PRICE $2.00

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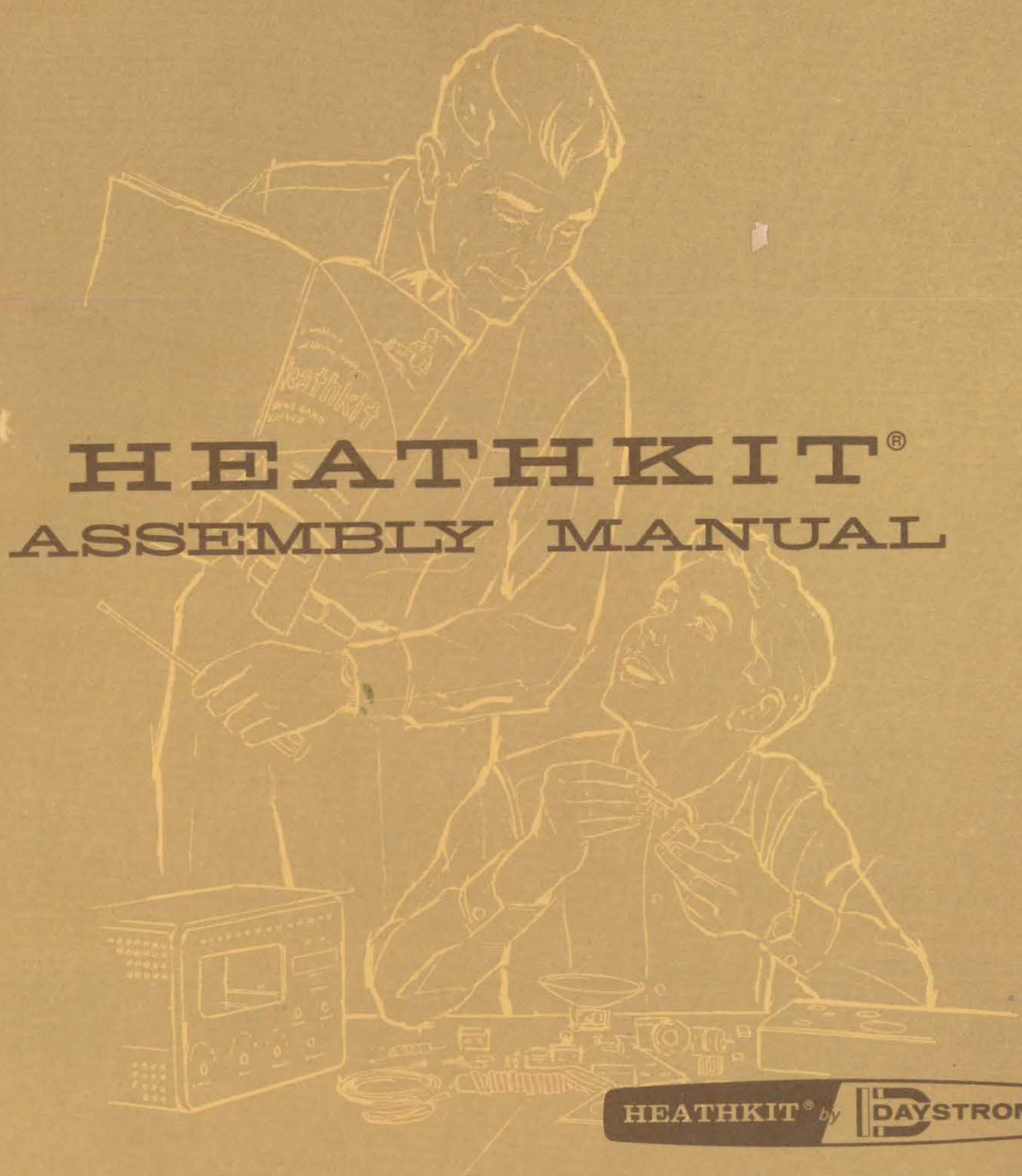


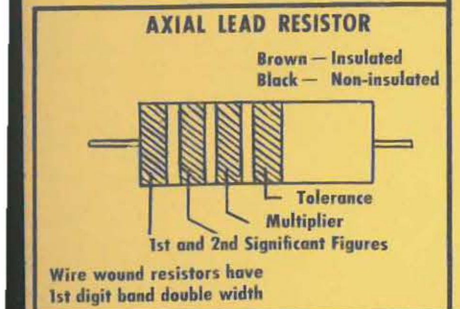
HEATHKIT®
ASSEMBLY MANUAL

HEATHKIT® by DAYSTROM

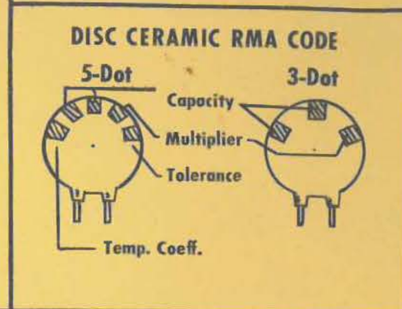
LABORATORY OSCILLOSCOPE

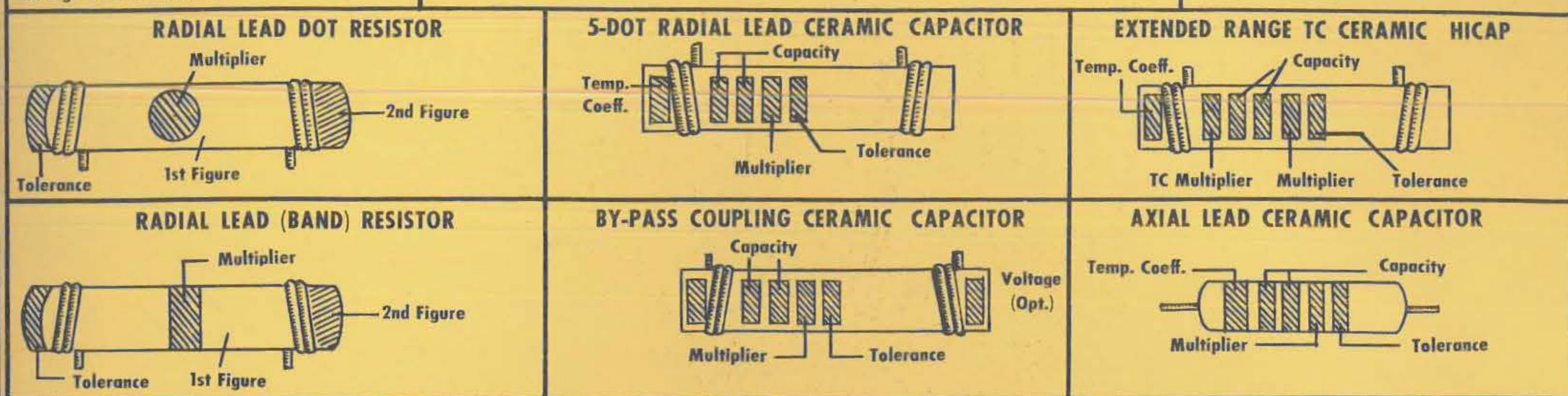
MODEL O-12

STANDARD COLOR CODE — RESISTORS AND CAPACITORS



INSULATED UNINSULATED Color	FIRST RING BODY COLOR First Figure	SECOND RING END COLOR Second Figure	THIRD RING DOT COLOR Multiplier
BLACK	0	0	None
BROWN	1	1	0
RED	2	2	00
ORANGE	3	3	,000
YELLOW	4	4	0,000
GREEN	5	5	00,000
BLUE	6	6	000,000
VIOLET	7	7	0,000,000
GRAY	8	8	00,000,000
WHITE	9	9	000,000,000

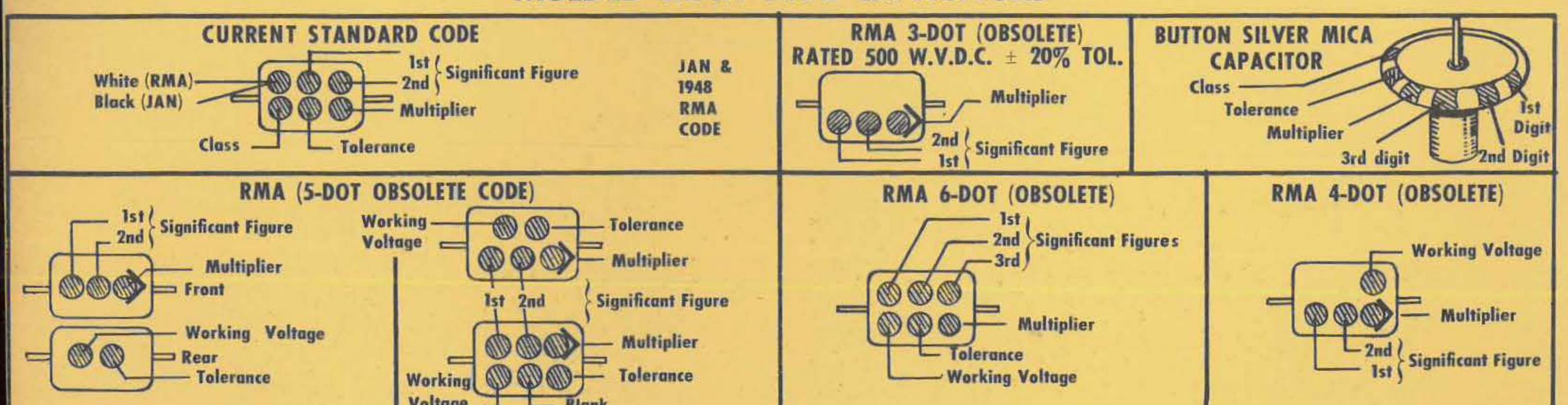




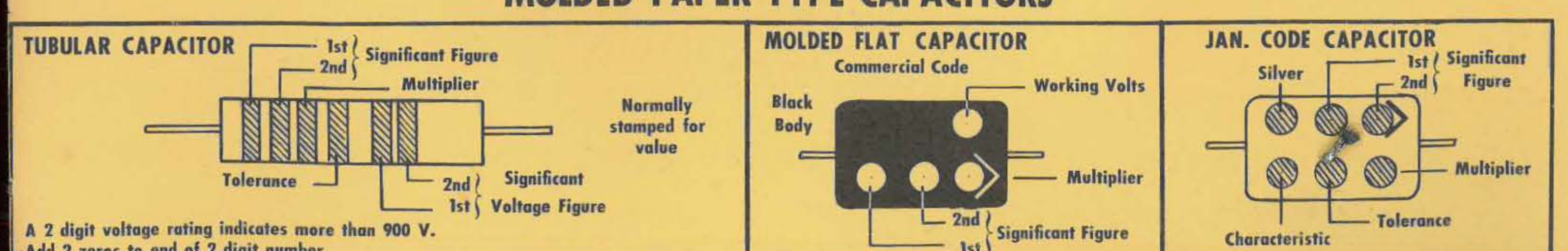
The standard color code provides all necessary information required to properly identify color coded resistors and capacitors. Refer to the color code for numerical values and the zeroes or multipliers assigned to the colors used. A fourth color band on resistors determines tolerance rating as follows: Gold = 5%, silver = 10%. Absence of the fourth band indicates a 20% tolerance rating.

The physical size of carbon resistors is determined by their wattage rating. Carbon resistors most commonly used in Heathkits are ½ watt. Higher wattage rated resistors when specified are progressively larger in physical size. Small wire wound resistors ½ watt, 1 or 2 watt may be color coded but the first band will be double width.

MOLDED MICA TYPE CAPACITORS



MOLDED PAPER TYPE CAPACITORS



The tolerance rating of capacitors is determined by the color code. For example: red = 2%, green = 5%, etc. The voltage rating of capacitors is obtained by multiplying the color value by 100. For example: orange = 3 × 100 or 300 volts. Blue = 6 × 100 or 600 volts.

In the design of Heathkits, the temperature coefficient of ceramic or mica capacitors is not generally a critical factor and therefore Heathkit manuals avoid reference to temperature coefficient specifications.

Courtesy of Centralab

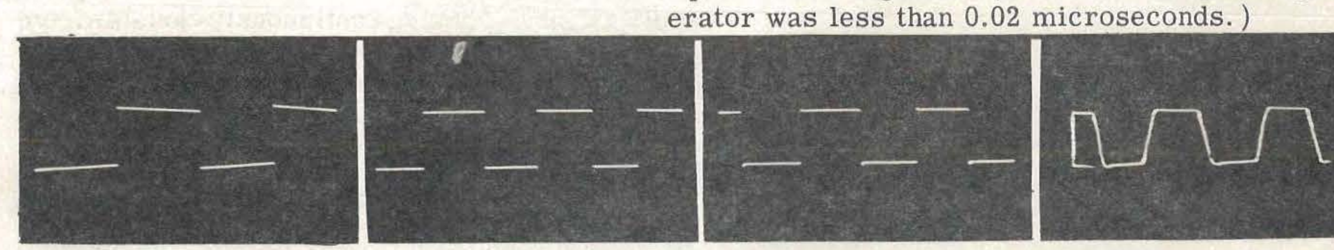
Heathkit Laboratory Oscilloscope

MODEL O-12

SPECIFICATIONS

Vertical Channel:

Sensitivity.......... 0.025 volts (RMS) per inch at 1 kc.
Frequency Response.......... Flat within ±1 db from 8 cps, to 2.5 mc.
Flat, +1.5 to -5 db; 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.
Transient Response.......... Oscillograms below are unretouched displays of square wave signals. (Rise time of source generator was less than 0.02 microseconds.)



50 CPS | 1000 CPS | 100 KC | 1 MC

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.......... Special 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 instantaneous and free of drift.

11/4/60

Horizontal Channel:

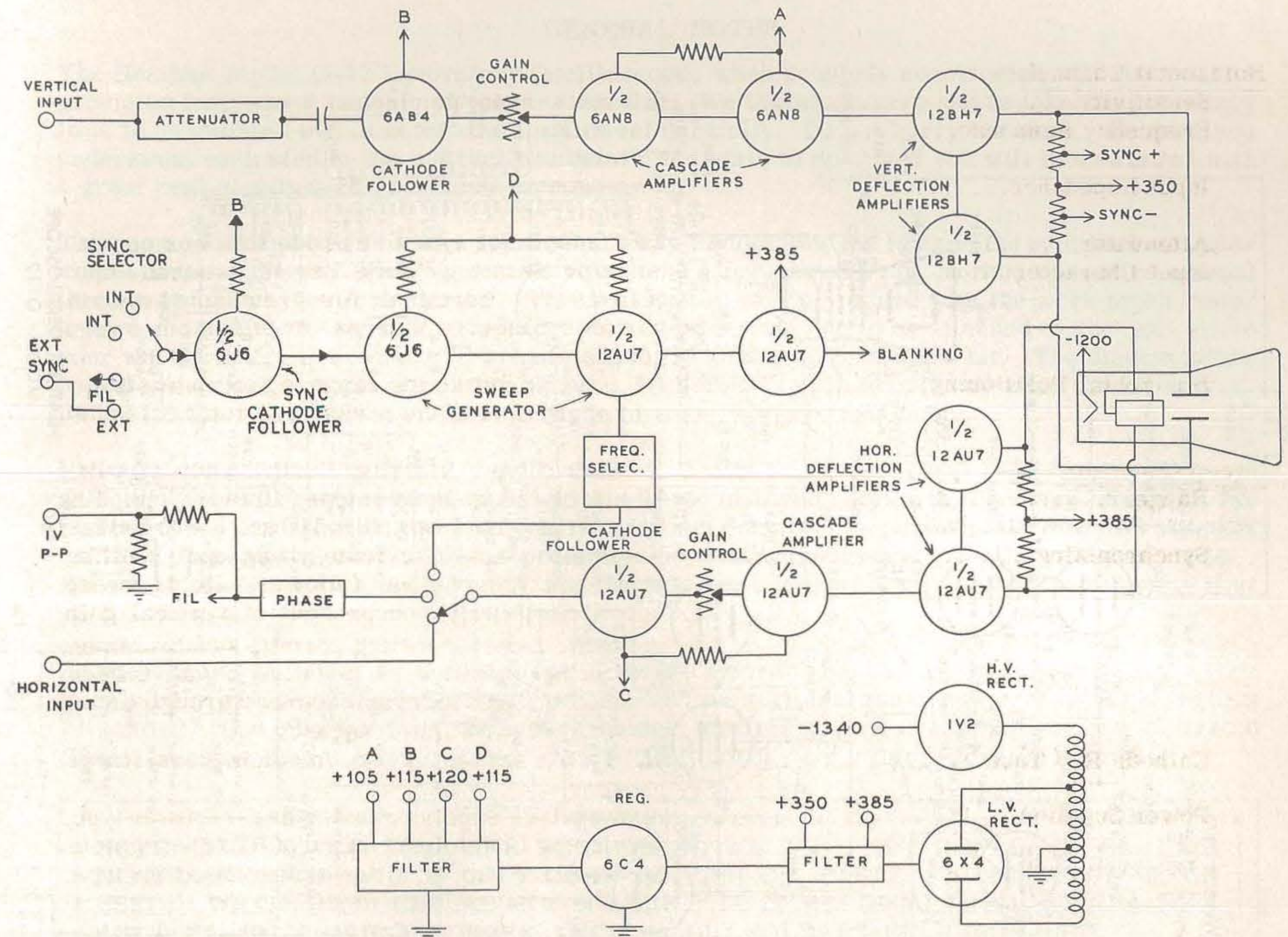
Sensitivity	0.3 volts (RMS) per inch at 1 kc.
Frequency Response	Flat within ± 1db 1 cps to 200 kc. Flat within ± 3db 1 cps to 400 kc.
Input Impedance	30 megohms shunted by 31 $\mu\mu$f. (1 kc impedance, 4.9 megohms)
Attenuator	Low impedance type in cathode follower output.
Input Characteristics	Selector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

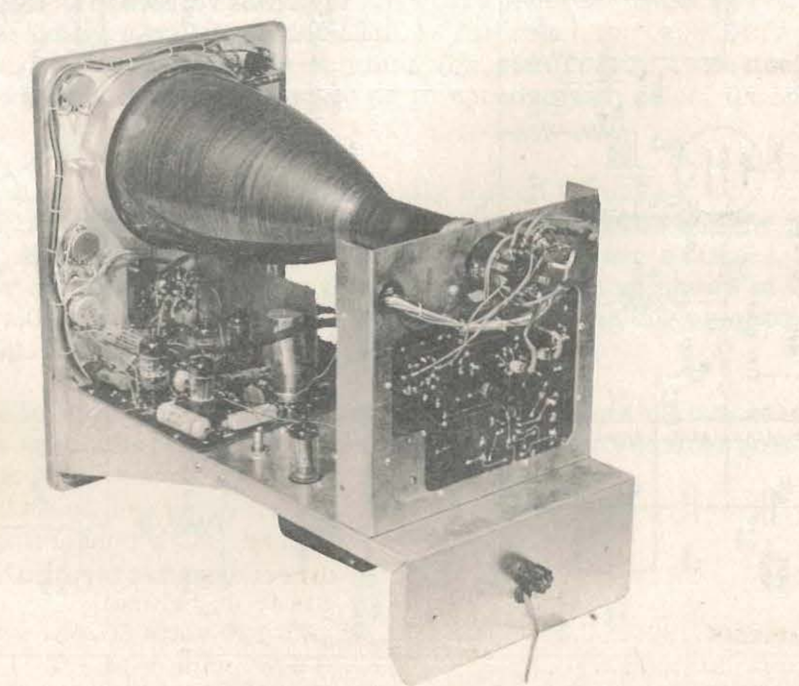
Sweep Generator: Recurrent type, utilizing Heath sweep circuit.

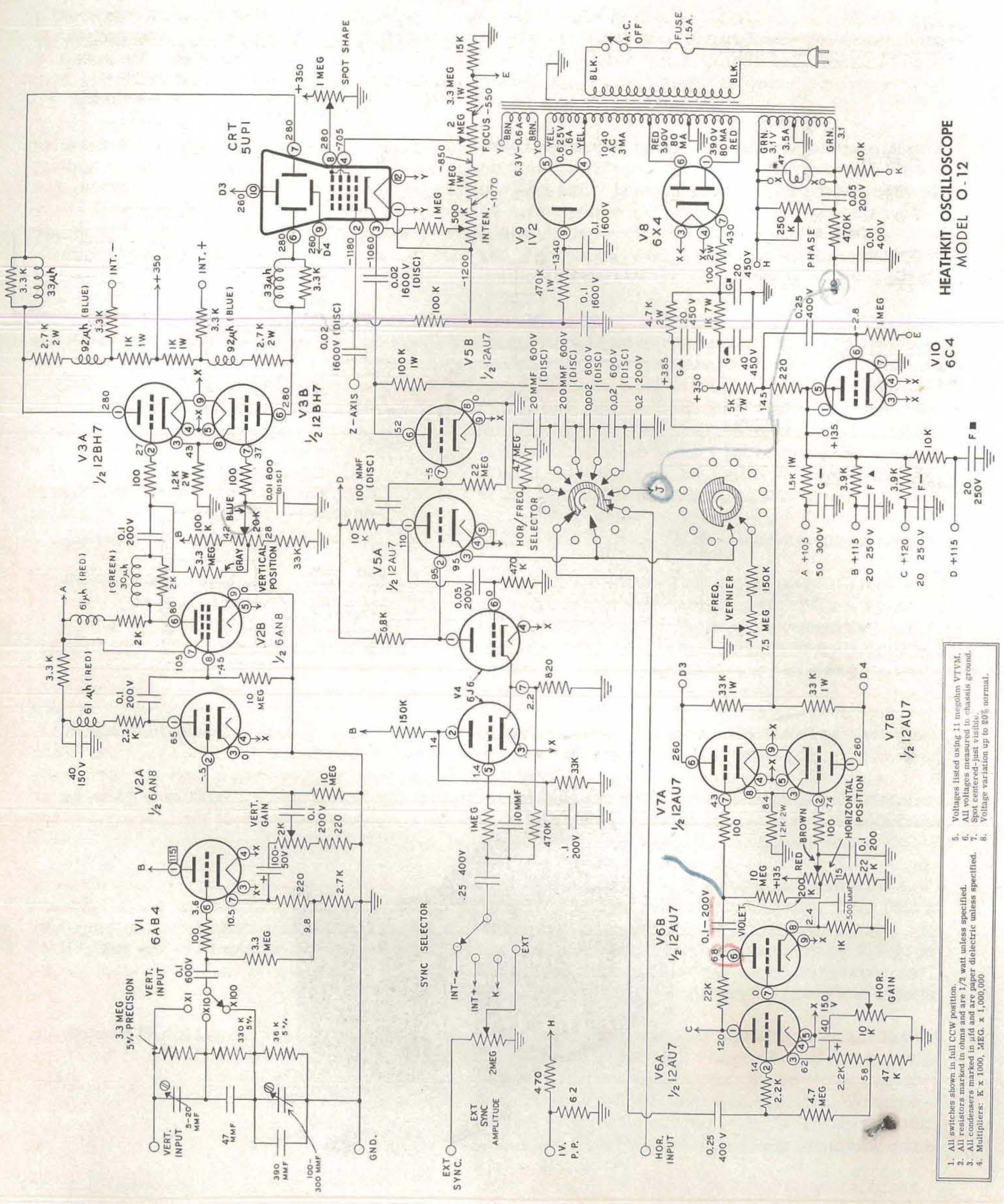
Range	10 cps to 500 kc in five steps: 10 to 100 cps, 100 to 1000 cps, 1 to 10 kc, 10 to 100 kc, 100 to 500 kc.
Synchronizing	Automatic lock-in circuit using self-limiting synchronizing cathode follower. Holds sweep speed essentially independent of vertical gain settings. Selector switch permits synchronizing with either positive or negative signal pulses internally, with external source through panel terminal or with line frequency.
Cathode Ray Tube	5UP1, 5" screen, green medium-persistence phospor.
Power Supplies	High-voltage supply; transformer-rectifier type, developing 1200 volts at output of RC filter system. Low-voltage supply; transformer-rectifier type, full electronic voltage regulation for all critical amplifier, sweep generator and positioning potentials.

General

Retrace Blanking	Blanking interval less than 30% sweep rate regardless of sweep speed. Blanking amplifier provided.
Phasing Control	Provides fully controlled phase shift for line sweep applications. Phasing continuously variable from zero to over 135 degrees.
Voltage Calibrator	Built-in source, 1 volt peak-to-peak; calibrated grid screen and accurately calibrated input attenuator to permit voltage measurements over range of 10,000 to 1 or more.
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 access to CRT socket terminals. No terminals are provided for direct connection, since stray capacities introduced would be detrimental. When required, such connections can be readily made direct to socket terminals, without removing chassis from cabinet.
Power Requirements	105-125 volts 50-60 cycles AC at 80 watts; fused.
Dimensions	8 5/8" wide x 14 1/8" high x 16" deep.
Net Weight	20 1/2 lbs.
Shipping Weight	21 lbs.







GENERAL NOTES

The Heathkit model O-12 Laboratory Oscilloscope, when properly constructed will represent a precision instrument capable of years of service. We therefore urge you to take the necessary time to assemble, wire and test the instrument carefully. Do not hurry the work. Be sure you understand each step in the instructions before you start to do it and you will be rewarded with a great deal of satisfaction.

This manual is supplied to assist you in every way to complete the instrument with the least possible chance for error. We suggest that you take a few minutes now to read the entire manual through before any work is started. This will enable you to proceed with the work much faster when construction is started. The large fold-in pictorials are to be attached to the wall above your work space. Their use will greatly simplify the completion of the kit. The diagrams are repeated in smaller form within the manual. Be sure to retain the manual after the kit is completed for future reference and maintenance of your Heathkit instrument.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with the parts involved. Refer to the charts shown on the inside covers of the manual to help you identify any doubtful components. If some shortage is found in checking, please notify us promptly and return the inspection slip with your letter. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

Read the notes on soldering on the inside of the back cover. Crimp all leads tightly to the terminals before soldering. Be sure both the lead and the terminal are clean and bright before heat is applied. Use only the best rosin core solder, preferably one containing the new activated fluxes, such as Kester "Resin-Five," Ersin "Multicore" or similar types.

> NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

Resistors and controls generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on capacitors are generally even greater. Limits of +100% and -50% are common for electrolytic condenser. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished instrument.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are carefully checked before they are approved and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you may find that a 2.2 megohm resistor has been supplied in place of a 2 megohm as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion to you in checking the contents of your kit.

We strongly urge that you follow the wiring and parts layout shown in this manual. The position of wires and parts is quite critical in this instrument and changes may seriously affect the characteristics of the circuit.

NOTES ON CIRCUIT BOARD WIRING

In line with the Heath Company's policy of continual improvement of its instruments, your Heathkit model O-12 Laboratory Oscilloscope utilizes circuit board, or "printed circuit" wiring. The Heath Company is the first kit manufacturer to make use of this advanced technique in kit instruments.

The process of etching, printing or silk screening a wiring pattern on a circuit board is not an untried or experimental process. For years, one of the greatest hazards to quantity production of electronic equipment has been the variable "stray" inductances and capacities caused by the physical placement of leads and components. In critical circuits, these variations become an uncontrollable problem. During the first great expansion of television in the late 1940's, a television tuner was developed using printed-circuit tuned circuits. It was so successful that the technique was applied to millions of military electronic items where absolute uniformity, reliability and low cost were paramount considerations. Today, the advantages of circuit board wiring have made it an almost mandatory system for any commercial electronic manufacturer. Since dip-soldering of many connections at one time reduces labor cost, there is a decided economic advantage to the technique. In kit applications, dip-soldering is not practicable of course. But even more important, is the absolute uniformity of each unit.

It is this predictable uniformity that makes circuit-board wiring a major improvement in kit-constructed electronic instruments. For the first time, you can be sure that your oscilloscope will have the same characteristics as the development model. And, our engineers have been able to incorporate refinements in circuitry which otherwise would have been entirely swamped by the uncontrollable variables and strays introduced by conventional wiring.

HOW A CIRCUIT BOARD IS PRODUCED

It is important to understand how a circuit board is developed and manufactured so that you may fully realize its advantages. The board itself consists of a low-loss phenolic sheet. To one face of this sheet is bonded a layer of pure metallic copper. This bonding process is the result of years of research and development and has successfully passed the most rigid military requirements for electronic equipment. The bond is not affected by moisture, aging, etching solutions or normal variations in temperature.

The circuit pattern is developed after many experimental circuit layouts are tried and refined. The circuit is finally reduced to a drawing, bearing in mind necessary clearances for voltage breakdown, capacity effects, elimination of undesired feedback possibilities and a minimum of cross-overs. The final drawing, enlarged several times for greater accuracy, is photographed and a negative of exact size is produced. The copper surface of the circuit board is sensitized and exposed to light through the master negative. An etching process then removes all the copper except that protected by the opaque areas of the negative. The result is a copper "print" of the circuit pattern, as originally drawn.

Necessary holes are punched through the circuit board and circuit components are then mounted. For physical support, these parts are generally mounted on the phenolic side of the board with their leads passed through holes and soldered directly to the pattern. Soldering is simple and quick, using conventional methods.

One word of caution; we recommend that a small iron be used for circuit board soldering. The amount of heat required is much less than used for conventional wiring. Soldering pencils are ideal; a 25 or 50 watt iron is entirely adequate. Soldering guns should be used carefully, since they produce heat in direct ratio to length of time the switch is closed. Overheating can damage the circuit board and should be avoided. It is not necessary to "sweat" the connections. Any of the radio grades of solder work very well. DO NOT USE SOLDER PASTES OR OTHER EXTERNAL FLUXES, as they will completely ruin the circuit board.

STEP-BY-STEP ASSEMBLY INSTRUCTIONS

Read the note on assembly on the inside rear cover of the manual before you start work.

