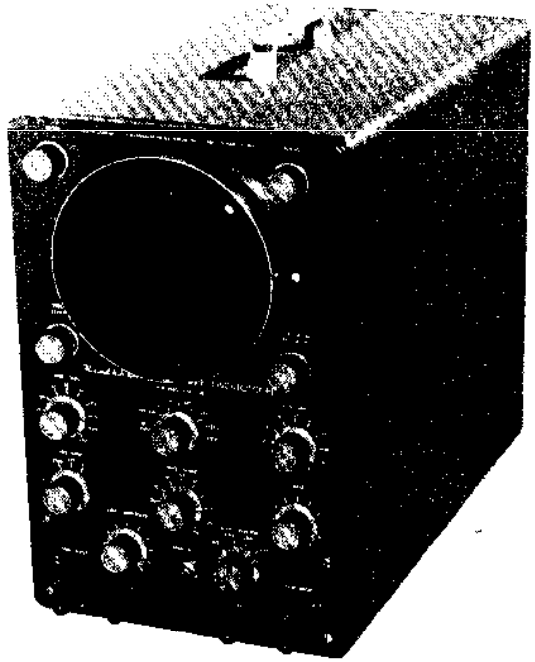
Heathkit Laboratory Oscilloscope

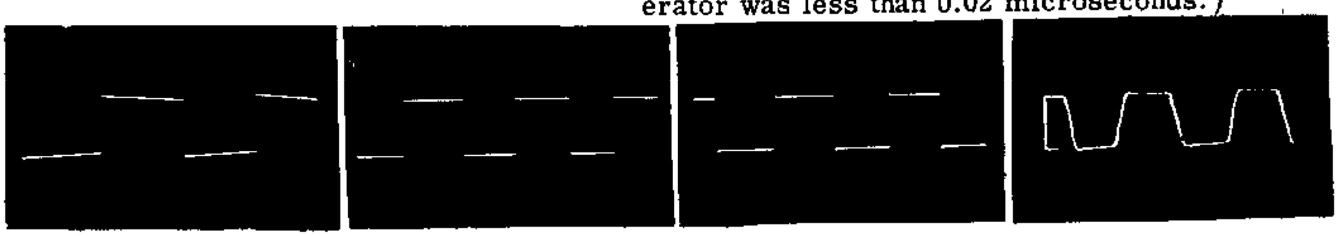
MODEL O-11



SPECIFICATIONS

Vertical Channel:

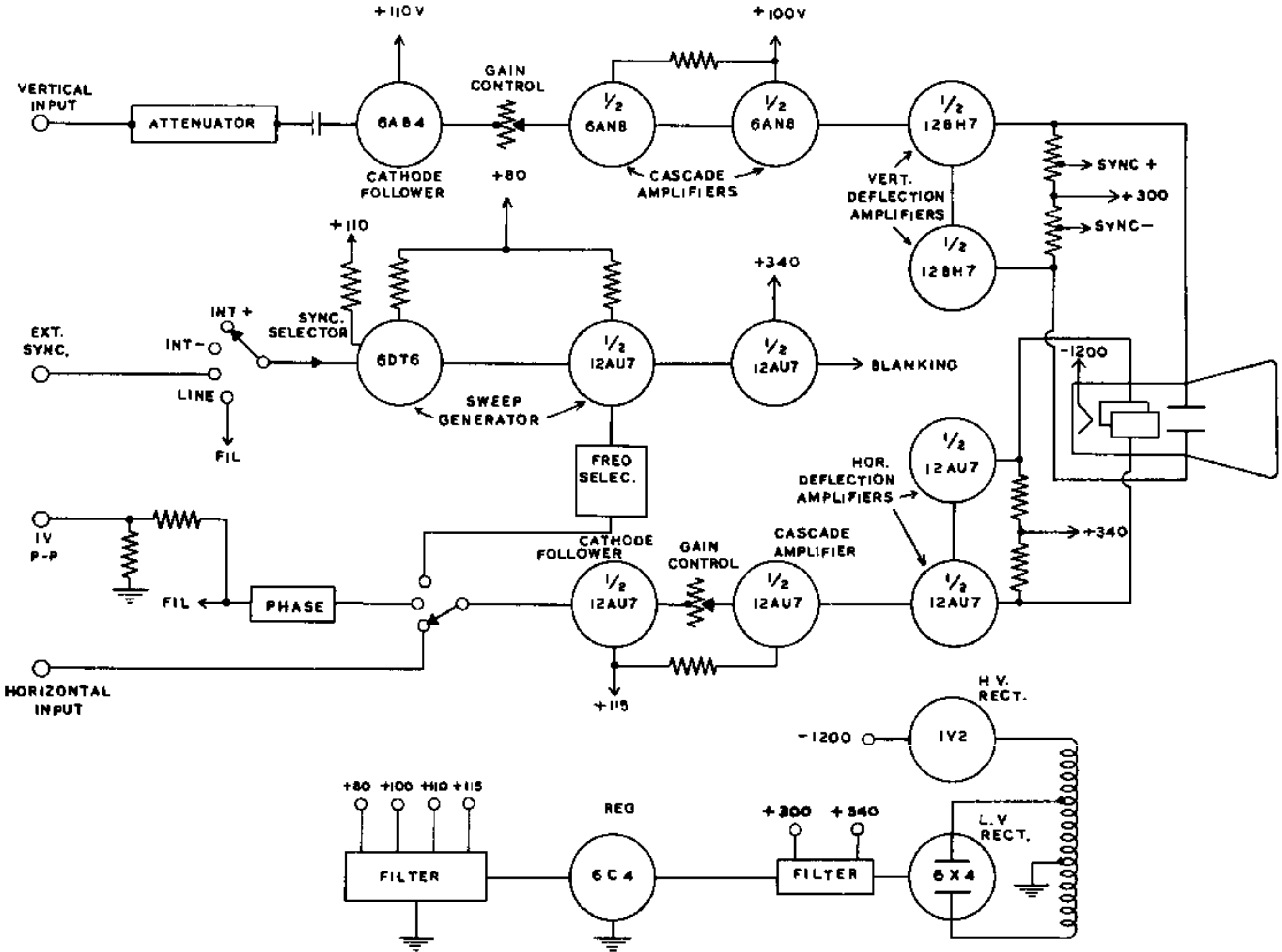
Sensitivity	0.025 volts (RMS) per inch at 1 kc.
Frequency Response	Flat within ±1 db from 8 cps, to 2.5 mc. Flat, + 1.5 to -5 db; 3 cps to 5 mc. Response at 3.58 mc, - 2.2 db. (All response measurements referred to 1 kc)
Rise Time	0.08 microseconds or less.
Overshoot	10% or less.
Transient Response	Oscillograms below are unretouched displays of square wave signals. (Rise time of source generator was less than 0.02 microseconds.)



