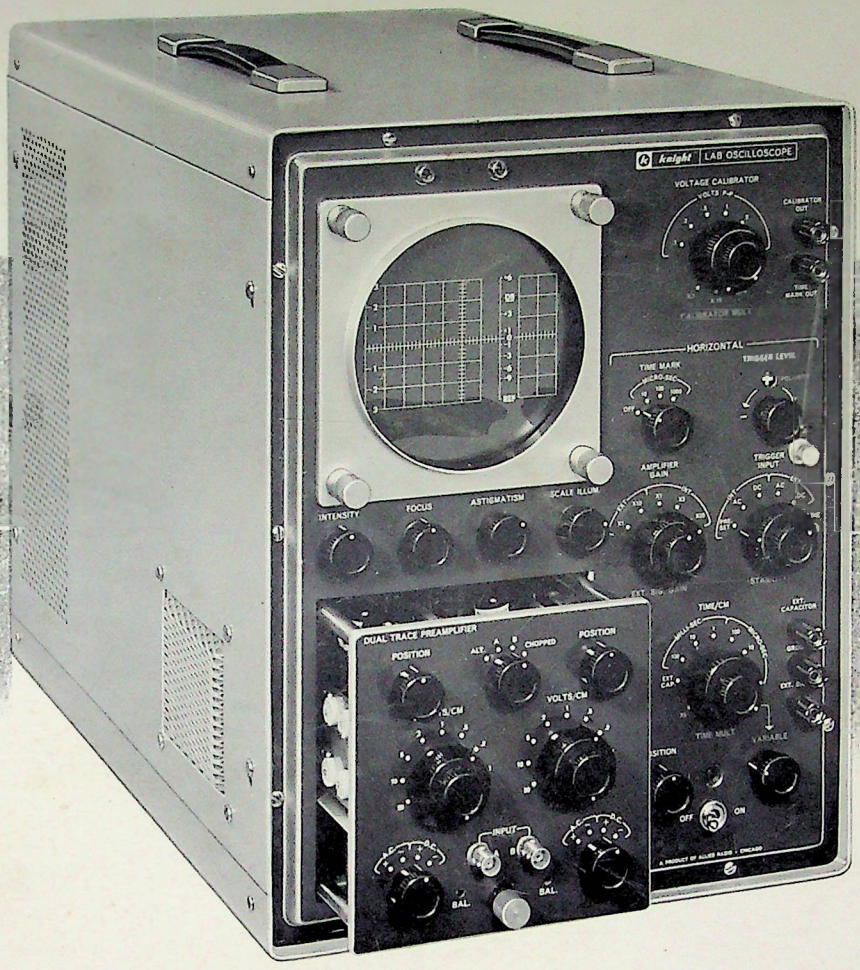



LAB OSCILLOSCOPE 83 YZ 945

**OPERATOR'S HANDBOOK**

A PRODUCT OF ALLIED RADIO · CHICAGO

knight®

# DC LABORATORY OSCILLOSCOPE

The Knight DC Lab Scope is designed for general laboratory and industrial use. Plug-in, interchangeable vertical amplifiers equip this instrument to meet almost any lab requirement. Featuring calibrated vertical amplifiers and calibrated horizontal sweep circuits, this scope can be used for quantitative time and amplitude measurements. Trigger and amplifier circuits are DC coupled throughout, for applications where very low frequencies, or DC levels must be displayed.

Push-pull amplifiers in all circuits, and electronic regulation of all power supplies assure a high degree of stability. Another outstanding feature is the wide frequency response of the vertical amplifier (to 10 mc), permitting the display of pulses of fast rise time.

The built-in time marker can be used to calibrate any particular sweep speed within 1% accuracy. Both time-mark output and voltage calibrator output are available at the front panel for external use. A complete cooling system (fan, filters, ventilated cabinet) assure long component life.

# SECTION 1 — SPECIFICATIONS

## VERTICAL

**(Using Dual-Trace or Wideband Preamplifier.)**

**BANDWIDTH** DC to 10 mc, within 3 db down. Reference to 50 kc, with vertical display height, 2 cm.

**RISE TIME** 40 nsec, vertical display height, 2 cm or less.

**SENSITIVITY** 50 mv/cm to 20 v/cm.

**INPUT IMPEDANCE** 1 meg shunted by 40 $\mu\mu$f.

**(Using High-Gain Preamplifier.)**

**BANDWIDTH** DC to 100 kc.

**SENSITIVITY** 1 mv/cm to 50 v/cm.

**DIFFERENTIAL RATIO** 5000:1.

**INPUT IMPEDANCE** 1 meg shunted by 40 $\mu\mu$f.

**CALIBRATED SWEEP RANGE**
0.5 sec/cm to 50 nsec/cm in 30 ranges by use of basic sweep ranges (100 msec, 10 msec, 1 msec; 100 $\mu$sec, 10 $\mu$sec, 1 $\mu$sec and horizontal amplifier gain (X1, X5 and X20); also horizontal sweep 10:1 multiplier vernier control. Provision for external capacitor for very slow sweeps.

**TIME MARKS**
Intensity modulated marks at 10 $\mu$sec, 100 $\mu$sec and 1000 $\mu$sec intervals—available from front panel. Permits adjusting sweep timing accuracy to 1%.

**TRIGGERING**
SENSITIVITY: 100 mv external, 2 mm deflection internal.
INPUTS: Line, external AC or DC, internal AC or DC, and preset.
LEVEL: Adjustable to provide triggering at selected points on waveform.

## HORIZONTAL AMPLIFIER

**BANDWIDTH**
DC to 2.5 mc within 3 db down.

**SENSITIVITY**
Approximately .1 v/cm and 1 v/cm.
10 to 1 attenuator.
Front panel vernier gain control.

**VOLTAGE CALIBRATOR**
1 kc square wave.
10 mv to 50 v. p-p ±1%, in 24 steps.
Output available at front panel.

**LOW-VOLTAGE POWER SUPPLY**
Regulated −150, +100, +250, +420-volts.

**HIGH-VOLTAGE SUPPLY**
Regulated −1750 and +3500 volts.

**POWER REQUIREMENTS**
105-130 volts, 60 cycle AC.

**POWER CONSUMPTION**
400-Watts with Dual-Trace Preamplifier.

## TUBE COMPLEMENT

**VERTICAL AMPLIFIER**
V-1 6EA8, voltage amplifier
V-2 6EA8, voltage amplifier
V-3 12BY7A, deflection amplifier
V-4 12BY7A, deflection amplifier
V-5 6DJ8, deflection c.f.
V-6 6EA8, sync amplifier
V-7 OA2, voltage regulator

**HIGH-VOLTAGE P.S.**
V-8 12BH7, oscillator-feedback amplifier
V-9 6W6, oscillator-power amplifier
V-10 1X2B, high voltage rectifier
V-11 1X2B, high voltage rectifier
V-12 6AU6, DC feedback amplifier
V-13 GV3-A, 1750, voltage regulator

**LOW-VOLTAGE P.S.**
V-14 6NO45T, time delay
V-15 EZ81/6CA4, rectifier
V-16 6DR7, regulator/control
V-17 6DR7, regulator/control
V-18 6DR7, regulator/control
V-19 6DR7, regulator/control
V-20 6DR7, regulator/control
V-21 6DR7, regulator/control
V-22 6DR7, regulator/control
V-23 6DR7, regulator/control
V-24 6DR7, regulator/control

**HORIZONTAL SECTION**
V-25 6DJ8, trigger amplifier/phase splitter
V-26 6EA8, trigger multivibrator
V-27 6DJ8, sweep gate multivibrator
V-28 6DJ8, hold-off c.f./charging c.f.
V-29 6DJ8, sweep gate/unblanking ampl.
V-30 6AW8, sweep c.f./bootstrap c.f.
V-31 6DJ8, horiz. ampl. input c.f.
V-32 6AU8, voltage ampl./deflection ampl.
V-33 6AU8, voltage ampl./defiection ampl.
V-34 6EA8, unblanking c.f.
V-35 6EA8, voltage calibrator multivibrator
V-36 6EA8, 1 kc time mark
V-37 6EA8, 10 kc time mark
V-38 6EA8, 100 kc time mark

**CRT**
C5-10/P2 post-accelerator crt

**SIZE AND WEIGHT**
16½ x 12½ x 21⅛" (HWD)
Shipping wt., 60 lbs.

The Knight DC LAB SCOPE is designed for operation from 105 to 130 volts, 60 cycle AC only. It is supplied with the primary tap connected for a line voltage of 110 to 120 volts. If your line voltage is lower than 110 or higher than 120, see the maintenance section of this manual to change the primary connections.

☐ Install a suitable preamp in your scope. Note: the plug-in connector of the preamp closes the heater circuit of the delay relay in the power supply of the scope. If for some special reason you wish to operate the scope without a preamp, use the extra 16-pin plug supplied with the scope and wire as shown in Figure 1.

☐ Connect the power cord to the male AC receptacle at the rear of your scope. Plug the line cord into a source of 105 to 130 volts, 60 cycle AC.

☐ Front panel controls are initially in the fully counterclockwise position. Set the controls as follows. (White dots point to white labels, red dots to red labels).

| | |
|---|---|
| INTENSITY | fully clockwise |
| FOCUS | center of range |
| ASTIGMATISM | center of range |
| SCALE ILLUM. | as desired |
| VOLTAGE CALIBRATOR (CALIBRATOR MULT.) | OFF |
| TIME MARK | OFF |
| TRIGGER LEVEL | center of range |
| AMPLIFIER GAIN | INT X1 |
| TRIGGER INPUT | PRE-SET |
| TIME/CM | 1 milli-sec |
| TIME MULT. | X1 |

☐ Turn the power switch (bottom of panel) ON. Allow a few minutes warmup.

☐ Turn the vertical POSITION control or controls on your preamp for vertical centering. Vertical centering is achieved when both deflection lamps above the crt go equally dim or both go out.

☐ Turn the horizontal POSITION control on the scope until a spot is seen.

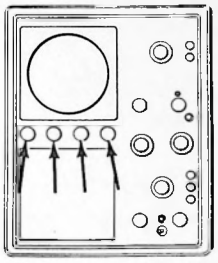
☐ Turn STABILITY clockwise until sweep starts, displaying a horizontal trace.

☐ Reduce the INTENSITY setting to the desired level.

☐ Re-adjust FOCUS and ASTIGMATISM for sharpest trace.

## CONTROL FUNCTIONS

### POWER SWITCH



Turning the power switch ON energizes the power transformer and the heater circuits are turned on immediately. A protective, 45-second delay tube keeps the control relay in the B+ supplies open, to allow time to develop the −150 bias supply. However, the +100 volts DC required for the heaters of the preamp tubes is supplied without delay.

When the preamp is unplugged, or the power switch turned off, the relay in the power supply recycles. Turning the power switch on again, or plugging a preamp in again, initiates another 45 second delay before B+ is applied. Naturally, if power has been off for just a few seconds, the delay may be less than 45 seconds because the heaters are still warm.

### INTENSITY

INTENSITY controls the brightness of the trace—clockwise for more brightness and counterclockwise for less brightness. If INTENSITY is set too low, the trace will not be visible. The recommended setting is the minimum level required for easy reading and sharpest trace. Never leave INTENSITY turned so high that halo is seen around the spot.

### FOCUS AND ASTIGMATISM

These controls are used together to control the shape and sharpness of the trace. Turn STABILITY fully counterclockwise to turn off the sweep. Then increase INTENSITY until a spot is visible and adjust ASTIGMATISM for the roundest spot. Now adjust FOCUS for the sharpest (smallest diameter) spot.

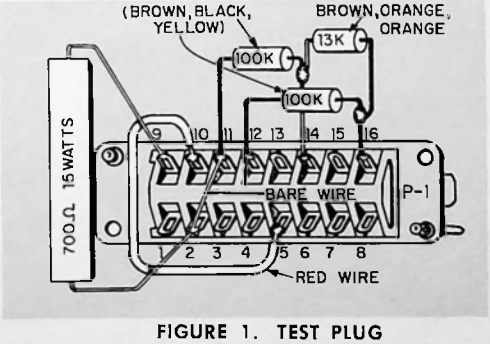



**FIGURE 1. TEST PLUG**

## TRIGGER INPUT SELECTOR

TRIGGER INPUT provides a choice of 3 trigger sources.

INT (PRE-SET, AC or DC) selects an internal signal source, using the signal under study for trigger information.

EXT (AC or DC) selects an external trigger source, introduced at the front panel connector labeled EXT. TRIGGER.

LINE selects the line frequency (power transformer heater winding) as the trigger source.

**Note: When TIME MARK is on, the TRIGGER inputs are out of the circuit and the time marks trigger the sweep.**

INT PRE-SET — With pre-set triggering, any signal greater than 2mm deflection will trigger the scope. However, the TRIGGER LEVEL control is in the PRE-SET position. Pre-set triggering is especially useful for the comparison of waveforms, such as output vs input. Signal levels can be changed without resetting TRIGGER LEVEL.

INT AC — This position is used for most applications. With INT AC, triggering is largely independent of vertical positioning, minimizing changes in level caused by repositioning.

INT DC — The DC component is retained in this triggering mode, to make it possible to trigger with signals of low DC level, or very low-frequency.

EXT AC — In this position, the DC component of the external trigger source is removed by a blocking capacitor, to eliminate the possibility of overloading the trigger amplifier with too high a DC voltage.

EXT DC — Where the external trigger source is at a low DC level, or a very low frequency, use the EXT DC mode.

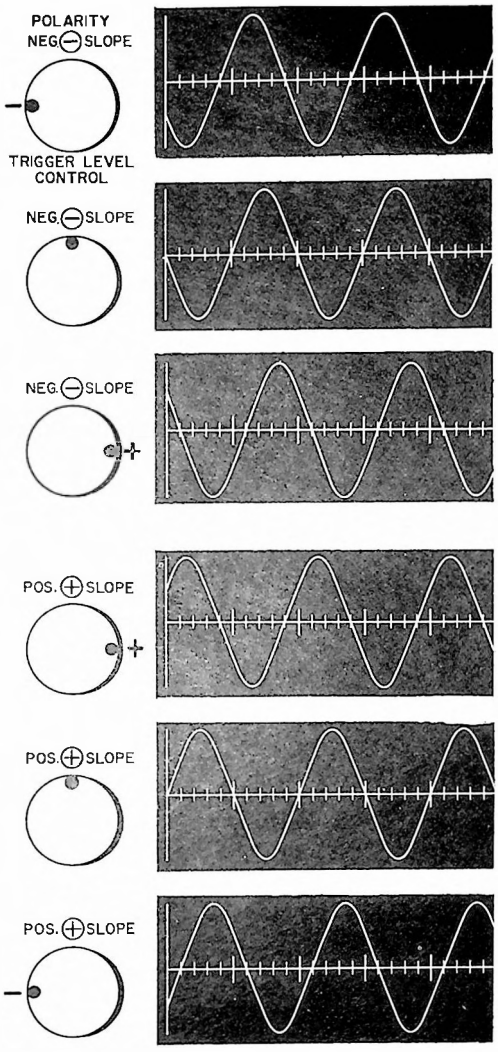
LINE — Since the trigger source here is the line frequency, use this position for waveforms of line frequency, or its harmonics, as in hum or ripple measurements.

## STABILITY

The STABILITY control adjusts the operating voltages of the sweep gate multivibrator to assure proper triggering. It should be set at the minimum level required for stable trigger. Setting the control below this level turns off the sweep. Advancing the control too far above this minimum level increases trigger sensitivity, but also allows the sweep to recur without trigger information.

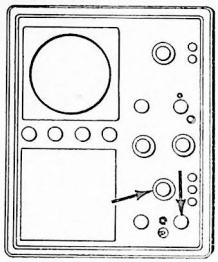
**POLARITY** The trigger POLARITY switch is actuated by the TRIGGER LEVEL CONTROL, at either extreme of the control range. The flag in the POLARITY window shows whether triggering is taking place on the ascending slope (+ flag) or the descending slope (— flag). To trigger on the positive (ascending) slope, turn TRIGGER LEVEL fully clockwise until a click is heard and the + flag appears. Turn TRIGGER LEVEL fully counterclockwise until the — flag appears, to trigger on the negative (descending) slope.

FIGURE 2. TRIGGER LEVEL AND POLARITY




**TRIGGER LEVEL.** The exact point of the waveform at which the sweep will trigger is set with the TRIGGER LEVEL CONTROL. When the control knob points in the direction of the + marking to the right of the control, triggering occurs at some positive point of the input waveform. As TRIGGER LEVEL is rotated in the counterclockwise direction, the sweep is triggered at successively less positive voltages. Past the center of its rotation, TRIGGER LEVEL selects increasingly negative points on the waveform to trigger the sweep.

TRIGGER POLARITY, which selects either the ascending or descending slope for triggering, should not be confused with TRIGGER LEVEL, which sets the relative positive or negative voltage (upper or lower portion of the waveform) at which triggering takes place.



**TIME/CM** (white markings) provides an accurate time base for the display and measurement of repetitive signals, ranging from extremely low sweep speeds (more than several minutes per sweep with and external capacitor) to as high as 50 nsec/cm. TIME/CM is the sweep speed selector and is calibrated in time per cm, with the graticule ruled for a width of 10 cm. To display higher frequencies, use a shorter time base (fewer microseconds per cm); to display lower frequencies, use a longer time base (more milliseconds per cm).

The sweeps selected by the TIME/CM switch are internally derived. Therefore, this control is effective only in the internal (INT) positions of the AMPLIFIER GAIN switch. For the following instructions, it is assumed that AMPLIFIER GAIN is set at INT X1.

TIME MULT (red markings) increases the time base by the selected factor: X1, X2 or X5. For example, with TIME/CM at 1 microsec and TIME MULT at X5, the time base or sweep speed is 5 microsec per cm.

$$\frac{\text{TIME/CM}}{\frac{1 \text{ microsec}}{\text{cm}}} \quad \frac{\text{TIME MULT}}{\text{X5}} \quad = \quad \frac{\text{RESULTANT TIME BASE}}{\frac{5 \text{ microsec}}{\text{cm}}}$$

Since the graticule is 10 cm wide, the sweep time is 50 microseconds. $\left(\frac{5 \text{ microsec}}{\text{cm}} \times 10 \text{ cm} = 50 \text{ microsec}\right)$

**FREQUENCY MEASUREMENTS.**

Frequency measurements can easily be calculated when the time for one cycle has been measured. Frequency is the reciprocal of the time for one cycle (period).

In the above example, if 5 cycles are displayed and sweep time is 50 microseconds, time for one cycle would be 10 microseconds. The reciprocal of 10 microseconds is 100 kc.

$$\frac{1}{10 \text{ microseconds } (10 \times 10^{-6})} = 100{,}000 \text{ cycles/sec or } 100 \text{ kc}$$

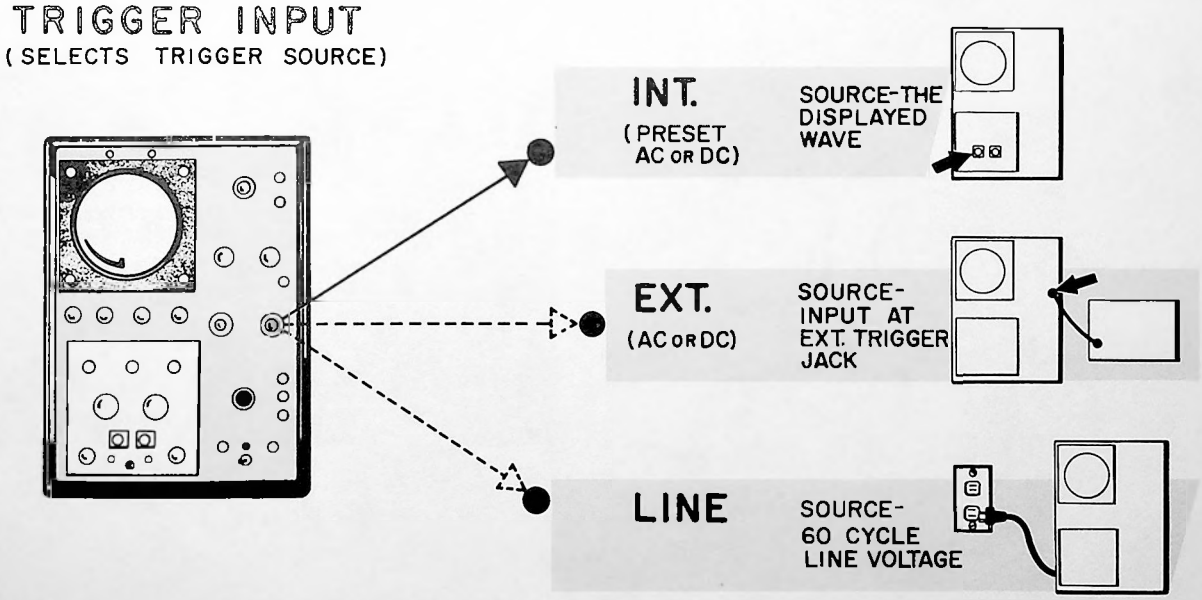
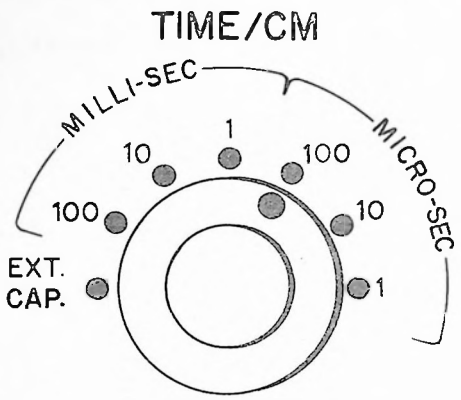
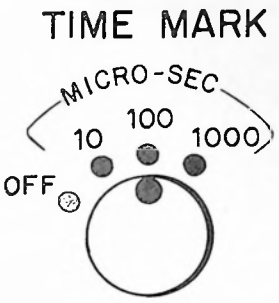



FIGURE 3. SELECTING THE TRIGGER SOURCE

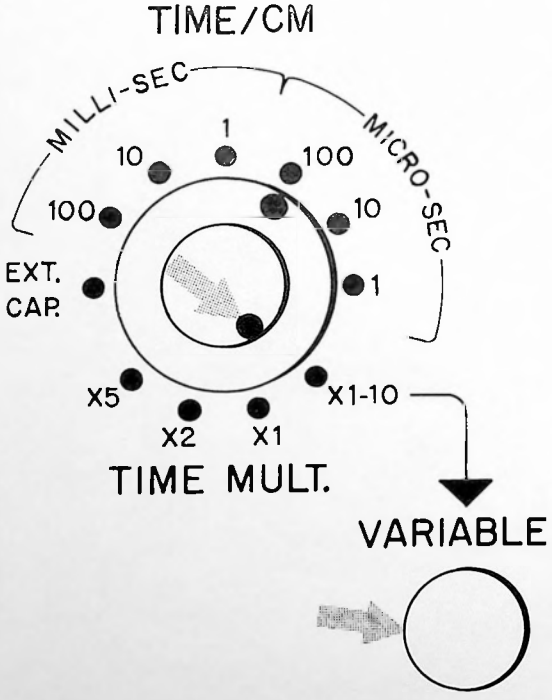
① SET TO DESIRED RANGE.