A space ( ) has been provided in front of each step so that you can check off each operation as it is completed. This will prevent confusion if your work is interrupted.

BE SURE TO READ EACH STEP ALL THE WAY THROUGH BEFORE YOU START TO DO IT.

CHASSIS SUB-ASSEMBLY

(✓) Refer to Figure 2. Mount the 9-pin socket V9, using 3-48 hardware. Be sure the blank space is located as shown. (Figure 3 shows in detail how socket pins are numbered)

(✓) Mount the 7-pin socket V8, orienting it as shown.

(✓) Install the capacitor mounting wafer at G, using 6-32 screws, nuts and lockwashers. Mount a 4-lug terminal strip AC on one screw as shown. Install the larger filter capacitor. Observe carefully the insulator at the terminal end of the capacitor and notice that each terminal is identified by markings punched adjacent to the lug. Be sure these terminals are oriented as shown in Figure 2. Slip the four mounting lugs through the slots and hold the capacitor can firmly against the wafer. Now twist each of the four mounting lugs about 1/8 of a turn to secure the capacitor to the wafer.

(✓) Install a fuse holder at FH, a rubber washer on the outside chassis, and a lockwasher on the inside chassis.

(✓) Install a 3-lug terminal strip at H, using 6-32 hardware.

(✓) Mount the 1 megohm SPOT SHAPE control QQ, following Figure 4 for assembly details. Use a control solder lug, QQG, in place of a lockwasher.

(✓) Insert a 3/4" rubber grommet at GC. Insert 3/8" rubber grommets at GF and GL.

(✓) Mount the power transformer, being sure that the two black and two yellow leads are nearest socket V9. Use 8-32 hardware. Twist together the two brown leads and pass them through grommet GF.

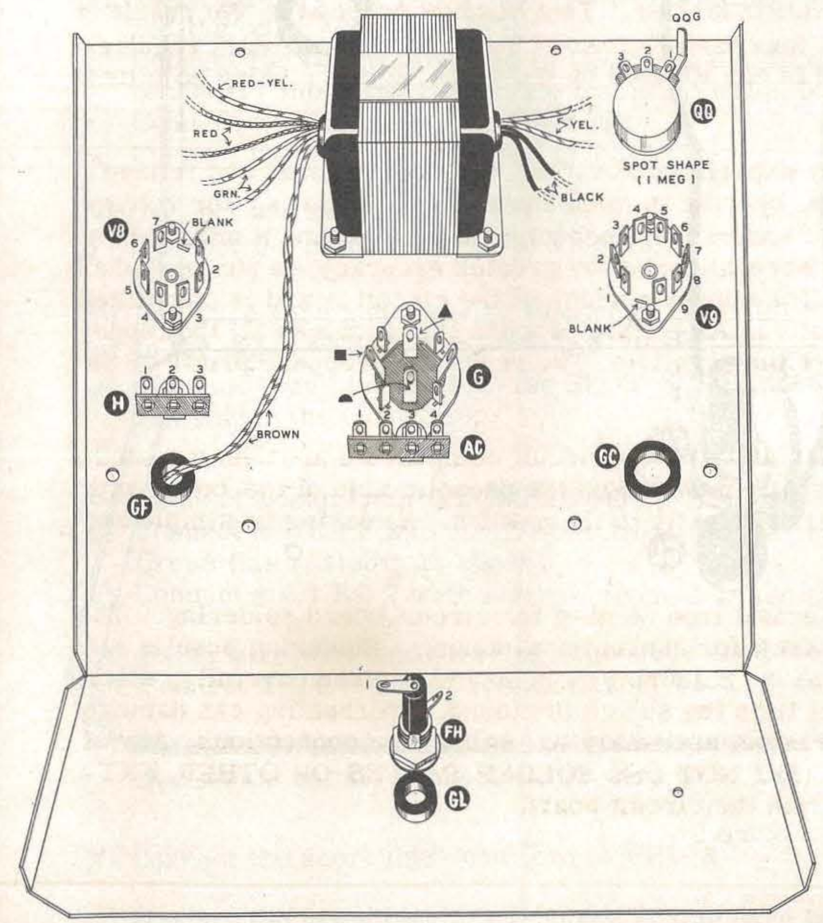


Figure 2

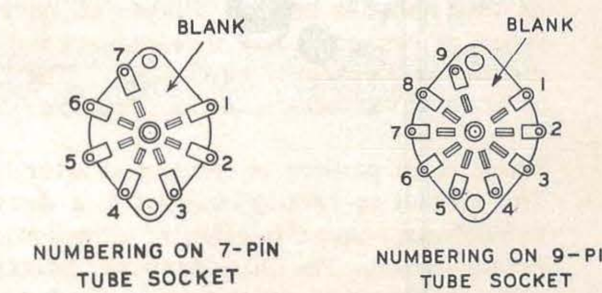


Figure 3

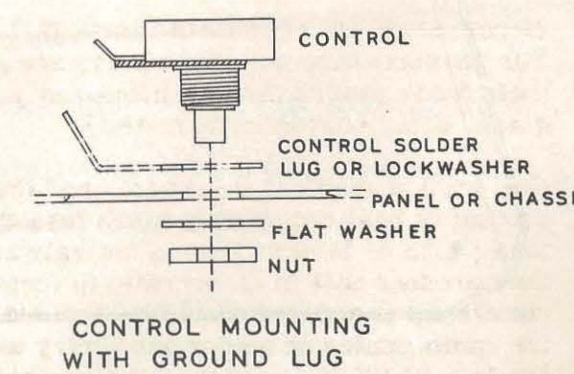


Figure 4

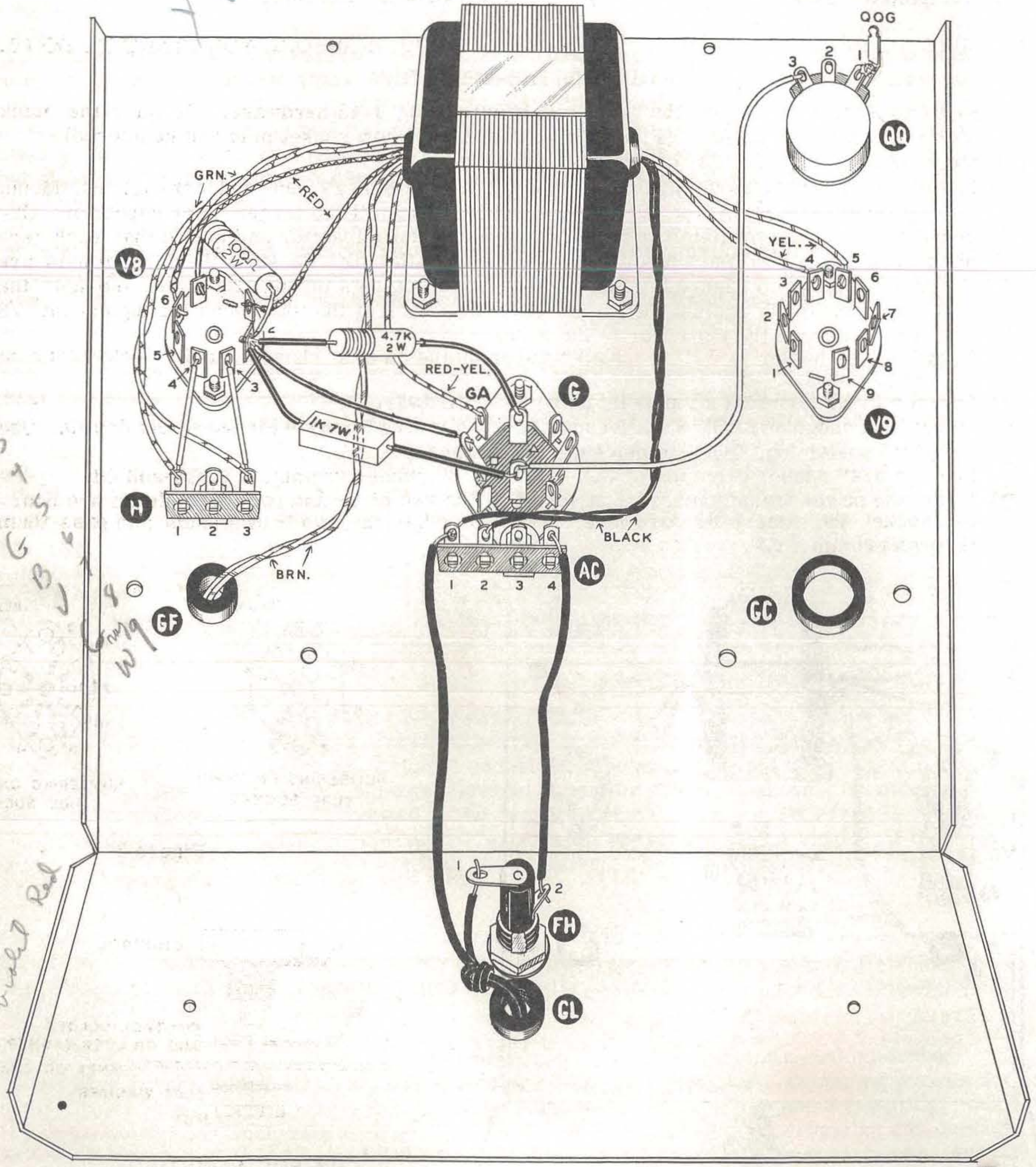


Figure 5

CHASSIS WIRING

We again suggest that you place the large pictorial fold-in diagrams on the wall above your work space so that they may be referred to readily.

Read the notes on the inside rear cover of this manual regarding wiring and soldering. Unless otherwise indicated, all wire used is insulated hookup wire. Wherever a possibility exists of a wire shorting to other parts, the lead should be protected by a length of insulated sleeving. This is indicated by the phrase, "use sleeving, " in the instructions.

Refer to Figure 5 and note that each terminal on each part has been numbered. When the wiring instructions read, "Connect a lead to V9-4, " it will be understood that the connection is to be made to pin 4 on socket V9.

In some cases, more than one connection is made to the same terminal and therefore no soldering should be done until all leads are attached. This is indicated in the instructions by the abbreviation "NS, " (no solder). When the last connection has been made, the joint may be soldered. This is indicated by the symbol "S, " (solder).

The leads on components are generally longer than necessary. These leads should be cut to the proper length, thus resulting in a neater looking instrument. In many instances, excessive lead lengths will actually affect the operation of the instrument and should be avoided.

POWER TRANSFORMER WIRING

(X) Twist together the two black leads from the power transformer. Cut them to proper length to reach terminal strip AC. Strip each lead and connect either one to AC1 (NS) and the other to AC2 (NS).

(X) Twist together the two green leads and in the same fashion, connect either one to H1 (NS) and the other one to H3 (NS).

(X) Connect the red-yellow lead to GA (S) on the filter capacitor and solder at least one of the condenser mounting tabs to the mounting wafer to assure a good ground connection.

(X) Connect one yellow lead to V9-4 (S).

(X) Connect the other yellow lead to V9-5 (S).

(X) Connect one red lead to V8-1 (S).

(X) Connect the other red lead to V8-6 (S).

(X) Use bare wire and sleeving to connect V8-4 (S) to H1 (NS).

(X) In the same way, connect V8-3 (S) to H3 (NS).

(X) Carefully bend lug QQ1 on the SPOT SHAPE control so that it touches the ground lug QQG and solder the connection.

(X) Connect a lead from G ▲ (NS) to QQ3 (NS).

(X) Connect a 1 KΩ 7 watt resistor from G ▲ (use sleeving) (NS) to V8-2 (use sleeving) (NS). Dress this resistor as shown.

(X) Connect a 4.7 KΩ 2 watt resistor from G ▲ (use sleeving) (NS) to V8-2 (use sleeving) (NS).

(X) Using bare wire and sleeving, connect a lead from G ■ (S) to V8-2 (NS).

(X) Connect a 100 Ω 2 watt resistor from V8-7 (S) to V8-2 (S).

(X) Pass the stripped end of the line cord through grommet GL, about 5" from the end, tie a knot for strain relief, connect either wire to AC1 (S). Cut 3 1/2" from the remaining lead.

(X) Connect the short line cord lead to FH1 (S).

(X) Connect the remaining 3 1/2" piece of line cord between FH2 (S) and AC4 (NS).

PANEL SUB-ASSEMBLY

NOTE: Place a soft cloth pad under panel to avoid damage.

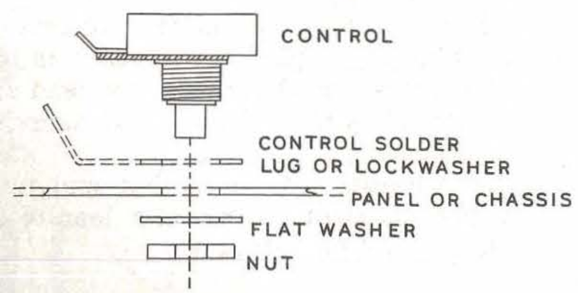
( ) Mount the 500 KΩ INTEN. control AA on the back of the panel, locating the terminals as indicated in Figure 8. Follow Figure 4 for assembly details.

( ) Install the 2 megohm FOCUS control BB.

( ) Mount the 20 KΩ center-tapped VERT. POS. control CC.

( ) Mount the 200 KΩ center-tapped HOR. POS. control DD, using a control solder lug between bushing and panel.

( ) Install the 2 KΩ VERT. GAIN control EE. This control has a dummy lug for use as a tie point.



CONTROL MOUNTING WITH GROUND LUG

Figure 4

( ) Install the 10 KΩ HOR. GAIN control GG.

( ) Mount the 4-terminal VERT. INPUT wafer switch at HH. Be sure the terminals are oriented as shown.

( ) Install the 7.5 megohm FREQ. VERNIER control KK.

( ) Mount the 250 KΩ PHASE control at MM, locating the terminals as shown in Figure 8.

( ) Install the 2 megohm EXT. SYNC. AMPLITUDE control at LL.

( ) Install the 5-terminal SYNC. SELECTOR wafer switch at NN, being sure the terminals are oriented as shown in Figure 8.

( ) Install the pilot lamp PP, following Figure 6 for assembly details. Insert the #47 lamp.

( ) Following Figure 7, install the VERT. INPUT binding post at RR, using the special low-capacity binding post insulators. These are the small round plastic parts drilled for a #6 screw. Note that four pins project from one face of the insulator, so spaced that two of the insulators can be meshed through the panel hole. Before tightening the nut, be sure the cross-drilled wire hole is horizontal. Add a red cap.

( ) In the same way, mount binding posts VV (1 V P-P), SS (EXT. SYNC.) and XX (HOR. INPUT). Be sure the wire hole is horizontal on all three. Put a red cap on XX and black caps on VV and SS.

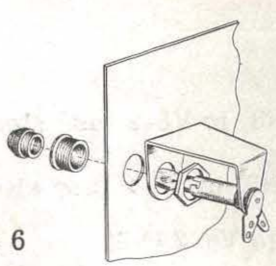


Figure 6

PILOT LIGHT ASSEMBLY

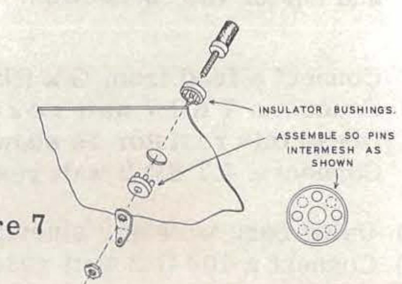


Figure 7

( ) Install the two ground binding posts RRG and XXG. Although these are ground points, use insulated bushings and solder lugs, since a wired ground will be connected to them later. Use black caps. These bushings also make all binding posts equal in height from the front panel so that laboratory-type dual connectors may be used for vertical and horizontal inputs.

( ) Install the tube panel ring in the large hole. The brackets go behind the panel. Use two #6 sheet metal screws through the panel into the bracket holes. Be sure the welded joint in the ring is toward the bottom edge of the panel.

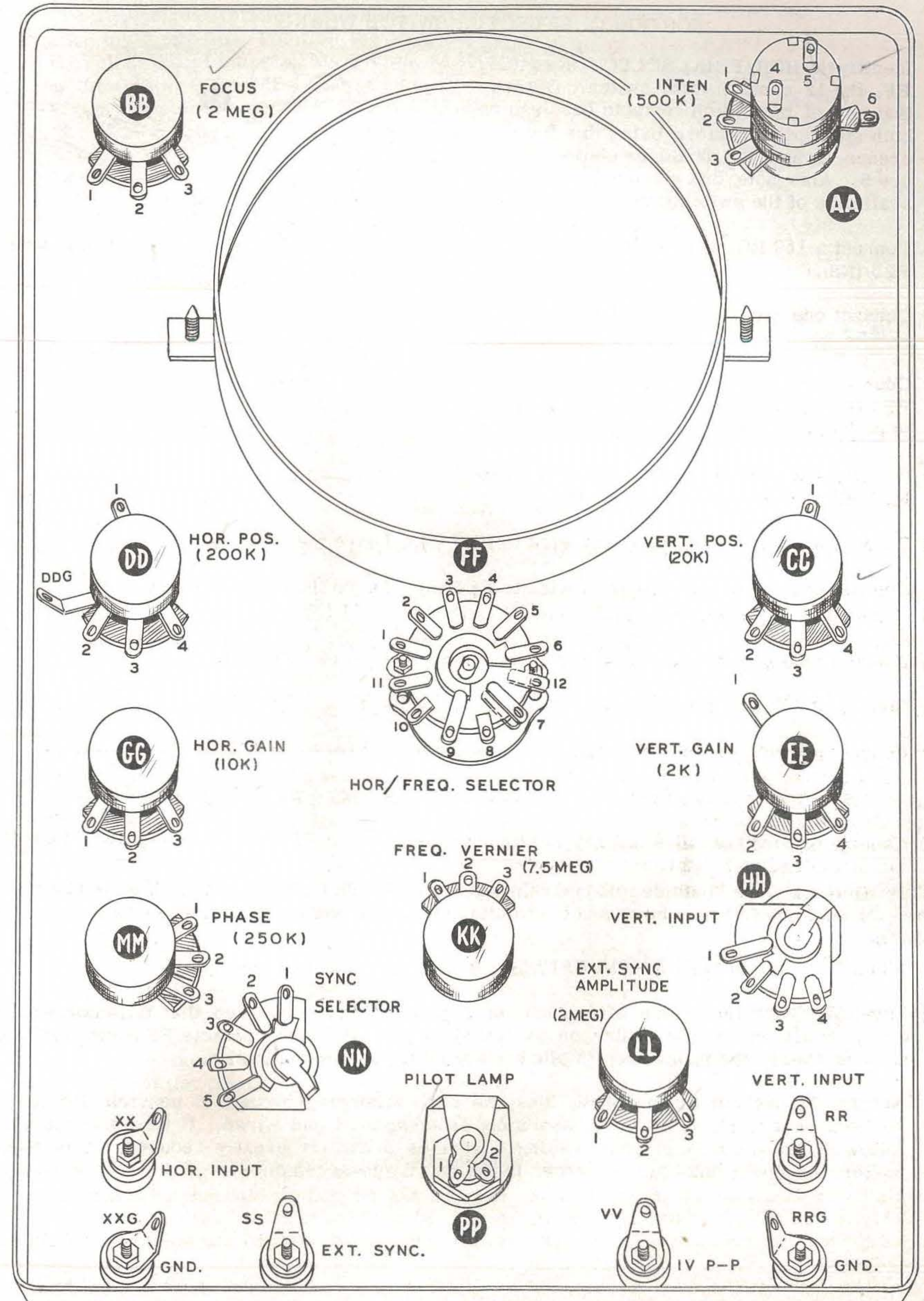


Figure 8

HOR/FREQ. SELECTOR SWITCH WIRING

( ) Identify the HOR/FREQ. SELECTOR switch, FF, the 12-contact wafer switch. Observe that one of the switch contacts has lugs on both sides of the wafer. Using this for reference, orient the switch as shown in Figure 9. Also note that contact 12 is on the shaft side of the switch wafer.

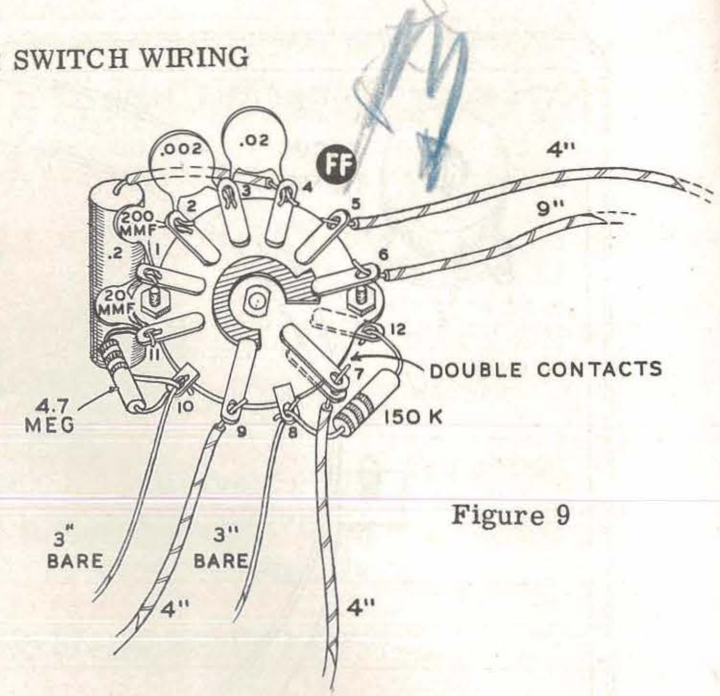


Figure 9

( ) Connect a 150 KΩ resistor from FF12 (S) to FF8 (NS).

( ) Connect one end of a 3" length of bare wire to FF8 (S). Leave the other end free.

( ) Connect one end of a 4" length of wire to FF7 (S). Be sure that this lead is soldered to both of the contacts at the position.

( ) Connect one end of a 4" length of wire to FF9 (S). Leave the other end free.

( ) Connect one end of a 4" length of wire to FF5 (S). Leave the other end free.

( ) Connect one end of a 9" length of wire to FF6 (S). Leave the other end free.

( ) Connect a 4.7 megohm resistor from FF10 (NS) to FF11 (NS).

( ) Connect a 20 $\mu\mu$f ceramic disc capacitor from FF11 (S) to FF1 (NS).

( ) Connect a 200 $\mu\mu$f ceramic disc capacitor from FF1 (S) to FF2 (NS).

( ) Connect a 0.002 μfd ceramic disc capacitor from FF2 (S) to FF3 (NS).

( ) Connect a small 0.02 μfd 600 volt ceramic disc capacitor from FF3 (S) to FF4 (NS).

( ) Connect one lead of a 0.2 μfd molded tubular capacitor to FF4 (use sleeving) (S). Connect the other lead to FF10 (NS).

NOTE: Disregard the "outside foil" markings on molded tubular capacitors. Unless otherwise stated, the outside foil may be connected to either terminal without affecting operation of your instrument.

( ) Add a 3" length of bare wire to FF10 (S). Leave the other end free.

( ) Carefully check the switch wiring against Figure 9. When satisfied that it is correct in every detail, mount the switch on the panel at FF. Be sure contacts FF3 and FF4 are pointing toward the panel ring. Follow Figure 4 for assembly details.

NOTE: Throughout these instructions, we have attempted to make it possible for you to recheck your work as each sub-assembly is completed and wired. If this procedure is followed, the chances of your making a serious error are greatly reduced. It is much easier to uncover and correct errors in the small sub-assemblies.

DUAL TRIMMER WIRING

( ) Identify the dual trimmer assembly by reference to Figure 10. Position the part so that the roll of the trimmer plates is down, as shown in the figure. Connect a 3.3 megohm 5% precision resistor from TT1 (NS) to TT2 (NS).

( ) Connect one end of a 3" bare wire to TT1 (S). Leave the other end free.

( ) Connect a 330 KΩ 5% resistor from TT2 (NS) to UU1 (NS).

( ) Connect a 47 $\mu\mu$f mica capacitor from TT2 (NS) to UU1 (NS).

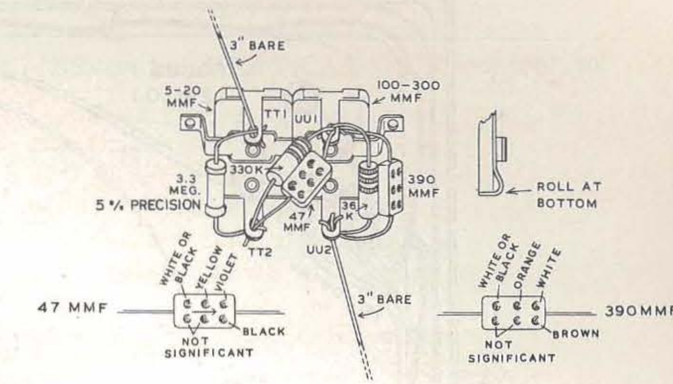


Figure 10

( ) Connect a 36 KΩ 5% resistor from UU1 (NS) to UU2 (NS).

( ) Connect a 390 $\mu\mu$f mica capacitor from UU1 (NS) to UU2 (NS)..

( ) Connect one end of a 3" bare wire to UU2 (S). Leave the other end free.

( ) Identify the left-hand bracket. This is the long triangular bracket with the group of four holes near its shortest side. Mount the dual trimmer assembly as shown in Figure 11, using 6-32 hardware.

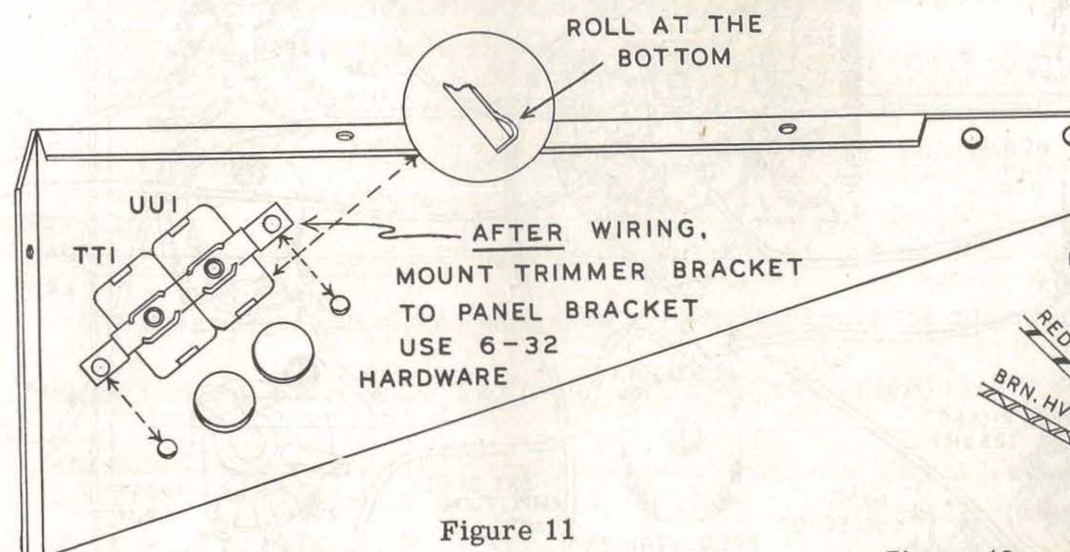


Figure 11

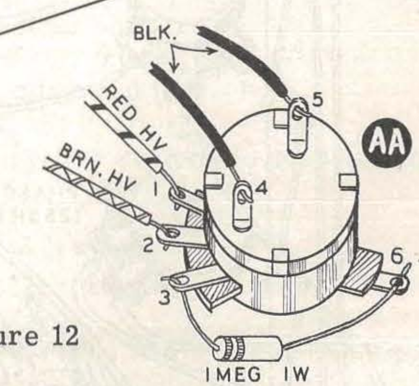


Figure 12

WIRING OF INTENSITY CONTROL

NOTE: Do not mount the left-hand bracket sub-assembly to the panel at this time. This will be done later after the panel wiring is completed.

PANEL WIRING

( ) Connect a 1 megohm 1 watt resistor from AA6 (NS) on the INTEN. control to AA3 (S). See Figure 12.

( ) Connect a lead from AA6 (S) to BB3 (S) on the FOCUS control.

( ) Connect a 22 KΩ resistor from DD2 (S) on the HOR. POS. control to DDG (S).

