Shape control. The control solder lug and one lead of the .02 μfd ceramic capacitor should now be soldered to lug 3 of the Spot Shape control.

( ) Connect a 3-1/4" length of bare wire to lug 9 of tube socket V9 (S-1). Place 2-1/2" of sleeving over this wire and connect it to lug 1 of terminal strip Y (NS).

NOTE: The purpose of using twisted pairs of hookup wire is to provide cancellation of hum in the filament leads. Best results will be obtained if the wires are twisted approximately two full turns per inch.

( ) Twist two 14-1/2" lengths of hookup wire together. At one end, connect one wire to lug 1 (NS) and connect the other wire to lug 2 (NS) of terminal strip W. Route this twisted pair of wires up to the circuit board.

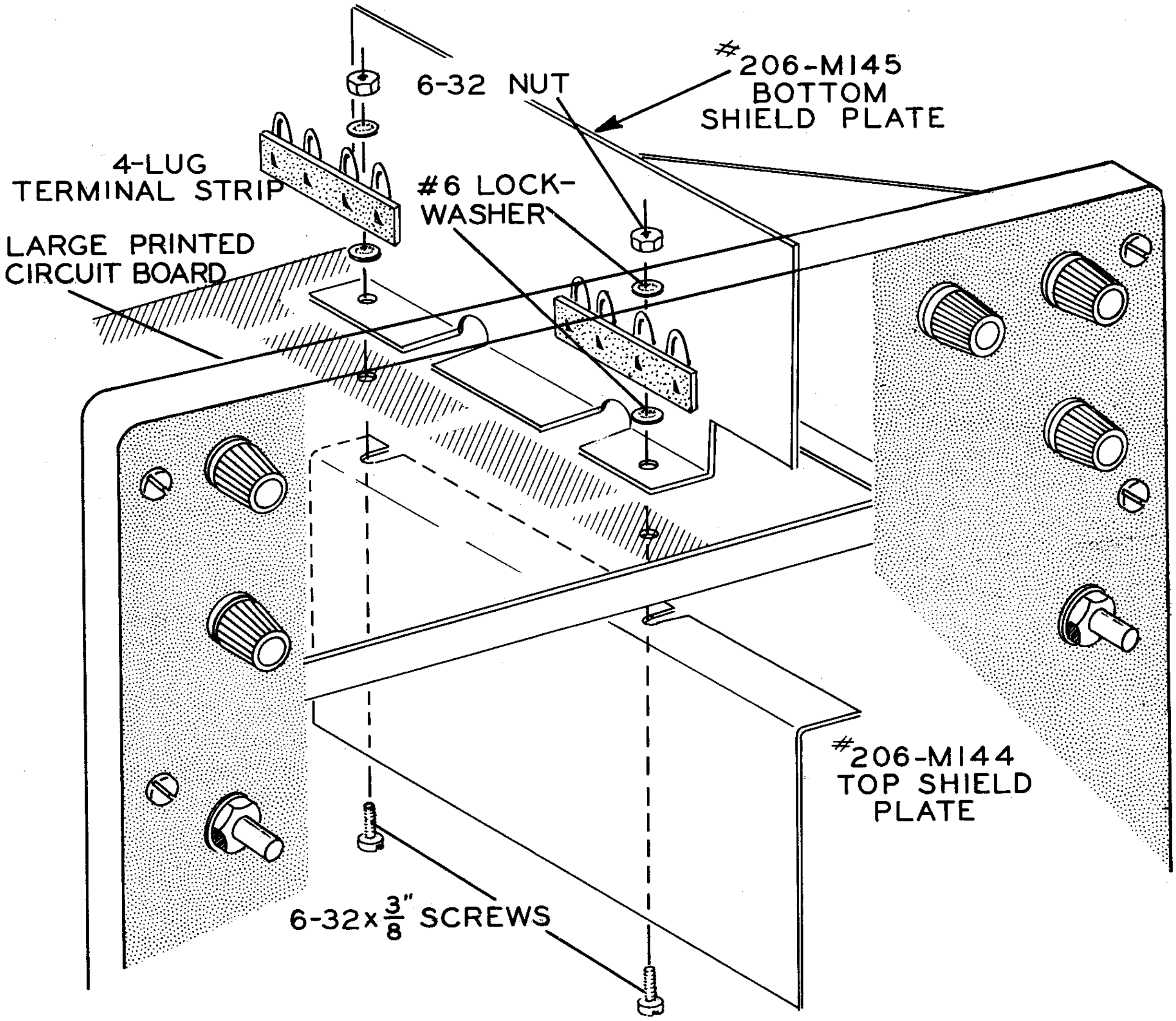
( ) At the other end of this twisted pair, connect one wire to point X at lug 3 (S-1), and connect the other wire to point X at lug 4 (S-1) of tube socket V10 on the circuit board.

( ) Connect a 2" length of hookup wire from lug 5 of tube socket V8 (S-1) to lug 1 of terminal strip W (NS).

( ) Connect a 2" length of hookup wire from lug 4 of tube socket V8 (S-1) to lug 2 of terminal strip W (NS).

( ) Twist two 10" lengths of hookup wire together, and at one end, connect one wire to lug 1 (S-4) and connect the other wire to lug 2 (S-4) of terminal strip W. Route the other end of this twisted pair of hookup wires up through grommet AA to be connected later.

( ) Connect a 5" length of hookup wire from lug 4 of terminal strip X (NS) to lug 2 of the fuse holder (S-1).



Detail 6A

INSTALLING THE SHIELD PLATES

Refer to Detail 6A for the following steps.

( ) Fasten the bottom shield first with 6-32 x 3/8" screws, #6 lockwashers, and 6-32 nuts, installed loosely in the mounting holes. Install a 4-lug terminal strip, with two lockwashers on each screw, as shown in Detail 6A.

NOTE: Position the bottom shield carefully so as not to short out any of the other foils that are close to its position on the board.

( ) Now slide the top shield in place beneath the heads of the screws, and then tighten the screws.

CHASSIS FRONT PANEL WIRING

Refer to Pictorial 6 for the following steps.

( ) R34. Connect a 1 megohm (brown-black-green) 1/2 watt resistor from lug 3 (NS) to lug 4 (NS) of terminal strip S.

( ) C13. Connect a 10$\mu\mu$f disc capacitor from lug 3 (NS) to lug 4 (NS) of terminal strip S.

( ) R35. Connect a 470 KΩ (yellow-violet-yellow) 1/2 watt resistor from lug 4 of terminal strip S (NS) to lug 1 of terminal strip U (NS).

( ) R38. Connect an 820 Ω (gray-red-brown) 1/2 watt resistor from lug 1 (NS) to lug 2 (NS) of terminal strip U.

( ) R37. Connect a 150 KΩ (brown-green-yellow) 1/2 watt resistor from lug 3 (NS) to lug 4 (NS) of terminal strip U.

( ) Connect a 1-1/4" length of bare wire from lug 3 of terminal strip U (S-2) to capacitor lug F ▲ (S-1).

( ) R36. Connect a 33 KΩ (orange-orange-orange) 1/2 watt resistor from lug 2 (NS) to lug 4 (NS) of terminal strip U.

( ) C14. Connect a .1 μfd 200 V capacitor from lug 2 (S-3) to lug 4 (NS) of terminal strip U.

( ) Connect a 1-3/4" length of hookup wire from lug 1 of terminal strip U (S-3) to point KA on the circuit board (S-1).

( ) Twist two 5" lengths of hookup wire together, and at one end connect one wire to point PP1 (S-1) and connect the other wire to point PP2 (S-1) on the circuit board. The other end of this twisted pair will be connected later.

( ) Connect a 2-1/4" length of hookup wire from lug 3 of terminal strip S (S-3) to point GR on the circuit board (S-1).

( ) Connect a 4" length of hookup wire from lug 4 of terminal strip U (S-4) to point PL on the circuit board (S-1).

( ) C12. Connect a .25 μfd 400 V capacitor from lug 1 (NS) to lug 4 (S-4) of terminal strip S. Use sleeving on both leads.

( ) Install the cable assembly as shown in Pictorial 6. Bend the front section of the cable around the front lip toward the top of the chassis. Insert the rear section of the cable up through grommet BB. Now inspect the cable carefully to make sure that the wires emerge as shown in Pictorial 6.

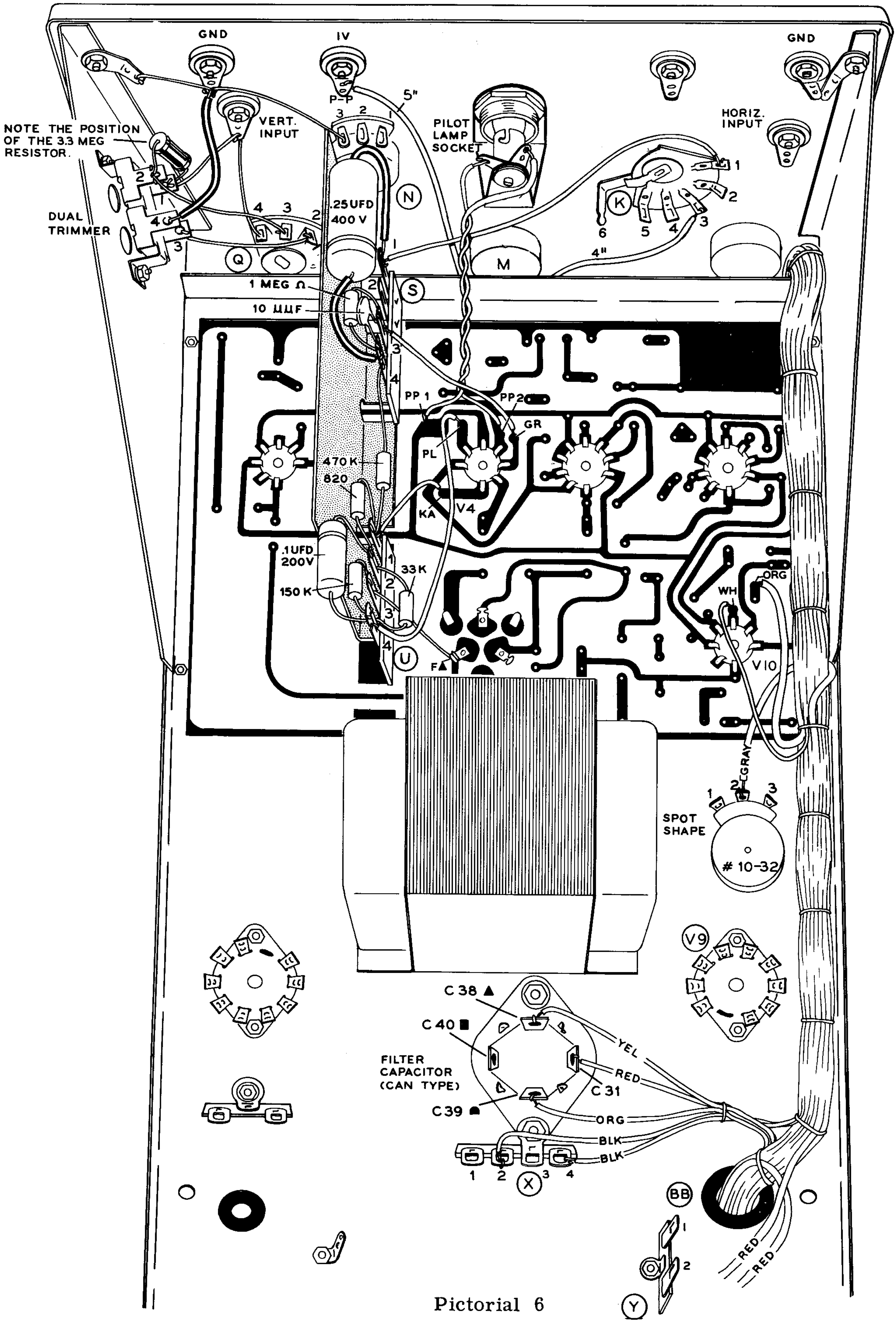
Connect each of the five wires (red, yellow, orange, black, black) that emerge from the cable near tube socket V9 as follows:

CONNECT THE	TO
( ) Red wire	C31 (S-2)
( ) Yellow wire	C38 (S-3)
( ) Orange wire	C39 (S-3)
( ) Longer black wire	lug 2 of terminal strip X (S-2)
( ) Shorter black wire	lug 4 of terminal strip X (S-2)

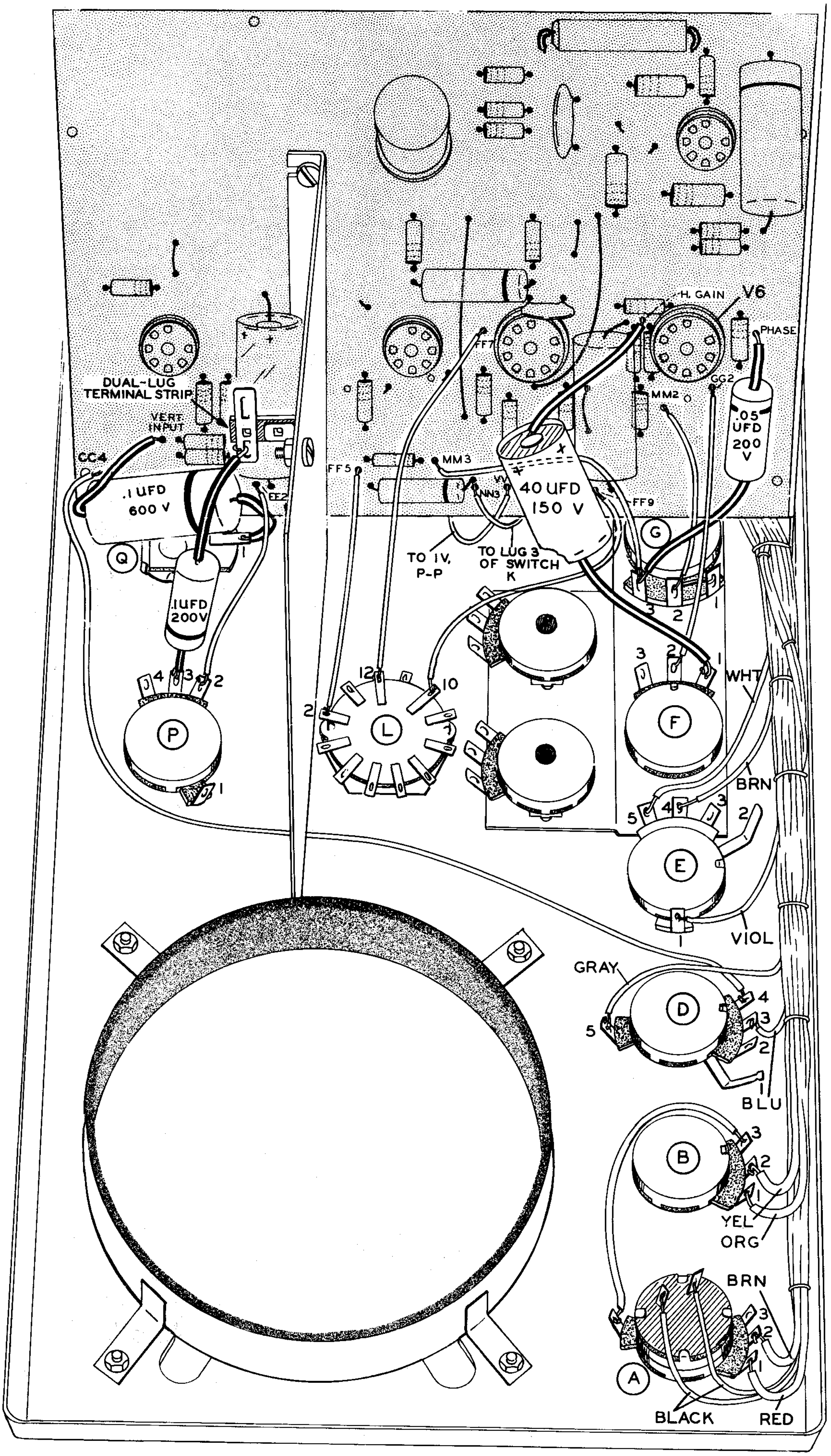
( ) Connect the heavy gray wire coming from the cable to lug 2 of the Spot Shape control (S-2).