② SET TO CORRESPONDING RANGE.




③ ADJUST UNTIL MARKERS LINE UP WITH CM LINES ON THE GRATICULE.



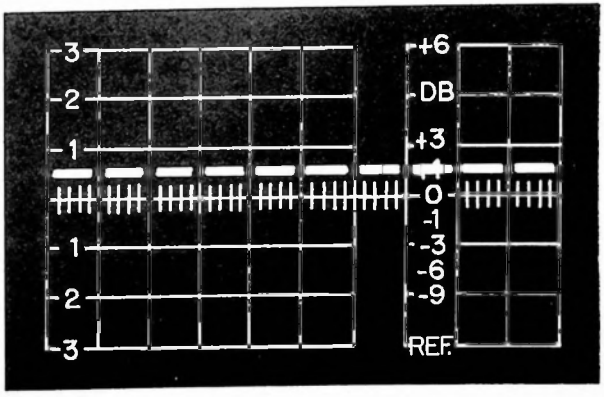




FIGURE 4.

**VARIABLE.** In the X1 - X10 position of TIME MULT, intermediate sweep speeds between the ranges, as adjusted by the VARIABLE control, are available. The VARIABLE control can also be used together with the TIME MARK for very accurate time measurements at a specified sweep speed.

For example, if an extremely accurate sweep speed of 100 microsec/cm is desired, set the controls as shown in Figure 4.

1. Set TIME/CM to 100 microsec.
2. Turn TIME MARK to the same range, 100 microsec.
3. Turn TIME MULT. to X1-X10, so that the VARIABLE control can be used.
4. Adjust VARIABLE until a marker lines up with each vertical cm line on the graticule. For greatest accuracy, measure from leading edge to leading edge of the markers.
5. Turn TIME MARK off to allow the waveform under study to trigger the sweep. DO NOT CHANGE THE SETTING OF VARIABLE or other sweep controls while you make the desired time measurements.

NOTE: These instructions for time and frequency measurements are based on a setting of AMPLIFIER GAIN at INT X1. Since the AMPLIFIER GAIN control provides sweep expansion up to X20, any setting other than INT X1 would change time measurements, as explained in the discussion of the GAIN control.

**EXT. CAPACITOR.**

An input for an external capacitor allows the use of sweep speeds slower than .5 sec/cm. Since the largest sweep timing capacitor is a 1 $\mu$f, connecting a larger capacitor across EXT. CAPACITOR and GROUND inputs provides a slower sweep speed than .5 sec/cm. The TIME/CM switch must be in the EXT CAP position to select this input.

## AMPLIFIER GAIN

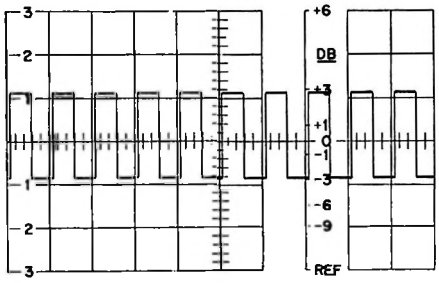
The horizontal AMPLIFIER GAIN switch performs 2 main functions—it selects an internal or an external source of sweep and selects the desired attenuation of the external signal or the desired sweep expansion for the internal sweep.

**EXT (X1, X10).** These positions are used when an external source of sweep is desired for some special application as for phase measurements where a horizontal signal is plotted against a vertical signal. The external signal can also be used to supply a special time base of a non-linear character. In this position, only the input at the EXT. SIGNAL jack is fed to the horizontal amplifier. Therefore the other horizontal controls, except POSITION, are not effective and the sweep should be turned off (STABILITY counterclockwise).

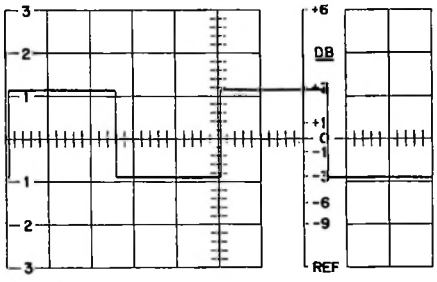
In the X10 position the signal goes straight through, without attenuation. In the X1 position, the signal receives 10:1 attenuation.

**EXT. SIGNAL GAIN** (red markings). This control is effective in the EXT X1, X10 positions and supplies variable attenuation between the 2 ranges.

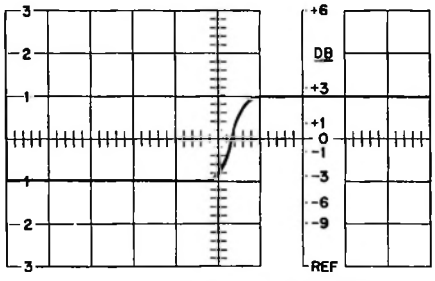
FIGURE 5. SWEEP EXPANSION




AMPLIFIER GAIN AT INT X1




AMPLIFIER GAIN AT INT X5




AMPLIFIER GAIN AT INT X20

**INT X1.** Here the internally derived sweep receives the amount of gain for which the TIME/CM ranges are calibrated directly.

**INT X5.** This position provides five times as much gain as INT X1. This is the equivalent of increasing (expanding) the sweep speed by a factor of 5. To calculate time per cm, divide the reading of TIME/CM X TIME MULT. by 5, because sweep time per cm is the reciprocal of sweep speed.

**INT X20.** Use this position for the largest amount of sweep expansion, twenty times the gain of INT X1. As shown in Figure 5, sweep expansion allows detailed study of a desired portion of the waveform.
For time per cm calculations, including the AMPLIFIER GAIN factor:

TIME/CM X TIME MULT ÷ AMPLIFIER GAIN

For example, if TIME/CM is at 1 microsec, TIME MULT at X2, then basic sweep time is 2 microsec/cm. With AMPLIFIER GAIN at X20, sweep time becomes 2 microsec/20 cm or 1 microsec/10 cm (.1 microsec/cm).

### POSITION

The position control provides horizontal centering by moving the trace to the left (turning control counterclockwise) or to the right (turning the control clockwise).

## CALIBRATORS

### TIME MARK

The time pulses are produced by a self-contained, crystal-controlled marker generator. For internal use, the time marks are seen as notches, or dark spots on the trace. Time mark output is available at the front panel connector labeled TIME MARK OUT, at a frequency selected by the TIME MARK switch.

The major use of the time mark circuits in the scope itself is in sweep calibration for highly accurate time measurements, as shown in Figure 4. WHEN TIME MARK IS ON, TIME MARK PULSES TRIGGER THE SWEEP AND TRIGGER INPUT AND LEVEL CONTROLS ARE DISCONNECTED.

Figures 6 and 7 each show a dual trace with voltage calibrator output above (1 kc square wave) and time mark output below. In Figure 6 a low-frequency range of TIME MARK is used. In Figure 7, where a high-frequency TIME MARK output is used externally, with another scope, some variation in amplitude is seen. This variation of amplitude can be eliminated by turning off the sweep of this scope (STABILITY counterclockwise). The spacing of the time marks remains constant, and any variation in amplitude may be ignored.

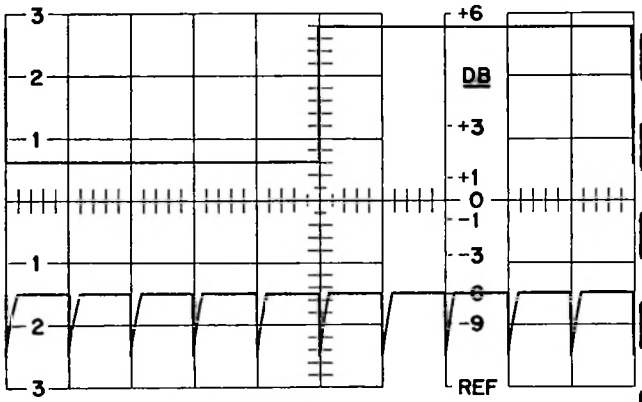



FIGURE 6. VOLTAGE CALIBRATOR AND LOW-FREQUENCY TIME MARK OUTPUT

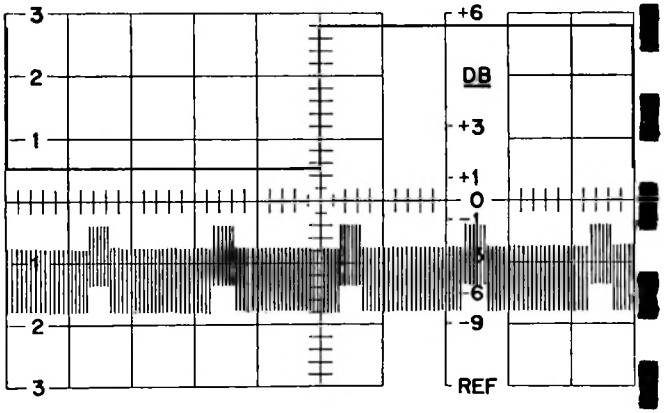



FIGURE 7. VOLTAGE CALIBRATOR AND HIGH-FREQUENCY TIME MARK OUTPUT

### VOLTAGE CALIBRATOR

The VOLTAGE CALIBRATOR (white markings) supplies reference voltages for amplitude measurements, from .01 to 50 volts. Since the calibrator multivibrator is syncronized with 1 kc time mark output, the time mark circuits always function when the voltage calibrator is on (CALIBRATOR MULT in an on position). However, trigger action continues normally because time mark pulses are not used for triggering unless the TIME MARK switch is on.

CALIBRATOR MULT. (red markings) selects the multiplying factor used with the setting of the VOLTAGE CALIBRATOR switch for the desired voltage output. (Read the preamplifier manuals for full instructions for amplitude measurements.)

### Z-AXIS INPUT

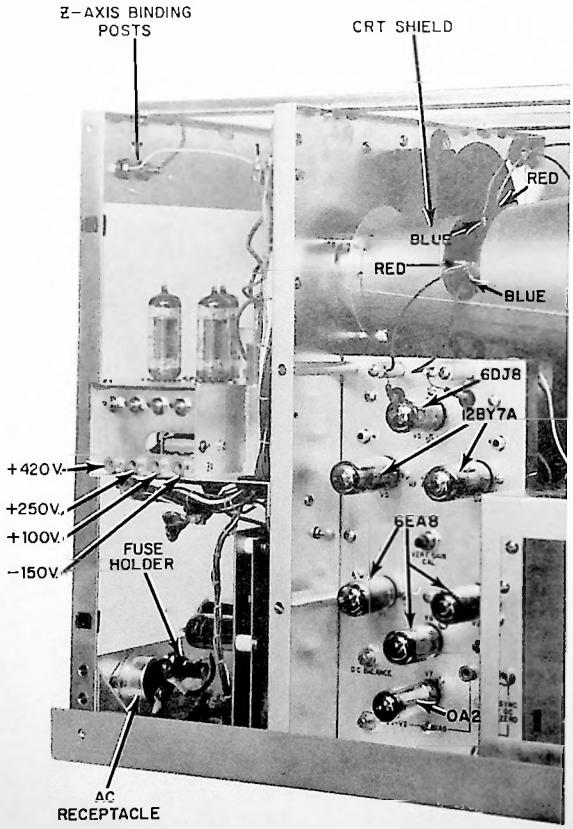
The Z-Axis input is located at the rear of the unit. The red binding post brings input to the cathode of the crt; the black binding post is connected to chassis ground.

This input provides a method of intensity modulation, thus adding a third variable. This is the equivalent of information along a third axis (vertical, horizontal and the Z-axis). ALWAYS KEEP THE Z-AXIS TIE BAR IN PLACE, ACROSS THE 2 BINDING POSTS, WHEN YOU ARE NOT USING THIS INPUT.

A 20,000 Ω/V (or better) meter is the only equipment needed to align your scope. The vertical amplifier is calibrated without the use of a preamp, by connecting the test plug prepared in Figure 1.

☐ Plug in the 16-terminal test plug, prepared as in Figure 1, to J-1 on the vertical amplifier.

☐ Turn your scope on and secure a trace as described under Operating Instructions. Allow at least 5 minutes warmup before making the following adjustments.




## LOW-VOLTAGE ADJUSTMENTS

Use a 20KΩ (or better) voltmeter for all voltage adjustments in your scope. Naturally, the accuracy of these adjustments will depend on the accuracy of your meter. Set your meter to read DC volts.

☐ Connect the positive meter lead to chassis ground. Insert the negative lead in the —150 volt test jack. Turn the —150 volt adjust (directly above the test jack) until the meter reads exactly —150 volts. Now remove the meter leads.

☐ Connect the negative meter lead to chassis ground and keep it there for the other low-voltage adjustments. Insert the positive meter lead in the +100 volt test jack. Turn the +100 volt adjustment (directly above the test jack) until the meter reads exactly +100 volts.

☐ Insert the positive meter lead in the +250 volt jack and set the +250 volt adjust for a meter reading of exactly +250 volts.

☐ Insert the positive meter lead in the +420 volt jack and set the +420 volt adjust for a meter reading of exactly +420 volts. Remove the meter leads.

## HIGH-VOLTAGE ADJUSTMENTS

CAUTION: High voltages are present. Do not touch any of the exposed wiring while the power is on. Use an insulated screwdriver to make all necessary adjustments.

☐ Turn the H.V. ADJUST (on the high voltage board) fully clockwise. Set INTENSITY at 10 o'clock.

☐ Turn the H.V. ADJUST slowly counterclockwise and set it at the point where the trace almost disappears.

### VERTICAL AMPLIFIER

#### V1-V2 BIAS

☐ Set your meter to read DC volts and ground the negative meter lead. Insert the positive meter lead in the test jack labeled V1-V2 BIAS on the vertical chassis. Adjust the BIAS screwdriver control (lower left corner) for +10 volts DC meter reading. Remove the positive meter lead.

#### DC BALANCE

☐ Turn the DC BALANCE screwdriver control to center the trace on the horizontal center line of the graticule.

#### SYNC DC ZERO

☐ Plug the positive meter lead into the SYNC DC ZERO test jack and adjust the control for a meter reading of 0 volts.

☐ Recheck the V1-V2 BIAS reading. If necessary reset to +10 volts DC.

#### VERT. GAIN CAL.

☐ Adjust VERT. GAIN CAL. for 4 cm deflection on the graticule. Use the DC BALANCE control, if necessary, to center the trace.

☐ Repeat the DC BALANCE (vertical centering) adjustment if this setting was disturbed during VERT. GAIN calibration. HF PEAKING will be adjusted later.

## HORIZONTAL ASSEMBLY

Adjust the screwdriver controls on the horizontal assembly control panel as follows:

### GATE ADJUST

☐ Pull V-27 out of its socket. The voltage at TEST POINT 4 near V-29 should now read 0 volts. (Readings other than zero indicate a condition which must be corrected before alignment can proceed).

☐ Also pull V-29 from its socket. Turn the GATE ADJUST control until the voltage at TEST POINT 4 reads +20 volts DC. Now replace V-27 and V-29.

### STABILITY RANGE

☐ Advance front panel controls INTENSITY and STABILITY to about 2 o'clock. Turn STABILITY RANGE clockwise until a trace is just obtained. Now turn STABILITY RANGE counterclockwise until the trace just turns off. This is the setting for proper trigger sensitivity.

### SWEEP START

Set for a reading of —35 volts DC at TEST POINT 5, the junction of R-184 (10K, 1 watt) and R-183 (6.8K, ½ watt).

### TRIGGER ADJUST

☐ Turn TRIGGER ADJUST fully CCW (counterclockwise).

☐ Set front panel controls as follows:

| | |
|---|---|
| TRIGGER LEVEL | Center of range |
| TRIGGER INPUT | INT AC |
| AMPLIFIER GAIN | INT X1 |
| POSITION | center of range |
| STABILITY | about 2 o'clock- as needed to obtain trace |
| TIME/CM | 100 microsec |

☐ Measure voltage between the plates of V-25A and B at posts XX and YY. Set TRIGGER LEVEL (front panel) until this voltage reads zero. (Alternate method: measure from XX to ground, then YY to ground. Adjust TRIGGER LEVEL until both readings are equal).

☐ Switch TRIGGER INPUT to LINE. Turn STABILITY counterclockwise until the trace blanks out. Turn TRIGGER ADJUST (screwdriver control) until trace just comes back. Note this position of the screwdriver slot. Now continue turning until trace blanks out again and note this position of the screwdriver slot. Halfway between these 2 positions is the approximate setting for the control. A finer adjustment will be made later.

### SWEEP CALIB.

☐ Set at the approximate center of range.

GAIN ADJUST (R-222, between V-32 and V-33 on small horizontal board).

☐ Set for a trace about 11 cm long (½ cm beyond each edge of the graticule).

## CALIBRATION OF THE SWEEP

### TIME MARK SYNC

☐ Read the voltage at TEST POINT 3 (pin 2 of V-26). Take 2 readings: first, with the front-panel TIME MARK switch OFF; then at 10 microsec. Adjust TIME MARK SYNC until these readings are the same for TIME MARK OFF or ON.

☐ Adjust R-272, 100KC adjust on the large board, for most stable trace.

☐ Set front panel controls as follows:

| | |
|---|---|
| TIME MARK | 10 microsec |
| TIME/CM | 10 microsec |
| TIME MULT | X1-10 |
| AMPLIFIER GAIN | INT X20 |
| POSITION | As needed to center trace |

Adjust VARIABLE (under TIME/CM) for 4 cm per marker (blanked spot on the trace every 4 cm). Use the leading edge of each marker for greatest accuracy.

### EXPAND ADJUST

☐ Switch AMPLIFIER GAIN to INT X5. (Other controls remain the same). Set EXPAND ADJUST, R-215 on the lower board, for 1 cm per marker, as shown in Figure 8.

### GAIN ADJUST

☐ Switch AMPLIFIER GAIN to INT X1. Set the GAIN ADJUST, R-222 on the upper board, for 10½ to 11 cm width of the trace.

### SWEEP CALIB.

☐ Switch TIME MULT to X1. Other controls remain as in the above step. Now adjust SWEEP CALIB., a screwdriver control on the control panel of the lower board, for 1 cm per marker, as shown in Figure 8.

☐ Turn TIME/CM to 1 microsec, TIME MULT to X5, AMPLIFIER GAIN to INT X1. Adjust C-77, the trimmer on the SWEEP TIMING switch board, to align 1 marker at every other vertical line (markers 2 cm. apart).

### SWEEP START

☐ Reset after the sweep is calibrated. Turn AMPLIFIER GAIN to EXT X1. Set the POSITION control at the center of its range. Now adjust SWEEP START so that the sweep starts at the first vertical line at the left of the graticule.

