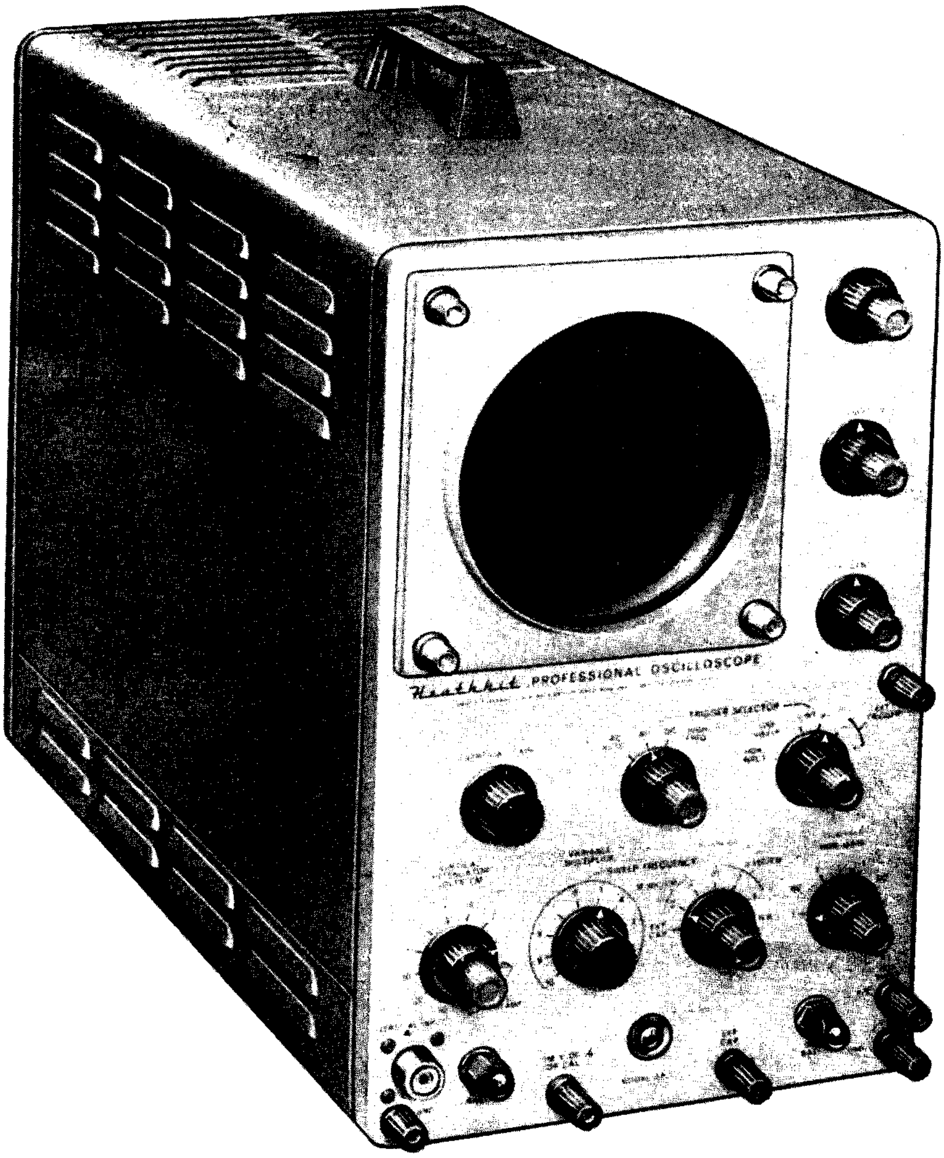
OPERATION AND USE OF THE HEATHKIT PROFESSIONAL OSCILLOSCOPE

MODEL OP-1



Power Requirements:....................	105-125 V 50/60 cycles 250 watts maximum
Net Weight:............................	24 lbs.
Shipping Weight:.......................	34 lbs.
Dimensions:............................	8 3/4" wide, 14 1/8" high, 19" deep

1/12/62

SPECIFICATIONS

VERTICAL CHANNEL

Frequency Response:	Within 1 DB from DC-2.2 MC. Within 3 DB from DC-3.6 MC. Within 6 DB from DC-4.5 MC.
Rise Time:	Less than .1 microsecond.
Input Impedance:	3.2 megohms at 1 KC (3.6 megohms shunted by 28 $\mu\mu$f).
Sensitivity:	DC coupled; .1 V peak to peak per centimeter. AC coupled; .01 V peak to peak per centimeter, using internal AC coupled preamp.
Attenuator, 12 positions:	9 levels of attenuation from 50 V to .1 V peak to peak. 3 levels of gain, .05, .02 and .01 V peak to peak (provided by the internal preamp). All positions fully compensated, and calibrated in volts per centimeter. (accuracy within ±5%) A continuously variable gain control is also provided. (uncalibrated)
Coupling:	Either AC or DC, switch selected. Blocking capacitor for AC coupling rated at 600 volts DC.
Vertical Centering:	DC coupled. Any portion of an 8 cm pattern may be positioned on the horizontal centerline of the graticule.
Polarity:	A positive signal will deflect the beam up.

HORIZONTAL CHANNEL

Frequency Response:	Within 1 DB from DC-450 KC. Within 3 DB from DC-600 KC. Within 6 DB from DC-900 KC.
Input Impedance:	1 megohm shunted by 37 $\mu\mu$f
Gain Control:	2 position switch, X1 and X5 normal 10 cm screen width, within 10%. Continuously variable gain control also provided. (uncalibrated)
Sensitivity:	2 V peak to peak per centimeter in X1 position. .4 V peak to peak per centimeter in X5 position. .2 V peak to peak per centimeter in X5 position with variable gain control set at maximum position.
Inputs:	May be switched to: Internal Sweep. Internal 60 cycle "Line Sweep" (variable phase). External input binding posts on front panel.

Coupling:........................... Internal positions DC.
External input: AC or DC. The blocking capacitor for AC coupling is rated at 600 volts DC.

Polarity:........................... A positive signal will deflect the beam to the left.

Horizontal Centering:................ DC coupled. Any portion of the trace may be positioned on the vertical centerline of the graticule in either the X1 or X5 position.

SWEEP GENERATOR

Driven Type:........................ Utilizing newly developed Heath circuit. Built-in triggering circuits provide reliable operation on signals of 5 mm peak to peak amplitude or more on scope screen. Triggering may be either internal or external, and either AC or DC coupled. The polarity of the triggering signal may also be selected, and any point on the wave form may be selected with the "Triggering Level" control. An "Automatic" position is also provided, in which the untriggered sweep recurs at a 50 cycle rate, but can be triggered over a wide range of frequencies with no additional adjustment. A "High Frequency" position is provided for synchronizing the sweep without the use of the internal triggering circuits, for frequencies above approximately 300 KC.

Sweep Frequencies:.................. Switch selected base rates of: 2 and .2 milliseconds per cm, and 20, 2 and 1 microsecond per cm, used in conjunction with a continuously variable 10 to 1 multiplier. The sweep frequencies are calibrated to within 10% at all control settings. An uncalibrated position for higher sweep frequencies (approximately 0.5 microsecond per cm) is also provided. The sweep frequency may be reduced by adding capacity to the "Ext. Cap." binding post on the front panel. 2 μf will reduce the sweep frequency to approximately 20 milliseconds/cm (2 sec. total for 1 sweep, in 10 times setting of variable multiplier control).

GENERAL

CR Tube:........................... Type 5ADP2. Medium long persistence, blue-green trace. Directly interchangeable with all 5AD and 5AB series tubes if a different screen characteristic is desired.

Power Supplies:..................... Transformer operated, fused. The low voltage B+ and bias supplies utilize full wave silicon diode voltage doubler circuits. The high voltage CR Tube supply uses a 1B3GT as a half wave rectifier. All critical voltages are regulated with gas-filled VR tubes.

Unblanking:........................ DC coupled to CR Tube grid. External connections provided. 40-50 V peak to peak positive will cause full conduction of the C. R. Tube.

Test Voltage:...................... 150 VDC is available on the front panel for vertical channel calibration.

Graticule:......................... Edgelighted molded plastic, in an 8 x 10 cm grid, with 2 mm marks on vertical and horizontal centerlines. DB gain and loss scales also provided.

Input Connections:.................. Horizontal: 5-way binding posts, with 3/4" spacing.
Vertical: Either coaxial or dual banana plug with 3/4" spacing.
Z-axis and ext. sync: 5-way binding posts.

APPLICATIONS

The oscilloscope is one of the most versatile instruments available. Properly used, there is almost no limit to the number and type of measurements and observations it can provide.

Your OP-1 Oscilloscope may be used to measure the amplitude of any signal from DC to several megacycles, and provide valuable information about the wave shape of the signal.

The sweep is calibrated, thus providing a method of determining the frequency or repetition rate of recurring phenomena.

To actually list the wide variation in applications in which your OP-1 Oscilloscope may be used would be well beyond the scope of this manual. However, several common applications are listed below.

Checking the output voltage and frequency developed in an oscillator circuit.

Checking the frequency response of an amplifier (either stage by stage, or as a complete unit).

Trouble-shooting radios, TV sets, hi-fi equipment, etc.

Using with a computer as a read-out device.

Measuring DC Voltages.

More applications will be found in the following reading material:

ZWICK, THE OSCILLOSCOPE--Gernsback Publications, New York

RUITER, OSCILLOSCOPES AND THEIR USES--Murray Hill Books, Inc, New York

PARR, THE CATHODE RAY TUBE--Chapman and Hall, London

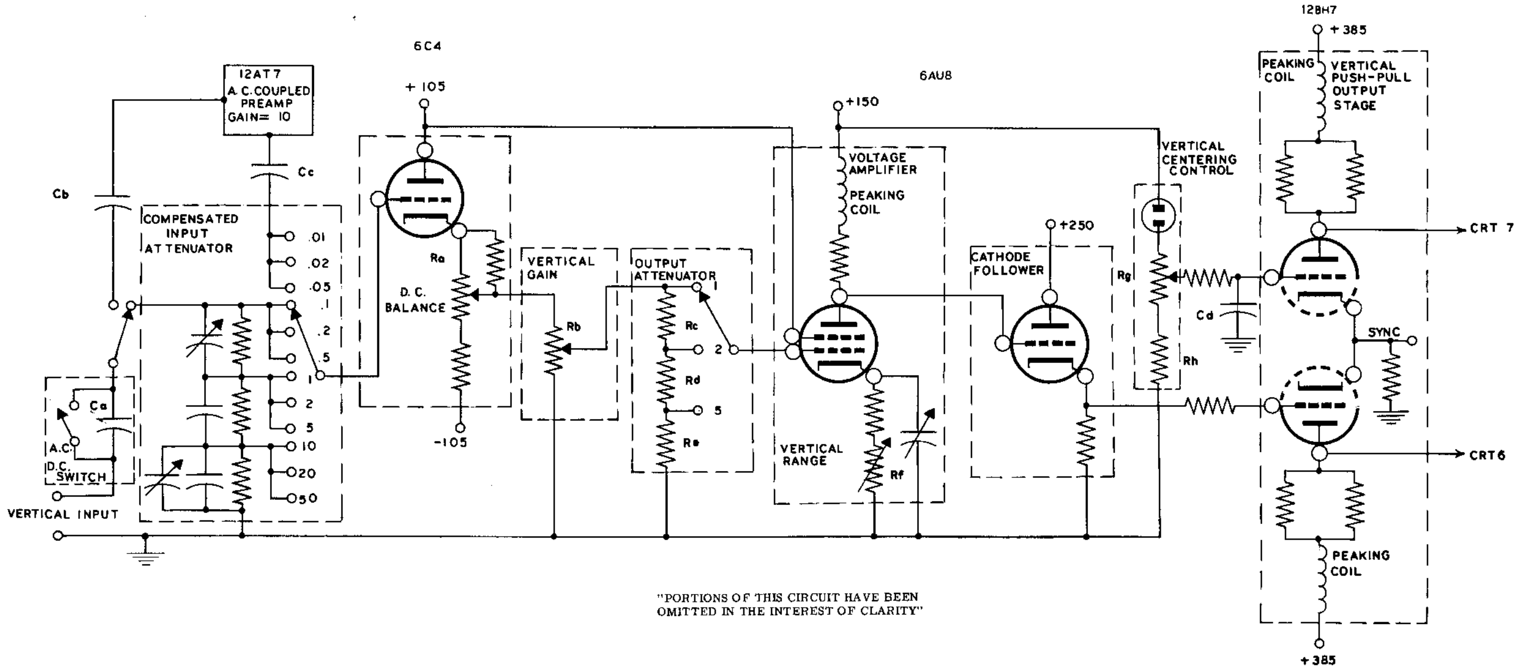
RIDER and USLAN, ENCYCLOPEDIA OF CATHODE RAY OSCILLOSCOPES-Rider, New York

BLY, GUIDE TO CATHODE RAY PATTERNS--John Wiley and Sons, New York

CIRCUIT DESCRIPTION

Descriptions of the various circuits used in the OP-1, are on the following pages.

VERTICAL CHANNEL



The vertical channel consists of the Compensated Attenuator Networks and 1-6C4 triode input cathode follower; 1-6AU8 pentode-triode voltage amplifier and cathode follower; 1-12BH7 push-pull output; and 1-12AT7 high gain preamp stage.

When a signal is applied to the vertical input connector, it passes either directly (DC coupled) or through the coupling capacitor (C-a) (AC coupled) into the input attenuator. The input attenuator is a frequency compensated voltage divider, offering two levels of attenuation. With the attenuator switch in the 50, 20 and 10 v/cm positions, the signal applied to the 6C4 cathode follower is attenuated 100 times. In the 5, 2 and 1 v/cm positions the signal is attenuated 10 times, and in the .5, .2 and .1 v/cm positions the signal is applied directly to the cathode-follower grid. In the .05, .02 and .01 v/cm positions, the input signal is applied to the 12AT7 two stage preamp through the coupling capacitor, (C-b). The preamp has a gain of 10. Thus, a signal of .01 volt, when applied to the input, will be amplified to .1 volt. This amplified signal is then fed through the coupling capacitor (C-c) into the 6C4 cathode follower.

The DC balance control (R-a) is a portion of the 6C4's cathode resistor. The bottom of the total cathode resistance is returned to -105 volts and the cathode is normally somewhat positive due to self-bias; at some point on the "DC BAL" control, 0 volts DC is present.

