EICO

435/DC Wideband Oscilloscope

OPERATING MANUAL

435 -Rev. I

SECTION 1 FEATURES AND SPECIFICATIONS

1-1. PHYSICAL & ELECTRICAL FEATURES

a. Half the weight, a third the size of conventional 5-inch CRT Oscilloscopes — truly portable for color tv service on location.

b. Weight and size reduction achieved without loss in performance or serviceability. Much sharper trace than in conventional 5-inch CRT 'scopes, plus flat CRT face for full utilization of screen area, offsets reduced screen size to give equal or better resolution. Professional calibre interior packaging of components demonstrates the possibility of compactness without crowding or loss of access to any component.

c. DC to 4.5Mc response (+1, -3db) of vertical amplifier needed for color and black-and-white tv servicing. Push-pull amplification throughout minimizes distortion. Direct-coupled design eliminates low-frequency phase shift or response fall-off, and also provides zero reference to permit true voltage readings at any point on waveform.

d. Zener-diode controlled voltage calibration source, with output voltage adjustment potentiometer, provides a precise and unvarying 200mv p-p square wave calibration voltage at line frequency for dc or ac voltage measurement.

e. Trace is extremely sharp and bright, and is free of "blooming". Accelerating potential is 1600 volts. Mu-metal neck shield minimizes effect of external fields.

f. Distortionless V & H trace expansion, and drift-free V & H positioning, up to many times screen diameter.

g. Automatic sync limiter and amplifier eliminates sync voltage adjustment.

h. Full retrace blanking.

i. Edge-lit calibration grid on green filter screen, with illumination level controlled by potentiometer at rear.

1-2. CONTROL FEATURES & FACILITIES

a. Four-position, frequency-compensated vertical input decade attenuator, plus a calibration position at which the calibration voltage described in 1-1d is fed in by-passing the decade attenuator. Concentric vertical gain control is effective in all positions including the calibration position. Slide switch selects either direct-coupling (dc) or capacitive-coupling (ac). DC balance control can be adjusted with a screwdriver through a hole on the left side of the cabinet.

b. Horizontal sync/input selector permits selection of (+) or (-) internal, external, and line frequency sync of the internal sweep, or either external or line frequency input to the horizontal amplifier. Concentric horizontal gain control.

c. Sweep range selection from 10 cps to 100kc in four overlapping ranges, plus pre-set TV-V and TV-H sweep positions (30 cps and 7875 cps). Concentric sweep vernier.

d. Vertical positioning, horizontal positioning, intensity and focus controls on panel. Astigmatism control can be adjusted with a screwdriver through a hole on the left side of the cabinet.

e. Sawtooth (sweep) output on panel; intensity modulation input at rear.

1-3. SPECIFICATIONS

a. V Amplifier: Frequency response from dc to 4.5mc, +1, -3db; sensitivity 18mv/cm rms (50mv/cm p-p); input impedance 1 megohm shunted by 35mmf; square wave calibration voltage of 200mV p-p ±1%; input decade attenuation 1/.1/.01/.001 providing corresponding calibrated sensitivities of .05/.5/5/50 V/cm at the 1/10/100/1000 positions, respectively.

b. H Amplifier: Frequency response from 1 cps to 500kc, +1, -3db; sensitivity 0.7 V/cm rms; input impedance 4 megohms shunted by 40mmf.

c. Sweep Ranges: 10-100, 100-1K, 1K-10K, 10K-100K cps; plus TV-VERT position (30 cps) and TV-HOR position (7875 cps).

d. Intensity Modulation Input: 3V rms blanking; input impedance 2.2 megohms.

e. Sawtooth Output: 10V p-p from 10 cps to 100kc, variable by H gain control; output impedance 300 ohms.

f. Tube Complement: 2-6AU8, 2-12BY7, 2-12AZ7, 1-6BL8, 1-EZ81, 1-1V2, 1-silicon diode, 1-Zener diode, 1-WX5013P1 CRT.

g. Power Supply: 117 VAC, consumption approximately 110 watts

h. Size (HWD): 8-1/2 x 5-3/4 x 12-5/8 inches

i. Weight: 15 lbs.

1-4. FUNCTIONS OF CONTROLS AND TERMINALS

The oscilloscope controls and terminals are easy to use once their functions are understood. If the controls are divided into specific groups, for purposes of explanation, it will be easier to understand and keep in mind just what these functions are.

a. The ac power switch is located on the INTENSITY control, and the unit is turned on by turning the INTENSITY control clockwise from OFF.

b. The INTENSITY & FOCUS controls together control the appearance of the trace. The INTENSITY knob controls the brightness of the trace, and the FOCUS knob controls the sharpness or definition of the trace on the 'scope screen. The astigmatism control, a potentiometer accessible to screwdriver adjustment through the hole nearer the front in the left-hand side of the cabinet, affects spot shape and is used to obtain a trace of uniform thickness. Proper adjustment of these controls should give a trace formed from a thin bright line, or an undeflected spot of light that is tiny, round, and bright. The INTENSITY & FOCUS controls interact to an extent; that is adjustment of the FOCUS knob is usually necessary when the setting of the INTENSITY knob is changed.

c. The VERTICAL POSITION and HORIZONTAL POSITION controls adjust the location of the trace on the screen. Turning the HORIZONTAL POSITION knob shifts the trace left or right, and turning the VERTICAL POSITION knob moves the trace up or down.

d. The VERTICAL ATTENUATOR provides a choice of no attenuation (1) or three decade steps of frequency-compensated attenuation (10, 100, 1000) of the input signal to the vertical amplifier. Each attenuation is obtainable with either direct coupling provided to the vertical amplifier (at DC position of AC-DC switch) or capacitive coupling to the vertical amplifier (at AC position of AC-DC switch). Direct coupling (DC) prevents phase and amplitude distortion of slowly varying waveforms and also permits a dc reference line to be established for accurate amplitude measurements; capacitive coupling (AC) is preferable when observing a small ac signal superimposed on a relatively large dc voltage. At the CAL position, the 200mV p-p square wave calibration voltage described in 1-1d is fed directly to the vertical amplifier, by-passing the decade attenuator but not the vertical gain control. By setting the VERTICAL GAIN control for a vertical trace size of four major grid divisions (equal to 4cm), the basic 50mv/cm sensitivity is obtained when re-setting the VERTICAL ATTENUATOR switch to the "1" position, and sensitivities of .5/5/50 V/cm at the 10/100/1000 positions respectively, provided that the VERTICAL GAIN control setting is not changed.

e. The VERTICAL GAIN control allows continuous adjustment of the vertical amplifier gain. It is used as described in paragraph c. above for voltage calibration, and also provides a useful degree of trace size variation for waveform observations.

f. The VERT. and G binding posts provide for connection of external signals to the vertical amplifier.

g. The HORIZONTAL SELECTOR has four SYNC positions to permit selection of sync voltages for the sweep oscillator, and two HOR positions for selection of input to the horizontal amplifier in place of the internal sweep. The SYNC positions are on the left half of the dial, and the HOR positions on the right half. At the "+" and "-" SYNC positions the synchronizing voltage is taken internally from the vertical amplifier. (At "-", sweep trace flyback starts during the negative-going excursion of the voltage applied to the vertical amplifier; at "+", sweep trace flyback starts during the positive-going excursion of the voltage applied to the vertical amplifier.) At the EXT. SYNC position, an external synchronizing voltage applied between the HORIZ. and G binding posts is fed to the sweep oscillator. At the 60 cps SYNC position, an ac signal of power line frequency is taken from the power supply and applied to the sweep oscillator to sync it at line frequency. At the 60 cps HOR. position, an ac signal of power line frequency is taken from the power supply and applied to the input of the horizontal amplifier. At the EXT. HOR. position, an external signal voltage applied between the HORIZ. and G binding posts is applied to the input of the horizontal amplifier.

h. The SWEEP SELECTOR selects the frequency band over which the SWEEP VERNIER can be varied for frequency adjustment of the internal linear sweep, or pre-set TV VERT. and TV HOR. positions designed to eliminate the need for repeated adjustment of the SWEEP VERNIER in tv work. In the four most counter-clockwise positions, the numbers above the position markers are the upper and lower limits of the band (approximately) covered by the SWEEP VERNIER at the particular position. The convenience provided by the TV VERT and TV HOR positions is as follows: if at the TV VERT position, the SWEEP VERNIER is set to display two full cycles of a 60 cps signal to obtain a sweep frequency of 30 cps, turning the SWEEP SELECTOR to TV HOR will result in a sweep frequency of 7875 cps without readjustment of the SWEEP VERNIER.

i. A sawtooth voltage from the output of the sweep oscillator is available from the panel pin jack designated by the sawtooth marking (⩘). The frequency of the sawtooth is, of course, variable by the SWEEP SELECTOR and SWEEP VERNIER controls. The amplitude is variable by the HORIZ. GAIN control.

j. An external voltage for purpose of intensity (Z-axis) modulation may be applied between the INTENSITY MODULATION pin jack on the rear panel and chassis ground (G binding post). See 1-3d. Never apply an intensity modulating signal that is large enough to swing the grid of the cathode ray tube positive, or the life of the tube may be greatly shortened. Positive grid swing is indicated by noticeable defocusing of the trace during the positive phase of the intensity modulating signal.

k. The SCALE ILLUMINATION control on the rear panel is a dimmer control for the lamp which edge-lights the calibration grid in front of the CRT.

1-5. NOTES ON CONTROLS AND TERMINALS

a. Proper trace definition will be obtained if the astigmatism control is correctly adjusted, and the 'scope is not operated in strong fields such as are found near transformers, transmitters, and power generating equipment, etc., which may distort the electron beam that produces the trace.

b. A sharply focused short line or a small spot of high intensity should not be permitted to remain stationary on the screen for any considerable length of time (more than 1/2 minute) or the screen will be burned. A trace of excessively high intensity will burn the screen in 3 to 5 minutes. These burned portions of the screen will no longer fluoresce and are useless for observation. If it is required to have a fixed trace on the screen for a long period, reduce the intensity of the trace to a minimum.

c. When the AC-DC switch is set in the DC position, the dc component of any signal fed to the vertical amplifier will be amplified along with the ac component of the signal and be reflected on the screen by a proportional vertical movement of the trace. The direction of trace movement depends on the polarity of the dc component. Therefore, when going from observation of a pure ac wave to one containing dc or vice versa, it may be necessary to use the VERT-POS control to bring the trace back to center screen. The dc component of a signal has no effect at the AC position of the AC-DC switch.

d. A trace can be expanded horizontally and/or vertically to several times full screen without distortion. This is particularly important in dealing with sweep waveforms. The range of horizontal or vertical positioning is several times full screen to permit examination of any part of the expanded trace.

e. Trimmer capacitors C6, C4, and C2 are used for compensating the vertical decade attenuator at the 10, 100, and 1000 positions respectively. See MAINTENANCE section 4-5 the trimmer adjustment procedure.

f. Rheostat R77 is used to set the peak-to-peak value of the calibrating voltage to the prescribed value. See MAINTENANCE section 4-6 for adjustment procedure.

g. Potentiometer R13 is the DC balance adjustment, accessible through the hole on the left-side of the cabinet nearest the rear. When R13 is adjusted properly, there will be no shifting up or down of the trace on turning the VERT. GAIN control from minimum to maximum with no input signal to the vertical amplifier. See MAINTENANCE section 4-4e for adjustment procedure.

h. The "+" and "-" SYNC positions of the HORIZ. SELECTOR allow the synchronization of any type of non-sinusoidal waveform.

i. The EXT. SYNC position of the HORIZ. SELECTOR is for use with generators or other devices which have sync outputs.

j. Trimmer C12 must be adjusted initially in kit instruments to display two full cycles of a 15750 cps signal at the TV-HOR. position after the SWEEP VERNIER has been set to display two full cycles of a 60 cps signal at the TV-VERT. positions. See MAINTENANCE section 4-7.

k. A slight overshoot may be evident with high-frequency square wave inputs. Keep in mind, however, that sometimes the square wave generator may be at fault. This should be checked before attributing the effect to the 'scope.

l. At maximum gain settings, the sensitivity of the amplifiers is very high. Under these conditions stray pickup may produce patterns on the screen when no signal source is connected to the vertical input terminals. This is normal and does not interfere with the scope operation.