( ) Connect the heavy orange wire coming from the cable to point ORG.-HV on the circuit board (S-1).

( ) Connect the white wire coming from the cable to point WH on the circuit board (S-1).


GND
IV
GND
P-P
5"
3
2
1
PILOT
LAMP
SOCKET
HORIZ.
INPUT
NOTE THE POSITION
OF THE 3.3 MEG
RESISTOR.
VERT.
INPUT
.25 UFD
400 V
N
K
DUAL
TRIMMER
4
3
2
Q
M
4"
6
5
4
3
1 MEG Ω
10 μμF
S
PP 1
PP2
GR
PL
470 K
820
KA
V4
.1 UFD
200V
33 K
150 K
U
F▲
ORG
WH
V10
GRAY
SPOT
SHAPE
10-32
V9
C 38 ▲
C 40 ■
FILTER
CAPACITOR
(CAN TYPE)
C 31
C 39
YEL
RED
ORG
BLK
BLK
X
BB
Y
RED
RED

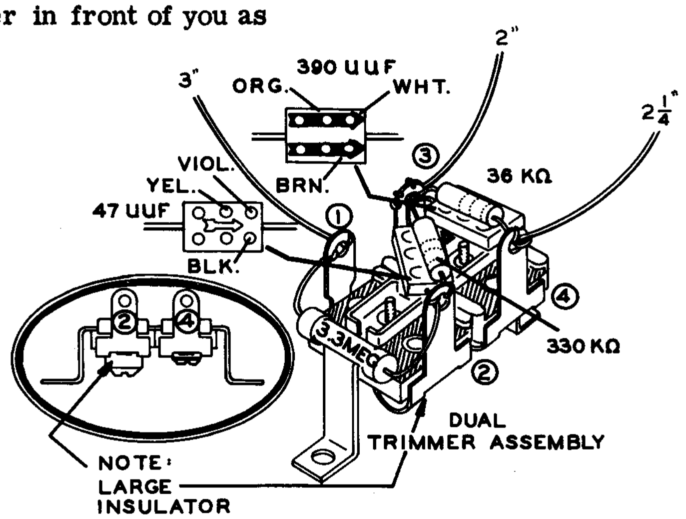
Pictorial 6


DUAL-LUG TERMINAL STRIP
VERT. INPUT
CC4
.1 UFD 600 V
EE2
Q
.1UFD 200V
P
FF5
MM3
FF7
TO 1V, P-P
TO LUG 3 OF SWITCH K
40 UFD 150 V
FF9
L
H. GAIN
V6
PHASE
GG2
MM2
.05 UFD 200 V
G
F
WHT
BRN
E
VIOL
GRAY
D
BLU
B
YEL
ORG
BRN
A
BLACK
RED

Pictorial 7

DUAL TRIMMER PREWIRING

( ) Place the dual trimmer in front of you as shown in Detail 6B.



VERTICAL TRIMMER
Detail 6B

CONNECT A	FROM	TO
(√) R1. 3.3 megohm 5% precision resistor	lug 1 (NS)	lug 2 (NS)
(√) C2. 47 $\mu\mu$f capacitor	lug 2 (NS)	lug 3 (NS)
(√) R2. 330 KΩ (orange-orange-yellow) resistor	lug 2 (NS)	lug 3 (NS)
(√) C3. 390 $\mu\mu$f capacitor	lug 3 (NS)	lug 4 (NS)
(√) R3. 36 KΩ (orange-blue-orange) resistor	lug 3 (NS)	lug 4 (NS)
(√) 3" bare wire	lug 1 (S-2)	not connected
(√) 2-1/4" bare wire	lug 4 (S-3)	not connected
(√) 2" bare wire	lug 3 (S-5)	not connected

Refer to Pictorial 6 for the following steps.

(√) Install the dual trimmer assembly as shown with 6-32 x 3/8" screws, #6 lockwashers, and 6-32 nuts.

(√) Connect the 3" wire coming from lug 1 of the dual trimmer through the VERT. INPUT lug (NS) to lug 4 of switch Q (S-1). Now solder the VERT. INPUT lug (S-2).

(√) Connect the 2" bare wire coming from lug 3 of the dual trimmer to lug 2 of switch Q (S-1).

(√) Connect a 2-1/2" bare wire from lug 3 of switch Q (S-1) to lug 2 of the dual trimmer (S-4).

(√) Place sleeving over the 2-1/4" bare wire coming from lug 4 of the dual trimmer and connect it to the GND lug (NS).

(√) Connect a 2-1/4" bare wire from lug 3 of control N (S-1) through the GND lug (NS) to the panel mounting solder lug (S-1). Now solder the GND lug (S-3).

(√) Connect a 5" length of hookup wire to the 1-V, P-P solder lug (S-1). Route the other end of this wire up past control M, to be connected later.

( ) Connect a 4" length of hookup wire to lug 3 of switch K (S-1). Route the other end of the wire past control M, to be connected later.

( ) Connect a 4-3/4" length of hookup wire from lug 1 of switch K (S-1) to lug 1 of terminal strip S (S-2).

( ) Solder the GND lug near the HOR. INPUT to the panel mounting solder lug adjacent to it (S-1).

( ) Connect the twisted hookup wires coming from PP1 and PP2 to the pilot lamp socket. Connect either wire to the front lug (S-1), and connect the remaining wire to the rear lug (S-1).

Refer to Pictorial 7 (fold-out from page 22) for the following steps.

Connect the wires that emerge from the cable assembly as follows:

CONNECT THE	TO
( ) Blue wire	lug 3 of control D (S-1)
( ) Gray wire	lug 5 of control D (S-1)
( ) Small brown wire	lug 4 of control E (S-1)
( ) White wire	lug 5 of control E (S-1)
( ) Violet wire	lug 1 of control E (S-1)
( ) Large yellow wire	lug 2 of control B (S-1)
( ) Large orange wire	lug 1 of control B (S-1)
( ) Large red wire	lug 1 of control A (S-1)
( ) Large brown wire	lug 2 of control A (S-1)
( ) Black wire	either rear lug of control A (S-1)
( ) Black wire	other rear lug of control A (S-1)

( ) Connect the 4" wire coming from lug 3 of switch K to NN3 on the front circuit board (S-1).

( ) Connect the 5" wire coming from the 1-V, P-P lug to VV on the front circuit board (S-1).

( ) Connect the 2-1/2" wire coming from lug 2 of switch L to FF5 on the front circuit board (S-1).

( ) Connect the 3-3/4" wire coming from lug 3 of control G to MM3 on the front circuit board (S-1).

( ) Connect the 4" wire coming from lug 12 of switch L to FF7 on the front circuit board (S-1).

( ) Connect the 2-3/4" wire coming from lug 10 of switch L to FF9 on the front circuit board (S-1).

( ) Connect the 3" wire coming from lug 2 of control G to MM2 on the front circuit board (S-1).

( ) C41. Connect a .05 μfd 200 V capacitor from lug 3 of control G (S-2) to the PHASE connection on the large circuit board (S-1). Use sleeving.

( ) Connect the 3" wire coming from lug 2 of control F to GG2 on the front circuit board (S-1).

( ) C127. Connect the negative (-) lead of a 40 μfd 150 V electrolytic capacitor to lug 1 of control F (S-1). Use sleeving.

( ) Connect the positive (+) lead of this capacitor to H-GAIN on the large circuit board (S-1). Use sleeving, and be sure that the body of the capacitor will not prevent tube V6 from being installed.

( ) Connect the 11-1/2" wire coming from control D to CC4 on the large circuit board (S-1).

( ) C5. Connect a .1 μfd 600 V capacitor from lug 1 of switch Q (S-1) to VERT. INPUT on the large circuit board (S-1). Use sleeving.

( ) Connect a 2" length of hookup wire from lug 2 of control P (S-1) to EE2 on the front circuit board (S-1).

( ) Install a dual-lug terminal strip at the hole in the upper shield. Use a 6-32 x 3/8" screw, two #6 lockwashers, and 6-32 nut.

( ) C7. Connect a .1 μfd 200 V capacitor from lug 3 of control P (S-1) to the dual lug terminal strip (NS). Use sleeving.

Refer to Pictorial 8 (fold-out from page 25) for the following steps.

( ) Route the main body of the cable assembly up the corner of the rear support bracket and through the 3/4" grommet, to the rear.

Connect and solder cable wires to the small circuit board as follows:

CONNECT	TO
( ) Red wire	RED
( ) Gray wire	GRAY
( ) Violet wire	VIOLET
( ) Brown wire	BROWN
( ) Yellow wire	YELLOW
( ) Orange wire	ORANGE
( ) Blue wire	BLUE

( ) Route the twisted pair of hookup wires coming from grommet AA across the chassis as shown. Connect one wire to the upper X (S-1) and connect the other wire to the lower X (S-1) on the circuit board.

( ) Connect a 14" length of hookup wire from lug 1 of front panel control P (S-2) to EE1 on the small circuit board (S-1).

( ) Connect an 8-3/4" length of hookup wire from the dual-lug terminal strip (S-2) (be sure to solder both sides) to VERT. IN. on the small circuit board (S-1).

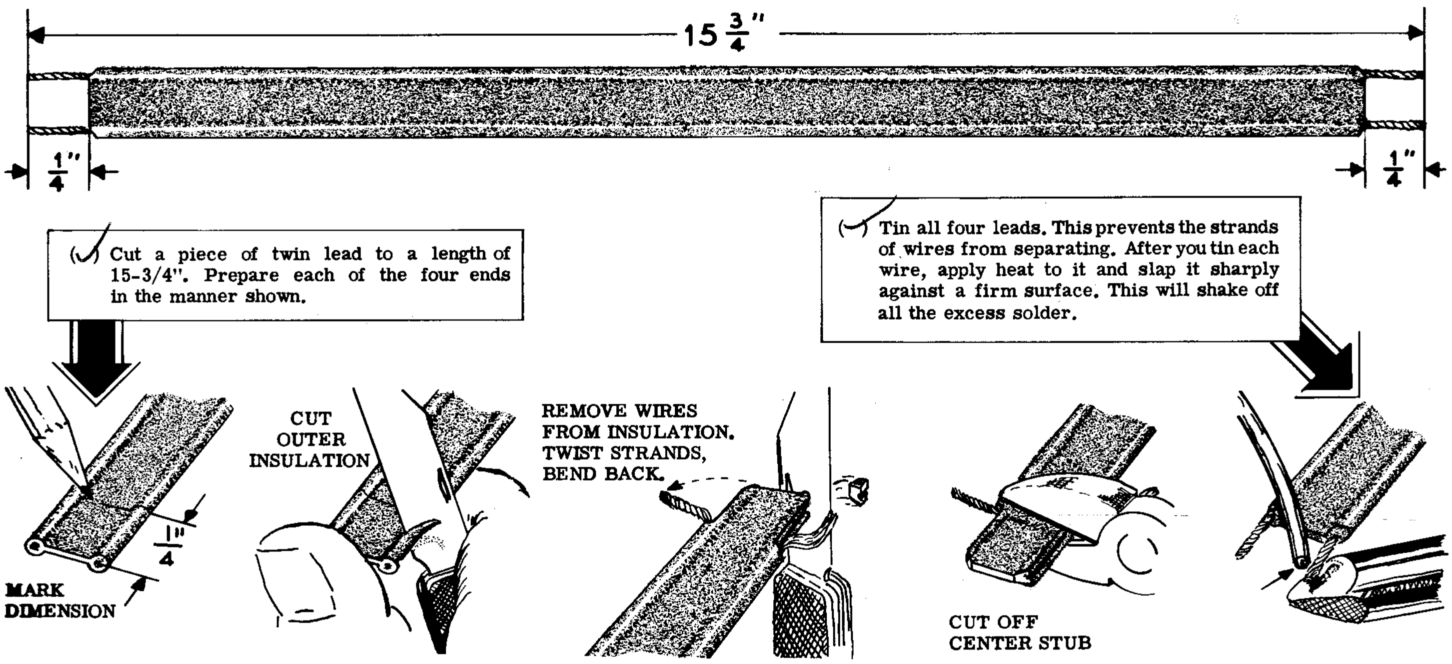
( ) Route the twisted pair of brown transformer leads up the corner of the rear support bracket and through the 3/8" grommet, to the rear of the bracket.

( ) Strip one end of a 13" length of hookup wire and connect it to the point marked "H-OUT" (S-1) on the front circuit board. Pull the wire straight back, around the body of socket V6 and to the rear circuit board. Measure carefully to the point marked "HOR. IN," allow about 1" for stripping, strip and push the wire through the hole. Then pull it taut, so that the wire clears the 7 watt resistor on the front circuit board and solder the connection at the rear. Do not cut off the excess wire; it will be required later.

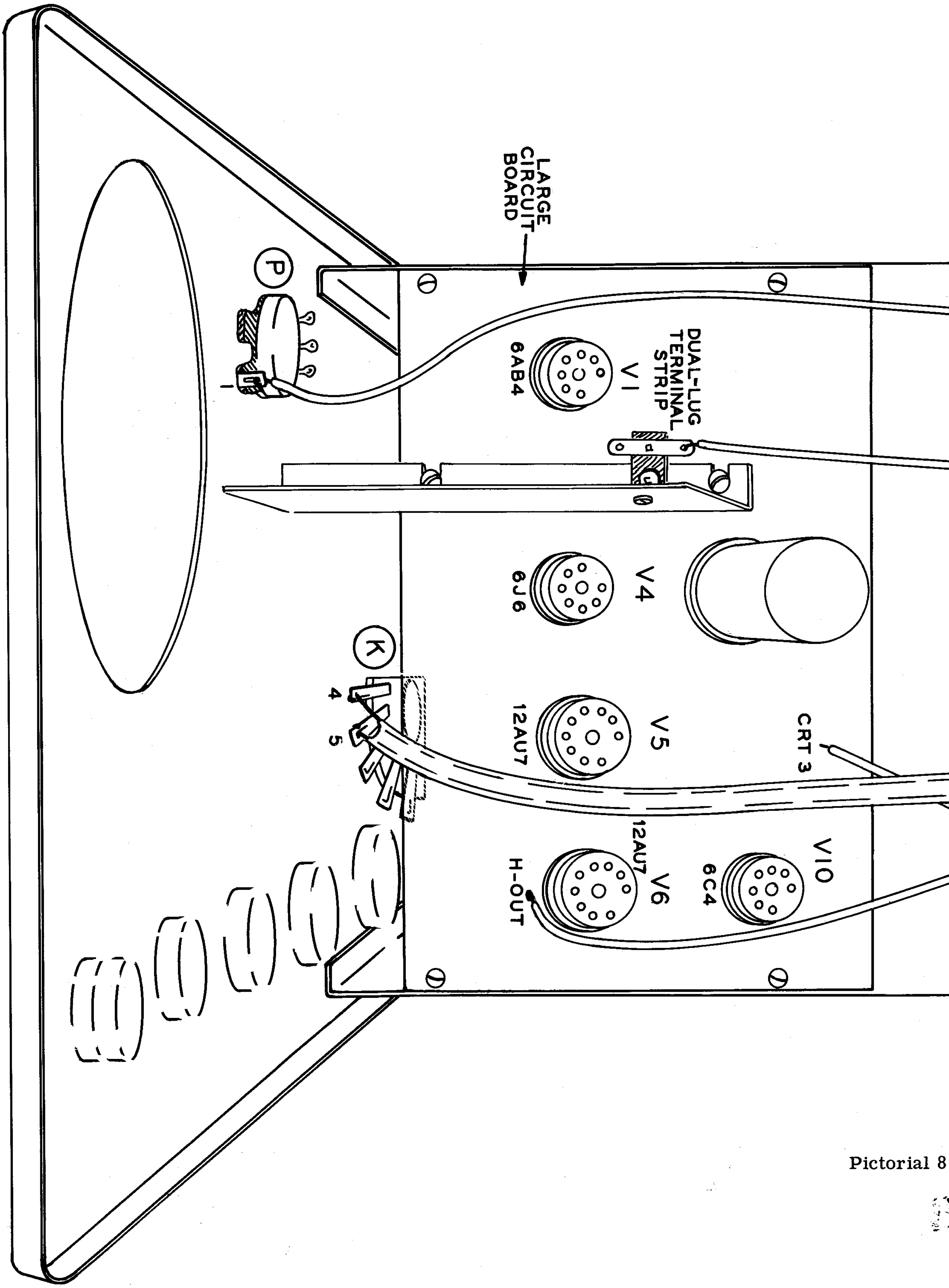
( ) Strip both ends of a 20" length of hookup wire. Connect one end of this wire to CRT3 on the large circuit board. Route the other end of this wire to the corner of the rear support bracket, and up through the 3/4" grommet, to be connected later.