The "Vertical Gain" control (R-b) is connected between the output of the "DC BAL" control and ground. If the "DC BAL" control is set to 0 volts DC, no voltage will be applied across the control. If a DC voltage were to be applied across the "Vertical Gain" control, any change in the setting of the control would cause a change in the bias on the 6AU8 pentode, and since the pentode is direct coupled to the 12BH7 vertical output stage, a shift in vertical centering would result.

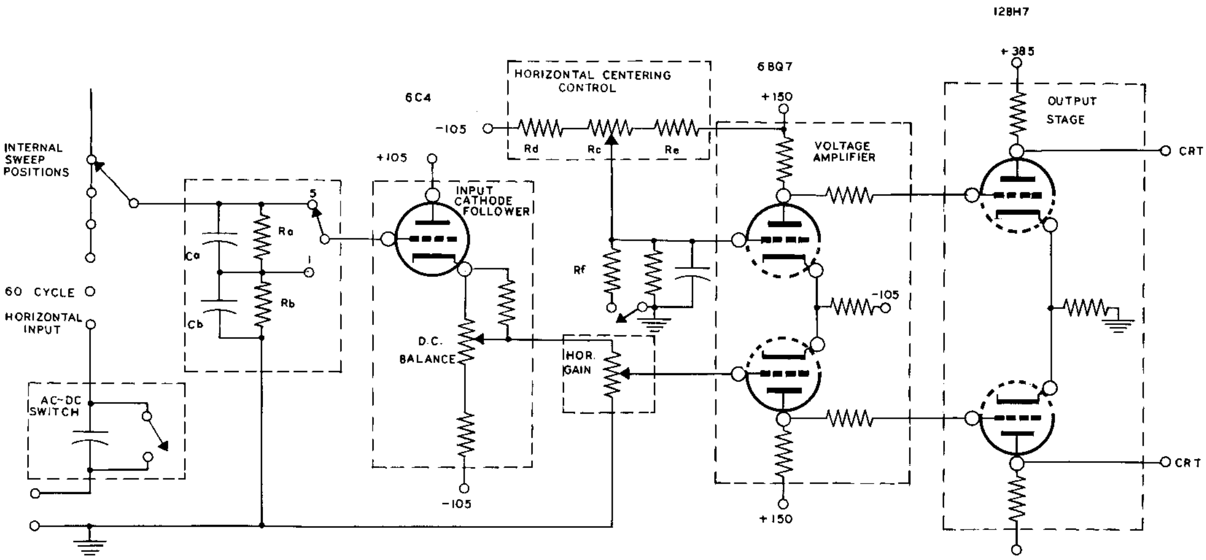
The output of the "Vertical Gain" control is applied to the cathode follower output attenuator network, consisting of (R-c), (R-d), and (R-e). This network attenuates the signal by a factor of either 2 or 5, depending on the setting of the "Vertical Attenuator" switch. The output of this network is fed to the grid of the 6AU8 pentode voltage amplifier.

The pentode section of the 6AU8 operates as a conventional voltage amplifier. The "Vertical Range" control (R-f) is provided to set the bias, and thus the idling plate voltage of the stage. The signal from the 6AU8 pentode is direct-coupled to the grid of the 6AU8 triode, which operates as a conventional cathode follower. This is necessary to prevent excessive capacitive loading of the pentode plate, which would result in poor high frequency response.

The signal from the 6AU8 stage is taken from the cathode follower and fed through a 100 Ω resistor (to prevent possible parasitic oscillation) to the input grid of the 12BH7 push-pull output stage. This section of the 12BH7 acts both as an amplifier and as a cathode follower. Since the cathodes of both triodes are tied together, the signal is also applied to the second triode, operating as a grounded grid amplifier. The output of both sections is very nearly equal, and the plates produce a signal 180° out of phase with each other. The signal from each is then fed to a vertical deflecting plate in the CR Tube.

The 20 K "Vertical Centering" control (R-g) is connected in series with the NE-2 neon bulb and +150 volts DC. The resistor (R-h), between the bottom of the centering control and ground, sets the current through the centering control (R-g), and thus the voltage across it, to provide the proper range of centering. The neon bulb is used because, when it is conducting (fired), it provides a low impedance path through the power supply to essentially ground (for signals only) the grid of the 12BH7. Capacitor (C-d) is used to ground the grid, for high frequencies, and the 100 Ω resistor prevents possible parasitic oscillation, as before.

The dual cathodes of the 12BH7 also provide a low impedance source of signals for internal triggering.



"PORTIONS OF THIS CIRCUIT HAVE BEEN OMITTED IN THE INTEREST OF CLARITY"

The horizontal amplifier consists of a Compensated Voltage Divider, 6C4 cathode follower, 6BQ7 voltage amplifier, and 12BH7 push-pull output stage.

Since the horizontal amplifier is normally used to display the internal sweep signal on the screen, assume that the "Trigger Selector" switches are set on one of the internal sweep positions, applying a saw-tooth sweep signal to the amplifier.

The signal is applied across the voltage divider consisting of (R-b) and (R-a). Capacitors (C-a) and C-b) are to compensate for stray capacity in the switch, tube socket, etc. This divider provides attenuations of 1 and 5.

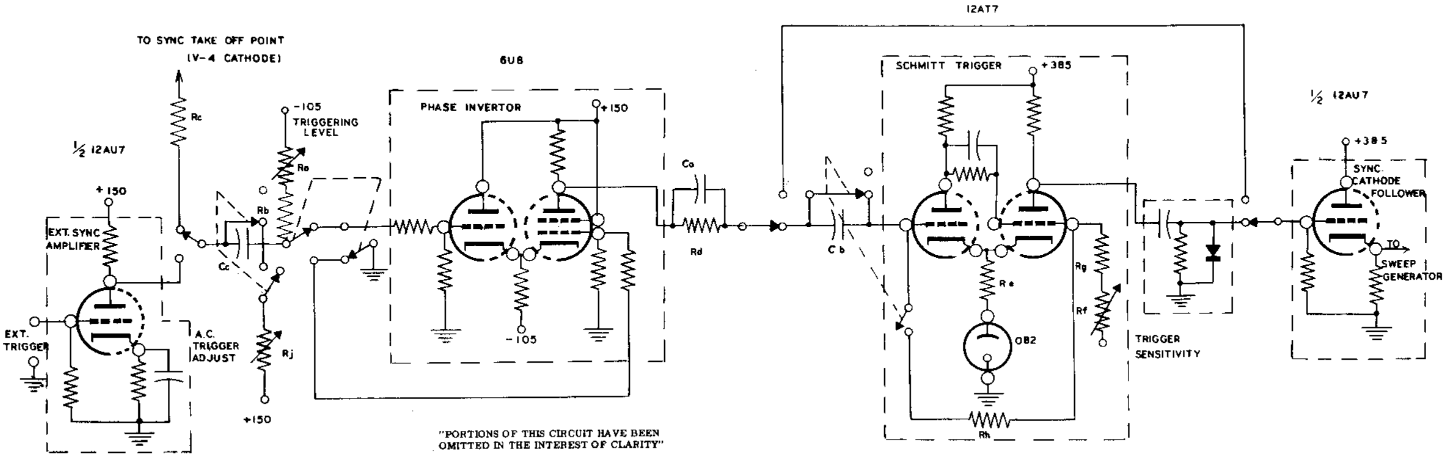
The output of this divider is fed to the grid of the 6C4 cathode follower. The "DC Balance Control", and "Horizontal Gain" control, operate exactly the same as their counterparts in the vertical channel.

The signal from the gain control is fed to the input triode of the 6BQ7 push-pull voltage amplifier stage. This stage acts as a cathode follower as well as an amplifier, and since the cathodes are both tied together, the second triode operates as a grounded grid amplifier. This voltage amplifier operates exactly as the vertical output stage previously described.

The push-pull output stage is essentially a pair of triode amplifiers to amplify the signal supplied by the 6BQ7 voltage amplifier. Since the 6BQ7 stage is self-inverting, the signals at the plates of the 12BH7 output stage are 180° out of phase. The signal from each triode plate is then applied to a horizontal deflecting plate.

The "Horizontal Centering" control (R-c), along with (R-d) and (R-e), form a voltage divider. This divider provides an adjustable voltage for centering the trace. This voltage is fed into the grid of one triode of the 6BQ7 dual triode Voltage Amplifier. In the X1 positions of the horizontal gain switch, a 1500 Ω resistor (R-f) is switched between the arm of the centering control and ground to reduce the range of the control. This resistor prevents "losing" the beam off the screen area on the CR Tube.

The operation of the horizontal channel, when the selector switches are in the "Horizontal Input" position, is the same except that either AC or DC coupling may be selected with the "Horizontal Gain" switch.



The triggering circuits consist of: 1-6U8 phase inverter; 1-12AT7 Schmitt trigger; a differentiating network and crystal diode; and a 12AU7, half used as the ext. sync. amplifier and half used as the sync. cathode follower.

Under most conditions, the internal sync. source is used, so assume that the "Trigger Selector" switches are in the "Int-" position. The signal is now applied to the grid of the triode section of the 6U8 phase inverter, which operates as a conventional cathode follower. Since the cathodes of the triode and the pentode sections of the tube are tied together, the pentode is driven as a grounded grid amplifier stage. (Note that the pentode grid is tied to ground at this time by another section of the "Trigger Selector" switches). If the "Trigger Selector" switches are in the DC position, the grid of the triode section is also connected to a voltage divider which consists of the "Triggering Level" control (R-a), resistor (R-b), and the DC voltage at the 12BH7 vertical output cathodes (the sync. take off point) through resistor (R-c). This network varies the grid voltage by means of the "Triggering Level" control (R-a). To invert phase, the signal and "Triggering Level" control voltages are fed into the pentode grid, and the triode grid is grounded. When the phase inverter plate voltage changes, the Schmitt trigger grid voltage changes also, because of the direct coupling through resistor (R-d). Capacitor (C-a) is to pass any high frequency component of the sync. signal with a minimum of attenuation.

The Schmitt trigger is used to provide a pulse of known characteristics from any type of incoming sync. signal. The input triode is essentially a voltage amplifier which is directly connected to the other triode grid. The cathodes are tied together, and draw current through a common resistor (R-e). The circuit values are so adjusted that the input half is cut off and the output half is in conduction with no signal applied. When a positive going signal is fed into the input half, it begins to go into conduction. This causes the plate voltage to fall, and because it is direct coupled to the other triode grid, this grid becomes less positive allowing the second triode to cut off. When this happens, the cathode current goes down, lowering the cathode voltage, to hold the first half in conduction. This condition is maintained until the positive signal is removed from the input grid. The "Trigger Sensitivity" control (R-f) and resistor (R-g) form the bottom leg of a voltage divider. This divider sets the point at which the second triode cuts off, and thus the "sensitivity" of the circuit.

The cathode of the 12AT7 Schmitt trigger is held at approximately 105 volts by the OB2 V. R. Tube in its cathode circuit. The change in grid voltage provided by the 6U8 phase inverter plate (varied by the "Triggering Level" control), changes the Schmitt trigger "firing" point. Thus the point at which a trigger pulse is produced with respect to the incoming signal is changed.

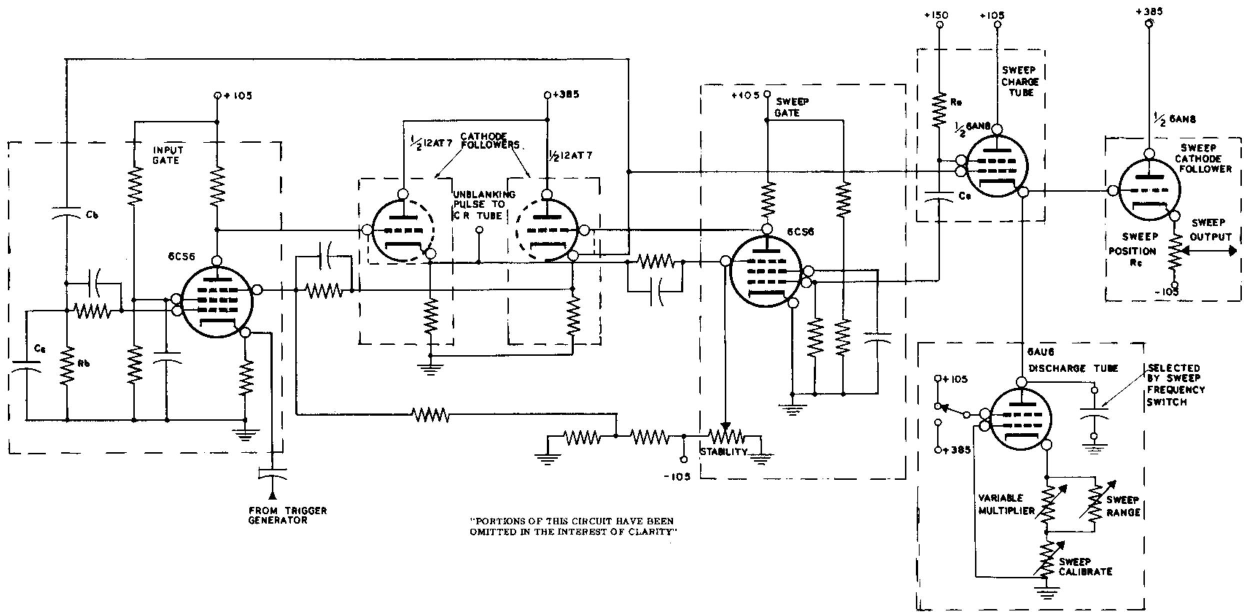
In the "AC Auto" position, the Schmitt trigger is converted into a multivibrator by connecting the grids together with resistor (R-h). The sync. signal is fed in with capacitor (C-b) instead of the direct coupling employed in the "AC" and "DC" triggering positions. This disables the "Triggering Level" control, yet still allows signals to pass into the Schmitt trigger, to change its frequency.

In the AC position, capacitor (C-c) is inserted in series with the sync. signal available at the 12BH7 vertical output stage. A DC level, set to equal the cathode voltage on the 12BH7, is provided by (R-j) to complete the "Triggering Level" voltage divider.