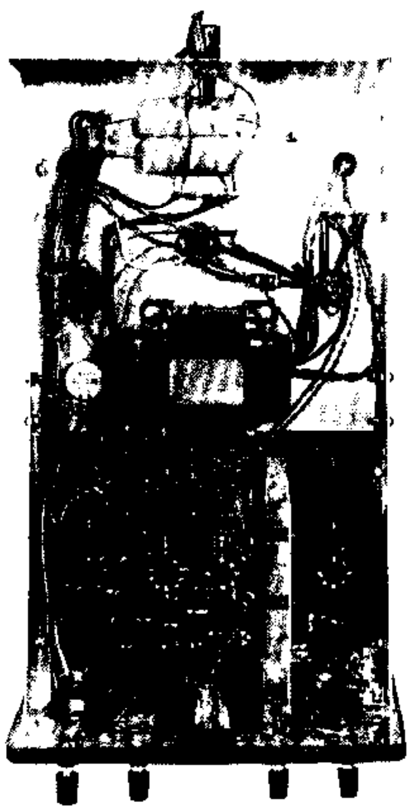
50 CPS 1000 CPS 100 KC 1 MC

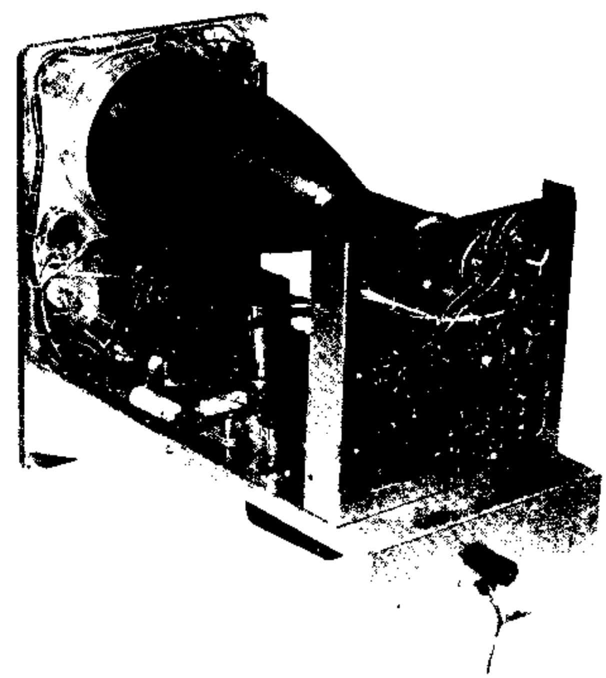
Input Impedance	In X1 attenuator position, 2.9 megohms shunted by 21 $\mu\mu$f. (1 kc impedance, 2.7 megohms) In X10 and X100 positions, 3.4 megohms shunted by 12 $\mu\mu$f. (1 kc impedance, 3.3 megohms)
Attenuator	Three-position, switch-type, fully compensated; no visible change in wave shape at any 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.

Horizontal Channel:	
Sensitivity	0.6 volts (RMS) per inch at 1 kc.
Frequency Response	Flat within ±1 db 1 cps to 200 kc. Flat within ±3 db 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	20 cps to 500 kc in five steps: 20 to 100 cps, 100 to 1000 cps, 1 to 10 kc, 10 to 100 kc, 100 to 500 kc.
Synchronizing	Selector switch permits synchronizing sweep generator with either positive or negative signal pulses iniernally, with external source through panel terminal or with line frequency.
Cathode Ray Tube	5UP1, 5" screen, green medium-persistence phosphor.
Power Supplies	High-voltage supply; transformer-rectifier type, developing 1200 volts at output of RC fiiter 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 20% of 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	Bnilt-in source, 1 volt peak-to-peak; calibrated grid screen and accurately calibrated input attenuator to permit voltage measurementa over range of 10,000 to 1 or more.
Z-Axis Modulation	Provision for intensity modulation of electron stream throngh high-voltage isolation condenser; 8 to 20 volta (RMS) reqnired 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 capecities introduced would be detrimental. When required, such connections can be readily made direct to socket terminals, without removing chassis from cabinet.
Power Reqnirements	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.



VERTICAL INPUT
ATTENUATOR
+110V
6AB4
CATHODE FOLLOWER
GAIN CONTROL
+80
1/2 6AN8
1/2 6AN8
+100V
CASCADE AMPLIFIERS
1/2 12BH7
1/2 12BH7
VERT. DEFLECTION AMPLIFIERS
SYNC +
+300
SYNC−
+110
SYNC. SELECTOR
INT +
INT −
EXT. SYNC.
LINE
FIL
6DT6
1/2 12AU7
SWEEP GENERATOR
+340
1/2 12AU7
BLANKING
-1200
FREQ SELEC.
1V P-P
FIL
PHASE
HORIZONTAL INPUT
CATHODE FOLLOWER
1/2 12AU7
+115
GAIN CONTROL
1/2 12AU7
CASCADE AMPLIFIER
HOR. DEFLECTION AMPLIFIERS
1/2 12AU7
1/2 12AU7
+340
H.V. RECT.
-1200
1V2
+80 +100 +110 +115
FILTER
REG
6C4
+300 +340
FILTER
L.V. RECT.
6X4