SECTION 2 OPERATION

NOTE: To obtain proper results with your 'scope, it is advisable to become acquainted with the functions and correct use of the panel controls and terminals by making some simple tests. These tests will also assure you that the instrument is in proper working condition. Do not attempt this procedure with kits before all final checks have been completed and all initial adjustments have been made as described in the MAINTENANCE section.

a. Set the INTENSITY, VERT. GAIN, and HORIZ. GAIN controls fully counter-clockwise.

b. Set the FOCUS, VERT. POS., and HORIZ. POS., controls at the center of their ranges. All other controls may be set at any position.

c. Insert the power cord into a nominal 120 VAC, 60 cycles outlet.

WARNING

This instrument will not operate, or operate improperly and even be seriously damaged, if connected to any other type of power line (such as dc, 25 cycles ac, 200-240 VAC unless fitted with an export transformer wired accordingly).

d. Turn the INTENSITY control clockwise from OFF to actuate the power switch, at which the pilot lamp should light. Allow the unit to warm up for about a minute. Then gradually turn the INTENSITY control clockwise until a spot appears somewhere on the screen of the cathode-ray tube. If the spot does not appear, adjust the VERT. POS. and HORIZ. POS. control slightly, as it may be off screen.

e. Adjust the VERT. POS. and HORIZ. POS. controls until the spot is in the exact center of the screen, and then adjust the FOCUS control for the sharpest image. Notice that for every setting of the INTENSITY control, there is a best setting for the FOCUS control. The finest focus is usually obtained at low intensity. If the spot shape is not round, adjust the astigmatism control, accessible through the hole in the left side of the cabinet nearest the front, for as round a spot shape as possible.

f. Set the HORIZ. SELECTOR at "+" SYNC and set the SWEEP RANGE switch at any one of the internal linear sweep positions. Now advance the setting of the HORIZ. GAIN control gradually, and note that the spot extends to a horizontal line. This is the linear horizontal sweep.

g. Set the HORIZ. SELECTOR at EXT. HOR. Notice that the horizontal line returns to a spot, as the horizontal amplifier input is now connected across the HORIZ and G binding posts. Any signal applied across these binding posts will cause the line to lengthen horizontally in proportion to the peak value of the applied signal.

h. Set the HORIZ. SELECTOR switch at 60 cps HOR. The horizontal line on the screen is the 60 cps sine sweep.

i. Set the HORIZ. SELECTOR switch at "+" SYNC, the SWEEP SELECTOR switch at 10-100, the SWEEP VERNIER control at MIN., and the VERT. ATTEN. switch at CAL. Now adjust the VERT. GAIN and HORIZ. GAIN controls until the pattern extends about two-thirds the width and height of the CRT. The pattern will not be clear because of its rapid horizontal drift. Advance the setting of the SWEEP VERNIER gradually until a single square wave of power line frequency appears and remains stationary on the screen.

NOTE 1: In rotating the SWEEP VERNIER, it will be noticed that the drift of the pattern slows down as certain critical frequencies are approached, and then reverses direction when the critical frequency is passed. At these critical frequencies, a clear pattern can be discerned. These critical sweep frequencies are sub-multiples of the signal frequency, or the signal frequency itself (when only one cycle of the signal is displayed). The pattern may be locked in at sub-multiples of the signal frequency when it is desired to view more than one cycle of the signal. The sweep frequency is equal to the signal frequency divided by the number of complete cycles displayed on the screen. For example, if two complete cycles of the 60 cps signal are displayed, the sweep frequency is 30 cps.

NOTE 2: At low sweep frequencies, flickering of the pattern is normal due to the slow writing speed of the spot and the persistance of the screen, which together are insufficient to cause the motion to blend into a fixed image.

j. With the single square wave pattern locked in, switch the HORIZ. SELECTOR from "+" SYNC to "-" SYNC. The same waveform should appear, but displaced by 180 degrees.

k. If it is desired to observe the operation of the intensity modulation facility, connect the output of an audio oscillator across the INTENSITY MODULATION pin jack on the rear and G binding post on the panel. Be sure that the INTENSITY control is set no higher than is necessary. Set the audio oscillator at 600 cps and bring up the oscillator output until the single square wave pattern breaks up into segments. Do not increase the oscillator output beyond the point needed to achieve this. Fine adjust the oscillator frequency carefully until the segments become stationary. If the segments are counted, it will be found that there are 10. This indicates that the ratio between the frequencies of the intensity modulating and vertical amplifier input signals is 600/60 or 10. The INTENSITY MODULATION jack may be used for inserting timing markers on a trace or determining the frequency of an unknown signal.

CAUTION

See section 1-4j. To comply with the caution given therein when using the INTENSITY MODULATION jack, the INTENSITY control should first be set at MINIMUM, and then turned clockwise just enough to obtain normal intensity. If this is done, the possibility of applying excessive intensity modulating signal voltage will be minimized.

l. To operate the internal calibrator for measuring p-p (peak-to-peak) voltage, refer to section 1-4d which describes the operation, and section 1-5f which refers to the calibration voltage adjustment procedure given in MAINTENANCE section 4-6. Note that one side of the calibration voltage source is grounded, and that the polarity of the Zener diode in the circuit is such as to develop a negative voltage. This means that if the top of the calibration square wave voltage is set at the horizontal center line of the CRT with the VERT. POS. control, then the horizontal center line becomes a "zero center" for the calibration grid (assuming that the DC BALANCE control is adjusted correctly as described in MAINTENANCE). Under these circumstances, direct reading of dc, ac, or dc + ac voltages can be made using the calibration grid. The horizontal center line is zero voltage; trace points above the horizontal center line are positive, and below the center line negative. The sensitivity at each position of the VERT. ATTENUATOR switch is given in section 1-4d. Pure dc voltages can be read by noting the displacement of the trace above the horizontal center line (positive) or below the horizontal center line (negative) and multiplying the displacement in centimeters (smallest grid division is 1/2 cm; major grid division is 1 cm) by the sensitivity at the particular VERT. ATTENUATOR position. For example, an unknown dc voltage applied to the VERT. and G binding posts at the "1" position of the VERT. ATTENUATOR switch cause a downward trace displacement of one small grid division (1/2 cm). Since the deflection is downward, the voltage is negative. As the sensitivity is 50mV/cm at the "1" position, the voltage value is 25mV. AC waveforms with or without dc components can be read as to absolute voltage at any point and as to value of any dc component. For example, an unknown voltage applied to the VERT and G binding posts at the "10" position of the VERT attenuator exhibits a waveform having a positive peak 4 major divisions above the horizontal center line and a negative peak 2 major divisions below the horizontal center line. As the sensitivity is 500mV/cm at the "10" position, the positive peak is 2 volts and negative peak is 1 volt (peak-to-peak 3 volts). When the AC-DC slide switch is thrown to AC, the positive peak of the waveform moves 1-1/2 major divisions (3 minor divisions) downward so that the positive peak is now only 2-1/2 major divisions (5 minor divisions) above the horizontal center line. Since 1 major division is 500mV at the "10" position, the dc component of the voltage is 1-1/2 cm x 500mV/cm or 750mV and positive.

NOTE: If the signal under observation is a sine wave (only), the rms value of the amplitude may be obtained by dividing the peak-to-peak value by 2.8.

The basic calibration sensitivity of 50mV/cm (200mV p-p for 4 cm deflection) is not always convenient and limits the maximum p-p voltage that can be measured to 300 volts. The table below gives alternative calibration sensitivities and includes the basic 50mV/cm sensitivity for comparison.

Calibration Sensitivity	Set CAL VOLTAGE For Deflection Of	Sensitivity At Each ATTENUATION POS. (--p-p/cm) 1	10	100	1000
50mV/cm	4 cm	50mV	.5V	5V	50V
100mV/cm	2 cm	100mV	1V	10V	100V
200mV/cm	1 cm	200mV	2V	20V	200V

SECTION 3 APPLICATION

GENERAL: The oscilloscope is an instrument designed for viewing electrical oscillations and transients. Phenomena having a repetition rate from a few cycles per second to many megacycles per second may be displayed on a 'scope.

WAVEFORM INVESTIGATION: When the output of the internal sweep generator is fed to the horizontal channel, the pattern on the screen is actually a graph showing the variation with time of the instantaneous amplitude of the signal applied to the vertical channel. The sweep frequency is usually a sub-harmonic of the signal frequency, so that several complete cycles of the signal are displayed on the screen.

DISPLAY OF WAVEFORMS: Displaying a waveform means obtaining a picture that shows how the amplitude of the signal under observation varies with time. It is generally most convenient to use a time-base signal that varies linearly with time, so that equal intervals of time are represented on the screen by equal intervals of distance along the same axis. The sawtooth output of the sweep generator gives such a time-base on the horizontal axis, the time (in seconds) represented by the overall horizontal deflection being equal to the reciprocal of the sweep frequency (in cycles per second).

Apparently, if the frequency of the observed signal is equal to the sweep frequency, one complete cycle will be observed on the screen. If the frequency of the applied signal is twice the sweep frequency, two complete cycles will be obtained on the screen and so on. Fig. 1 is a projection drawing of a sine wave applied to the vertical plates and a sawtooth wave of the same frequency applied to the horizontal plates. Fig. 2 is a projection drawing showing the resultant pattern when the frequency of the sawtooth is one-half that employed in Fig. 1.