The Schmitt trigger provides a rectangular pulse. Only the positive going edge of the second triode's **plate** wave-form is required to drive the sweep generator, so the pulse is fed through a differentiating network, followed by a crystal diode to clip off the negative peaks. The remaining positive spike is fed into the trigger cathode follower (1/2 12AU7), and then into the sweep generator.

The "High Frequency" position by-passes the Schmitt trigger circuitry completely, and feeds the signal from the phase inverter directly into the trigger cathode follower.

The external sync. amplifier (1/2 12AU7) is used to amplify the external signal and also superimpose it on the DC level necessary to allow the "Triggering Level" voltage divider to operate.



The sweep generator consists of: 1-6CS6 input gate tube; 1-6CS6 sweep gate tube; 1-12AT7 dual cathode follower; 1-6AN8 sweep charge tube, cathode follower; and 1-6AU6 discharge tube.

The two 6CS6 dual control pentodes are connected in a "flip-flop" circuit. A triode, connected as a cathode follower, is connected between each 6CS6 plate and its load, to reduce capacitive loading.

In order to more easily understand the following description, consider the cathode follower connected to each 6CS6 plate as being removed, and all leads going to the cathode follower connected directly to the 6CS6 plate.

The two 6CS6 dual control pentodes are cross connected such that when either is conducting, the other must be cut off. The "Stability" control, in the sweep gate circuitry, is set so that the sweep gate tube is held at cutoff when no trigger is being applied to the input gate stage (which is now conducting). When a positive pulse is applied to the cathode of the input gate stage, it cuts off, causing its plate voltage to rise. This forces the sweep gate tube into conduction, and the input gate tube to cutoff. The 6AN8 pentode charge tube grid is connected to the sweep gate tube plate, and when the sweep gate tube conducts its plate voltage falls, causing the pentode charge tube grid to fall also. The cathode of the charge tube is held positive by the charge on the timing capacitor that has been selected by the "Sweep Frequency" switch. Since the cathode is now more positive than the grid, the charge tube is cut off.

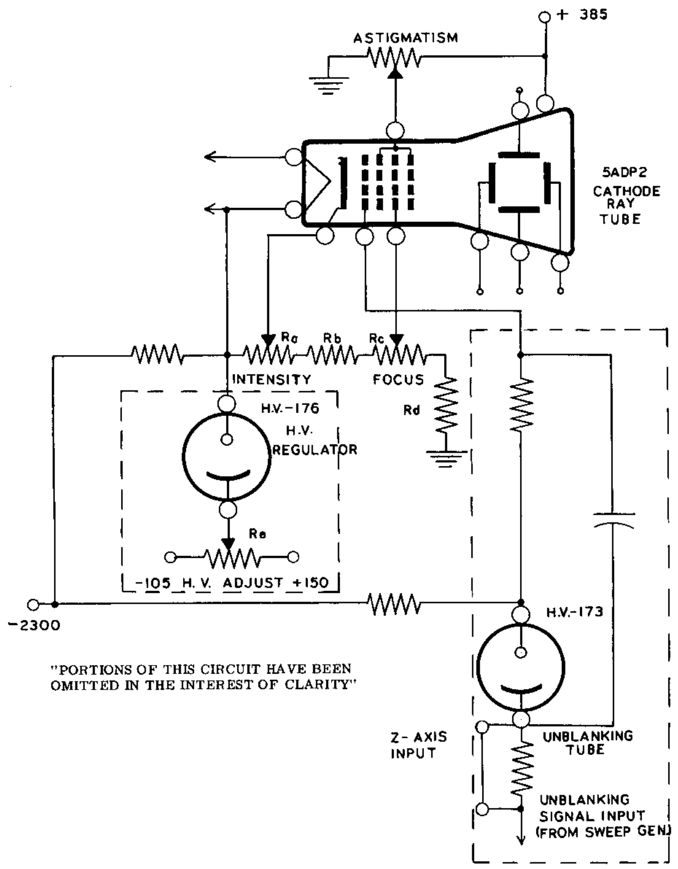
The timing capacitor is discharged through the 6AU6 pentode discharge tube, generating the saw-tooth voltage. The time required to discharge the timing capacitor is determined by the bias on the discharge tube. This bias is controlled by the "Frequency Vernier" control, which is in the discharge tube cathode circuit. Lowering the bias effectively reduces the tube's internal resistance, and thus a fast discharge of the timing capacitor will result.

When the voltage on the timing capacitor nearly equals the grid voltage of the pentode charge tube, the charge tube screen begins to draw current through (R-a) causing the screen voltage to drop. This negative-going voltage is applied to the first control grid of the sweep gate tube, through (C-a). This cuts off the sweep gate tube, and forces the input gate into conduction. (C-b). (C-c) and (R-b) form a capacitive-resistive voltage divider. This divider feeds the plate wave-form from the sweep gate tube into the input gate to prevent it from triggering while the timing capacitor is charging (flyback time).

A pentode is used as a discharge tube because it is essentially a constant current discharge path for the timing capacitor, resulting in a very linear sweep.

The saw-tooth voltage formed at the plate of the discharge tube, by the discharge of the timing capacitor, is fed into a cathode follower. The cathode resistor for this cathode follower is (R-c) the "Sweep Positioning" control. This control is adjusted to set the starting point of the sweep at 0 volts DC. The output of this control is the output of the sweep generator.

The unblanking voltage for the grid of the CR Tube is supplied by the input gate tube plate. This plate cuts off during sweep only, and thus the CR Tube grid bias is reduced (allowing the tube to conduct) only during the sweep. A further explanation of the method of unblanking is included in the CR TUBE CIRCUITS description.



"PORTIONS OF THIS CIRCUIT HAVE BEEN OMITTED IN THE INTEREST OF CLARITY"

The CR Tube circuits consist of: 1-5ADP2 CR Tube; 1-HV-173 corona discharge unblanking tube; 1-HV-176 corona discharge voltage regulator tube; and the "Intensity", "Focus", and "Astigmatism" controls.

The HV-176 regulator tube is connected between the negative high voltage supplied by the high voltage power supply and the "High Voltage Adjust" control (R-e). This control permits adjusting the high voltage over a 250 volt range to allow the intensity and focus controls to operate within their range of adjustment. The normal voltage obtained when the "High Voltage Adjust" control is properly set, is approximately -1750 volts.

This regulated high voltage is fed into a voltage divider consisting of: the "Intensity" control (R-a); the "Focus" control (R-c), and resistors (R-b) and (R-d). The CR Tube grid is connected to the cathode end of the unblanking tube HV-173. This tube is designed to maintain a constant voltage between its cathode and anode (approximately 1800 volts). The anode of this tube is connected to the plate signal of the 6CS6 input gate tube, through its associated cathode follower.

You will remember from the Sweep Generator circuit description, that the input 6CS6 is conducting with no trigger information, and cut off when a trigger pulse is received. The input gate stays cut off until the timing capacitor has discharged (one entire sweep). The plate voltage of the 6CS6, when in conduction, (no-sweep condition) is approximately +55 volts. 1800 volts in a negative direction from +55 volts is -1745. This is the potential on the grid of the CR Tube without sweep.

When the 6CS6 input gate tube goes into cut off, its plate voltage goes positive to approximately +100 volts. 1800 volts in a negative direction from +100 volts is -1700 volts. This is the voltage applied to the CR Tube grid during sweep.

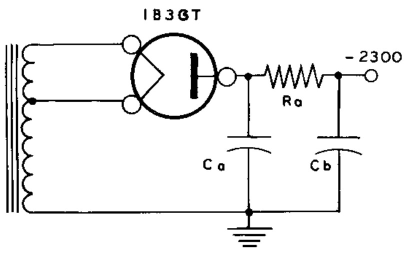
If the "Intensity" control in the CR Tube cathode circuit is set to provide a cathode voltage of -1700 volts, and the grid voltage is -1745 volts (no-sweep condition), 45 volts of negative bias is applied to the CR Tube grid, holding the tube cut off (screen dark). When the 6CS6 input gate tube cuts off, the grid voltage drops to -1700 volts, allowing the CR Tube to conduct (screen light). Since the 6CS6 input gate tube is cut off only during sweep, the CR Tube is allowed to light only during sweep.

The "Focus" control permits adjustment of the voltage on the focusing electrode within the CR Tube, to provide a sharp, well defined trace on the CR Tube screen.

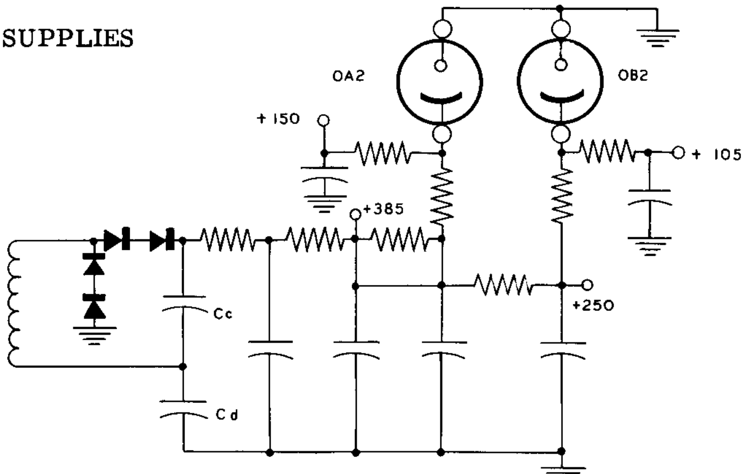
The "Astigmatism" control permits adjustment of the voltage on the second anode within the CR Tube. In practice, this voltage is set to equal the average voltage on the two pairs of deflecting plates. This setting normally provides the best overall trace clarity and definition.

The "Intensity", "Focus" and "Astigmatism" controls inter-react somewhat with each other, but in normal operation, they seldom require adjustment.

POWER SUPPLIES



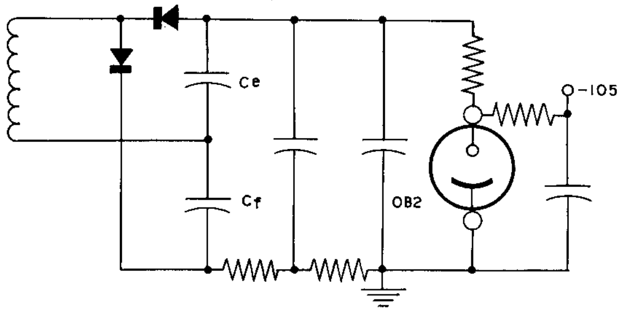
HIGH VOLTAGE SUPPLY



"PORTIONS OF THIS CIRCUIT HAVE BEEN OMITTED IN THE INTEREST OF CLARITY"

B + SUPPLY

B- SUPPLY



The power supplies consist of: 1-1B3GT High Voltage Rectifier; 6 silicon diode rectifiers; 1-OA2 +150 V regulator; 1-OB2 +105 V regulator; and 1-OB2 -105 V regulator.

The negative high voltage necessary for the CR Tube circuitry is provided by the 1B3GT, operating as a half wave rectifier. The DC voltage obtained from the rectifier is filtered by (C-a), (R-a) and (C-b).

The positive voltage (B+) is provided by a full wave voltage doubler consisting of four silicon diodes and capacitors (C-c) and (C-d). Two silicon diode rectifiers are connected in series for each half of the voltage doubler, to prevent exceeding the inverse voltage rating.

The +150 volt OA2 voltage regulator and the +105 volt OB2 voltage regulator are each connected through a suitable current limiting resistor to B+.

The negative voltage supply (bias) is provided by a full wave voltage doubler, consisting of two silicon diodes and capacitors (C-e) and (C-f). The -105 volt OB2 voltage regulator is connected through a suitable current limiting resistor to the output of this supply.

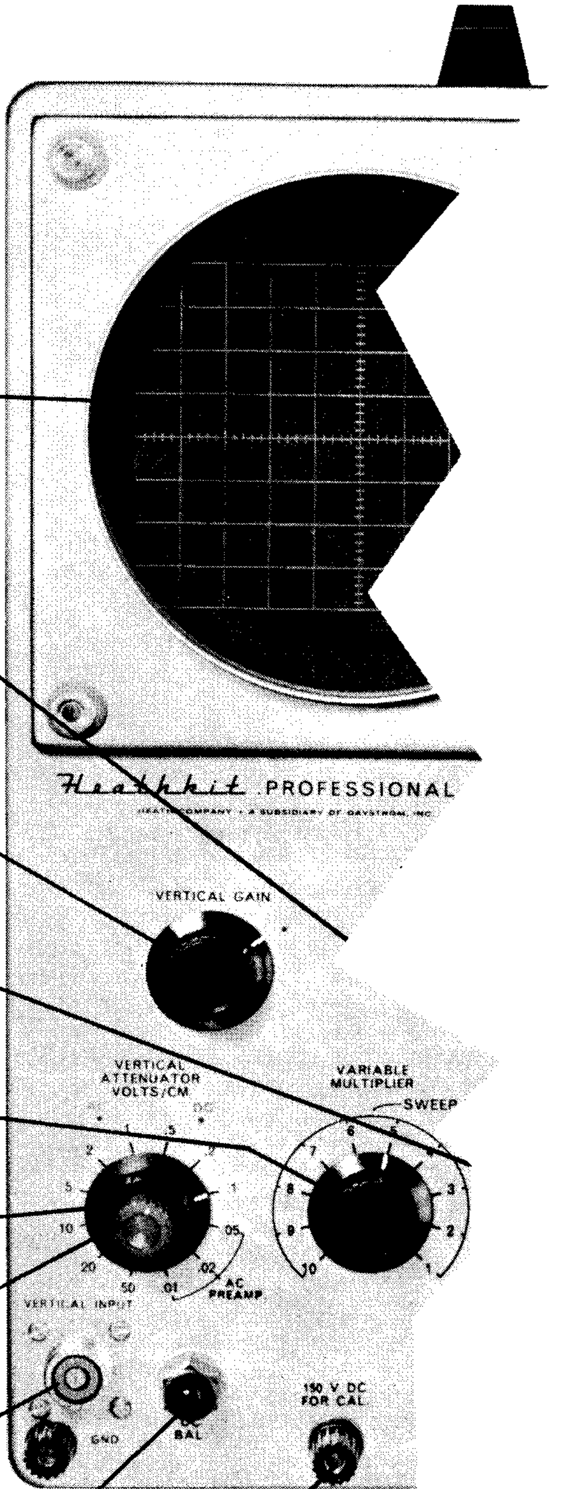
A decoupling network, consisting of a 100 Ω resistor and a 40 μfd capacitor, is provided after each voltage regulator.