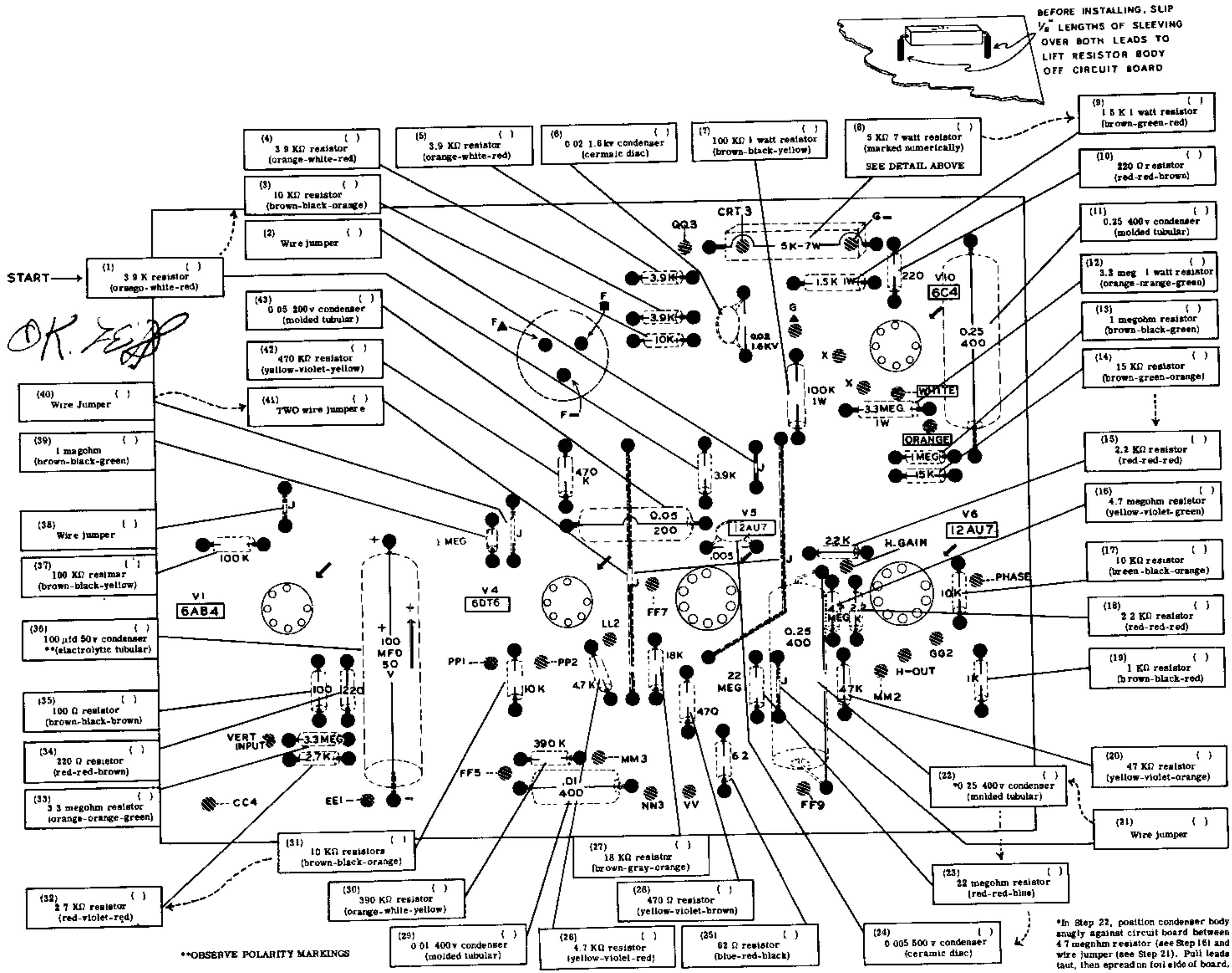

BEFORE INSTALLING, SLIP 1/8" LENGTHS OF SLEEVING OVER BOTH LEADS TO LIFT RESISTOR BODY OFF CIRCUIT BOARD
START
(1) 3 9 K resistor ( ) (orange-white-red)
(2) Wire jumper ( )
(3) 10 KΩ resistor ( ) (brown-black-orange)
(4) 3 9 KΩ resistor ( ) (orange-white-red)
(5) 3.9 KΩ resistor ( ) (orange-white-red)
(6) 0 02 1.6 kv condenser ( ) (cermaic disc)
(7) 100 KΩ 1 watt resistor ( ) (brown-black-yellow)
(8) 5 KΩ 7 watt resistor ( ) (marked numerically)
SEE DETAIL ABOVE
(9) 1 5 K 1 watt resistor ( ) (brown-green-red)
(10) 220 Ω resistor ( ) (red-red-brown)
(11) 0.25 400 v condenser ( ) (molded tubular)
(12) 3.3 meg 1 watt resistor ( ) (orange-orange-green)
(13) 1 megohm resistor ( ) (brown-black-green)
(14) 15 KΩ resistor ( ) (brown-green-orange)
(15) 2.2 KΩ resistor ( ) (red-red-red)
(16) 4.7 megohm resistor ( ) (yellow-violet-green)
(17) 10 KΩ resistor ( ) (brown-black-orange)
(18) 2 2 KΩ resistor ( ) (red-red-red)
(19) 1 KΩ resistor ( ) (brown-black-red)
(20) 47 KΩ resistor ( ) (yellow-violet-orange)
(21) Wire jumper ( )
(22) *0 25 400 v condenser ( ) (molded tubular)
(23) 22 megohm resistor ( ) (red-red-blue)
(24) 0 005 500 v condenser ( ) (ceramic disc)
(25) 62 Ω resistor ( ) (blue-red-black)
(26) 470 Ω resistor ( ) (yellow-violet-brown)
(27) 18 KΩ resistor ( ) (brown-gray-orange)
(28) 4.7 KΩ resistor ( ) (yellow-violet-red)
(29) 0 01 400 v condenser ( ) (molded tubular)
(30) 390 KΩ resistor ( ) (orange-white-yellow)
(31) 10 KΩ resistors ( ) (brown-black-orange)
(32) 2 7 KΩ resistor ( ) (red-violet-red)
(33) 3 3 megohm resistor ( ) (orange-orange-green)
(34) 220 Ω resistor ( ) (red-red-brown)
(35) 100 Ω resistor ( ) (brown-black-brown)
(36) 100 μfd 50 v condenser ( ) **(electrolytic tubular)
(37) 100 KΩ resistor ( ) (brown-black-yellow)
(38) Wire jumper ( )
(39) 1 megohm ( ) (brown-black-green)
(40) Wire Jumper ( )
(41) TWO wire jumpers ( )
(42) 470 KΩ resistor ( ) (yellow-violet-yellow)
(43) 0 05 200 v condenser ( ) (molded tubular)
CRT 3
QQ3
5K-7W
G−
1.5 K 1W
220
V10
6C4
0.25
400
3.9K
10K
.002
1.6KV
G
X
100K
1W
3.3MEG
WHITE
ORANGE
1 MEG
15K
F
F−
470 K
0.05
200
V5
12AU7
.005
22 K
H. GAIN
V6
12AU7
PHASE
10K
4.7 MEG
2.2 K
GG2
H-OUT
MM2
1K
47K
22 MEG
18K
470
62
FF7
FF9
LL2
47K
PP1
PP2
V4
6DT6
V1
6AB4
100K
1 MEG
J
100
MFD
50
V
100
220
VERT INPUT
3.3MEG
2.7K
CC4
EE1
390 K
.01
400
MM3
NN3
VV
FF5
**OBSERVE POLARITY MARKINGS
*In Step 22, position condenser 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.

Figure 16

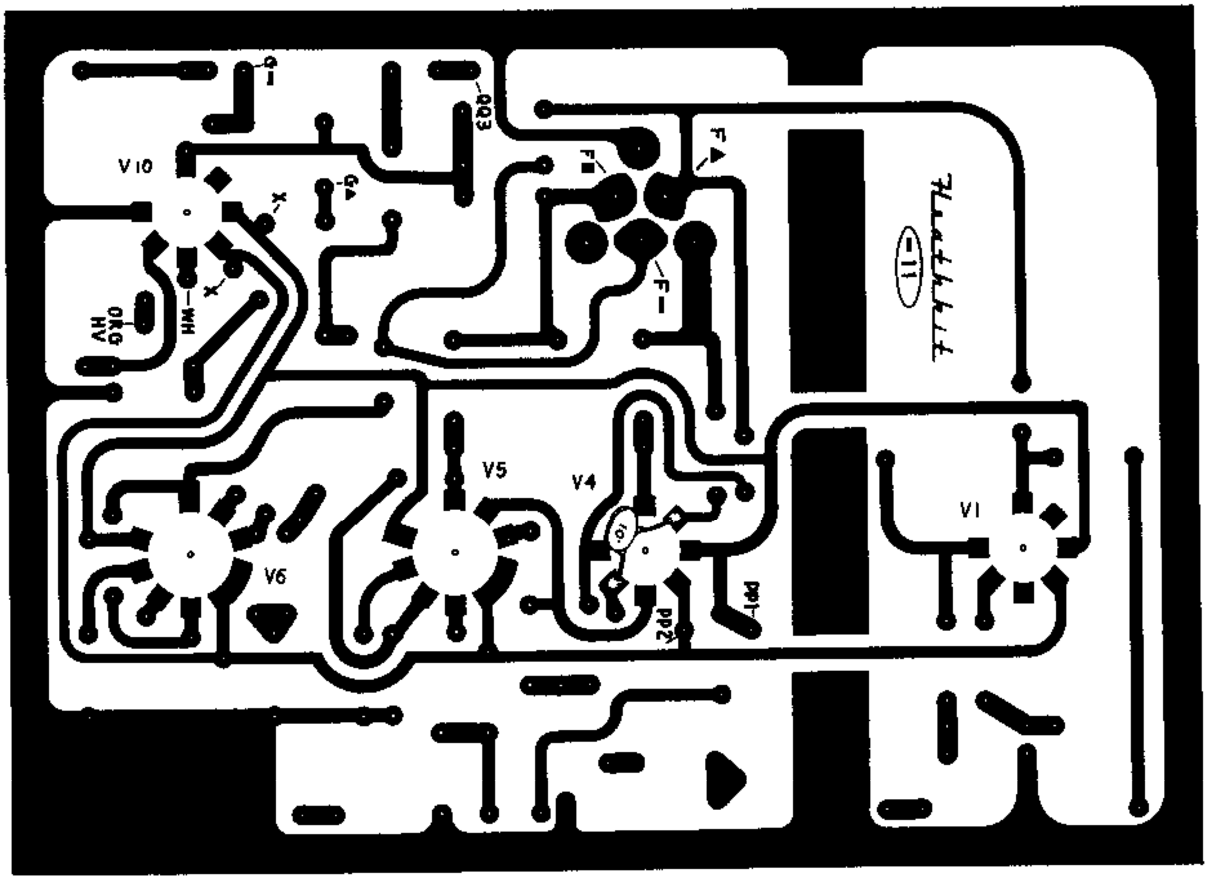


Figure 17

NOTE: Make sure a 0.01 disc condenser is installed between pins 2 and 6. See the second step on Page 19.