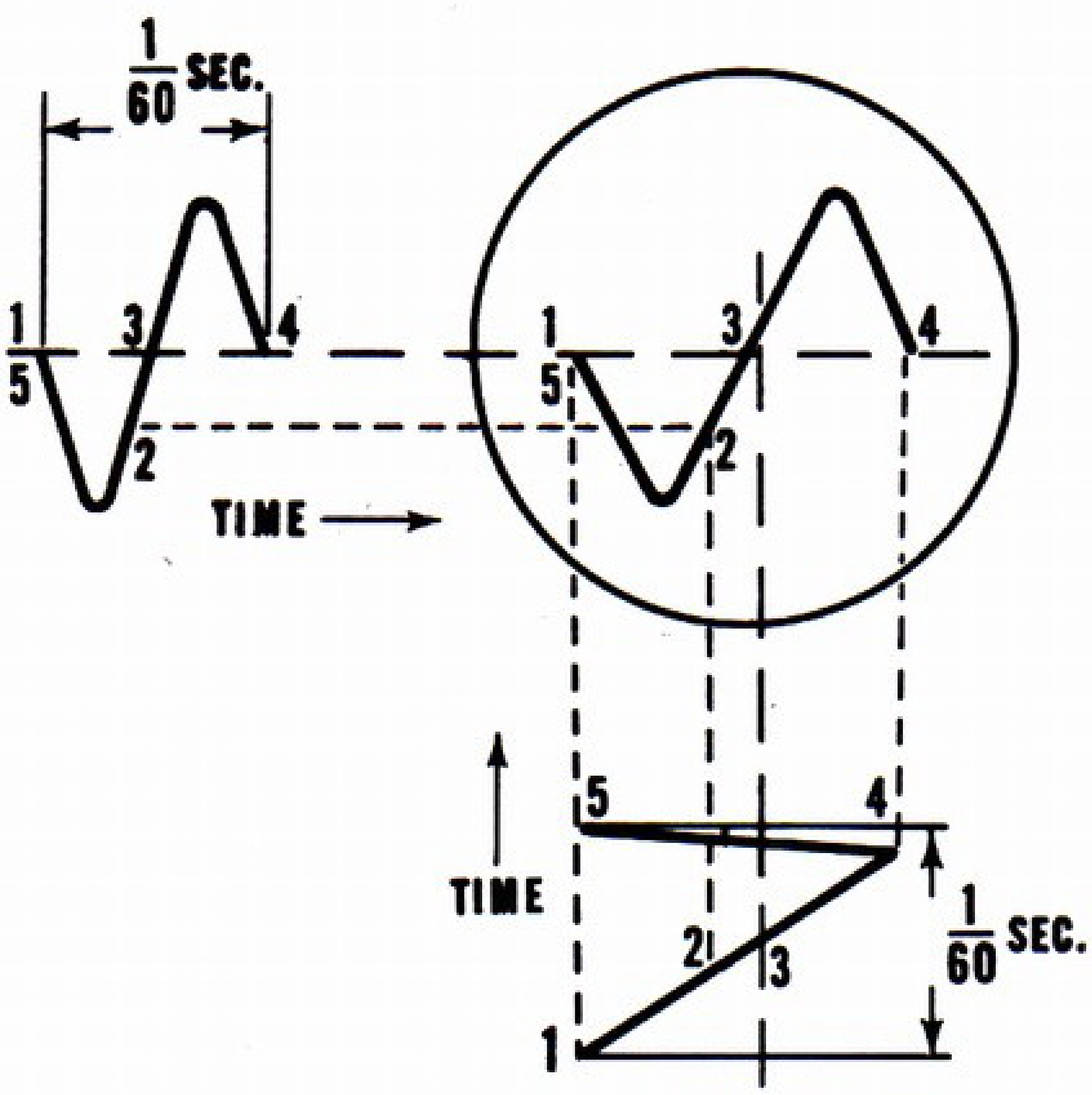

FIGURE 1

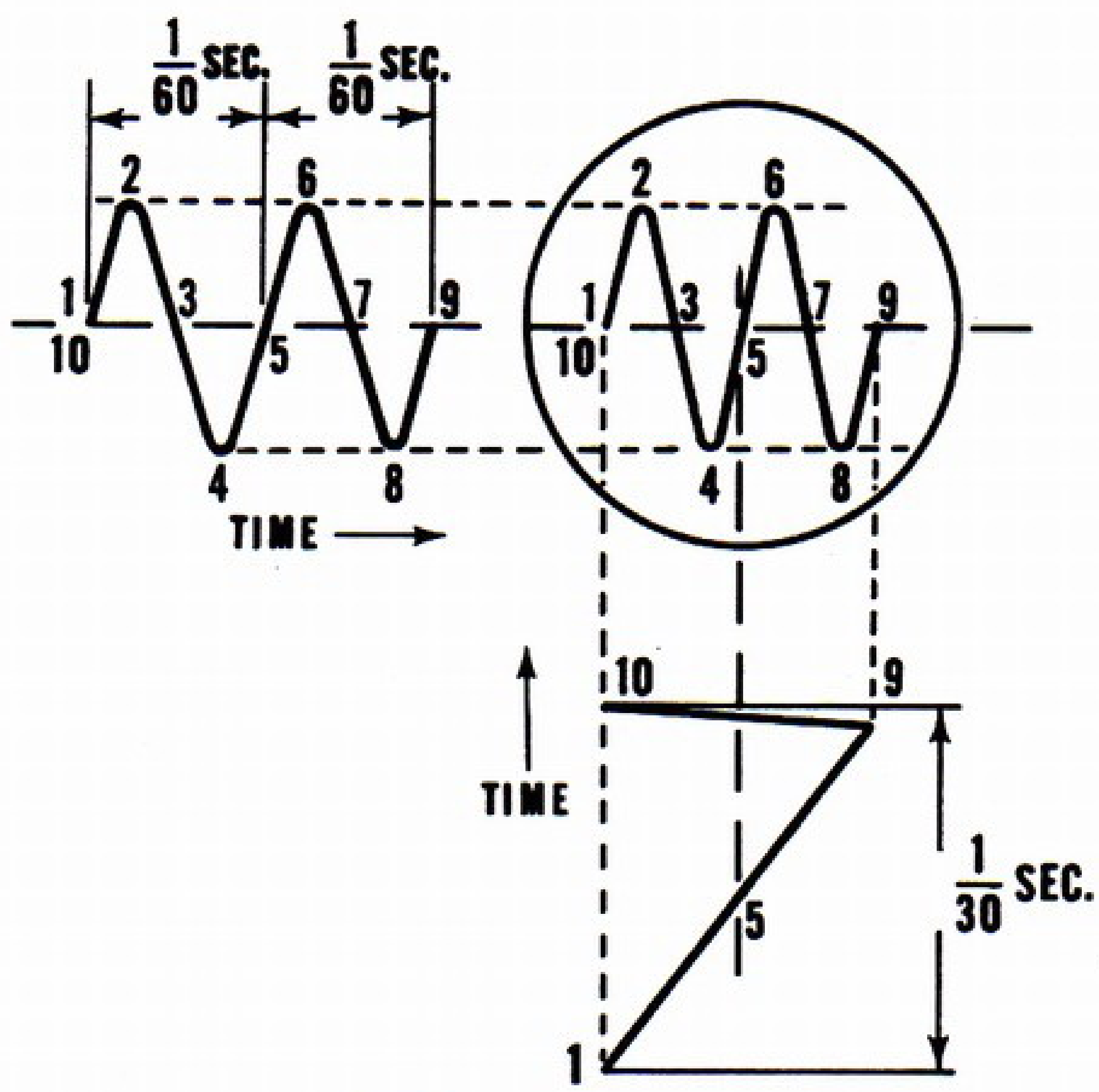

FIGURE 2

In these figures, points that occur simultaneously are numbered the same. The circle represents the tube screen. If simultaneous projections were drawn from every point on each wave, the intersections would trace out the sine waves shown in the circles. The sections of sawtooth between 1 and 4 in Fig. 1 and between 1 and 9 in Fig. 2 are the sweep sections during which the displays are produced. The sections of the sawtooth between 4 and 5 in Fig. 1 and between 9 and 10 in Fig. 2 are the sections during which the beam is returned very rapidly to the starting point at the left-hand side of the screen. The return trace is prevented from appearing on the screen by the blanking circuit.

LISSAJOUS PATTERNS: Another type of fundamental pattern is obtained when both the vertical and horizontal deflection voltages are sinewaves that are related in frequency as follows: one frequency is a whole number of times larger than the other; one frequency is a simple fraction of the other. When one or the other of these conditions is fulfilled, stationary closed-loop patterns are obtained. These patterns are called Lissajous figures after the 19th century French scientist. They are particularly useful in determining the frequency ratio between two sinewave signals. If the frequency of one signal is known, the frequency of the other signal can be easily determined from the frequency ratio. Usually the known signal is applied to the horizontal channel and the unknown signal to the vertical channel. The shape of the pattern changes with the phase relationship between the known and unknown signals. For example, all the patterns shown in Fig. 3 (and those intermediate) are possible with a frequency ratio of 1:1 if the phase differences indicated exist.

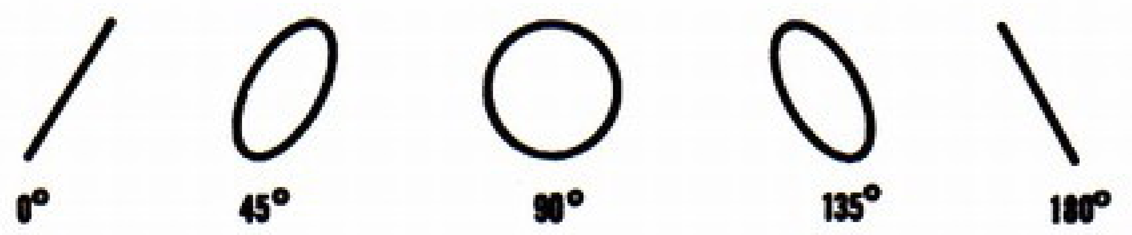

FIGURE 3

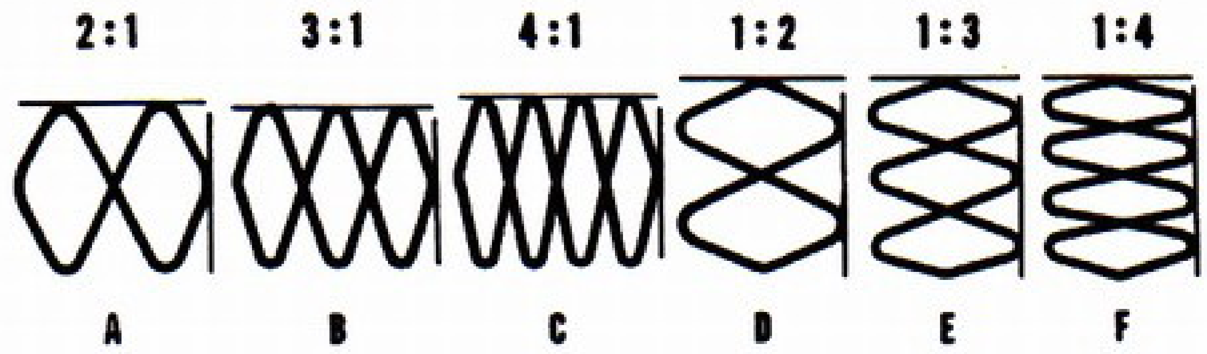

FIGURE 4

In general, to determine frequency ratio from the Lissajous figure, count the number of points of tangency to horizontal and vertical lines, drawn or imagined (see Fig. 4). Points of tangency at the top of the figures result from the unknown frequency applied to the vertical channel. Those at the side of the figure result from the known frequency applied to the horizontal axis. As a matter of fact, the following relationship holds true in all cases:

$$\frac{\text{V axis freq}}{\text{H axis freq}} = \frac{\text{V pts of tangency}}{\text{H pts of tangency}}$$

As an example, take Fig. 4c, which shows four points of tangency at the top and one point at the side. This indicates that the unknown frequency applied to the vertical axis is four times the known frequency. In Fig. 4f, one point of tangency at the top and four at the side indicate that the unknown frequency is one-fourth the known frequency.

Model 377 Audio Generator or Model 488 Electronic Switch can be used to check amplifiers as to frequency response, phase shift, transient response, deficient design, or faulty components. The equipment is set up as shown in Fig. 5.