The 3 amp fuse in series with the 117 volt line feeding the power transformer protects the power supplies in case of an accidental short or component failure.

The preceding circuit descriptions and diagrams are by no means complete. In several instances, switch positions are not drawn in proper sequence, and several components have been omitted. The purpose of this section is to familiarize you with the various circuit theories, not the actual values and components used.

A photograph of the front panel of the completed unit, along with a description of each of the control functions, follows. The time required to carefully study this information will be time well spent. Each of the controls has a definite purpose, and only a thorough understanding of their operation will permit you to fully realize the versatility of the OP-1.

CONTROL FUNCTION CHART



Graticule: Edgelighted clear plastic, with reference lines permanently molded in. Each large division equals 1 cm, and each small division on the centerline equals 2 mm.

Stability Control: Sets the operating voltages in the sweep generator to allow the sweep to trigger only on the proper trigger information, and prevent "recurrent" operation.

Vertical Gain Control: A continuously variable control of gain in the vertical channel. When set to the red dot on the front panel, the vertical attenuator switch is calibrated in v/cm.

Sweep Frequency Switch: Sets the base rate for the sweep generator. The actual time duration of the sweep is obtained by multiplying the base rate by the "multiplier" control setting.

Variable Multiplier Control: Used in conjunction with the "Sweep Frequency" switch to select the time duration of the sweep.

Vertical Attenuator Switch: Used to set the sensitivity of the Vertical Channel (calibrated in v/cm).

AC-DC Switch: Selects either AC or DC coupling in the vertical channel.

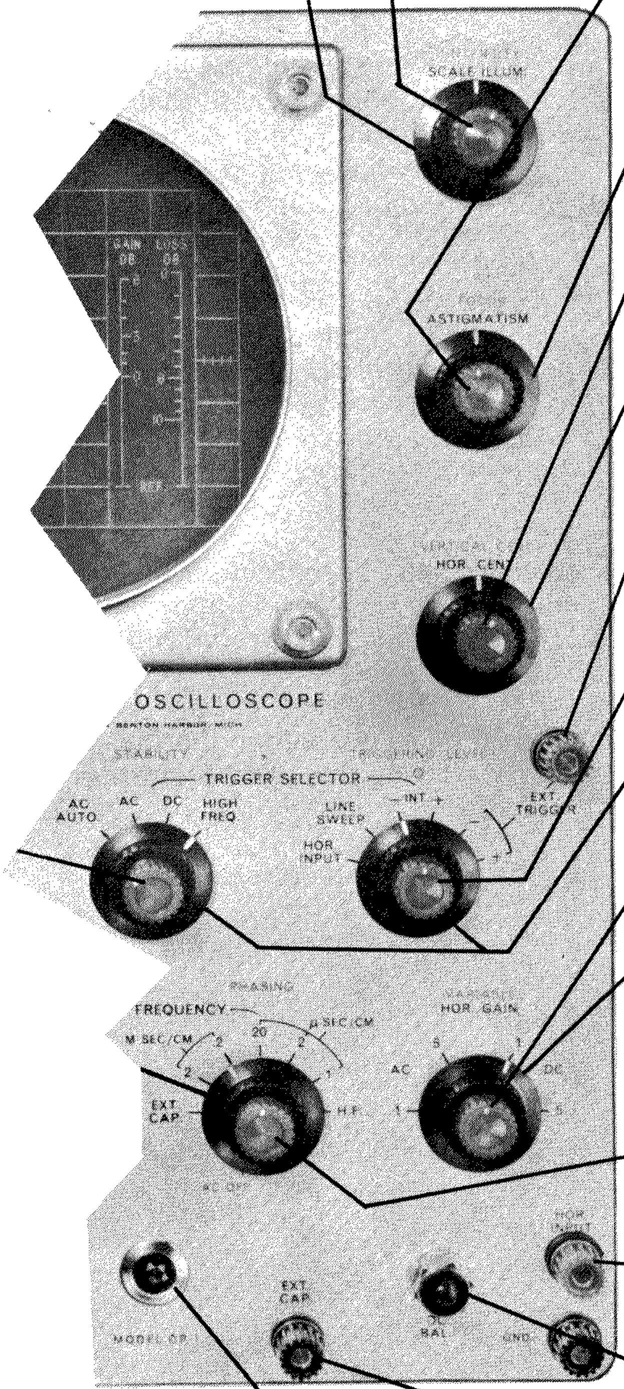
Vertical Input Connector: Provides a means of connecting the unit to the signal to be observed.

Vertical Channel DC Balance Control: Is adjusted to permit changes in the vertical gain control setting without a shift in centering.

Calibration Voltage Connector: Provides a source of regulated, 150 VDC for calibration of the vertical channel.

Intensity Control: Controls the brightness of the trace.

Scale Illumination Control: Permits varying the visibility of the reference lines molded in the graticule.



Pilot Light: Informs the operator when power is applied to the unit.

Focus Control: Controls the definition of the trace-is used in conjunction with the "Astigmatism" control.

Astigmatism Control: Controls the definition of the trace-is used in conjunction with the "focus" control.

Vertical Centering Control: Positions the trace vertically: clockwise rotation-up, counterclockwise rotation-down.

Horizontal Centering Control: Positions the trace horizontally: clockwise rotation, right; counterclockwise rotation, left.

External Trigger Signal Input: Permits application of an external "sync" signal to the triggering circuit.

Triggering Level Control: May be adjusted to select the point at which the sweep starts on the wave form being observed.

Trigger Selector Switches: Are used in conjunction with each other to provide the proper method of triggering for the signal being observed.

Variable Horizontal Gain Control: A continuously variable control of gain in the horizontal channel.

Horizontal Gain Switch: Has 2 output levels: one times normal sweep length and five times normal sweep length; selects AC or DC coupling when using the horizontal input position.

Phasing Control-AC off-on switch: The phasing control is used to adjust the phase of the internal 60 cycle signal applied to the horizontal amplifier in the "Line Sweep" position. The AC off-on switch operates at the counterclockwise end.

Horizontal Input Connector: Permits application of a signal to the horizontal channel when in "Horizontal Input" position.

Horizontal Channel DC Balance Control: Is adjusted to permit changes in the variable gain control setting without a shift in centering.

External Capacity Connector: Permits connection of a larger sweep timing capacitor to reduce the sweep rate.

OPERATIONAL EXAMPLE

An example which will enable you to become more familiar with the control functions previously described, especially the triggering and sweep controls, follows.

Connect a sine wave signal source to the vertical input connector. Almost any frequency will do. Set the "Trigger Selector" switches to "AC Auto", "Int. +". Adjust the "Vertical Attenuator" and "Vertical Gain" controls to provide a trace 3 to 4 cm high. The "Sweep Frequency" controls should be adjusted to provide a trace consisting of 4 or 5 complete cycles on the screen.

Now switch the "Trigger Selector" to the "AC" position. Adjust the "Triggering Level" control until a trace appears. Now slowly rotate the "Triggering Level" control, and note that the left edge starting point of the sweep moves vertically on the wave-form. See Figure A.

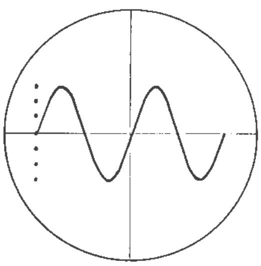
Switch to the "Int. -" position, and note that the "Triggering Level" control has the same effect, only this time the sweep is starting on the negative slope.

There is no one correct setting for the "Triggering Level" control as no two wave-forms are alike. For example, assume that the wave-form being observed had a "spike" superimposed on it as in Figure B. With one or two cycles on the screen, it would be difficult to measure the time duration of the "spike". By properly adjusting the "Triggering Level" control, so that the sweep starts just before the "spike", as in Figure C, and decreasing the time required for one complete sweep, you will be able to spread the "spike" across a large area of the screen for close observation. See Figure D.

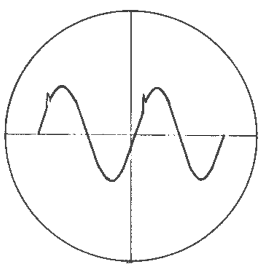
Another good example of this feature is in square-wave observation. A perfect square-wave would appear as in Figure E. This is rarely obtained, although it is very closely approximated in many high quality square-wave generators. If such a near perfect square-wave were fed into a circuit with high frequency resonance, its output might look like Figure F.

By adjusting the "Triggering Level" control so that the sweep starts just before the distorted corner of the square-wave, and with the sweep time duration reduced, the wave-form may be much more closely observed. See Figure G.

Needless to say, this makes the job of "tracking down" the offending resonance in the circuit much easier.



A



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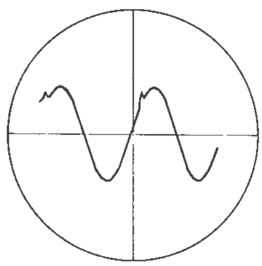

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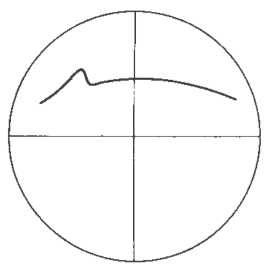

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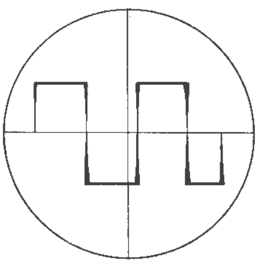

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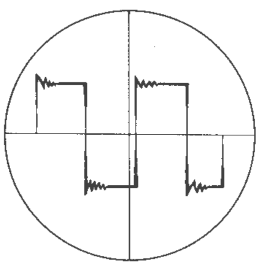
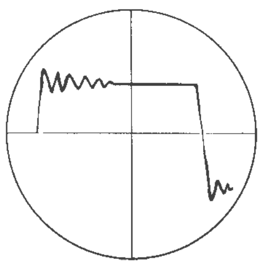


F



G

CALIBRATION AND TEST PROCEDURE

NOTE: The following steps must be performed in the order listed, to prevent possible damage to vacuum tubes and/or other components.

( ) Refer to the tube location charts on Page 28, and install all of the tubes except the 12BH7 vertical output stage (V-4), the 12BH7 horizontal output stage (V-16), and the OB-2 Voltage Regulator in the triggering circuits (V-10).

( ) Referring to Figure 1, install the silicon diodes, #57-21. Note that the diodes have a groove in the connector on one end. This groove must match the corresponding projection on the diode clip. If a great amount of force is required to press the diode into its clip, you are probably trying to install the diode in its clip backwards.

( ) Install one of the 3 amp. 3AG fuses supplied with your kit in the fuse holder on the chassis rear apron.

( ) Refer to the charts on Pages 15 and 16. Set all the controls and switches as indicated. DO NOT CHANGE THESE SETTINGS UNLESS INSTRUCTED TO DO SO.

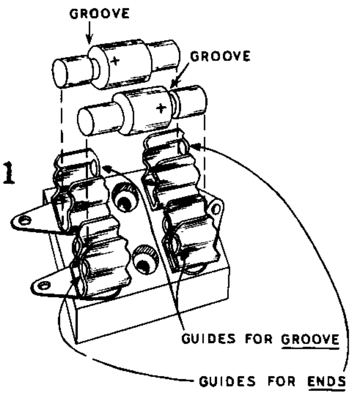


Figure 1

( ) Connect the instrument to a source of 105-125 volts 50-60 cycle AC only.

( ) Turn the power switch on. The pilot light on the front panel should now light. If it does not, or if any of the following adjustments do not have the proper effect, turn the unit off and refer to the "In Case of Difficulty" section.

( ) You will note that the Voltage Regulator tubes are glowing. This is normal. The neon bulb on the vertical amplifier strip pack #84-3 should also be lit with an orange glow. A large spot of light will probably appear on the tube face. Reduce the "Intensity" control until it is barely visible.

NOTE: The OB-2 voltage regulator tubes may glow with either an orange or blue light. This is normal and your instrument will operate equally well, regardless of which of these two colors appears, since tubes which glow with either color are electrically the same.

( ) Connect the common lead of a VTVM or 20,000 ohm/volt meter to the chassis (ground) and the DC lead to the center lug on the vertical channel "DC Bal." control. Set the control to provide a reading of 0 volts DC (accuracy at this point is not too important, as this adjustment will be "touched up" later in the testing procedure).

( ) Next, connect the voltmeter DC lead to the center lug on the horizontal channel "DC Bal" control. As before, set the control to provide approximately 0 volts DC.

( ) Now connect the voltmeter DC lead to the center lug on the "Sweep Positioning" control. Set this control to provide a reading of approximately 0 volts DC.

( ) Turn the unit off, and install tubes (V-4), (V-10) and V-16).

( ) Turn the unit on again, allow one minute for warmup and slowly rotate the "Vertical Range" control counterclockwise, until the spot comes into view on the cathode ray tube screen. Adjust the control so the spot comes to rest in the middle of the screen. NOTE: As soon as the spot becomes visible, reduce the setting of the intensity control until the spot is just visible. This will prevent the stationary electron beam from "burning" the phosphors on the surface of the CR tube.

( ) Now rotate the horizontal gain control fully clockwise, and connect a lead from the red horizontal input binding post to either pin 3 or pin 4 of horizontal channel input cathode follower, (V-14). A horizontal line should result. Do not be alarmed if the line is not exactly horizontal, as a slight rotation of the CR tube will correct the fault. NOTE: Be extremely careful whenever any adjustments involving the CR tube are to be performed.

CAUTION:
The voltages provided for the CR tube are high enough to be lethal under some conditions. Under no circumstances attempt to rotate the tube with the power applied to the unit. A wax

pencil line lightly drawn on the face of the CR tube to correspond to the trace will enable you to rotate the tube to provide a horizontal trace. Now, carefully tighten the CR Tube neck clamps to hold the tube in place. Be sure not to overtighten and break the tube neck. Now, turn the unit on again and check to be sure the trace is horizontal. If it is, wipe the wax pencil line off the tube face with a soft cloth.

( ) Remove the lead between the horizontal input binding post, and the input cathode follower. Rotate the "Horizontal Gain" control to the fully counterclockwise (minimum) position. Note the position of the spot. Now rotate the gain control to its maximum gain position (full clockwise). If the spot moved, rotate the "DC Balance" control to return the spot to the original location.