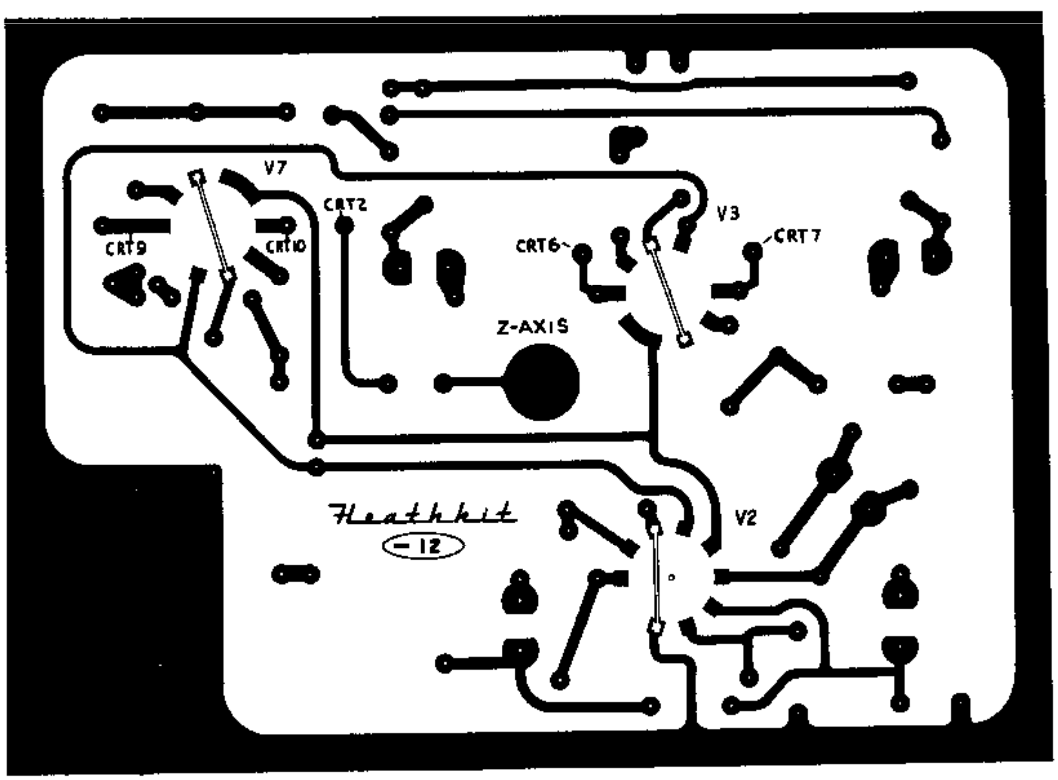
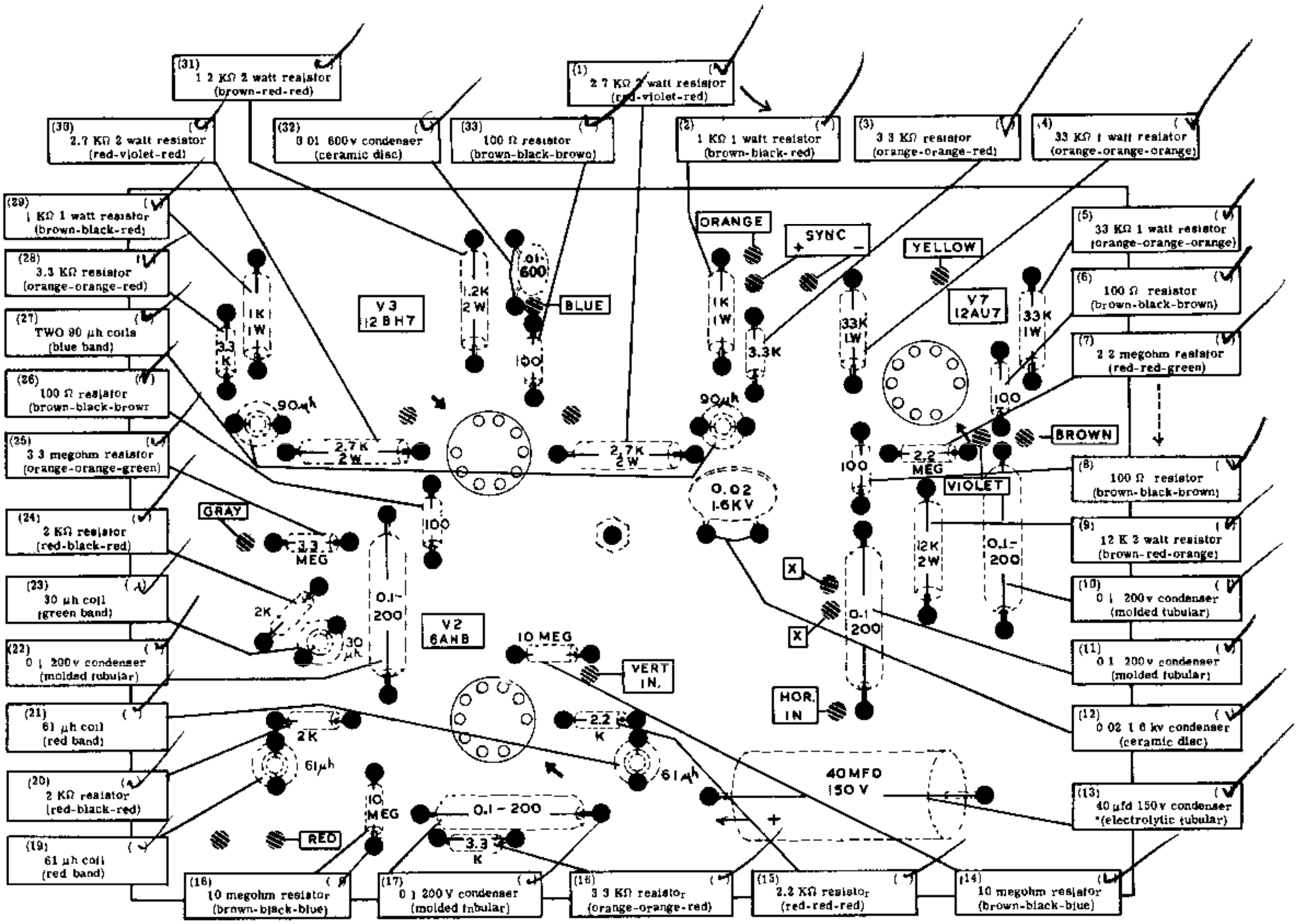


Figure 18

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



*OBSERVE POLARITY MARKINGS

Figure 19

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 - 0
HOR/FREQ. SELECTOR - Full counterclockwise
HOR. GAIN - 0
VERT. INPUT - X100
FREQ. VERNIER - 50
PHASE - At approximate center of rotation
SYNC. AMP. - Two marks from 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.

NOTE: 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 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 tha screen, adjust the Spot Shape control (at the right side of the chassis) so as to maks 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.

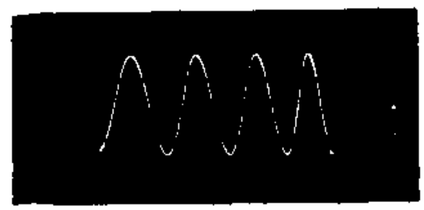
( ) Using one of the test leads, connect a jumper from the 1 V. P-P terminal to the HOR. INPUT terminal. Turn the HOR. GAIN control clockwise. The spot should now become a horizontal line, whose length increases to a maximum of about 7/8" as the HOR. GAIN control is advanced. If the trace is not level, 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 the 1 V. P-P terminal to the VERT. INPUT terminals. 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. Try the X1 position and notice that the same height can be obtained with a very small amount of vertical gain.

( ) 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 30. This check indicates that the sweep generator is operating normally at a frequency of 60/4 or 15 cycles per second. See NOTES ON THE OPERATION OF THE OSCILLOSCOPE for operation of the SYNC. AMPLITUDE control. Reduce the HOR. GAIN setting if necessary.

NOTE: Breaks are caused by the fielde of the power transformer. This will not be present with the external signal.

Figure 30



( ) 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 31 A or B. Reduce both gain control settings so that the trace is about 2" long.