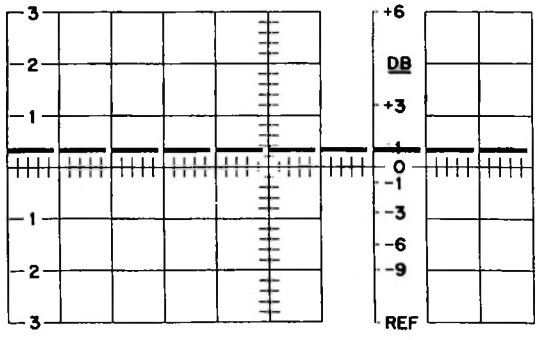



**FIGURE 8. ONE TIME MARK PER CM**

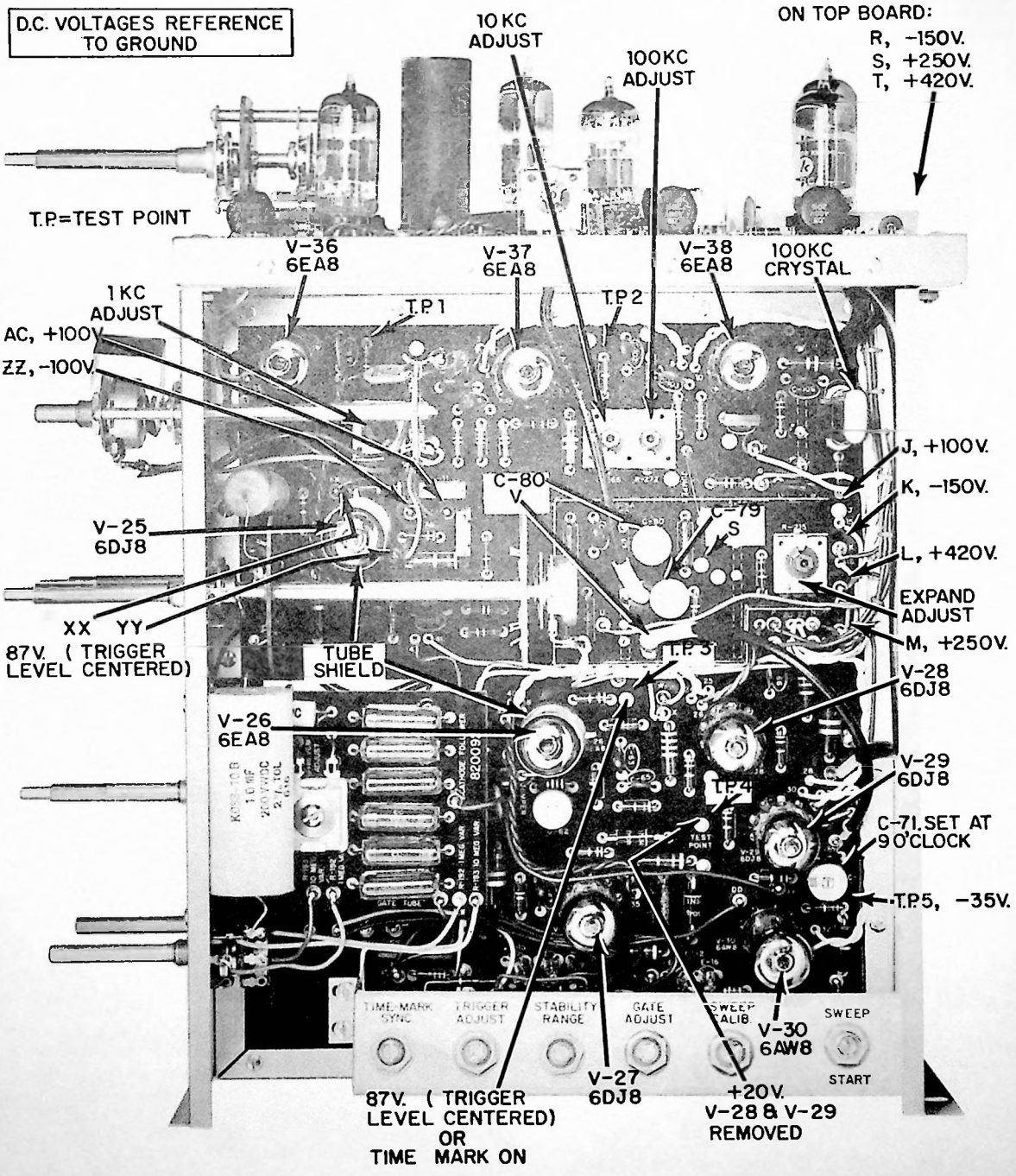



FIGURE 9. TUBES AND CALIBRATION POINTS ON LOWER BOARD

## CALIBRATION AFTER PREAMP IS INSTALLED

☐ Remove the test plug from J-1, the 16-pin input connector of the vertical amplifier. Plug in your preamp (dual trace or wide band) after it has been built and checked according to your preamp manual. Allow a warmup period of 15 minutes or more.

### ALIGNING THE TIME MARKER

☐ Set front panel controls: TIME MARK at OFF, TIME/CM at 10 microsec, TIME MULT at X2, VOLTAGE CALIBRATOR MULT at X10, TRIGGER INPUT at INT AC.

#### 10 KC ADJUST, R-265

☐ Place the test lead from the Scope Preamp on TEST POINT 2 (near V-37). Adjust front panel TRIGGER LEVEL and STABILITY to obtain a trace as shown below.
Set R-265, the 10KC adjust on the large board for 10 counts for each count-down period.

#### 1 KC ADJUST, R-258

☐ With front panel controls as above, except TIME/CM at 100 microsec,, place the test lead on TEST POINT 1 (near V-36). Set R-258, the 1KC adjust, for 10 counts.

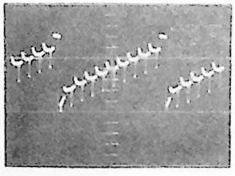


FIGURE 10.
10:1 COUNT DOWN

### ADJUSTING THE VOLTAGE CALIBRATOR

#### SYMMETRY (R-251 on small board).

☐ Connect the test lead to the CALIBRATOR OUT jack. Set TIME/CM to 100 microsec, TIME MULT to X1.

Adjust SYMMETRY for a 50% duty cycle. Figure 12 illustrates the correct adjustment and Figure 11 shows an incorrect adjustment of this control. After the adjustment is correct, remove the test lead from CALIBRATOR OUT jack.

#### CAL. ADJUST (R-242 on the small board).

☐ Set front panel VOLTAGE CALIBRATOR to 5, CALIBRATOR MULT to X10. Temporarily connect a short wire jumper between pin 1 of V-35, at R-247 (3.3K, 1 watt) and R-248) 470 K resistor, on the small board.

☐ Turn the CAL. ADJUST for a meter reading of +50 volts DC at the CALIBRATOR OUT jack (negative meter lead grounded). Use a long screwdriver, carefully inserted between the wafers of the voltage calibrator switch, to make this adjustment.

### ADJUSTING THE TRIMMERS

The trimmers in the horizontal attenuator are adjusted for proper compensation as follows:

#### C-79

☐ Set the front panel controls as follows: TIME MARK, OFF; AMPLIFIER GAIN, EXT. X1; EXT. SIG. GAIN, fully clockwise; STABILITY, fully counterclockwise. Preamp V/CM at 2 V/CM (inner knob fully clockwise). Set the VOLTAGE CALIBRATOR for 10 volts output. Connect CALIBRATOR OUT to one preamp input. Also connect CALIBRATOR OUT to post S of the large board.

☐ Adjust C-79 for correct compensation, as shown in Figure 14. Notice that the trace for correct compensation makes as small an angle as possible, entering both intense points of light, without actually crossing over. Figure 13 shows insufficient compensation, with the trace making a relatively broad arc at each intense point, rather than a narrow angle.

#### C-80

☐ Use the same test setup as for C-79, except set AMPLIFIER GAIN at INT X1, preamp at 10V/CM and connect the CALIBRATOR OUT to a preamp input and to post V of the large board. Adjust C-80 in the same way as C-79, for a trace with the sharpest convergence at each end, without crossover.

#### C-81

☐ Set C-81 to 9 o'clock.

### TRIGGER ADJUST

☐ Set AMPLIFIER GAIN at INT X1, TRIGGER INPUT to PRE-SET, and TRIGGER LEVEL midway. Turn STABILITY counterclockwise until the sweep just turns off.

☐ Turn VOLTAGE CALIBRATOR to 1 volt and V/CM control of the preamp to 1 volt. Connect CALIBRATOR OUT to the preamp input and observe that the sweep has turned on again.

☐ Reduce VOLTAGE CALIBRATOR setting until sweep is just lost. Readjust TRIGGER ADJUST (screwdriver control on the horizontal control panel) until sweep turns on again. Continue to reduce VOLTAGE CALIBRATOR setting and readjust TRIGGER ADJUST until no further improvement of sensitivity takes place. Sensitivity of the TRIGGER PRE-SET position is now properly adjusted.

### VERTICAL ADJUSTMENTS

☐ Set the POSITION control of the preamp at the center of its range. (If you are using the dual-trace preamp, adjust the POSITION control on the preamp for minimum shift of the trace as the preamp POLARITY control is switched.) Now adjust DC BALANCE, on the vertical chassis, to center the trace.

☐ Turn HF PEAKING (on the vertical chassis) fully counterclockwise. If a pulse of fast rise time is available, feed it into the preamp and adjust HF peaking for minimum overshoot. Note that in the fully clockwise position of VERT GAIN CAL, HF PEAKING has least effect.

☐ After approximately 40 hours operating time, repeat the complete calibration procedure. The calibration should now hold for a considerable period of time.

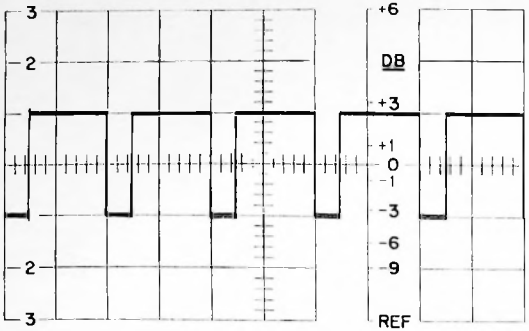



FIGURE 11. INCORRECT SYMMETRY ADJUSTMENT

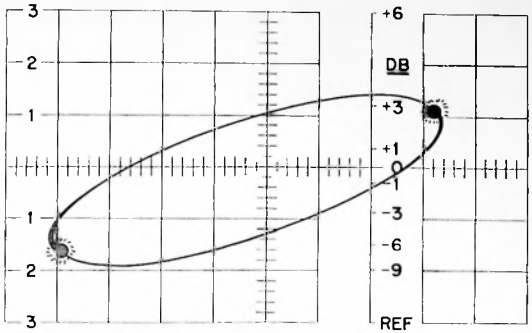



FIGURE 13. INCORRECT COMPENSATION

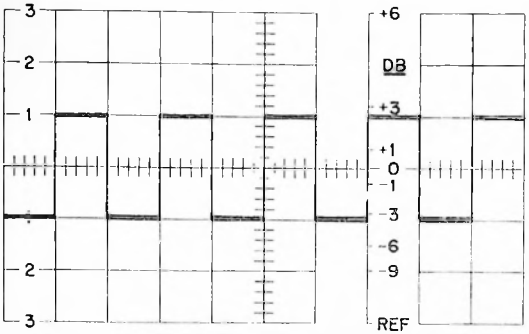



FIGURE 12. CORRECT SYMMETRY ADJUSTMENT

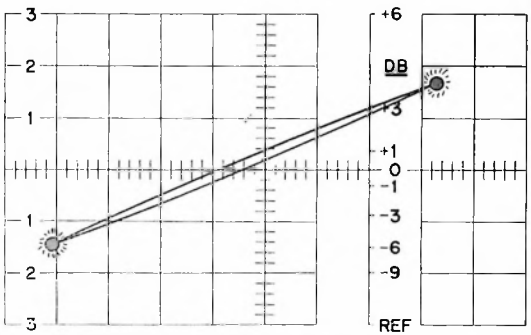



FIGURE 14. CORRECT COMPENSATION

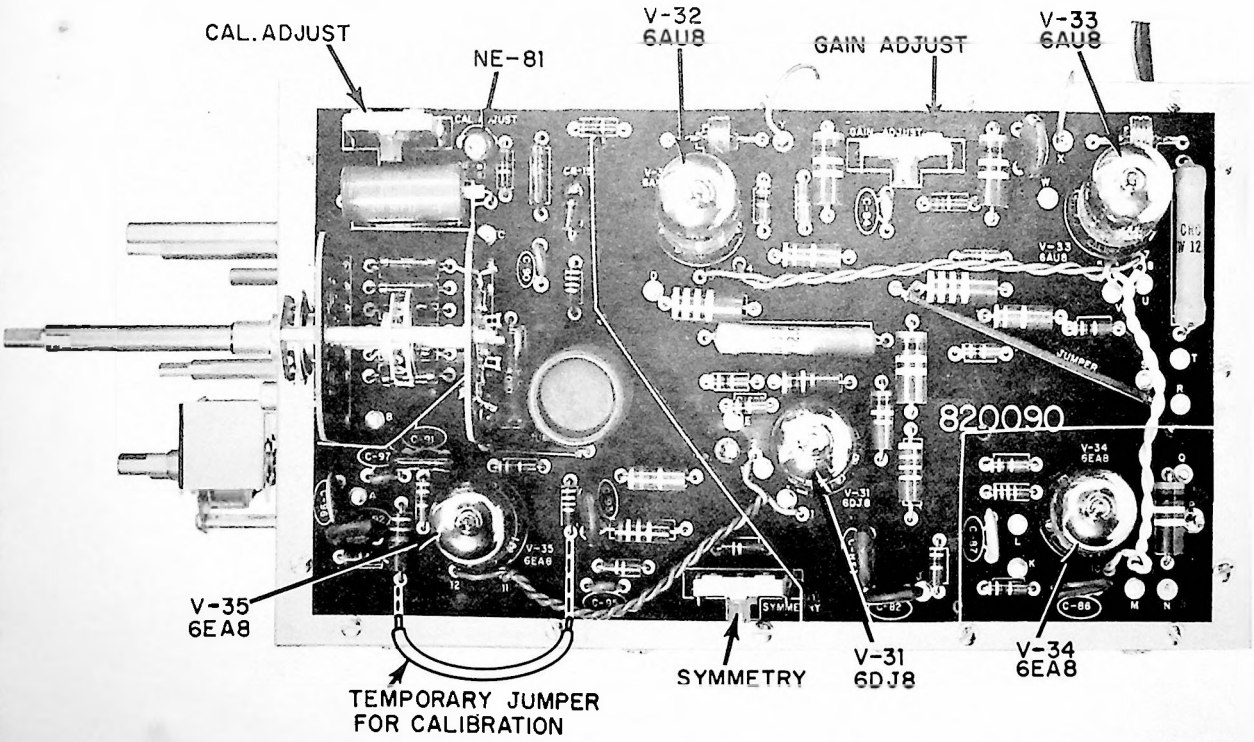



FIGURE 15. TUBES AND CALIBRATION POINTS ON THE UPPER BOARD

## ROUTINE MAINTENANCE

**Ventilation.** A very efficient fan, air filters and a ventilated cabinet assure proper air cooling of the scope. To assure maximum component life, place the instrument where air can freely flow around the cabinet. Never obstruct the vents or other air openings.

About every 3 months, or sooner if conditions warrant, remove the vent filters and clean under running water. Follow the manufacturer's directions for fan lubrication (some models have sealed, lifetime oiled, bearings).

**Relay.** Blow out any dust accumulated between the relay contacts. The exhaust of a vacuum cleaner is fine for this purpose. Clean the contacts by pulling a piece of brown Kraft paper between them while you *gently* close the contacts by placing your finger on top of the relay.

**Visual Inspection.** It is a good idea to make a careful visual check of all sections of the scope at the time you remove the cabinet sides to clean the air filters. Check for loose connections, tubes and tube shields not properly seated, broken terminals or signs of overheating. If there is any indication of overheating, do not put the scope back in operation until the condition causing the overheating has been corrected.

**Line Voltage.** If your line voltage measures between 110-120 volts (60 cycle AC only) the correct taps on the primary of the power transformer are connected. However, if your line voltage measures below 110 volts, move the tap to terminal 3 of TS-13, as shown in Figure 16. If your line voltage measures 120 to 130 volts, move the tap to terminal 1 of TS-13.

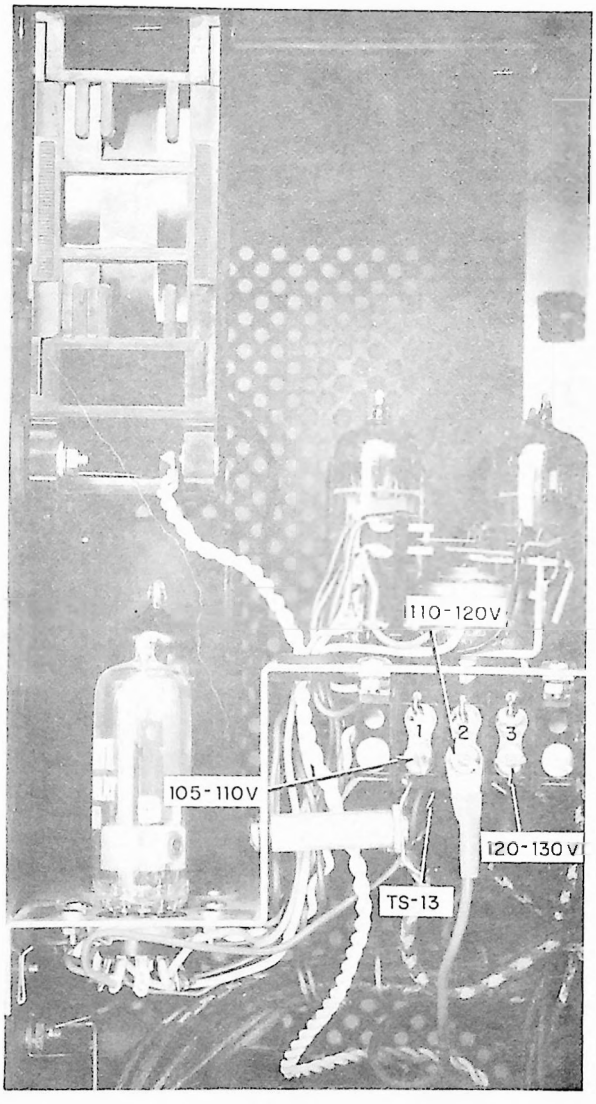



FIGURE 16. PRIMARY TAPS

## REMOVING THE CABINET

For easy accessibility, the cabinet is designed so that either side can be removed separately. Simply remove the truss-cross screw in each corner; slide the side forward to disengage the top and bottom tabs; then remove the side. When replacing a side, be sure that the air filter is at the bottom of the side.

The top of the cabinet is held in position by the handles and 4 screws at the sides. The handles are easily removed by unscrewing the thumb nuts and are replaced as shown in Figure 18B. To remove the rear panel, first remove the tie-bar across the Z-axis binding posts.

When the rear panel is replaced, be sure to put this shorting bar back in place because noise or hum may be picked up if the Z-axis input is left open.

NOTES FOR FIGURE 18.
ALL MEASUREMENTS MADE WITH A 20,000 Ω/V METER. RESISTANCE CHECKS MADE WITH REFERENCE TO GROUND, NO PREAMP OR TEST PLUG INSTALLED. VOLTAGE CHECKS MADE WITH PREAMP OR TEST PLUG INSTALLED.
*Reading may momentarily drop to low value and then should read greater than value shown.
†Reading changes when ohmmeter leads are reversed.
TOLERANCES: ±5% for voltages at J-17. Others not marked ±5% are ±10%.

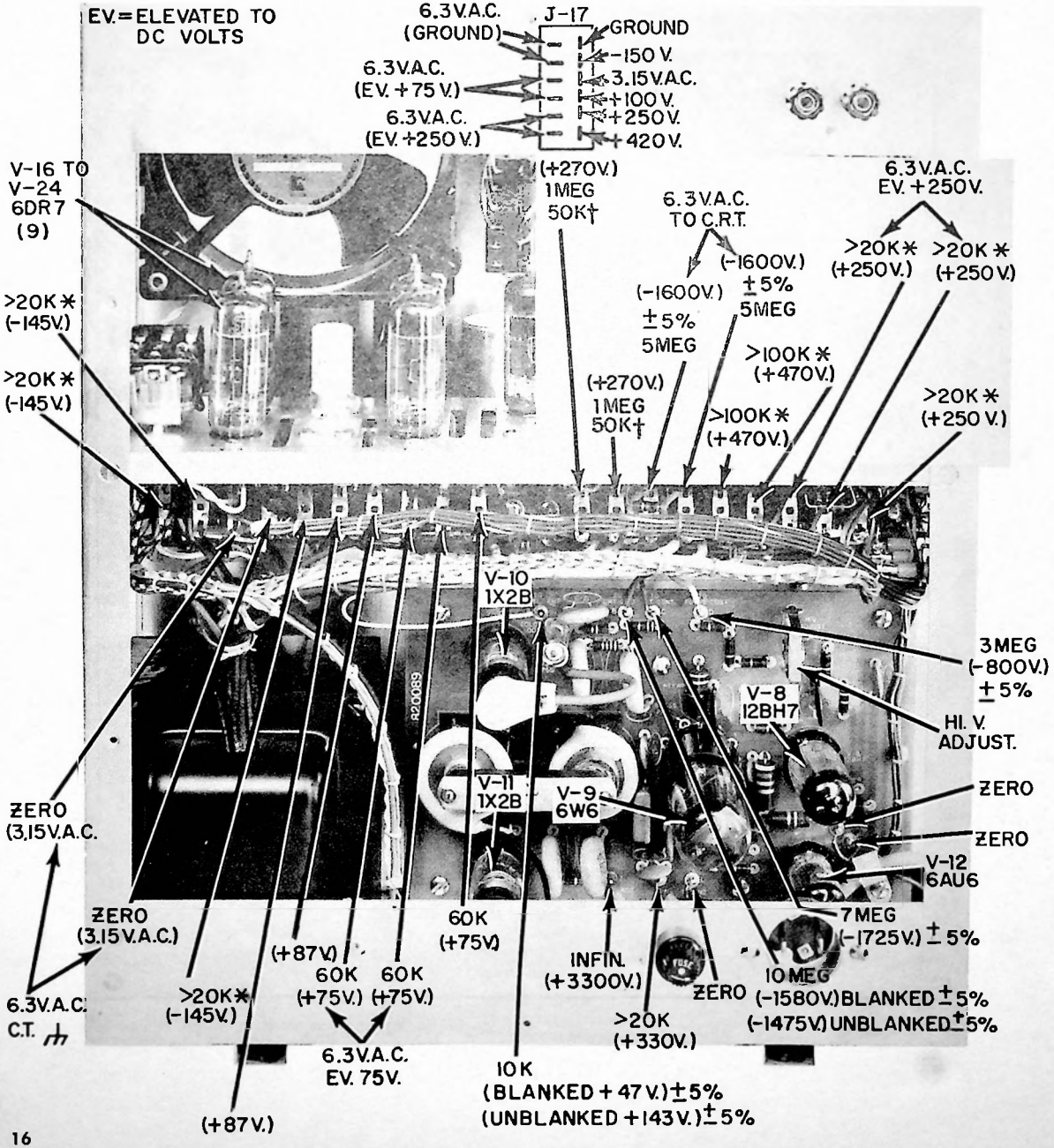



FIGURE 17. POWER SUPPLY VOLTAGES AND RESISTANCES

## TROUBLESHOOTING

The circuit descriptions, and the functional and schematic diagrams showing voltages and waveforms, contain the most essential information for troubleshooting. At the end of this section additional troubleshooting aids are provided, including voltage and resistance readings, and foil side views of the 3 printed circuit boards showing component connections. An outline of suggested troubleshooting procedure follows:

Make sure that the trouble is in the scope itself, before you begin to troubleshoot. First check the operating controls, and attempt to obtain a trace, as outlined in the Operating Instructions. Then eliminate the possibility that the trouble is in the plug-in preamp. Plugging in another preamp, one that you know is working, is the quickest way of eliminating the preamp as the source of your trouble.