( ) Set the "Trigger Selector" to the "Int. -" position, and the "Stability" control fully clockwise. A horizontal line should again result, this time provided by the sweep circuits (you may have to adjust the "Horizontal Centering" control to center the trace). Reduce the "Horizontal Gain" control until the line is just 10 cm long (one full screen width). Now, rotate the "Horizontal Gain" switch to the X5 position, and rotate the "Horizontal Centering" control from one end to the other. If the entire trace can be centered, no further adjustment of the "Sweep Positioning" control is indicated. If the entire trace cannot be centered, carefully adjust the "Sweep Positioning" control. NOTE: A clockwise rotation will shift the trace to the right, and a counterclockwise rotation to the left. The range of this control is quite large, and a slight change in setting will cause a great change in positioning.

( ) Next, check the adjustment of the vertical "DC Balance" control. As before, note the position of the trace with the "Vertical Gain" control in the full counterclockwise position. Rotate the "Vertical Gain" control to its maximum position (full clockwise) and if the trace has moved, return it to the original position with the "DC Balance" control.

( ) Set the "Trigger Selector" to the "DC" position. Turn the "Triggering Level" and "Stability" controls to the counterclockwise position. Turn the "Stability" control clockwise, until the sweep begins. Reduce the "Stability" control setting just below this point. Do not readjust the "Stability" control unless told to do so.

NOTE: In the following step, do not turn the "Trigger Sensitivity" control any further clockwise than necessary to stop the sweep, as to do so will reduce the trigger sensitivity.

( ) Turn the "Triggering Level" control clockwise until a trace appears; now, turn the "Trigger Sensitivity" control clockwise, until the sweep stops. Again readjust the "Triggering Level" control and if a trace appears, again adjust the "Trigger Sensitivity" control. Continue this procedure until no continuous sweep occurs at any setting of the "Triggering Level" control.

( ) Now connect a wire from the vertical input connector to either pin 3 or pin 4 of the 6C4 vertical input cathode follower (V-2). Set the "Vertical Attenuator" switch to the 2 v/cm position. Rotate the "Triggering Level" control until a trace appears. Adjust the "Vertical Gain" control for a trace approximately 3-4 cm high. Note that rotation of the "Triggering Level" control causes a change in the position of the start of the trace.

( ) Next, set the "Trigger Selector" to the "AC" position. Rotate the "AC Trigger Adjust" control until the trace appears, and the starting point (left edge) is in exactly the same position as before in the "DC" position. This adjustment is quite narrow, and until the control is properly adjusted, no sweep at all will be present.

( ) Next, rotate the "Trigger Selector" to the "Int. +" position. Now, rotate the "Triggering Level" control until a trace appears. Operation in this position should be exactly as in the "Int. -" position, except the sweep will now start on the positive slope.

( ) Check the operation in the "Ext. Trigger" positions as follows. Connect a wire between the vertical input connector and the "Ext. Trigger" binding post. This will feed the same signal to both the vertical amplifier and the triggering circuits. The operation of the "Trigger

Selector" and "Triggering Level" controls in the "Ext. Trigger" positions remain the same as in the internal triggering positions. Remove the leads after completion of this test.

( ) Set the "Trigger Selector" to "AC Automatic". A trace should appear. If not, a slight readjustment of the Trigger Sensitivity" control may be required. If a slight adjustment does not result in sweep, refer to the trouble shooting chart in the "In Case of Difficulty" section of the manual.

( ) Calibration of the vertical input proceeds as follows: set the "Trigger Selector" to "AC Automatic" position. Remove the knob which was temporarily installed on the "Vertical Gain" control. Set the "Vertical Attenuator" switch to the 50 V per cm position, and connect a lead from the vertical input connector to the "150 V DC for Cal." binding post on the front panel. Rotate the AC-DC input switch to DC. With the "Vertical Gain" control in the minimum (CCW) position, adjust the "Vertical Centering" control to position the trace on the center horizontal line of the graticule. Now rotate the "Vertical Gain" control clockwise until the trace moves upward 3 cm (large divisions). Install the knob and tighten the setscrew with the pointer indexed on the red dot on the front panel (to the right of the control.) As a double check, set the "Vertical Gain" control to minimum, and switch the "Vertical Attenuator" to the 20 v/cm position. Adjust the "Vertical Centering" control to position the trace on the bottom line in the graticule. Now advance the "Vertical Gain" control to the red dot. The trace should move upward approximately 7 1/2 cm.

( ) Turn the "Intensity" control fully counterclockwise. Set the "H. V. Adjust" control so that the trace is just extinguished.

( ) To calibrate the sweep, a source of signal (may be sine wave, square wave or spikes) of known frequency is required. A frequency of 1000 cps is recommended, if available. To calibrate the sweep using 1000 cps, set the "Frequency Selector" switch to .2 ms/cm, and the "Variable Multiplier" to 1. Rotate the "Sweep Calibrate" control until 2 complete cycles appear on the C. R. Tube screen. Now set the "Variable Multiplier" to 10, and adjust the "Sweep Range" control until 20 complete cycles are visible on the CR Tube screen.

( ) Set the "Frequency Selector" switch to the 1 μsec/cm position and the "Variable Multiplier" to 4. Apply a 50 kc signal and set the "H. F. Sweep Adjust" trimmer to provide 2 complete cycles on the CR tube screen. NOTE: If no suitable source of signal is available for this adjustment, set the trimmer with the screwdriver slot parallel to the trimmer connecting lugs. NOTE: The 1 μsec/cm position will not be accurately calibrated by this method, but the calibration will be reasonably close.

( ) A less accurate method of calibrating the sweep is as follows; First, re-connect the lead from the vertical input connector to either pin 3 or 4 on the 6C4 vertical input cathode follower (V-2). Now, set the "Frequency Selector" switch on the .2 ms/cm position, and the "Variable Multiplier" at approximately 8.3. Adjust the "Sweep Calibrate" control to provide one complete cycle on the screen. It will not be possible to accurately adjust the "Sweep Range" control by this method. Leave the "Sweep Range" control in the full CW position. Remember that this method of calibration is quite inaccurate, and any measurements of time (frequency) will be equally inaccurate.

This completes the sweep calibration. Remember that the accuracy of the sweep timing is no more accurate than the signal used for a standard, and the care with which the calibrate controls are adjusted.

( ) Set the "Vertical Attenuator" switch to the .1 V/cm position, and locate the trimmer capacitor on the vertical channel components strip pack. If a source of one megacycle square waves is available, set the trimmer to provide a square wave with a "flat" top and a reasonably "sharp" corner (see Figure H). If no suitable square wave signal is available, set the trimmer as follows: turn the adjusting screw until the trimmer is snugly closed. Now "back off" the adjustment 1/2 turn. This will approximate the proper setting.

( ) The last step in the calibration and test procedure is adjustment of the "Vertical Attenuator" compensation trimmer capacitors. Set the "Vertical Attenuator" switch to the 1v/cm position. Connect a lead from the vertical input connector to the center lug on the horizontal gain control. Turn the stability control full clockwise and the "Frequency" selector switch to the .2 ms/cm position. Adjust the "Horizontal" and "Vertical Gain" controls to provide a trace similar to Figure J.

( ) Adjust the trimmer nearest the front panel to provide the straightest line. Now set the switch to the 10 v/cm position. Turn the unit off, and connect the lead between the vertical input connector and pin 1 of the horizontal output stage, (V-16). Turn the unit on again, and allow a minute or so for warm up. Now adjust the controls to provide a trace similar to Figure K.

( ) Adjust the other compensating trimmer to provide the straightest line, as before. Turn the unit off and remove the lead between the vertical input connector and the horizontal output stage.

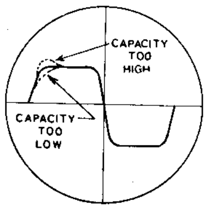
( ) Select the power supply shield and secure one of the 1/4" x 1/4" angle brackets on the inside surface with a 6-32 x 3/16" screw, lockwasher, and nut. Refer to Figure L.

( ) Now install the shield on the chassis, and secure with 6-32 x 5/16" screws (with lockwashers attached). Again, refer to Figure L.

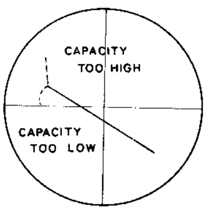
( ) Peel off the paper backing, and cement the label between the two rows of holes on the bottom of the cabinet with the lettering toward the front.

( ) Install the handle on the cabinet, using #10 x 1/2" self tapping screws.

( ) Install the instrument in the cabinet, using 6-32 x 1/2" pan head screws.



H



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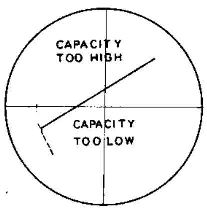


K

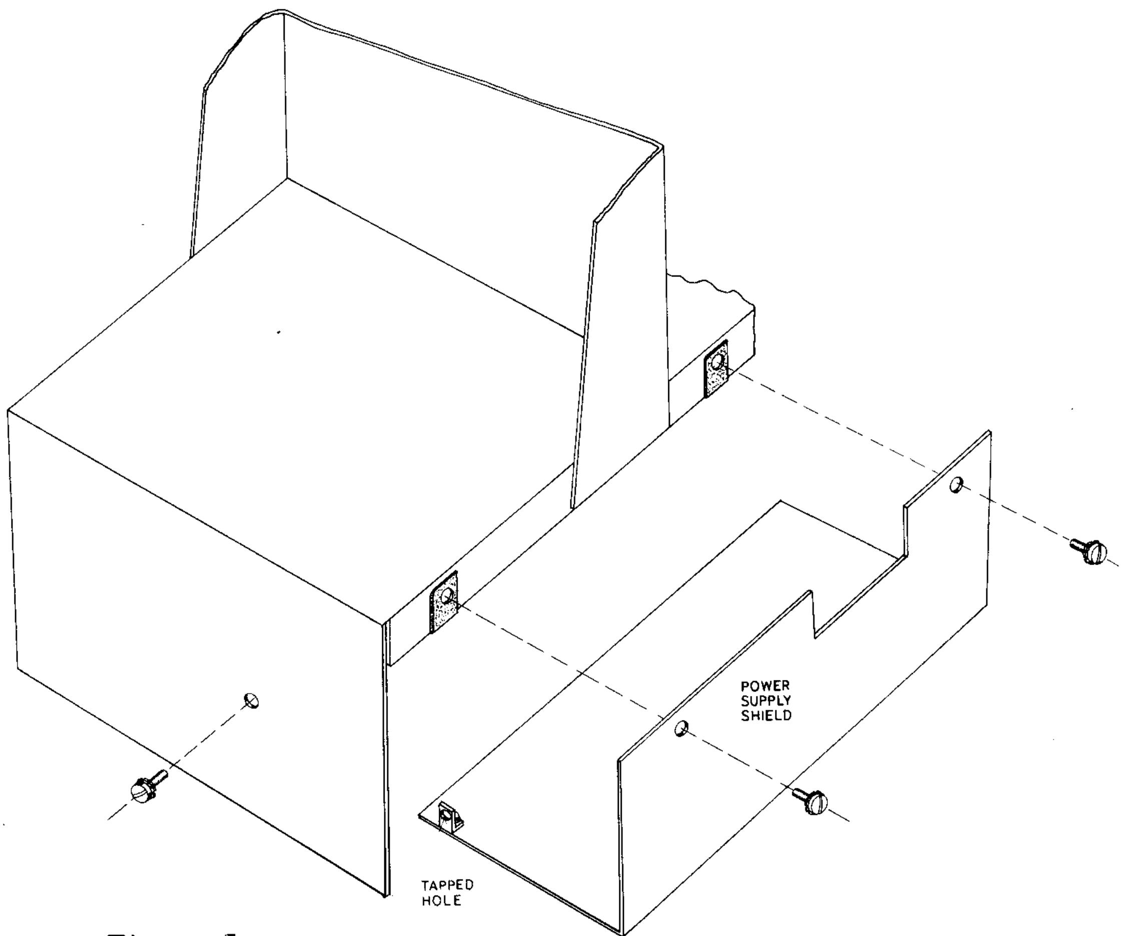


Figure L

NOTES ON OPERATION

VERTICAL CHANNEL

Always reduce the amplitude of a large signal with the input "Attenuator" switch, not the "Vertical Gain" control.

When using DC coupling, remember that if the signal you wish to observe is superimposed on a high DC level, you may have to reduce the input "Attenuator" switch in order to bring the signal within the range of the "Vertical Centering" control. A good procedure to follow is to set the "Vertical Attenuator" on the 50 v/cm position, and then increase the sensitivity as desired.

If it is desired to view a relatively small signal superimposed on a relatively large DC potential, it is possible to supplement the range of the "Vertical Centering" control somewhat with the "DC Balance" control. A clockwise rotation will shift the trace up and a counterclockwise rotation will shift the trace down.

This method should not be used as a normal practice for two reasons: first, it will cause a shift in centering with any change in the "Vertical Gain" control: second, it changes the calibration of the vertical channel. When using this procedure, be sure to reset the "DC Balance" control to the proper setting as outlined in the "Test and Calibration" section after your observations are complete.

Remember that the .05, .02 and .01 v/cm positions are AC coupled, and frequencies below approximately 50 cps may be attenuated, or, in the case of square waves, tilted.

SWEEP CIRCUITS

Be sure that the setting of the "Stability" control is correct. In most cases, the "Stability" control should be just below the point at which the sweep "free runs". The only exception to this rule is: In the "AC Auto." position, a trace should be present at all settings of the "Frequency Selector" controls. The best way to set the "Stability" control in the "AC Auto." position, is to observe the starting point (left edge) of the sweep. As the control is advanced clockwise, you will note that the sweep starts, and further rotation causes an abrupt "jump" of the trace to the right. The proper setting for the "Stability" control is just below this point.

In the "AC Auto." position, some instability in the presentation may be noted, especially at low amplitudes. This is normal. The main reason that the "AC Auto." position is provided, is to facilitate observation of signals of varying or widely different amplitudes without the need for constant adjustment of the scope.

In the "High Frequency" position, the "Stability" control will have to be adjusted to provide a stable presentation.