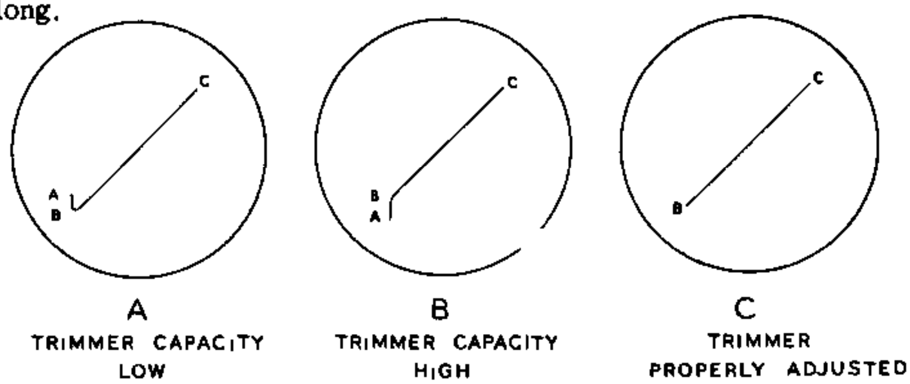


Figure 31

( ) 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."

NOTE: 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-11 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 SYNC. AMP., 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 SYNC. AMP. knob provides the stabilizing action needed to keep the pattern from drifting left or right.

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, control 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. SYNC. SWEEP: Same as LINE but synchronizes 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 78 volts. Connect the 1 V P-P terminal to the VERT. INPUT terminal. With the VERT. INPUT switch in the X1 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 100 volts. (With the VERT. INPUT switch in the X10 position, it would indicate 10 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 0.8" or 80 volts.

NOTES ON THE OPERATION OF THE OSCILLOSCOPE

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 amplifier when the pickup or the microphone is disconnected. Such behavior is a normal characteristic of the instrument and does not interfere with proper operation.

The maximum undistorted output voltage of the vertical amplifier generally does not provide deflection much in excess of 5". Maximum deflection of 3" will provide adequate utilization of the available screen area. Vertical deflection of greater than 3" will give an apparent distortion, as the trace is then oparating 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 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-10 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 0. 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. For example, during development of the O-11, a pronounced deflection of over 1/16" was obtained from a 30 hp AC motor some 75 feet from the scope. 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 sigual frequencies of 1 megacycle and higher, some fuzziness of the trace is normal. With signal frequencies higher than 3 mc, sync. settings 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. A minor condition of nonlinearity may exist when using sweep frequencies below 20 cps. This again is inherent as the oscilloscope amplifiers are functioning at their lower limits of operation. Oscilloscope applications usually require sweep frequencies above 20 cps, thus maximum efficiency will be obtained at higher frequencies.

Let us assume that a sweep frequency oı 60 cps is applied to the vertical input with the synchronization controls adjusted so that four complete wave forms appear on the screen. Thus, the horizontal amplifier is operating at 15 cps. (60 cps divided by 4 complete wave forms equals 15.) Therefore, as previously stated, we find that the amplifier is operating at its lower limits.

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 tn 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 obeerve a "dead spot" at about the center of rotation; that is, the position of the spot does not change even thongh the control is turning throngh several degrees. This is perfectly normal, and is caused by the slider of the control passing over the tap position on ihe resistance element. At this tap position, no change in resistance takes place, hence the spot does not change position.

11. To obiain maximum performance from your O-11 Oscilloscope you should operate the sync. amplitude control at the "second mark from the full counterclockwise" position.

    You should first set the sync. amplitude control as mentioned above. Set the Hor/freq. selector switch to the proper range and carefully adjust the freq. vernier control until ihe trace is locked in".

    If, for some reason, the trace is not stable, and drifts, you should then adjust the sync. amplitude control. However, it is not felt that this conirol will have to be turned up more than three marks. This control has a great effect on frequency of the sweep oscillator.

12. After a wave form has been locked in place on the CRT, you will notice that changing the height of the trace with the vertical gain control will change the frequency, as the amount of the sync. is changed, and make it necessary to readjust the freq. vernier control to again stabilize the trace. This is normal.

    Again we must warn you noi to exceed 3" of vertical trace expansion. Using greater than 3" verttcal height will cause the sweep oscillator to stop operating at its high frequency operating limits when using internal sync.

13. Some de-focusing may be experienced ai 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 hand width and will in no way interfere with normal oscilloscope operation.

    An interesting experiment can be made because of this condition and the phenomena of the earth's magnetic iofluence. Experiment by placing the oscilloscope first on the left side, then on the righi side. In each instance note the change in centering and also in edge focusing. When re-focusing, always be guided by the focus at the center of the CRT Screen.

Repeat the experiment by standing the scope on its back, again noting the change and another change when it is rotated. This characteristic is entirely normal and does not distract from the instrument's sensitivity.

14. 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-11 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 resulte, 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. Chacking 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 compare with the table on Page 38, 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 bronght hack by adjusting the positioning controla, 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 dingonal lines when adjusting the vertical trimmers, please refer to Figure 31 on Page 31 of your O-11 manual. Tha petterns 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 thay 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 oversboot or slow rise time on the sharp wave-front of the sawtooth generated by the sweep oscillator. If the remaining portion of the line hallies 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-11 is operated with shorted vertical input terminals, please make the following checke:

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 throngh the various stages untti 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-11 power transformer, but the relation between the CR tube and transformer has been carefully established so that the sensittve portions of the tube structure are located in a null of the magnetic field surrounding the transformer. Severe overloading of the power transformer will upset this balanced condition, however. The greatest sources of trouble in this respect are magnetic fields from equipment external to the scope itself. Anything which consumes power at power-line frequencies creates a certain magnetic field. The worst offenders are those equipments which draw a constderable amount of current--soldering irons, soldering guns, AC motors, electric heaters and similar items.

Fignre 32A 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. Fignre 32B, 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 20% of its cycle or so.

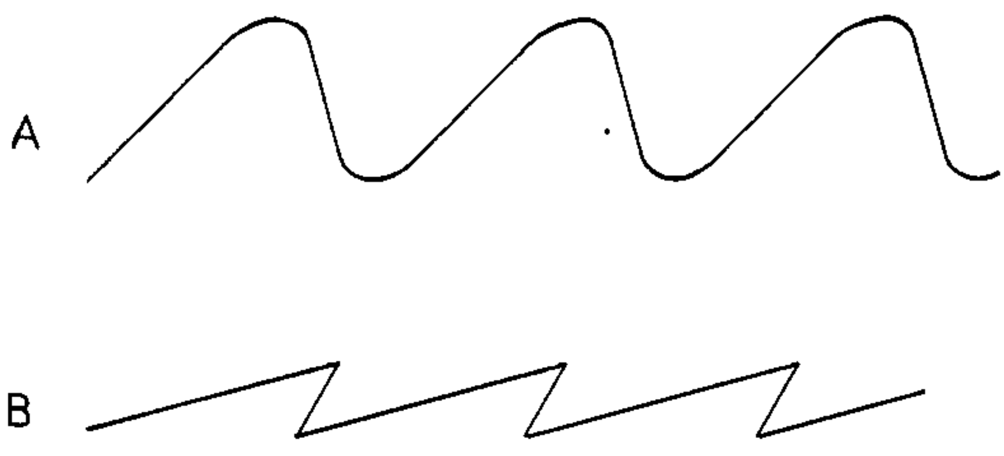


Figure 32

Variations in the ripple appearance with chaages in physical location of the scope are definite proof that the deflection is not caused by a defect in the O-11, 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 abvious impossibility in a kit selling for as low a price as the O-11

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 in 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 details, 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-11 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. Thoronghly 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 the order number and 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-11 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-011F	Repair Kit, Front Circuit Board	$5.80
Kit No. R-011R	Repair Kit, Rear Circuit Board	$5.00

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $8.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