### POWER SUPPLY

The first step in troubleshooting is to check the power supply, starting with the low-voltage chassis. Remove the sides of the cabinet, then turn the power on. The pilot light on the front panel should light and all tube filaments should light. If a group of tubes in any section does not light, or the plate of V-9, the 6W6 on the high voltage board glows red, TURN THE POWER OFF IMMEDIATELY.

If all tubes light and after a 45 second delay the NE-2 neons glow steadily, measure the voltages at the 4 test jacks on the low-voltage chassis. If all voltages are correct, or can be accurately set with the controls over the jacks, the low-voltage power supply is working properly. On the high-voltage power supply board, a red-orange glow near the base of V-10 and V-11 (the 1X2B rectifiers), shows the high voltage oscillator is operating. V-13, the 1750 volt regulator, will not have a visible glow.

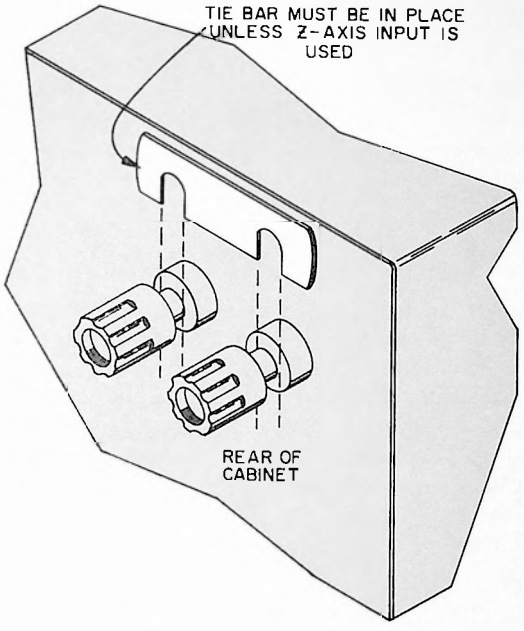



FIGURE 18A. TIE BAR FOR THE Z-AXIS INPUTS

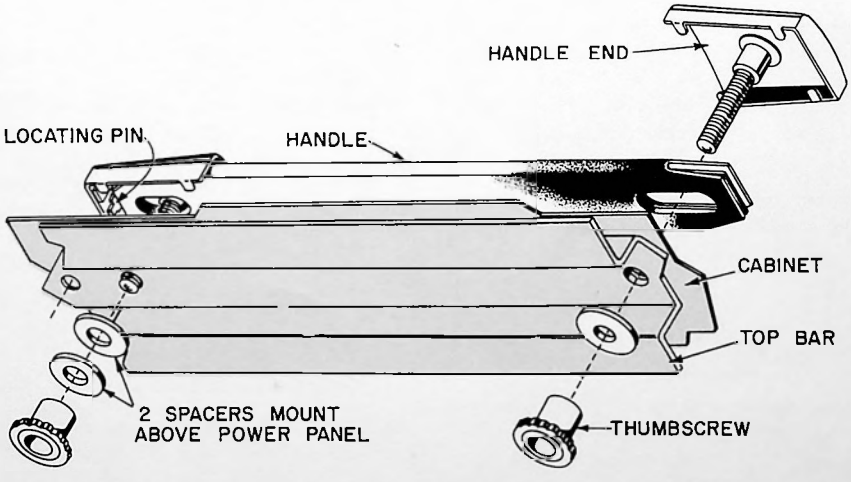



FIGURE 18B. DETAIL OF HANDLE ASSEMBLY

MAINTENANCE

| SYMPTOM | SERVICE PROCEDURE |
|---|---|
| Fuse blown (No pilot light or fan operation with Power ON). | Replace with good fuse. If fuse blows again, check for shorts in the wiring of the primary taps (TS-13), filament windings, fan, silicon diodes or input filter capacitors. |
| Filaments of a group of tubes not lit. | TURN POWER OFF IMMEDIATELY. Check the low-voltage power supply schematic to see what group of tubes is connected to the filament winding in question. Check the filament wiring for continuity or short circuits. |
| Relay fails to close in 45 seconds after power is on. (Click not heard and neons do not glow after 45 seconds.) | V-14, the 6N045T delay tube may be defective. Check filaments of V-14 for continuity and inspect contacts visually. Replace if indicated. This check assumes that the plug-in connector of the preamp is not defective, because the V-14 heater circuit is closed by a jumper between pins 5 and 10 of the connector. |
| No delay period after power comes on. Neons glow immediately, after application of power. | TURN POWER OFF to prevent damage. Check the relay for contacts welded or stuck together, or wiring shorts. |
| NE-2 neon flickers; fails to glow steadily. | Place a known good NE-2 neon across the intermittent lamp. If it glows steadily, replace the flickering lamp. |
| Intermittent operation or no output at any one of the B+ supplies. | Check the 1-watt fuse resistors (R-76, 77 or 78), for cracking or other heat damage. Replace. |
| Output at Test Jack 4 cannot be adjusted to −150 volts. | Measure voltages as shown on schematic. Check V-15, V-22, V-23, V-24, the neon regulators and filter capacitors C-31 and C-32. |
| NOTE: If the −150 voltage cannot be set, it is not possible to adjust the other outputs. | |
| No output, or low output at J-5, the +100 v. jack. Below normal outputs at J-6 and J-7. | Disconnect power. Read resistance across J-5. If resistance reads low, disconnect vertical and horizontal power plugs (P-15 and P-17) from the power panel.<br>If resistance across J-5 is still low, the trouble is in the +100 volt circuit itself. Check filter capacitors and associated components, especially silicon diodes CR-9 to CR-11. However if resistance is now high, plug in P-15, the horizontal power plug and measure resistance at J-5 to determine whether the trouble is in the horizontal or the vertical section. |
| +250 volt output very low; +420 volt output below normal though −150 volt and +100 volt are normal. | Read resistance across J-6. If low, disconnect P-15 and P-17. If still low, check the +250 circuit, especially silicon diodes CR-5 to CR-8, and the filter capacitors for shorts or leakage. If unplugging P-15 and P-17 brings the resistance across J-6 up to normal, isolate the trouble to the horizontal or vertical section. |
| +420 volt output low; other outputs normal. | Read resistance across J-7 and follow a procedure similar to the above. |

## HIGH-VOLTAGE POWER SUPPLY AND CRT

| SYMPTOM | SERVICE PROCEDURE |
|---|---|
| Plate of 6W6 (V-9) glows red. | Turn power off immediately. The tube is not oscillating and may be damaged and may also damage R-103 in the low-voltage supply. Check tubes and circuits of 6W6, 6AU6 and 12BH7. Check for shorts in the post-accelerator circuit. Check C-17, C-18, C-19 and C-20 for shorts or leakage. C-15, .005 $\mu$f, may be open or leaky. |
| No high-voltage. V-10 and V-11 do not glow; plate of V-9 may glow red. | Turn power off immediately. Read above procedure. Also check the INTENSITY and FOCUS control circuits for shorts. Check the V-10 and V-11 tubes. |
| HIGH-VOLTAGE ADJUST has no effect. | Check the control and the V-12 and V-8 tubes and circuits. |
| High voltage low. | Check the HIGH VOLTAGE ADJUST control — sliding contact may be open. |
| High voltage present, but no spot visible on crt. | Check pins 1 and 12 of the crt for filament continuity. Check POSITION control settings. |
| NOTE: Normal B+ drain of the high-voltage power supply is 55 to 70 ma. | |

## VERTICAL SECTION

If power supply voltages are normal but vertical deflection is absent, check the vertical amplifier. The vertical deflection lamps are useful indicators for troubleshooting the vertical amplifier.

| SYMPTOM | SERVICE PROCEDURE |
|---|---|
| FILAMENTS of V-3, V-4, V-5, V-6 are on but V-1 and V-2 are off (or vice versa). | TURN POWER OFF IMMEDIATELY. Check the filament wiring of the tubes not on for shorts or opens. |
| No vertical deflection. Both deflection lights lit. | Check the 6DJ8 (V-5) tube and its circuit. |
| No vertical deflection and E-2, the deflection lamp pointing up, is lit while E-1 is not lit. | Check circuits of V-2, and V-4. |
| No vertical deflection and E-1, the deflection lamp pointing down, is lit while E-2 is not lit. | Check the circuits of V-1 and V-3. |
| No vertical deflection and neither of the 2 deflection lamps is lit. | Check V-3 and V-4, the 12BY7A tubes and circuits Also V-1 and V-2. |
| V-7, the OA-2 does not glow. | Check V-6 and the V-6 circuit. |

## HORIZONTAL CIRCUITS

### CALIBRATORS

The voltage calibrator and time mark circuits can be checked with the scope itself by turning the VOLTAGE CALIBRATOR on. Then use the scope probe to check each stage visually.

### SWEEP CIRCUIT

Since feedback is employed in the sweep circuit, the sections of this circuit are interdependent. If sweep is absent, the first step is to check out the power supplies, the crt and the horizontal amplifier, then work back to the sweep. To isolate the stages responsible for loss of sweep, proceed as follows:

| CAUSE | SERVICE PROCEDURE |
|---|---|
| No sweep or spot | ☐ Turn INTENSITY fully clockwise, AMPLIFIER GAIN at EXT X10. Make sure vertical output is balanced by adjusting the POSITION control on the preamp for vertical centering (both deflection lamps off). This procedure eliminates the possibility that the spot or trace has been deflected off the screen by vertical unbalance. |

| SYMPTOM | SERVICE PROCEDURE |
|---|---|
| No sweep or spot (continued) | ☐ Turn the horizontal POSITION control through its entire range until a spot is visible. If no spot is visible for the entire range of this control, make sure the trouble is not in the POSITION control as follows:<br>☐ Measure voltage at J on the top board. Turn horizontal POSITION until this voltage reads O v. DC. If the POSITION control cannot bring this voltage to zero, inspect R-194, R-195, R-197, R-199 and replace if indicated.<br>☐ If there still is no spot, the trouble is probably in the power supplies, the crt or the deflection amplifier tubes V-32 and V-33. Check the 2 tubes. Then check the voltages at the 4 test jacks of the low voltage power supply and make the other checks outlined in servicing of the low and the high voltage power supplies. |
| Spot visible but no sweep | ☐ Set AMPLIFIER GAIN at INT X1, TIME/CM to 100 microsec, TIME MARK off, and STABILITY fully clockwise. (Other front panel controls not important.) Now turn STABILITY RANGE, a screwdriver control on the horizontal chassis, through its entire range to see if a trace can be obtained. If there still is no sweep, return STABILITY RANGE to the middle of its rotation.<br>☐ Switch AMPLIFIER GAIN to EXT X10 and feed a signal into the EXT SIGNAL input at the front panel. If horizontal deflection is present, the horizontal amplifier is functioning and the trouble must be elsewhere.<br>☐ Recheck all preset voltages, starting with the low-voltage power supply adjusts, as outlined in the Calibration Instructions. Make any indicated adjustments.<br>☐ Check the V-27, 28, 29, and 30 tubes or substitute good tubes. Check CR-14.<br>☐ Check voltages at tube sockets for V-27, 28, 29 and 30, as shown on the sweep circuit schematic. Voltages which deviate more than 10% from those given on the schematic should be investigated. |

| SYMPTOM | SERVICE PROCEDURE |
|---|---|
| Retrace visible (No Blanking) | ☐ Check setting of INTENSITY control.<br>☐ Check the unblanking circuits, tubes V-29 (lower board) and V-34 (upper board).<br>☐ Check setting of the H.V. Adjust on the high voltage board. See the Calibration Instructions and readjust accordingly.<br>☐ Set TIME/CM switch to 100 millisec, and advance STABILITY control for sweep. Measure CRT grid voltage (Point "B" on H.V. board.) The voltage should be about −1450 v during sweep, and −1520 volts during retrace (use 20KΩ/volt meter).<br>☐ Measure voltage at point A on H.V. board with same sweep conditions as above. Voltage during sweep should be about 200, dropping to about 50 volts during retrace. The exact voltage is not critical, as long as a *minimum* ratio of 3 to 1 is maintained.<br>☐ Measure voltage at point K on the top board with the same sweep conditions. Voltage should be about 200 v during sweep, and about 50 v during retrace.<br>☐ Check setting of GATE ADJUST control as outlined in the Calibration section. |
| Lack of Triggering (sweep present) | ☐ Turn on TIME MARK and try to obtain a stable marker pattern. If no sync, check V-26 and associated circuitry.<br>☐ Turn TRIGGER INPUT switch to LINE. Measure voltage at point AB on the top board, near V-25, and set to 0 volts with TRIGGER LEVEL control. Advance STABILITY control for trace; then back off until trace just stops. Turn TRIGGER ADJUST control on lower board control panel, attempting to get a trigger action.<br>☐ If sychronization with time-mark information occurs, but still no internal triggering, check V-25 and associated circuitry.<br>☐ Check V-6 and V-7 on vertical amplifier chassis.<br>☐ Check sync cable connections between Vertical chassis and Horizontal section at the rear panel of the horizontal. |