In the internal sweep positions, some horizontal trace shift with changes in the "Horizontal Gain" control setting may occur. This is normal, and should cause no difficulty, as the "Horizontal Gain" control is seldom adjusted.

The sweep calibration is based on the time required for the spot to scan the 10 cm graticule from left to right. Regardless of the settings of the "Frequency Selector", the sweep will be calibrated if the trace exactly fills the graticule. On the 1 microsecond/cm position, some adjustment of the "Horizontal Gain" control may be necessary to keep the graticule filled at all settings of the "Variable Multiplier" control.

Remember that the sweep is calibrated in units of time per single cm. Don't forget to multiply the time required for 1 cm by 10 to obtain the time required for one complete sweep (10 cm).

When using the X5 position of the "Horizontal Gain" switch, divide the time/cm reading by 5 to get the actual time for one screen width (10 cm).

To measure time with your OP-1 Oscilloscope, simply multiply the fixed base rate by the variable multiplier. This product is the time required for the sweep to move one cm. To obtain the time required for one complete sweep, multiply this time by 10, as the total sweep length is 10 cm.

To determine frequency, measure the time required to display a complete cycle on the scope screen. Use this factor in the following formula: A cycles ÷ B seconds equals frequency in cycles per second. For example: if the time required to display one cycle is 20 milliseconds (.02 seconds), then 1 cycle ÷ by .02 seconds equals 50 cycles per second.

GENERAL

It will be noted that the operating temperature of this unit will be quite high after a 15-20 minute warmup period. This is an entirely normal condition, and does not indicate any difficulty. The rear area of the chassis and the resistor mounting bracket mounted above the power transformer may become painfully hot to the touch. All components used in the OP-1 Oscilloscope are adequately rated to operate properly under these temperature conditions. Of course, it is necessary to keep all the air openings and exits clear of obstructions, and to provide an unimpeded flow of air around the unit to keep the operating temperature normal.

If any problems arise in routine operation, it is strongly suggested that you refer back to the control function chart at the beginning of this section. Further information is also available in the circuit description section.

IN CASE OF DIFFICULTY

The first things to check in case of any difficulty, are the voltages developed by the power supplies. If any of the voltage regulator tubes are not glowing, it indicates either too great a load (possibly a short circuit) or insufficient voltage being developed in the power supply to ignite the tube. Be sure to refer to the voltage readings as well as the current notations on the schematic to localize the difficulty. If the problem does not appear to have an immediate solution, be sure and turn the unit on only as long as necessary to make quick checks, as the power transformer and other components may be severely overloaded. Prolonged operation in this overloaded condition will almost certainly cause component damage, and perhaps failure.

You will note that a large number of the circuits within the scope rely on the -105 V supply voltage. Operation for any appreciable time without the proper voltage at this point will almost surely cause damage to several tubes and/or components. Next, a check of the tube or tubes in the area of difficulty is in order. Substitute a tube of known good quality for the suspected tube if at all possible.

If you are unable to get any indication on the CR tube screen, it is often a good idea to remove the 12BH7 vertical output stage (V-4) and the 12BH7 horizontal output stage (V-16). This removes all deflecting voltages from the CR tube deflecting plates, allowing the beam to rest at the center of the screen. (Do not allow a bright spot to rest in one place on the tube face, as damage to the phosphors on the screen area may result.)

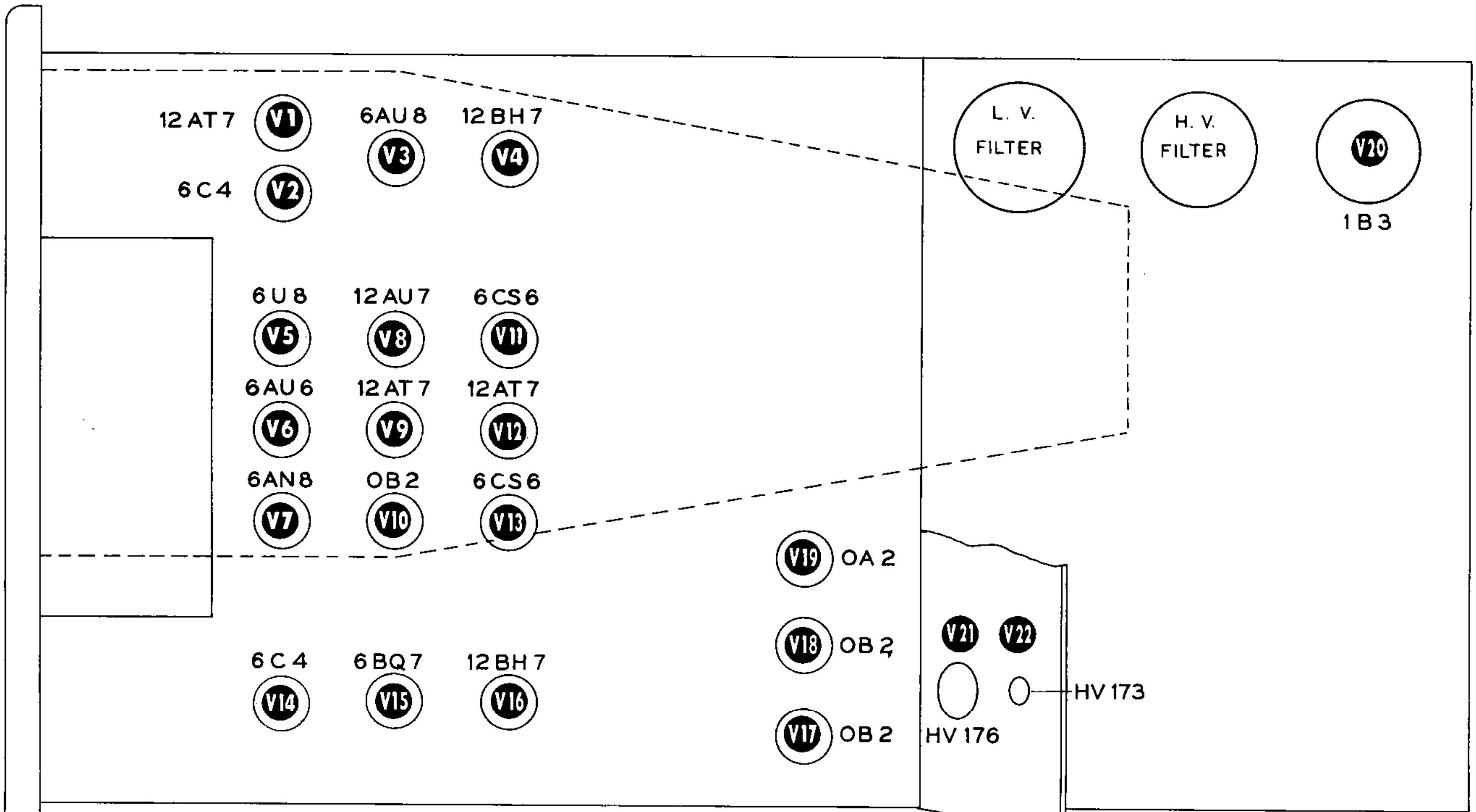
If no spot is visible with (V-4) and (V-16) removed, carefully check all wiring in the CR tube circuits, especially the grid and cathode wiring. Do not attempt to measure any voltages in the CR tube circuits unless you are sure all wiring is correct.

If voltage checks prove necessary, be sure you are adequately protected against the high potentials involved. Do not stand on a damp floor, or with your body in contact with any grounded object. It is good practice to keep one hand behind your back or in your pocket when making voltage measurements in any circuit, to prevent accidental contact with the chassis, grounded object, etc.

The best approach to any problem is logical thinking. It would be virtually impossible to list all of the possible difficulties you might encounter. Keep in mind, that the majority of Heathkit owners who find it necessary to return their completed kit to the Heath Company for service, could have saved the expense and inconvenience by spending just a few minutes extra time checking for wiring errors and poor solder connections.

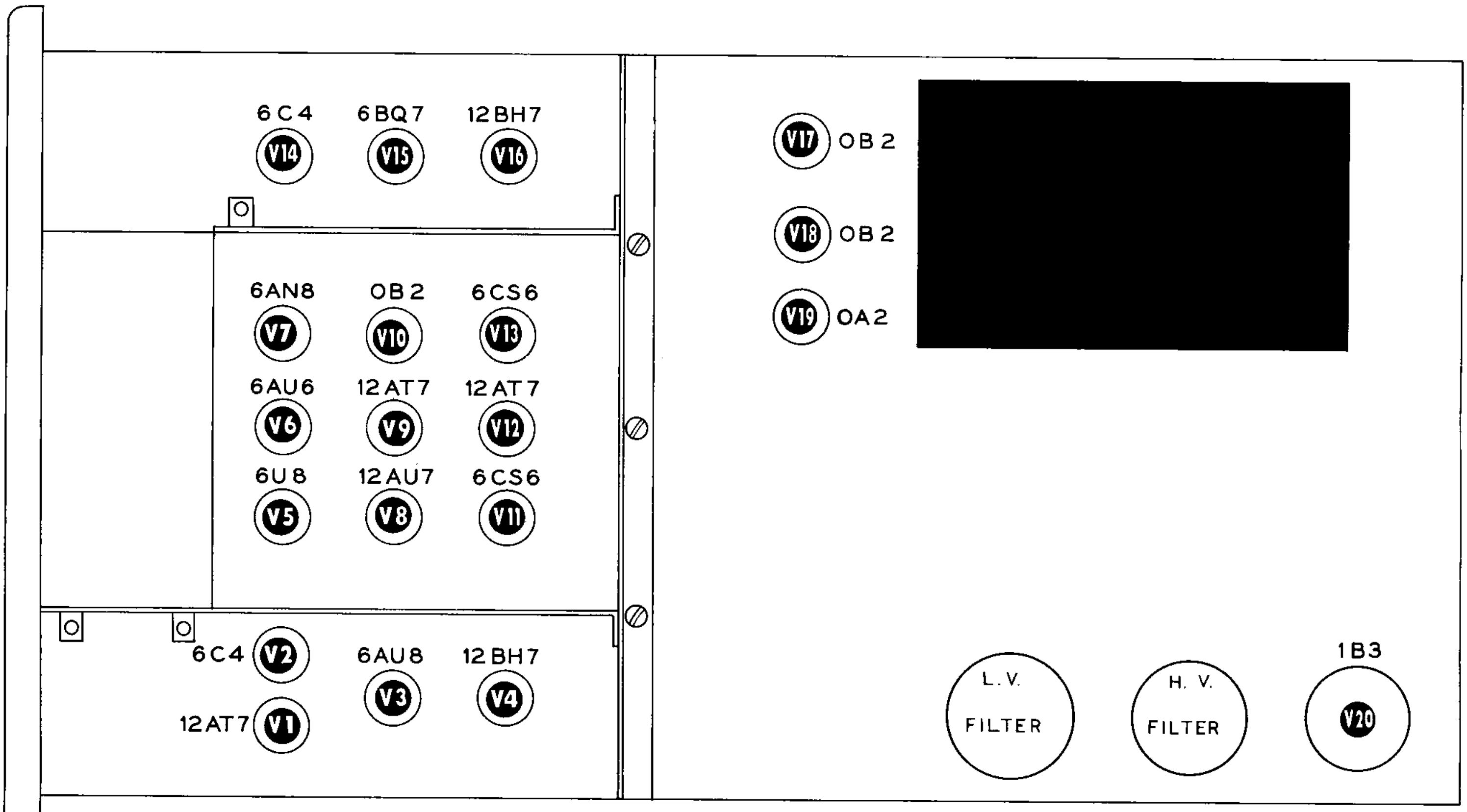
The following chart represents a few typical problems and their possible solution. By all means, check this chart before proceeding with any repair work, as it may save you considerable time.

SYMPTOM	PROBABLE CAUSE
No B+.	Defective silicon diode. Check polarity of (C-34) and (C-35).
No B-.	Defective silicon diode. Check polarity of (C-31), (C-32) and (C-33).
Cannot obtain proper "DC Bal." control operation (either channel).	Defective 6C4 tube, wiring error, open resistance in grid circuit.
Cannot obtain proper "Vertical Centering Range" control operation. Cannot center the trace vertically.	Defective 6AU8 tube (V3), defective 12BH7 tube (V4), defective neon bulb (V-23). Open peaking coil or coils, defective "Range" control (R-11), defective "Centering" control (R-13), wiring error.
Cannot center the trace horizontally.	Defective 6BQ7 tube (V15), defective 12BH7 tube (V16), improper adjustment of the "Sweep Positioning" control (R-68).
Severe trace distortion above .2 millisecond/cm sweep frequency.	Lead dress in sweep circuitry, improper ground in shielded lead at (R-68), poor grounding of control mounting bracket.
Sweep is recurrent at all settings of stability control.	Wiring error in "Stability" control circuits or 6CS6 input gate circuit, defective 6CS6 input gate (V-11).
Unable to get proper "H. V. Adjust" control range, "Intensity" control inoperative, or range insufficient.	Defective high voltage regulator (V-21). Defective unblanking regulator (V-22). Wiring error, defective "Intensity" or "Focus" control, open resistor in H. V. divider string.
"Triggering Level" control is apparently inoperative, or has limited range, in either or both of the internal triggering positions.	Measure the voltage at pins 2 and 9 of V5 in both the INT- and INT+ positions of the trigger selector. It should be possible to read and pass through "0" volts on either grid by adjusting the "Triggering Level" control. If not, recheck the following adjustments: "Vertical DC Balance," "Vertical Centering," and "Vertical Range." After these adjustments have been rechecked, repeat the measurement at pins 2 and 9 of V5. If it is still incorrect, the value of R22 in the "Triggering Level" circuit should be changed, with the objective of achieving an equal swing above (+) and below (-) ground reference, in both the INT+ and INT- positions. If the voltage at either pin 2 or pin 9 tends to be negative, increase R22; if positive, decrease R22.