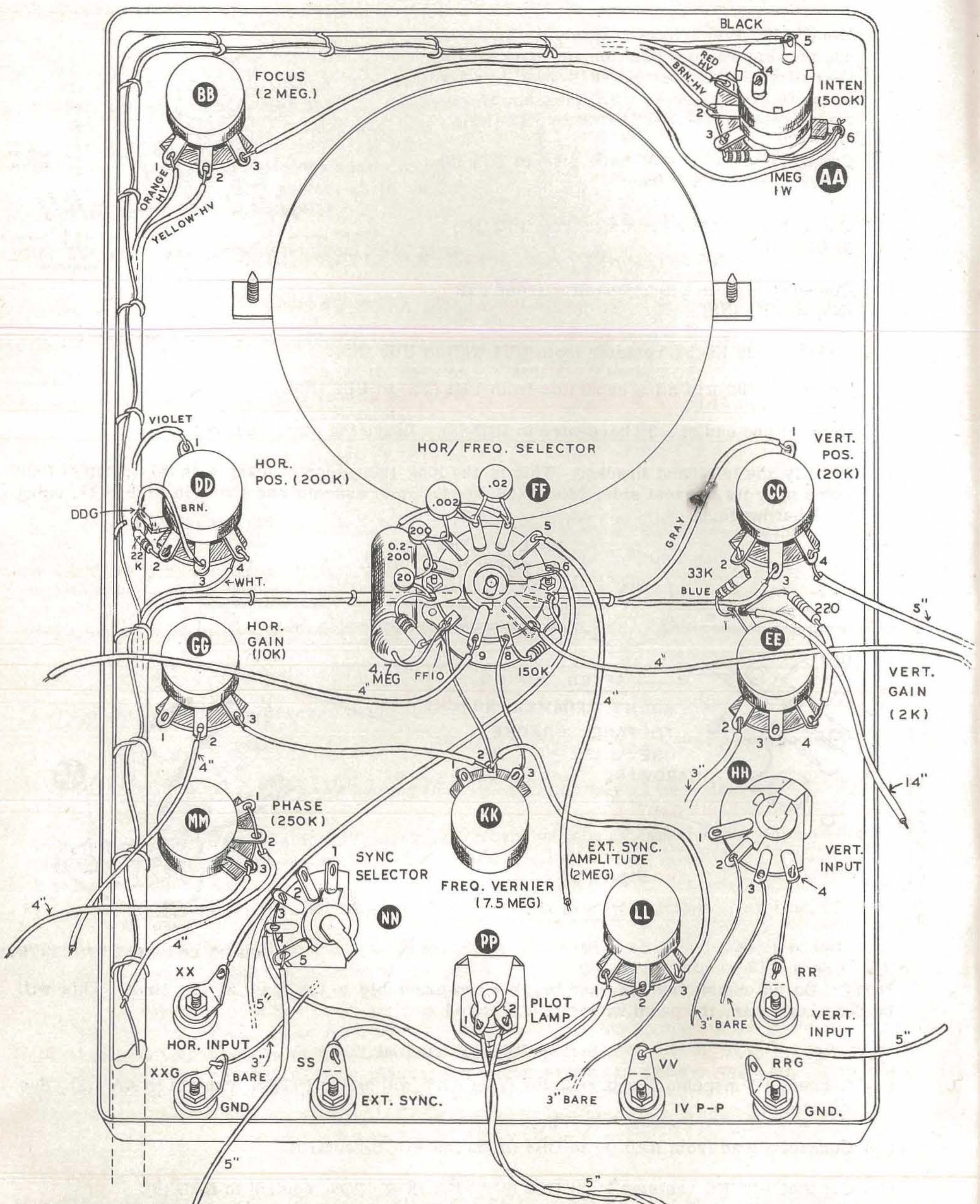


Figure 13

( ) Connect a 33 KΩ resistor from CC2 (S) on the VERT. POS. control to EE1 (NS) on the VERT. GAIN control.

( ) Connect a 220 Ω resistor from EE1 (use sleeving) (NS) on the VERTICAL GAIN control to EE4 (S).

( ) Using bare wire and sleeving, connect GG3 (S) to KK2 (NS).

( ) Connect the short bare wire from FF10 to KK2 (NS).

( ) Connect the wire from FF8 to KK3 (S).

( ) Using bare wire and sleeving, connect KK2 (S) to LL3 (NS).

( ) Connect one end of a 3" bare wire to LL3 (S). Leave the other end free.

( ) Connect the free end of the wire (previously soldered to FF6 on the HOR/FREQ. SELECTOR switch) to XX (S), the HOR. INPUT binding post.

( ) Connect one end of a 5" wire to CC4 (S) on the VERT. POS. control. Leave the other end free.

( ) Connect one end of a 14" wire to EE1 (S) on the VERT. GAIN control. Leave the other end free.

( ) Connect one end of a 3" wire to EE2 (S). Leave the other end free.

( ) Connect one end of a 4" wire to GG2 (S) on the HOR. GAIN control. Leave the other end free.

( ) Connect a short bare wire from HH4 (S) on the VERT. INPUT switch to RR (NS), the VERT. INPUT binding post.

( ) Connect one end of a 3" bare wire to HH2 (S). Leave the other end free.

( ) Connect one end of a 3" bare wire to HH3 (S). Leave the other end free.

( ) Connect a wire from LL2 (S) on the EXT. SYNC. AMPLITUDE control to NN4 (S) on the SYNC. SELECTOR.

( ) Connect a wire from LL1 (S) to the EXT. SYNC. binding post SS (S).

( ) Connect one end of a 5" wire to VV (S), the 1 V. P-P binding post. Leave the other end free.

( ) Connect one end of a 5" wire to NN5 (S) on the SYNC. SELECTOR switch. Leave the other end free.

( ) Connect one end of a 5" wire to NN3 (S). Leave the other end free.

( ) Connect one end of a 4" length of wire through MM2 (NS) on the PHASE control, to MM1 (S). Now solder MM2. Leave the other end free.

( ) Connect one end of a 4" length of wire to MM3 (NS). Leave the other end free.

( ) Connect one end of a 3" bare wire to XXG (S). Leave the other end free.

( ) Twist together two 5" lengths of hookup wire. Strip all four ends. At one end of this pair, connect either lead to PP1 (S). Connect the other lead to PP2 (S). Leave the other ends free.

(✓) Identify the panel end of the wiring harness or cable. This is the end with four leads, two black conductors with thin insulation and two conductors with thick, or high-voltage insulation. These high-voltage conductors are color coded brown and red. The abbreviation HV, will refer to the conductors with heavy-wall insulation.

(✓) Place the panel end of the cable near the INTEN. control AA. Connect the brown HV lead to AA2 (S).

(✓) Connect the red HV lead to AA1 (S).

(✓) Connect either of the black leads to AA4 (S) and the other to AA5 (S).

(✓) Dress the cable along the top edge of the panel to the FOCUS control, then down along the "horizontal channel" side of the panel (the right edge viewed from the front). Near the FOCUS control, connect the orange HV lead to BB1 (S).

(✓) Connect the yellow HV lead to BB2 (S).

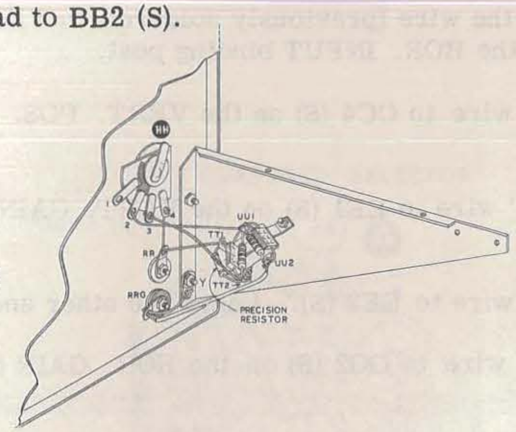


Figure 14

(✓) Just below the HOR. POS. control, dress the branch of the cable with the gray and blue wires across the panel, between the tube ring and the HOR/FREQ. SELECTOR switch, to the VERT. POS. control. Connect the gray wire to CC1 (S).

(✓) Connect the blue wire to CC3 (S).

(✓) Connect the violet wire to DD1 (S) and the brown wire to DD3 (S).

(✓) Connect the white lead to DD4 (S).

(✓) Next assemble the left-hand bracket to the front panel using 6-32 Binder Head Screws. Place a solder lug Y under the lower nut, as shown in Figure 14.

(✓) Connect the bare wire (previously soldered to TT1) to RR (S), the VERT. INPUT binding post.

(✓) Connect the bare wire (previously soldered to HH3) to TT2 (S).

(✓) Connect the bare wire (previously soldered to HH2) to UU1 (S).

(✓) Connect the bare wire (previously soldered to UU2) to RRG (NS) (use sleeving), the VERT. GND. binding post.

(✓) Connect a short wire from RRG (S) to the solder lug Y (NS).

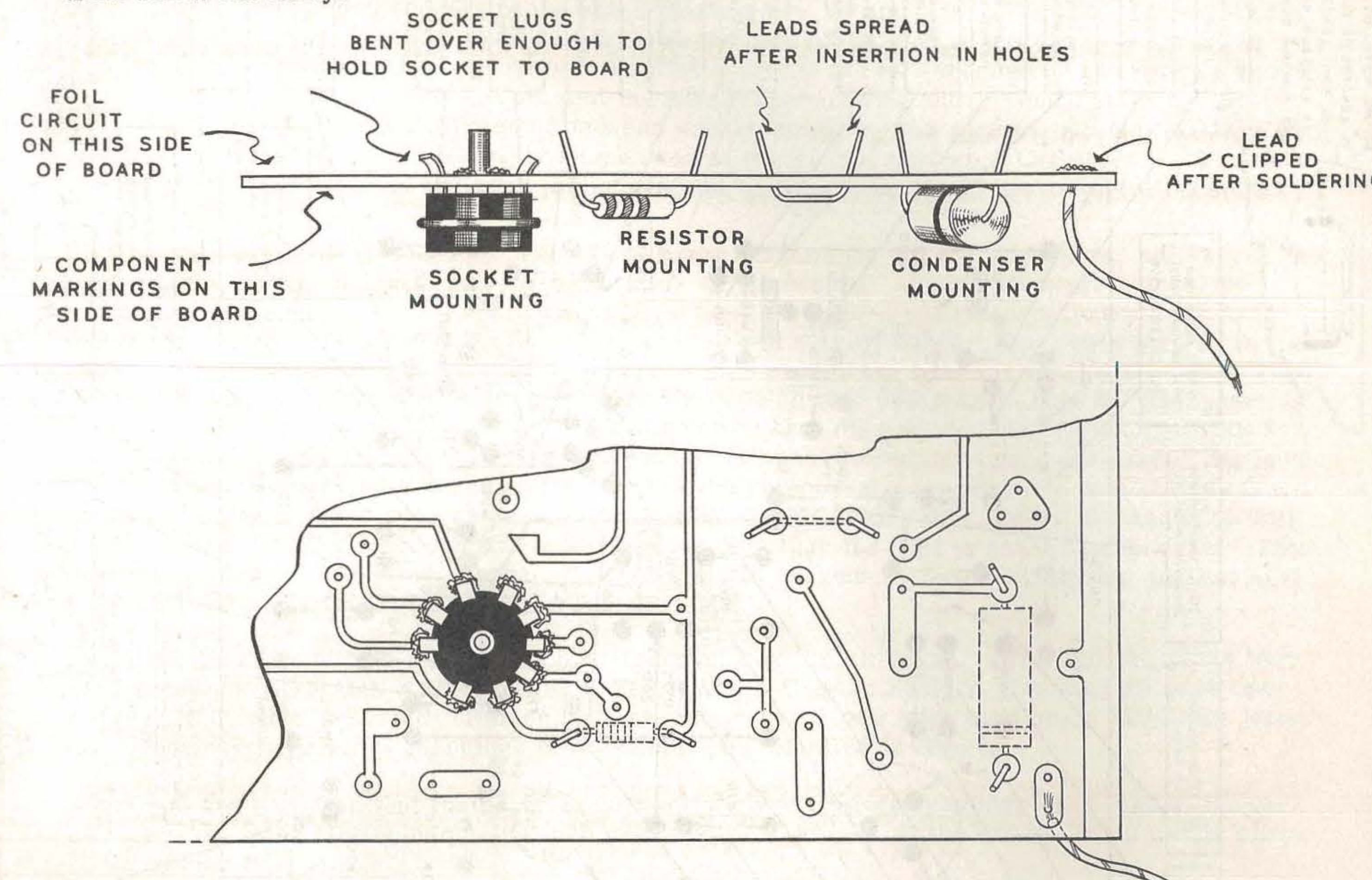
(✓) Connect the short bare wire (previously soldered to LL3, the EXT. SYNC. AMPLITUDE control) to Y (S).

(✓) Now mount the right-hand bracket using 6-32 Binder Head Screws, again using a solder lug Z under the lower screw.

(✓) Connect the short bare wire (previously soldered to XXG, the HOR. GND. binding post) to lug Z (S). (See Figure 20).

CIRCUIT BOARD WIRING

Before attempting any work on the circuit boards, study Figure 15 and read the general instructions below carefully.



GENERAL CIRCUIT BOARD WIRING PRACTICE

Figure 15

The following general rules are very simple and a few minutes spent in learning them will be an excellent investment. The growing application of circuit boards to all electronic equipment will soon require all technicians to be familiar with these practices:

1. NEVER USE SO-CALLED "NON-CORROSIVE" PASTES OR OTHER FLUXES. The copper foil on the circuit board has been specifically processed for ease in soldering. It will take solder perfectly, provided radio-grade rosin-core solder is used. Very little solder is required to make a perfect connection. Try to prevent flow of flux onto the circuit board proper.

2. DO NOT OVERHEAT THE CONNECTION. A 25 or 50 watt iron is entirely adequate for circuit board wiring. A soldering pencil is ideal. If a soldering gun is used, be very careful to avoid excessive heating. Try to develop a technique to "solder it and get off."

3. Remember that components are generally placed on the phenolic side of the board, with their leads passing through holes to the foil side of the board. Bend the leads slightly to prevent parts falling out as they are mounted. It is generally easier to mount most or all the parts in this way and then solder all the connections at one time.

4. The markings on the phenolic side of the board are there to assist you in wiring and to expedite your assembly. Follow the wiring sequence diagrams (Figures 16, 17, 18 and 19) so that no parts or jumpers are omitted.

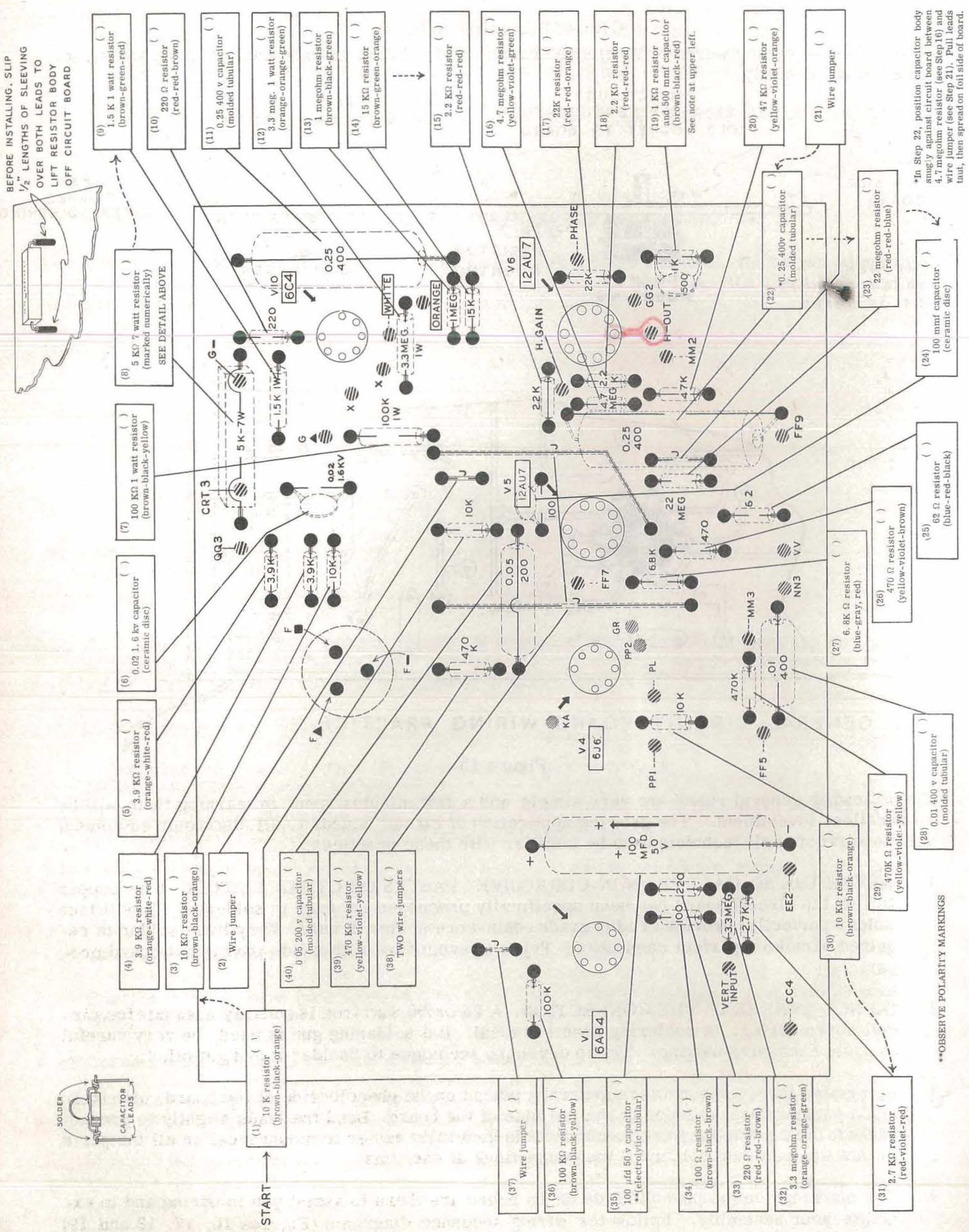


Figure 16

FRONT (LARGE) CIRCUIT BOARD WIRING

(✓) Insert 7-pin molded sockets in the holes marked V1, V4 and V10. The body of the socket goes on the phenolic side of the board, with the contact extending through to the pattern or foil side. Align the blank space of the socket with the arrow screened on the side. Fan out the socket contacts enough to prevent the socket from falling out. Then 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. Carefully solder each contact to the adjacent pattern. Do not attempt to cut off the top of the contact after soldering.

(✓) Next install the 9-pin sockets V5 and V6.

Figure 16 is the wiring sequence diagram for the front 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 5 KΩ 7 watt resistor in Step 8. This part is mounted above the circuit board to provide for 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 sharply down as near the component body as possible. IF THE PART DOES NOT SEEM TO MATCH THE HOLES, RECHECK YOUR WORK. It is very possible that the part is not the proper one. Slip both leads through the holes, spread them slightly to prevent the part falling out, but DO NOT CUT OFF EXCESS LEAD LENGTHS AT THIS TIME.

Note that there is a space ( ) in each instruction box for checking. After all the parts have been mounted, GO BACK AND RECHECK YOUR WORK COMPLETELY, checking off each operation in the space provided. Remember, an error found now will save much difficulty later on. Observe the polarity markings of the condenser installed in Step 35.

After you are satisfied that the board is correctly wired, carefully solder each lead to the circuit pattern, using the technique outlined previously. Then cut off the excess leads neatly close to the solder fillet.

AFTER the operations outlined in Figure 16 have been completed: ok

(✓) Mount the remaining filter capacitor can at F. Match the markings stamped in the insulator at the base of the capacitor, with those screened on the phenolic side of the board. DO NOT attempt to mount this capacitor by twisting the mounting lugs in conventional fashion, but 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.

REAR (SMALL) CIRCUIT BOARD WIRING

(✓) Mount the three 9-pin sockets and fan out the leads. 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 Figure 18. Then solder the sockets in place, being sure that the short jumper is well soldered to the contacts, as they are soldered to the pattern.

Following Figure 19, proceed to complete the rear circuit board. Start at the top center 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.

Follow the general procedure outlined for the front circuit board regarding assembly, soldering and lead clipping.

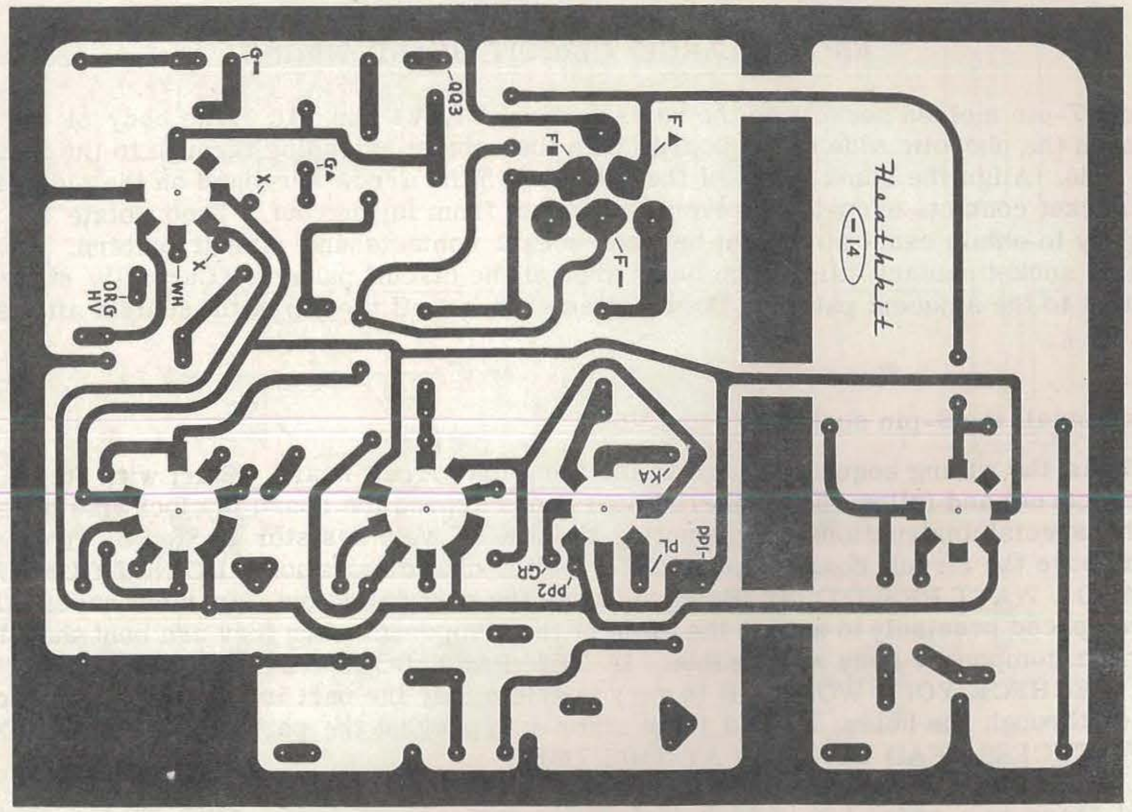


Figure 17

Bk-0
Br-1
R-2
O-3
Y-4
G-5
B-6
V-7
G-8
W-9

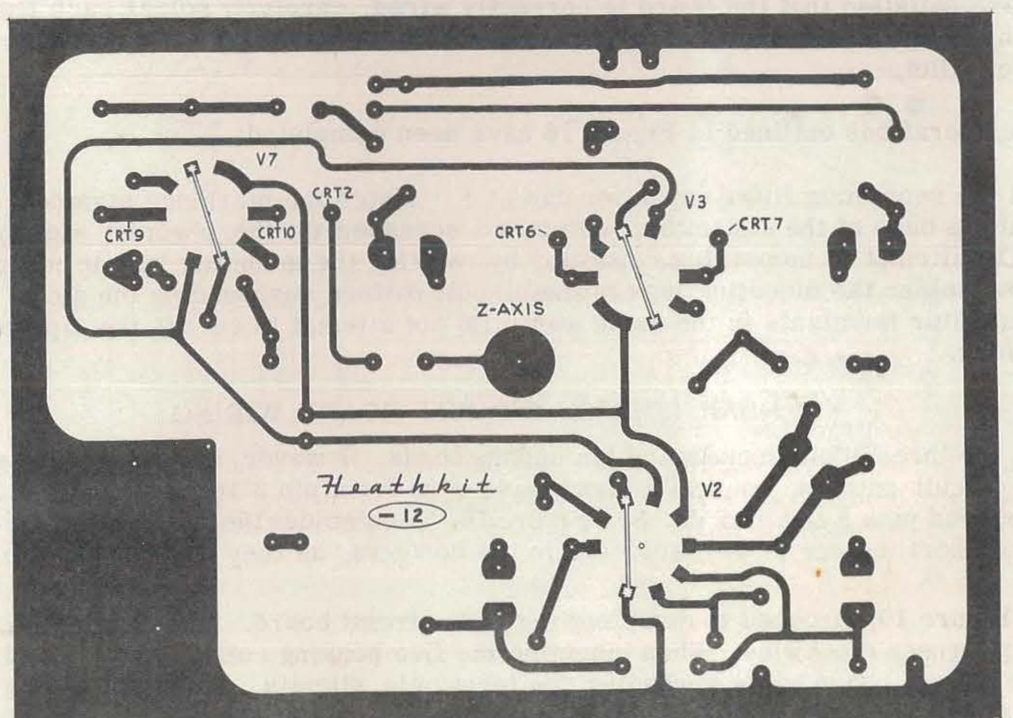


Figure 18

NOTE: Make sure jumper wires are installed between pins 3 and 8 on V3 and V7 and between 3 and 9 on V2. See the last step on Page 19.

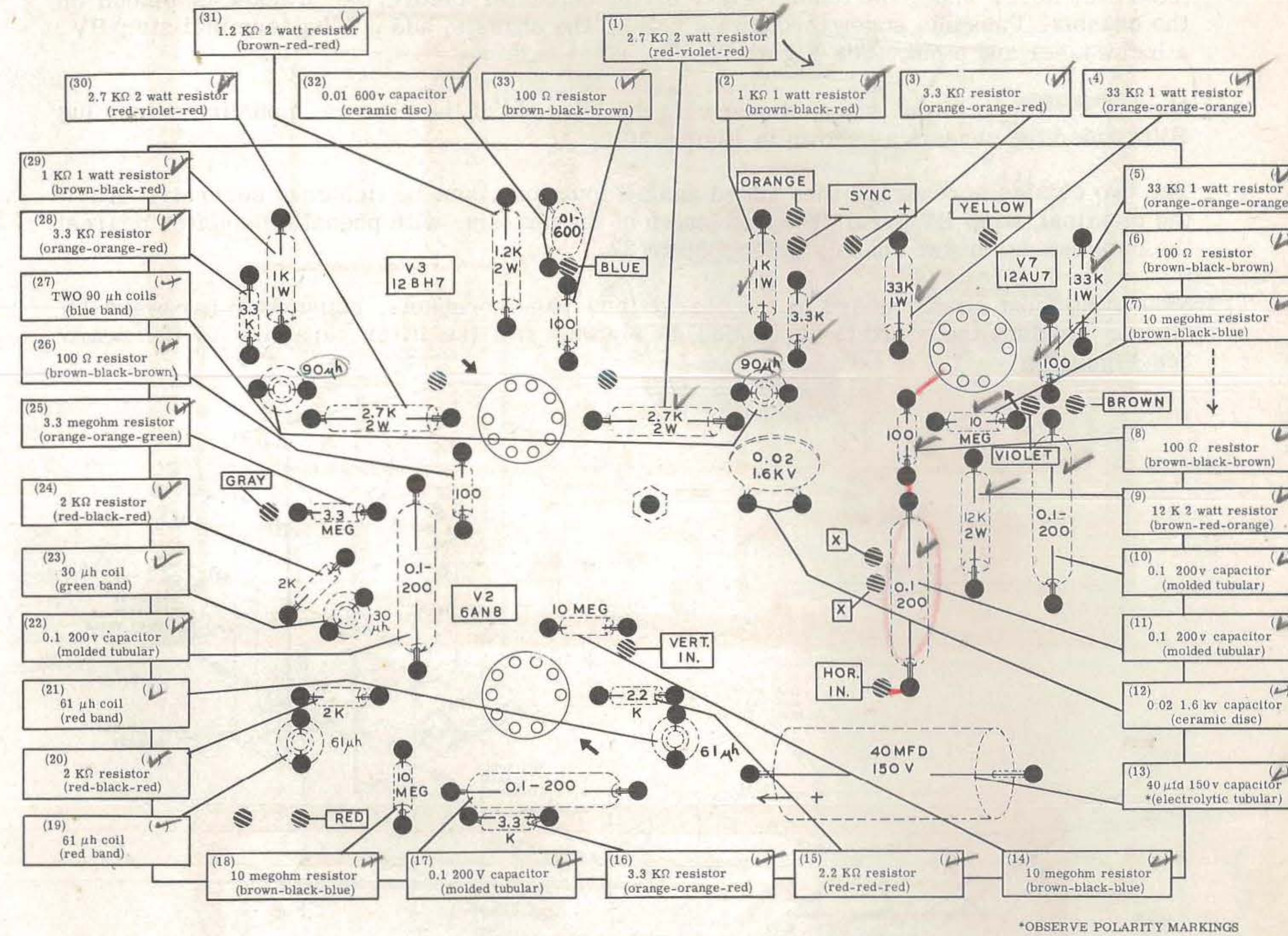


Figure 19

AFTER the operations outlined in Figure 19 are completed:

(✓) Assemble the Z-axis binding post to the circuit board using the 5/32" hole provided. The body of the binding post goes on the foil side of the circuit board. Use a 6-32 nut and lockwasher on the phenolic side. (See Figures 18 and 28.) Add a black cap.

(✓) Now mount the rear circuit board inside the tube-support bracket, following Figure 20 for assembly details. Use 3-48 hardware. The foil side of the board goes toward the rear of the instrument and the tubular electrolytic capacitor goes at the bottom.

FINAL ASSEMBLY

(✓) Attach the front panel and bracket assembly to the chassis, using 6-32 hardware as shown in Figure 20. Be sure the panel brackets go inside the chassis lip. Before tightening these screws be sure the chassis and panel bracket lips are aligned so no "droop" exists at the center. Then tighten the screws securely. Be sure cable is inside bracket.

( ) Mount the tube-support bracket to the chassis, using 6-32 hardware. It will be helpful to insert the screw under the tubular electrolytic capacitor before the bracket is placed on the chassis. Pass this screw through its hole in the chassis, add a 2-lug terminal strip HV, a lockwasher and a nut. See Figure 20.

( ) Next, install the similarly placed screw on the left side of the chassis, mounting solder lug HVG under the chassis as shown in Figure 20.

( ) The two outside screws are then added and all four may then be tightened securely. Align the terminal strip HV parallel to the length of the chassis, with phenolic insulator nearest the outside edge of the chassis. (See Figure 22.)

( ) Mount the front circuit board to the chassis and panel brackets, using 3-48 hardware as shown. Be sure the board is positioned as shown, with the filter capacitor to the rear. See Figure 20.