SOCKET TUBE TYPE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
V1 6AB4	115	NS	H	H	NC	4	11.5	—	—
V2 6AN8	65	-0.7	0	H	H	80	100	-0.6	0
V3 12BH7	(1) 280	(1) 25	(1) 40	H		(1) 280	(1) 32	(1) 40	H
V4 6DT6	NS	0	H	H	58	71	NS	—	—
V5 12AU7	84	58	68	H		51	(2) -0.8	0	H
V6 12AU7	115	14	54	H		88	NS	3	H
V7 12AU7	(1) 285	(1) 87	(1) 78	H		(1) 245	(1) 60	(1) 78	H
V8 6X4	390 AC	420	H	H	NC	390 AC	420	—	—
V9 1V2	NC	NC	NC	1030 VAC	1030 VAC	NC	NC	NC	-1300
V10 6C4	130	NC	H	H	130	-2.7	—	—	—
CRT 5UP1	HVH	-1220	(3) -1120	(4) -760	NC	(1) 275	(1) 275	(5) 270	(1) 285

SOCKET TUBE TYPE	Pin 10	Pin 11	Pin 12
CRT 5UP1	(1) 245	NC	HVH

NC - No connection.
— No reading, or no contact on socket.
NS - Not significant

H - AC voltage this point to chassis: 3.15 volt.
Between points: 8.3 volt.
HVH - AC voltage between points: 6.3 volt. CAUTION: These terminals 1200 volts OFF chassis.
HVR - High voltage Rectifier Filament - 970 volt AC to chassis. Do not attempt to measure AC voltage between terminals. Check each terminal to ground with socket empty. Readings should be equal.
(1) - Varies with position control setting.
(2) - Varies with HOR/FREQ. SELECTOR and FREQ. VERNIER setting.
(3) - Varies with INTEN. setting.
(4) - Varies with FOCUS setting.
(5) - Varies with Spot Shape setting.

CONTROL SETTINGS

INTEN. - Full 50% rotation.
FOCUS - Minimum spot size.
VERT. POSITION - Spot centered.
HOR. POSITION - Spot centered.
VERT. INPUT - 0.
HOR. INPUT - 0.
HOR/FREQ. SELECTOR - 10-100.
FREQ. VERNIER - 100.
PHASE - Full clockwise.
SYNC. AMP. - Full counterclockwise.
SYNC. SELECTOR - INT.

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 nf 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 nf 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-11 Oscilloscope.

WAVEFORM INVESTIGATION

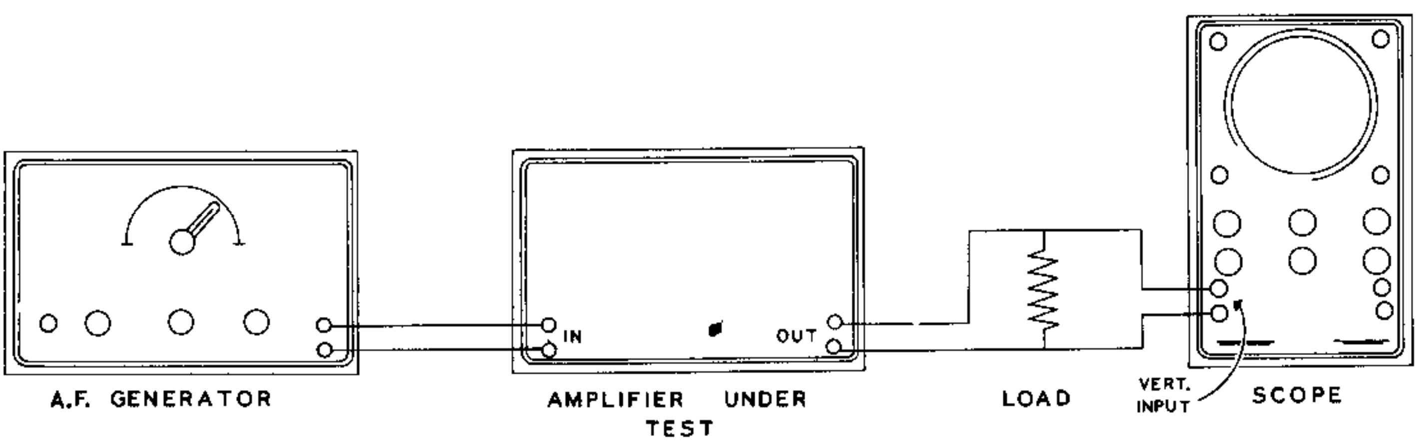
Probably the major use of most oscilloscopes is in the study of recurrent or transient variations in an electrical quantity. Since the oscilloscope is a voltage-operated device, these variations must be first converted into changes in voltage.

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 signai 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 33 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.



Fignre 33

Figure 34A 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 34B indicates third harmonic distortion, a particularly objectionable fault. Figure 34C shows flattening of both peaks, usually an indication of over-load somewhere in the circuit.

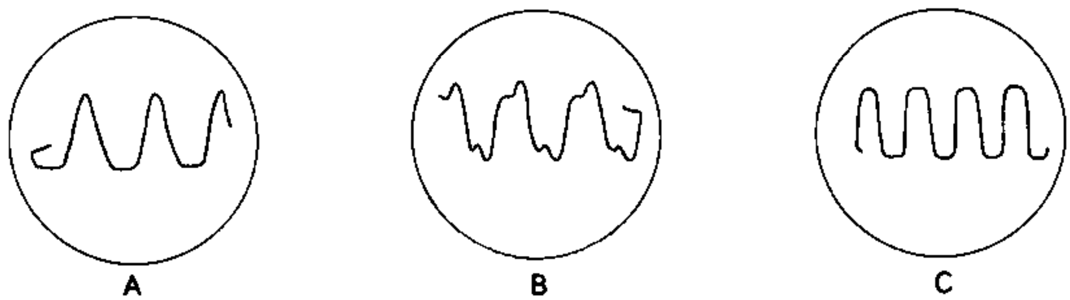


Figure 34

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 35A, 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

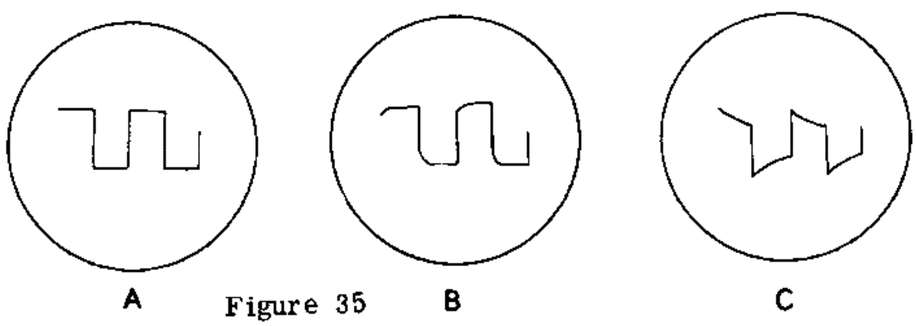


Figure 35

that shown in Figure 35B indicates poor high frequency response, which may be amplitnde 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 flst-top portion of the wave indicates the performance of the amplifier in the low frequency range. Figure 35C 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 is recommended.

Further discussion of this method is beyond the scope of this manual. Interested readers are referred to the bibliography for futher 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-11.

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 36

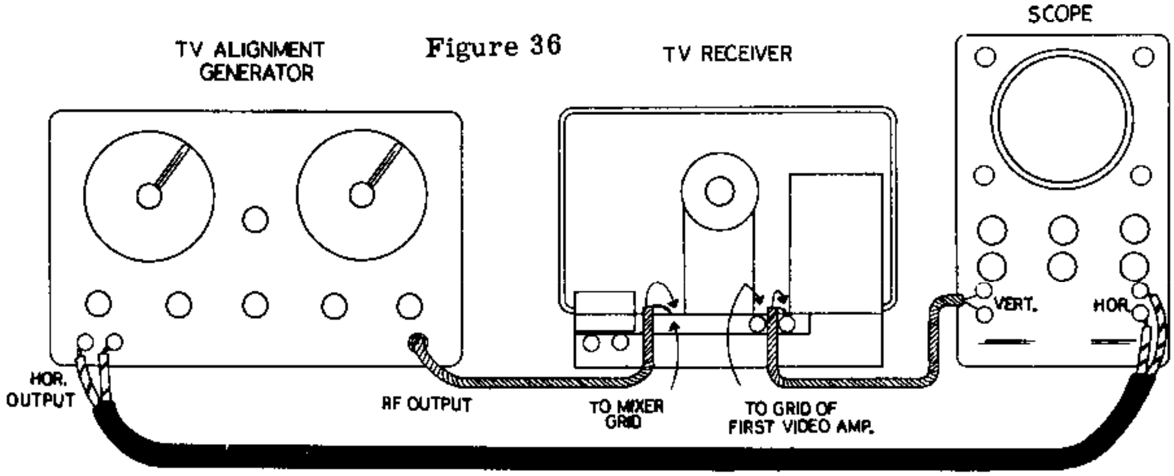


Figure 36 outlines the connections between the alignment generator, the receiver, and the oscilloscope. The exact procedure for alignment varies greatly. This information is generally available in the manufacturer's service information. Usually, a drawing of the desired response curve is given, together 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-11 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.