FIGURE 5

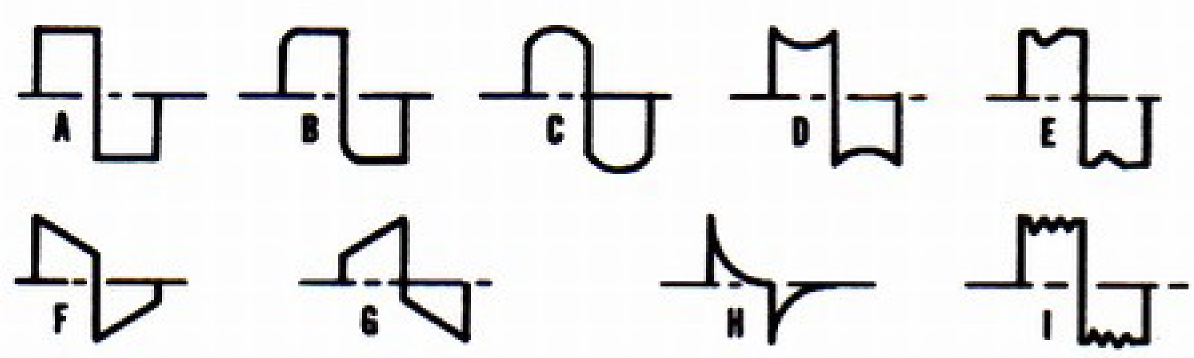

FIGURE 6

First, a means of comparison, the square wave output from the Audio Generator is viewed on the 'scope. The horizontal sweep of the 'scope should be adjusted so that at least two full cycles can be seen on the screen. (Fig. 6a shows one full cycle of a perfect square wave). The 'scope is then connected to the output of the amplifier under test so that the modified square wave can be viewed on the screen. Possible output wave shapes are shown in Fig. 6b to 6i, and the significance of each waveshape is explained below.

Fig. 6b shows "rounding" of the leading edge of square wave. This indicates a drop off in gain at high frequencies. "Rounding" will generally be observable when there is a substantial drop in the gain by the tenth harmonic (or less). Therefore, if a 2kc square wave fed to the amplifier is reproduced on the 'scope without "rounding", the amplifier is flat to 10 x 2kc = 20kc.

Fig. 6c shows the effect of increased gain and Fig. 6d shows the effect of decreased gain of the square wave frequency. Fig. 6e indicates lowered gain at a narrow frequency band. If the square wave frequency is brought into this narrow frequency band, Fig. 6d will result.

The effect of phase shift in the amplifier is shown in Figs. 6f and 6g. If, at low frequencies, there is phase shift in the leading direction, the square wave will be tilted as in Fig. 6f. If there is phase shift in the lagging direction, the top of the square wave will be tilted as in Fig. 6g. The steepness of the tilt is proportional to the amount of phase shift. Phase shift is not important in audio amplifiers, although the ear is not entirely insensitive to it. In television and 'scope amplifiers, however, phase shift should not be tolerated.

Fig. 6h shows the pulse output from the amplifier that results when the square wave has undergone differentiation. This will happen when the grid resistor or the coupling condenser is too low in value or if the coupling condenser is partially open. Lastly, Fig. 6i, shows a square wave with damped oscillations following the leading edge. This results when a high frequency square wave is fed to an amplifier in which distributed capacities and lead inductances resonate at low frequencies. In television and 'scope amplifiers it may result from an undamped peaking coil.

High fidelity audio amplifiers may be given a rapid check by testing first with a square wave of fundamental frequency not less than 3 to 4 times the low frequency limit of the amplifier (3db point) and then with a square wave of fundamental frequency which may be anywhere between 1/100 to 1/10 of the high frequency limit of the amplifier depending upon how many harmonics are considered necessary to produce an acceptable version of a square waveform. Usually, square waves of fundamental frequency from 40 to 60 cps and 1000 to 2000 cps are employed to cover the range up to 20,000 cps.

To insure correct results, the following is suggested: Connect the proper value of load across the amplifier output terminals; use low capacitance cable for connecting the generator to the amplifier input; set the generator output to an ample value but be sure not to overload the amplifier. The square wave signal is fed to the amplifier input and the 'scope is connected across the amplifier load. Use the internal linear sweep to observe the waveform. Note that tone controls have a very marked effect on square wave response and should be set to the "flat" positions unless it is desired to observe their effect. Note, also, that low fidelity and p.a. amplifiers will not reproduce the square waveform.

Video amplifiers may be square wave tested in the same manner as described for testing audio amplifiers. The test frequencies might be 60 cps for the low end, and 25,000 cps for the high end.

SERVICING TV RECEIVERS: One major use of the 'scope in tv servicing is alignment in conjunction with a TV/FM Sweep Generator. First, the IF stages are aligned, and then the RF and local oscillator stages, following the general method and theory of alignment described in the sweep generator instruction manuals. The specific methods of alignment depend on the receiver, and the manufacturer's service instruction should always be followed.

Another major use of the 'scope is to check the waveform of the complex tv signal as it passes through the receiver. The exceptional fidelity of the Model 435 'scope is very important in this application, since you must be able to observe small variations in waveform in order to localize and correct the cause of poor picture quality. Here again, the set manufacturer provides representative waveforms to be expected at specific points in a specific model of receiver. These waveform pictures are furnished for the entire receiver, with the exception of the tuner portion. EICO manufactures a complete line of high quality oscilloscope probes meeting all the requirement for waveform observation in any part of a tv receiver.

Keep in mind that two basic frequencies are involved in checking waveform of signals in tv receivers. The vertical or field frequency is 60 cps. Any waveform check, except with the horizontal oscillator, its differentiator network, and the horizontal amplifier stages, can generally be made using an internal linear sweep frequency of 30 cycles to show two complete fields of the signal. To examine the horizontal pulse shape, or the operation of the horizontal deflection system, it is generally suitable to use an internal linear sweep frequency of 7875 cps, again to show two complete lines of the signal. The TV-VERT position (30 cps) and the TV-HOR position (7875 cps) on the SWEEP RANGE switch were provided to permit rapid changeover from one basic tv sweep frequency to the other without need for other control readjustments.

SECTION 4 MAINTENANCE

4-1. GENERAL

Included in this section are the following:

a. Cabinet removal
b. Astigmatism adjustment
c. Vertical amplifier internal adjustments: DC Balance, Vertical Input Bias, Vertical Output Bias
d. Frequency-compensation trimmers (VERT. ATTEN. switch)
e. Calibration voltage adjustment
f. Adjustment of TV-HOR sweep trimmer (SWEEP RANGE switch).
g. Trouble-Shooting Chart
h. Schematic Diagram and Block Diagram
i. Voltage and Resistance Charts

The need for repetition of any of the adjustments after the instrument has been in use can be determined by referring to the trouble-shooting chart. Therefore, no reference will be made here to the symptoms which indicate readjustment is necessary.

4-2. REMOVAL FROM CABINET

To remove the instrument from the cabinet, first disconnect it from the power line and remove the two No. 8-32 x 3/8 machine screws in the cabinet rear. Then slide the chassis out the front of the cabinet.

WARNING

The voltages in this instrument are dangerous. Take caution to avoid personal contact with these voltages when the instrument is being operated outside of its cabinet. Remember that capacitors may remain charged to dangerously high voltages for a considerable time after power has been removed.

4-3. ASTIGMATISM ADJUSTMENT

a. Insert the ac plug in the 117 VAC line outlet and turn the power on by rotating the INTENSITY control clockwise from OFF. While the 'scope is warming up, set the panel controls as follows: INTENSITY, FOCUS, VERT. POS., HOR. POS., SWEEP VERNIER, VERT. GAIN, and HOR. GAIN to approximate middle of rotation: SWEEP RANGE at "10-100"; VERT. ATTENUATOR AT CAL; AC-DC switch at DC; HOR. SELECTOR to "+" SYNC.