( ) Prepare a 15-3/4" length of 300 Ω twin lead as shown in Detail 8A. At one end of this twin lead, connect one conductor to lug 4 (S-1) and connect the other conductor to lug 5 (S-1) of front panel switch K.

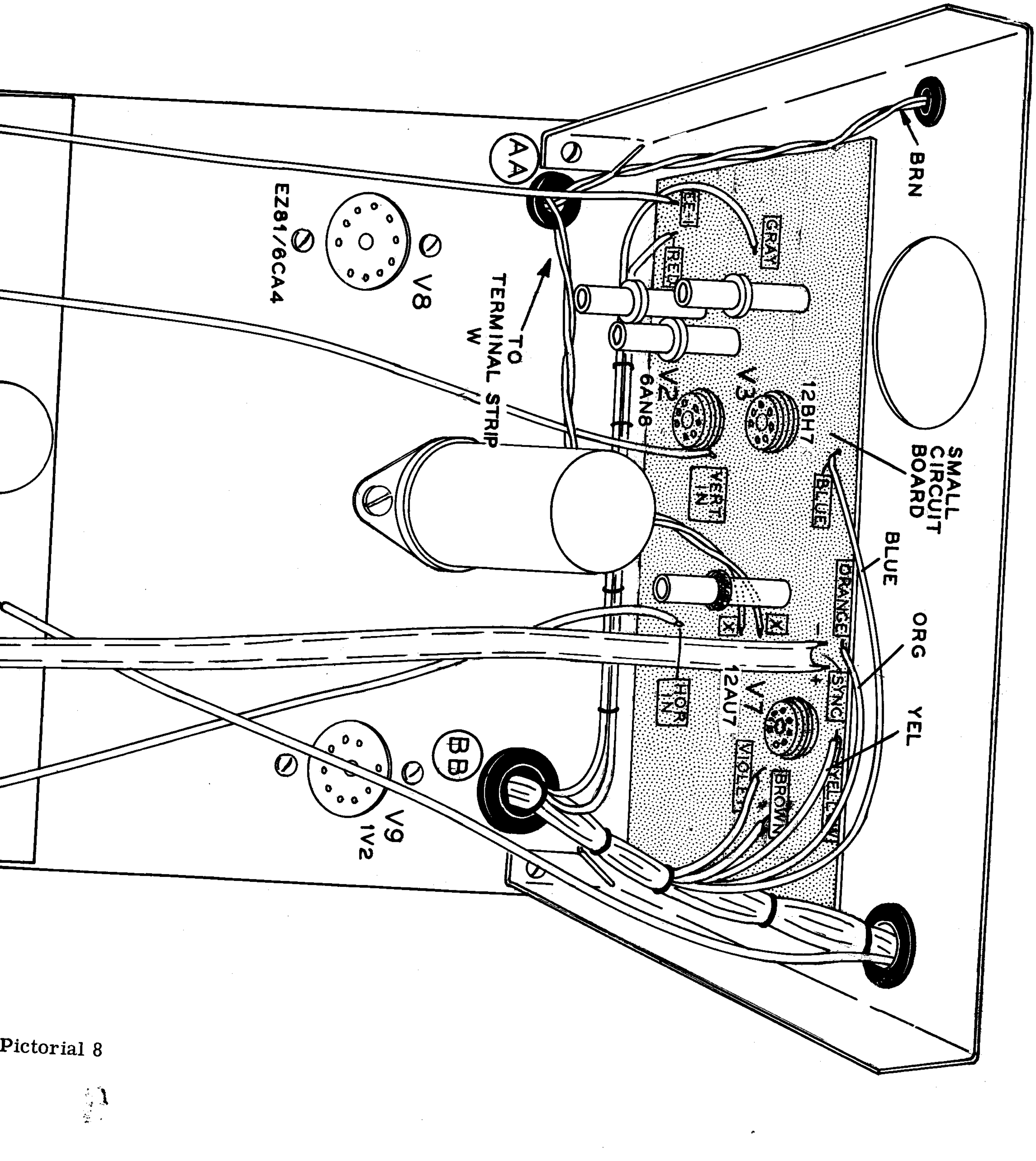
( ) At the other end of this twin lead, connect one lead to SYNC- (S-1) and connect the other lead to SYNC+ (S-1) on the small circuit board. Do not twist the twin lead between the front panel and the small circuit board.



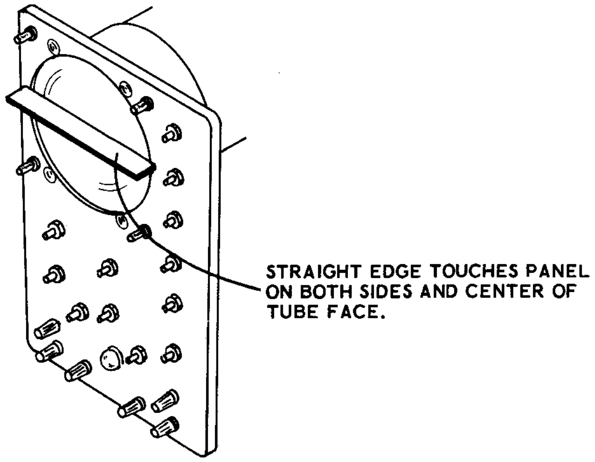
Detail 8A

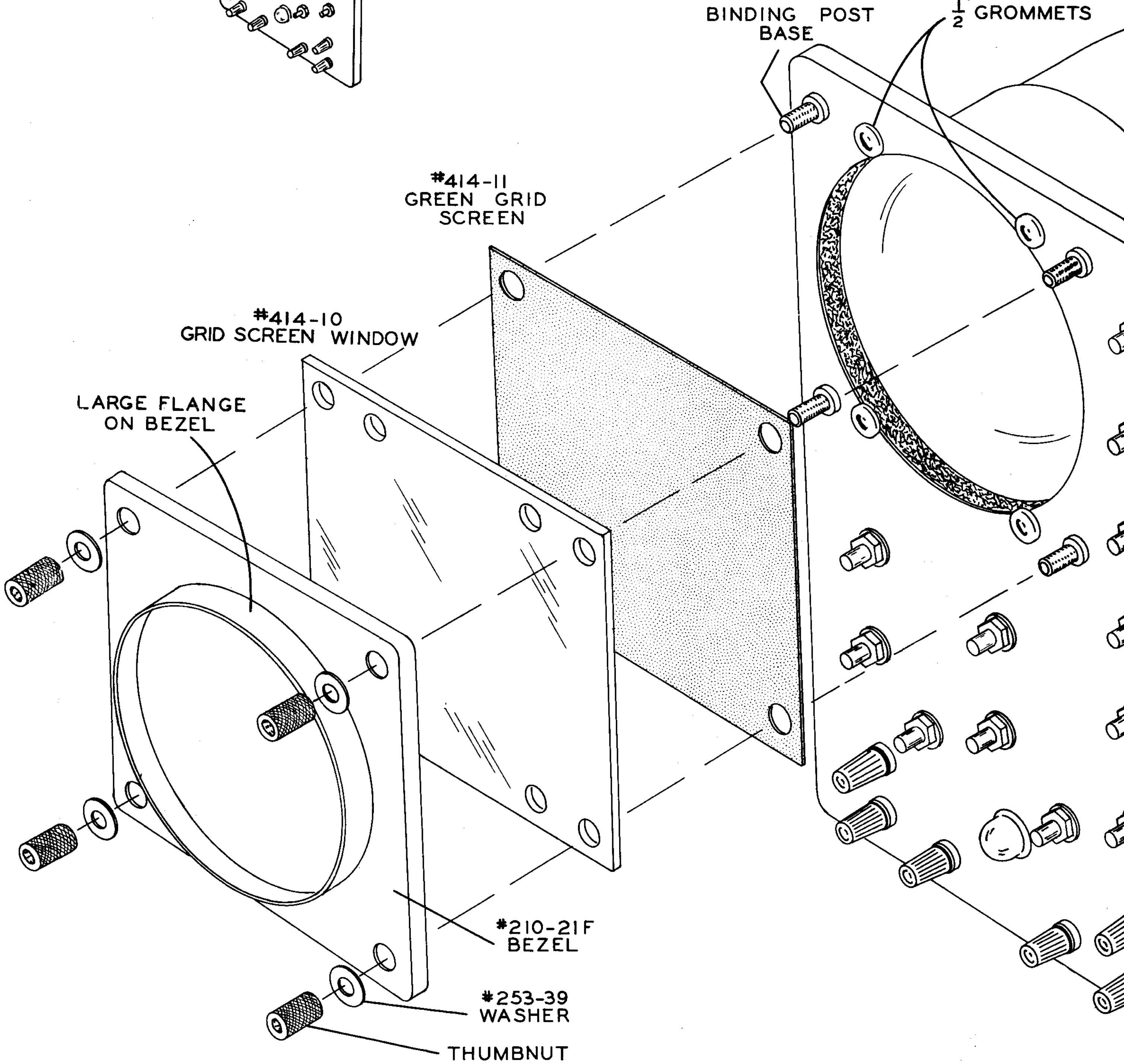

LARGE CIRCUIT BOARD
P
1
DUAL-LUG TERMINAL STRIP
V1
6AB4
V4
6J6
K
4
5
V5
12AU7
CRT 3
V6
12AU7
H-OUT
V10
6C4

Pictorial 8

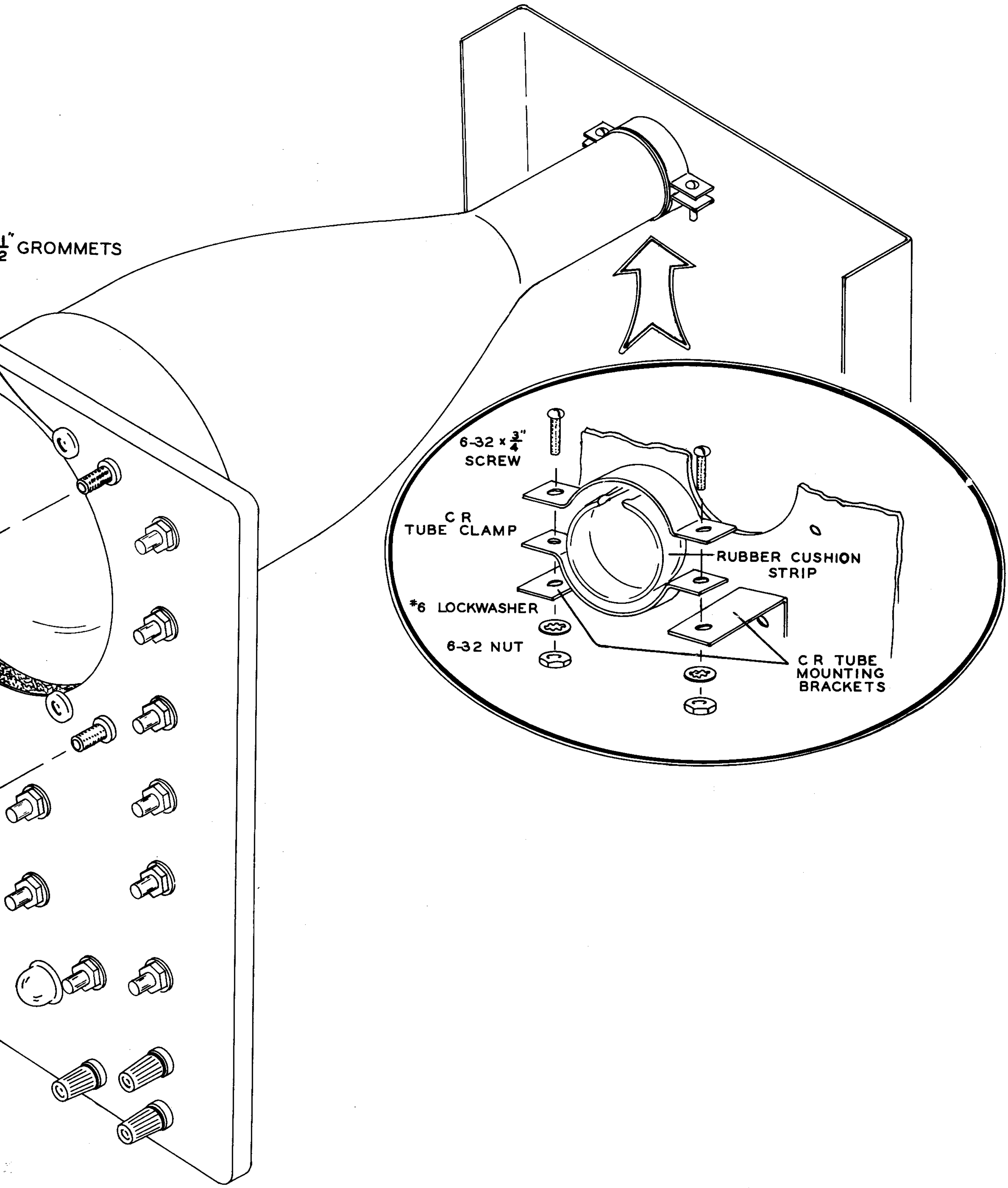

AA
EZ81/6CA4
V8
TO TERMINAL STRIP W
BRN
GRAY
RED
V2 6AN8
V3 12BH7
SMALL CIRCUIT BOARD
BLUE
VERT IN
ORANGE
ORG
X
HOR IN
V7 12AU7
SYNC
YEL
VIOLET
BROWN
YELLOW
BB
V9 1V2

Pictorial 8


STRAIGHT EDGE TOUCHES PANEL ON BOTH SIDES AND CENTER OF TUBE FACE.


BINDING POST BASE
½" GROMMETS
#414-11 GREEN GRID SCREEN
#414-10 GRID SCREEN WINDOW
LARGE FLANGE ON BEZEL
#210-21F BEZEL
#253-39 WASHER
THUMBNUT

Picto



1/2" GROMMETS
6-32 x 3/4" SCREW
C R TUBE CLAMP
RUBBER CUSHION STRIP
*6 LOCKWASHER
6-32 NUT
C R TUBE MOUNTING BRACKETS

Pictorial 9

CATHODE RAY TUBE INSTALLATION

Refer to Pictorial 9 for the following steps.

( ) Assemble the two halves of the CR tube clamp on the mounting brackets as shown in Pictorial 9. Do not tighten the 6-32 x 3/4" screws, #6 lockwashers and 6-32 nuts used to install the clamp.

( ) Insert the rubber cushion strip, being sure that the clamps are seated in the groove.

CAUTION: Carefully open the carton containing the 5UP1 cathode ray tube. Handle the tube with reasonable caution, since it has been highly evacuated. Should the envelope be broken, the resulting implosion could spray the area with shattered glass with possible serious consequences. Avoid handling the tube while wearing diamond rings which might scratch the glass. Do not strike the envelope with tools and do not subject it to impact or shock.

( ) Slip the base end of the tube through the front panel ring and through the tube clamp. Position the tube with pin 1 straight up and align the front of the tube with the panel, using a straightedge as shown in Pictorial 9. Now, tighten the 3/4" screws sufficiently to hold the neck firmly. Do not overtighten; the clamps are purposely fabricated from light stock to avoid undue strain on the tube envelope. Note that the pins on this tube are numbered clockwise, starting with the first pin clockwise from the key.