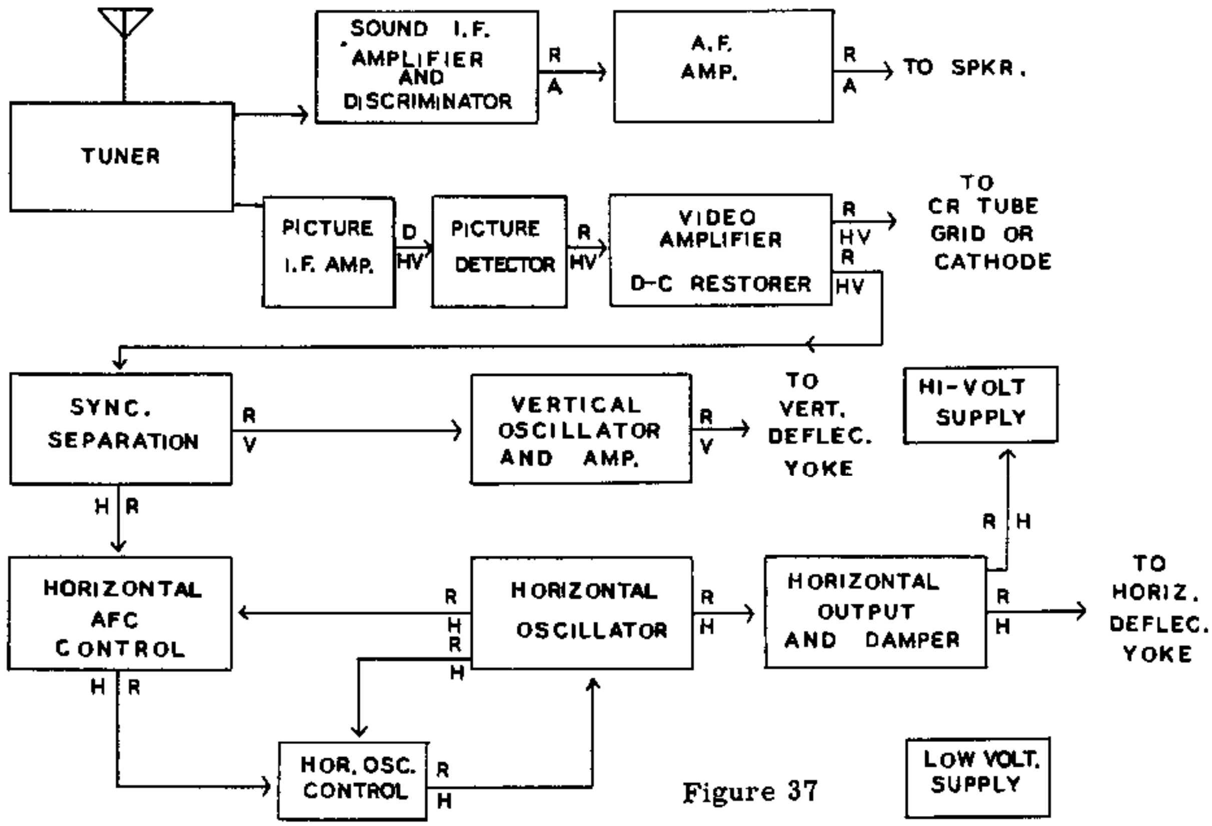


Figure 37

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.

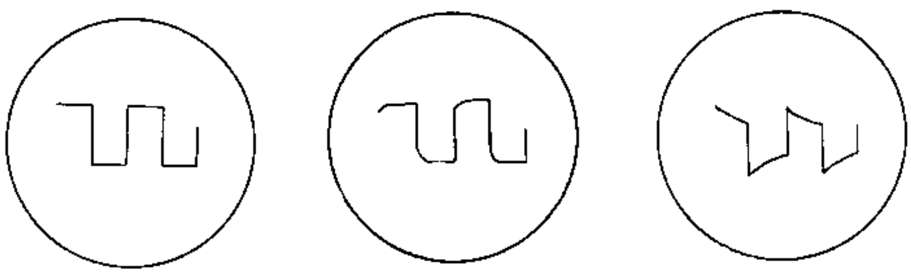
In either case, the signal voltage is fed into the vertical amplifier of the oscilloscope as shown in Figure 37. At any point up to the video detector, the voltages picked off will be quite small, and very little vertical attenuation will be required. Within the sync circuits and deflection circuits, 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-11 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 looke 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 cyclss 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-11. The signal-tracing technique can be used in these tests alao. 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 35B are responsible for poor picture detail, or "fuzziness," while distortion of the form shown in Figure 35C can cause shading of the picture from top to bottom.



A B C

Figure 35

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 super-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-11 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:

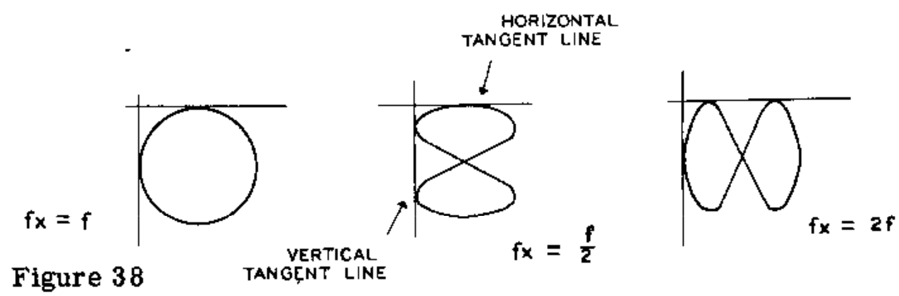


Figure 38

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:

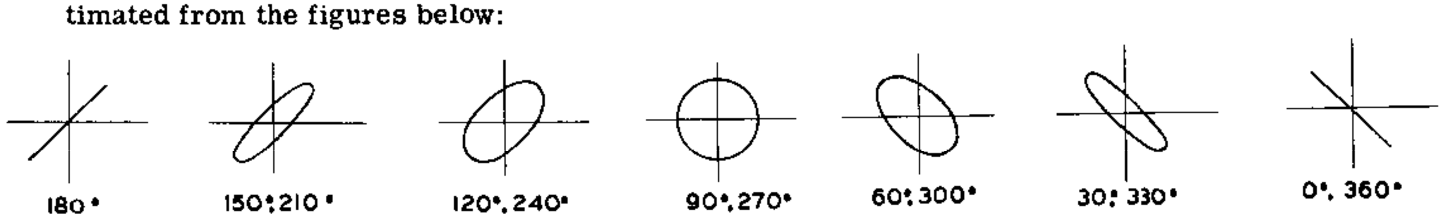


Figure 39

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

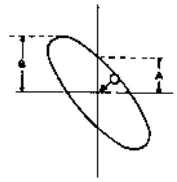


Figure 40

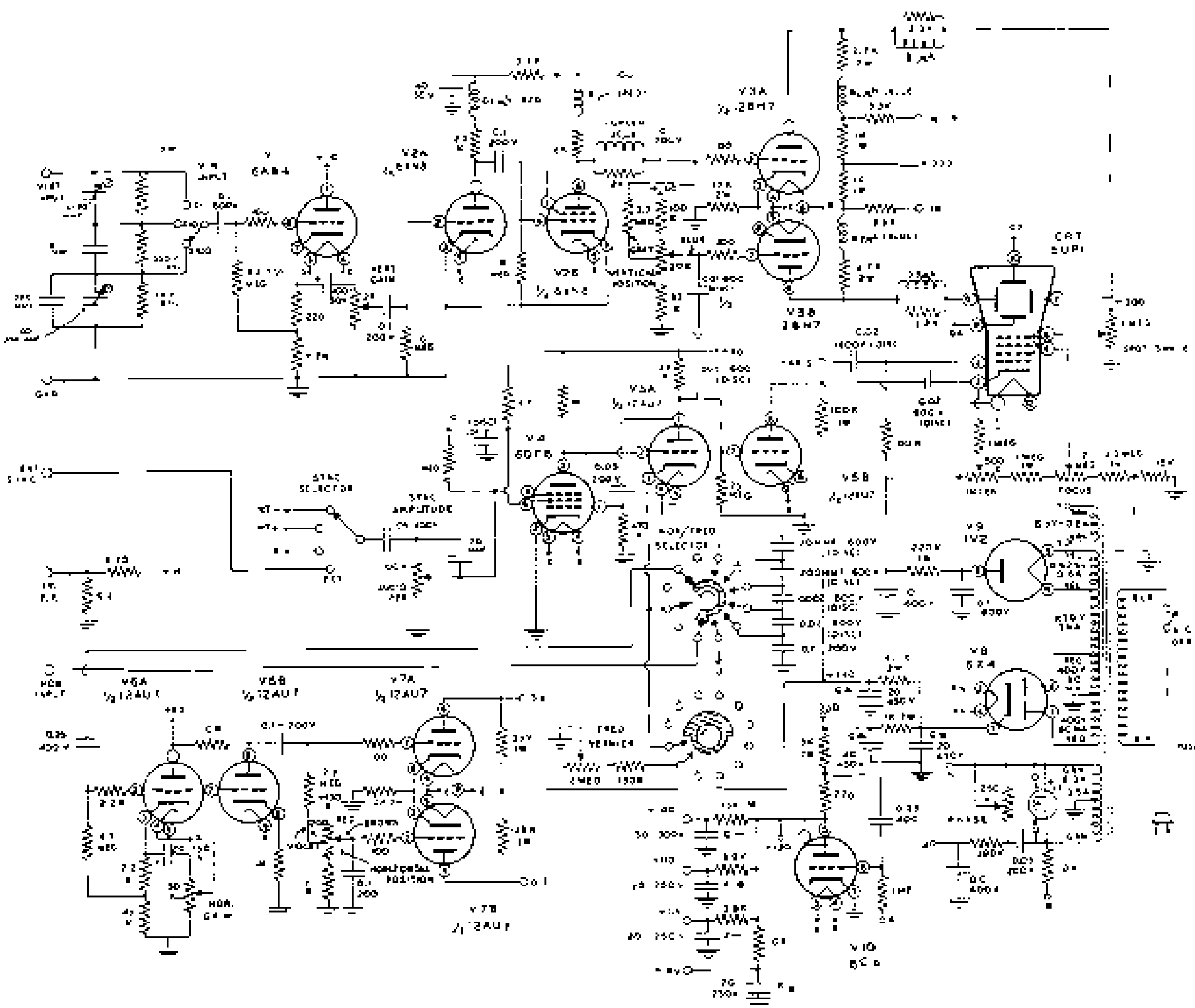
The distance A is measured from the X axis to the intercept point of the trace and the Y axis. The distance B represents the height of the pattern above the X axis. The axes of the ellipse must pass through the point O.

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	1	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
411-99	1	6DT6 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
250-9	23	6-32 x 3/8 machine screw
250-29	2	6-32 x 3/4 machine screw
250-18	4	8-32 x 3/8 machine screw
250-19	2	10-24 x 3/8 machine screw
250-8	5	#6 x 3/8 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	6-32 lockwasher
254-2	4	8-32 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
203-68F143	1	Panel
206-M28	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
85-11F141	1	Circuit board, front
85-12F142	1	Circuit board, rear
211-1	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
595-146	1	Instruction manual.

PART No.	PARTS Per Kit	DESCRIPTION
Composition Resistors		
1-84	1	62 Ω 1/2 watt 5%
1-3	5	100 Ω 1/2 watt
1-45	2	220 Ω 1/2 watt
1-6	1	470 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
1-16	1	4.7 KΩ 1/2 watt
1-46	3	3.9 KΩ 1/2 watt
1-20	3	10 KΩ 1/2 watt
1-21	1	15 KΩ 1/2 watt
1-69	1	18 KΩ 1/2 watt
1-22	1	22 KΩ 1/2 watt
1-24	1	33 KΩ 1/2 watt
1-88	1	36 KΩ 1/2 watt
1-25	1	47 KΩ 1/2 watt
1-26	2	100 KΩ 1/2 watt
1-27	1	150 KΩ 1/2 watt
1-87	1	330 KΩ 1/2 watt 5%
1-77	1	390 KΩ 1/2 watt 5%
1-33	1	470 KΩ 1/2 watt
1-35	3	1 megohm 1/2 watt
1-37	1	2.2 megohm 1/2 watt
1-78	3	3.3 megohm 1/2 watt 5%
1-71	1	4.7 megohm 1/2 watt
1-40	2	10 megohm 1/2 watt
1-70	1	22 megohm 1/2 watt
1-2A	2	1 KΩ 1 watt
1-22A	1	1.5 KΩ 1 watt
1-27A	2	33 KΩ 1 watt
1-28A	1	100 KΩ 1 watt
1-30A	1	220 KΩ 1 watt
1-34A	1	1 megohm 1 watt
1-37A	1	3.3 megohm 1 watt
1-19B	1	12 KΩ 2 watt
1-1B	2	2.7 KΩ 2 watt
1-2B	1	4.7 KΩ 2 watt
1-22B	1	12 KΩ 2 watt
Wirewound Resistors		
3-3E	1	1 KΩ 7 watt
3-4G	1	5 KΩ 7 watt
Condensers, Tubular		
23-59	2	0.05 μfd 200 volt
23-28	5	0.1 μfd 200 volt
23-58	1	0.2 μfd 200 volt
23-3	1	0.01 μfd 400 volt
23-61	1	0.05 μfd 400 volt
23-63	2	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		
21-5	2	20 μμf 600 volt
21-21	1	200 μμf 600 volt
21-36	1	0.002 μfd 600 volt
21-27	1	0.005 μfd 600 volt
21-16	2	0.01 μfd 800 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
25-19	1	20 μfd 150 volt
25-20	1	40 μfd 150 volt
Controls-Switches		
10-5	1	2 KΩ (Vert. Gain)
10-41	1	20 KΩ C.T. (Vert. Pos.)
10-11	1	50 KΩ (Hor. Gain)
10-46	1	100 KΩ (Sync. Amp.)
10-13	1	200 KΩ C. T. (Hor. Pos.)
10-14	1	250 KΩ (Phase)
19-24	1	500 KΩ w/switch (Inten.)
10-32	1	1 megohm (Spot Shape)
10-39	2	2 megohm (Freq. Vernier and Focus)
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 hand-resistor form)
45-23	2	61 μh (red band)
45-24	2	90 μh (blue hand)
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
69-1	1	Line cord
100-50	1	Cable assembly
347-2	1	300 Ω transmission line


V3A
V3B
CRT
5UP1
V9
1V2
V8
6X4
V10
V4
V5A
V5B
V6A
V6B
V7A
V7B
SYNC SELECTOR
SYNC AMPLITUDE
HOR/FREQ SELECTOR
FREQ VERNIER
VERT GAIN
VERTICAL POSITION
HORIZONTAL POSITION
FOCUS
INTEN
PHASE
HOR. INPUT
GND