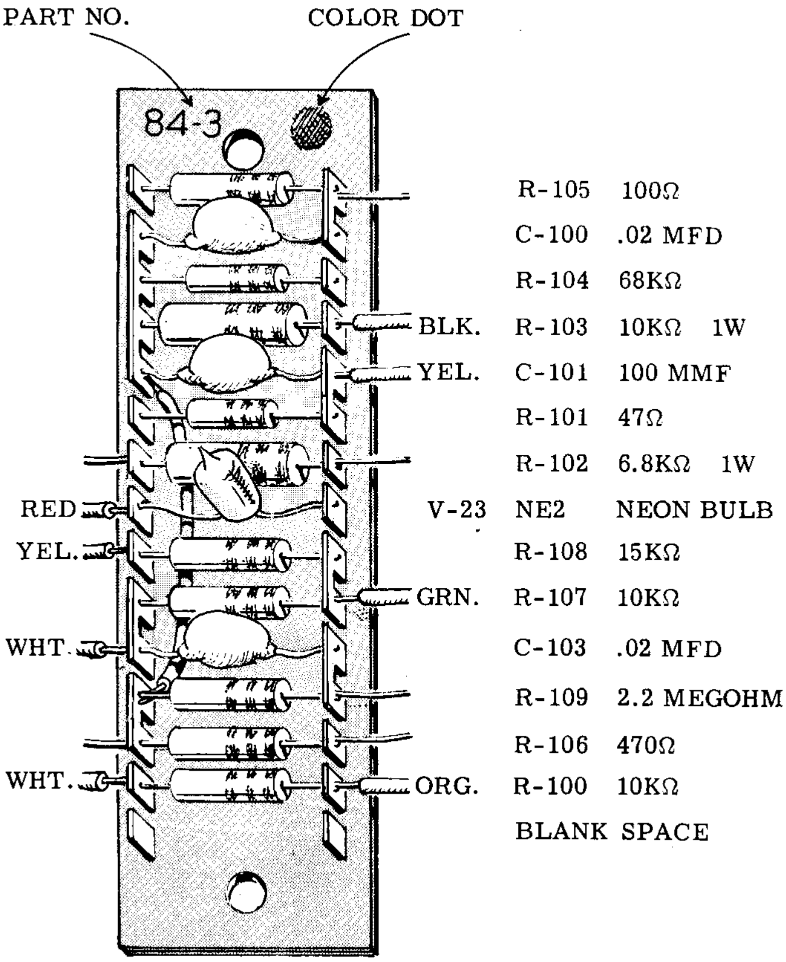


TOP VIEW

TUBE LOCATION CHART



BOTTOM VIEW

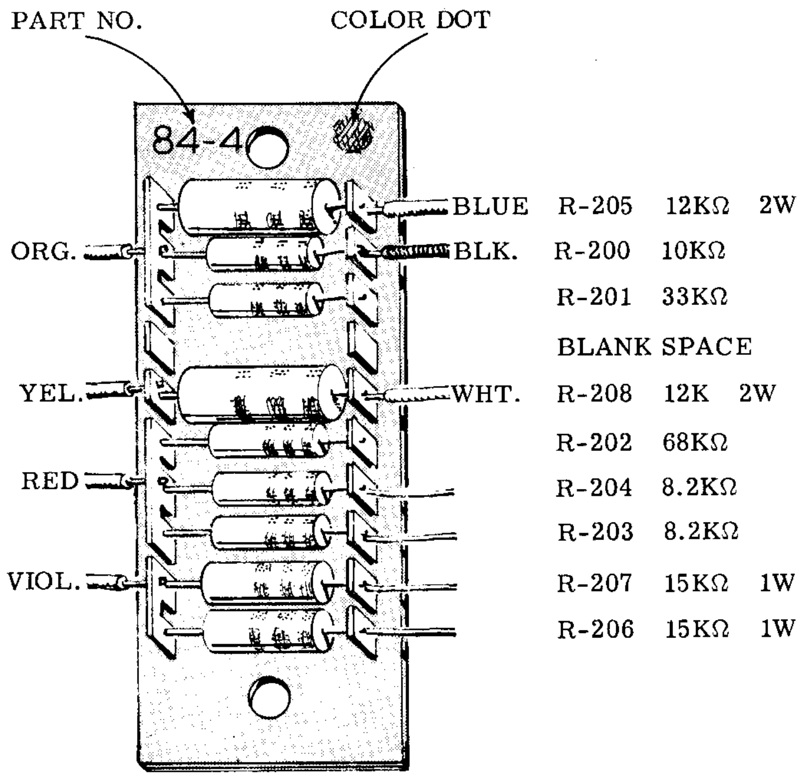


WARRANTY

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



PART NO.
COLOR DOT
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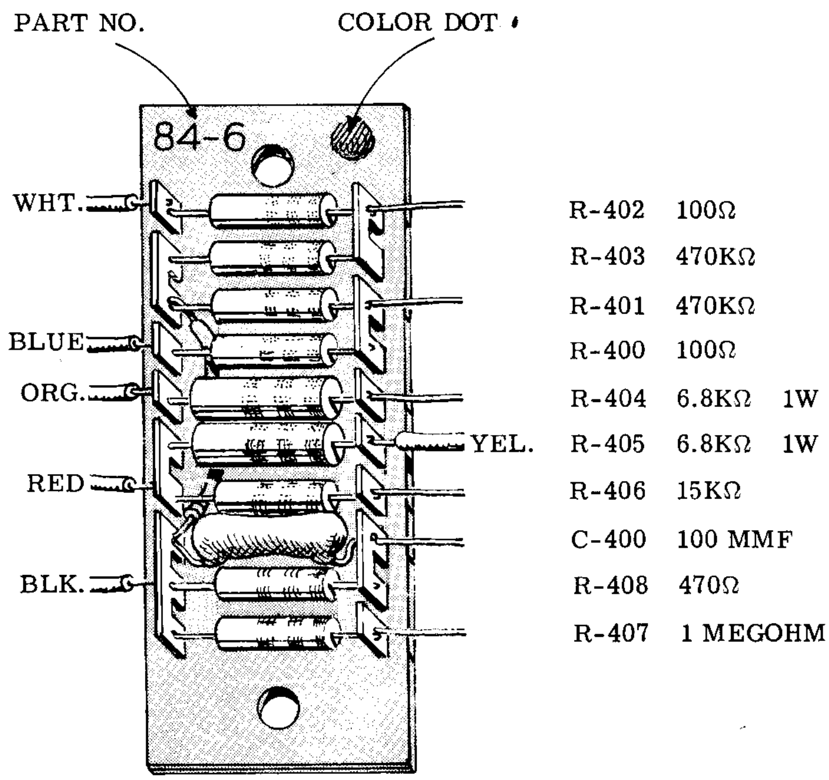
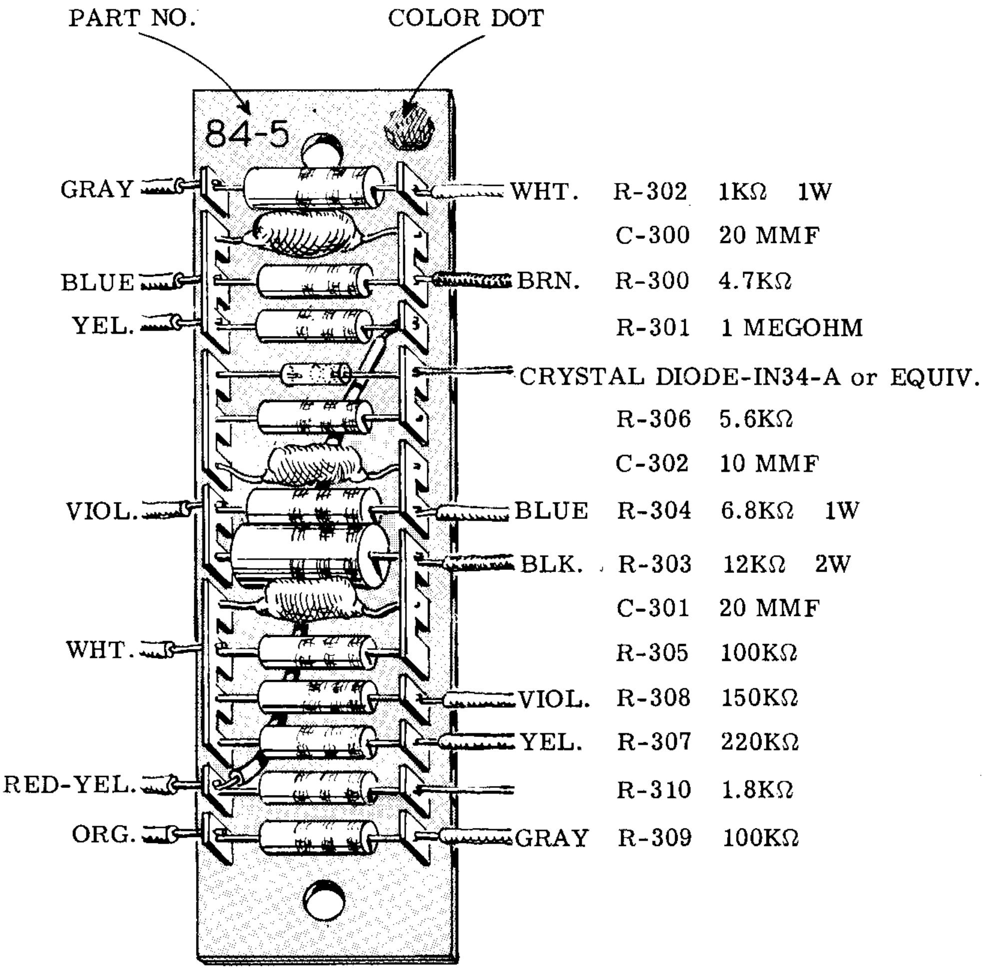
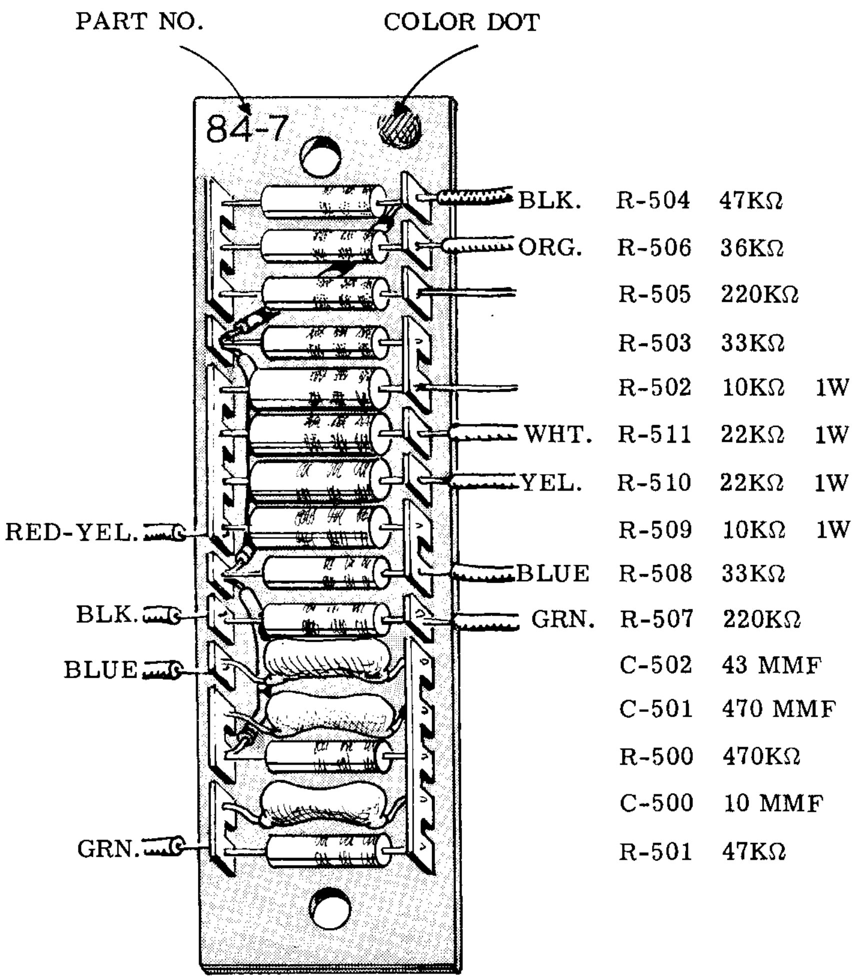
BLUE
R-205 12KΩ 2W
ORG.
BLK.
R-200 10KΩ
R-201 33KΩ
BLANK SPACE
YEL.
WHT.
R-208 12K 2W
R-202 68KΩ
RED
R-204 8.2KΩ
R-203 8.2KΩ
VIOL.
R-207 15KΩ 1W
R-206 15KΩ 1W