( ) Mount a 2-lug terminal strip on the 12-contact CRT socket, using the hole next to contact 3 of the socket as shown in Pictorial 10. Slip the socket on the base of the cathode ray tube.

( ) Install the four 1/2" grommets in the slots around the panel ring.

( ) Install the green grid screen (#414-11), the grid screen window (#414-10), and the bezel (#210-21F) on the front panel with four flat washers (#253-39), and four thumbnuts. Note that the large flange of the bezel is toward the top of the front panel.

NOTE: In making connections to the socket of the CR tube, leave enough slack in the leads to permit rotating the socket 10 degrees either way from its present position. This may be necessary to level the horizontal trace on the face of the tube.

CR TUBE WIRING

Refer to Pictorial 10 for the following steps.

( ) Connect one of the brown transformer leads (from the 3/8" grommet) to lug 1 (NS), and connect the other brown transformer lead to lug 12 (S-1) of the CR tube. Now remove any slack from these leads by pulling them gently from below the chassis.

( ) R76. Insert one lead of a 100 KΩ (brown-black-yellow) 1/2 watt resistor through lug 1 of the CRT terminal strip (NS) to lug 1 of the CR tube socket (S-2).

( ) Now connect the other lead of the 100 KΩ resistor to lug 2 of the CR tube socket (NS).

( ) Connect the hookup wire coming from the 3/4" grommet (from CRT3 on the large circuit board) to lug 3 of the CR tube socket (NS).

( ) R77. Connect a 1 megohm (brown-black-green) 1/2 watt resistor from lug 3 of the CR tube socket (S-2) to lug 2 of the CRT terminal strip (NS).

( ) Connect the large yellow wire of the cable to lug 4 of the CR tube socket (S-1).

( ) Connect the large brown wire of the cable to lug 2 of the CRT terminal strip (S-2).

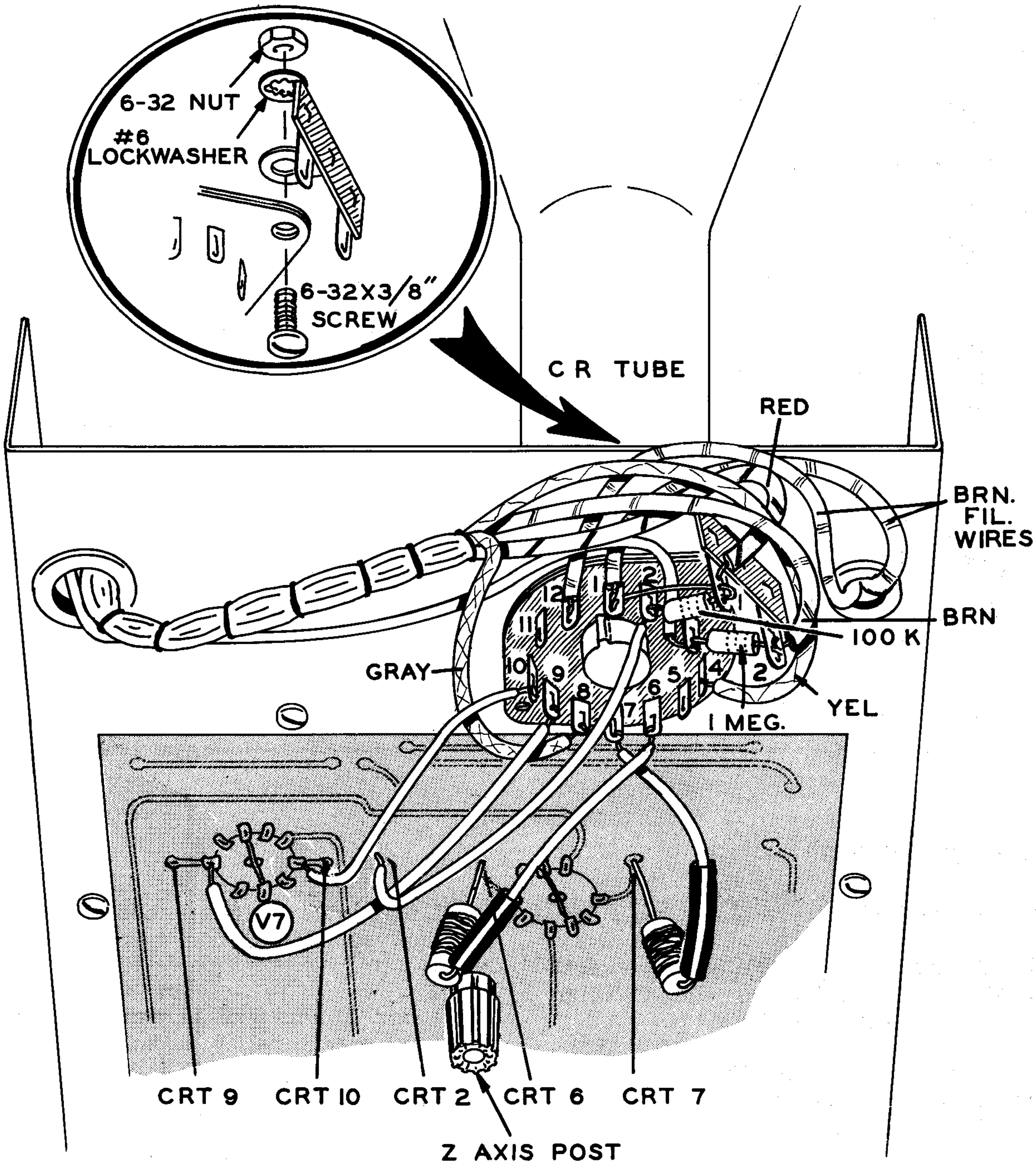
( ) Connect the large red wire of the cable to lug 1 of the CRT terminal strip (S-3).

( ) Connect the large gray wire of the cable to lug 8 of the CR tube socket (S-1).

( ) Connect a 4" length of hookup wire from lug 10 of the CR tube socket (S-1) to lug 6 of tube socket V7 on the small circuit board (S-1). Now solder lug 6 to its foil on the circuit board.

( ) In the same manner, connect a 4-1/4" length of hookup wire from lug 9 of the CR tube socket (S-1) to lug 1 of tube socket V7 on the small circuit board (S-1). Now solder lug 1 to its foil on the circuit board.

( ) Connect a 5-1/2" length of hookup wire from lug 2 of the CR tube socket (S-2) to CRT2 on the small circuit board (S-1).



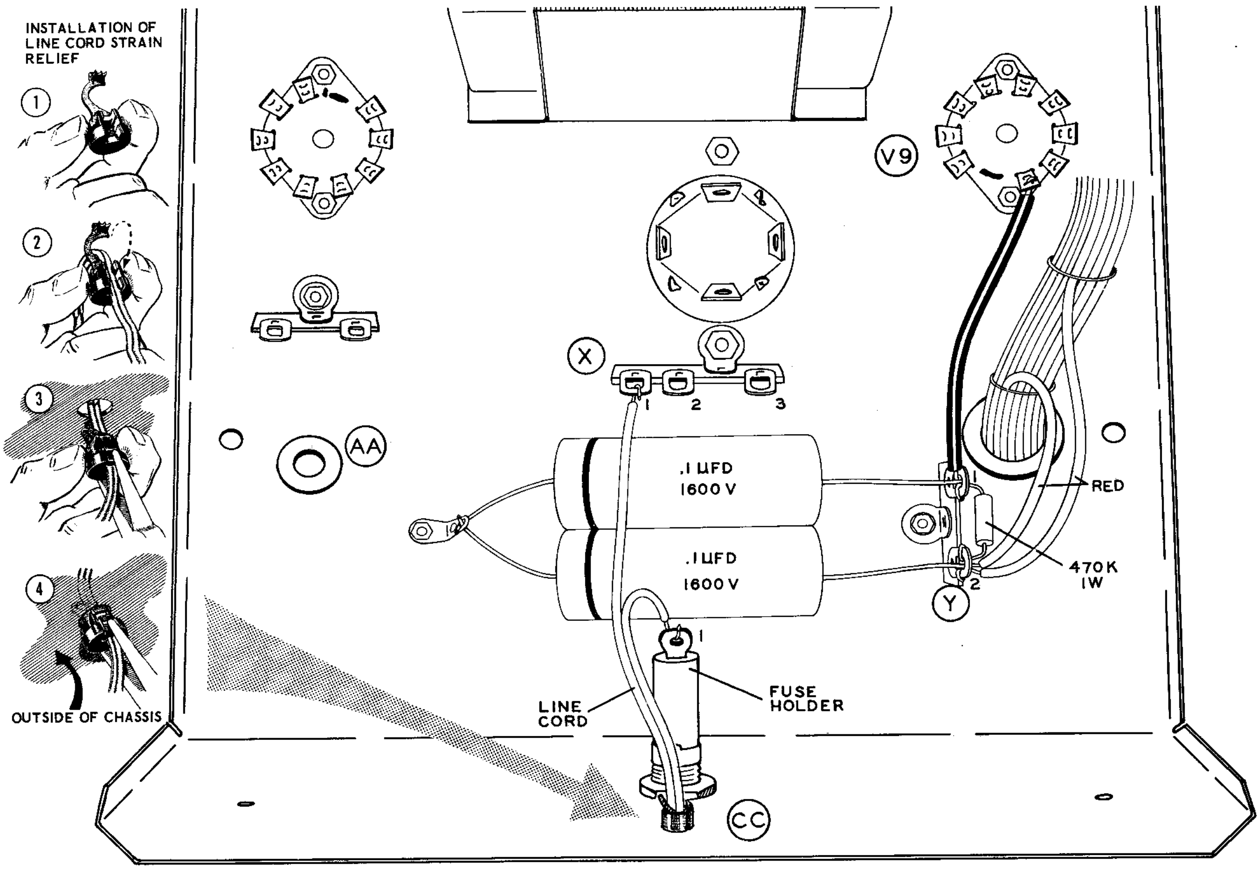
Pictorial 10

(√) Connect the solid lead from one of the 33 μh chokes to CRT7 on the small circuit board (S-1).

( ) Connect the stranded lead of this choke to lug 7 of the CR tube socket (S-1).

( ) Connect the solid lead from the other 33 μh choke to CRT6 on the small circuit board (S-1).

( ) Connect the stranded lead of this choke to lug 6 of the CR tube socket (S-1).



Pictorial 11

FINAL CHASSIS WIRING

Refer to Pictorial 11 for the following steps.

( ) R71. Connect a 470 KΩ (yellow-violet-yellow) 1 watt resistor from lug 1 (NS) to lug 2 (NS) of terminal strip Y.

( ) C37. Connect a .1 μfd 1600 V capacitor from lug 1 of terminal strip Y (S-3) to the solder lug near grommet AA (NS).

( ) C36. Connect a .1 μfd 1600 V capacitor from lug 2 of terminal strip Y (NS) to the solder lug near grommet AA (S-2).

( ) Connect both of the heavy red wires coming from the cable to lug 2 of terminal strip Y (S-4).

( ) Pass the end of the line cord through hole CC and connect one of the line cord leads to lug 1 of terminal strip X (S-2).

( ) Connect the other line cord lead to lug 1 of the fuse holder (S-1).

( ) Refer to Pictorial 11 and install the line cord strain relief in hole CC as shown.

( ) Turn all controls and switches to their full counterclockwise position.

( ) Install small knobs on the INTEN., FOCUS, VERT. POS. and HOR. POS. controls and tighten the setscrews.

( ) Install the large knobs on the remaining controls and switches with the pointer at the extreme counterclockwise panel mark, and tighten the setscrews.

NOTE: In the following step, use care when installing tubes in the circuit board. If the tubes are forced into their sockets with extreme pressure, the circuit board may crack.

( ) Insert the tubes in their sockets as follows: (See Pictorial 8.)

V1 = 6AB4	V6 = 12AU7
V2 = 6AN8	V7 = 12AU7
V3 = 12BH7	V8 = EZ81/6CA4
V4 = 6J6	V9 = IV2
V5 = 12AU7	V10 = 6C4

( ) Secure the cover plate on the back of the cabinet with a #6 sheet metal screw.

( ) Install the handle on the top of the cabinet, using the #10 sheet metal screws. It may be helpful if the screws are run into the handle first, and then removed, before the handle is installed.

( ) Install the rubber feet in the bottom of the cabinet as shown in Detail 11A. Use 6-32 x 1/2" screws, #8 flat washers, #6 lockwashers, and 6-32 nuts.

( ) Assemble the pair of test leads, one red and one black, as shown in Detail 11B.

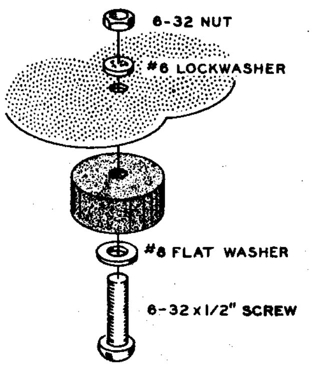
NOTE: The blue and white identification label shows the Model Number and Production Series Number of your kit. Refer to these numbers in any communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

( ) Install the identification label in the following manner:

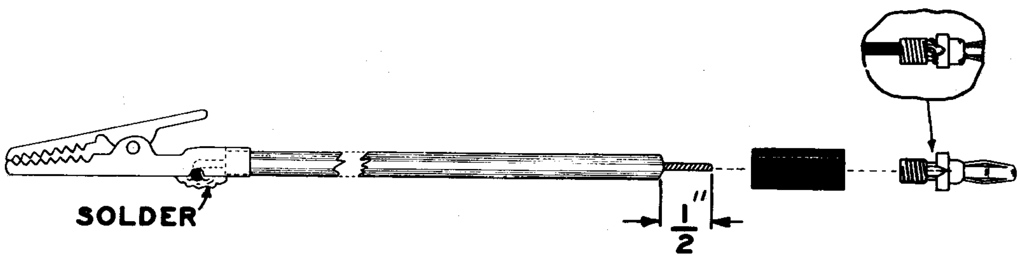
1. Select a location for the label where it can easily be seen when needed, but will not show when the unit is in operation. This location might be on the rear panel or the top of the chassis, or on the rear or bottom of the cabinet.
2. Carefully peel away the backing paper. Then press the label into position.

This completes the construction and wiring of your HEATHKIT oscilloscope.

Before attempting to operate the instrument, remove any loose bits of solder or wire clippings. Check the instrument against the pictorial diagrams for any obvious mistakes. Now proceed to the ADJUSTMENT section.



Detail 11A



Detail 11B

ADJUSTMENT

> CAUTION: The voltages in the instrument are dangerous. Extreme care should be exercised whenever the instrument is connected to the AC line without being installed in its case. DO NOT connect the line cord to an AC outlet until you have read and fully understand the following instructions on testing the oscilloscope.

Some of the adjustments which must be made on the instrument cannot be performed with the cabinet in place. Whenever the oscilloscope is operated without the cabinet, be sure to remove the line cord from the outlet before attempting to change the position of the scope on the bench. Some of the highest voltages in the circuit appear on the INTEN. and FOCUS control terminals, just below the top edge of the panel. It is easy to get a finger on one of these terminals.

(✓) Set the controls as follows BEFORE connecting the line cord to an AC outlet:

INTEN. - Full counterclockwise.
FOCUS - At approximate center of rotation.
VERT. POS. - At approximate center of rotation.
HOR. POS. - At approximate center of rotation.
VERT. GAIN - Full counterclockwise.
HOR./FREQ. SELECTOR - Full counterclockwise.
HOR. GAIN - 0.
VERT. INPUT - X100.
FREQ. VERNIER - 50.
PHASE - At approximate center of rotation.
EXT. SYNC. AMPLITUDE - Full counterclockwise.
SYNC. SELECTOR - EXT. Spot Shape (on chassis) - At approximate center of rotation.

(✓) Connect the line cord to a 105-125 volt 50/60 cycle AC outlet. CAUTION: This instrument will not operate and may be seriously damaged if connected to a DC or 25 cycle AC power source, or to an AC line of more than 125 volts.