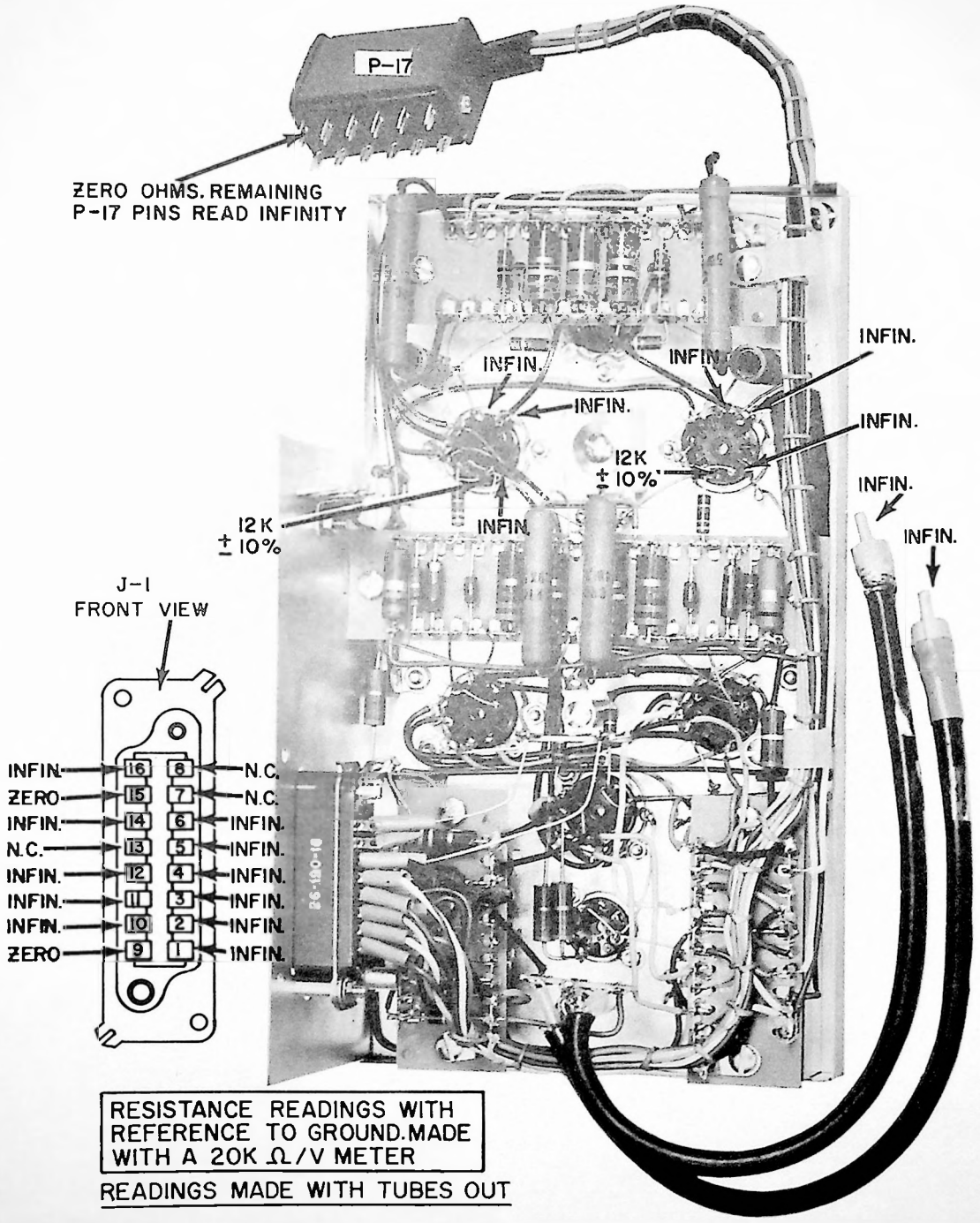



FIGURE 19. RESISTANCE READINGS ON VERTICAL CHASSIS

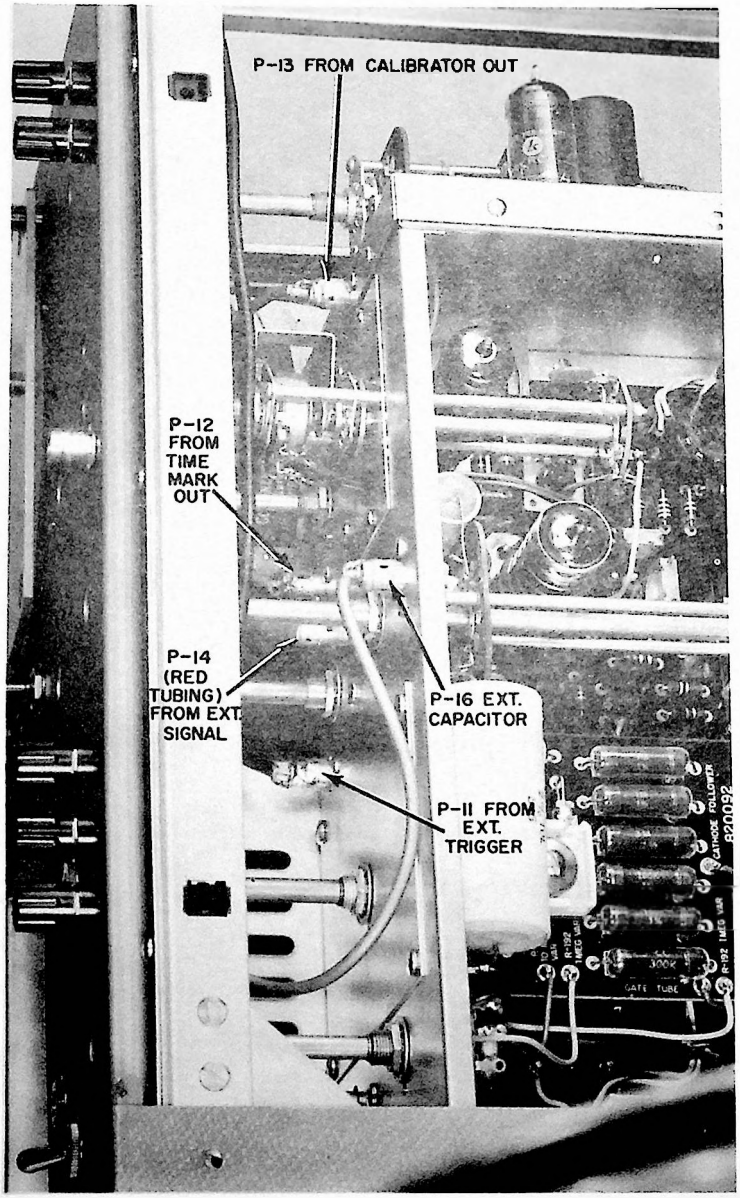



FIGURE 20. FRONT PANEL CONNECTIONS TO THE HORIZONTAL CHASSIS

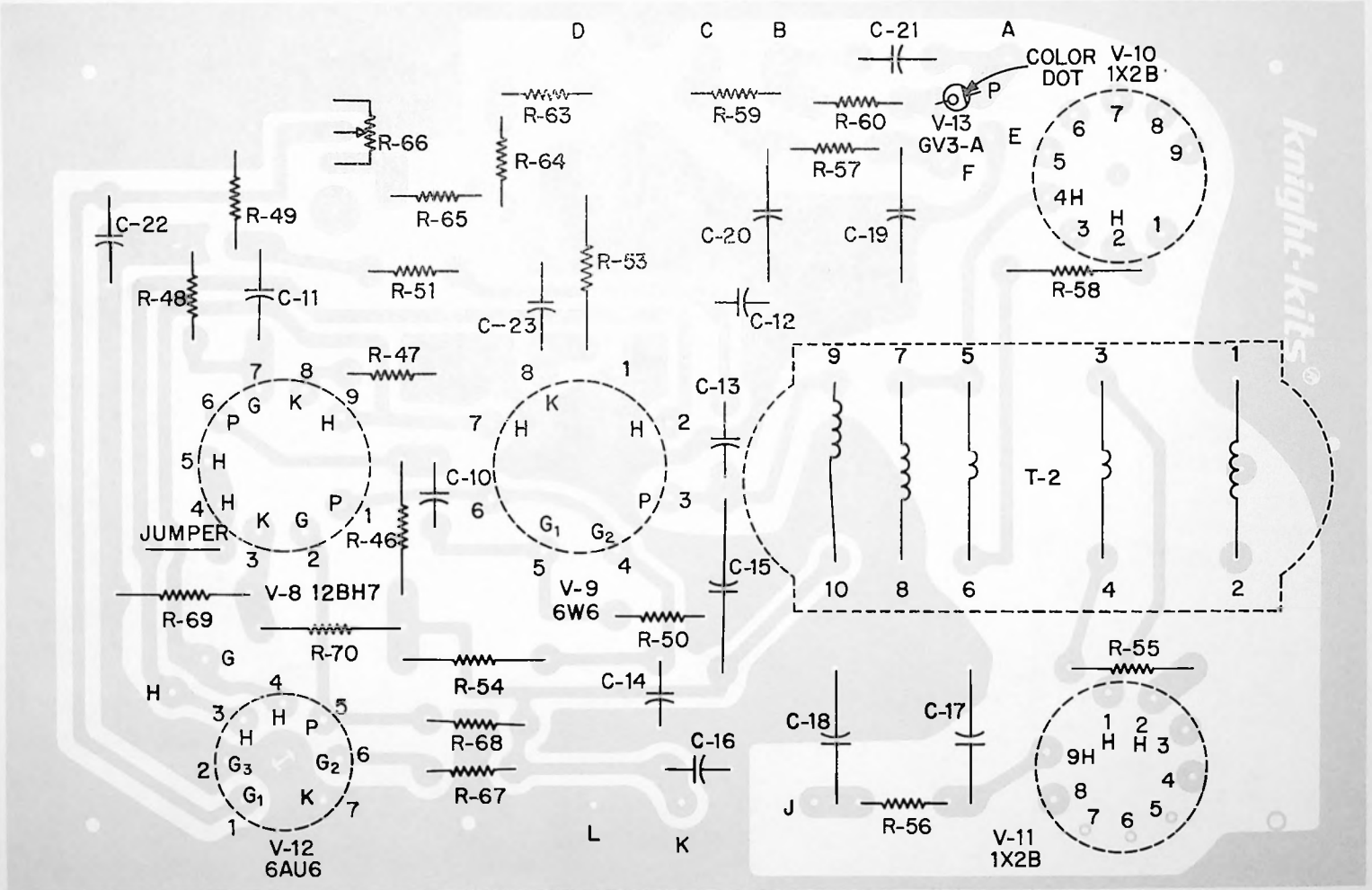



FIGURE 21. H. V. BOARD, FOIL SIDE

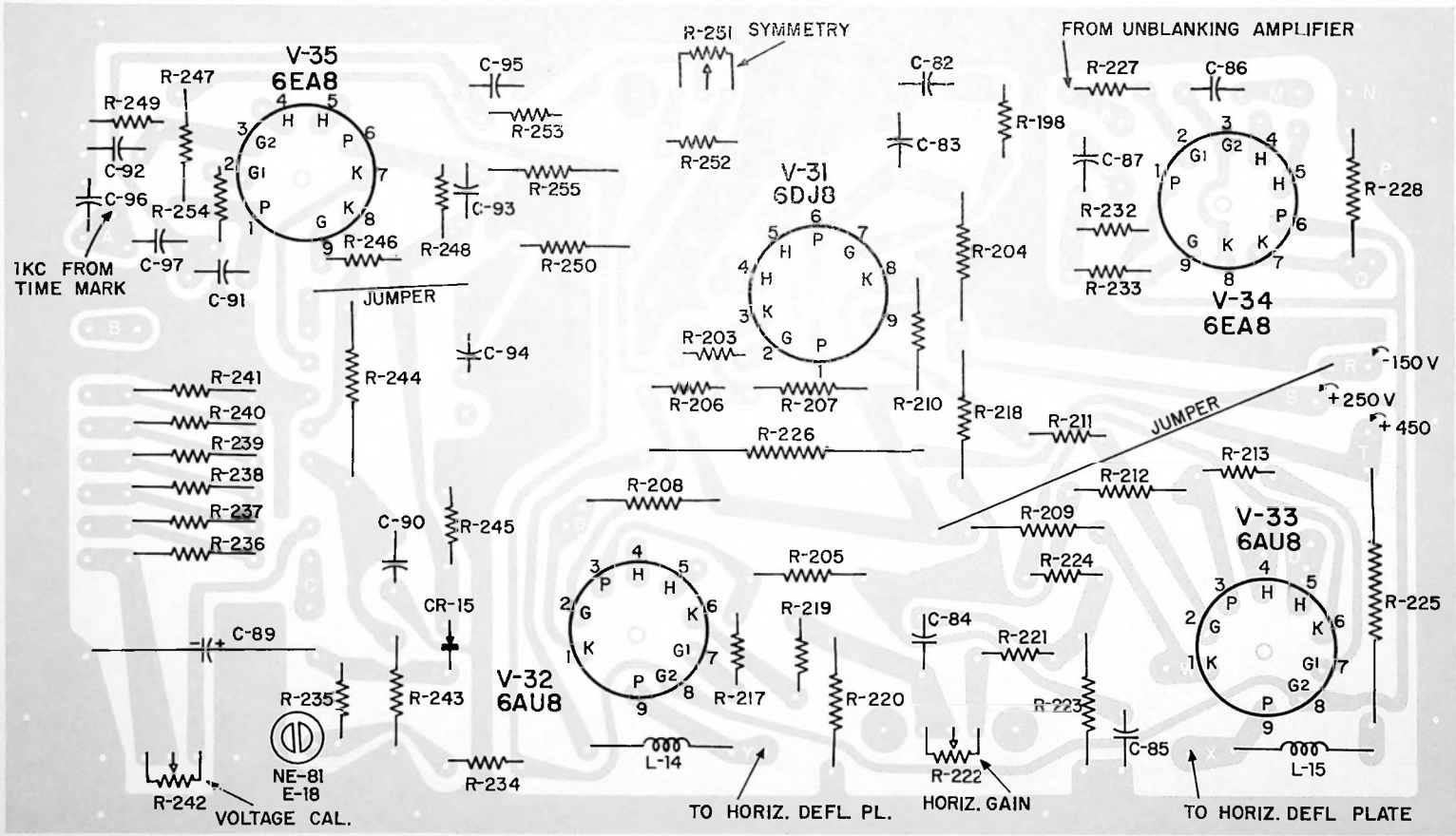



FIGURE 22. TOP BOARD, FOIL SIDE

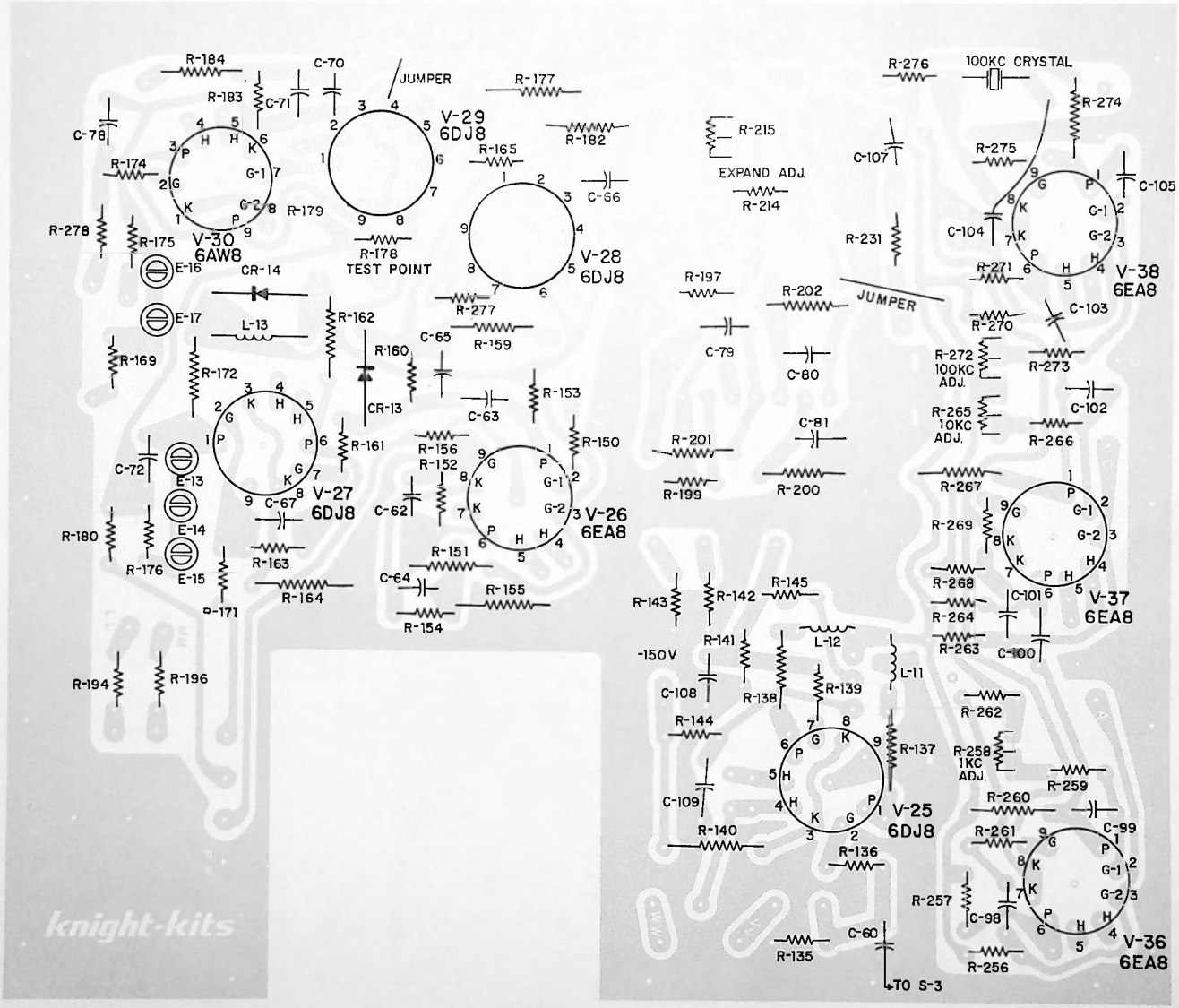
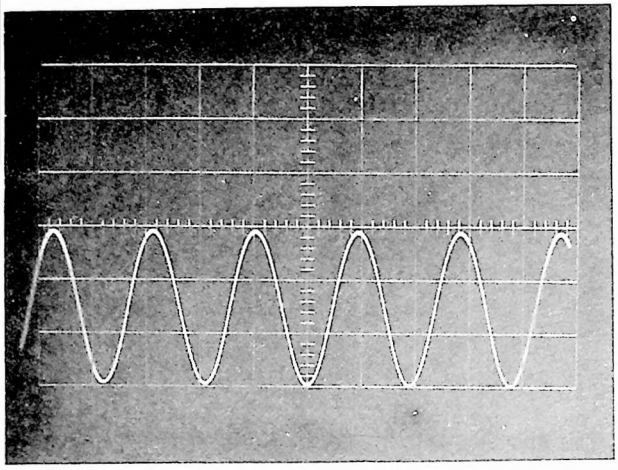
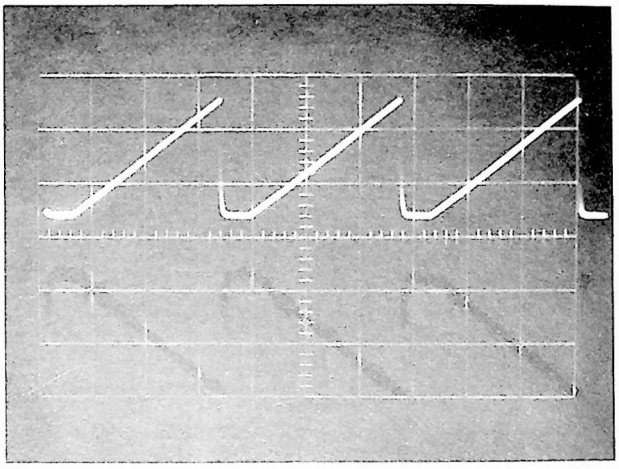


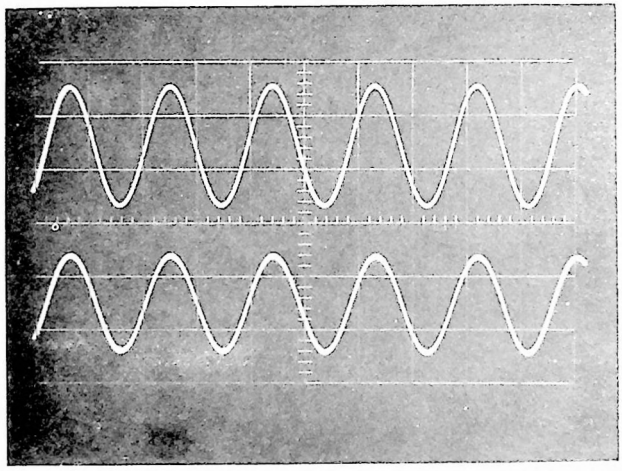

FIGURE 23. LOWER BOARD, FOIL SIDE



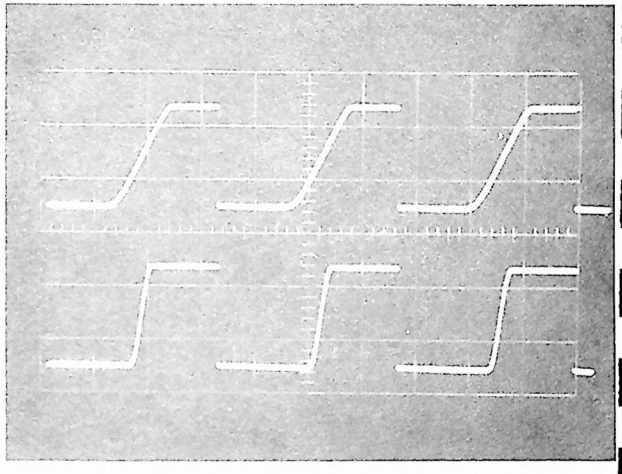
SYNC DC ZERO Test Jack. Output of V-6, Sync Amplifier. (6 cm deflection on crt). 2 v/cm



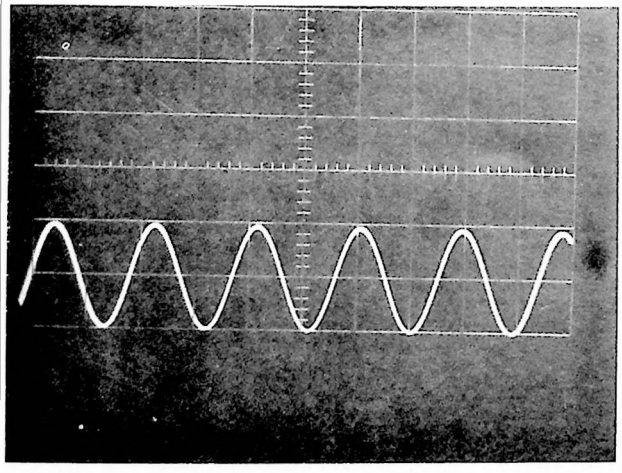
V-32 pin 9 to V-33 pin 9. Plates of Hor. Deflection Amp. Plate-to-plate, GAIN X1. 50 v/cm



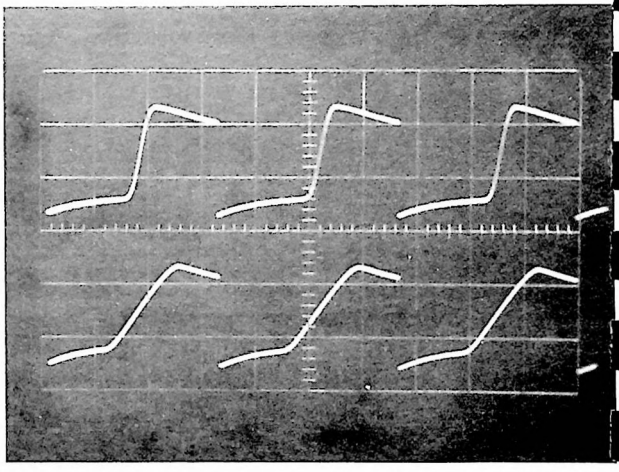
(Upper) V-5 pin 3 or 8. Cathode of Vertical Deflection CF. 20 v/cm (subject to setting of VERT. GAIN CAL.)
(Lower) V-1 pin 8 or V-2 pin 8. Cathode of Vertical CF. 2 v/cm



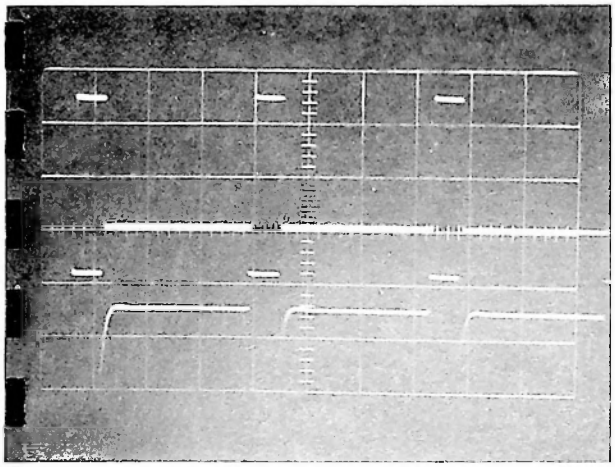
(Upper) GAIN X5 } V-32 pin 9 to V-33 pin 9. Plates of Hor.
(Lower) GAIN X20 } Deflection Amp. 100 v/cm



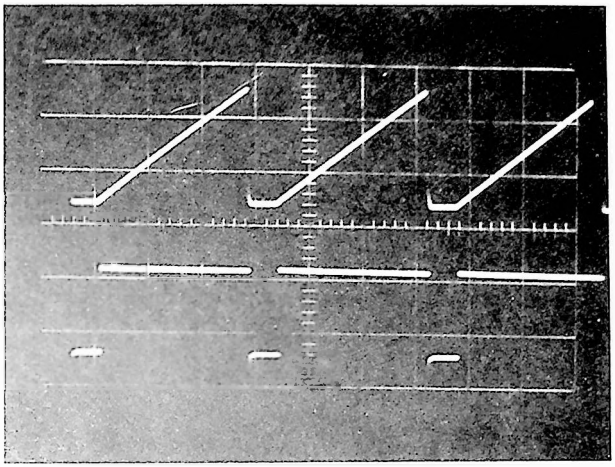
V-1 pin 2 or V-2 pin 2. Input to basic vertical amplifier. GAIN set for 6 cm deflection. 0.5 v/cm



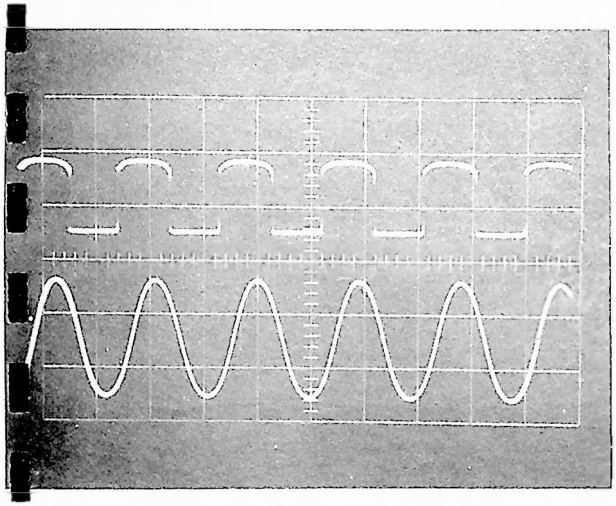
(Upper) GAIN X20 } V-32 pin 3 to V-33 pin 3. Plates of the
(Lower) GAIN X5 } Hor. Voltage Amp. 20 v/cm



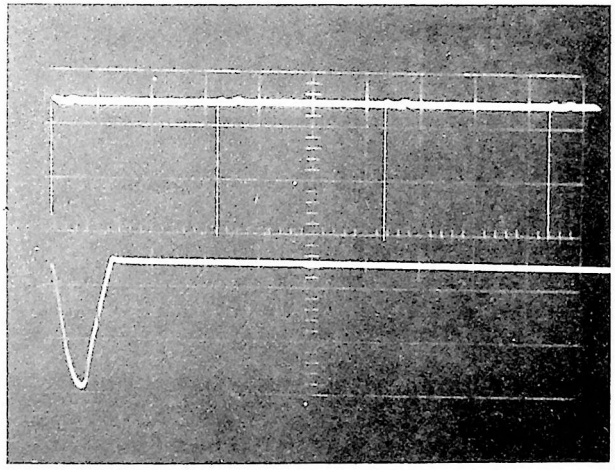
(Upper) V-27 pin 1. Output of Sweep Gate Multivibrator. 20 v/cm
(Lower) V-29 pin 2 (TEST POINT 2). Input to Gate Tube. 20 v/cm



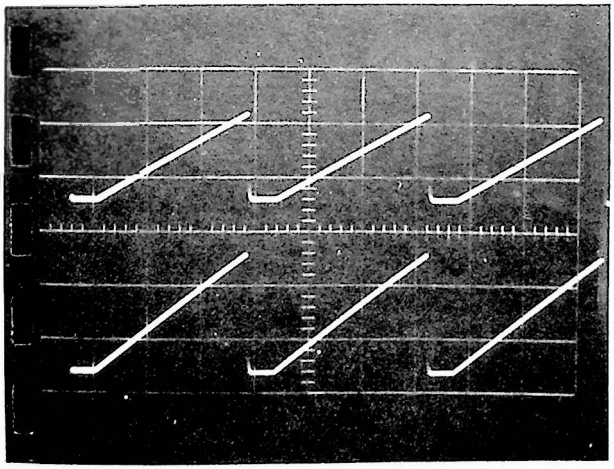
(Upper) V-30 pin 8. Screen of Sweep CF. 50 v/cm
(Lower) V-29 pin 1. Plate of Unblanking Amplifier. 100 v/cm



(Upper) V-26 pin 1. Output of Trigger Multivibrator. 20 v/cm
(Lower) TEST POINT 3. Output of Trigger Amplifier (Input To Trigger MV.) 20 v/cm



(Upper) J-10 or anode of CR-14. Output of preamp sync circuit. 10 v/cm
(Lower) Same as above but shown on a time base of 1 $\mu$sec/cm

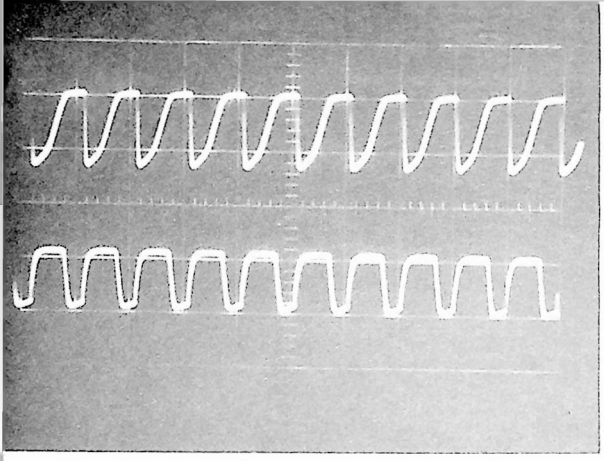


(Upper) TEST POINT 5. Output of Sweep CF (to S-5) 50 v/cm
(Lower) V-30 pin 7 (V-29 pin 1). Grid of Sweep CF (Plate of Gate tube) 50 v/cm

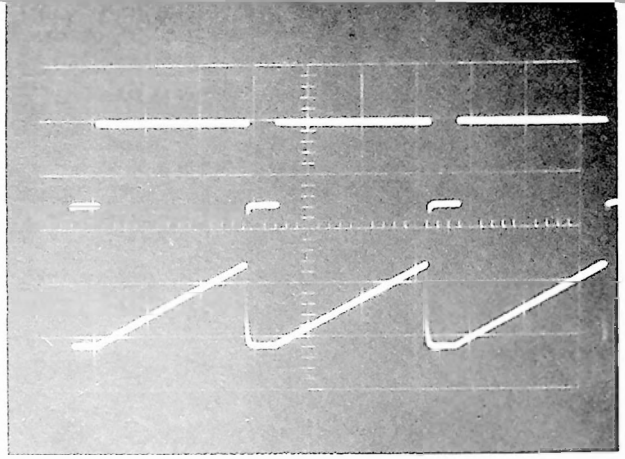
## NOTES FOR THE OSCILLOGRAMS ON THESE PAGES

Time Mark or Voltage Calibrator waveforms can be seen on the scope itself by placing the scope probe at the point under study and turning the Voltage Calibrator on.