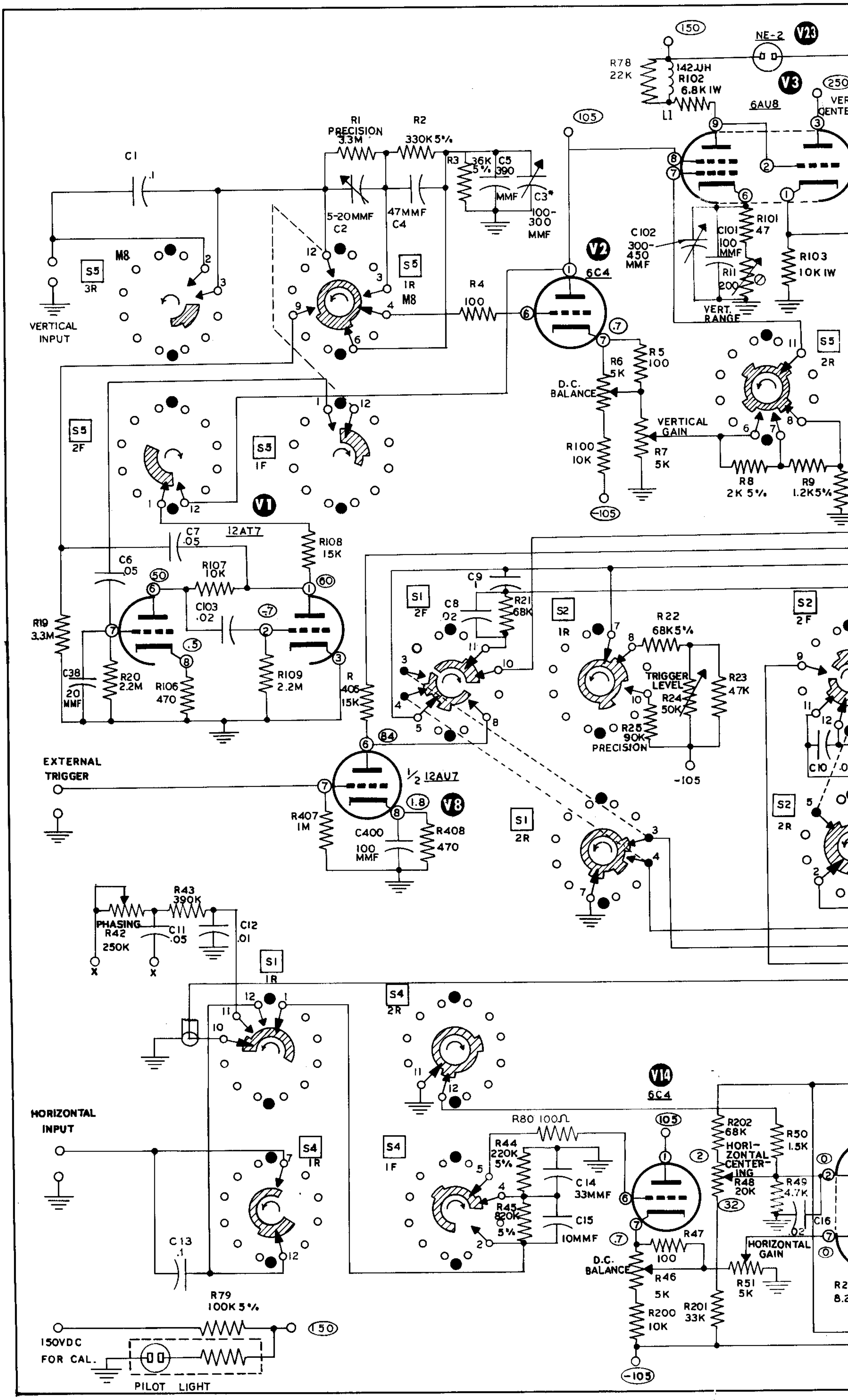
PART NO.
COLOR DOT
84-6
WHT.
R-402 100Ω
R-403 470KΩ
R-401 470KΩ
BLUE
R-400 100Ω
ORG.
R-404 6.8KΩ 1W
YEL.
R-405 6.8KΩ 1W
RED
R-406 15KΩ
C-400 100 MMF
BLK.
R-408 470Ω
R-407 1 MEGOHM



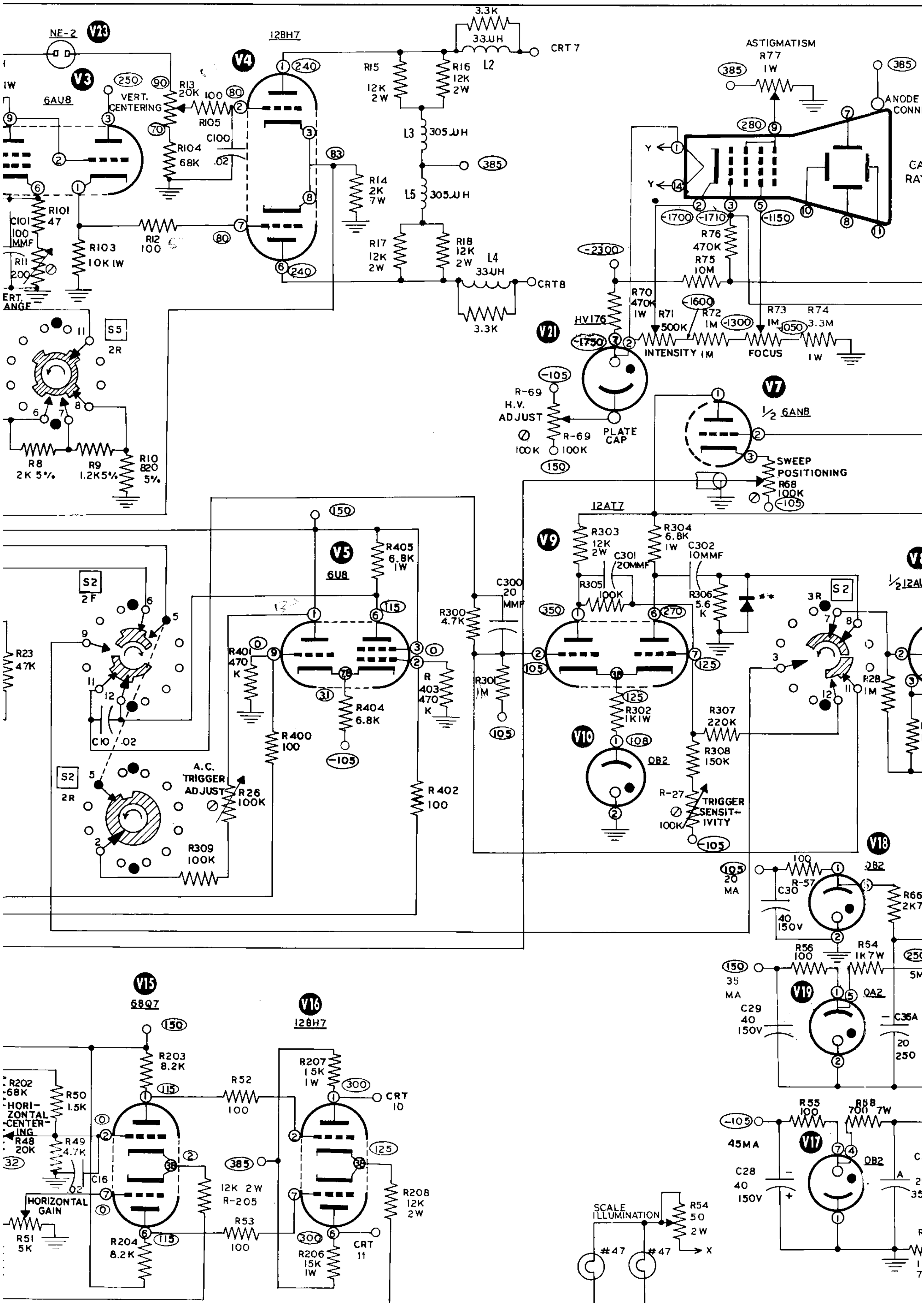
PART NO.
COLOR DOT
84-5
GRAY
WHT.
R-302 1KΩ 1W
C-300 20 MMF
BLUE
BRN.
R-300 4.7KΩ
YEL.
R-301 1 MEGOHM
CRYSTAL DIODE-IN34-A or EQUIV.
R-306 5.6KΩ
C-302 10 MMF
VIOL.
BLUE
R-304 6.8KΩ 1W
BLK.
R-303 12KΩ 2W
C-301 20 MMF
WHT.
R-305 100KΩ
VIOL.
R-308 150KΩ
YEL.
R-307 220KΩ
RED-YEL.
R-310 1.8KΩ
ORG.
GRAY
R-309 100KΩ



PART NO.
COLOR DOT
84-7
BLK.
R-504 47KΩ
ORG.
R-506 36KΩ
R-505 220KΩ
R-503 33KΩ
R-502 10KΩ 1W
WHT.
R-511 22KΩ 1W
YEL.
R-510 22KΩ 1W
RED-YEL.
R-509 10KΩ 1W
BLUE
R-508 33KΩ
BLK.
GRN.
R-507 220KΩ
BLUE
C-502 43 MMF
C-501 470 MMF
R-500 470KΩ
C-500 10 MMF
GRN.
R-501 47KΩ



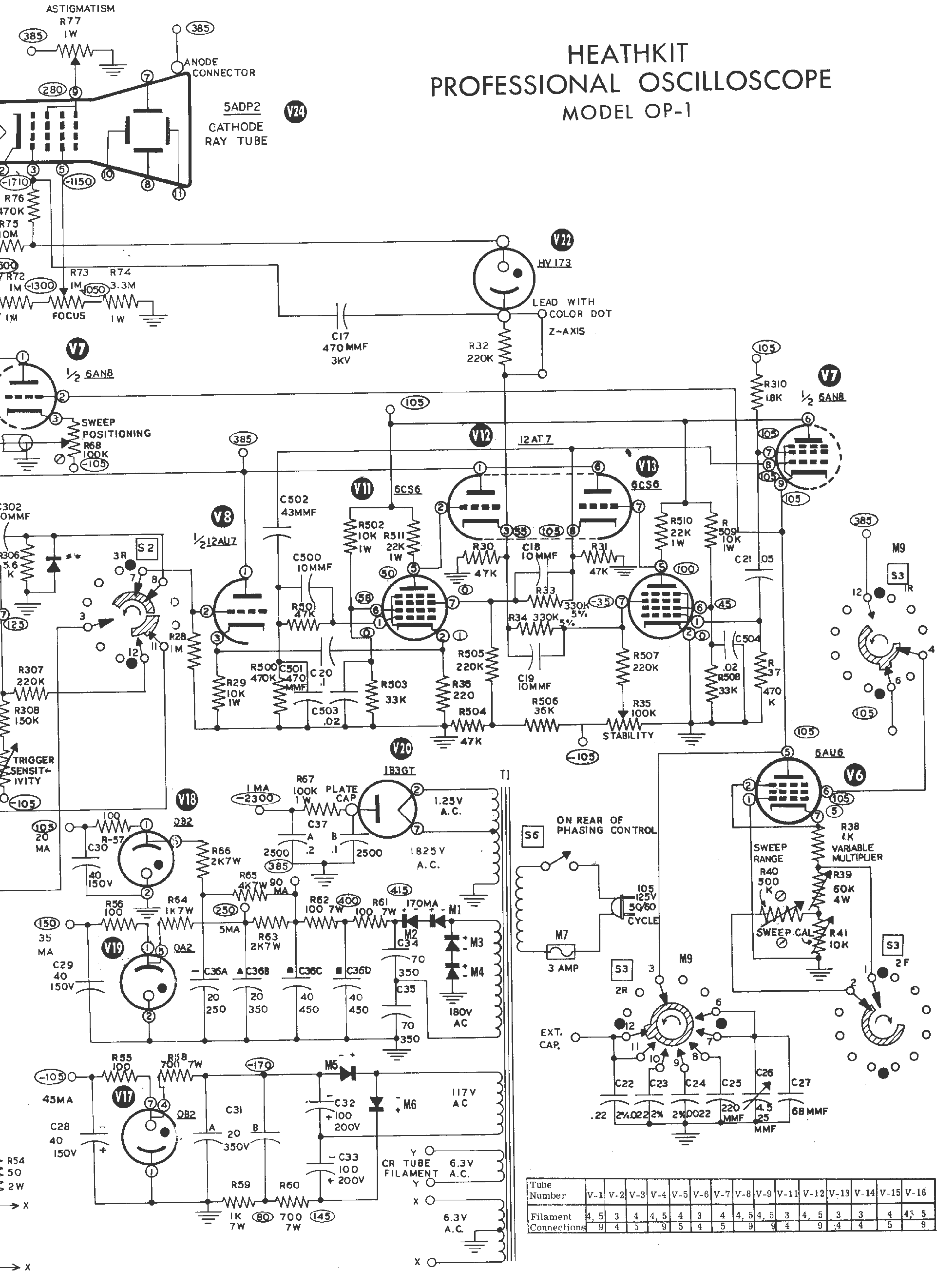
VERTICAL INPUT
EXTERNAL TRIGGER
HORIZONTAL INPUT
150VDC FOR CAL.
PILOT LIGHT
R1 PRECISION 3.3M
R2 330K 5%
C1 .1
V1 12AT7
V2 6C4
V3 6AU8
V8 1/2 12AU7
V14 6C4
V23 NE-2
D.C. BALANCE
VERTICAL GAIN
VERT. RANGE
TRIGGER LEVEL
PRECISION
PHASING
HORIZONTAL GAIN
HORIZONTAL CENTERING



NE-2
V23
V3
6AU8
VERT. CENTERING
R13 20K
R105 100
C100 .02
R104 68K
R101 47
C101 100 MMF
R11 200
R103 10K 1W
R12 100
V4
12BH7
3.3K
33UH
L2
CRT 7
R15 12K 2W
R16 12K 2W
L3 305UH
L5 305UH
R14 2K 7W
R17 12K 2W
R18 12K 2W
L4 33UH
CRT8
3.3K
S5
2R
R8 2K 5%
R9 1.2K5%
R10 820 5%
ASTIGMATISM
R77 1W
ANODE CONN
Y
R76 470K
R75 10M
R70 470K 1W
R71 500K
R72 1M
R73 1M
R74 3.3M 1W
INTENSITY
FOCUS
HV176
V21
PLATE CAP
R-69 H.V. ADJUST
R-69 100K
100K
V7
1/2 6AN8
SWEEP POSITIONING
R68 100K
12AT7
V9
R303 12K 2W
R304 6.8K 1W
C301 20MMF
C302 10MMF
R305 100K
R306 5.6 K
S2
3R
1/2 12AU
R28 1M
V5
6U8
R405 6.8K 1W
S2 2F
R23 47K
C10 .02
R401 470 K
R403 470 K
R404 6.8K
R400 100
R402 100
C300 20 MMF
R300 4.7K
R301 1M
R302 1K1W
V10
OB2
R307 220K
R308 150K
R-27
TRIGGER SENSITIVITY
100K
S2 2R
A.C. TRIGGER ADJUST
R26 100K
R309 100K
V18
OB2
R-57 100
R66 2K7
C30 40 150V
20 MA
R56 100
R64 1K 7W
35 MA
V19
OA2
C29 40 150V
C36A 20 250
V15
6BQ7
R203 8.2K
R202 68K
R50 1.5K
HORIZONTAL CENTERING
R48 20K
R49 4.7K
C16 .02
HORIZONTAL GAIN
R51 5K
R204 8.2K
R52 100
R53 100
12K 2W R-205
V16
12BH7
R207 15K 1W
CRT 10
R208 12K 2W
R206 15K 1W
CRT 11
SCALE ILLUMINATION
R54 50 2W
#47
#47
X
R55 100
R58 700 7W
45MA
V17
OB2
C28 40 150V

HEATHKIT PROFESSIONAL OSCILLOSCOPE

MODEL OP-1



Tube Number	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-11	V-12	V-13	V-14	V-15	V-16
Filament Connections	4, 5 / 9	3 / 4	4 / 5	4, 5 / 9	4 / 5	3 / 4	4 / 5	4, 5 / 9	4, 5 / 9	3 / 4	4, 5 / 9	3 / 4	3 / 4	4 / 5	4, 5 / 9