(✓) Turn the INTEN. control full clockwise. The pilot light should light and all tube filaments (except IV2) should show color. Allow about one minute for the tube filaments to reach operating temperature.

(✓) Watch the screen of the CR tube carefully until a green spot appears. Reduce the brightness of the spot at once by rotating the INTEN. control counterclockwise. Now, adjust the FOCUS control to reduce the size of the spot to a minimum.

CAUTION: DO NOT PERMIT A HIGH INTENSITY SPOT TO REMAIN STATIONARY ON THE SCREEN FOR ANY LENGTH OF TIME. THIS MAY DESTROY THE FLUORESCENT MATERIAL ON THE SCREEN AND LEAVE A DARK SPOT.

(✓) Rotate the HOR. POS. control and notice that the spot moves horizontally across the screen. Now, using the VERT. POS. control, move the spot up and down. Adjust these two controls so that the spot is centered on the screen.

If no spot appears, rotate the HOR. control, since this control may position the spot well off the screen. It may also be necessary to readjust the FOCUS and INTEN. controls to form the spot. If still no spot can be seen, refer to the IN CASE OF DIFFICULTY section of this manual.

(✓) With the spot centered on the screen, adjust the Spot Shape control (at the right side of the chassis) to make the spot as round as possible. It may be necessary to readjust the FOCUS and INTEN. controls several times during this procedure as there is some interaction between the circuits. The result should be a sharply defined spot of small size, the brightness of which can be varied with the INTEN. control. CAUTION: In making this adjustment, be careful not to touch any of the wiring at the rear of the chassis.

(✓) Using one of the test leads, connect a jumper from the 1-V, P-P terminal to the HOR. INPUT terminal. Turn the HOR. GAIN control clockwise. The spot should now become a horizontal line, whose length increases to a maximum of about 1-1/4" as the HOR. GAIN control is advanced. If the trace is not level, turn off the power, loosen the tube clamp on the base of the CR tube and rotate the tube slightly to make the trace horizontal. Tighten clamp and check trace to see that it is level.

CAUTION: DO NOT ATTEMPT TO MAKE THIS ADJUSTMENT WITHOUT TURNING OFF THE INSTRUMENT. SOME SOCKET CONTACTS ON THE CR TUBE ARE APPROXIMATELY 1200 VOLTS "HOT". CONTACT WITH THESE TERMINALS WOULD CAUSE A SEVERE ELECTRIC SHOCK.

(✓) Next, connect the jumper from the 1-V, P-P terminal to the VERT. INPUT terminal. Turn the HOR. GAIN to "0." Rotate the VERT. GAIN control clockwise and notice that the trace is now vertical and controlled in length by the VERT. GAIN control setting. Switch the VERT. INPUT to X10. The line now can be extended to the same length at a fairly low setting of the VERT. GAIN control.

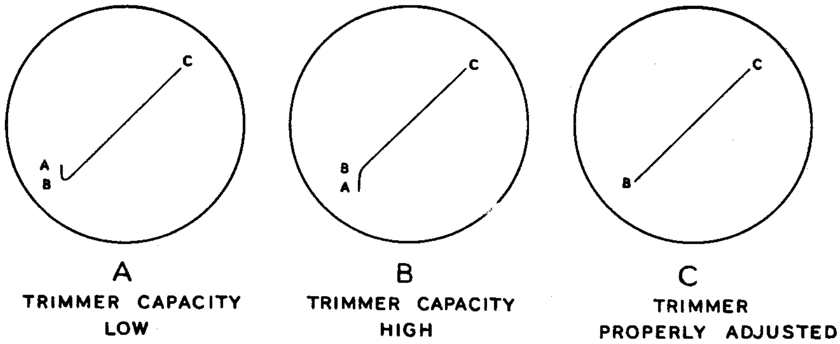


Figure 2

( ) Set the SYNC. SELECTOR switch to the +INT. position, the HOR. GAIN control to 30, the VERT. INPUT switch to X10, and the VERT. GAIN control to 100. Now set the HOR./FREQ. selector to the dot between 10 and 100, and adjust the FREQ. VERNIER to obtain a pattern consisting of four complete sine waves similar to that shown in Figure 1. This check indicates that the sweep generator is operating normally at a frequency of 60/4, or 15 cycles per second. Reduce the HOR. GAIN setting if necessary. The breaks in the trace are caused by the fields of the power transformer. This will not be present with external signals.

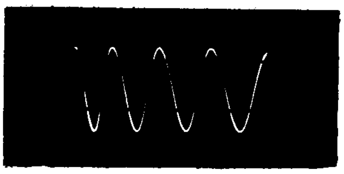


Figure 1

( ) Disconnect the jumper from the 1-V, P-P terminal. Turn off the power and connect the free end of the jumper to the excess lead coming from HOR. IN. on the rear circuit board. Set the HOR./FREQ. SELECTOR to the dot between 1000 and 10 kc, and the FREQ. VERNIER to 0. Now turn on the power. You should get a trace similar to that in Figure 2A or B. Reduce both GAIN control settings so that the trace is about 2" long.

( ) With the VERT. INPUT switch in the X10 position, adjust the front trimmer of the dual trimmers until the AB portion of the trace disappears and only a straight sloping line remains. (The dual trimmer is located on the left front part of the chassis.)

( ) Switch the VERT. INPUT to X100 and adjust the rear trimmer of the dual trimmer to obtain the same result as in the preceding step. In this adjustment, you will notice that the slope of the BC portion of the trace is more nearly horizontal because of the lower vertical gain being employed. The adjustment can still be made very accurately. Turn power off and disconnect jumper from rear circuit board. Clip off the excess wire at HOR. IN.

The adjustments just made are to compensate the vertical input attenuators so that they are not frequency conscious. This compensation preserves the excellent frequency response of the vertical amplifier even with high input attenuation.

NOTE: Adjustment of the PRESET ADJUST controls is described in the OPERATION section of this manual on Page 32.

( ) The chassis should now be installed in the cabinet. Pass the line cord through the large hole in the back of the cabinet, then slide the chassis in and fasten it in place, using two #6 sheet metal screws through the back of the cabinet and into the rear chassis apron. Be careful not to pinch the wires along the edge of the front panel when installing the cabinet.

OPERATION

The operation of an oscilloscope and its many controls is quite simple once the basic principles are clear.

The controls can be divided into groups with specific functions.

Two knobs, marked INTEN. and FOCUS, control the quality of the trace. The INTEN. control adjusts the brightness and the FOCUS control adjusts the sharpness of the trace on the oscilloscope screen.

Two knobs, marked VERT. POS. and HOR. POS., control the location of the trace on the screen. Turning the VERT. POS. knob shifts the trace up or down; the HOR. POS. knob is used to move the trace left or right.

The knob marked HOR. GAIN, varies the length of the pattern on the screen.

Two knobs, marked VERT. GAIN and VERT. INPUT, control the height of the pattern on the screen.

The PHASE knob controls the phase shift of the line-frequency voltage used for LINE sweep (LINE SW.).

Three knobs, marked HOR./FREQ. SELECTOR, FREQ. VERNIER and EXT. SYNC. AMPLITUDE, control the operation of the sweep generator. The HOR./FREQ. SELECTOR and FREQ. VERNIER permit selection of the desired sweeping rate to provide a clear pattern. The EXT. SYNC. AMPLITUDE control operates only on external synchronization to adjust the voltage input to the synchronizing circuit.

The HOR./FREQ. SELECTOR switch also performs the following functions:

EXT. INPUT: The HOR. INPUT binding post is connected directly to the input grid of the horizontal amplifier system. The sweep generator is not operating and external signals can be applied to the binding posts.

LINE SW.: Line frequency voltage, controlled in phase by the PHASE control, is applied to the horizontal amplifier system. The sweep thus applied to the amplifier is sinusoidal in waveform.

PRESETS #1 and #2: Often used horizontal sweep frequencies (such as the sweep frequencies of a TV set) can be preadjusted by means of the screwdriver adjustments available on the front panel of the oscilloscope.

See the ADJUSTMENT section (Page 33) for these controls.

The SYNC. SELECTOR switch operates as follows when the sweep generator is operating.

-INT. and +INT.: The sweep generator is synchronized internally with the signal applied at the VERT. INPUT binding post; in the +INT. position, the sweep will start on the positive slope of the signal, and in the -INT. position, the sweep starts on the negative slope.

LINE: The sweep generator is synchronized with the line frequency.

EXT.: The sweep generator is synchronized with the signal applied to the EXT. SYNC. binding post.

The 1-V, P-P binding post supplies a voltage for establishing the overall gain of the vertical amplifier. When this voltage is applied to the VERT. INPUT terminal and the VERT. GAIN control and VERT. INPUT switch are set for a given measured vertical deflection on the grid screen, it becomes a simple matter to determine the peak-to-peak value of any unknown voltage. For example; a service specification refers to a particular waveform, designating the normal peak-to-peak voltage as 25 volts. Connect the 1-V, P-P terminal to the VERT. INPUT terminal. With the VERT. INPUT switch in the X10 position, adjust the VERT. GAIN control for a deflection of 1" on the grid screen. Do not touch the VERT. GAIN control again until the measurement is completed. Disconnect the calibrating voltage and apply the unknown voltage to the VERT. INPUT post. Set the VERT. INPUT switch to the X100 position. Now, a 1" deflection indicates a peak-to-peak voltage of 10 volts. (With the VERT. INPUT switch in the X1 position, it would indicate 0.1 volts.) Adjust the sweep controls to lock the waveform and adjust the positioning controls for convenient vertical measurement. Observe that the unknown voltage shows a peak-to-peak deflection of 2.5", or 25 volts.

ADJUSTING THE PRESET ADJUST CONTROLS

Adjustment of the PRESET ADJUST controls may be made directly from the front panel of the oscilloscope with a screwdriver, making possible two completely preadjusted horizontal sweep frequencies. The instrument does not need to be removed from its case for these two adjustments. The frequency range of PRESET ADJUST control number 1 is from 10 cps to 100 cps, and the frequency range of PRESET ADJUST control number 2 is from 1000 cps to 10 kc. By changing the values of C22 or C23 to the values of C17, C18, or C20, the PRESET controls may be used to set fixed sweep frequencies at any frequencies within the range of the sweep generator.

Since the most common use of this facility will be in television repair work, we will describe the adjustment procedure for presetting them for the vertical and horizontal sweep frequencies of a television set.

NOTE: When making these adjustments, be careful not to come into contact with the high voltages present in television sets.

PRESET ADJUST 1

(✓) Connect the vertical input of the oscilloscope to a point where a waveform is present in the vertical section of a television set.

(✓) Allow sufficient time for both the television set and the oscilloscope to warm up thoroughly, and turn the SYNC. SELECTOR switch of the oscilloscope to the EXT. position. Turn the HOR./FREQ. SELECTOR to PRESET 1.

(✓) Turn PRESET ADJUST control number 1 until two complete cycles appear on the oscilloscope. Now check this adjustment by turning the SYNC. SELECTOR to the INT. position to make sure the waveforms lock in solidly.

PRESET ADJUST 2

(✓) Turn the HOR./FREQ. SELECTOR to PRESET 2. Turn the SYNC. SELECTOR back to the EXT. position.

(✓) Connect the vertical input of the oscilloscope to a point where a waveform is available in the horizontal section of a television set.

(✓) Turn PRESET ADJUST control number 2 until two complete cycles of the horizontal waveform appear on the oscilloscope. Now check the waveform for stability by turning the SYNC. SELECTOR back to the INT. position.

NOTES ON OSCILLOSCOPE OPERATION

One of the outstanding features of this instrument is the ease with which the sweep may be synchronized with the incoming signal. You will notice that the EXT. SYNC. AMPLITUDE control has no effect at any setting of the SYNC. SELECTOR switch except in the EXT. position. The AMPLITUDE control is unnecessary in the other positions because of the built-in sync. limiting circuit. This circuit makes synchronization easily adjustable by the FREQ. VERNIER control. Settings of this control may become quite critical at low vertical gain settings and at very high frequencies.

When operating on external synchronization, the EXT. SYNC. AMPLITUDE control should be set just above the lowest setting which will give the desired synchronization.

At maximum gain settings, the sensitivity of the amplifiers is very high. Therefore, without a signal source connected to the input terminal, stray pickup may produce patterns on the screen. This is equivalent to the noise obtained from high gain audio amplifiers when the pickup or the microphone is disconnected. Such behavior is a normal characteristic of the instrument and does not interfere with proper operation.

The maximum undistorted output voltage of the vertical amplifier generally does not provide deflection much in excess of 5". Maximum deflection of 3" will provide adequate utilization of the available screen area. Vertical deflection of greater than 3" will give an apparent distortion, as the trace is then operating in the curved portion of the CR tube face. Some scope manufacturers incorporate vertical limiting circuits or a mask to limit the trace to 3", which then utilizes only the flat portion of the CR tube giving greatest accuracy.

At low sweep rates (30 cycles or less) the screen has insufficient persistence to provide a steady picture. The resulting flicker is inherent with medium persistence screens at low sweep rates and represents a compromise with the ability to follow high sweep rates.

In addition to the above notes, there are several other effects which might be noticed under actual operation of the scope. All the following characteristics are normal to the oscilloscope design and should cause no concern:

1. At extreme sweep rates with high intensity settings, some indication of the retrace, particularly at the left side, is to be expected.

2. When adjusting for minimum spot size, some deflection of the beam will take place due to external magnetic fields. This condition will remain, even with both the HOR. and VERT. GAIN controls set to minimum. It is caused by magnetic fields generated by other electrical equipment in proximity to the oscilloscope and the extent of such fields is often amazing. These extraneous fields can be identified by observing whether the spot shape, adjusted for minimum size, seems to change with orientation of the instrument. To check, turn the scope cabinet around its vertical axis. Soldering guns, fan motors, power transformers, voltage regulators, and conduit carrying heavy AC conductors are particularly bad offenders in this respect. In the past, such deflections have been swamped out by the relatively large minimum spot size which could be resolved. With the present day high resolution cathode ray tubes and improved circuitry, the effect is much more noticeable.

3. The same magnetic deflection mentioned above may cause a "breathing" or hum-modulation effect on any waveform displayed, if the sweep circuit is operating near the line frequency or a harmonic of it. Although not so easy to identify, one can usually spot this effect by varying the sweep speed slightly to present one less or one more full cycle in the display; the "breathing" rate will change and may even become evident as a dual trace under some conditions.

4. At signal frequencies of 1 megacycle and higher, some fuzziness of the trace is normal. With signal frequencies higher than 3 mc, settings of the frequency vernier become critical and great care must be used.

5. Vertical positioning range is deliberately limited to ±1-1/2" from center, while horizontal positioning has been extended to several times screen width at normal sweep frequencies. This limited vertical positioning is required to maintain proper operating conditions in the vertical deflection amplifier and no attempt to correct it should be considered.

6. You will note that it is impossible to turn the signal entirely off with the vertical gain control. This has been done purposely in order to force the user of the scope to reduce gain with the vertical input switch to keep from overloading the input stage of the vertical amplifier. If you cannot reduce the waveform height on the screen to a useable level with these controls, an external attenuator probe or voltage divider may be used to reduce the input signal.

7. A slight overshoot or ringing effect may be noticed with square-wave inputs at frequencies of 100 kc and higher. This effect should not exceed 10%. However, since square-wave generators are prone to create this condition themselves, be sure of the output waveform of your generator.

8. As sweep rates are increased, particularly above 200 kc, a definite reduction in available sweep amplitude will be noted. This is a function of the rapidly-falling frequency response of the horizontal amplifier and is perfectly normal. At maximum sweep rates, at least 4" of horizontal deflection should be obtained with full horizontal gain. Bear in mind that under these conditions, the sweep generator is operating at broadcast band frequencies and may be heard on adjacent radio receivers.

9. At reduced intensity settings and low sweep speeds, some intensity modulation of the trace may be noticed. This condition is normal and may be eliminated by a slight increase in trace intensity.