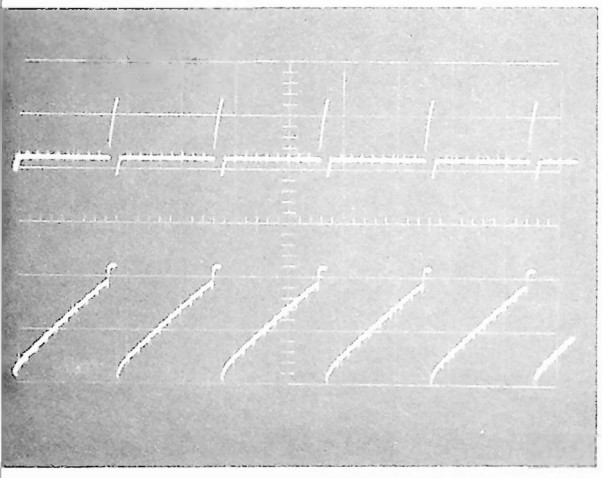
Other traces shown are viewed on a second scope. Vertical amplifier waveforms shown are for 6 cm vertical deflection on the scope under study. Horizontal deflection voltages are plate-to-plate. All other waveforms are from point indicated to ground.



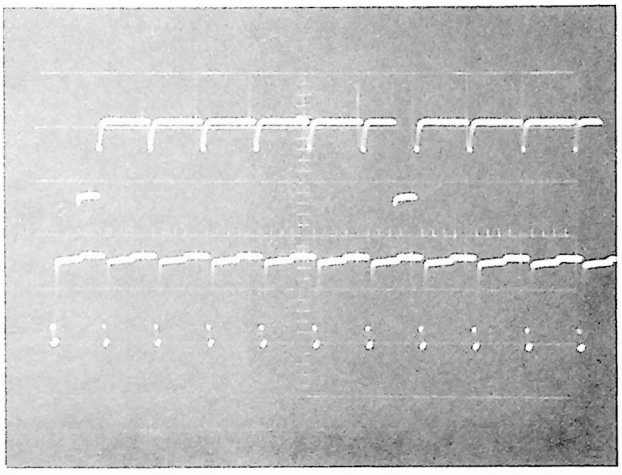
(Upper) V-38 pin 1. Plate of 1st section 10 μsec Time Mark. 50 v/cm, 10 μsec/cm
(Lower) V-38 pin 3. Screen of 2nd section 10 μsec Time Mark. 50 v/cm, 10 μsec/cm



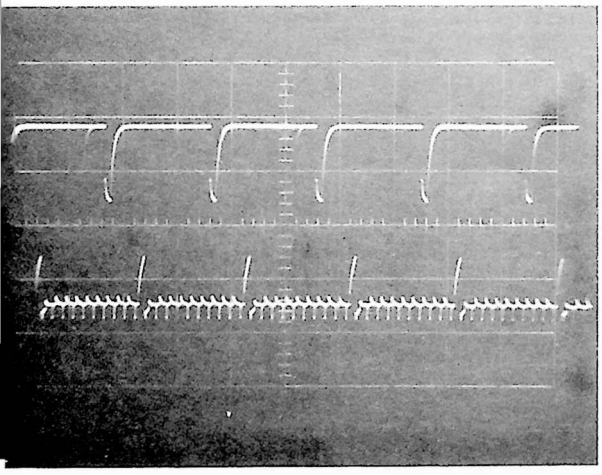
(Upper) V-31 pin 7. Cathode of Unblanking CF. 100 v/cm
(Lower) V-31 pin 3. Cathode of Hor. Amp. Input CF, (GAIN X1). 10 v/cm



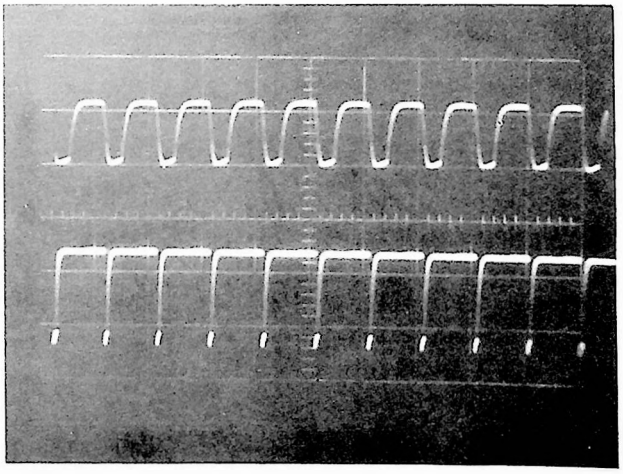
(Upper) V-37 pin 6. Plate of 2nd section 100 μsec Time Mark. 50 v/cm, 50 μsec/cm
(Lower) V-37 pin 1. Plate of 1st section 100 μsec Time Mark. 50 v/cm, 50 μsec/cm



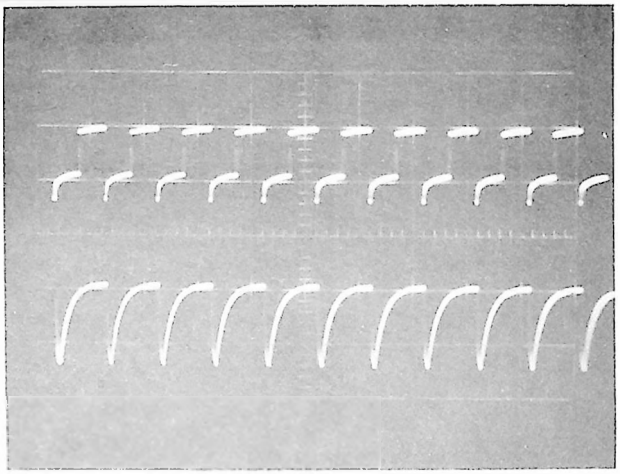
(Upper) V-31 pin 7. Cathode of Unblanking CF. 100 v/cm, 100 μsec/cm
(Lower) V-31 pin 9. Time Mark in to Unblanking CF, S-6 at 1000 μsec, 50 v/cm, 1 millisec/cm



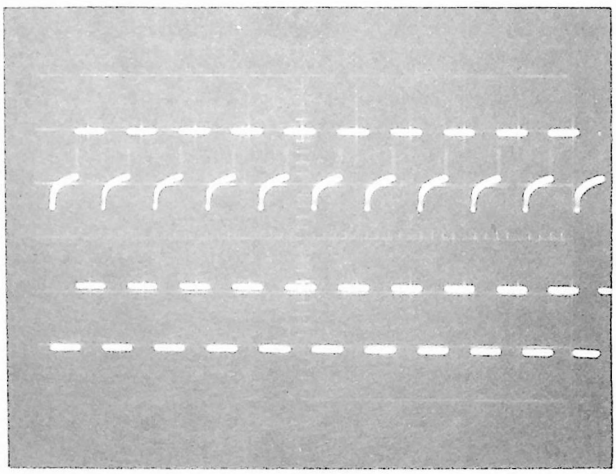
(Upper) V-36 pin 1. Plate of 1st section 1000 μsec Time Mark. 50 v/cm, 500 μsec/cm
(Lower) V-36 pin 9. Grid of 1st section 1000 μsec Time Mark. 10 v/cm, 50 μsec/cm



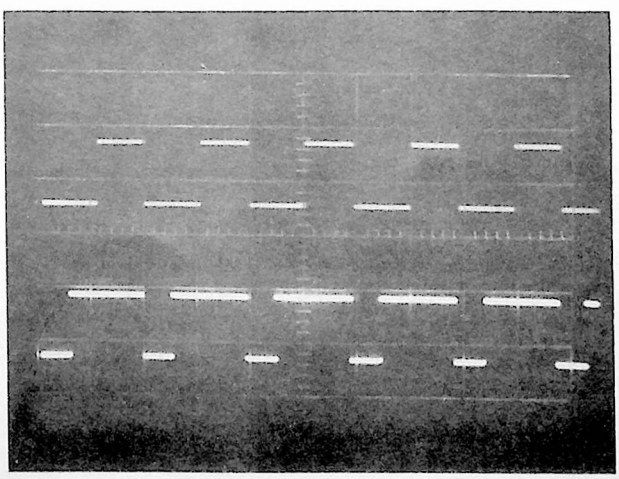
(Upper) V-34 pin 9. Output 10 μsec Time Mark (input to unblanking CF). 50 v/cm, 10 μsec/cm
(Lower) V-34 pin 9. Output 100 μsec Time Mark (S-6 at 100). 50 v/cm, 100 μsec/cm



(Upper) V-35 pin 6. Plate of 1st stage of Voltage Calibrator. 200 v/cm, 1000 μsec/cm
(Lower) V-35 pin 2. Input to Voltage Calibrator. 50 v/cm, 1000 μsec/cm



(Upper) V-35 pin 9. Grid of Voltage Calibrator CF. 200 v/cm, 1000 μsec/cm
(Lower) V-35 pin 8. Cathode of Voltage Calibrator CF. 50 v/cm, 1000 μsec/cm



(Upper) V-35 pin 8. Output of Voltage Cal. CF; duty cycle properly adjusted. 50 v/cm, 500 μsec/cm
(Lower) Same as above, but duty cycle not properly adjusted

# REPLACEMENT PARTS LIST

## HIGH-VOLTAGE POWER SUPPLY

### CAPACITORS

| Symbol Number | Description | Part Number |
|---|---|---|
| C-10 | 680 μμf, ± 20%, 600 v. Disc. | 277688 |
| C-11 | .02 μf, ± 20%, 600 v. Disc. | 276025 |
| C-12 | 20 μμf, ± 10%, 600 v. Disc. | 296014 |
| C-13 | .01 μf, ± 10%, 600 v. Disc. | 276015 |
| C-14 | .01 μf, ± 10%, 600 v. Disc. | 276015 |
| C-15 | .002 μf, 1500 v. + 20% mica | 298003 |
| C-16 | .01 μf, ± 20%, 500 v. Disc. | 276015 |
| C-17 | 750 μμf, 6KV. ± 20%, Disc. | 299002 |
| C-18 | 750 μμf, 6KV. ± 20%, Disc. | 299002 |
| C-19 | 750 μμf, 6KV. ± 20%, Disc. | 299002 |
| C-20 | 750 μμf, 6KV. ± 20%, Disc. | 299002 |
| C-21 | .005 μf, 3KV. ± 20%, Disc. | 299003 |
| C-22 | .01 μf, ± 20%, 500 v. Disc. | 276015 |
| C-23 | .02 μf, ± 20%, 500 v. Disc. | 276025 |

### TRANSFORMER

| | | |
|---|---|---|
| T-2 | High-voltage transformer | 121500 |

### TUBES

| | | |
|---|---|---|
| V-8 | 12BH7 | 611004 |
| V-9 | 6W6 | 610065 |
| V-10 | 1X2B | 610066 |
| V-11 | 1X2B | 610066 |
| V-12 | 6AU6 | 610013 |
| V-13 | GV3-A-1750 ± 2%, voltage regulator | 613008 |

### MISCELLANEOUS

| Description | Qty. | Part No. |
|---|---|---|
| Plate caps | 2 | 940013 |
| Printed circuit board | 1 | 820089 |

### RESISTORS

Resistance in ohms. ½ watt, 10% tolerance, unless otherwise specified.

| Symbol Number | Description | Part Number |
|---|---|---|
| R-46 | 47K, 2-watt | 307473 |
| R-47 | 220, ½ watt | 301221 |
| R-48 | 3.9K, ½ watt | 301392 |
| R-49 | 1 meg, ½ watt | 301105 |
| R-50 | 150K | 301154 |
| R-51 | 100K | 301104 |
| R-53 | 390, 2-watt | 307391 |
| R-54 | 22K, 2-watt | 307223 |
| R-55 | 9.1, 5%, 1-watt | 304918 |
| R-56 | 22 meg | 301226 |
| R-57 | 47K | 301473 |
| R-58 | 9.1, 5%, 1-watt | 304918 |
| R-59 | 4.7 meg | 301475 |
| R-60 | 100K | 301104 |
| R-63 | 1 meg | 301105 |
| R-64 | 1 meg | 301105 |
| R-65 | 1 meg | 301105 |
| R-66 | 20K control | 420031 |
| R-67 | 1 meg | 301105 |
| R-68 | 680K | 301684 |
| R-69 | 10K, 1-watt | 304103 |
| R-70 | 220K, 1-watt | 304224 |

## LOW-VOLTAGE POWER SUPPLY

### CAPACITORS

| Symbol Number | Description | Part Number |
|---|---|---|
| C-31 | 100 μf, 300 v. electrolytic | 224100 |
| C-32 | 100 μf, 300 v. electrolytic | 224100 |
| C-33 | .01 μf, 600 v. ceramic disc | 276015 |
| C-34 | 100-60-20 μf, 350-350-200 v. electrolytic | 235307 |
| C-35 | | |
| C-36 | 100-40 μf, 450 v. electrolytic | 235202 |
| C-37 | 100 μf, 300 v. electrolytic | 224100 |
| C-38 | .02 μf, 500 v. disc. | 276025 |
| C-39 | .02 μf, 500 v. disc. | 276025 |
| C-40 | .01 μf, 600 v. disc. | 276015 |
| C-41 | .1 μf, 200 v. tubular | 293014 |
| C-42 | .02 μf, 500 v. disc. | 276025 |
| C-43 | .02 μf, 500 v. disc. | 276025 |
| C-44 | .02 μf, 500 v. disc. | 276025 |
| C-46 | .02 μf, 500 v. disc. | 276025 |
| C-49 | .02 μf, 500 v. disc. | 276025 |
| C-50 | 100-40 μf, 450 v. electrolytic | 235202 |

### CONNECTORS

| Symbol Number | Description | Part Number |
|---|---|---|
| J-4—J-7 | Pin jacks | 502243 |

### NEON BULBS

| | | |
|---|---|---|
| E-7—E-12 | NE-2 | 640001 |

### RELAY

| | | |
|---|---|---|
| K-1 | 3PDT | 190015 |

### SILICON DIODES

| | | |
|---|---|---|
| CR-1—CR-12 | Type CER-70 | 630052 |
| | or | |
| | Type 5E4 | 622201 |

### TUBES

| | | |
|---|---|---|
| V-14 | 6N045T Time Delay | 195000 |
| V-15 | EZ81/6CA4 | 611022 |
| V-16—V-24 | 6DR7 | 611033 |

### RESISTORS

½ watt, carbon resistors, ± 10% unless otherwise specified. Resistance in ohms.

| Symbol Number | Description | Part Number |
|---|---|---|
| R-76 | 10, 1 watt, ± 20% | 303100 |
| R-77 | 4.7 | 311050 |
| R-78 | 10, 1 watt, ± 20% | 303100 |
| R-79 | 1 meg | 301105 |
| R-80 | 220K | 301224 |
| R-81 | 2.2 meg | 301225 |
| R-82 | 27K | 301273 |
| R-83 | 1 meg | 301105 |
| R-84 | 1 meg | 301105 |
| R-85 | 220K | 301224 |
| R-86 | 270K | 301274 |
| R-87 | 1 meg | 301105 |
| R-88 | 1 meg | 301105 |
| R-89 | 220K | 301224 |
| R-90 | 200K | 302204 |
| R-91 | 470K | 301474 |

| Symbol Number | Description | Part Number |
|---|---|---|
| R-92 | 1K | 301102 |
| R-93 | 1 meg | 301105 |
| R-94 | 47K | 301473 |
| R-95 | 1K | 301102 |
| R-96 | 470K | 301474 |
| R-97 | 1K | 301102 |
| R-98 | 470K | 301474 |
| R-99 | 1K | 301102 |
| R-100 | 470K | 301474 |
| R-101 | 750, 10 watt | 374018 |
| R-102 | 4K, 10 watt | 374017 |
| R-103 | 330, 2 watt | 307331 |
| R-104 | 100K | 301104 |
| R-105 | 4K, 10 watt | 374017 |
| R-106 | 680K | 301684 |
| R-107 | 100K | 301104 |

| Symbol Number | Description | Part Number |
|---|---|---|
| R-108 | 100K, control | 390157 |
| R-109 | 56K | 301563 |
| R-110 | 270K | 301274 |
| R-111 | 270K | 301274 |
| R-112 | 100K, control | 390157 |
| R-113 | 100K | 301104 |
| R-114 | 56K | 301563 |
| R-115 | 220K | 301224 |
| R-116 | 100K, control | 390157 |
| R-117 | 82K | 301823 |
| R-118 | 470K | 301474 |
| R-119 | 200K | 302204 |
| R-120 | 270K | 301274 |
| R-121 | 100K, control | 390157 |
| R-122 | 100K | 301104 |
| R-123 | 820K | 301824 |

# REPLACEMENT PARTS LIST (Continued)

## PARTS LIST FOR VERTICAL SECTION

### CAPACITORS

| Symbol Number | Description | Part Number |
|---|---|---|
| C-1 | 100 μμf 600 v. ± 20%, disc. | 276017 |
| C-2 | .005 μf 500 v. ± 20%, disc. | 276054 |
| C-3 | 15-130 μμf trimmer | 283004 |
| C-4 | .047 μf + 20%, 600 v. tubular | 257476 |
| C-6 | 2.2 μμf, ± 10%, NPO disc. | 277229 |
| C-7 | 47 μμf, ± 20%, NPO disc. | 276479 |

### COILS

| | | |
|---|---|---|
| L-1 | 5.6 μh peaking coil | 152055 |
| L-2 | 5.6 μh peaking coil | 152055 |
| L-3 | .47 μh peaking coil | 162045 |
| L-4 | .47 μh peaking coil | 162045 |
| L-5 | 20-40 μh peaking coil | 162043 |
| L-6 | 20-40 μh peaking coil | 162043 |
| L-7 | 100 μh peaking coil | 162044 |
| L-8 | 5.6 μh peaking coil | 152055 |
| L-9 | 5.6 μh peaking coil | 152055 |

### CONNECTORS

| | | |
|---|---|---|
| J-1 | 16-pin receptacle | 502203 |
| J-2 | Test jack | 502243 |
| J-3 | Test jack | 502243 |
| P-9 | Pin plug | 502123 |
| P-10 | Pin plug | 502123 |
| P-17 | 12-pin plug | 502101 |
| | Pin connectors, 2 | 502244 |

### RESISTORS

½ watt carbon, ± 10% unless otherwise specified. Resistance in Ohms.