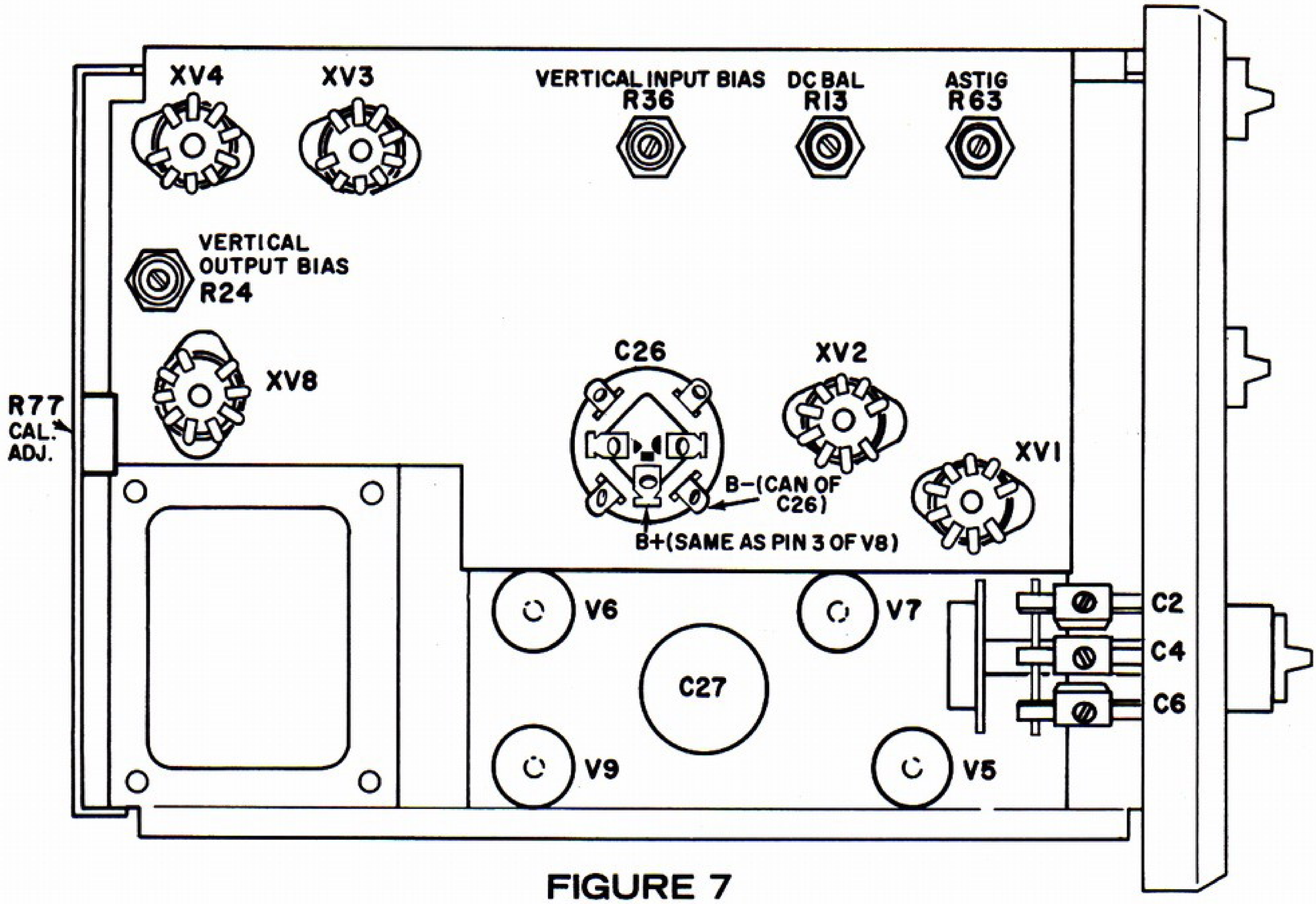

FIGURE 7

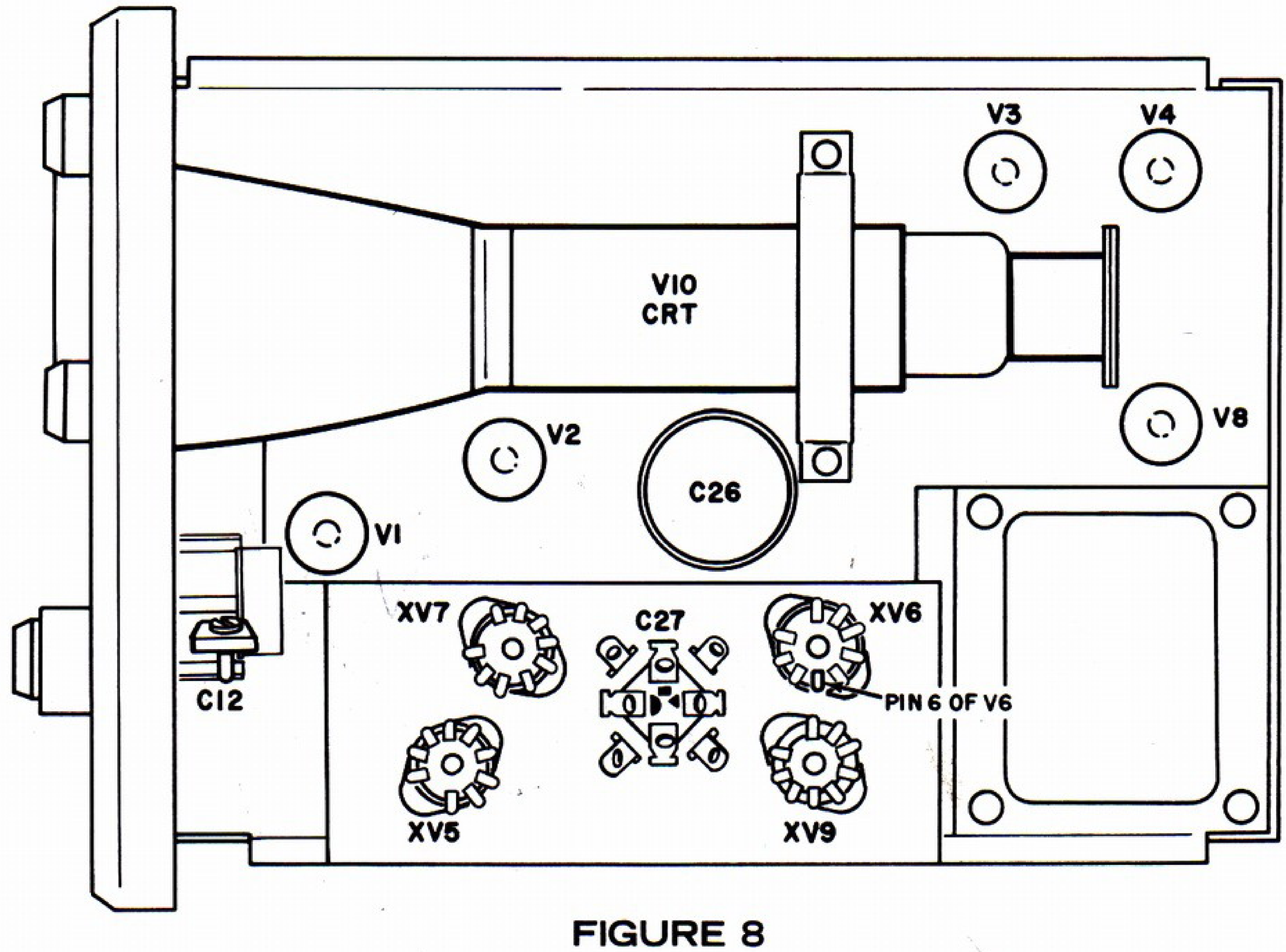

FIGURE 8

b. Adjust panel controls for a stationary pattern of several line frequency square waves. Adjust R77 (Fig. 7) temporarily for a pattern height of 3 or 4 cm. Adjust the HOR. GAIN control for a pattern width of 4 to 5 cm. Make a preliminary adjustment for the sharpness of the trace with the FOCUS control. Then set the INTENSITY control to produce a trace of normal brightness (excessive intensity will be evidenced by "blooming" of the trace). At this point, any astigmatism in the trace will be evidenced by some portions of the trace being thicker than others. Now jointly adjust the astigmatism control R63 (Fig. 7) and the FOCUS control until a sharp trace with the greatest possible uniformity of thickness is obtained.

4-4. VERTICAL AMPLIFIER INTERNAL ADJUSTMENTS

a. After completing 4-3 above, short VERT and G binding posts. Set VERT. ATTENUATOR switch at "1000". All other controls remain as set previously.

b. Connect a VTVM from pin 6 of either tube V1 or V2 (Fig. 7) to ground. Adjust vertical input bias potentiometer R36 (Fig. 7) for a dc bias reading of 2.5 volts.

c. Unsolder and temporarily disconnect 1.8KΩ, 5W Resistor, R23 from pin 1 of tube XV4 (Fig. 7). Connect a VOM, set to a DC current range suitable for measuring 50mA, between pin 1 of XV4 and the unsoldered end of resistor R23. Adjust VERTICAL OUTPUT BIAS potentiometer R24 for a DC current reading of 50mA.

d. Repeat steps b. and c. until the specified bias voltage in step b. and the specified current in step c. are both obtained. After this is done, disconnect the VOM and re-solder R23 to pin 1 of XV4.

e. Set the VERT. GAIN control fully counter-clockwise (minimum gain). Adjust the VERT. POS. control for a trace exactly on the horizontal center line of the calibration grid. Now turn the VERT. GAIN control fully clockwise (maximum gain), and adjust the DC balance R13 (Fig. 7) until the trace is returned exactly to the horizontal center line. Repeat until no vertical shift can be detected when the VERT. GAIN control is turned from minimum to maximum. It is advisable to repeat this procedure finally, after the 'scope has warmed up for at least a half hour.

4-5. FREQUENCY-COMPENSATION TRIMMERS (VERT. ATTEN. SWITCH)

a. Stray capacities shunting the resistive components in each of the vertical input attenuator networks would result in frequency discrimination, were not each of these attenuator networks frequency-compensated by an individual trimmer. These trimmers are located in Fig. 7. The trimmers for the 10, 100, 1000 positions of the VERT. ATTENUATOR switch are C6, C4, and C2, respectively.

b. To adjust the trimmers, connect a jumper between the SAWTOOTH (⩘) pin jack and the VERT. binding post. Set the SWEEP SELECTOR at the 1K-10K position and the SWEEP VERNIER at MIN. Set the HORIZONTAL SELECTOR at "+" SYNC. Set the AC-DC switch at AC. Turn down the VERT. GAIN control to minimum.

c. Now set the VERT. ATTENUATOR switch at the 10 position. Adjust the HOR. GAIN for a trace about 2/3 the screen width. Use the panel controls to center and focus the trace. With trimmer C6 adjusted improperly, the trace will appear as in Fig. 9a or Fig. 9b. If this is the case, adjust trimmer C6 until the hook disappears and the trace is a straight line as in Fig. 9c.

d. Now set the VERT. ATTENUATOR switch at the 100 position. Turn the VERT. GAIN control to maximum. With trimmer C4 adjusted improperly, the trace will appear as in Fig. 9a or Fig. 9b. If this is the case, adjust trimmer C4 until the hook disappears and the trace is a straight line as in Fig. 9c.

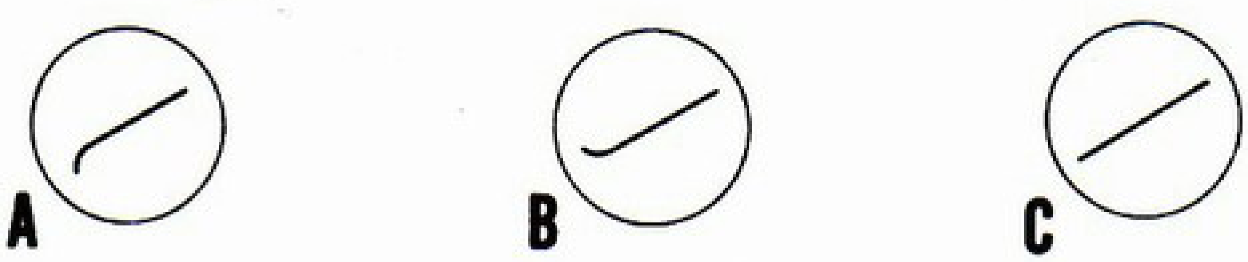

FIGURE 9

e. Now set the VERT. ATTENUATOR switch at the 1000 position. At this position, a higher sawtooth voltage than is available from the SAWTOOTH (∿∿) pin jack is required to make the trimmer adjustment, which can be obtained from the output of the horizontal amplifier. Therefore, remove the jumper between the SAWTOOTH (∿∿) pin jack and the VERT. binding post. Instead, connect a jumper between pin 6 of V6 (See Fig. 8) and the VERT. INPUT binding post (AC-DC switch in AC position). The VERT. GAIN control remains turned to maximum. With trimmer C2 adjusted improperly, the trace will appear as in Fig. 9a or Fig. 9b. If this is the case, adjust trimmer C2 until the hook disappears and the trace is a straight line as in Fig. 9c.

4-6. CALIBRATION VOLTAGE ADJUSTMENT

a. The calibration voltage is adjusted with rheostat R77, located in Fig. 7. If the DC balance is not properly adjusted (trace shifts vertically as VERT. GAIN control is turned from minimum to maximum), adjust it beforehand as described in 4-4e. Keep the VERT. GAIN control at maximum position.

b. Set VERT. ATTENUATOR switch at the 10 position and the AC-DC switch at DC.

c. Connect a shorting jumper between the VERT. and G binding posts. Use the VERT. POS. control to set the trace on the lowest horizontal center line of the calibration grid. Set the HORIZ. GAIN control to zero so that the trace is simply a spot.

d. Remove the jumper and connect a 1.5V dry cell across the VERT. and G binding posts. Adjust the VERT. GAIN control until the deflected spot is 3 cm (3 major divisions or 6 minor divisions) away from the lowest horizontal center line. Remove the battery, but do not change the VERT. GAIN control setting.

e. Reset the VERT. ATTENUATOR switch at CAL. Do not change the VERT. GAIN control position set in d. above. Now adjust rheostat R77 until the peak-to-peak deflection of the square wave calibrating voltage, appearing as a vertical line with the HORIZ. GAIN control at minimum, is 4 cm* (4 major divisions or 8 minor divisions). This completes the calibration voltage adjustment for a basic sensitivity of 50mV/cm. (*Shift trace upward with VERT. POS. control to see 4 cm deflection entirely on screen).

NOTE: The method of calibration voltage adjustment given here is convenient, but does not yield the maximum possible accuracy because the voltage divider at the "10" position of the VERT. ATTENUATOR switch introduces a possible 5% inaccuracy in step d, and there is another 5% possible inaccuracy in use of the calibrator at the "100" and "1000" positions of the VERT. ATTENUATOR switch. A more accurate calibrating technique would be the following: a) Connect a voltage source as close to 200mV dc as possible to the VERT and G binding posts at the "1" position of the VERT. ATTENUATOR switch and adjust the VERT. GAIN control for a 4 cm deflection (presuming DC balance is correctly adjusted and the undeflected spot is positioned upward 1 or 2 cm from center); b) Set the VERT. ATTENUATOR switch at CAL and adjust R77 for a peak-to-peak deflection of 4 cm. This is the method used in factory adjustment. A suggested possible source of 200mV dc that may be constructed is given in Fig. 10.