10. In operating the positioning controls, you will observe a "dead spot" at about the center of rotation; that is, the position of the spot does not change even though the control is turning through several degrees. This is perfectly normal, and is caused by the slider of the control passing over the tap position on the resistance element. At this tap position, no change in resistance takes place, hence the spot does not change position.

11. Some defocusing may be experienced at the extreme right-hand edge of the trace. This condition does not indicate a fault in the CR tube. It is caused in part by amplifier design and is an intended compromise between sensitivity and bandwidth which will in no way interfere with normal oscilloscope operation.

12. If the scope is operating with a total horizontal sweep width of 4", for example, and the HOR. GAIN setting is increased to give a much greater sweep width, the apparent intensity of the trace will be reduced. This action is normal. It is caused by the fact that the trace intensity is inversely related to the writing rate of the electron beam. As the sweep width is increased, this rate increases also and the intensity will drop. If proper voltages are obtained at the CR tube socket, and adequate intensity is available under normal room lighting with 5" total sweep width, your oscilloscope is performing normally. As sweep width is increased beyond this, the trace intensity will be reduced.

OSCILLOSCOPE APPLICATIONS

The cathode ray oscilloscope is a most versatile device. It has the unique ability to measure the basic electrical quantities and, more important, to show the relationships between as many as three of these quantities at any one time. Or, it can relate one or two of the variables against a controlled time reference. Therefore, it can indicate such characteristics as frequency, phase relations, and waveform.

By the use of supplementary devices, called transducers, a great variety of other physical attributes can be investigated with the oscilloscope. These transducers are used to convert sound, heat, light, stress, or physical movement into electrical impulses. The impulses can be studied by displaying them on the screen of the oscilloscope.

The following portion of this manual is provided simply to familiarize you with the basic applications of your oscilloscope. Each one of the uses described is well within the capabilities of the oscilloscope.

WAVEFORM INVESTIGATION

Probably the major use of most oscilloscopes is in the study of recurrent or transient variations in an electrical quantity. Since the oscilloscope is a voltage-operated device, these variations must be first converted into changes in voltage.

It is common practice to apply the signal voltage to the vertical input of the oscilloscope. By means of attenuators and amplifiers, this voltage is made to vertically displace the electron beam in the cathode ray tube. At the same time, the beam is being swept horizontally by the sweep generator within the instrument. The sweep frequency is normally a sub-harmonic or simple fraction of the signal frequency. Therefore, more than one complete cycle of the signal is shown on the screen.

With this brief background, we have described below the more common applications of the oscilloscope in studying waveforms.

Testing Audio Amplifiers and Circuits

Figure 3 shows the conventional setup of equipment for this application. The audio generator should be capable of producing a pure sine wave with very low harmonic distortion. The load resistor should match the output impedance of the amplifier. The usual practice is to perform all tests at an input voltage sufficient to develop a reference power output. This prevents overloading of any portion of the amplifier and consequent inaccuracies in measurements.

Figure 4A shows serious flattening of one peak, representing about 10% harmonic distortion in the amplifier. This condition may be caused by incorrect bias on any stage, or by an inoperative tube in a push-pull stage. Figure 4B indicates third harmonic distortion, a particularly objectionable fault. Figure 4C shows flattening of both peaks, usually an indication of overload somewhere in the amplifier circuit.

Although the use of sine-wave input tells us a lot about an amplifier, the use of a square wave input waveform gives a very accurate and extremely sensitive indication of the performance of the audio system with respect to both amplitude distortion and phase shift. Assume that we apply a wave of the form shown in Figure 5A, with a fundamental frequency of 60 cycles. In a theoretically perfect amplifier, the output waveform would be an exact duplicate except at a greater power level as determined by the gain of the amplifier. Actually, the distortion of this waveform as shown in the scope tells a great deal about the amplifier at frequencies considerably separated from the test frequency. If the high frequency performance of the amplifier is excellent, the front of the square wave will be sharp cornered and clean. A distortion similar to that shown in Figure 5B indicates poor high frequency response, which may be amplitude distortion, phase shift, or both. We may assume, therefore, that the shape of the rising portion of the waveform indicates the ability of the amplifier to faithfully reproduce high frequencies. Conversely, the slope of the flat-top por-

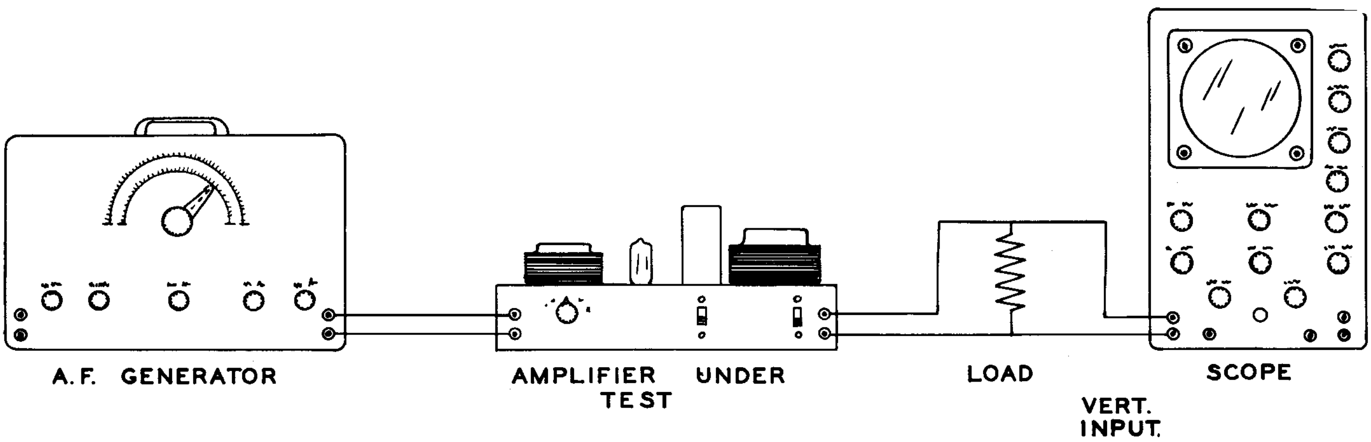


Figure 3

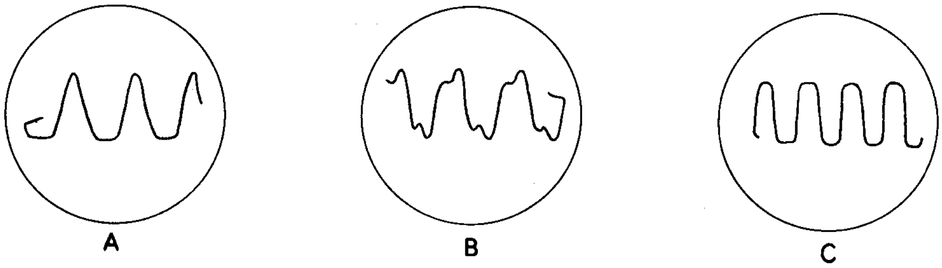


Figure 4

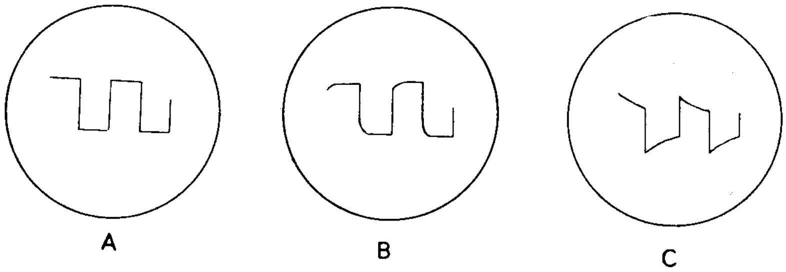


Figure 5

tion of the wave indicates the performance of the amplifier in the low frequency range. Figure 5C is the characteristic indication of an amplifier with poor low frequency response. Again, the square-wave generator used must be capable of producing the desired waveform with excellent voltage regulation and low inherent distortion.

Further discussion of this method is beyond the scope of this manual. Interested readers are referred to the BIBLIOGRAPHY for further sources of information.

Servicing Television Receivers

Servicing of television receivers is a rapidly expanding application of the cathode ray oscilloscope. Each of the following basic uses requires some additional equipment, but none of them can be performed without using an oscilloscope. This particular field was given specific attention in the design of the oscilloscope.

1. Alignment of a television receiver is virtually impossible without the use of an oscilloscope and a television alignment generator. This generator supplies an RF signal over all VHF frequencies involved in modern television receiver operation. The signal can be frequency modulated at 60 cycles per second with a deviation of several megacycles. The generator also provides a 60 cycle sweep voltage, controllable in phase, to drive the horizontal deflection amplifiers in the oscilloscope. It also provides a blanking system which cuts off the RF output of the generator during one-half of its operating cycle. In effect, the generator output sweeps several megacycles at a uniform rate. The oscillator output is then cut off, and the cycle is repeated. The vertical input to the scope is driven by the voltage developed at the input to the video amplifier in the television set. Since this voltage varies in exact accordance with the gain of the RF and/or IF amplifier stages over the frequency range being swept, the trace on the scope screen is actually a graphic representation of the response of the amplifiers being tested.

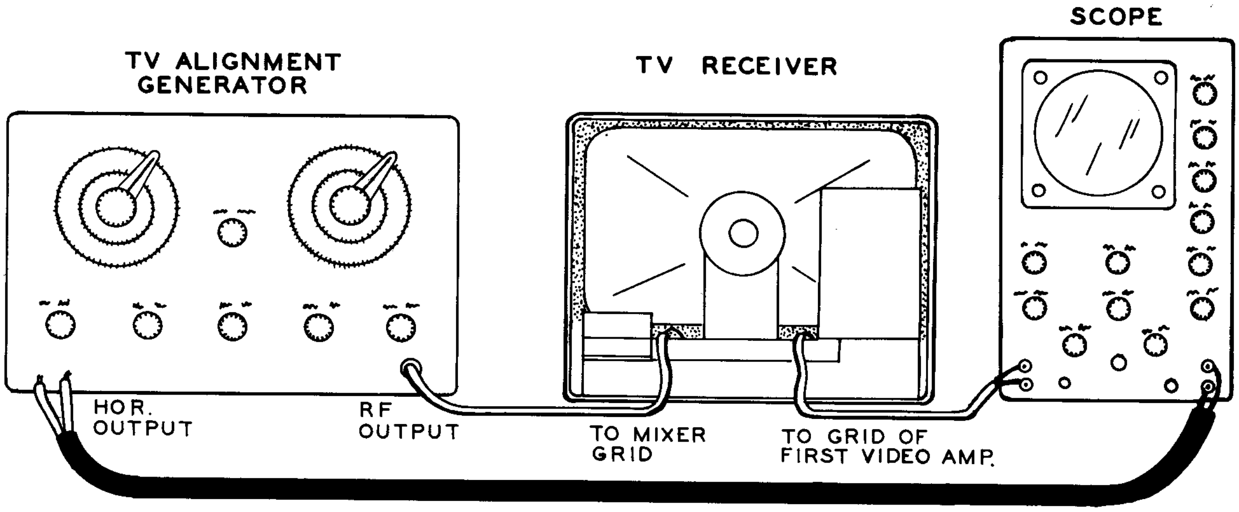


Figure 6

Figure 6 outlines the connections between the alignment generator, the receiver, and the oscilloscope. The exact procedure for alignment varies greatly. This information is generally available in the TV manufacturer's service information. Usually, a drawing of the desired response curve is given, together with a sequence of adjustments to roughly approach the desired pattern. Final adjustments are made while watching the trace on the oscilloscope.

2. The waveform of the complex television picture signal as it is passed through the receiver is undoubtedly the most important characteristic of the signal voltage. In order to properly display the minute variations in waveform, which incidentally make the difference between good and bad picture quality, the oscilloscope is required to attenuate, amplify, and display voltage changes over an extremely wide frequency range without in any way distorting them. The performance of the oscilloscope is entirely adequate for this application.

Again, you must rely upon the manufacturer to furnish representative patterns showing the waveform to be expected at specific test points within the receiver. You will find that these diagrams cover the entire receiver with the exception of the "front-end," or tuner portion. However, in order to pick off the modulation envelope in the IF amplifier section, a demodulator probe is used to make connection to the plate, grid, or cathode of the stage being investigated. This is necessary since the signal in these stages is still contained in the amplitude-modulated envelope of the carrier and must be detected, or demodulated, before it can be shown on the oscilloscope. The HEATHKIT Demodulator Probe is designed for this purpose. At any point after the video detector, no such probe is necessary and a simple shielded low capacity cable can be used.

NOTE: For simplicity, all amplifier stages are shown within one block in the diagram. Tests may be made at the input or output of individual amplifier stages using the indicated mode of operation. At several of the points designated "R", some waveform distortion may result, due to capacitive loading. If this problem exists, it is recommended that a low-capacity scope input probe be used.

In either case, the signal voltage is fed into the vertical amplifier of the oscilloscope as shown in Figure 7. At any point up to the video detector, the voltages picked off will be quite small, and very little vertical attenuation will be required. Within the sync circuits and deflection circuits, however, these voltages can reach very respectable proportions, and considerable attenuation is required. It is for this reason that the vertical input section of the oscilloscope utilizes fully compensated attenuators. Any other method of reducing such voltages would result in enough distortion to render the displayed signal completely useless.

In checking waveform, remember that two basic frequencies are involved in the television signal. The vertical, or field frequency is 60 cycles per second. Any investigation of the circuit, except within the horizontal oscillator, its dif-

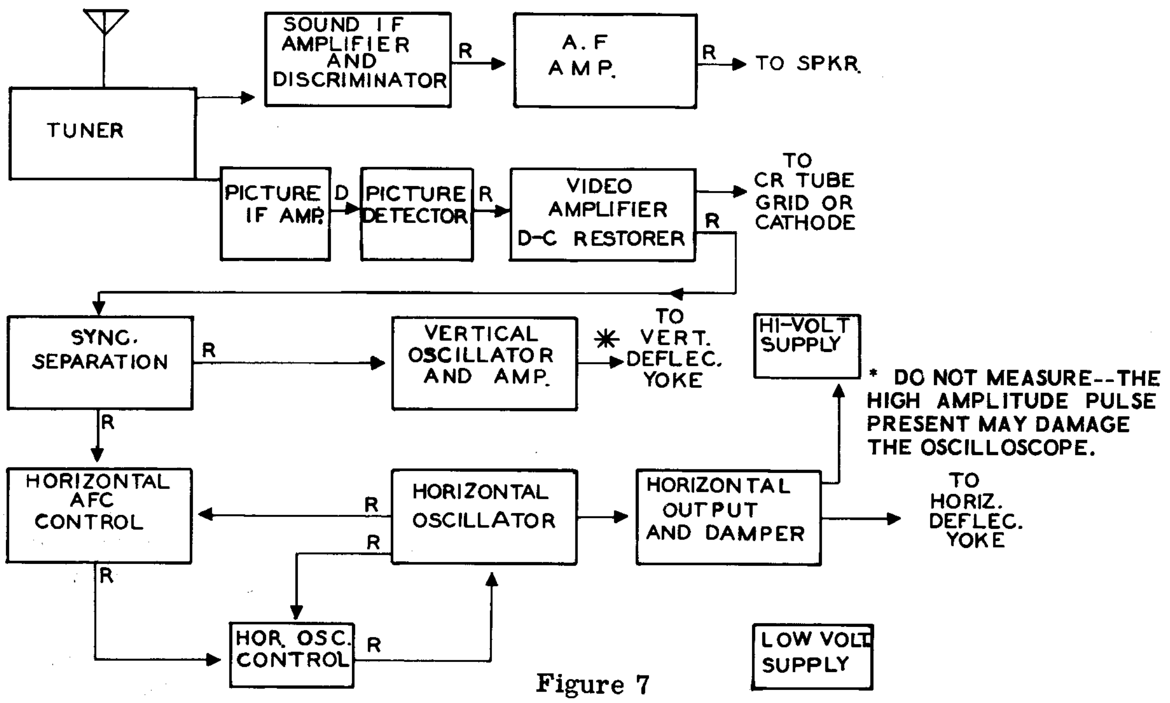


Figure 7

ferentiator network, and the horizontal amplifier stages, can generally be made using a sweep generator frequency of 20 to 30 cycles, thus showing two or three complete fields of the signal. In order to study the horizontal pulse shape, or the operation of the horizontal deflection system, it is generally necessary to operate the sweep generator at 15,750 or 7,875 cycles per second. This sweep rate will show the waveform of one or two complete lines of the signal. The use of PRESET ADJ. #1 and PRESET ADJ. #2 are especially useful in investigating these horizontal or vertical sweep circuits. See the PRESET ADJUST section on Page 33.