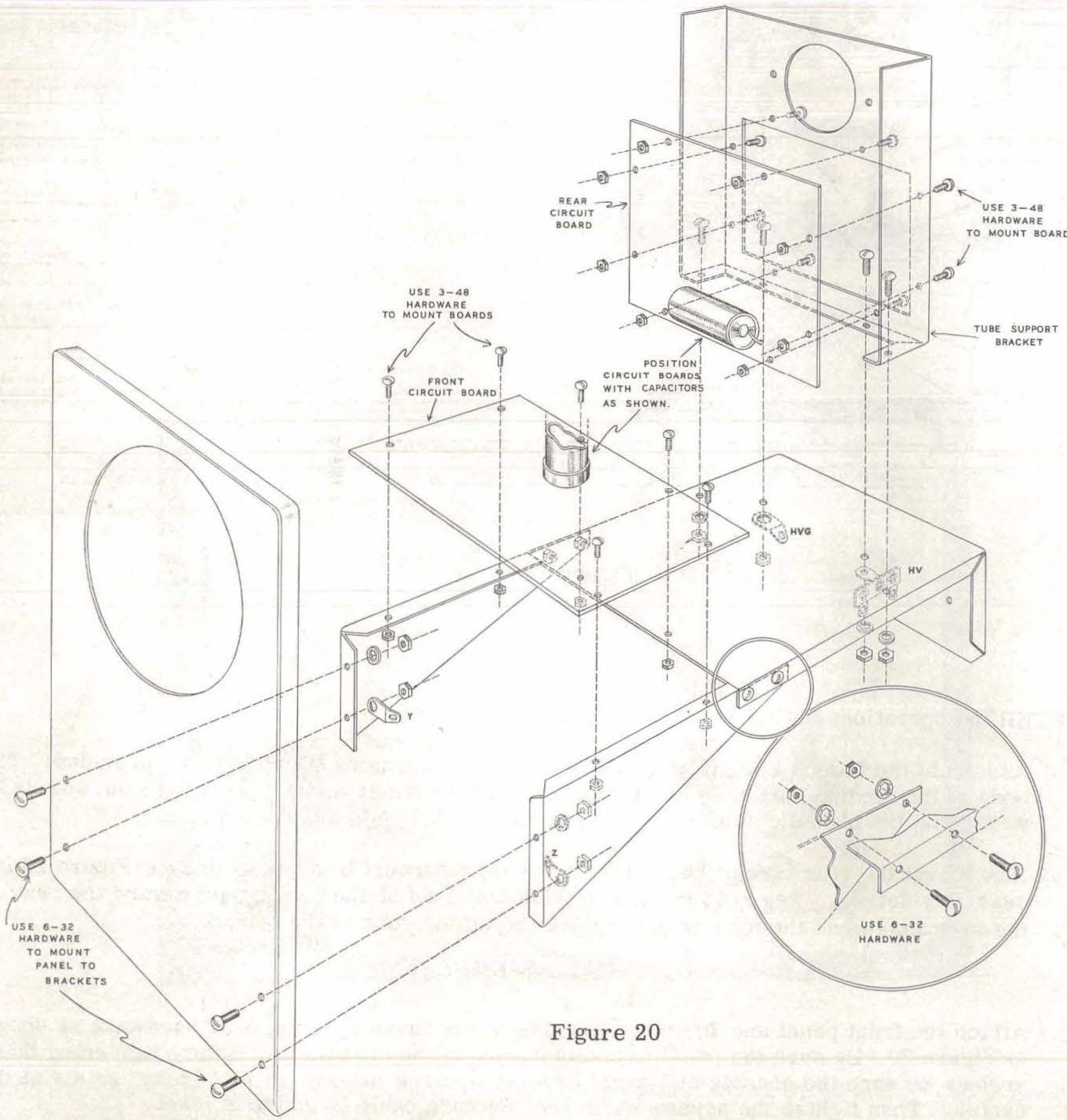


Figure 20

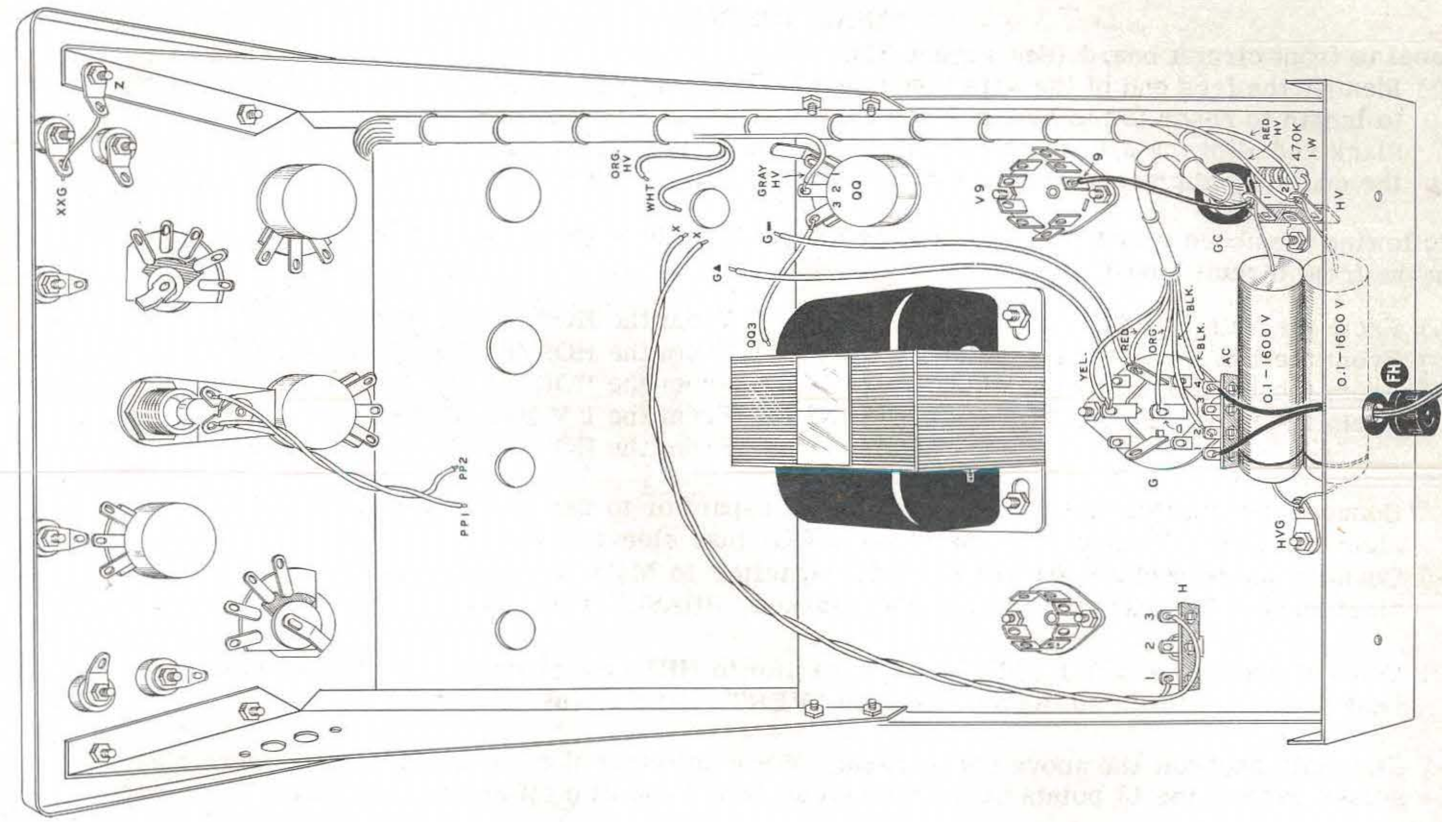


Figure 22

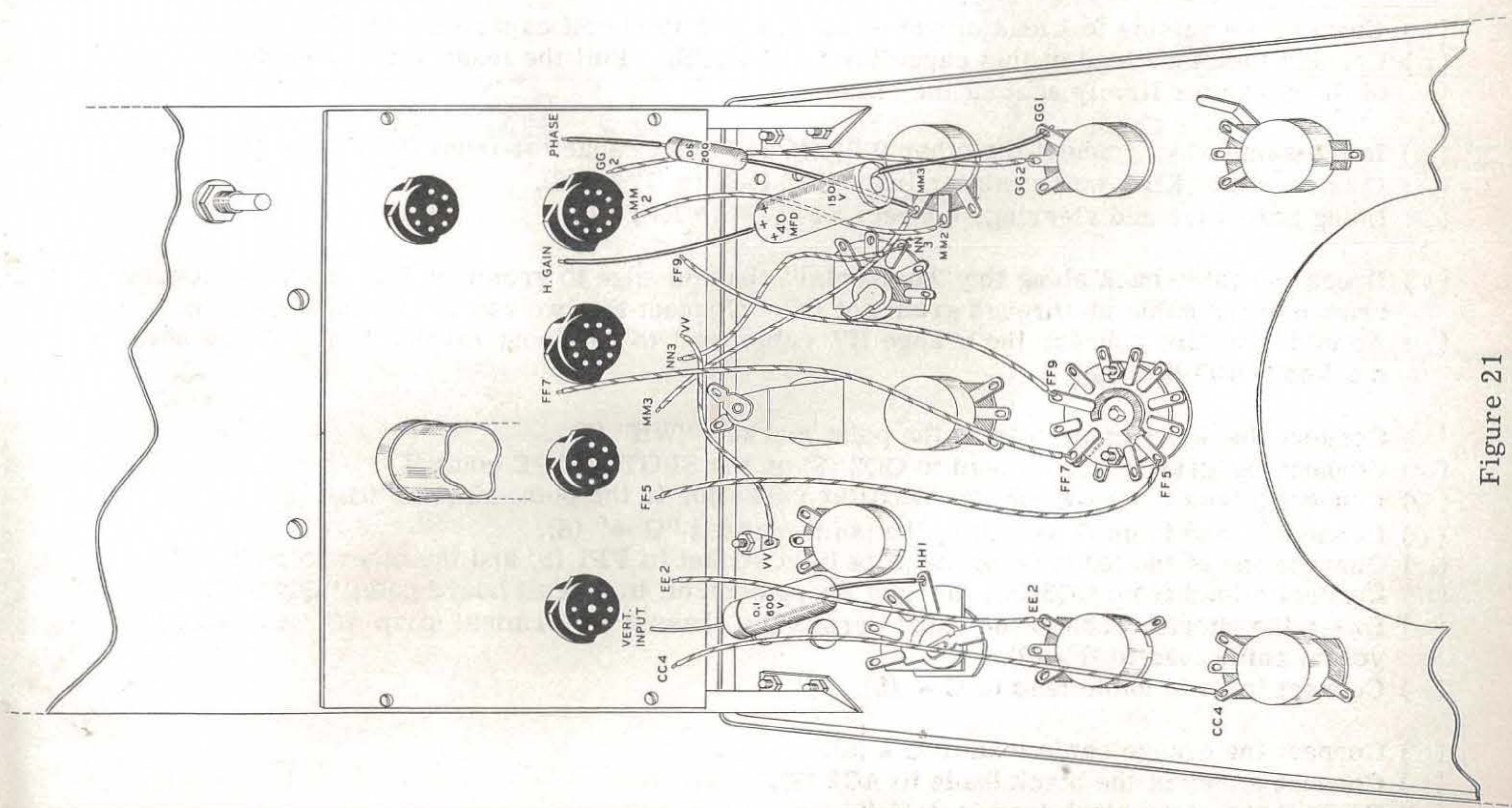


Figure 21

FINAL WIRING

Panel to front circuit board (See Figure 21).

(✓) Identify the free end of the wire connected to CC4, the VERT. POS. control. Cut the wire to length to reach to the hole marked CC4 of the front circuit board, leaving about 1/2" for slack and allowing 3/8" for stripping. Strip and insert the bare wire through the hole. Bend the end over slightly to secure the wire in place but do not solder.

Following the above procedure, connect the following leads to their respectively identified holes on the front circuit board:

(✓) From the VERT. GAIN control - EE2
(✓) From the PHASE control - MM3
(✓) From the PHASE control - MM2
(✓) From the SYNC. SELECTOR switch - NN3
(✓) From the HOR/FREQ. switch - FF5
(✓) From the HOR/FREQ. switch - FF7
(✓) From the HOR/FREQ. switch - FF9
(✓) From the 1 V P-P binding post - VV
(✓) From the HOR. GAIN control - GG2

soldered

(✓) Connect the positive end of a 40 μfd 150 volt capacitor to the hole marked "H. GAIN" (use sleeving) (NS). Connect the other lead to GG1 (use sleeving) (S).

(✓) Connect one lead of a 0.05 μfd 200 volt capacitor to MM3 (use sleeving) (S). Connect the other lead of this capacitor to the hole marked "PHASE" (use sleeving) (NS).

(✓) Connect one lead of a 0.1 μfd 600 volt capacitor to HH1 (use sleeving) (S). Connect the other lead of this capacitor to the hole marked "VERT. INPUT" (use sleeving) (NS).

(✓) Carefully recheck the above connections. When satisfied that the work is done correctly, solder each of the 13 points below the circuit board and clip off any excess leads.

Under-chassis wiring

Before doing any of the inter-assembly wiring, the high-voltage power supply wiring should be completed. (Refer to Figure 22.)

(✓) Connect the outside foil lead of one of the 0.1 μfd 1600 volt capacitors to HVG (NS).
(✓) Connect the other lead of this capacitor to HV1 (NS). Pull the leads taut to hold the body of the capacitor firmly against the chassis.

(✓) In the same way, connect the other 0.1 μfd 1600 volt capacitor from HVG (S) to HV2 (NS).
(✓) Connect a 470 KΩ 1 watt resistor from HV1 (NS) to HV2 (NS).
(✓) Using bare wire and sleeving, connect V9-9 (S) to HV1 (S).

(✓) Dress the cable back along the "horizontal" chassis edge to grommet GC. Pass the longer branch of the cable up through grommet GC. Connect the two red HV leads to HV2 (S).
(✓) At mid-chassis, connect the orange HV cable lead to the front circuit board at the point marked "ORG HV" (S).

(✓) Connect the white cable lead to the point marked "WH" (S).
(✓) Connect the gray HV cable lead to QQ2 (S) on the SPOT SHAPE control.
(✓) Connect a lead from G▲ (NS) on the filter capacitor to the point marked "G▲" (S).
(✓) Connect a lead from G ▬ (NS) to the point marked "G ▬" (S).
(✓) Connect one of the leads from the pilot light socket to PP1 (S) and the other to PP2 (S).
(✓) Connect a lead from QQ3 (S), the Spot Shape control, to circuit board point "QQ3" (S).
(✓) Dress the short branch of the cable across the chassis to terminal strip AC. Connect the yellow cable lead to G ▲ (S).
(✓) Connect the red cable lead to G ▬ (S).

(✓) Connect the orange cable lead to G ● (S).
(✓) Connect either of the black leads to AC2 (S).
(✓) Connect the other black lead to AC4 (S).
(✓) Twist together two 12" lengths of hookup wire. Strip all four ends. Connect either wire at one end of this twisted pair to H1 (NS) and the adjacent wire to H3 (NS). At the other end, connect a lead to each of the points marked X. Solder the two points.

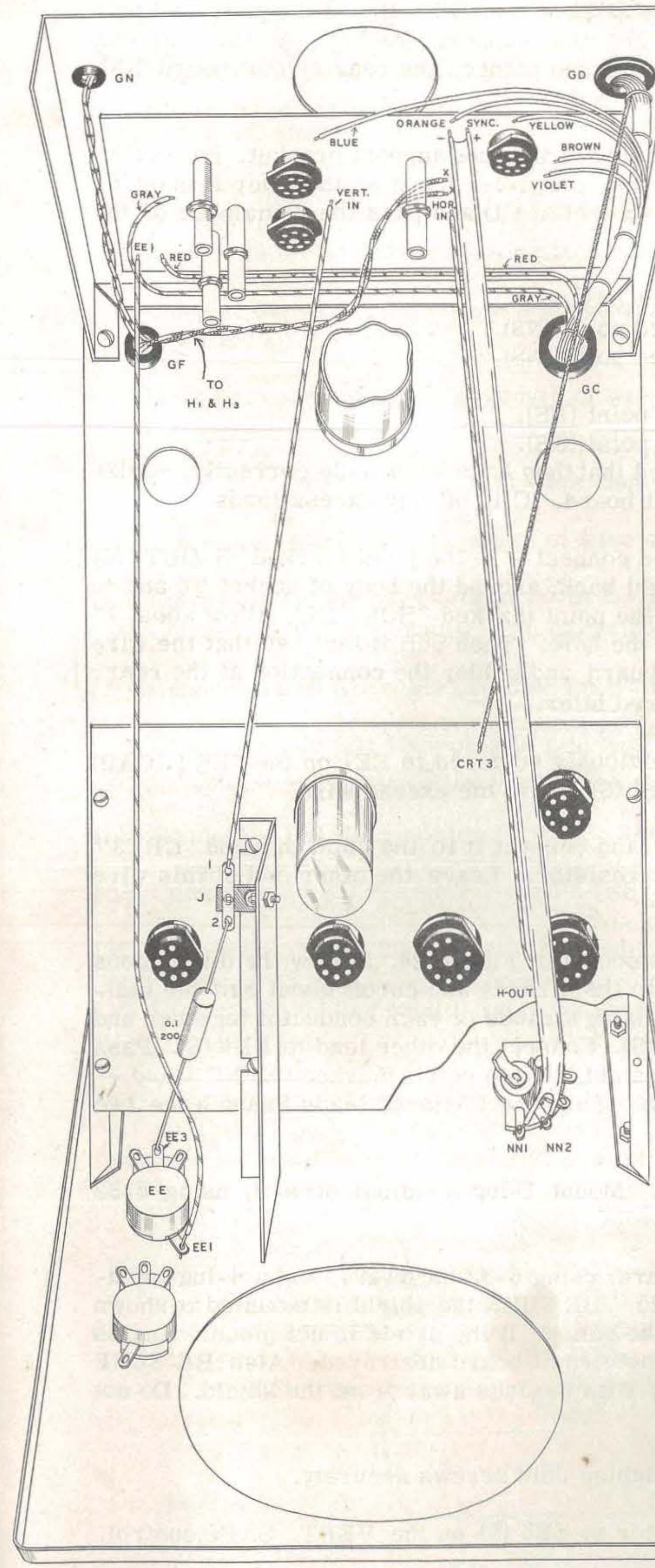


Figure 23

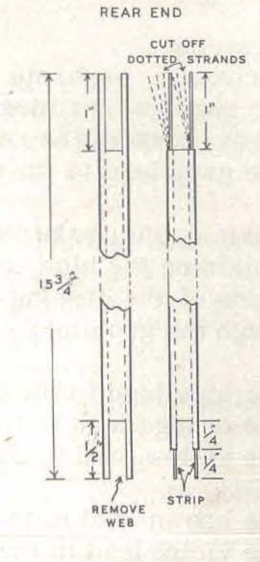


Figure 24

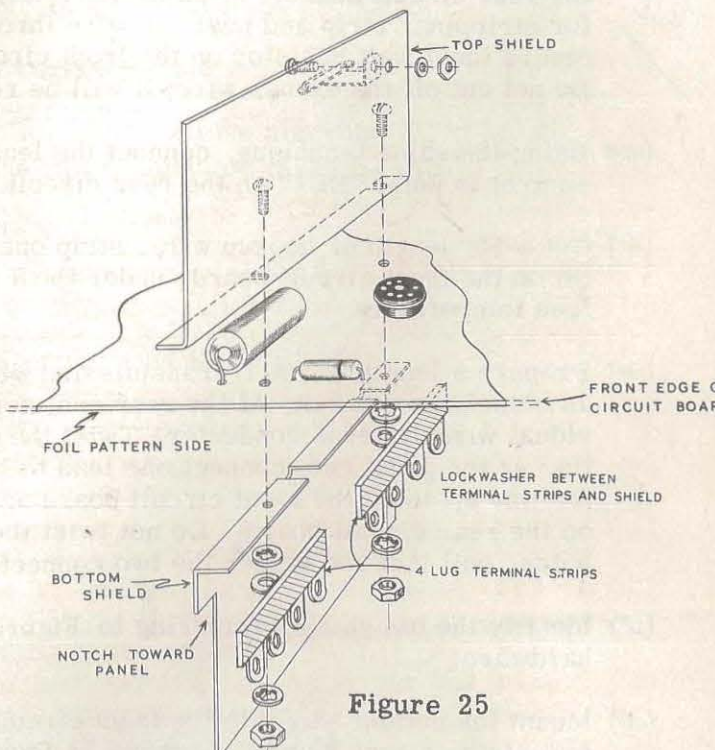


Figure 25

Rear Board

Above chassis wiring

( ) Above the chassis, separate the cable branches at grommet GC. Dress the gray-red pair across the chassis, forming it into the lip of the tube support bracket. At the "vertical channel" side, connect the red lead to the RED marked point on the rear circuit board (NS).

( ) Connect the gray lead to the GRAY marked point (NS).

( ) Pass the main cable up the "horizontal channel" side of the tube support bracket. Fan out the branch containing the blue, orange, yellow, brown and violet leads so that they remain on the front side of the bracket. Insert a 3/4" grommet at GD and pass the remainder of the cable through the grommet.

( ) Connect the blue lead to the BLUE marked point (NS).
( ) Connect the orange lead to the ORANGE marked point (NS).
( ) Connect the yellow lead to the YELLOW marked point (NS).

( ) Connect the brown lead to the BROWN marked point (NS).
( ) Connect the violet lead to the VIOLET marked point (NS).
( ) Recheck the above connections and when satisfied that they have been made correctly, solder the seven connections on the rear of the circuit board. Clip off any excess leads.

( ) Strip one end of a 14" length of hookup wire and connect it to the point marked "H-OUT" (S) 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.

( ) Using the same technique, connect the lead previously soldered to EE1 on the VERT. GAIN control to point "EE1" on the rear circuit board (S). Clip the excess wire.

( ) Cut a 15" length of hookup wire, strip one end and connect it to the point marked "CRT3" (S) on the front circuit board, under the 7 watt resistor. Leave the other end of this wire free temporarily.

( ) Prepare a length of 300 Ω transmission line as shown in Figure 24. Follow the dimensions as closely as you can. At the rear end, separate the strands and cut off about half the individual wires in each conductor. Twist the remaining strands of each conductor together and tin. At the panel end, connect one lead to NN2 (S). Connect the other lead to NN1 (S). Pass the line up above the front circuit board and straight back to points marked "SYNC + and -" on the rear circuit board. Do not twist the line. Pass the 1" tinned leads through the two holes, pull taut and solder the two connections.

( ) Identify the top shield, referring to Figure 25. Mount 1-lug terminal strip J, using 6-32 hardware.

( ) Mount the bottom shield to the front circuit board, using 6-32 hardware, and a 4-lug terminal strip on each screw, as shown in Figure 25. BE SURE the shield is mounted as shown in Figure 25, with the notched corner next to the panel. If the shield is not mounted in this manner, the filament bus will be shorted and the circuit board destroyed. Also BE SURE that the terminal strips are oriented as shown, with the lugs away from the shield. Do not tighten the hardware yet.

( ) Slip the top shield under the screw heads and tighten both screws securely.

( ) Connect one lead of a 0.1 μfd 200 volt capacitor to EE3 (S) on the VERT. GAIN control. Connect the other lead to J2 (S).

( ) Connect one end of a 9" length of hookup wire to J1 (S). Strip the other end to expose about 1" of bare wire, push the stripped end through the hole in the rear circuit board, marked "VERT. IN", pull the wire taut and solder the connection. Cut off the excess wire.

( ) Twist together two 10" lengths of hookup wire. Strip all four ends. At one end of the pair connect either wire to "X" on the rear circuit board (S). Connect the adjacent end to the other "X" (S). Pass the twisted pair through grommet GF and below the chassis. At the other end of the pair, connect one lead to H1 (S) and the other to H3 (S).

( ) Lay the scope over on its left side, and wire the two 4-lug terminal strips mounted on the flange of the bottom shield. The front terminal strip will be designated by the letter L (left) and the rear one by R (right). On each strip the lugs are numbered left to right (front to rear). Refer to Figure 26 for placement of parts.

( ) Connect the free end of the wire previously soldered to NN5 on the SYNC SELECTOR control to L1 (NS).

( ) Strip both ends of a 2 1/2" length of wire, and push one end into the hole in the circuit board marked GR. Solder the wire to the foil. Then connect the other end of the wire to L3 (NS).

( ) Similarly, with a 4" length of wire connect hole PL (S) to lug R4 (NS).

( ) Similarly, with a 1 1/2" length of wire connect hole KA (S) to lug R1 (NS).

( ) Connect a 1 megohm resistor from L3 (NS) to L4 (NS).
( ) Connect a 10 μμf ceramic disc capacitor from L3 (S) to L4 (NS).

( ) Connect a 470 KΩ resistor from L4 (NS) to R1 (NS).

( ) Connect a .25 μfd 400v plastic molded capacitor from L1 (use sleeving) (S) to L4 (S).
( ) Connect a short bare wire from lug F ▲ on the filter capacitor (S) to R3 (NS).

( ) Connect a 150 KΩ resistor from R3 (S) to R4 (NS).

( ) Connect a 33 KΩ resistor from R4 (NS) to R2 (NS).

( ) Connect a .1 mfd 200v plastic molded capacitor from R4 (S) to R2 (NS).

( ) Connect an 820Ω resistor from R1 (S) to R2 (S).

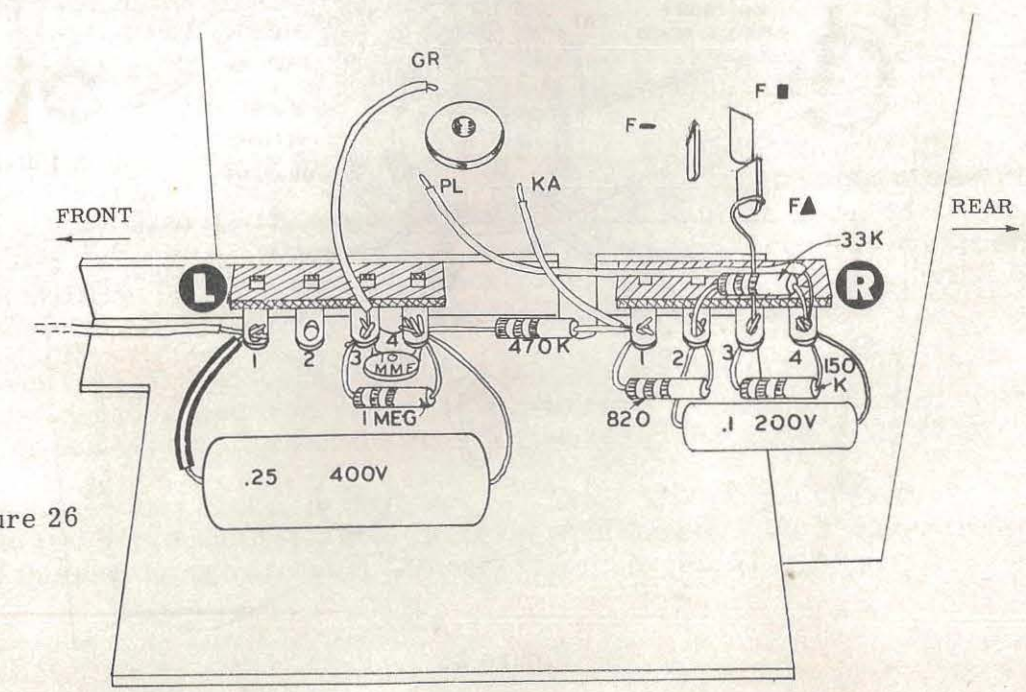


Figure 26

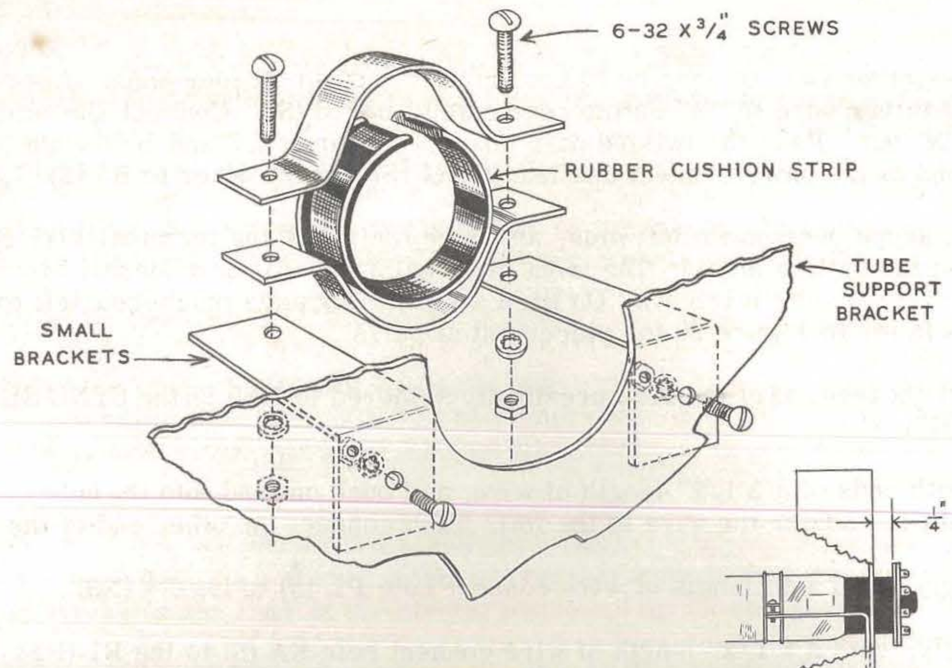


Figure 27

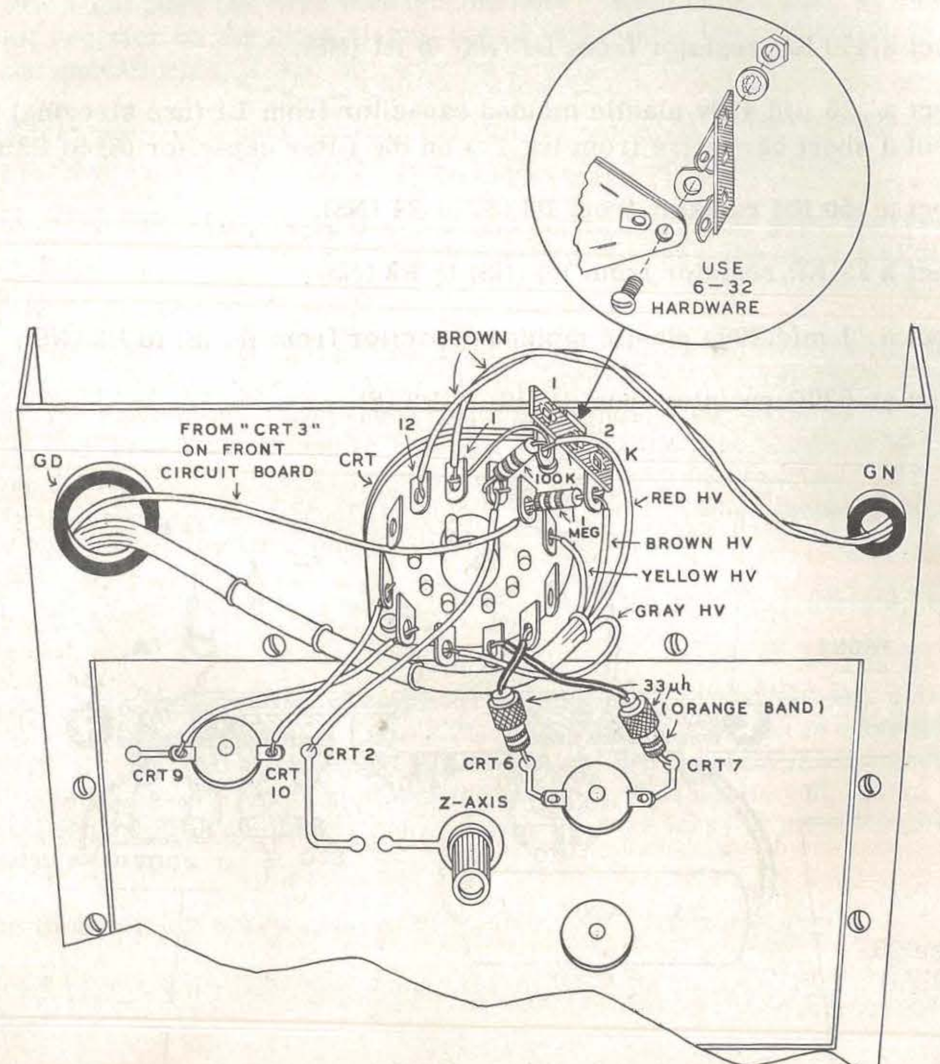


Figure 28

CATHODE RAY TUBE INSTALLATION AND WIRING

( ) Mount the two small brackets on the front side of the tube support bracket as shown in Figure 27, using 6-32 hardware.