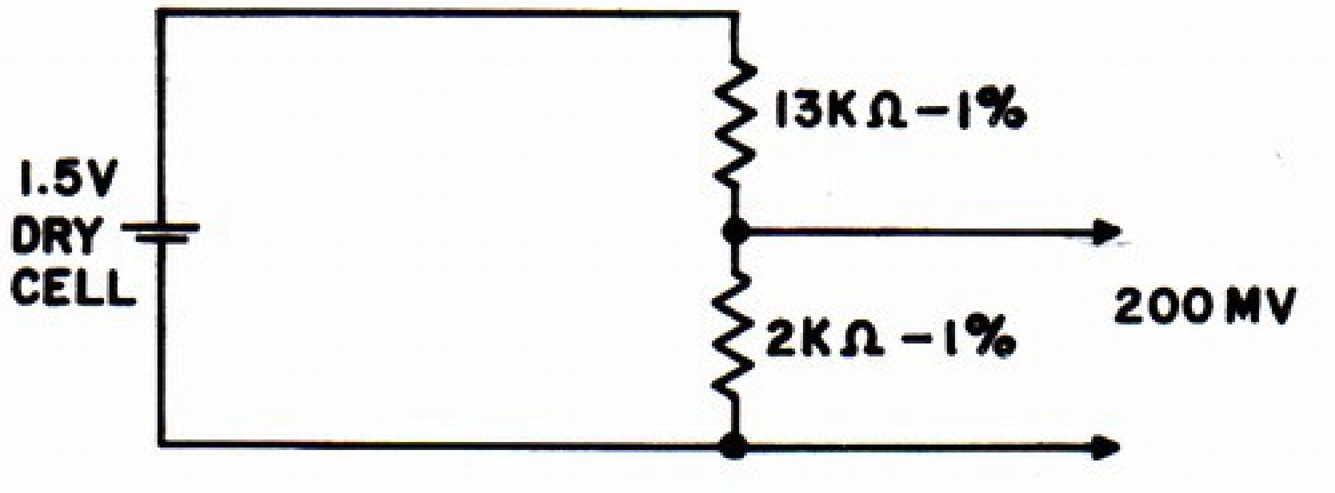

FIGURE 10

4-7. ADJUSTMENT OF TV-HOR. SWEEP TRIMMER

a. Set the SWEEP RANGE switch at TV VERT., the VERT. ATTENUATOR switch at CAL, and adjust the SWEEP VERNIER to obtain a station pattern of two complete cycles on the screen, indicating a 30 cps sweep frequency. The SWEEP VERNIER setting should not be changed from this point on.

b. Next, set the SWEEP RANGE switch at the TV-HOR. position and apply a 15,750 cps signal taken from the horizontal section of any tv set across the VERT and G binding posts. Adjust the VERT. ATTENUATOR switch and the VERT. GAIN controls to obtain a drifting pattern entirely on screen, but do not touch the SWEEP VERNIER. Now adjust trimmer C12 (Fig. 8) until a stationary pattern of two complete cycles is obtained on the screen, indicating a 7875 cps sweep frequency. This completes the adjustment, with the result that whenever the SWEEP VERNIER is set to produce a 30 cps sweep (indicated by two cycles of the 60 cps signal) with the SWEEP SELECTOR set at TV-VERT, resetting the SWEEP SELECTOR to TV-HOR without touching the SWEEP VERNIER will automatically give a 7875 cps sweep.

4-8. TROUBLE-SHOOTING THE 435 OSCILLOSCOPE

a. The block diagram of the 435 (Fig. 11) should aid in isolating the circuit in which the trouble is located. Once this is done, reference should be made to the appropriate section of the complete schematic. The next step is to localize the trouble in the particular section to the tube circuit involved, and then to try a replacement tube. If the trouble is not eliminated, voltage checks should be made using the schematic diagram.

b. As an aid in localizing trouble, common symptoms together with their possible causes and remedies have been listed in groups corresponding to the major sections of the instrument. Of course, all possible troubles could not be included in the chart, and the make-up of the chart has been based on the assumption that the instrument has worked properly at some previous time. Keep in mind that in trouble-shooting, the main endeavor is to find and eliminate the source of the trouble. Recurrence of the trouble usually indicates that the effect, not the cause has been remedied.

4-9. TUBE REPLACEMENT

Tube location is shown in Figs. 7 & 8. Readjustment will be required, as described in 4-4, when replacing V1, V2, V3, or V4. When the CRT is replaced, it must be rotated until the horizontal trace is level.

4-10. FUSE REPLACEMENT

A 2 Amp fuse is located in the fuseholder on the rear chassis apron. If the fuse should blow, the component that has failed and caused the excessive current drain must be found and replaced before a new fuse is inserted.

4-11. TROUBLE-SHOOTING CHART

SYMPTOM	POSSIBLE CAUSE	REMEDY
	POWER SUPPLY	
Pilot lamp fails to light.	INTENSITY switch in OFF position. No AC line voltage Pilot lamp open Fuse defective Broken lead/or leads in the filament path.	Turn INTENSITY switch clockwise. Trace line failure Replace I1 Replace F1 Repair defective connections
Fuse F1, blows when AC power is turned on.	Shorted AC line cable on the primary side of the power transformer. Defective rectifier tubes Defective filter capacitors Short in filament connections	Repair the short Check V8, V9. Replace if bad. Check C26, C27 for low resistance or short. Replace if necessary. Check filament connections for shorts. Repair if necessary.
Some or all filaments fail to light.	Defective tube or tubes. Broken leads from power transformer. Power transformer defective	Replace tube or tubes* Check with an ohmmeter for continuity. Repair if necessary. Replace
	CRT CIRCUIT	
No spot on CRT screen.	High voltage rectifier tube, V9, defective. Filament leads broken. No voltage on second anode. NOTE: Spot may be deflected off screen. Adjust VERT. POS. control for equal voltages from CRT pins 6 & 7 to ground (Vertical deflection plates), and HORIZ. POS. control for equal voltages from CRT pins 9 & 10 to ground (horizontal deflection plates). The spot should then be centered. If either adjustment is impossible, refer to the vertical or horizontal amplifier sections.	Replace Repair Check circuit. Repair if necessary.

SYMPTOM	POSSIBLE CAUSE	REMEDY
No spot on CRT screen. (All CRT voltages correct).	Defective CRT (V10)	Replace
Retrace blanking inoperative.	CR1, CR18 open. Open lead in path from sweep generator to cathode of CRT(V10).	Replace Check if necessary
Intensity modulation of trace with internal sync.	R44, R45 defective.	Check. Replace if necessary.
No focusing.	FOCUS control R65 defective. Astigmatism control R63 defective.	Replace Replace
No horizontal positioning.	Refer to horizontal amplifier.	
No vertical positioning.	Refer to vertical amplifier.	
Astigmatism control inoperative.	R63 defective.	Replace
	SWEEP CIRCUIT	
No sweeps (horizontal amplifier checks o.k.)	SWEEP RANGE switch is not set to sweep positions. Lead or leads broken. SWEEP RANGE switch S3 defective. HORIZ. SELECTOR switch S2 defective. SWEEP VERNIER R41 defective. One of R38-43 defective. V5 defective	Set SWEEP RANGE switch to one of sweep positions. Check and repair if necessary. Check. Replace if necessary. Check. Replace if necessary. Check. Replace if necessary. Replace defective resistor. Replace
Sweep inoperative on some ranges.	One of C12-17 defective. SWEEP RANGE switch S3 defective.	Replace defective capacitor. Check. Replace if necessary.
Incorrect sweep frequency obtained at TV-HOR. position.	C12 out of adjustment.	Adjust C12. See MAINTENANCE.
Loss of synchronization.	V5 defective. HORIZ. SELECTOR switch S2 defective. C10 defective Sync leads defective.	Replace Replace Replace Repair

VERTICAL AMPLIFIER

SYMPTOM	POSSIBLE CAUSE	REMEDY
With appropriate signal applied across VERT and G binding posts, no vertical displacement of the trace results.	VERT. ATTEN. switch S1 defective. One or more of tubes V1-4 defective. One or more components in the vertical amplifier defective.	Replace Check. Replace if necessary. * Check resistors and potentiometers with ohmmeter. Replace if defective. *
Signal distorted; unable to obtain DC balance.	Peaking coil or coils open. R13 defective. V1-4 defective. Check adjustments of R36 and R24.	Replace Replace* Replace* See MAINTENANCE
No vertical positioning.	VERT. POS. control R16 defective.	Replace
VERT. GAIN control affects position of trace.	DC balance control R13 out of adjustment.	See MAINTENANCE
No vertical signal in AC position of AC-DC switch.	C1 open.	Replace
Square wave (1kc) distorted on 10, 10, 100, 1000 positions of VERT. ATTEN. switch.	C2, C4, C6 out of adjustment.	See MAINTENANCE
VERT. GAIN control inoperative.	VERT. GAIN control R12 defective. (Note: Inability to reduce trace size to zero is not a defect, but inherent in DC amplifier design).	Replace
Trace "jumps" on CRT screen in vertical direction.	Loose connection in vertical amplifier section. One of tubes V1-4 is microphonic.	Repair Tap tubes lightly. Replace one which is microphonic. *
No trace when VERT. ATTEN. switch set at CAL.	R75, 76, 77 defective. CR2 shorted.	Replace* Replace*
Calibration inaccurate.	R77 out of adjustment.	See MAINTENANCE

HORIZONTAL AMPLIFIER

SYMPTOM	POSSIBLE CAUSE	REMEDY
No horizontal deflection at either HOR 60 cps or SYNC positions of HORIZ. SELECTOR (sweep circuit checks o.k.)	C19 open. V5, 6 defective. C27 shorted. C21 open. HORIZ. GAIN R53 defective. HORIZ. SELECTOR S2 defective.	Replace Replace Replace Replace Replace Replace
No horizontal positioning.	R55, 59 defective. HORIZ. POS. control R59 defective. C22 shorted.	Check and replace if necessary. Replace Replace
Horizontal deflection present but distorted.	C27 open. C22 open. V6 defective. R61, 62 defective.	Replace Replace Replace Replace

*Indicates replacement of component in this group makes it necessary to repeat some part of the adjustment procedure given in MAINTENANCE.

VOLTAGE CHART

PIN NO.