The signal-tracer method of analysis is most helpful in going through a receiver in this fashion, 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 the means available to determine 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.

Remember, in making connections to the test points, that grid circuits are generally high-impedance points, and that the addition of any capacity can disrupt the performance of the stage to some degree. Plate circuits and cathode circuits are usually lower-impedance points, and more desirable for testing purposes. Also, bear in mind that the plate-circuit indication with respect to polarity will be exactly opposite to indications obtained on grid or cathode, since a phase difference of 180 degrees takes place within the tube. Therefore, the pattern shown on the scope screen may be inverted when such interchanges are made. The form of the wave will not be changed, however.

3. Video amplifier response can be measured in exactly the same manner described for testing audio amplifiers, and again a square-wave signal is the most efficient method to use. Because a video amplifier must pass signals as low as 20 cycles and as high as 4 or 5 megacycles, however, a more comprehensive test is required. Usually a 60 cycle check is made to cover low and medium-frequency characteristics. A second check at 25,000 cycles covers the high-frequency portion of the response curve. Again, such tests require extreme fidelity on the part of the oscilloscope, and these requirements are fully met by the oscilloscope. The signal-tracing technique can be used in these tests also. The squarewave generator is fed directly into the first video amplifier grid. Very low signal input will be required. Then the oscilloscope is con-

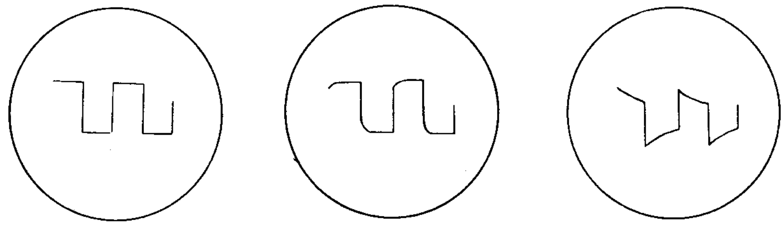


Figure 8

nected to various tube plates, starting near the output end and working back until any distortion is isolated. Patterns such as Figure 8B are responsible for poor picture detail, or "fuzziness," while distortion of the form shown in Figure 8C can cause shading of the picture from top to bottom.

Miscellaneous Waveform Measurements

In this category, we can place such waveform investigations as measurement of modulation percentage, studies of noise and vibration, subsonic and ultrasonic applications and hundreds of others. Each of these fields is highly specialized, and it is obviously impossible to cover each here. We again refer you to the BIBLIOGRAPHY for further reading.

AC VOLTAGE MEASUREMENTS

Because of its peculiar characteristics, the oscilloscope is particularly suited to the measurement of AC voltages. With the advent of television, it has become imperative that such measurements be made accurately without respect to waveshape. Most television service bulletins specify peak-to-peak voltages which appear at various points of the circuit. Other applications for such measurements are becoming more common every day.

The oscilloscope was designed to accurately measure and display these voltages. Former instructions have shown how to calibrate the instrument for direct measurement of peak-to-peak amplitudes. The attenuators are especially designed for maximum accuracy, and readings can be relied on to within ±2 db when referred to a calibration voltage of the same frequency. An additional error of 1 db may be encountered when the calibrating voltage and the signal voltage are greatly different in frequency.

When using the grid screen for AC voltage measurements, it is sometimes helpful to use the EXT. INPUT setting for the HOR./FREQ. SELECTOR switch. This produces a vertical line which can be focused and centered exactly for the most accurate readings.

The following relationships exist between sine wave AC voltages:

rms times 1.414 = peak voltage.
rms times 2.828 = peak-to-peak voltage.
Peak voltages times 0.707 = rms voltage.
Peak-to-peak voltage times 0.3535 = rms voltage.

AC CURRENT MEASUREMENTS

To measure AC currents, the unknown current must be passed through a resistor of known value. The voltage drop across this resistor is measured as described above. From Ohm's law, I equals E/R, the current can be calculated. It is important that the resistor be non-reactive at the frequency involved. It should also be relatively small with respect to the resistance of the normal circuit load.

FREQUENCY MEASUREMENTS

Frequency measurements can be made with an accuracy limited only by the reference frequency source available. In most cases, this can be the 60 cycle line frequency which is usually controlled very closely. The unknown frequency is applied to the vertical input, and the reference frequency to the horizontal input. (Sweep generator input is not used.) The resultant pattern may take on any one of a number of shapes. Typical patterns are shown below:

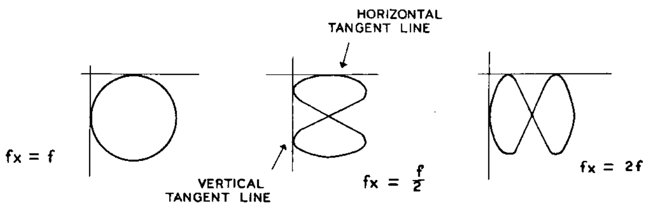


Figure 9

The frequency ratio can be calculated from the formula:

$$f_x = \frac{T_h \times f}{T_v}$$

where f_x is the unknown frequency; f is the reference frequency; T_h is the number of loops which touch the horizontal tangent line; T_v is the number of loops which touch the vertical tangent line.

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

PHASE MEASUREMENTS

It is sometimes necessary to determine the phase relationship between two AC voltages of the same frequency. This can be accomplished quite easily by applying one of the voltages to the horizontal input and the other voltage to the vertical input. The phase relationship can be estimated from Figure 10.

To calculate the phase relationship, use the following formula:

$$\sin \theta = \frac{A}{B}$$

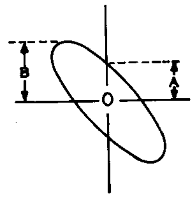


Figure 11

The distance A is measured from the X axis to the intercept point of the trace and the Y axis. The distance B represents the height of the pattern above the X axis. The axis of the ellipse must pass through point 0.

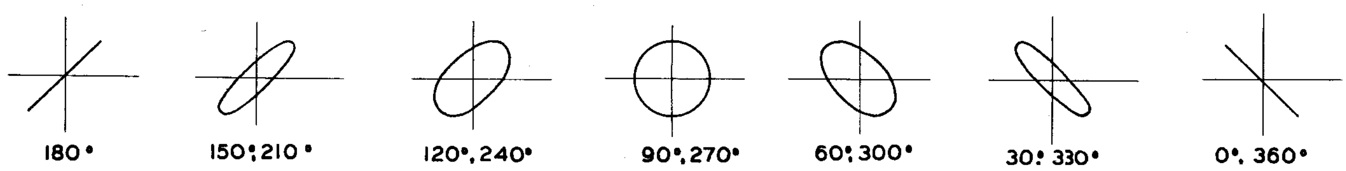


Figure 10

BIBLIOGRAPHY

While many issues of the popular radio and service magazines have carried excellent articles on the construction and application of oscilloscopes, and their reading is highly reccommended, we also suggest the following excellent books:

Ruiter; Modern Oscilloscopes and Their Uses.

Rider; The Cathode Ray Tube at Work.
Turner; Basic Electronic Test Instruments.

Editors and Engineers; Radio Handbook.
ARRL; Radio Amateurs Handbook.

Rider and Uslan; Encyclopedia on Cathode Ray Oscilloscopes and Their Uses.

IN CASE OF DIFFICULTY

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

2. It is interesting to note that about 90% of the kits that are returned for repair, malfunction due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as illustrated in the Figures found in the SOLDERING TECHNIQUES section of this manual.

3. Check to be sure that all tubes are in their proper locations. Make sure that all tubes light up properly.

4. Check the tubes with a tube tester or by substitution of tubes of the same types and known to be good.

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

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

7. If, after careful checks, the trouble is still not located and a voltmeter is available, check voltage readings against those found on the Schematic Diagram. NOTE: All voltage readings were taken with an 11 megohm input vacuum tube voltmeter. Voltages may vary 10% due to line voltage variations.

8. A review of the Circuit Description and Block Diagram will prove helpful in indicating where to look for trouble

9. If the dot moves off the face of the CR tube right after the oscilloscope warms up, and cannot be brought back by adjusting the positioning controls, it is generally caused by a defective deflection amplifier tube. If the trace drifts up or down, check the 12BH7 at V3. If the drift is right or left, check the 12AU7 at V7. Other probable causes are incorrect or defective plate load resistors for these stages, the 2.7 K 2 watt and 1 K 1 watt resistors to V3, and the 33 K 1 watt resistors to V7.

10. If you are unable to obtain straight diagonal lines when adjusting the vertical trimmers, please refer to Figure 2 on Page 31. The patterns shown there present a perfectly straight line between points B and C on the traces. Some users have raised questions on this point, stating that they cannot obtain a straight line between B and C. This is perfectly normal. The indication which is significant is that portion of the trace between A and B. The intention of the adjustment is to reduce this portion of the trace to a point at the lower end of the trace, thus indicating neither overshoot or slow rise time on the sharp wavefront of the sawtooth generated by the sweep oscillator. If the remaining portion of the line bellies up or down, a readjustment of the sweep oscillator frequency will probably locate a point where the effect is changed radically. This variation is due to minor phase shift relationships in the amplifier circuits, not to defective or improper compensating.

11. If you are troubled with hum or ripple when the oscilloscope is operated with shorted vertical input terminals, please make the following checks.

A. To determine if the hum level is abnormal, short the VERT. INPUT terminals, increase the VERT. GAIN control to 100, and set the VERT. INPUT attenuator to X1. The total vertical trace width should not exceed 1/16" peak-to-peak. With the input terminals open-circuited and not shielded, this deflection will increase several times because of the normal pickup of the input circuit. This condition is perfectly normal, and is typical of any high-gain, high-impedance amplifier circuit.

B. If the shorted-input condition results in a trace more than 1/16" in vertical width, connect a shorting lead between CRT6 and CRT7 on the cathode ray tube socket. This will eliminate any electrostatic deflection of the beam, which is the normal method by which the scope operates. If the trace height then appears to be normal (that is, in the order of 1/16" or so) the difficulty lies in the vertical deflection amplifier circuits and may be isolated readily by tracing back through the various stages until the source of hum or noise is located.

C. If, with CRT6 and CRT7 shorted, the vertical width of the trace exceeds 1/16", the deflection or ripple is caused by magnetic deflection of the beam by stray magnetic fields passing through the beam path. This is the same type of deflection used in most modern television receivers.

The magnetic field creating the deflection is almost always a composite of many separate field patterns. A portion of this field is created by the oscilloscope power transformer, but the relative position of the CR tube and transformer has been carefully established so that the sensitive portions of the tube structure are located in a null of the magnetic field surrounding the transformer. Severe overloading of the power transformer will upset this balanced condition, however. The greatest sources of trouble in this respect are magnetic fields from equipment external to the scope itself. Anything which consumes power at power-line frequencies creates a certain magnetic field. The worst offenders are those devices which draw a considerable amount of current such as soldering irons, soldering guns, AC motors, electric heaters, and other similar items.

Figure 12A shows the general type of wave shape caused by external magnetic fields. Notice the semi-sawtooth wave shape. It is possible to change the wave shape by simply rotating the oscilloscope physically about any of its axes. Figure 12B, for example, was obtained by tilting the scope about 45 degrees to its left. Observe that now the ripple has actually reduced itself in height, but appears to sweep back on itself for 30% of its cycle or so.

Variations in the ripple appearance with changes in physical location of the scope are definite proof that the deflection is not caused by a defect in the oscilloscope and no known way exists for eliminating the difficulty except by complete shielding of the entire cathode ray tube from socket to face with a high permeability metallic shield. Such a shield would cost at least $15.00 for the 5UP1, and is an obvious impossibility in a kit selling for as low a price as this oscilloscope.

Fortunately, interference of this kind is usually small in amplitude and presents no problem to the average user. A little judicious experimenting will isolate the principal offender creating the field. Physical separation is in general a quick and easy solution to the problem.

Should the procedure as outlined fail to correct your difficulty, refer to the SERVICE INFORMATION section of this manual.

Figure 12

SERVICE INFORMATION

SERVICE

If, after applying the information contained in this manual and your best efforts, you are still unable to obtain proper performance, it is suggested that you take advantage of the technical facilities which the Heath Company makes available to its customers.

The Technical Consultation Department is maintained for your benefit. This service is available to you at no charge. Its primary purpose is to provide assistance for those who encounter difficulty in the construction, operation or maintenance of HEATHKIT equipment. It is not intended, and is not equipped to function as a general source of technical information involving kit modifications nor anything other than the normal and specified performance of HEATHKIT equipment.

Although the Technical Consultants are familiar with all details of this kit, the effectiveness of their advice will depend entirely upon the amount and the accuracy of the information furnished by you. In a sense, YOU MUST QUALIFY for GOOD technical advice by helping the consultants to help you. Please use this outline:

1. Before writing, fully investigate each of the hints and suggestions listed in this manual under "IN CASE OF DIFFICULTY." Possibly it will not be necessary to write.

2. When writing, clearly describe the nature of the trouble and mention all associated equipment. Specifically report operating procedures, switch positions, connections to other units and anything else that might help to isolate the cause of trouble.

3. Report fully on the results obtained when testing the unit initially and when following the suggestions under "IN CASE OF DIFFICULTY." Be as specific as possible and include voltage readings if test equipment is available.

4. Identify the kit Model Number and Series Number, and date of purchase, if available. Also mention the date of the kit assembly manual. (Date at bottom of Page 1.)

5. Print or type your name and address, preferably in two places on the letter.

With the preceding information, the consultant will know exactly what kit you have, what you would like it to do for you and the difficulty you wish to correct. The date of purchase tells him whether or not engineering changes have been made since it was shipped to you. He will know what you have done in an effort to locate the cause of trouble and, thereby, avoid repetitious suggestions. In short, he will devote full time to the problem at hand, and through his familiarity with the kit, plus your accurate report, he will be able to give you a complete and helpful answer. If replacement parts are required, they will be shipped to you, subject to the terms of the Warranty.

The Factory Service facilities are also available to you, in case you are not familiar enough with electronics to provide our consultants with sufficient information on which to base a diagnosis of your difficulty, or in the event that you prefer to have the difficulty corrected in this manner. You may return the completed instrument to the Heath Company for inspection and necessary repairs and adjustments. You will be charged a minimal service fee, plus the price of any additional parts or material required. However, if the completed kit is returned within the Warranty period, parts charges will be governed by the terms of the Warranty. State the date of purchase, if possible.

Local Service by Authorized HEATHKIT Service Centers is also available in some areas and often will be your fastest, most efficient method of obtaining service. HEATHKIT Service Centers will honor the regular 90 day HEATHKIT Parts Warranty on all kits, whether purchased through a dealer or directly from the Heath Company; however, it will be necessary that you verify the purchase date of your kit.

Under the conditions specified in the Warranty, replacement parts are supplied without charge; however, if the Service Center assists you in locating a defective part (or parts) in your kit, or installs a replacement part for you, you may be charged for this service.

HEATHKIT equipment purchased locally and returned to Heath Company for service must be accompanied by your copy of the dated sales receipt from your authorized HEATHKIT dealer in order to be eligible for parts replacement under the terms of the Warranty.

THIS SERVICE POLICY APPLIES ONLY TO COMPLETED EQUIPMENT CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Equipment that has been modified in design will not be accepted for repair. If there is evidence of acid core solder or paste fluxes, the equipment will be returned NOT repaired.