( ) Assemble the two halves of the tube clamp, following Figure 27 closely. Use the two 6-32 x 3/4" screws but do not tighten them. Insert the rubber cushion strip, being sure that the clamps are seated in the groove. Position of the gap in the strip is not critical.

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 possibly 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 while unmounted.

( ) Slip the base end of the tube through the panel ring and through the tube clamp. Position the tube with pin 1 straight up and the base about 1/4" behind the tube support bracket. 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 pins on this tube are numbered clockwise, starting with the first pin clockwise from the key.

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

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

( ) Slip one lead of a 100 KΩ resistor through K1 (NS) and bend back to CRT1 (NS). Connect the other lead to CRT2 (NS).
( ) Connect a 1 megohm resistor from K2 (NS) to CRT3 (NS).

( ) Dress the cable under the CRT socket and form it against the tube support bracket as shown in Figure 28. Connect the red HV lead to K1 (S).
( ) Connect the brown HV cable lead to K2 (S).

( ) Connect the yellow HV cable lead to CRT4 (S).
( ) Connect the gray HV cable lead to CRT8 (S).
( ) Install a 3/8" grommet at GN and pass the brown twisted pair of transformer leads through it. Connect either lead to CRT1 (S) and the other lead to CRT12 (S).

( ) Cut two pieces of hookup wire, each 3 1/2" long. Strip all four ends. Don't twist. Connect one lead from CRT9 (S) to the lug on socket V7 marked "CRT 9" (S). Connect the other lead from CRT10 (S) to the lug on socket V7 marked "CRT 10" (S). Note: These connections have both been soldered previously in assembling the circuit board. It is not necessary to crimp these leads to the contacts of V7. Simply heat the contact slightly, insert the wire in the solder fillet, remove the iron and hold the lead until the joint cools.

( ) Connect a 4 1/2" lead from CRT2 (S) to the point marked "CRT2" (S).
( ) Connect the solid lead from one of the 33 µh chokes to the point marked "CRT 7" (S) on the rear circuit board. Connect the stranded lead from this choke to CRT7 (S).

( ) Connect the other choke, in the same way, from "CRT 6" (S) to CRT6 (S).
( ) Identify the free end of the lead connected to point marked "CRT 3" on the front circuit board. Pass this end through grommet GD, cut to length to reach CRT3, strip and connect to CRT3 (S).

FINAL ASSEMBLY

IMPORTANT WARNING: MINIATURE TUBES CAN BE EASILY DAMAGED WHEN PLUGGING THEM INTO THEIR SOCKETS. THEREFORE, USE EXTREME CARE WHEN INSTALLING THEM. WE DO NOT GUARANTEE OR REPLACE MINIATURE TUBES BROKEN DURING INSTALLATION.

( ) Insert tubes in sockets as follows:

Socket V1 - 6AB4	Socket V6 - 12AU7	Install fuse
Socket V2 - 6AN8	Socket V7 - 12AU7	
Socket V3 - 12BH7	Socket V8 - 6X4	
Socket V4 - 6J6	Socket V9 - 1V2	
Socket V5 - 12AU7	Socket V10 - 6C4	

( ) Install the 4 skirtless knobs on the following controls:

INTEN.	FOCUS
VERTICAL POSITION	HORIZONTAL POSITION

( ) Install the 8 skirted knobs on the other controls. Adjust the knob and tighten the set screws so that the pointer indicates as follows in the full clockwise position:

VERT. GAIN - 100
VERT. INPUT - X1
FREQ. SELECTOR - Line between 100 kc and 500 kc.
FREQ. VERNIER - 100
HOR. GAIN - 100
PHASE - Last clockwise marking
EXT. SYNC. AMPLITUDE - Last clockwise marking
SYNC. SELECTOR - EXT.

Figure 29

( ) Mount 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.
( ) Insert the rubber feet in the bottom of the cabinet as shown in Figure 29.
( ) Assemble the pair of test leads, one red and one black, as shown in Figure 30.

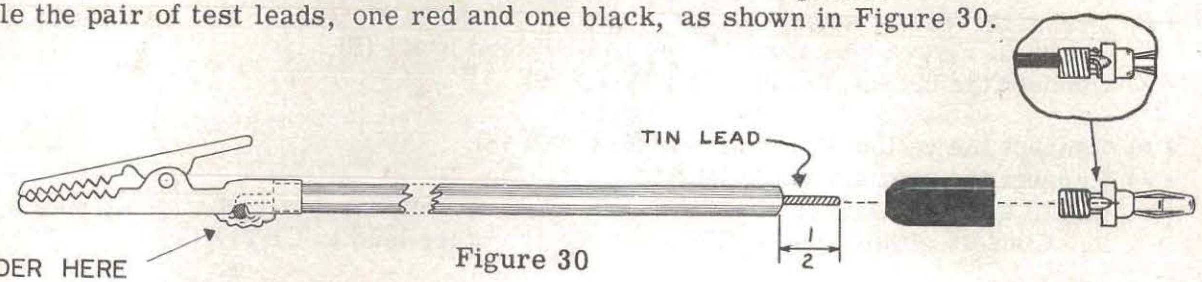


Figure 30

This completes the actual construction and wiring of your Heathkit model O-12.

Before attempting to operate the instrument, recheck each step in the wiring against the pictorial diagrams. It is sometimes helpful to mark each lead on the diagram with a colored pencil as it is checked. This precludes the possibility of missing a connection. When satisfied that the wiring is complete and correct, proceed with the adjustment and testing of the instrument.

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 O-12 is operated without the cabinet, be sure to remove the line cord from the outlet before attempting to change 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 when moving the O-12.

ADJUSTING THE OSCILLOSCOPE

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

INTEN. - Full counterclockwise
FOCUS - At approximate center of rotation
HORIZONTAL POSITION - At approximate center of rotation
VERTICAL POSITION - 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. LEVEL - Full counterclockwise.
SYNC. SELECTOR - EXT.
Spot Shape - 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 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 HORIZONTAL POSITION control and notice that the spot moves horizontally across the screen. Now, using the VERTICAL POSITION 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 both the HORIZONTAL and VERTICAL POSITION controls simultaneously, since the controls 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, some error has been made in assembly or wiring. Refer to a later section of this manual, entitled IN CASE OF DIFFICULTY, for a trouble-shooting procedure.

( ) With the spot centered on the screen, adjust the Spot Shape control (at the right side of the chassis) so as 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 three 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, indicate the slope of the line with a wax pencil or crayon on the glass face of the CR tube. Turn off the power, loosen the tube clamp on the base of the CR tube and rotate it slightly until the markings are 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 TO THESE TERMINALS COULD EASILY BE FATAL.

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

( ) 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 line 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 31. 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 are caused by the fields of the power transformer. This will not be present with the external signal.

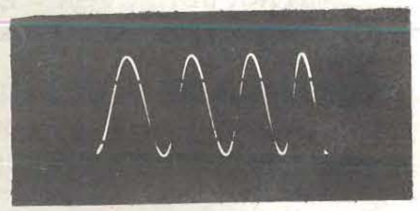


Figure 31

( ) 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 from "HOR. IN" on the rear circuit board. Set the FREQ. SELECTOR to the line between 1000 and 10 K and the FREQ. VERNIER to 0. Now turn on the power. You should get a trace similar to that in Figure 32 A or B. Reduce both gain control settings so that the trace is about 2" long.

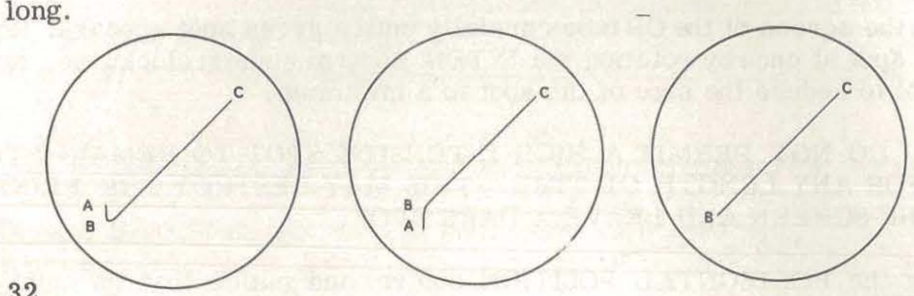


Figure 32

A — TRIMMER CAPACITY LOW

B — TRIMMER CAPACITY HIGH

C — TRIMMER PROPERLY ADJUSTED

( ) With the VERT. INPUT switch in the X10 position, adjust trimmer TT until the AB portion of the trace disappears and only a straight sloping line is left. (TT is the front trimmer on the left panel bracket.)

( ) Switch the VERT. INPUT switch to the X100 position and adjust trimmer UU to obtain the same result. 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 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.

( ) Carefully trim the green plastic grid screen to size so that it slips snugly within the felt-lined panel ring. Insert the screen so that it rests against the face of the tube.

( ) 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 into the rear chassis apron.

This completes the construction and adjustment of your Heathkit model O-12 Oscilloscope.

OPERATION OF THE OSCILLOSCOPE

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 the sharpness of the trace on the oscilloscope screen.

Two knobs, marked VERTICAL POSITION and HORIZONTAL POSITION, control the location of the trace on the screen. Turning the vertical knob shifts the trace up or down and the horizontal knob moves the trace to left or right.

One knob, marked HOR. GAIN, varies the width 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 sinusoidal sweep.

Three knobs, marked HOR/FREQ. SELECTOR, FREQ. VERNIER and EXT. SYNC. AMPLITUDE, control the operation of the sweep generator. The selector switch and vernier control permit selection of a suitable 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 performs the following additional functions:

Ext. input: The HOR. INPUT binding post is connected directly to the input grid of the horizontal amplifier system. The sweep generator is non-operating.

Line sw.: Line frequency voltage, controlled in phase by the PHASE control, is applied to the horizontal amplifier system. The sweep thus applied is sinusoidal in wave-form.

The SYNC. SELECTOR switch operates as follows:

- and + INT.: The sweep generator is operating, furnishing saw-tooth sweep at any frequency within its range, synchronized with the signal applied at the VERT. INPUT binding post.

LINE: The sweep generator is operating, furnishing saw-tooth sweep at any frequency within its range, but synchronized with the line frequency or its harmonics.

EXT.: The sweep generator is operating, furnishing sawtooth sweep at any frequency within its range, but synchronized with any 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.

NOTES ON THE OPERATION OF THE OSCILLOSCOPE

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. LEVEL control has no effect at any setting of the SYNC. SELECTOR switch beside the EXT. position. The level 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 very high frequencies.

When operating on external synchronization, the EXT. SYNC. LEVEL 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 input 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 CRT 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 CRT giving greatest accuracy.

At a low sweep rates (30 cycles or less) the screen has insufficient persistence to provide a steady picture. This flicker is inherent with medium persistence screens at low 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 O-12 design and should cause no concern:

1. At extreme sweep rates and with fairly high intensity settings, retrace blanking is not complete. 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 horizontal and vertical gain controls set to min. 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 the orientation of the instrument. To check, turn the scope cabinet around the 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 spot size which could be resolved. With present day cathode ray tube designs 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.

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%. Bear in mind, however, that square-wave generators are prone to create this condition themselves. Do not condemn your oscilloscope until this possibility has been checked.

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 de-focusing may be experienced at the extreme right hand edge of the trace. This condition does not indicate a fault in the CRT. It is caused in part by amplifier design and compromise between sensitivity and band width and 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 horizontal 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 O-12 is performing normally. As sweep width is increased beyond this, the trace intensity will be reduced.

IN CASE OF DIFFICULTY

If the test procedure described does not produce the expected results, the following procedure is recommended:

1. Check the wiring against the pictorial diagrams. Follow each wire in the instrument and check the connections at each end for good solder joints and for termination at the proper points. We cannot over emphasize the importance of good solder connections. A good solder connection will appear shiny. If a connection is dull looking, we suggest it be resoldered. Checking each lead off in colored pencil on the pictorial as it is compared with the instrument will sometimes reveal an error consistently overlooked. Sometimes having a friend check over the wiring will help to locate a wiring error which may be overlooked repeatedly by the kit builder. Mistakes in wiring are responsible for the majority of troubles experienced by kit builders.

2. Check the voltages at the tube socket terminals. The readings should be compared with those indicated on the Schematic, within 25%. These measurements were made with a Heathkit VTVM with an input resistance of 11 megohms. Voltage checks made with instruments of other input characteristics may vary greatly. Should a discrepancy in voltage readings show up, carefully check the components associated with that tube.

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

4. If the dot moves off the face of the CRT right after the kit 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.

5. If you are unable to obtain straight diagonal lines when adjusting the vertical trimmers, please refer to Figure 32 on Page 32 of your O-12 manual. 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 wave-front 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.

6. If you are troubled with hum or ripple when the O-12 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 O-12 power transformer, but the relation between 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 externals to the scope itself. Anything which consumes power at power-linr frequencies creates a certain magnetic field. The worst offenders are those equipments which draw a considerable amount of current--soldering irons, soldering guns, AC motors, electric heaters and similar items.

Figure 33A 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 33B, 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.

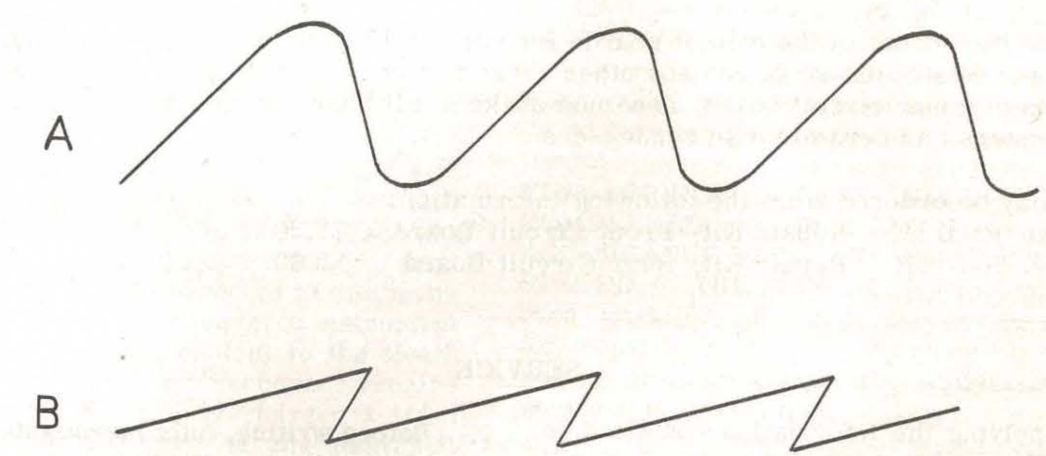


Figure 33

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 O-12, 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 the O-12.

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.

7. Should the procedure as outlined fail to correct your difficulty, write to the Heath Company describing the nature of the trouble by giving all possible detail, including voltage readings obtained and other indications you may have noticed. We will try to analyze your trouble and advise you accordingly. No charge is made for this service.

IN ALL CORRESPONDENCE, REFER TO THIS INSTRUMENT AS THE MODEL O-12 OSCILLOSCOPE.

REPLACEMENTS

Material supplied with Heathkits 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 tube or 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 type and model number of kit in which it is used.
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. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. 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 O-12 have been ruined through accidental use of acid or paste fluxes, or for any other reason, a convenient repair kit is available. The kit consists of a new circuit board, new tube sockets, all board-mounted resistors, molded tubular condensers and ceramic disc condensers.

The kits may be ordered from the following information:

Kit No. R-O12F	Repair Kit, Front Circuit Board	$5.80
Kit No. R-O12R	Repair Kit, Rear Circuit Board	$5.00

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 date of purchase, if available.

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

With the above 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. He will make no incorrect assumptions nor waste time checking files for the correct spelling of name and address. (The automatic letter opener sometimes cuts through the letter, hence the suggestion to print the name and address twice.) 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 (including all connecting cables) to the Heath Company for inspection and necessary repairs and adjustments. You will be charged a fixed fee of $8.00, 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 for your HEATHKIT equipment. Although you may find charges for local service somewhat higher than those listed in HEATHKIT manuals (for factory service), the amount of increase is usually offset by the transportation charge you would pay if you elected to return your kit to the Heath Company.

HEATHKIT Service Centers will honor the regular 90 day HEATHKIT Parts Warranty on all kits, whether purchased through a dealer or directly from 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.

SHIPPING INSTRUCTIONS

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

ATTACH A TAG TO THE EQUIPMENT BEARING YOUR NAME, COMPLETE ADDRESS, DATE OF PURCHASE, AND A BRIEF DESCRIPTION OF THE DIFFICULTY ENCOUNTERED. 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

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 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.

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.

WARRANTY

Heath Company warrants that for a period of three months from the date of shipment, all Heathkit parts shall be free of defects in materials and workmanship under normal use and service and that in fulfillment of any breach of such warranty, Heath Company shall replace such defective parts upon the return of the same to its factory. 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.

NOTE: The foregoing warranty is completely void and we will not replace, repair or service instruments or parts thereof in which acid core solder or paste fluxes have been used.

HEATH COMPANY

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 recommended, we also suggest the following excellent books:

Ruiter; Modern Oscilloscopes and Their Uses
Hickok; How to Use the CR Oscilloscope in Servicing Radio and TV
Rider; The Cathode Ray Tube at Work
Turner; Basic Electronic Test Instruments
Editors and Engineers; Radio Handbook
A. R. R. L.; Radio Amateurs Handbook
Rider and Uslan; Encyclopedia on Cathode Ray Oscilloscopes and Their Uses

SOME OSCILLOSCOPE APPLICATIONS

As mentioned in the introduction to this manual, 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 simply to familiarize you with the basic applications of your oscilloscope. Each one of the uses described is well within the capabilities of the Heathkit model O-12 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 to the oscilloscope. By means of attenuators and amplifiers, this voltage is made to displace vertically 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 34 shows the conventional set-up 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.

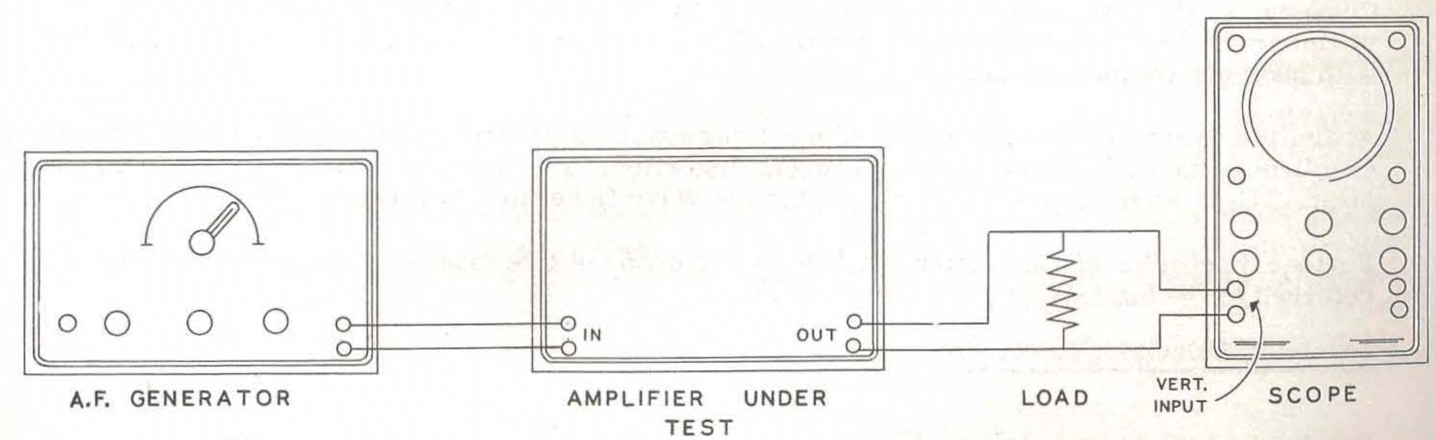


Figure 34

Figure 35A shows serious flattening of one peak, representing about 10% harmonic distortion. This condition may be caused by incorrect bias on any stage, or by an inoperative tube in a push-pull stage. Figure 35B indicates third harmonic distortion, a particularly objectionable fault. Figure 35C shows flattening of both peaks, usually an indication of over-load somewhere in the circuit.

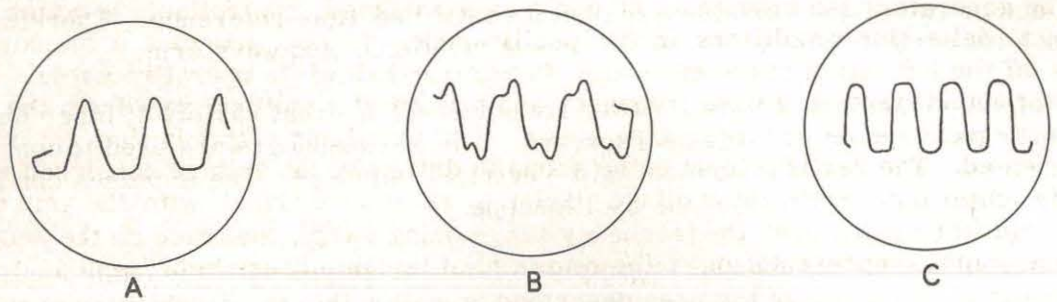


Figure 35

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 system with respect to both amplitude distortion and phase shift. Assume that we apply a wave of the form shown in Figure 36A, 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

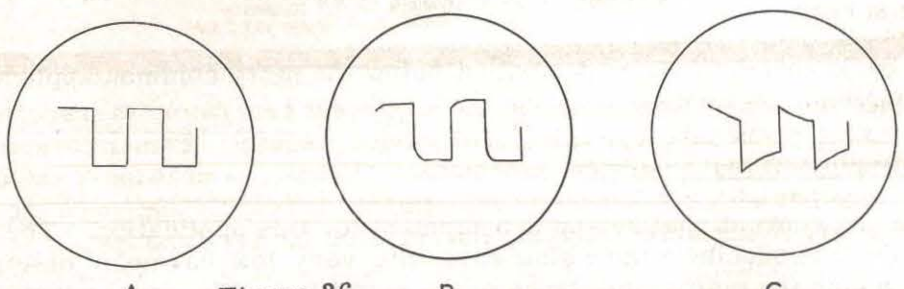


Figure 36

that shown in Figure 36B 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 portion of the wave indicates the performance of the amplifier in the low frequency range. Figure 36C 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. The Heathkit model AO-1 Audio Oscillator, AG-10 Audio Generator, or SQ-1 Square Wave Generator is recommended.

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

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 the oscilloscope. This particular field has been given specific attention in the design of the Heathkit model O-12.

1. Alignment of a television receiver is virtually impossible without the use of an oscilloscope and a television alignment generator, such as the Heathkit model TS-4A. 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 starts at a base frequency and sweeps at a uniform rate from the base frequency to a frequency several megacycles above. 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. 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 37

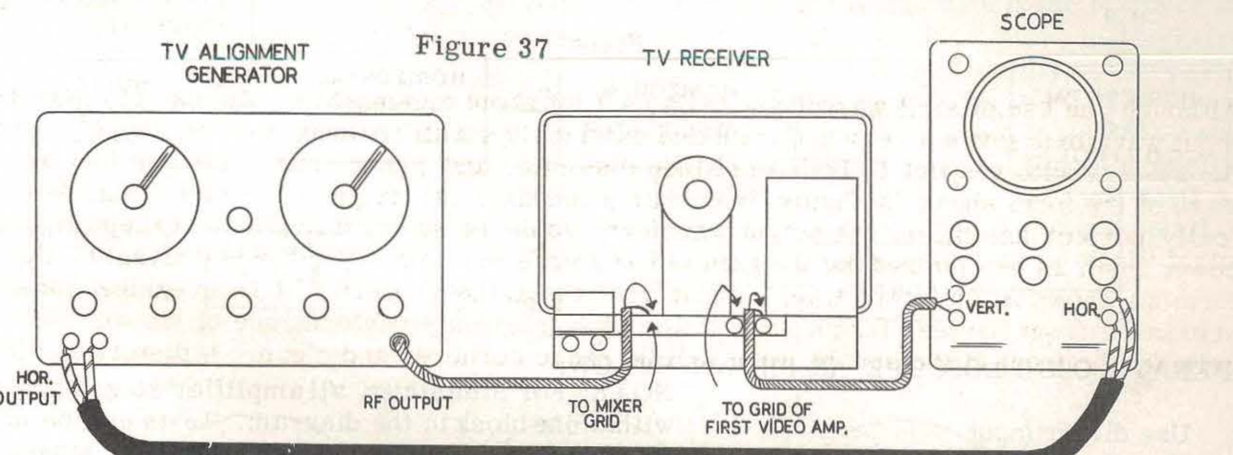


Figure 37 outlines the connections between the alignment generator, the receiver, and the oscilloscope. The exact procedure for alignment varies greatly. This information is generally available in the manufacturer's service information. Usually, a drawing of the desired response curve is given, together with a sequence of adjustments to roughly approach the desired pattern. Final adjustments are made while watching the trace on the oscilloscope.

2. 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 Heathkit model O-12 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 or video amplifier sections, 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 #337-C 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.