TYPE	1	2	3	4	5	6	7	8	9	10	11	12
V1 6AU8	93V*	90V*	280V	3.15V AC	3.15V AC	2.5V	0	112V	90V*	—	—	—
V2 6AU8	93V*	90V*	280V	3.15V AC	3.15V AC	2.5V	0	112V	90V*	—	—	—
V3 12BY7	95V*	93V*	95V*	3.15V AC	3.15V AC	3.15V AC	270V*	240V	95V*	—	—	—
V4 12BY7	95V*	93V*	95V* AC	3.15V AC	3.15V AC	3.15V AC	270V*	240V	95V*	—	—	—
V5 6BL8	200V	0**	47V	3.15V AC	3.15V AC	5V	0	20V	12V***	—	—	—
V6 12AZ7	200V*	0	1.7V	3.15V AC	3.15V AC	200V*	-15V to +10V	1.7V	3.15V AC	—	—	—
V7 12AZ7	130V	50V	65V	3.15V AC	3.15V AC	200V	64V	65V	3.15V AC	—	—	—
V8 EZ81	360V AC	—	430V	—	—	—	360V AC	—	—	—	—	—
V9 IV2	—	—	—	**** 1070V AC	**** 1070V AC	—	—	—	-1600V	—	—	—
V10 WX5013	-1400V	-1400V	-1400V to -1300V	-760V to -1200V	—	270V*	270V*	0 to 360V	200V*	200V*	—	-1400V

REFERENCE FOR VOLTAGE CHART

*Varies with VERT. POS./HORIZ. control settings; center values given.
**Goes negative with vertical input signal applied at SYNC "+" or "-" positions of HORIZ. SELECTOR.
***Difficult to measure at this point. Make measurement at junction of R51 and R52.
****Measure with tube V9 (IV2) out of socket, each pin to ground. Do not attempt to measure filament voltage between pins 4 and 5 of V9.
UNLESS OTHERWISE INDICATED, ALL VOLTAGES ARE DC, POSITIVE AND MEASURED TO CHASSIS.
Line Voltage: 117V, 60 cps
All measurements made with VTVM of approximately 11 megs input impedance.
All voltages may normally vary by ±15%.

RESISTANCE CHART

PIN NO.

Tube	1	2	3	4	5	6	7	8	9	10	11	12
V1 6AU8	47K	12.9K*	3K**	NS F	NS F	800 to 2.8K	1M****	18K***	12.8K*			
V2 6AU8	47K	12.9K*	3K**	NS F	NS F	800 to 2.8K	100	18K***	12.8K*			
V3 12BY7	1.8K to 2.5K	47K	1.8K to 2.5K	NS F	NS F	NS F	4.17K*	11K*	1.8K to 2.3K			
V4 12BY7	1.8K to 2.5K	47K	1.8K to 2.5K	NS F	NS F	NS F	4.17K*	11K*	1.8K to 2.3K			
V5 6BL8	16K**	150K	136K**	NS F	NS F	4.5K	0	2.5K*	2.2M			
V6 12AZ7	48K*	100 to 10K	6.8K	NS F	NS F	48K*	10.5K* to 45K	6.8K*	NS F			
V7 12AZ7	27K*	680K* to 11M	4.7K	NS F	NS F	10K*	20.5K*	4.7K	NS F			
V8 EZ81	100	—	0	NS F	NS F	—	100	—	—			
V9 IV2	—	—	—	750	750	—	—	—	6M*			
V10 WX5013	5.95M*	6M*	5.78M to 6.28M	3.3M to 5.3M		4.17K*	4.17K*	0* to 2M	48K*	48K*	—	5.95M*

REFERENCES FOR RESISTANCE CHART

IMPORTANT: All resistance measurements in table are made with pin 3 of EZ81 power rectifier V8 (B+) and can of C26 (B-), located in Fig. 7, shorted to ground with temporary jumper leads. Remove these B+ and B- shorts to check resistance at pin 3 of V8 (should be greater than 70K ohms) and before connecting unit to power line.

*Small delay until final reading can be obtained due to capacitor charging.
**Large delay until final reading can be obtained due to capacitor charging.
***Depends on setting of DC balance adjust R13.
****reading taken in X1 position.
N.S. — Not significant
F — Filament pin
All resistance values may normally vary by ±15%.

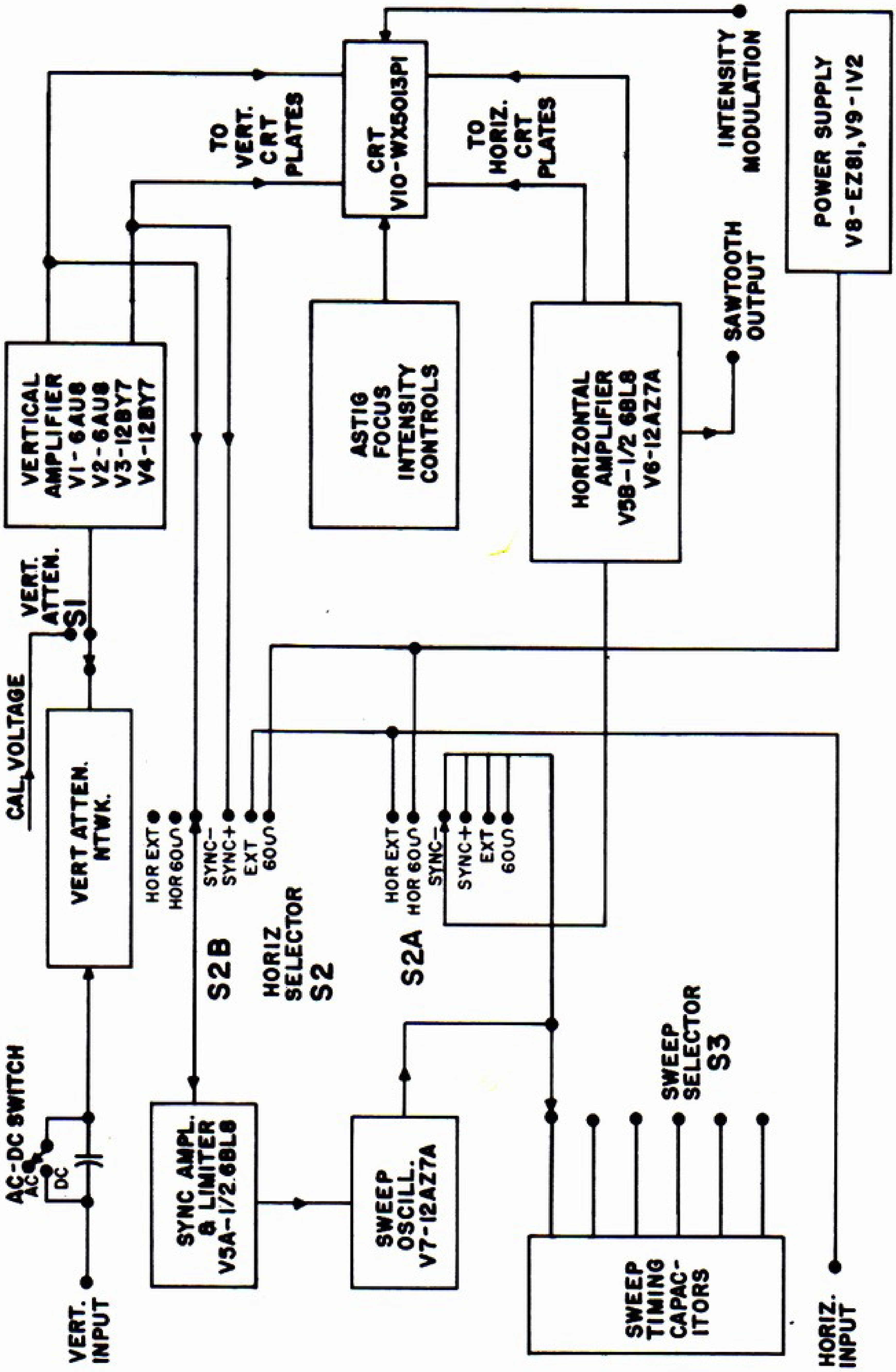
VERT. INPUT
AC-DC SWITCH
AC
DC
VERT ATTEN. NTWK.
CAL. VOLTAGE
VERT. ATTEN. S1
VERTICAL AMPLIFIER V1-6AU8 V2-6AU8 V3-12BY7 V4-12BY7
TO VERT. CRT PLATES
CRT V10-WX5013P1
INTENSITY MODULATION
TO HORIZ. CRT PLATES
ASTIG FOCUS INTENSITY CONTROLS
HORIZONTAL AMPLIFIER V5B-1/2 6BL8 V6-12AZ7A
SAWTOOTH OUTPUT
POWER SUPPLY V8-EZ81, V9-1V2
SYNC AMPL. & LIMITER V5A-1/2 6BL8
SWEEP OSCILL. V7-12AZ7A
HOR EXT
HOR 60∿
SYNC-
SYNC+
EXT
60∿
S2B
HORIZ SELECTOR S2
S2A
SWEEP SELECTOR S3
SWEEP TIMING CAPACITORS
HORIZ. INPUT

FIGURE 11

SCHEMATIC DIAGRAM

HORIZ SELECTOR S2

POSITION	CONTACTS MADE S2-A	CONTACTS MADE S2-B
60 SYNC	5-6, 11-12	1-4
EXT SYNC	5-7, 11-12	1-4
INT SYNC +	5-8, 11-12	1-4
INT SYNC −	5-9, 11-12	1-4
60 HOR	———	4-6
EXT HOR	———	4-7

VERT ATTEN S1

POSITION	CONTACTS MADE S1-A	CONTACTS MADE S1-B
1	5-8	8-12
10	5-9	9-12
100	5-10	10-12
1000	5-11	11-12
CAL	———	4-12

NOTES

1. RESISTOR VALUES ARE IN OHMS. RESISTORS ARE 1/2 W, 10 % UNLESS OTHERWISE STATED
2. CAPACITANCE VALUES ARE IN µF (MICROFARAD) UNLESS OTHERWISE STATED.
3. ALL ROTARY SWITCHES ARE SHOWN IN MAX COUNTER CLOCKWISE POSITION, VIEWED FROM KNOB END.
4. "D" DENOTES DUMMY LUG ON SWITCH.

PRICE EACH	SYM. #	STOCK#	DESCRIPTION
			CAPACITORS
.56	C1, 19	20015	mylar, .25, 600V, 20%
.55	C2, 4, 6, 12	29519	trimmer, 7-60uuf
.21	C3, 16	20087	mylar, .01, 400V, 10%
.15	C5	22521	disc, .001, 500V, 10%
.12	C7, 11	22509	disc, 100uuf, 500V, 10%
.12	C8, 9	22594	disc, 5uuf, 500V, 10%
.33	C10	20089	mylar, .1, 400V, 10%
.21	C13	21018	mica, 270uuf, 500V, 20%
.13	C14	22556	disc, 68uuf, 500V, 10%
.22	C15	20088	mylar, .001, 400V, 10%
.33	C17	20089	mylar, .1, 400V, 10%
.77	C18	20096	mylar, .047, 1600V, 10%
.80	C20	23010	elect., 10, 150V
.75	C21	23011	elect., 50, 50V
.48	C22	20080	mylar, .33, 200V, 10%
.27	C23	22583	disc, .01, 2KV, 10%
1.12	C24, 25	20090	mylar, .1, 1600V, 10%
3.45	C26	24025	elect., 40-40-300/450V
2.70	C27	24004	elect., 20-20-20/450V
			RESISTORS
.42	R1, 7	11548	1MΩ, 1/2W, 5%
.14	R2, 51	11566	1KΩ, 1/2W, 5%
.26	R3	11577	990KΩ, 1/2W, 5%
.14	R4, 59, 76	11500	10KΩ, 1/2W, 5%
.26	R5	11576	900KΩ, 1/2W, 5%
.14	R6	11527	100KΩ, 1/2W, 5%
.14	R8, 9, 18, 19, 49, 57, 58	11505	100Ω, 1/2W, 5%
.14	R10, 11	11542	1.6KΩ, 1/2W, 5%
.42	R14	14301	6KΩ, 10W, 10%
.34	R15, 17	~~10967~~ 11958	~~2.5KΩ, 2W, 10%~~ 2.7K 2W 10%
.18	R20, 21	10849	47KΩ, 1W, 10%
.36	R22	14503	2.5KΩ, 5W, 10%
.36	R23	14502	1.8KΩ, 5W, 10%
.32	R25, 26, 32, 33	10952	4.7KΩ, 2W, 10%
.14	R27, 31	11559	12KΩ, 1/2W, 5%
.47	R28, 30	10771	820Ω, 1W, 5%
.36	R29	10956	10KΩ, 2W, 10%
.12	R34, 35, 38	11538	22KΩ, 1/2W, 5%
.14	R37	11525	150KΩ, 1/2W, 5%
.11	R39	10430	4.7KΩ, 1/2W, 10%
.18	R40	10855	4.7KΩ, 1W, 10%
.14	R41	11563	18KΩ, 1/2W, 5%
.45	R42	14300	10KΩ, 10W, 10%