| | | |
|---|---|---|
| R-1 | 6.8K, 1 watt, ± 5% | 305682 |
| R-2 | 6.8K, 1 watt, ± 5% | 305682 |
| R-3 | 10 | 301100 |
| R-4 | 1K, ± 5% | 302102 |
| R-5 | 6.8K, 2 watt, ± 5% | 308682 |
| R-6 | 12K, 2 watt, ± 5% | 308123 |
| R-7 | 6.8K, 2 watt, ± 5% | 308682 |
| R-8 | 1K, ± 5% | 302102 |
| R-9 | 1K, 1 watt, ± 5% | 305102 |
| R-10 | 1K, 1 watt, ± 5% | 305102 |
| R-11 | 12K, 2 watt, ± 5% | 308123 |
| R-12 | 3.9K, 4 watt, 5% | 333008 |
| R-13 | 3.9K, 4 watt, 5% | 333008 |
| R-14 | 2.7K, 5 watt, 5% | 382001 |
| R-15 | 2.7K, 5 watt, 5% | 382001 |
| R-16 | 100 Ω control | 390155 |
| R-17 | 5.6K, 2 watt | 307562 |
| R-18 | 12K, 2 watt, ± 5% | 308123 |
| R-19 | 12K, 2 watt, ± 5% | 308123 |
| R-20 | 1.5K, 1 watt | 304152 |
| R-21 | 33 | 301330 |
| R-22 | 1.5 meg, + 5% | 302155 |
| R-23 | 3.3K, 1 watt, ± 5% | 305332 |
| R-24 | 33 | 301330 |
| R-25 | 6.8K, 1 watt, ± 5% | 305682 |
| R-26 | 200, ± 5% | 302201 |
| R-27 | 8.2K, 1 watt, ± 5% | 305822 |
| R-28 | 33 | 301330 |
| R-29 | 100K | 301104 |
| R-30 | 100K | 301104 |
| R-31 | 100K control | 390136 |
| R-32 | 2K, 2 watt control | 402108 |
| R-33 | 10K, 2 watt control | 392100 |
| R-34 | 200K, ± 5% | 302204 |
| R-35 | 200K, ± 5% | 302204 |
| R-36 | 200K, ± 5% | 302204 |
| R-37 | 200K, ± 5% | 302204 |
| R-38 | 33 | 301330 |
| R-39 | 470 | 301471 |
| R-40 | 470 | 301471 |
| R-41 | 1.5 meg, ± 5% | 302155 |

### TUBES AND BULBS

| | | |
|---|---|---|
| E-3 to E-6 | NE-2 Lamp | 640001 |
| V-1, 2 | 6EA8 | 611037 |
| V-3, 4 | 12BY7A | 610070 |
| V-5 | 6DJ8 | 611040 |
| V-6 | 6EA8 | 611037 |
| V-7 | 0A2 | 610019 |

## FRAME AND PANEL ASSEMBLY

### BULBS

| Symbol Number | Description | Part Number |
|---|---|---|
| E-1 | NE-2 indicator, with wires | 642003 |
| E-2 | NE-2 indicator, with wires | 642003 |
| I-1, 2, 3 | #1490 bulb | 640012 |

### CAPACITORS

| | | |
|---|---|---|
| C-24 | .005 μf, 3 KV disc. | 299003 |
| C-25 | .02 μf, 600 v. disc | 277025 |
| C-35 | .05 μf, 400 v. disc | 275506 |

### CONNECTORS

| | | |
|---|---|---|
| J-8 | Pin jack | 502220 |
| J-15 | 12-terminal conncetor | 502202 |
| J-17 | 12-terminal connector | 502202 |
| P-11, 12, 13 14, 16 | Pin plug (5) | 503123 |
| | Anode connector | 501510 |
| | Binding post, black, 2 | 502218 |
| | Binding post, red, 5 | 502217 |
| | Coaxial connector, BNC | 507245 |
| | Power receptacle, male | 502102 |

### CRT

| | | |
|---|---|---|
| CRT | C510/P2 | 612004 |

### RESISTORS

| | | |
|---|---|---|
| R-52 | 68K, ½ watt carbon | 301684 |
| R-61 | 1 meg, high-voltage type control | 420029 |
| R-62 | 2 meg, high-voltage type control | 420030 |
| R-71 | 500K control | 390159 |
| R-279 | 25Ω, 2-watt control | 402109 |

### SWITCH

| | | |
|---|---|---|
| S-1 | Toggle switch | 430001 |

### TRANSFORMER

| | | |
|---|---|---|
| T-1 | Power transformer (105-130v) | 101900 |

## MISCELLANEOUS PACK PARTS LIST

| Description | Qty. | Part No. |
|---|---|---|
| Bezel, anodized aluminum | 1 | 721001 |
| CRT Scale graticule | 1 | 870056 |
| Fuse, 4 amp. Slo-Blo type 3 AG | 2 | 491005 |
| Green light filter | 1 | 870043 |
| Knobs, ⅞", with white marker | 8 | 761004 |
| Knobs, ⅞", with orange marker | 4 | 761005 |
| Knobs, 1⅜" | 4 | 761305 |
| Nuts, knurled | 4 | 572950 |
| Test & Calibration parts | | |
| Resistor, 750Ω, 10 watt | 1 | 374018 |
| Resistor, 100K, 5% | 2 | 302104 |
| Resistor, 13K, 5% | 1 | 302133 |
| Wire, stranded, red | 2 | 809002 |
| Male connector, 16 terminal | 1 | 502103 |
| Female connector, 16 terminal | 1 | 502203 |
| 8 conductor cable, 4 ft. | 1 | 803092 |
| Tubing, medium 8" | 3 | 812021 |
| Tubing, thin, 36" | 1 | 812031 |
| Tubing, medium, 136" | 1 | 802032 |
| Tubing, large, 12" | 1 | 802033 |

# REPLACEMENT PARTS LIST (Continued)

## PARTS LIST FOR HORIZONTAL CIRCUITS

### CAPACITORS

| Symbol Number | Description | Part Number |
|---|---|---|
| C-60 | .1 μf, 20%, 600 v. mylar | 247014 |
| C-61 | .01 μf, 20%, 600 v. disc. | 276015 |
| C-62 | 1.5-7 μμf, NPO trimmer | 284012 |
| C-63 | 20 μμf, 20%, 600 v. disc. | 296014 |
| C-64 | .05 μf, 20%, 400 v. disc. | 275506 |
| C-65 | 10 μμf, 20%, 600 v. disc. | 276018 |
| C-66 | .001 μf, 20%, 600 v. disc. | 276016 |
| C-67 | 10 μμf, 20%, 600 v. disc. | 276018 |
| C-68 | .47 μf, 5%, 200 v. mylar | 293020 |
| C-69 | 470 μμf, 5%, 200 v. silver mica | 293021 |
| C-70 | 100 μμf, 20%, 600 v. | 266017 |
| C-71 | 8-50 μμf, trimmer, 600 v. | 284009 |
| C-72 | 200 μμf, 5%, silver mica | 296001 |
| C-73 | 1 μf, 2%, 200 v. tubular | 293012 |
| C-74 | .01 μf, 2%, 200 v. tubular | 293013 |
| C-75 | .001 μf, 2%, 200 v. silver mica | 293019 |
| C-76 | 200 μμf, 5%, silver mica | 296001 |
| C-77 | 50-240 μμf, trimmer | 283006 |
| C-78 | 200 μμf, 5%, silver mica | 296001 |
| C-79 | 3-12 μμf, NPO trimmer | 284008 |
| C-80 | 1.5-7 μμf, NPO trimmer | 284012 |
| C-81 | 10 μμf, 5%, 500 v. silver mica | 294109 |
| C-82 | .05 μf,20%, 400 v. disc. | 275506 |
| C-83 | .05 μf, 20%, 400 v. disc. | 275506 |
| C-84 | 150 μμf, 20%, 600 v. disc. | 276158 |
| C-85 | .05 μf, 20%, 400 v. disc. | 275506 |
| C-86 | .05 μf, 20%, 400 v. disc. | 275506 |
| C-87 | .01 μf, 20%, 600 v. disc. | 276015 |
| C-88 | .01 μf, 20%, 600 v. disc. | 276015 |
| C-89 | 10 μf, 90 v. tubular, electrolytic | 292002 |
| C-90 | 100 μμf, 20%, 600 v. disc. | 276017 |
| C-91 | .001 μf, 300 v. silver mica | 293019 |
| C-92 | .05 μf, 20%, 400 v. disc. | 275506 |
| C-93 | .05 μf, 20%, 400 v. disc. | 275506 |
| C-94 | 40 μf, 250 v. electrolytic in can | 224101 |
| C-95 | 470 μμf, 20%, 600 v. disc | 276478 |
| C-96 | .005 μf, 20%, 500 v. disc. | 276054 |
| C-97 | 100 μμf, 20%, 600 v. disc. | 276017 |
| C-98 | 780 μμf, 1%, 300 v. silver mica | 294002 |
| C-99 | .005 μf, 5%, 500 v. silver mica | 294506 |
| C-100 | 20 μμf, 20%, 600 v. disc. | 294209 |
| C-101 | 200 μμf, 5%, 500 v. silver mica | 296001 |
| C-102 | 470 μμf, 20%, 600 v. disc. | 276478 |
| C-103 | .01 μf, 20%, 600 v. disc. | 276015 |
| C-104 | 20 μμf, 5%, 500 v. silver mica | 294209 |
| C-105 | 470 μμf, 20%, 600 v. disc. | 276478 |
| C-107 | .05 μf, 400 v. 20%, disc. | 275506 |
| C-108 | .05 μf, 400 v. 20%, disc. | 275506 |
| C-109 | .05 μf, 400 v. 20%, disc. | 275506 |

### COILS

| | | |
|---|---|---|
| L-10 | 38 μh, peaking coil | 142012 |
| L-11 | 88 μf, peaking coil | 152033 |
| L-12 | 88 μh, peaking coil | 152033 |
| L-13 | 1.1 μh, Q-175 peaking coil | 161007 |
| L-14 | 500 μh, peaking coil | 152042 |
| L-15 | 500 μh, peaking coil | 152042 |

### CONNECTORS

| | | |
|---|---|---|
| J-9 | Pin jack | 502220 |
| J-10 | Pin jack, red center | 502236 |
| J-11 | Pin jack | 502220 |
| J-12 | Pin jack | 502220 |
| J-13 | Pin jack | 502220 |
| J-14 | Pin jack, red center | 502236 |
| J-16 | Pin jack | 502220 |
| P-8 | Pin plug | 502123 |
| P-15 | 12-terminal connector | 502101 |
| Pin connectors, 2 | | 502244 |

### CRYSTAL

| | | |
|---|---|---|
| | 100kc crystal | 614000 |

### DIODES

| | | |
|---|---|---|
| CR-13 | IN34 crystal | 630006 |
| CR-14 | IN34 crystal | 630006 |
| CR-15 | CER-70 silicon | 630052 |
| CR-16 | CER-70 silicon | 630052 |

### NEON BULBS

| Symbol Number | Description | Part Number |
|---|---|---|
| E-13—E-17 | NE-2 | 640001 |
| E-18 | NE-81, (white dot) | 642001 |

### RESISTORS

½ Watt, 10% tolerance unless otherwise specified. Resistance in ohms.

| | | |
|---|---|---|
| R-135 | 100K | 301104 |
| R-136 | 33 | 301330 |
| R-137 | 4.7K, 1-watt | 304472 |
| R-138 | 4.7K, 1-watt | 304472 |
| R-139 | 33 | 301330 |
| R-140 | 27K, 2-watt | 307273 |
| R-141 | 150K, 5% | 302154 |
| R-142 | 150K, 5% | 302154 |
| R-143 | 1K, 5% | 302102 |
| R-144 | 62K, 5% | 302623 |
| R-145 | 1 meg | 301105 |
| R-146 | 250K control | See S-2 |
| R-147 | 1 meg | 301105 |
| R-150 | 33 | 301330 |
| R-151 | 3.3K, 1-watt | 304332 |
| R-152 | 270K | 301274 |
| R-153 | 1.5K | 301152 |
| R-154 | 220 | 301221 |
| R-155 | 6.8K, 2-watt | 307682 |
| R-156 | 47K | 301473 |
| R-157 | 250K screwdriver control | 390160 |
| R-158 | 5K control | See S-3 |
| R-159 | 33K, 1-watt | 304333 |
| R-160 | 4.7K | 301472 |
| R-161 | 33 | 301330 |
| R-162 | 4.7K, 1-watt | 304472 |
| R-163 | 220K | 301224 |
| R-164 | 12K, 2-watt | 307123 |
| R-165 | 33 | 301330 |
| R-166 | 10 meg, 1-watt, film type | 330050 |
| R-167 | 1 meg, 1-watt, film type | 351004 |
| R-168 | 100K, 1-watt, film type | 351003 |
| R-169 | 820K, 5% | 302824 |
| R-170 | 150K screwdriver control | 390162 |
| R-171 | 150K | 301154 |
| R-172 | 4.7K, 1-watt | 304472 |
| R-173 | 1 meg, screwdriver control, ¼ watt | 390161 |
| R-174 | 33 | 301330 |
| R-175 | 330K | 301334 |
| R-176 | 100K | 301104 |
| R-177 | 12K, 2-watt | 307123 |
| R-178 | 33 | 301330 |
| R-179 | 33 | 301330 |
| R-180 | 220K | 301224 |
| R-181 | 250K, screwdriver control | 390160 |
| R-182 | 27K, 1-watt | 304273 |
| R-183 | 6.8K | 301682 |
| R-184 | 10K, 1-watt | 304103 |
| R-185 | 50K, 2-watt, screwdriver control | 392101 |
| R-186 | 100K, 1-watt, 1%, film type | 351003 |
| R-187 | 100K, 1-watt, 1%, film type | 351003 |
| R-188 | 300K, 1-watt, 1%, film type | 353003 |
| R-189 | 1 meg, 1-watt, 1%, film type | 351004 |
| R-190 | 1 meg, 1-watt 1%, film type | 351004 |
| R-191 | 3 meg, 1-watt, 1%, film type | 353004 |
| R-192 and R-193 | Dual control, Front, 1 meg, Rear, 10 meg | 420034 |
| R-194 | 18K, 5% | 302183 |
| R-195 | 20K control | 390149 |
| R-196 | 33K, 5% | 302333 |
| R-197 | 820K, 5% | 302824 |
| R-198 | 33 | 301330 |
| R-199 | 430K, 5% | 302434 |
| R-200 | 100K, 1%, film type | 341003 |
| R-201 | 400K, 1%, film type | 344003 |
| R-202 | 900K, 1%, film type | 349003 |
| R-203 | 33 | 301330 |
| R-204 | 47K, 1-watt | 304473 |
| R-205 | 4.7K, 1-watt, 5% | 305472 |
| R-206 | 33 | 301330 |
| R-207 | 100K, 1-watt, 5% | 305104 |
| R-208 | 33K, 2-watt | 307333 |
| R-209 | 33K, 2-watt | 307333 |

# REPLACEMENT PARTS LIST (Continued)

## HORIZONTAL CIRCUITS

### RESISTORS (Cont.)

| Symbol Number | Description | Part Number |
|---|---|---|
| R-210 | 100K, 1-watt, 5% | 305104 |
| R-211 | 33 | 301330 |
| R-212 | 4.7K, 1-watt, 5% | 305472 |
| R-213 | 33 | 301330 |
| R-214 | 1.5K | 301152 |
| R-215 | 2K control, printed circuit type | 420032 |
| R-216 | 10K control | See S-5 |
| R-217 | 33 | 301330 |
| R-218 | 10K, 2-watt | 307103 |
| R-219 | 220 | 301221 |
| R-220 | 10K, 2-watt | 307103 |
| R-221 | 2.2K | 301222 |
| R-222 | 5K control, printed circuit type | 420033 |
| R-223 | 10K, 2-watt | 307103 |
| R-224 | 220 | 301221 |
| R-225 | 12.5K, 4-watt, 5%, film type | 333011 |
| R-226 | 12.5K, 4-watt, 5%, film type | 333011 |
| R-227 | 33 | 301330 |
| R-228 | 10K, 2-watt | 307103 |
| R-229 | 1 meg screwdriver control | 390161 |
| R-230 | 1 meg | 301105 |
| R-231 | 100K | 301104 |
| R-232 | 470K | 301474 |
| R-233 | 33 | 301330 |
| R-234 | 1 meg | 301105 |
| R-235 | 1K | 301102 |
| R-236 | 30K, 1%, film type | 343002 |
| R-237 | 10K, 1%, film type | 341002 |
| R-238 | 5K, 1%, film type | 345001 |
| R-239 | 3K, 1%, film type | 343001 |
| R-240 | 1K, 1%, film type | 341001 |
| R-241 | 1K, 1%, film type | 341001 |
| R-242 | 20K control, printed circuit type | 420031 |
| R-243 | 100, 1%, film type | 341000 |
| R-244 | 9.9K, 1-watt, 1%, film type | 359901 |
| R-245 | 470K | 301474 |
| R-246 | 33 | 301330 |
| R-247 | 3.3K, 1-watt | 304332 |
| R-248 | 470K | 301474 |
| R-249 | 10K | 301103 |
| R-250 | 6.8K, 1-watt | 304682 |
| R-251 | 1 meg control for upright mounting on board | 390142 |
| R-252 | 220K | 301224 |
| R-253 | 220K | 301224 |
| R-254 | 33 | 301330 |
| R-255 | 27K, 1-watt | 304273 |
| R-256 | 22K | 301223 |
| R-257 | 47K | 301473 |
| R-258 | 1 meg control for horizontal mtg. on board | 420035 |
| R-259 | 1.5 meg | 301155 |
| R-260 | 15K, 1-watt | 304153 |
| R-261 | 33 | 301330 |
| R-262 | 1 meg | 301105 |
| R-263 | 12K | 301123 |

### RESISTORS (Cont.)

| Symbol Number | Description | Part Number |
|---|---|---|
| R-264 | 47K | 301473 |
| R-265 and R-272 | Dual 1 meg control, printed circuit type | 420018 |
| R-266 | 2.2 meg | 301225 |
| R-267 | 15K, 1-watt | 304153 |
| R-268 | 150K | 301154 |
| R-269 | 33 | 301330 |
| R-270 | 12K | 301123 |
| R-271 | 220K | 301224 |
| R-273 | 100K | 301104 |
| R-274 | 15K, 1-watt | 304153 |
| R-275 | 33 | 301330 |
| R-276 | 100K | 301104 |
| R-277 | 33 | 301330 |
| R-278 | 100K | 301104 |

### SWITCHES

| | | |
|---|---|---|
| S-2 | TRIGGER POLARITY, with R-146 control attached | 434701 |
| S-3 | TRIGGER INPUT, with R-158 control attached | 435022 |
| S-4 | TIME/CM switch | 435026 |
| S-5 | AMPLIFIER GAIN, with R-216 control attached | 435023 |
| S-6 | TIME MARK | 435024 |
| S-7 | VOLTAGE CALIBRATOR | 435025 |

### TUBES

| | | |
|---|---|---|
| V-25 | ECC88/6DJ8 | 611040 |
| V-26 | 6EA8 | 611037 |
| V-27 | ECC88/6DJ8 | 611040 |
| V-28 | ECC88/6DJ8 | 611040 |
| V-29 | ECC88/6DJ8 | 611040 |
| V-30 | 6AW8 | 611026 |
| V-31 | ECC88/6DJ8 | 611040 |
| V-32 | 6AU8 | 611039 |
| V-33 | 6AU8 | 611039 |
| V-34 | 6EA8 | 611037 |
| V-35 | 6EA8 | 611037 |
| V-36 | 6EA8 | 611037 |
| V-37 | 6EA8 | 611037 |
| V-38 | 6EA8 | 611037 |

### MISCELLANEOUS

| Description | Qty. | Part No. |
|---|---|---|
| Clip for crystal | 1 | 532031 |
| Printed circuit board: | | |
| Horizontal circuits, large | 1 | 820091 |
| Horizontal circuits, small | 1 | 820090 |
| Switch board, sweep-timing | 1 | 820092 |
| Switch board, hold-off | 1 | 820093 |

## ACCESSORIES FOR THE LABORATORY OSCILLOSCOPE

DIFFERENTIAL HIGH-GAIN PREAMPLIFIER KIT ..... 83 YZ 946

WIDE-BAND PREAMPLIFIER KIT ..... 83 YZ 947

DUAL-TRACE PREAMPLIFIER KIT ..... 83 YZ 948

BLANK PREAMP CHASSIS ..... 83 Y 977

LOW-CAPACITY PROBE KIT ..... 83 Y 949
For use with Knight-Kit DC Lab Scope. Provides high-accuracy readings with minimum circuit loading.

KNIGHT SCOPE CART ..... 83 YU 67
See latest Allied Radio Catalog for prices and description.

# PART 6 - CIRCUIT DESCRIPTION

## THE POWER SUPPLIES

The power supplies include a low-voltage DC power supply with regulated −150, +100, +250 and +420 volt outputs, and a high-voltage power supply which develops −1600 volts DC and +3400 volts DC.

## THE LOW-VOLTAGE POWER SUPPLY

### INITIAL WARMUP

With the initial application of power, the −150 v. supply for bias and the +100 v. supply for preamp filament voltages begin to operate. To protect tubes and components throughout the scope, a normally-open, 45-second delay tube (V-14) keeps the +250 and +420 volt supplies open, allowing time for the development of bias voltages before plate voltages are applied. After 45 seconds, the V-14 heaters are hot enough for the V-14 contacts to close, energizing the coil of the K-1 relay and closing the +420 and +250 v. circuits. When the K-1 relay closes, it also opens the heater circuit of the V-14 delay tube, so the delay tube can cool and be ready for another cycle. K-1 remains closed until the S-1 power switch is opened. Then K-1 opens, closing the V-14 heater circuit. When S-1 is closed again, the entire cycle repeats.

Unplugging the preamp will also open the K-1 coil circuit and the V-14 relay heaters. Then, if a cold preamp is plugged in while the scope is on, V-21A and V-22A of the +100 v. supply are protected from overload by temporarily bypassing them with R-101. Within 45 seconds, preamp filament current drops to normal as the filaments heat; V-14; then K-1 closes, switching R-101 out and V-21A, V-22A back into the +100 v. supply.