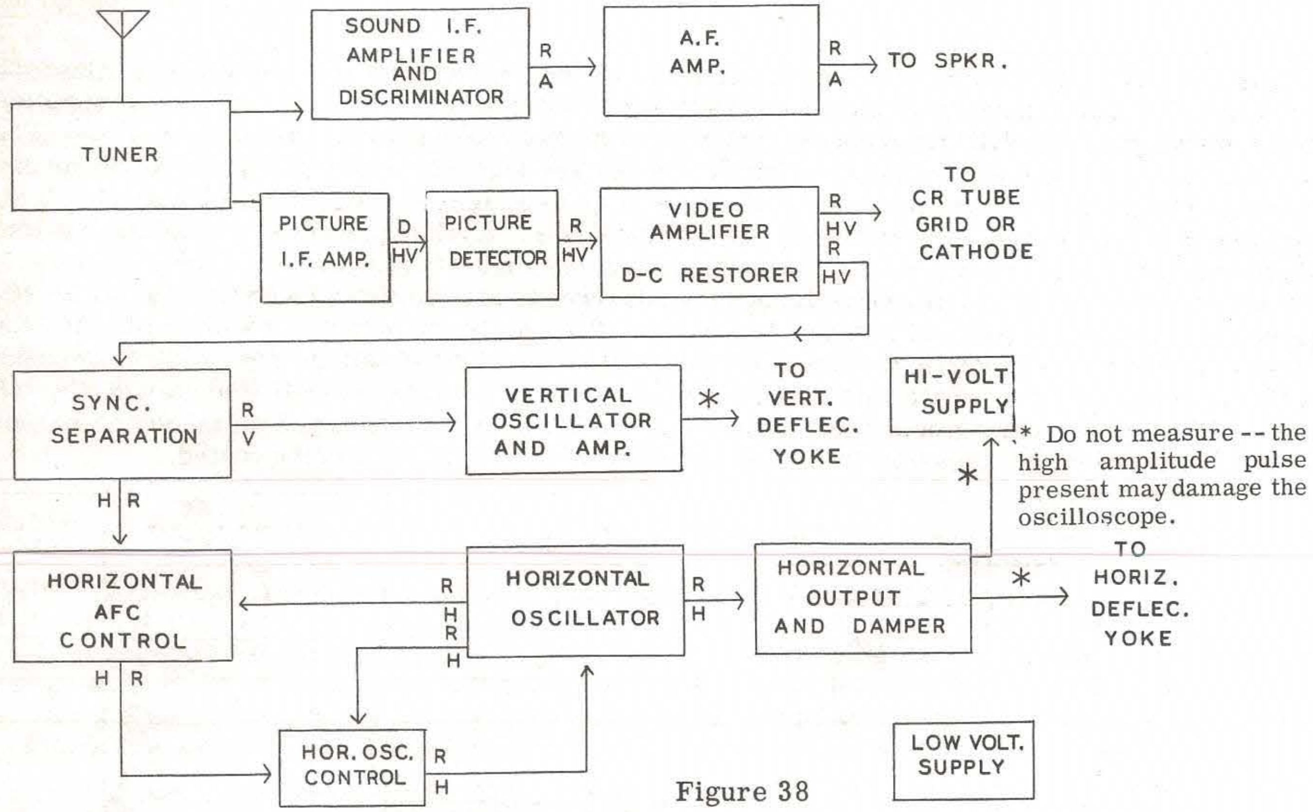


Figure 38

OPERATE OSCILLOSCOPE AS SHOWN BELOW:

R Use direct input
D Use demodulated input
H Use 7,875 or 15,750 cps sweep
V Use 20, 30, or 60 cps sweep
A Use audio test frequency sweep, or half this frequency

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 37. 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 O-12 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 differentiator 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 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 Heathkit model O-12. The signal-tracing technique can be used in these tests also. The square-wave generator is fed directly into the first video amplifier grid. Very low signal input will be required. Then the oscilloscope is connected to various plates, starting near the output end and working back until any distortion is isolated. Patterns such as Figure 36B are responsible for poor picture detail, or "fuzziness," while distortion of the form shown in Figure 36C can cause shading of the picture from top to bottom.

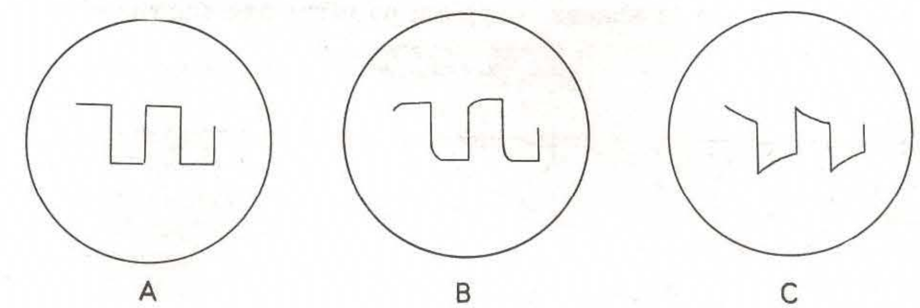


Figure 36

Miscellaneous Waveform Measurements

In this category, we can place such waveform investigations as measurement of modulation percentage, studies of noise and vibration, sub-sonic and ultra-sonic applications and hundreds of others. Each of these fields is highly specialized, and it is obviously impossible to cover them here. We again refer you to the bibliography for further reading in this field.

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 wave-shape, so that the conventional RMS reading AC voltmeter is no longer adequate. 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 O-12 Oscilloscope has been 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. SELECTOR switch. This produces a vertical line which can be focused and centered exactly for most accurate readings.

The following relationships exist between sine wave AC voltages:

RMS times 1.414 gives peak voltage.
RMS times 2.828 gives peak-to-peak voltage.
Peak voltage times 0.707 gives RMS voltage.
Peak-to-peak voltage times 0.3535 gives 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 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:

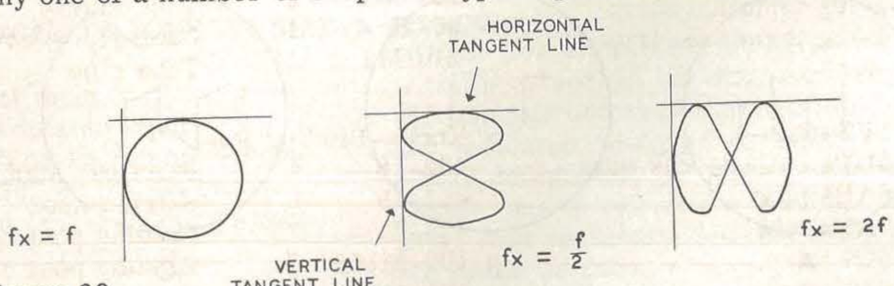


Figure 39

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 similar to the figure below 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 the figures below:

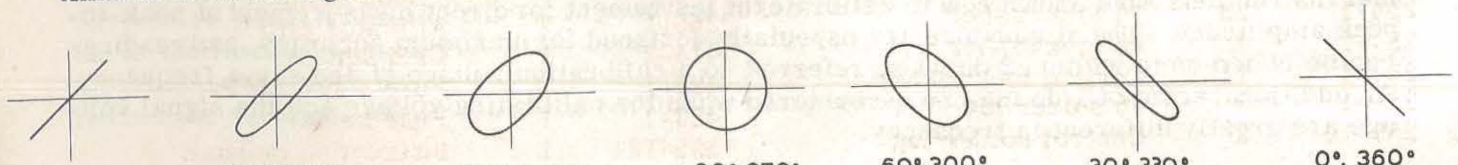


Figure 40

To calculate the phase relationship, use the following formula: $\sin \theta = \frac{A}{B}$

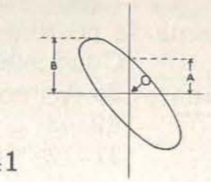


Figure 41

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 axes of the ellipse must pass through the point O.

PART No.	PARTS Per Kit	DESCRIPTION
Sockets-Terminal Strips		
434-15	1	7-pin wafer socket
434-16	1	9-pin wafer socket
434-45	3	7-pin molded socket
434-46	5	9-pin molded socket
434-41	1	12-pin wafer socket
434-22	1	Pilot lamp socket
431-1	1	1-lug terminal strip
431-2	2	2-lug terminal strip
431-10	1	3-lug terminal strip
431-12	3	4-lug terminal strip
Tubes-Lamp		
411-65	1	1V2 tube
411-49	1	5UP1 cathode ray tube
411-58	1	6AB4 tube
411-68	1	6AN8 tube
411-4	1	6C4 tube
411-79	1	6J6 tube
411-64	1	6X4 tube
411-25	3	12AU7 tube
411-73	1	12BH7 tube
412-1	1	#47 pilot lamp
Hardware		
250-2	18	3-48 x 3/8 machine screw
250-8	5	#6 x 3/8 sheet metal screw
250-9	20	6-32 x 3/8 machine screw
250-18	4	8-32 x 3/8 machine screw
250-29	2	6-32 x 3/4 machine screw
250-56	4	6-32 binder head machine screw
250-83	2	#10 x 1/2 sheet metal screw
252-1	18	3-48 hex nut
252-3	32	6-32 hex nut
252-4	4	8-32 hex nut
252-7	13	Control hex nut
253-10	13	Flat control washer
254-1	23	#6 lockwasher
254-2	4	#8 lockwasher
254-4	11	Control lockwasher
259-1	9	#6 solder lug
259-10	2	Control solder lug

PART No.	PARTS Per Kit	DESCRIPTION
Sheet Metal Parts		
200-M116	1	Chassis
204-M77	1	Tube support bracket
203-68F180	1	Panel
206-M144	1	Top shield
206-M29	1	Bottom shield
204-M81	1	Left-hand bracket
204-M82	1	Right-hand bracket
204-M68	2	Angle bracket
207-M1	2	Tube clamp
90-25	1	Cabinet, w/cover plate
210-M1	1	Tube ring
Knobs-Binding Posts		
462-18	4	Skirtless knob
462-19	8	Skirted knob
427-2	7	Binding post base
100-M16B	5	Binding post cap, black
100-M16R	2	Binding post cap, red
Insulators		
73-1	3	Grommet, 3/8"
73-2	2	Grommet, 3/4"
75-17	12	Insulator bushing
346-1	1	Length sleeving
73-5	1	Cushion strip
261-1	4	Rubber feet
70-5	1	Banana plug insulator, black
70-6	1	Banana plug insulator, red
Miscellaneous		
481-1	1	Condenser mounting wafer
54-26	1	Power transformer
85-14F178	1	Circuit board, front
85-12F179	1	Circuit board, rear
211-4	1	Handle
438-13	2	Banana plug assembly, less insulator
260-1	2	Alligator clip
414-2	1	Grid screen
421-1	1	Fuse 1 1/2 AMP.
423-1	1	Fuse holder
595-184	1	Instruction manual.

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-84	1	62 Ω 1/2 watt 5%
1-3	5	100 Ω 1/2 watt
1-45	3	220 Ω 1/2 watt
1-6	1	470 Ω 1/2 watt
1-8	1	820 Ω 1/2 watt
1-9	1	1 KΩ 1/2 watt
1-90	2	2 KΩ 1/2 watt
1-57	3	2.2 KΩ 1/2 watt 5%
1-13	1	2.7 KΩ 1/2 watt
1-14	3	3.3 KΩ 1/2 watt
1-46	2	3.9 KΩ 1/2 watt
1-19	1	6.8 KΩ 1/2 watt
1-20	3	10 KΩ 1/2 watt
1-21	1	15 KΩ 1/2 watt
1-22	2	22 KΩ 1/2 watt
1-24	2	33 KΩ 1/2 watt
1-88	1	36 KΩ 1/2 watt 5%
1-25	1	47 KΩ 1/2 watt
1-26	2	100 KΩ 1/2 watt
1-27	2	150 KΩ 1/2 watt
1-87	1	330 KΩ 1/2 watt 5%
1-33	3	470 KΩ 1/2 watt
1-35	3	1 megohm 1/2 watt
1-38	2	3.3 megohm 1/2 watt
1-71	2	4.7 megohm 1/2 watt
1-40	3	10 megohm 1/2 watt
1-70	1	22 megohm 1/2 watt
1A-2	2	1 KΩ 1 watt
1A-22	1	1.5 KΩ 1 watt
1A-27	2	33 KΩ 1 watt
1A-28	1	100 KΩ 1 watt
1A-32	1	470 KΩ 1 watt
1A-34	1	1 megohm 1 watt
1A-37	1	3.3 megohm 1 watt
1B-19	1	1.2 KΩ 2 watt
1B-1	2	2.7 KΩ 2 watt
1B-2	1	4.7 KΩ 2 watt
1B-20	1	100 Ω 2 watt
1B-22	1	12 KΩ 2 watt
2-129	1	3.3 megohm 1/2 watt 5% precision
3G-15	1	1 KΩ 7 watt wirewound
3G-4	1	5 KΩ 7 watt wirewound
Condensers, Tubular		
23-59	2	0.05 μfd 200 volt
23-28	6	0.1 μfd 200 volt
23-58	1	0.2 μfd 200 volt
23-3	1	0.01 μfd 400 volt
23-63	3	0.25 μfd 400 volt
23-11	1	0.1 μfd 600 volt
23-62	2	0.1 μfd 1600 volt

PART No.	PARTS Per Kit	DESCRIPTION
Condensers, Mica		
20-1	1	47 μμf 500 volt
20-43	1	390 μμf 500 volt
31-12	1	Dual trimmer; 5-20 and 100-300 μμf
Condensers, Ceramic Disc		
21-3	1	10 μμf 600 volt
21-5	1	20 μμf 600 volt
21-9	1	100 μμf 600 volt
21-21	1	200 μμf 600 volt
21-13	1	500 μμf 600 volt
21-36	1	0.002 μfd 600 volt
21-16	1	0.01 μfd 600 volt
21-31	1	0.02 μfd 600 volt
21-38	2	0.02 μfd 1600 volt
Condensers, Electrolytic		
25-32	1	40-20-20 μfd at 450 volt, 50 μfd at 300 volt
25-31	1	20-20-20 μfd at 250 volt
25-28	1	100 μfd 50 volt
25-20	2	40 μfd 150 volt
Control-Switches		
10-65	1	2 KΩ (Vert. Gain)
10-41	1	20 KΩ C. T. (Vert. Pos.)
10-8	1	10 KΩ (Hor. Gain)
10-13	1	200 KΩ C. T. (Hor. Pos.)
10-14	1	250 KΩ (Phase)
19-40	1	500 KΩ w/switch (Inten.)
10-32	1	1 megohm (Spot Shape)
10-39	2	2 megohm (Ext. Sync Amplitude and Focus)
10-45	1	7.5 Megohm (Freq. Vernier)
63-47	1	1 sec. 3 pos. wafer switch (Vert. Input)
63-88	1	1 sec. 4 pos. wafer switch (Sync. Selector)
63-87	1	1 sec. 7 pos. wafer switch Hor/Freq. Selector
Coils		
45-12	2	33 μh (orange band-resistor form)
45-23	2	61 μh (red band)
45-24	2	90 μh (blue band)
45-25	1	30 μh (green band)
Wire-Cable		
340-2	1	length Bare wire
344-1	1	length Hookup wire
341-1	1	length Test lead wire, black
341-2	1	length Test lead wire, red
89-1	1	Line cord
100-50	1	Cable assembly
347-2	1	300 Ω transmission line

HELPFUL KIT BUILDING INFORMATION

Before attempting actual kit construction read the construction manual through thoroughly to familiarize yourself with the general procedure. Note the relative location of pictorials and pictorial inserts in respect to the progress of the assembly procedure outlined.

This information is offered primarily for the convenience of novice kit builders and will be of definite assistance to those lacking thorough knowledge of good construction practices. Even the advanced electronics enthusiast may benefit by a brief review of this material before proceeding with kit construction. In the majority of cases, failure to observe basic instruction fundamentals is responsible for inability to obtain desired level of performance.

RECOMMENDED TOOLS

The successful construction of Heathkits does not require the use of specialized equipment and only basic tools are required. A good quality electric soldering iron is essential. The preferred size would be a 100 watt iron with a small tip. The use of long nose pliers and diagonal or side cutting pliers is recommended. A small screw driver will prove adequate and several additional assorted screw drivers will be helpful. Be sure to obtain a good supply of rosin core type radio solder. Never use separate fluxes, paste or acid solder in electronic work.

ASSEMBLY

In the actual mechanical assembly of components to the chassis and panel, it is important that the procedure shown in the manual be carefully followed. Make sure that tube sockets are properly mounted in respect to keyway or pin numbering location. The same applies to transformer mountings so that the correct transformer color coded wires will be available at the proper chassis opening.

Make it a standard practice to use lock washers under all 6-32 and 8-32 nuts. The only exception being in the use of solder lugs—the necessary locking feature is already incorporated in the design of the solder lugs. A control lock washer should always be used between the control and the chassis to prevent undesirable rotation in the panel. To improve instrument appearance and to prevent possible panel marring use a control flat nickel washer under each control nut.

When installing binding posts that require the use of fiber insulating washers, it is good practice to slip the shoulder washer over the binding post mounting stud before installing the mounting stud in the panel hole provided. Next, install a flat fiber washer and a solder lug under the mounting nut. Be sure that the shoulder washer is properly centered in the panel to prevent possible shorting of the binding post.

WIRING

When following wiring procedure make the leads as short and direct as possible. In filament wiring requiring the use of a twisted pair of wires allow sufficient slack in the wiring that will permit the twisted pair to be pushed against the chassis as closely as possible thereby affording relative isolation from adjacent parts and wiring.

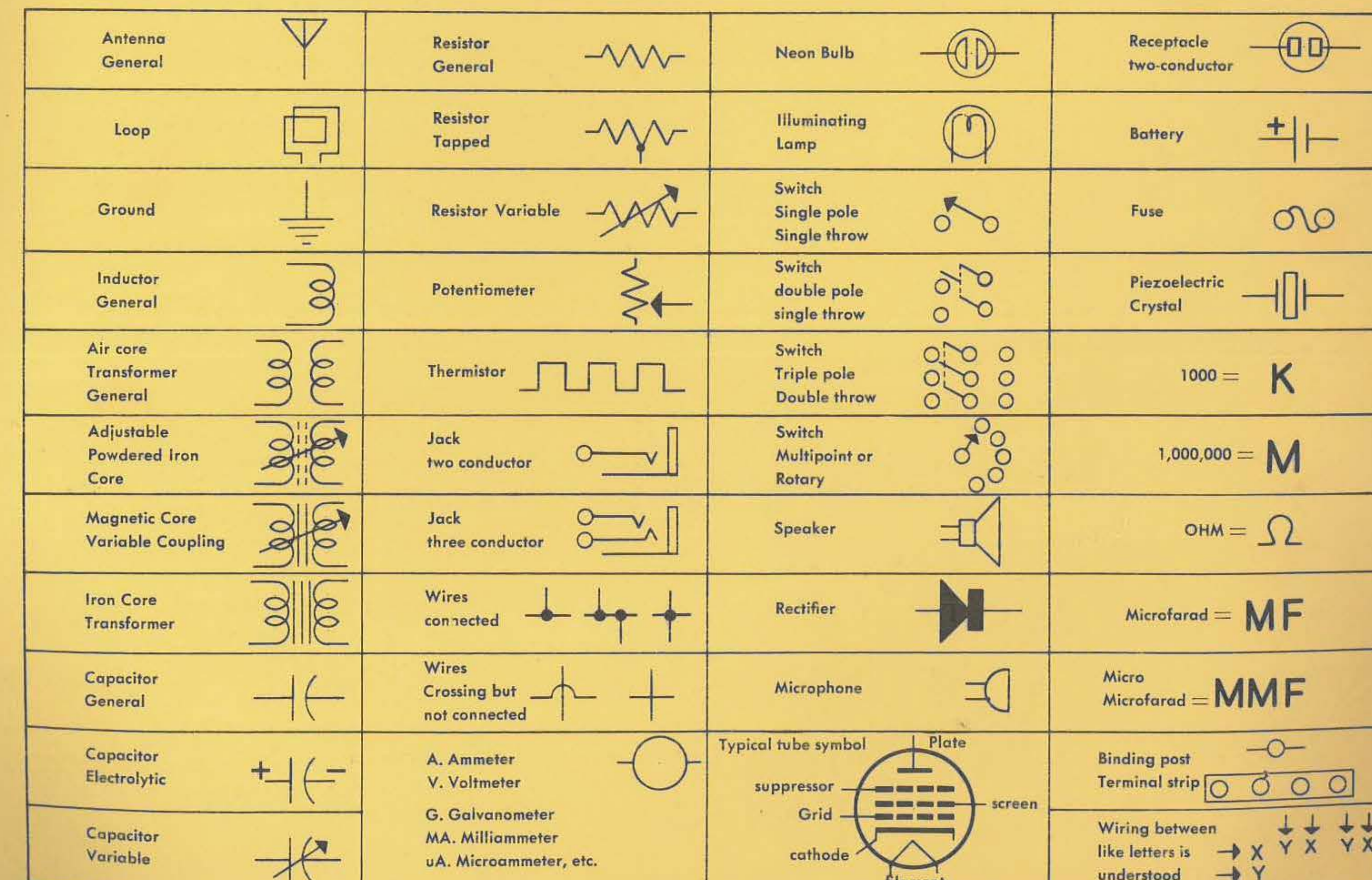
When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the wire. Excessive insulation removal may cause a short circuit condition in respect to nearby wiring or terminals. In some instances, transformer leads of solid copper will have a brown baked enamel coating. After the transformer leads have been trimmed to a suitable length, it is necessary to scrape the enamel coating in order to expose the bright copper wire before making a terminal or soldered connection.

In mounting parts such as resistors or condensers, trim off all excess lead lengths so that the parts may be installed in a direct point-to-point manner. When necessary use spaghetti or insulated sleeving over exposed wires that might short to nearby wiring.

It is urgently recommended that the wiring dress and parts layout as shown in the construction manual be faithfully followed. In every instance, the desirability of this arrangement was carefully determined through the construction of a series of laboratory models.

SOLDERING

Much of the performance of the kit instrument, particularly in respect to accuracy and stability, depends upon the degree of workmanship used in making soldered connections. Proper soldered connections are not at all difficult to make but it would be advisable to observe a few precautions. First of all before a connection is to be soldered, the connection itself should be clean and mechanically strong. Do not depend on solder alone to hold a connection together. The tip of the soldering iron should be bright, clean and free of excess solder. Use enough heat to thoroughly flow the solder smoothly into the joint. Avoid excessive use of solder and do not allow a flux flooding condition to occur which could conceivably cause a leakage path between adjacent terminals on switch assemblies and tube sockets. This is particularly important in instruments such as the VTVM, oscilloscope and generator kits. Excessive heat will also burn or damage the insulating material used in the manufacture of switch assemblies. Be sure to use only good quality rosin core radio type solder.



Courtesy of I. R. E.

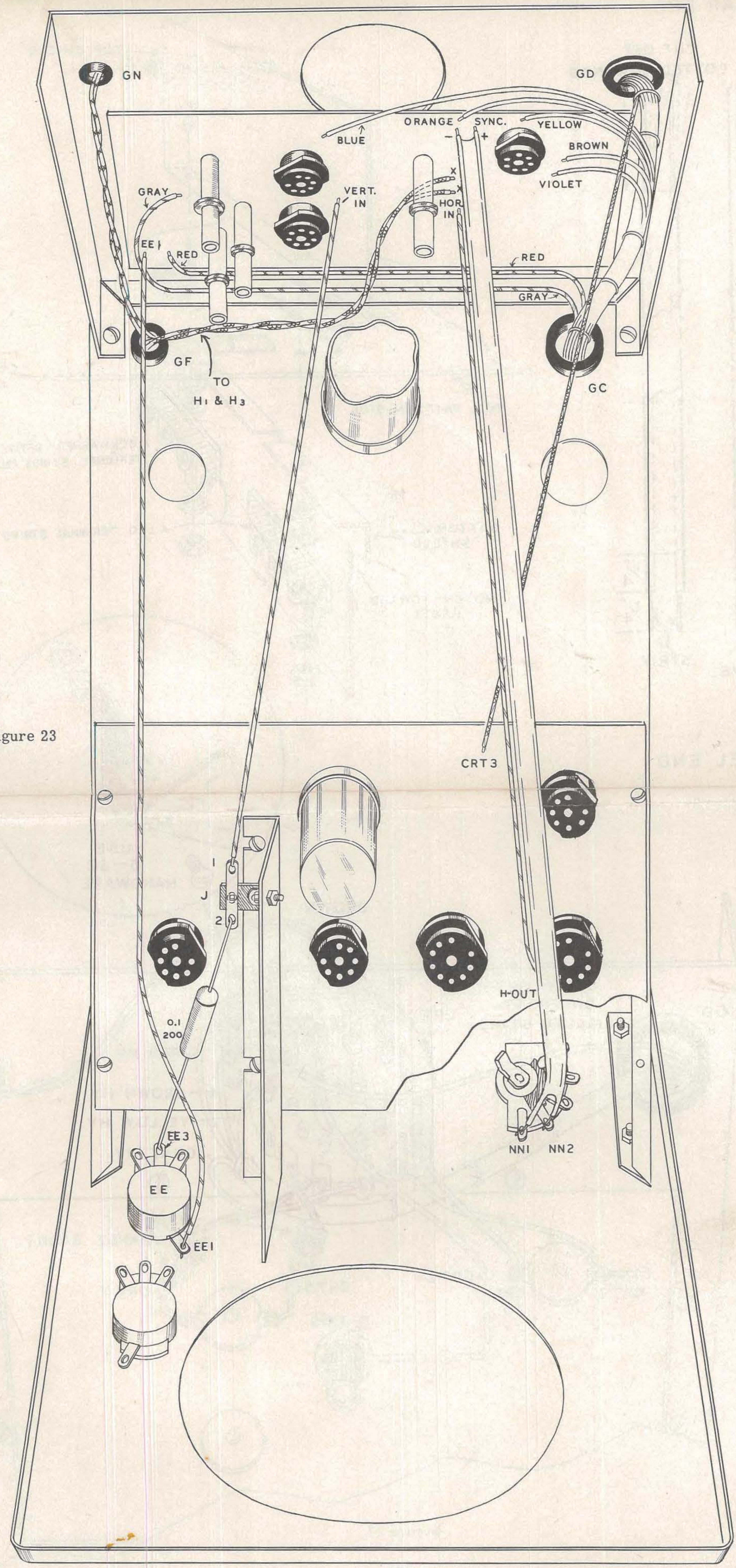

GN
GD
ORANGE
SYNC.
YELLOW
BLUE
BROWN
VIOLET
GRAY
VERT. IN
HOR. IN
EE1
RED
RED
GRAY
GF
TO H1 & H3
GC
CRT3
1
J
2
H-OUT
0.1 200
EE3
EE
EE1
NN1
NN2