For information regarding modification of HEATHKIT equipment for special applications, it is suggested that you refer to any one or more of the many publications that are available on all phases of electronics. They can be obtained at or through your local library, as well as at most electronic equipment stores. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for special purposes. Therefore, such modifications must be made at the discretion of the kit builder, using information available from sources other than the Heath Company.

REPLACEMENTS

Material supplied with HEATHKIT products has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information.

A. Thoroughly identify the part in question by using the part number and description found in the manual Parts List.

B. Identify the kit Model Number and Series Number.

C. Mention date of purchase.

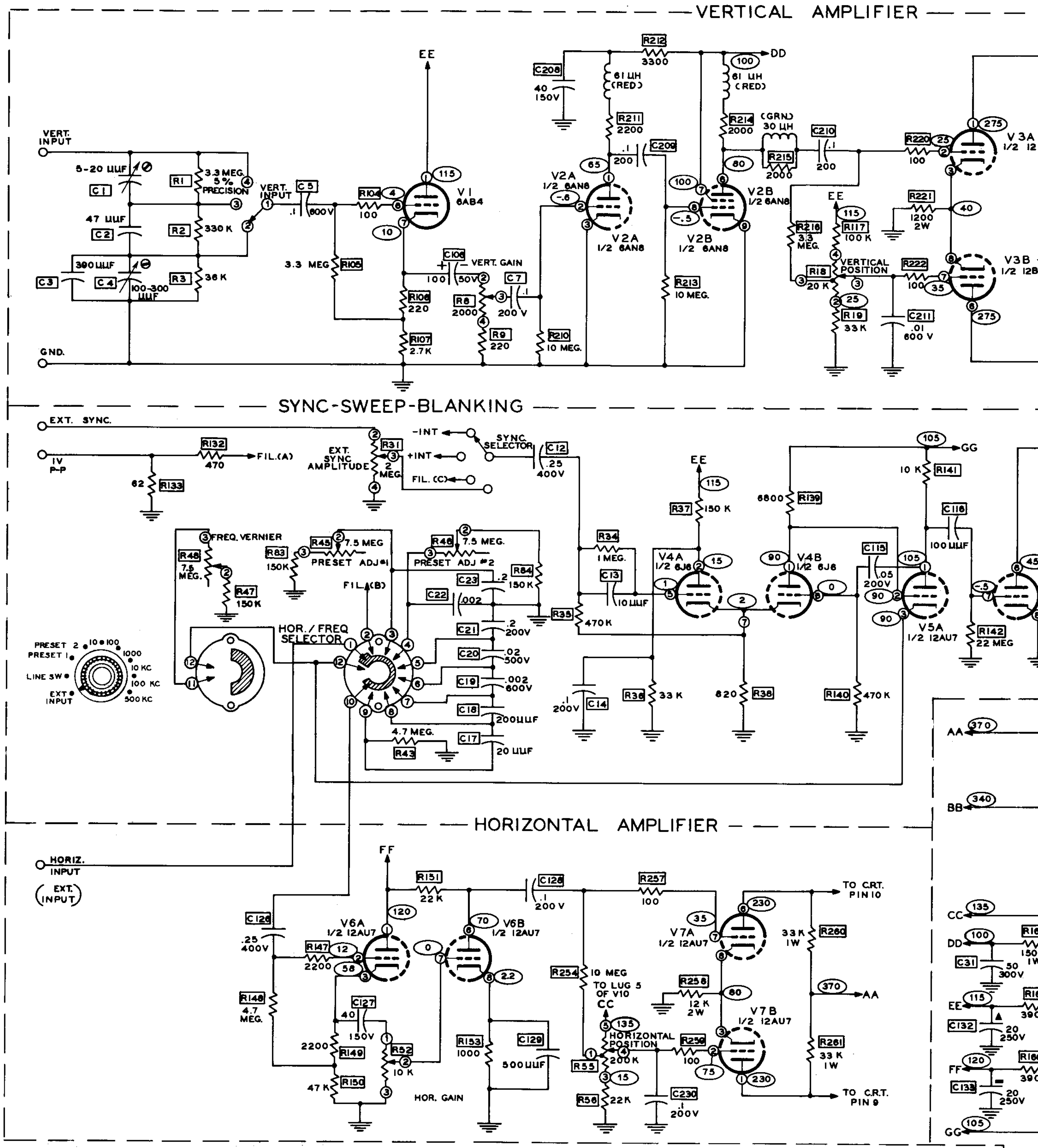
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. PLEASE DO NOT RETURN THE ORIGINAL COMPONENT UNTIL SPECIFICALLY REQUESTED TO DO SO. Do not dismantle the component in question as this will void the guarantee. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

In the event that either of the circuit boards for your oscilloscope have been ruined through accidental use of acid or paste fluxes, or for any other reason, a convenient repair kit is avilable. The kit consists of a new circuit board, new tube sockets, all board-mounted resistors, molded tubular capacitors and ceramic disc capacitors.

The kits may be ordered from the following information:

Kit No. IOR-30-1	Repair Kit, Front Circuit Board
Kit No. IOR-30-2	Repair Kit, Rear Circuit Board



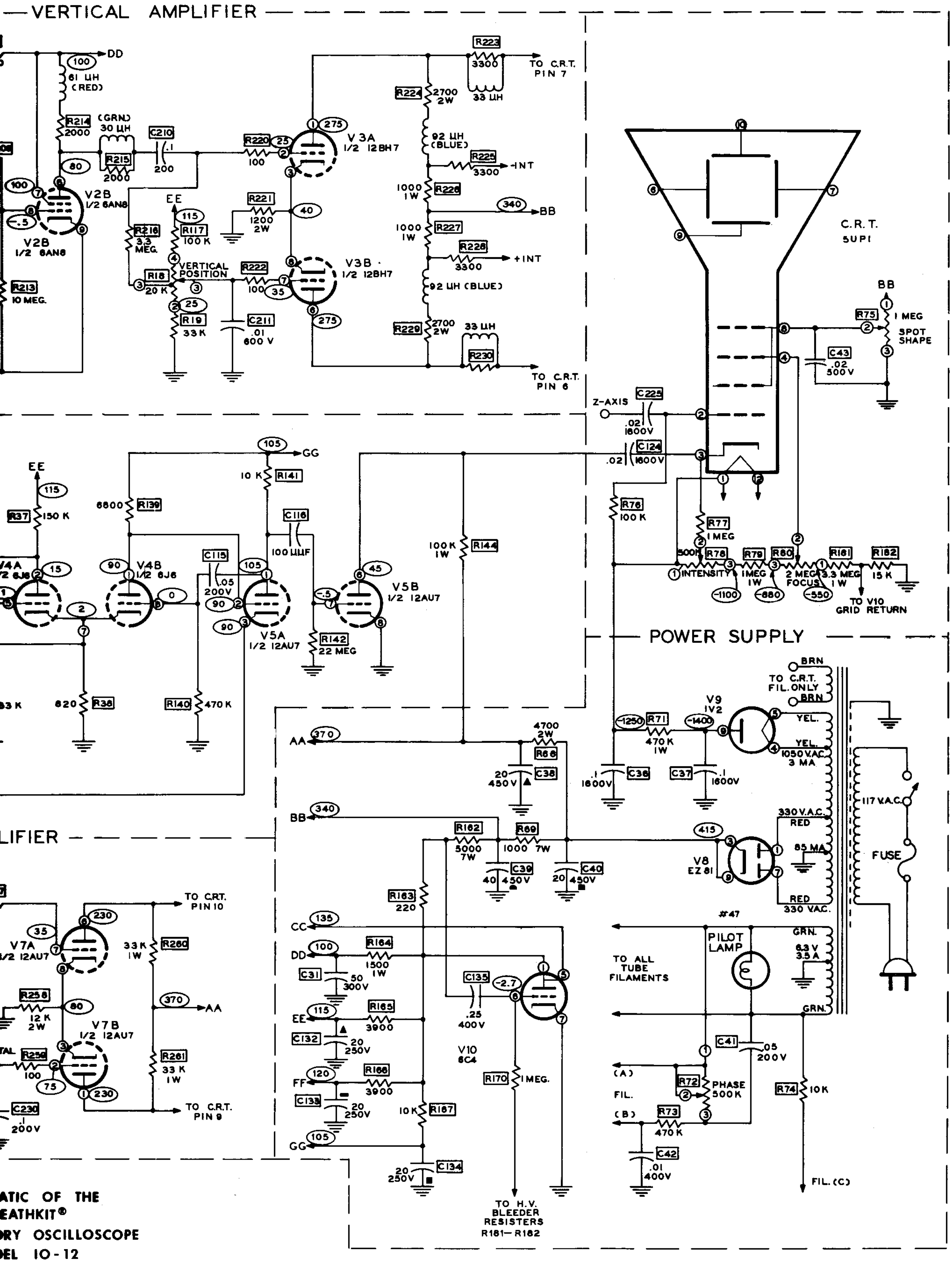
R AND C NUMBERS ON LARGE FRONT CIRCUIT BOARD = 100-199.
R AND C NUMBERS ON SMALL REAR CIRCUIT BOARD = 200-242
ALL OTHER R AND C NUMBERS = 1-99

HORIZONTAL FREQUENCY SELECTOR SWITCH VIEWED FROM THE FRONT AND IN THE POSITION SHOWN BY THE FRONT PANEL MARKING.

ALL RESISTORS ARE 1/2 WATT UNLESS OTHERWISE SHOWN.
ALL RESISTOR VALUES ARE IN OHMS, 1 K = 1000 Ω, 1 MEG = 1,000,000 Ω
ALL CAPACITOR VALUES ARE IN μfd UNLESS OTHERWISE SHOWN.

ALL VOLTAGES ARE FROM POINT INDICATED TO CHASSIS GROUND EXCEPT AC VOLTAGES ON POWER TRANSFORMER WINDINGS. READINGS WERE TAKEN WITH AN 11 MEGOHM INPUT VTVM.

SCHEMATIC OF THE HEATHKIT®
5'' LABORATORY OSCILLOSCOPE
MODEL IO-12



ATIC OF THE
EATHKIT®
RY OSCILLOSCOPE
EL IO-12

SHIPPING INSTRUCTIONS

In the event that your instrument must be returned for service, these instructions should be carefully followed.

Wrap the equipment in heavy paper, exercising care to prevent damage. Place the wrapped equipment in a stout carton of such size that at least three inches of shredded paper, excelsior, or other resilient packing material can be placed between all sides of the wrapped equipment and the carton. Close and seal the carton with gummed paper tape, or alternately, tie securely with stout cord. Clearly print the address on the carton as follows:

To: HEATH COMPANY
Benton Harbor, Michigan 49023

ATTACH A LETTER TO THE OUTSIDE OF THE CARTON BEARING YOUR NAME, COMPLETE ADDRESS, DATE OF PURCHASE, AND A BRIEF DESCRIPTION OF THE DIFFICULTY ENCOUNTERED. Also, include your name and return address on the outside of the carton. Preferably affix one or more "Fragile" or "Handle With Care" labels to the carton, or otherwise so mark with a crayon of bright color. Ship by insured parcel post or prepaid express; note that a carrier cannot be held responsible for damage in transit if, in HIS OPINION, the article is inadequately packed for shipment.

WARRANTY

Heath Company warrants that all Heathkit parts shall be free of all defects in materials and workmanship under normal use and service, and in fulfillment of such warranty Heath Company will, for a period of three months from the date of shipment, replace any part upon verification that it is defective.

The foregoing warranty shall apply only to the original buyer, and is and shall be in lieu of all other warranties, whether express or implied and of all other obligations or liabilities on the part of Heath Company and in no event shall Heath Company be liable for any anticipated profits, consequential damages, loss of time or other losses incurred by the buyer in connection with the purchase, assembly or operation of Heathkits or components thereof. No replacement shall be made of parts damaged by the buyer in the course of handling or assembling Heathkit equipment.

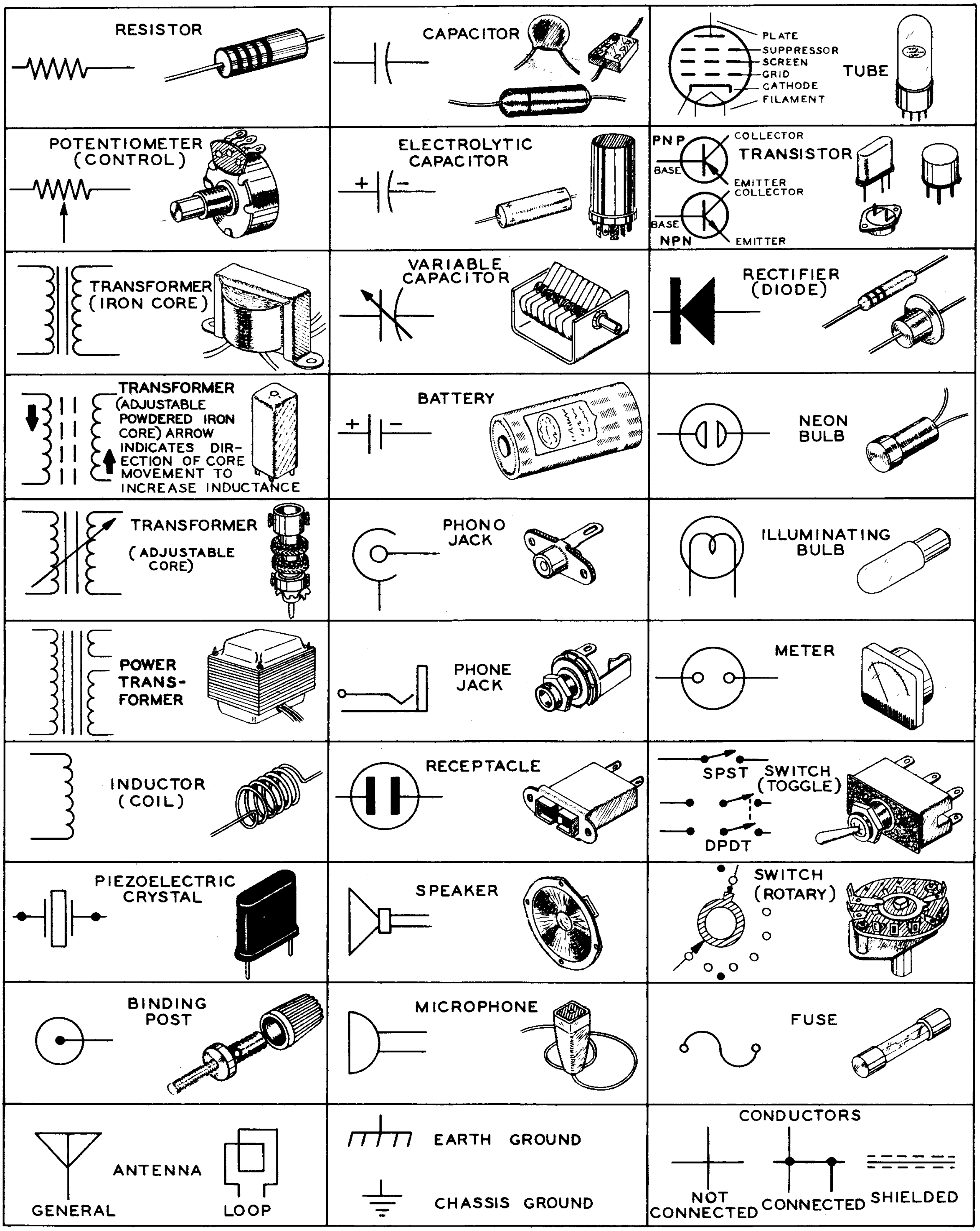
The foregoing warranty is completely void if corrosive solder or fluxes have been used in wiring the equipment. Heath Company will not replace or repair any equipment in which corrosive solder or fluxes have been used.

This warranty applies only to Heath equipment sold and shipped within the continental United States including APO and FPO shipments. Warranty replacement for Heathkit equipment outside the United States is on an f.o.b. factory basis. Contact the Heathkit authorized distributor in your country or write: Heath Company, International Division, Benton Harbor, Michigan, U.S.A.

HEATH COMPANY

TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations should prove helpful in identifying most parts and reading the schematic diagrams.



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