PRICE EACH	SYM. #	STOCK#	DESCRIPTION
.18	R43	10848	68KΩ, 1W, 10%
.14	R44, 50, 70	11518	2.2MΩ, 1/2W, 5%
.11	R45	10455	1.5MΩ, 1/2W, 10%
.14	R46	11561	680KΩ, 1/2W, 5%
.11	R48	10444	120KΩ, 1/2W, 10%
.14	R52	11540	1.5KΩ, 1/2W, 5%
.34	R54	10972	15KΩ, 2W, 10%
.18	R55, 66, 75	10846	150K, 1W, 10%
.18	R60	10854	6.8KΩ, 1W, 10%
.34	R61, 62	10955	47KΩ, 2W, 10%
.18	R64	10838	3.3MΩ, 1W, 10%
.14	R68	11550	330KΩ, 1/2W, 5%
.14	R69, 71	11553	220KΩ, 1/2W, 5%
.36	R72, 73	14500	500Ω, 5W, 10%
.36	R74	14314	500Ω, 10W, 10%
			POTENTIOMETERS
—	R12	On S1	2KΩ
.92	R13	16010	10KΩ, linear
.91	R16	16001	1KΩ, linear
2.28	R24	19026	500Ω, WW
.92	R36	16000	2KΩ, linear
—	R47	On S3	10MΩ
—	R53	On S2	10KΩ
.94	R56	16004	50KΩ, linear
1.14	R63, 65	16011	2MΩ, linear
2.06	R67/S5	18129	500KΩ, CCW
.53	R77	19003	500Ω
1.54	R78	19013	35Ω, WW
			SWITCHES
11.52	S1	60150	switch, rotary, w/2K pot.
10.16	S2	60151	switch, rotary, w/10K pot.
10.16	S3	60152	switch, rotary, w/10M pot.
.31	S4	62015	switch, slide, SPST
14.96	T1	30059	transformer, power
			TERMINAL STRIPS
.10	TB1, 7	54015	3 post, 2 left w/gnd.
.10	TB2, 5	54003	2 post
.10	TB3	54004	2 post w/gnd.
.10	TB4	54005	2 post right, w/gnd.
.10	TB6	54009	2 blank upright
.10	TB8, 20	54000	1 post left

PRICE EACH	SYM. #	STOCK#	DESCRIPTION
.10	TB9, 10	54013	1 post left w/gnd.
.10	TB11	54008	4 post
.10	TB12	54014	3 post, 2 left
.10	TB13, 19	54007	3 post, 2 right w/gnd.
.12	TB14	54054	5 post, 1 right w/2 gnd.
.10	TB15, 16	54067	1 blank upright
.10	TB17	54001	1 post right
.10	TB18	54024	2 post left
			TUBES
3.60	V1, 2	90027	6AU8
3.16	V3, 4	90064	12BY7
2.60	V5	90071	6BL8/ECF80
2.60	V6, 7	90098	12AZ7
1.80	V8	90038	EZ81
2.04	V9	90030	1V2
38.60	V10	90086	CRT, WX5013P1
2.28	CR1	93007	diode
3.00	CR2	93018	diode, Zener, 1N713
.15	F1	91000	fuse, 2 Amp
.43	I1	97734	bulb assy., filament
.15	I2	92000	bulb, #47
.34	J1, 2, 3	52007	post, binding
.21	J4	50046	jack, white
.14	J5	50029	jack, black
.58	L1, 2, 3, 4	36010	coil, variable, 100uh
.23	XV1, 2, 3, 4, 5, 6, 7, 8, 9	97081	socket, 9 pin miniature
.42	XV10	97026	socket, 12 pin CRT
.23	XI2	97712	socket, pilot light assembly
.96	XF1	97800	fuseholder
			MISCELLANEOUS
.01		40000	nut, #6-32 (43)
.02		40001	nut, 3/8" (12)
.01		40007	nut, #4-40 (27)
.07		40016	nut, 1/2-24 (1)
.04		40017	nut, Tinnerman, #8-32 (4)
.04		40019	nut, Tinnerman, #6-32 (2)
.04		40034	nut, Tinnerman, #4-40 (2)
.02		40055	nut, #8-32 (4)
.01		41003	screw, #8-32 x 3/8 (4)
.01		41007	screw, #6-32 x 3/4 (2)
.01		41086	screw, #6-32 x 5/16 (36)
.01		41088	screw, #6-32 x 3/8 F.H. (7)
.01		41090	screw, #4-40 x 5/16 (25)
.01		41091	screw, #4-40 x 1/4 F.H. (4)

PRICE EACH	STOCK#	DESCRIPTION
.02	41115	screw, #8-3/8 Type Z, sheet metal (4)
.01	41140	screw, #6-32 x 1/4, Type F (10)
.02	42000	washer, lock, 3/8" (5)
.01	42001	washer, flat, 3/8" (8)
.01	42002	washer, lock, #6 (43)
.01	42005	washer, flat, #6 (4)
.01	42007	washer, lock, #4 (27)
.01	42008	washer, lock #8 (7)
.03	42029	washer, rubber, 1/2" (1)
.01	42061	washer, flat, #8 (4)
.02	42511	retainer, bulb indicator (2)
.02	43000	lug, #6 (2)
.02	43001	lug, 3/8 (2)
.01	43004	lug, #8 (3)
.02	46001	grommet, rubber, 1/4" (3)
.04	46014	grommet, rubber, 1/8" (7)
.08	46016	foot, plastic (4)
.20	53001	knob, round, black (1)
.50	53037	knob, small, dark gray (4)
.50	53040	knob, concentric, outer (3)
.38	53041	knob, concentric, inner (3)
.54	57004	line cord (1)
2.82	59007	screen, 3" scaled (1)
.24	59008	screen, green filter (1)
.15	59306	cushion, foam rubber (2)
.30	59308	cushion, CRT felt (4)
.10	59508	insulator, capacitor (1)
4.10	80161	panel, front (1)
1.30	81362	bezel, plastic (1)
2.70	81409	panel, back (1)
.66	81410	bracket, CRT support (1)
5.10	81411	chassis, main (1)
.70	81412	support, frame (4)
2.70	81413	panel, sub (1)
.70	81414	bracket, frame (1)
.70	81415	clamp, CRT bracket (2)
.15	82100	clamp, black cable (4)
.10	82104	clamp, line cord (1) (strain relief)
2.66	86005	frame (1)
.80	86548	assy., handle and links. (1)
9.00	88125	cabinet (1)
n/c	89336	label, rear nomenclature (1)
n/c	89337	label, rear layout (1)
.03	89613	sleeve, cardboard for bulb (1)
.05	89649	bracket, handle mounting (2)
.05	97310	shield, neon bulb (1)
1.50	66158	manual, operating (1)
3.00	66397	manual, assembly (1)

To order replacement parts, specify description and part number. Remittance must be made with order, and include $1.00 for mailing and handling with each order ($1.50 for each transformer if order includes 1 or more output or power transformers). Prices subject to change without notice.

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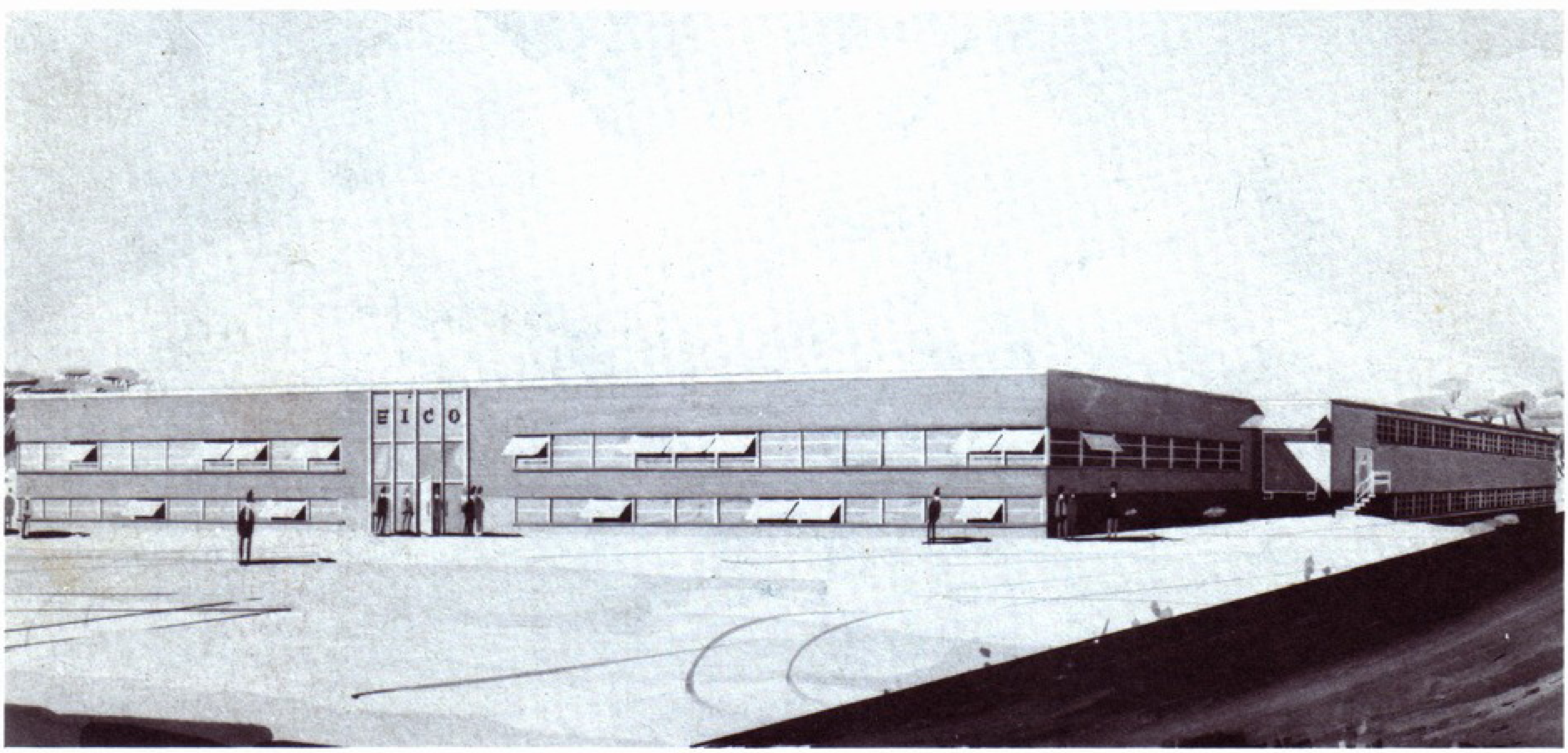

EICO Eico Electronic Instrument Co., Inc., 131-01 39th Avenue, Flushing, N.Y. 11352