Figure 23

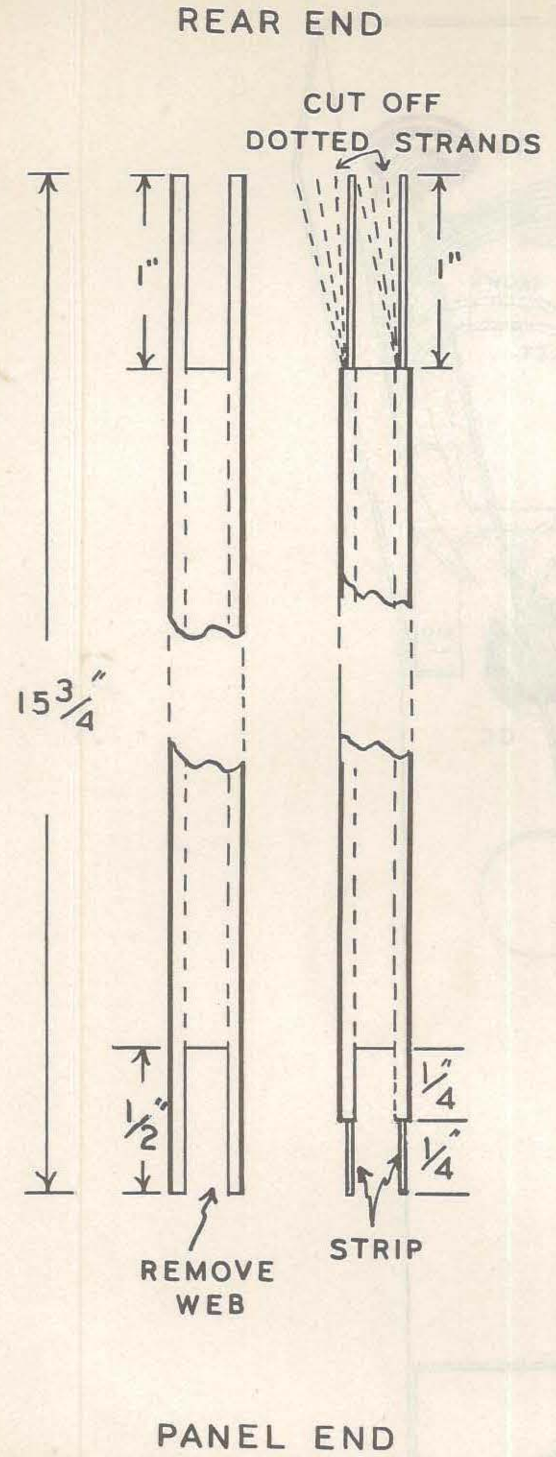


Figure 24

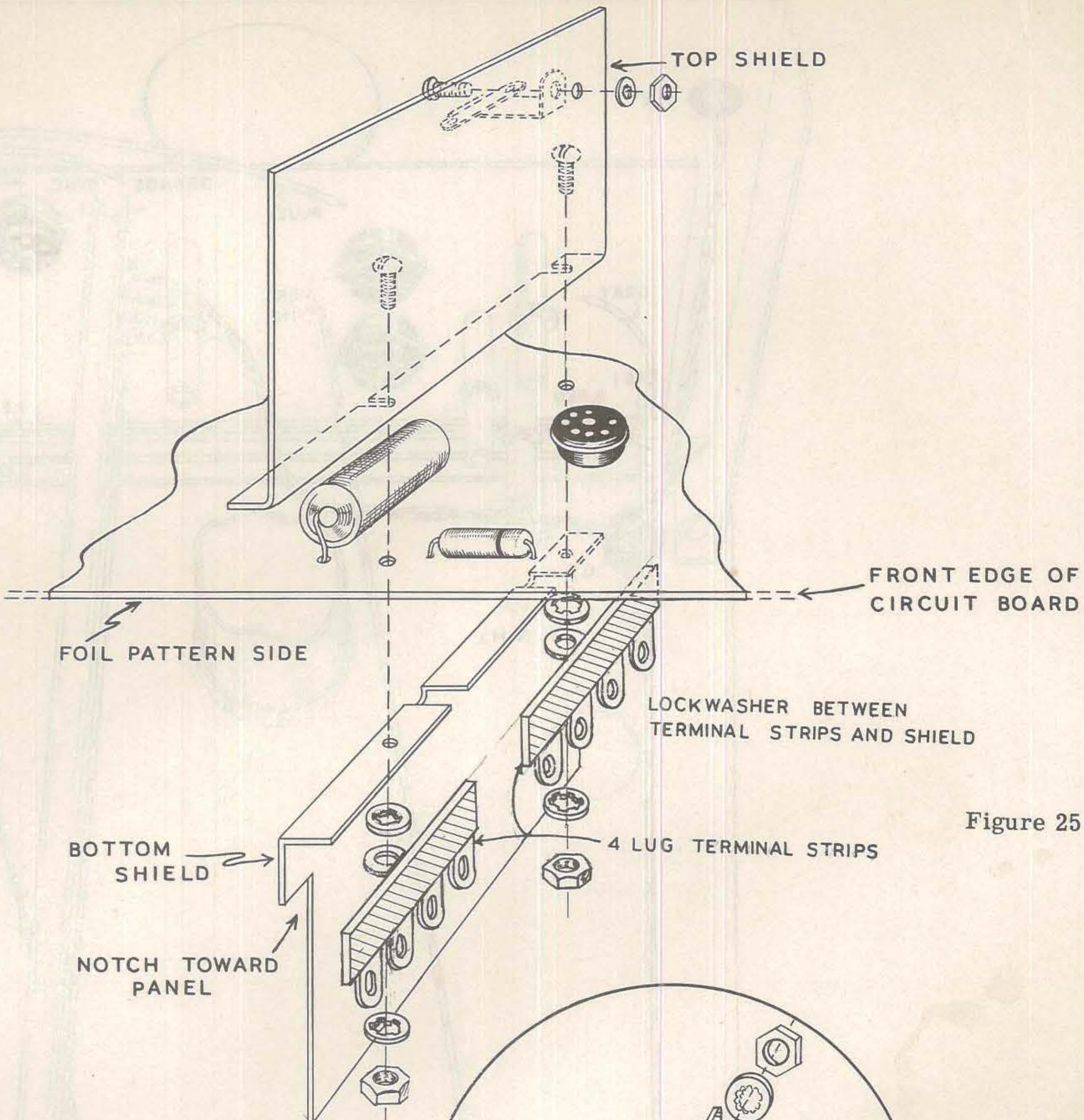


Figure 25

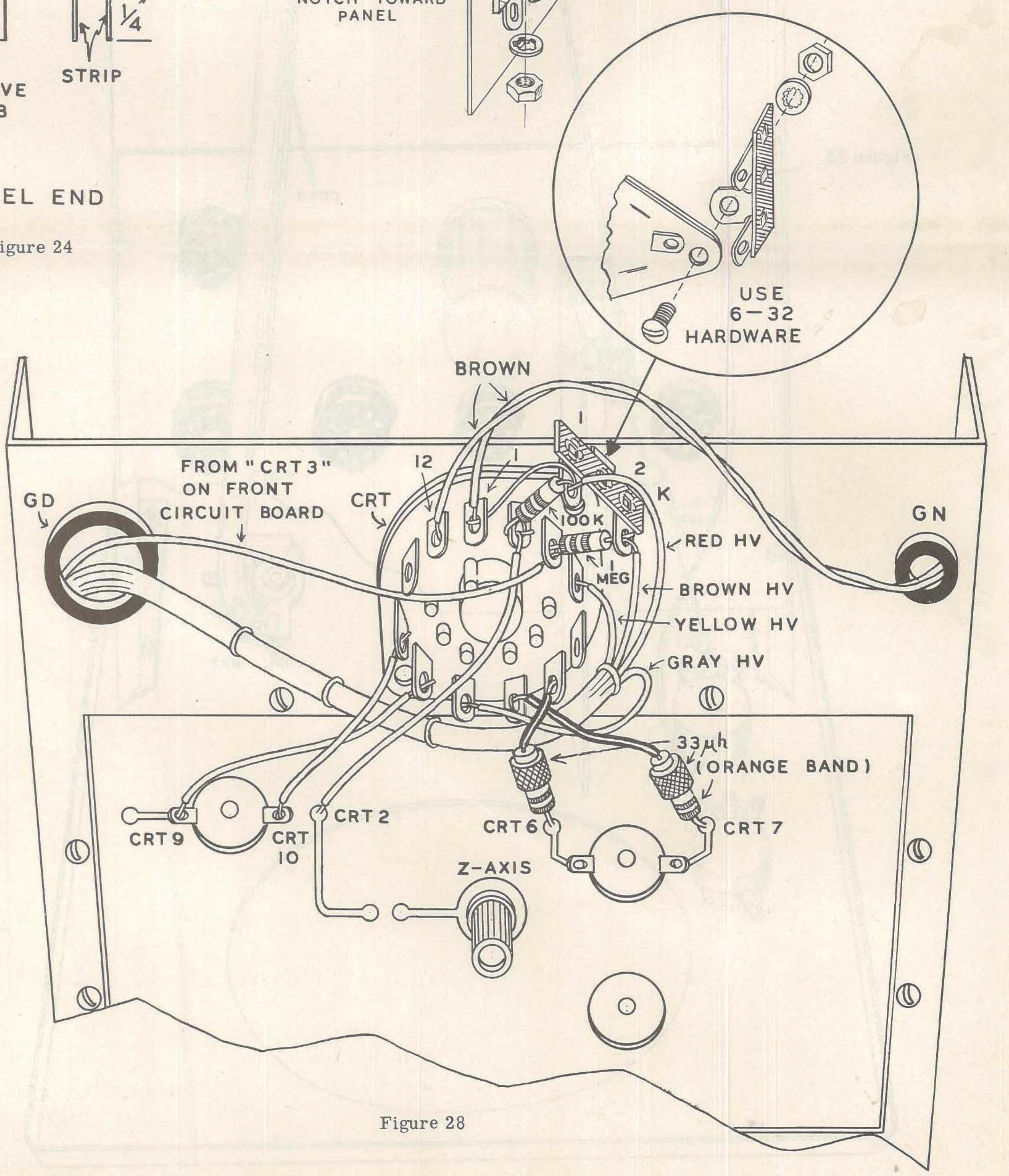


Figure 28

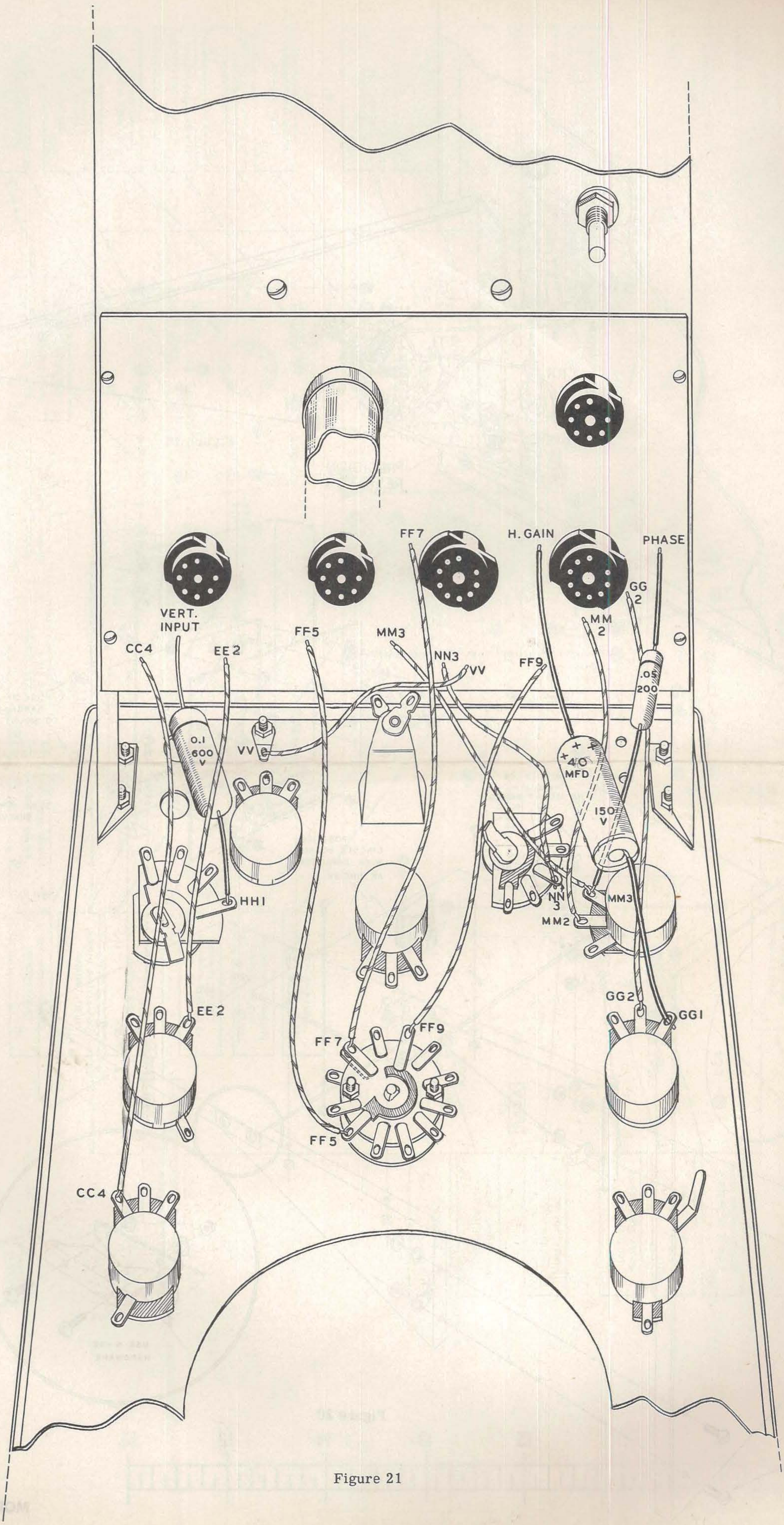
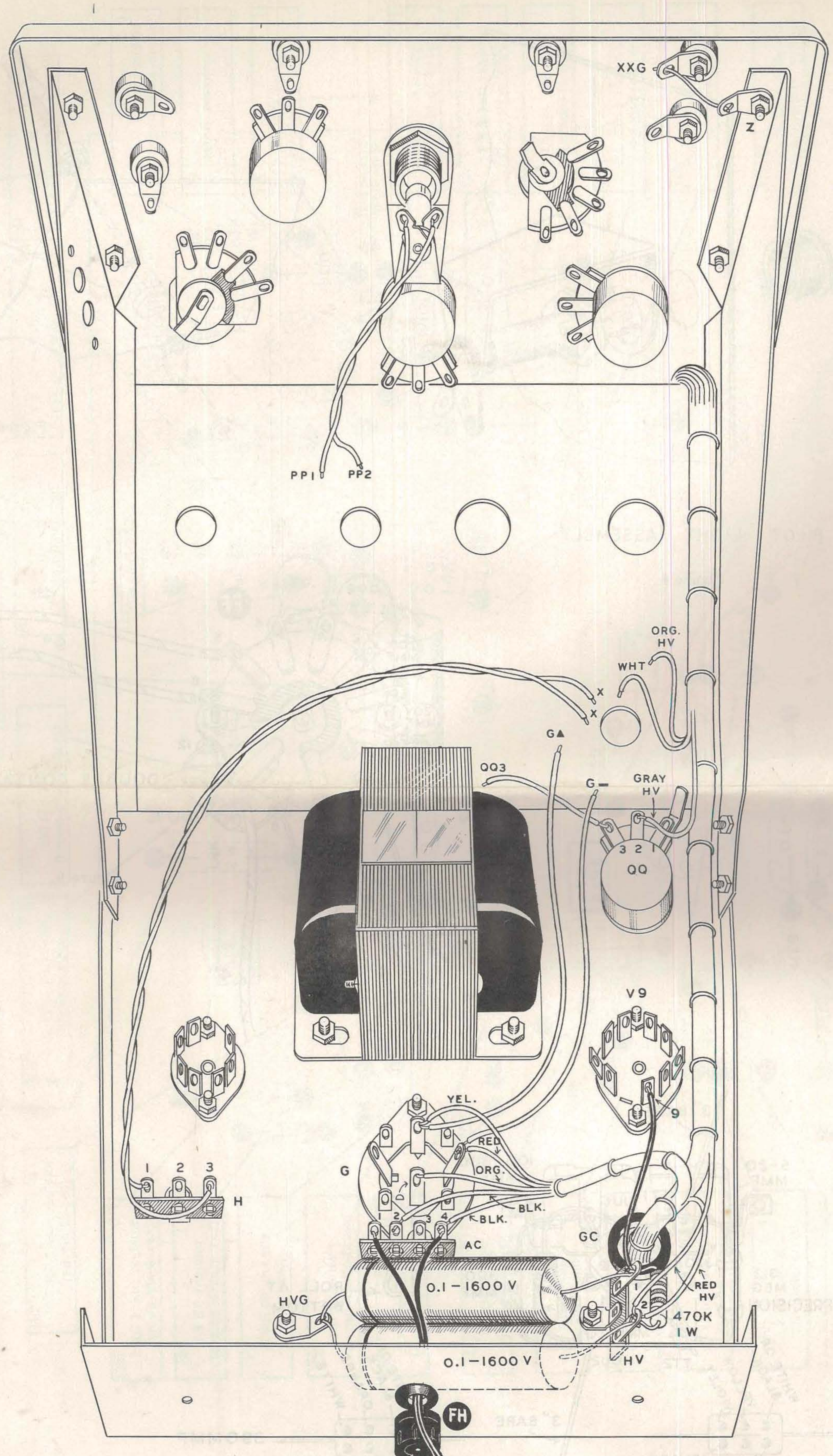

FF7
H. GAIN
PHASE
GG
2
VERT.
INPUT
MM
2
CC4
EE2
FF5
MM3
NN3
VV
FF9
.05
200
0.1
600
V
VV
40
MFD
150
V
HH1
NN
3
MM3
MM2
GG2
GG1
EE2
FF9
FF7
FF5
CC4

Figure 21



MODEL O-12

fig 22

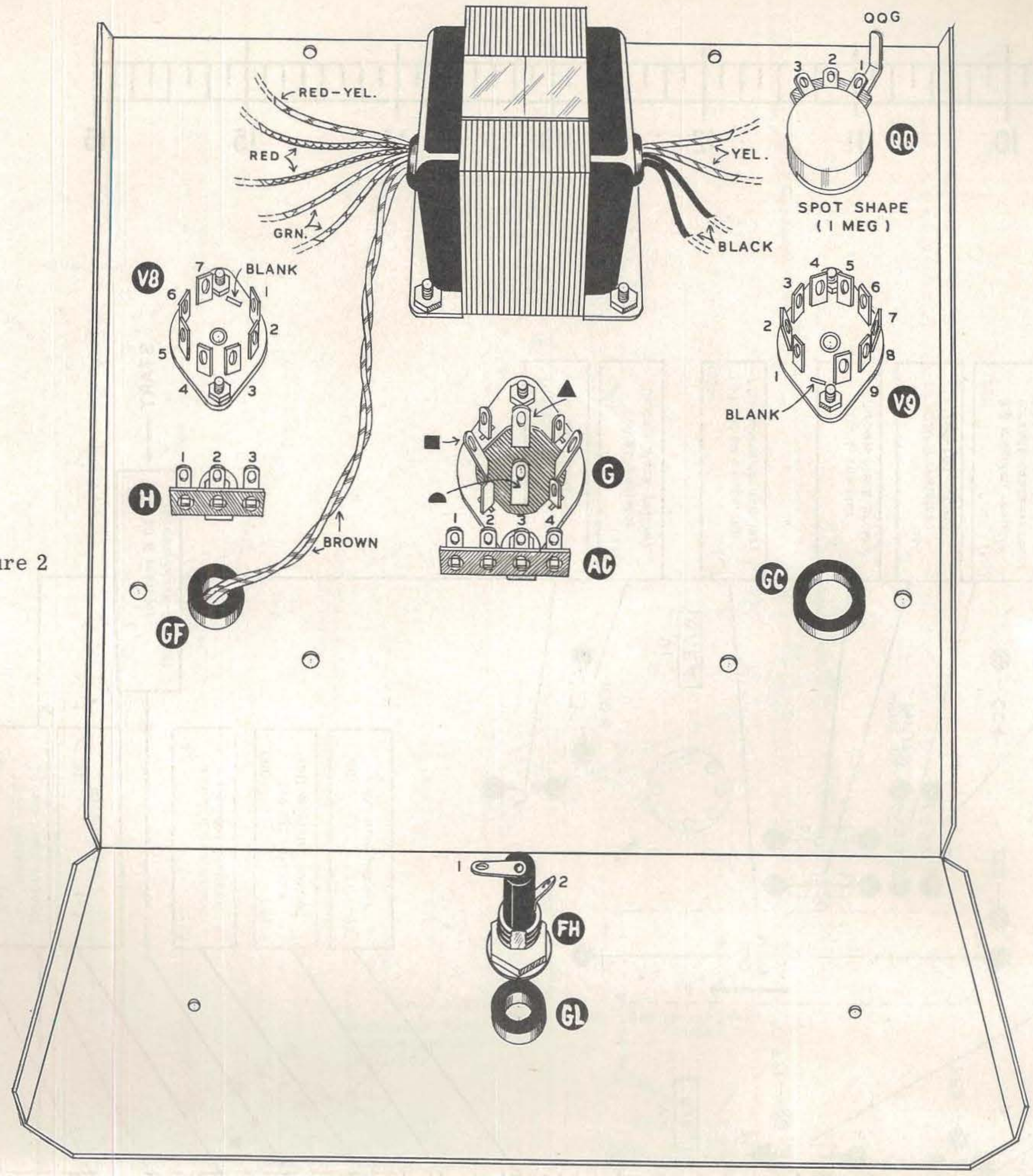


Figure 2

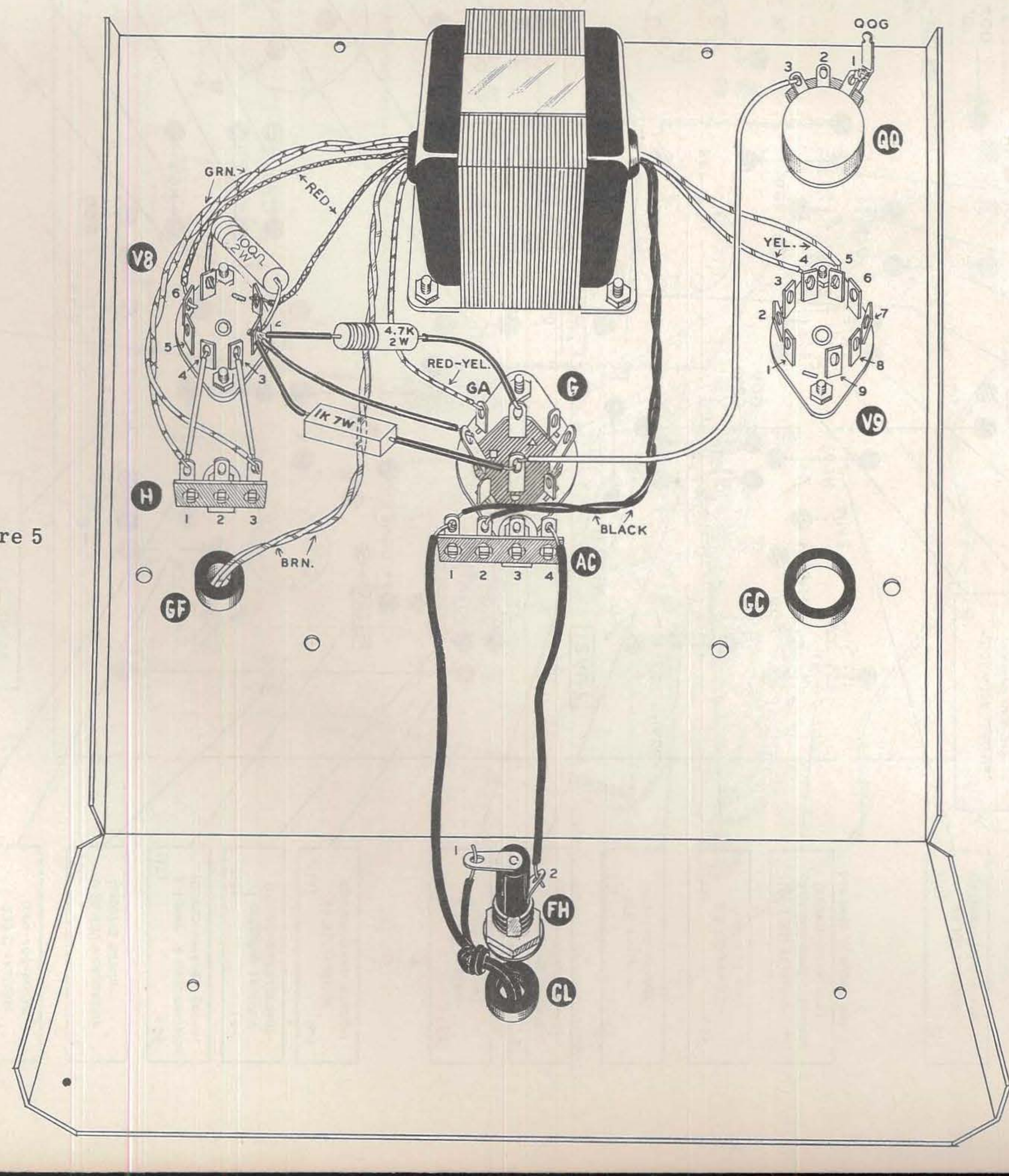
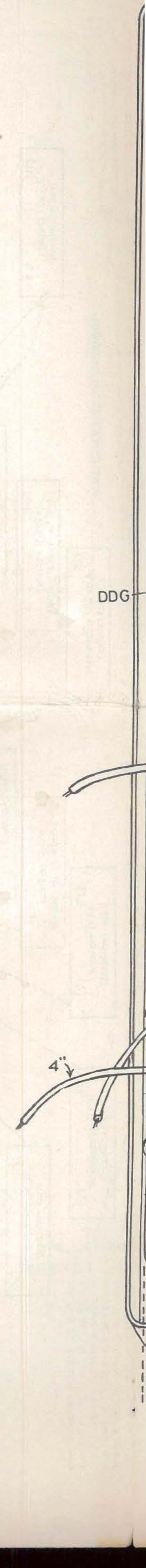


Figure 5



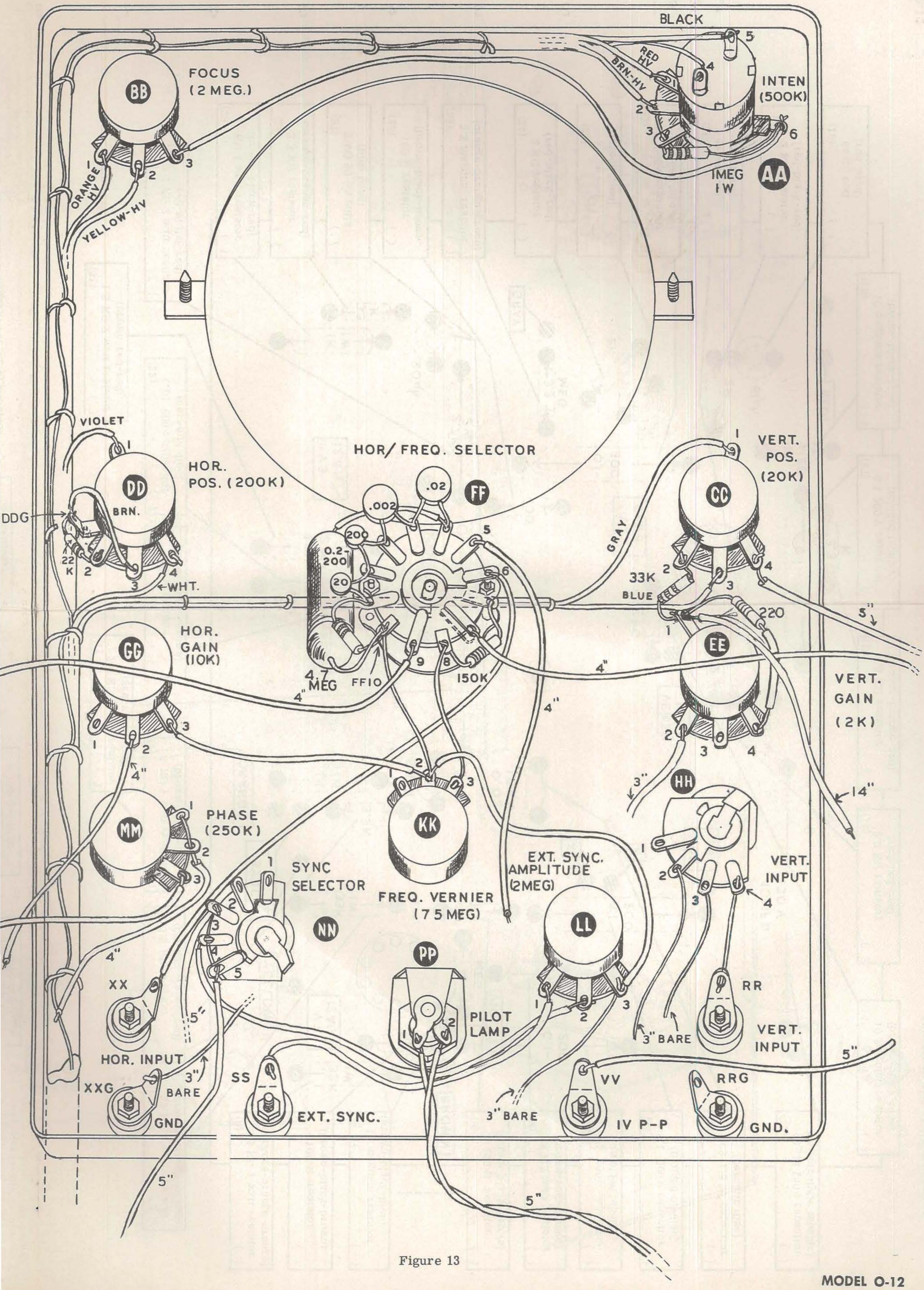
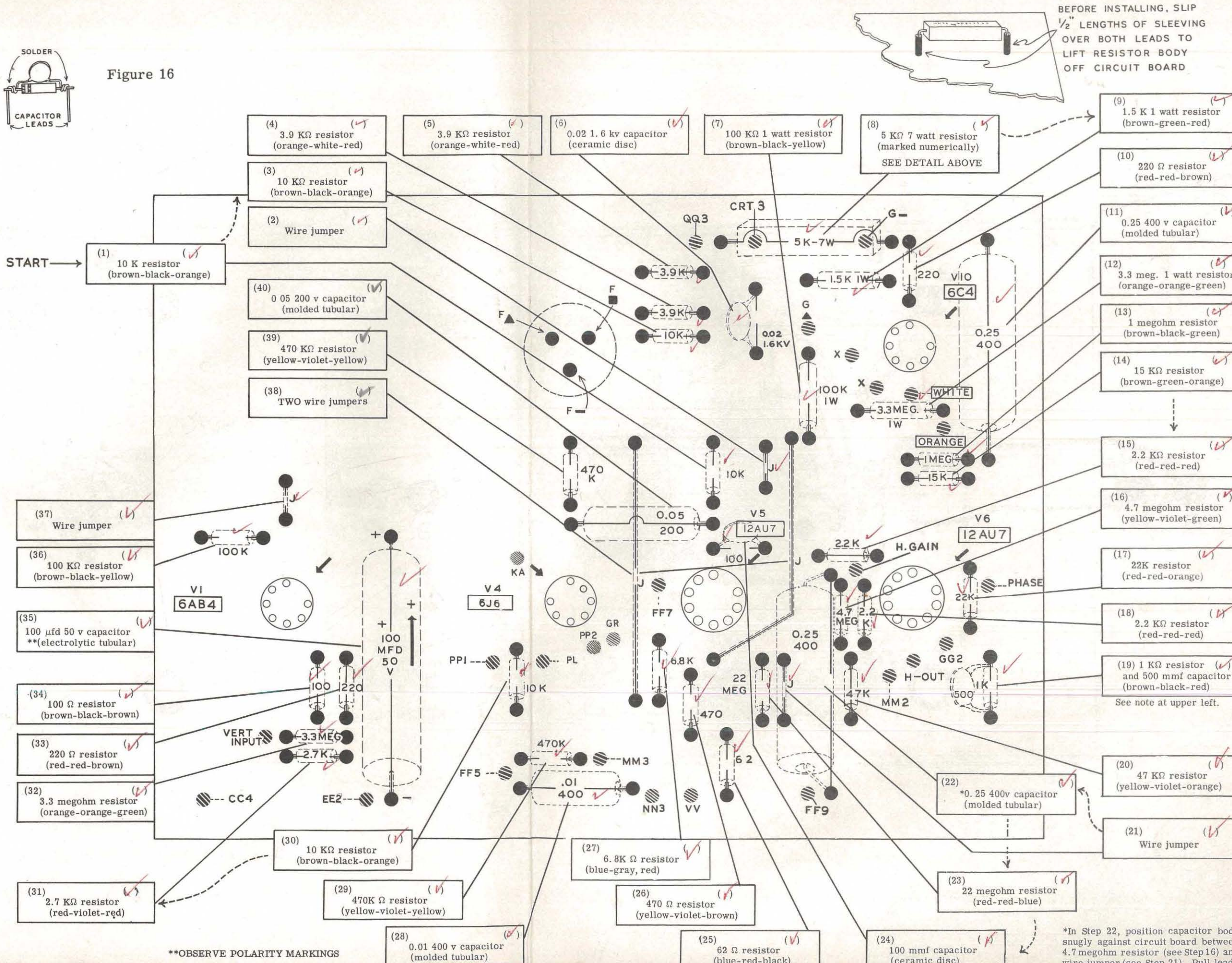
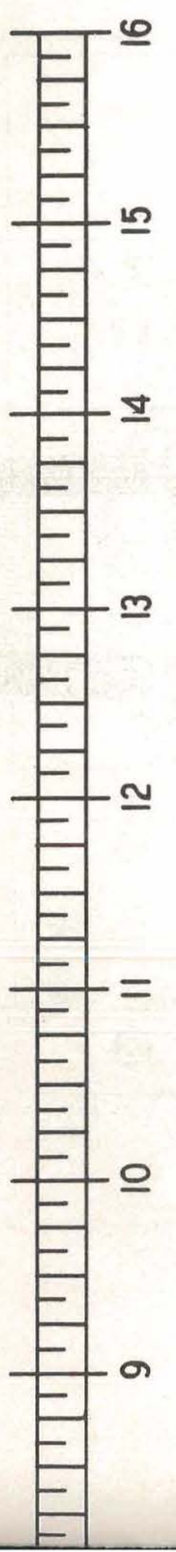

BLACK
FOCUS (2 MEG.)
BB
ORANGE HV
YELLOW-HV
RED HV
BRN-HV
INTEN (500K)
IMEG IW
AA
VIOLET
HOR. POS. (200K)
DD
BRN.
DDG
22 K
WHT.
HOR/ FREQ. SELECTOR
FF
.002
.02
0.2-200
200
20
4.7 MEG
FF10
150K
VERT. POS. (20K)
CC
GRAY
33K
BLUE
220
EE
VERT. GAIN (2K)
HOR. GAIN (10K)
GG
PHASE (250K)
MM
KK
FREQ. VERNIER (7 5 MEG)
EXT. SYNC. AMPLITUDE (2MEG)
LL
HH
VERT. INPUT
SYNC SELECTOR
NN
PP
PILOT LAMP
XX
HOR. INPUT
XXG
GND
3" BARE
SS
EXT. SYNC.
VV
IV P-P
RR
VERT. INPUT
RRG
GND.
5"
4"
14"
Figure 13

Figure 16



**OBSERVE POLARITY MARKINGS

*In Step 22, position capacitor body snugly against circuit board between 4.7 megohm resistor (see Step 16) and wire jumper (see Step 21). Pull leads taut, then spread on foil side of board.



**OBSERVE POLARITY MARKINGS

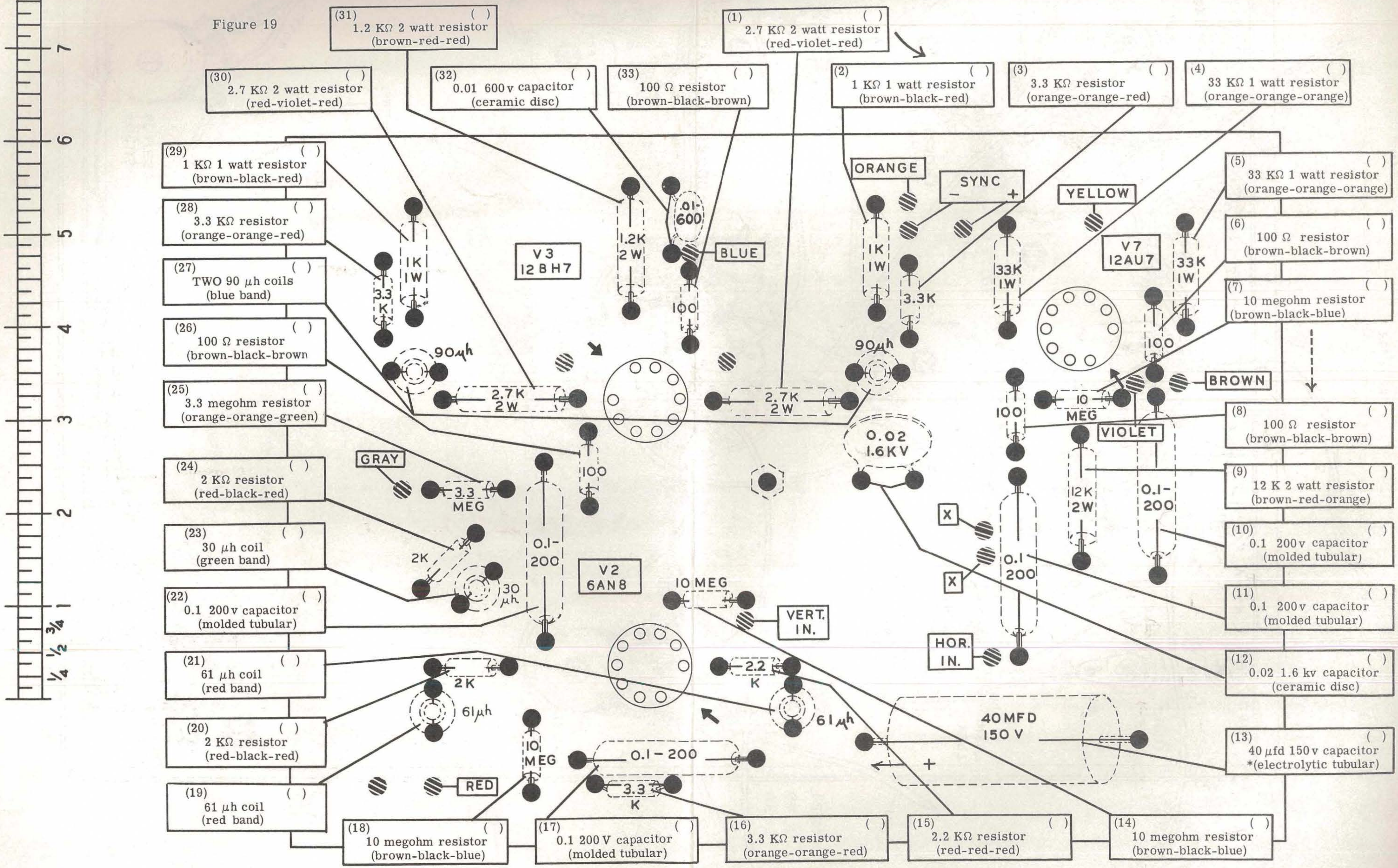
(molded tubular)

(blue-red-black)

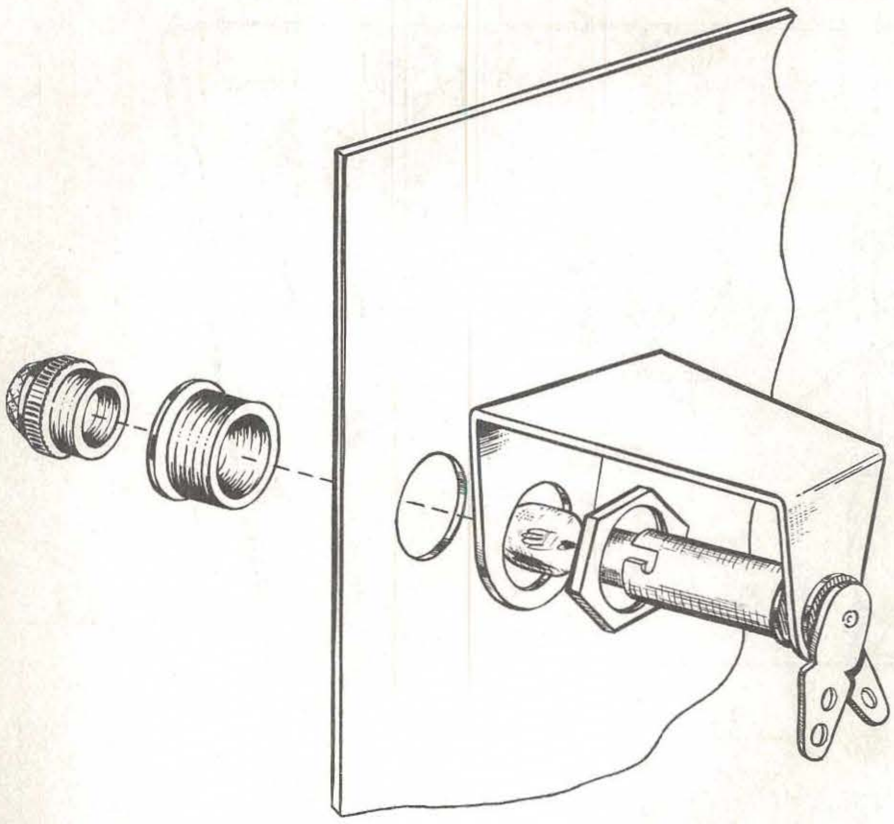
(ceramic disc)

wire jumper (see Step 21). Pull leads taut, then spread on foil side of board.

Figure 19



*OBSERVE POLARITY MARKINGS



PILOT LIGHT ASSEMBLY

Figure 6

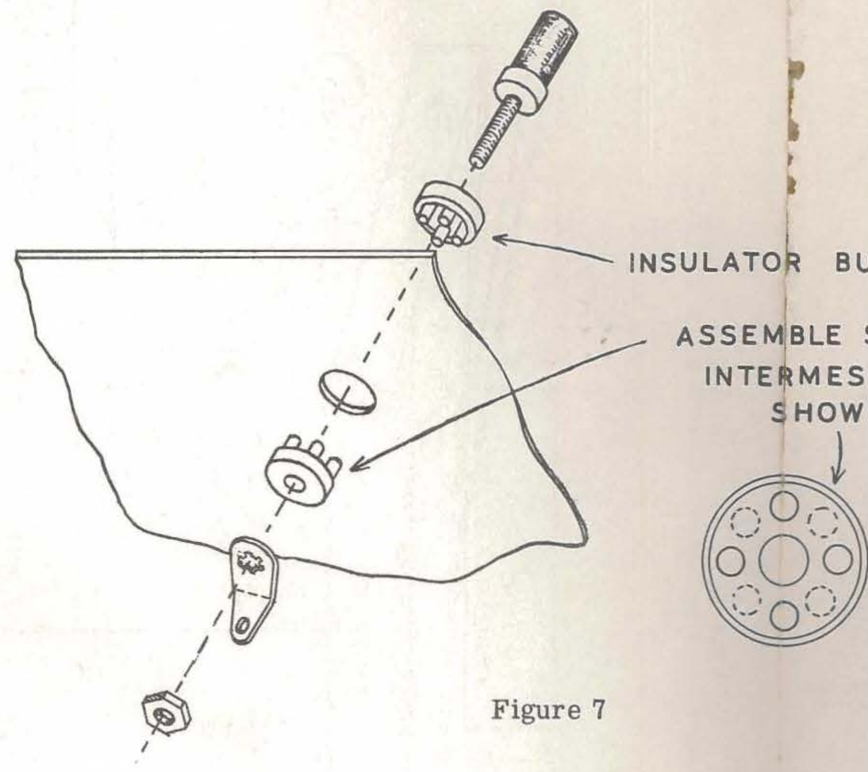


Figure 7

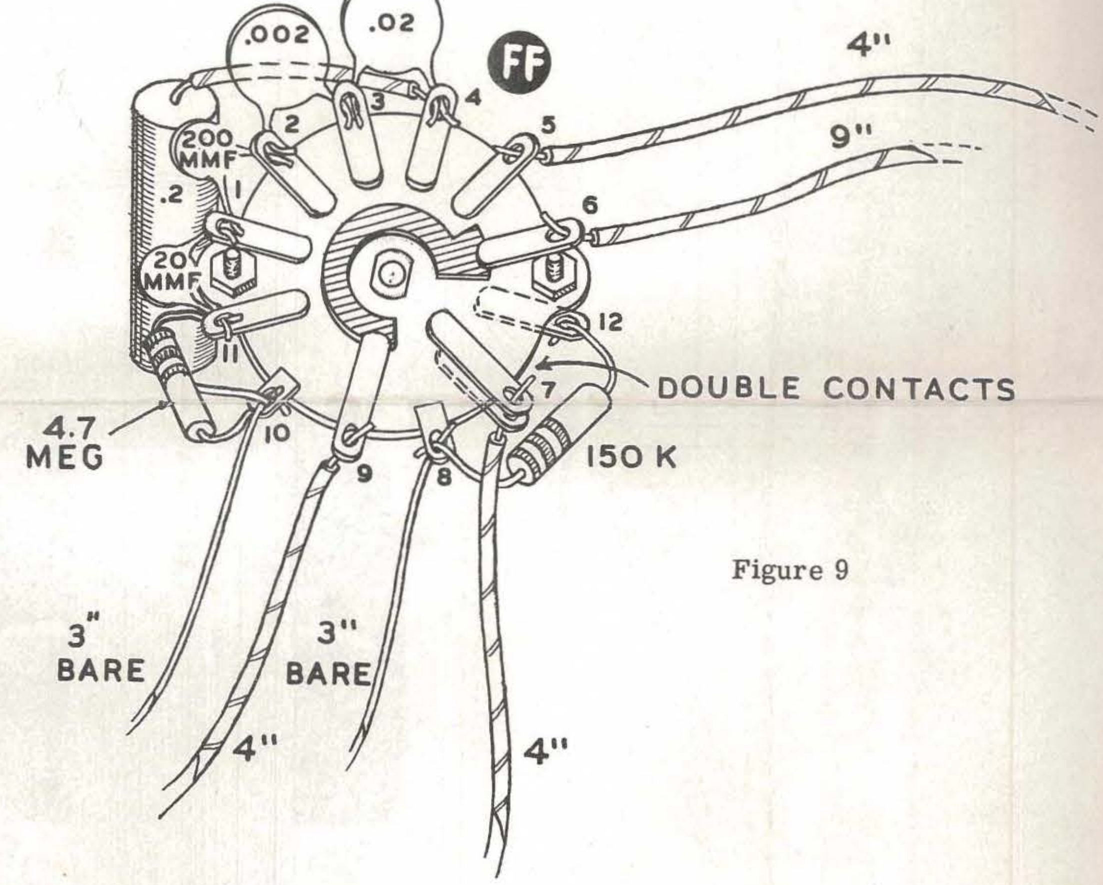


Figure 9

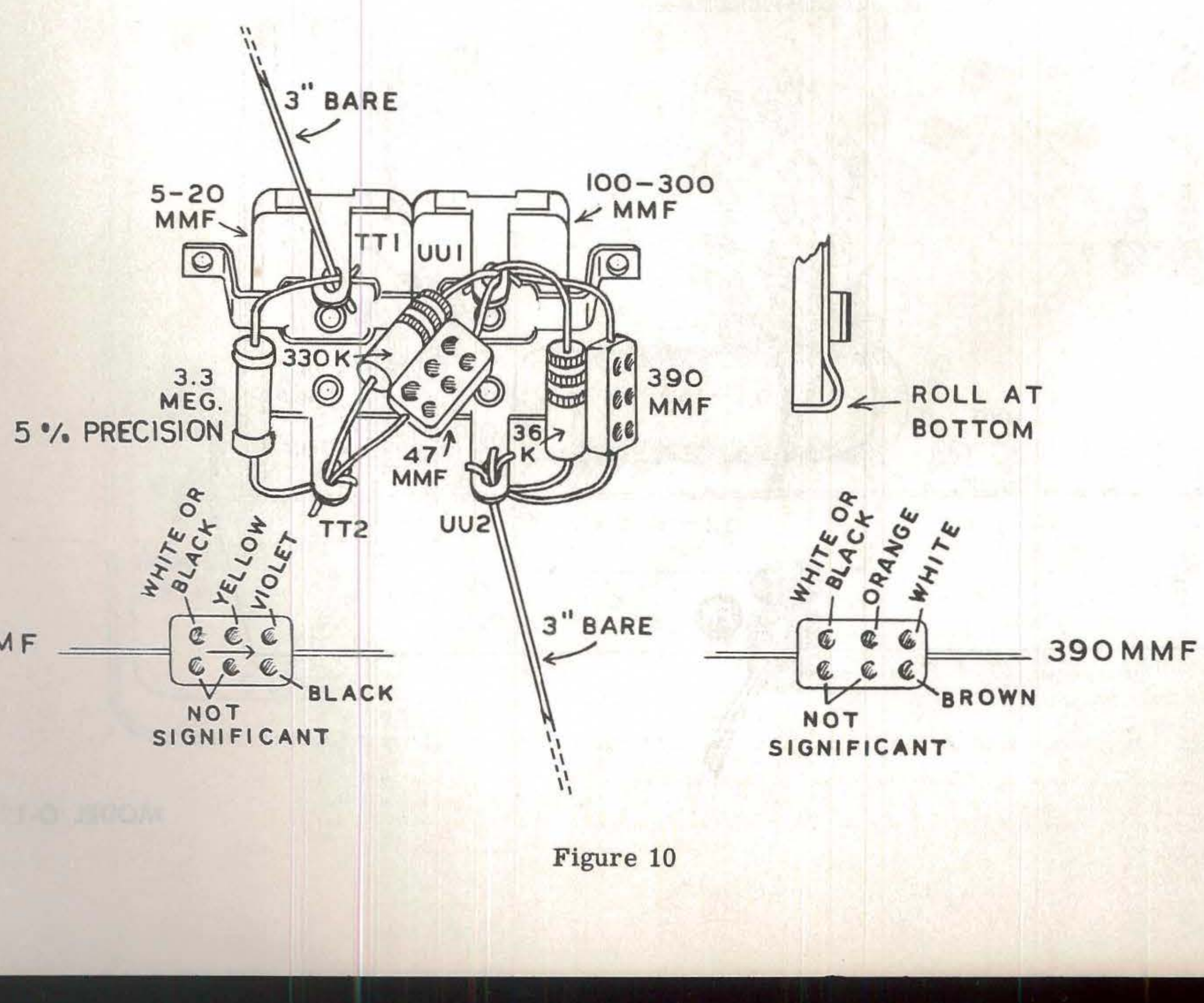
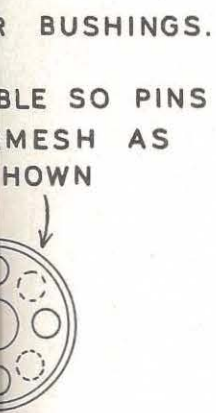


Figure 10



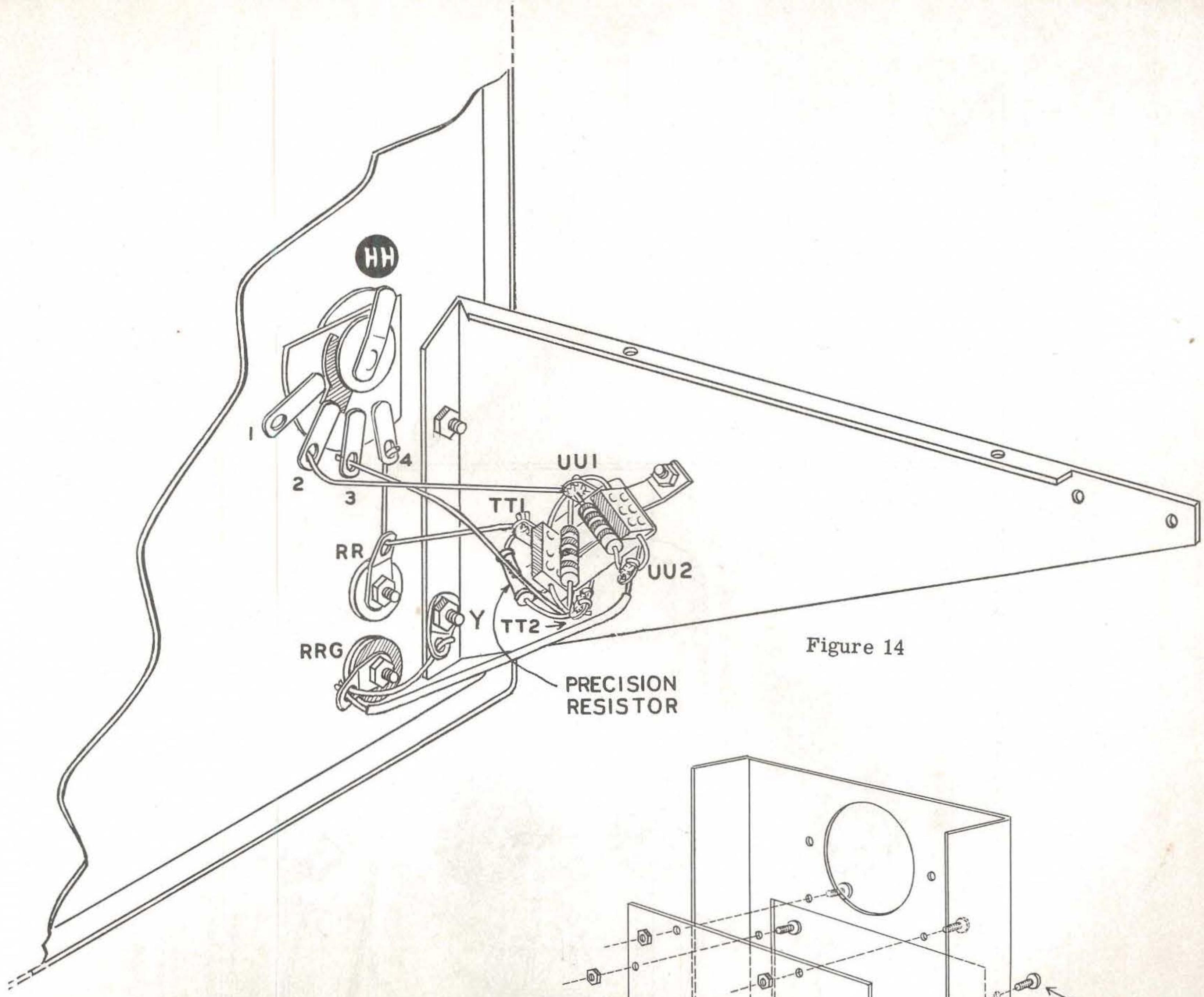


Figure 14

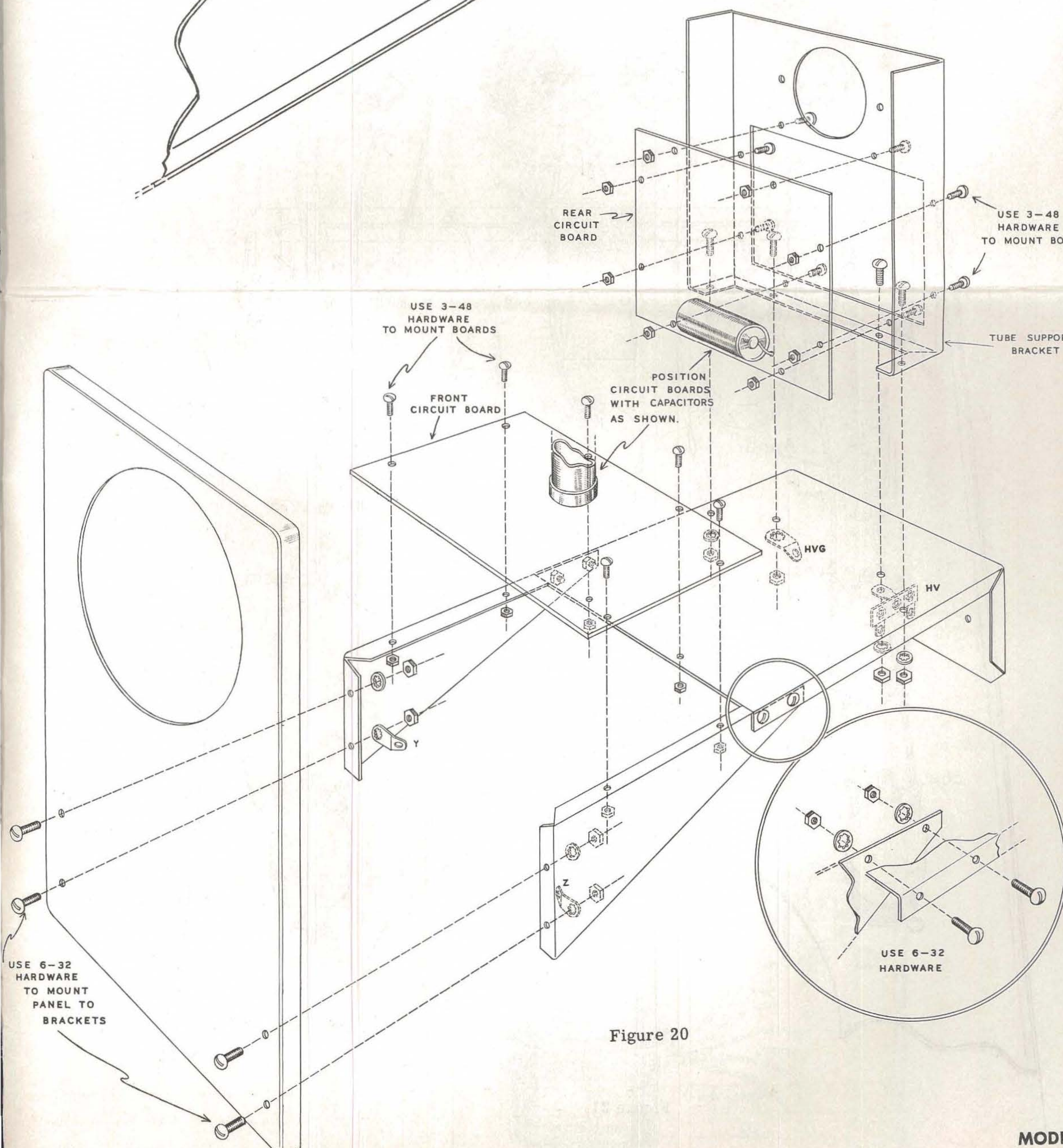
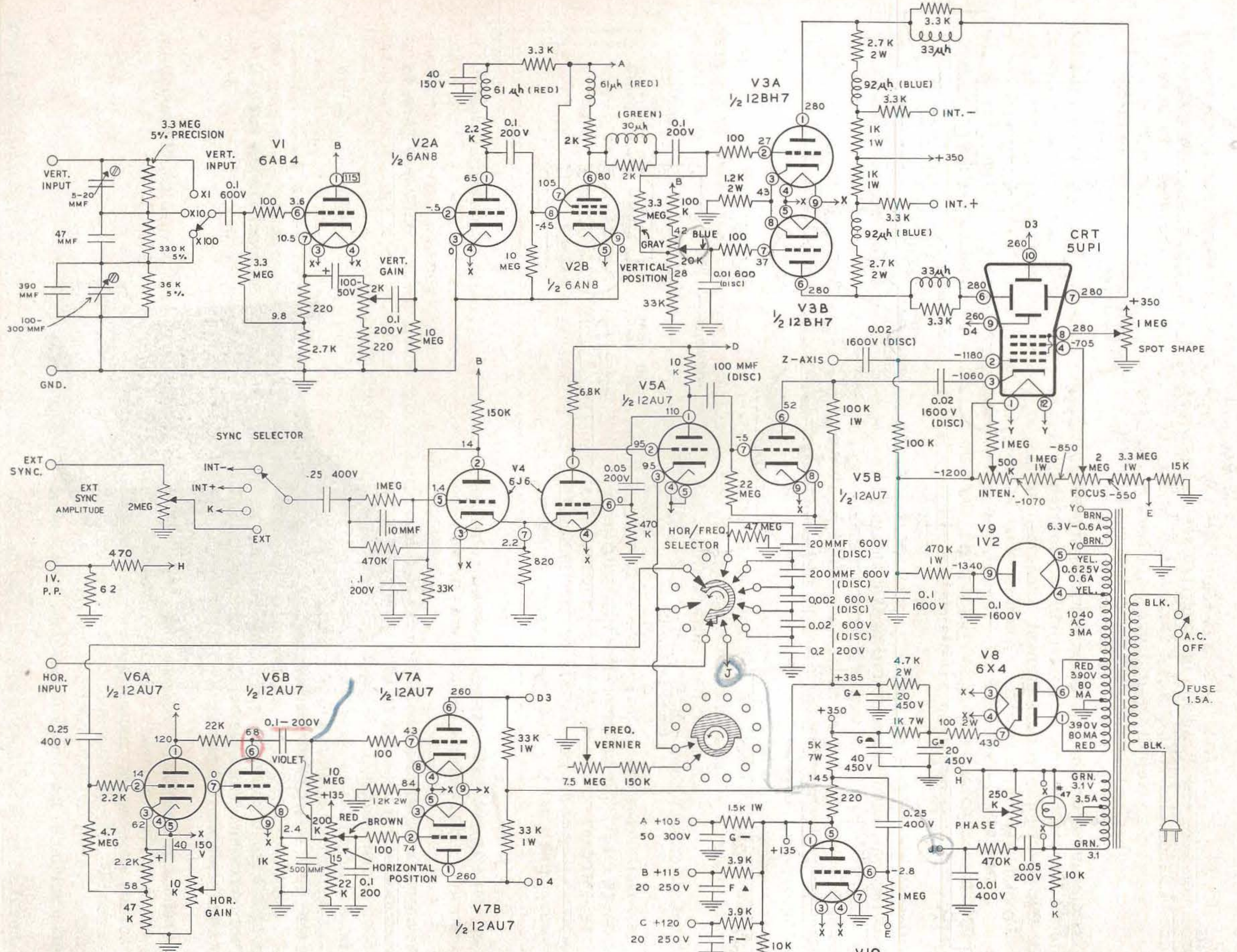


Figure 20



HEATHKIT OSCILLOSCOPE
MODEL O-12

1. All switches shown in full CCW position.
2. All resistors marked in ohms and are 1/2 watt unless specified.
3. All condensers marked in µfd and are paper dielectric unless specified.
4. Multipliers: K x 1000, MEG. x 1,000,000
5. Voltages listed using 11 megohm VTVM.
6. All voltages measured to chassis ground.
7. Spot centered-just visible.
8. Voltage variation up to 20% normal.