### THE —150 VOLT SUPPLY

The —150 volt supply is used for bias voltages throughout the scope and as the reference voltage for the +100, +250 and +420 volt supplies. Approximately 250 DC volts are present at the cathode of V-15 (EZ81), a full-wave rectifier connected across the 380 v secondary of T-1, the power transformer. This voltage is divided across series-pass tubes V-23A and V-24A, resistors R-109 and R-108, and the E-10 neon regulator. Since the cathodes of V-23A and V-24A are grounded, there is approximately +102 v at the plate, and —150 v at the negative side of E-10. Effective filtering is provided by filter capacitors C-31, C-32 and C-34C.

Any change in the level of the —150 v. output is applied as an error signal from R-108 to the grid of V-24B. The cathode of V-24B is held constant by direct tie to the cathode of V-22B, whose grid is controlled by the E-9 neon regulator. If the error is in the positive direction, V-24B plate voltage will drop, making the grid of V-23B more negative. At the same time, the cathode of V-23B has become more positive because the positive change in the —150 voltage is applied to the cathode across E-7 and E-8.

At V-23B, the negative change at the grid, combined with the positive change at the cathode, produces a considerable positive change at the plate of V-23B and the grids of V-23A and V-24A. This is the same as a decrease of resistance of V-23A and V-24A or increased current flow through the voltage divider (V-23A, V-24A, R-109, R-108, E-10). The output voltage is now more negative with respect to ground, correcting the original positive error.

Following the signal path just described, it can be seen that the setting of the R-108 control determines bias levels for the series pass tubes and consequently, the voltage output at J-4. A voltmeter of high accuracy should be used when this control is set because the —150 v. output serves as the reference voltage for calibration of all other sections of the low-voltage power supply.

### THE +100 VOLT SUPPLY

The +100 volt supply uses CR-9, 10, 11 and 12 silicon rectifiers connected in a bridge circuit, and C-34A and B, filter capacitors. Voltage is regulated by controlling the drop across the series pass tubes V-21A and V-22A. R-105, a 4K 10-watt resistor, reduces the amount of current the series pass tubes must handle.

The 100 volt adjust, R-112, is part of a voltage divider network which uses the —150 volt line as a reference. The position of the tap on R-112 determines the bias of the regulator and series pass tubes in this circuit, and therefore the exact value of the +100 volt output. R-78, a 10-ohm fuse resistor protects the rectifiers and other components in case of serious overload. If excessive current is drawn, R-78 will open and can easily be replaced after the overload condition is corrected.

Any change in the 100 v. output is applied across E-12 to the cathode of V-16B, further amplified by V-21B and applied to the grids of V-21A and V-22A series pass tubes. The flow through the series pass tubes changes accordingly, to bring the output back to +100 volts. For closeness of regulation, an NE-2 neon (E-11) is used to fix cathode voltage of V-21B, assuring maximum sensitivity of this tube to changes in grid voltage.

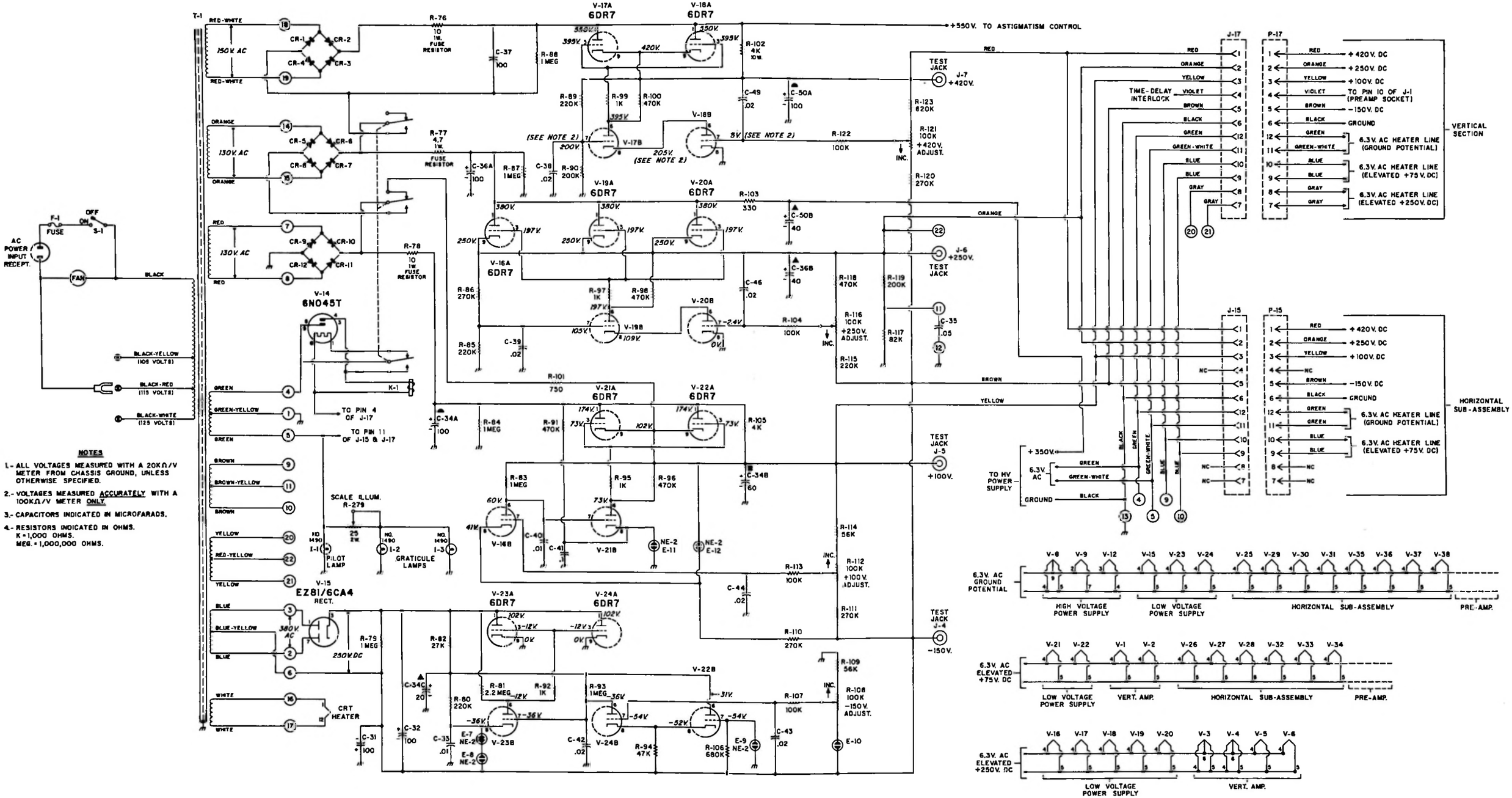
### THE +250 VOLT SUPPLY AND THE +420 VOLT SUPPLY

The +250 volt supply consists of a secondary winding of T-1, silicon rectifiers CR-5, 6, 7, and 8 connected in a bridge circuit, series pass tubes V-16A, V-19A and V-20A connected in parallel, regulator tubes V-19B and V-20B and filter capacitors and resistors. The return line for these rectifiers is through the +100 volt power supply, elevating the junction of CR-5 and CR-8 to approximately +175 volts. When the K-1 relay is open, this return line is open, making this section of the power supply inoperative. In a similar manner, output from the CR-5, 6, 7, 8 rectifiers is applied to the bridge circuit used for the +420 v. supply (CR-1, 2, 3, 4) and the +420 v. circuit will also be open when K-1 is open.

The +420 volt supply also has 2 series pass tubes, V-17A and V-18A, paralleled with R-102, a 4K 10-watt resistor, and regulator tubes V-17B and V-18B. R-116, the 250 volt adjust, and R-125, the 420 volt adjust operate in a similar manner by setting bias levels for the regulator and series pass tubes. Regulation takes place, as previously described, by bringing about a change of current through the series pass tubes to counteract any deviation in output level. Both R-116 and R-121 are part of voltage divider networks which use the regulated —150 v. supply as a reference level.

### +350 VOLT TAKEOFF

From the +250 volt supply, unregulated output of +350 volts is taken off, ahead of the series pass tubes, and receives further filtering from R-103 and C-50B. This output is used for plate voltage for the 6W6 high-voltage oscillator tube in the high-voltage power supply.




NOTES

1.- ALL VOLTAGES MEASURED WITH A 20KΩ/V METER FROM CHASSIS GROUND, UNLESS OTHERWISE SPECIFIED.

2.- VOLTAGES MEASURED ACCURATELY WITH A 100KΩ/V METER ONLY.

3.- CAPACITORS INDICATED IN MICROFARADS.

4.- RESISTORS INDICATED IN OHMS.
K = 1,000 OHMS.
MEG. = 1,000,000 OHMS.

DIAGRAM, L.V. POWER SUPPLY SCHEMATIC (DC SCOPE)

## HIGH-VOLTAGE POWER SUPPLY

High voltage is developed by using a high-voltage, RF transformer (T-2) in the plate circuit of V-9, the 6W6 oscillator and power amplifier tube. T-2, tuned by C-15, a .002$\mu$f capacitor, oscillates at 80 to 100 Kc. The oscillations are amplified by V-8B and fed back to the grid of V-9, in proper phase to sustain oscillations.

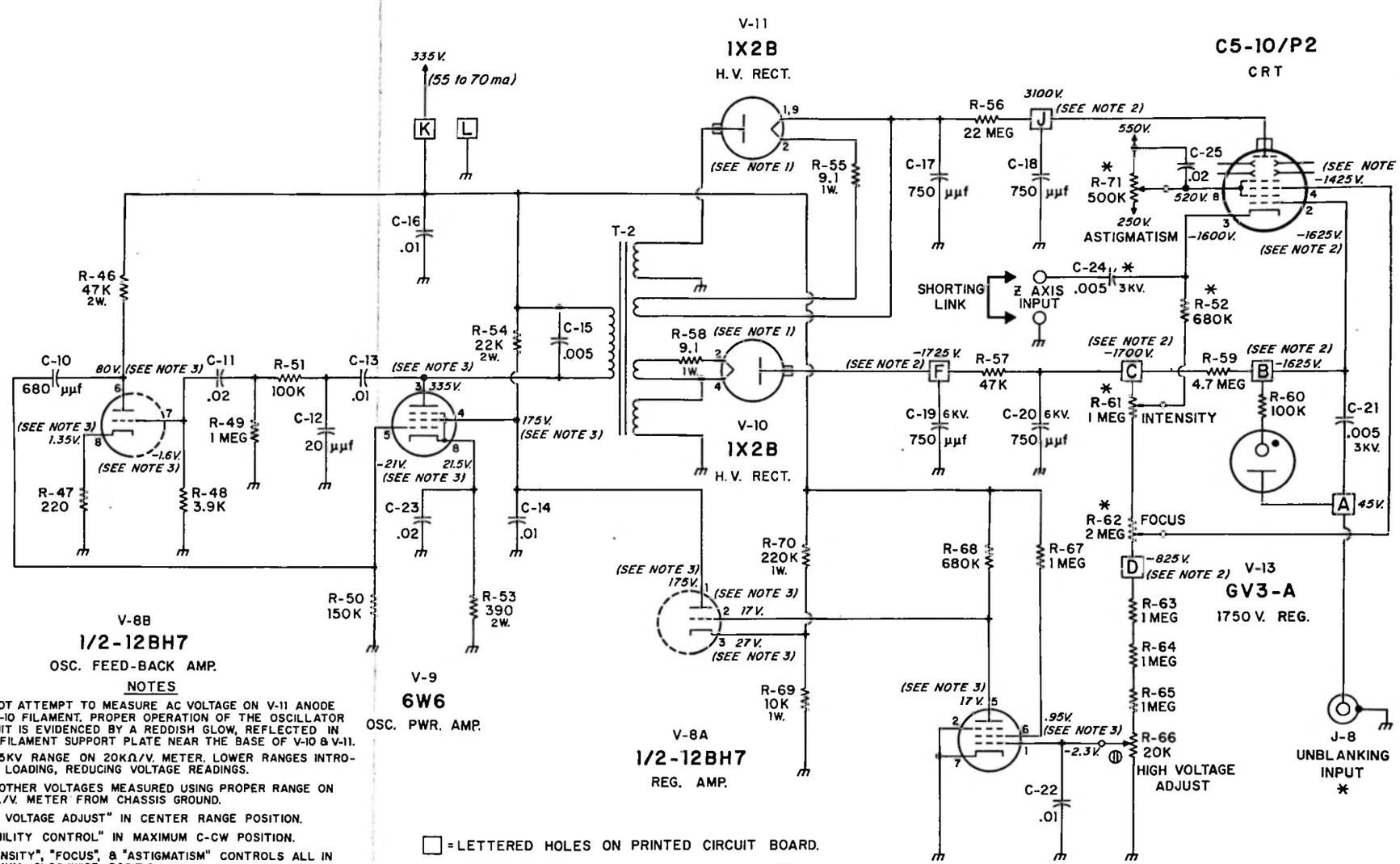
The secondary of T-2 has 4 separate windings for two separate high-voltage supplies: 3.4KV for the post-accelerator anode of the CRT and −1.8KV for the CRT control and focus grids and cathode. The half-turn windings are used for the filaments of V-10 and V-11, 1X2B rectifiers.

**The +3.4KV supply** consists of the 600 turn secondary of T-2, the V-11 rectifier and filter components, R-56, C-17 and C-18.

**The −1.8KV supply** consists of the 300 turn secondary of T-2, the V-10 rectifier, a filter network of C-19, R-57 and C-20, a voltage divider for tapping off the needed CRT cathode and grid voltages, and regulator tubes V-12 and V-8A. R-61, a 1-meg control in this voltage divider, varies the cathode voltage, making the trace more intense as the cathode becomes more negative. R-62, a 2-meg control, varies the focus grid voltage.

When unblanking voltage is not present, CRT grid voltage will be approximately −1650 volts, sufficiently negative with respect to cathode to cut off (blank) the CRT. With the application of unblanking voltage, a step of +70 volts is applied to the grid, causing the CRT to conduct (unblank) V-13, a GV3-A 1750 v. regulator tube, provides DC coupling from the unblanking cathode follower to the grid circuit of the CRT, supplying the needed DC drop while offering very low impedance to the unblanking voltage.

Regulation of the negative high voltage supply is effected by varying the screen voltage of the 6W6 oscillator-amplifier tube to counteract any change in the level of the negative output. For example, if the 1.8KV output changes in the negative direction, the change will be applied through the tap of R-66 to the grid of V-12, the DC feedback amplifier. As a result, plate voltage of V-12 increases. Since the plate of V-12 is tied to the grid of V-8A, V-8A draws more current and plate voltage of V-8A drops. This drop in voltage appears at the screen of V-9 and current through the T-2 primary also decreases. With less output from T-2 there is less negative output at V-10, correcting the negative deviation in the output voltage.



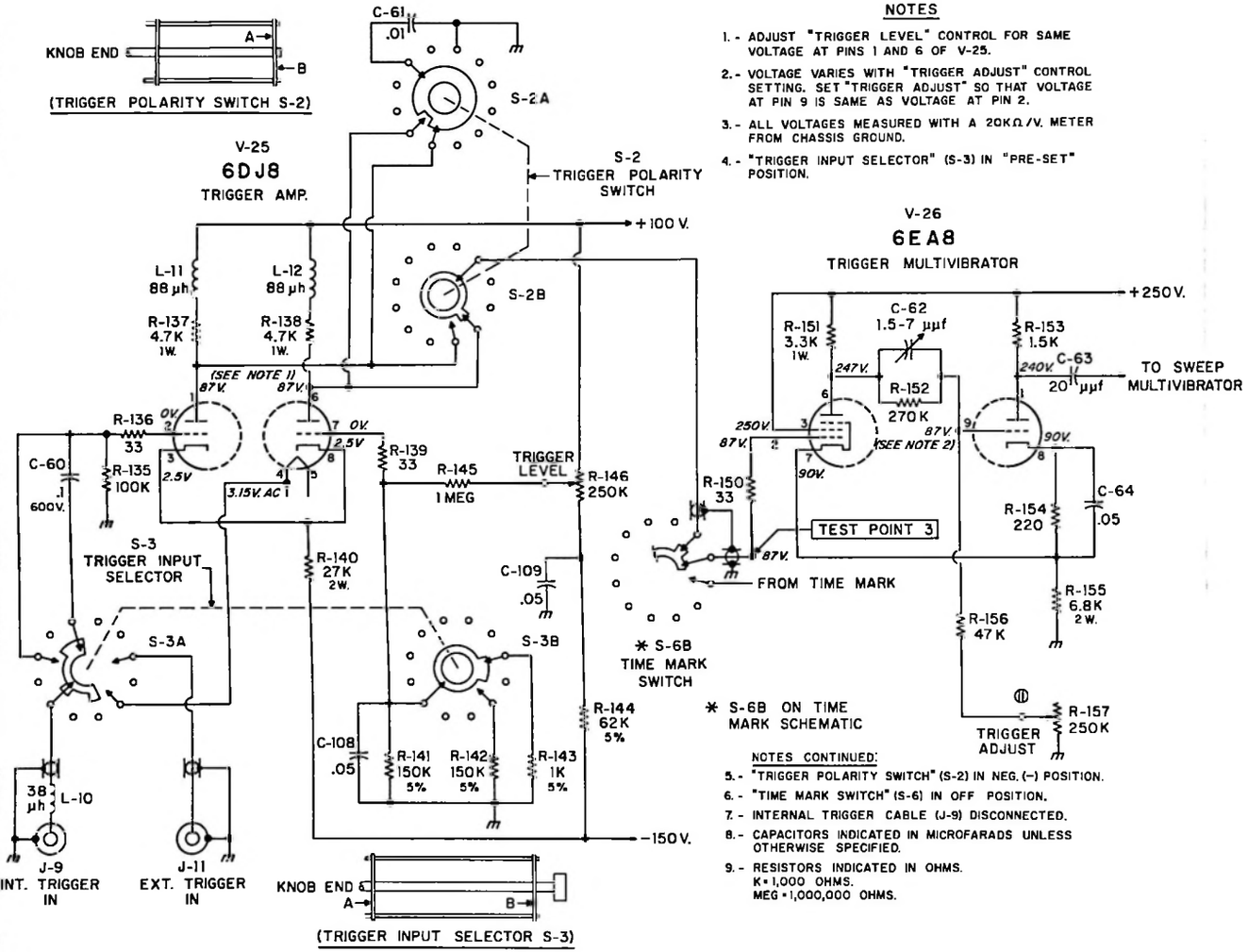

NOTES

1. - DO NOT ATTEMPT TO MEASURE AC VOLTAGE ON V-11 ANODE OR V-10 FILAMENT. PROPER OPERATION OF THE OSCILLATOR CIRCUIT IS EVIDENCED BY A REDDISH GLOW, REFLECTED IN THE FILAMENT SUPPORT PLATE NEAR THE BASE OF V-10 & V-11.
2. - USE 5KV RANGE ON 20K$\Omega$/V. METER. LOWER RANGES INTRODUCE LOADING, REDUCING VOLTAGE READINGS.
3. - ALL OTHER VOLTAGES MEASURED USING PROPER RANGE ON 20K$\Omega$/V. METER FROM CHASSIS GROUND.
4. - "HIGH VOLTAGE ADJUST" IN CENTER RANGE POSITION.
5. - "STABILITY CONTROL" IN MAXIMUM C-CW POSITION.
6. - "INTENSITY", "FOCUS", & "ASTIGMATISM" CONTROLS ALL IN MAXIMUM CLOCKWISE POSITION.
7. - CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
8. - RESISTORS INDICATED IN OHMS.
   K = 1,000 OHMS.
   MEG = 1,000,000 OHMS.

☐ = LETTERED HOLES ON PRINTED CIRCUIT BOARD.

* — COMPONENTS NOT ON HIGH VOLTAGE PRINTED CIRCUIT BOARD.

DIAGRAM, H.V. POWER SUPPLY SCHEMATIC (DC SCOPE)




TRIGGER CIRCUIT (DC SCOPE)

## THE TRIGGER CIRCUITS

A synchronizing source for the sweep circuits is selected by S-2, the TRIGGER INPUT switch. In INT positions of this switch (PRESET, AC or DC) a portion of the signal under study is used as the trigger source. This signal is taken from the sync output of the vertical amplifier. In EXT positions of S-2 (AC or DC) the triggering source is introduced at the EXT TRIGGER jack from an external instrument. LINE, or 60 cycle filament voltage can also be selected to trigger the sweep. When the TIME MARKER is "ON" time mark, pulses are used as the trigger input and S-2 and V-25 are switched out of the circuit. We will assume the TIME MARKER is OFF.

The trigger signal is introduced at the grid of V-25, directly for DC positions of S-2, and through C-60 for AC positions of S-2. V-25 is essentially a cathode-coupled amplifier and phase inverter. It provides a choice of trigger polarity by supplying output at one plate 180 degrees out of phase with the other plate.

In the plus (+) position of the TRIGGER POLARITY switch, output is selected from the plate of V-25A while the plate of V-25B is bypassed by C-61. Since only negative-going output can trigger the next stage (V-26), the sweep will trigger on the positive-going portion of the incoming signal. (There is a 180 degree phase shift in V-25A). In V-25B, however, no phase inversion occurs because this section is cathode driven. Therefore, in the minus(—) position of TRIGGER POLARITY, with output taken from V-25B, the sweep triggers on the negative slope of the incoming signal.

TRIGGER LEVEL, R-146, sets the DC operating levels of V-25, controlling the gain of this circuit. Since a minimum signal level is required for triggering, TRIGGER LEVEL setting determines the exact point of the displayed waveform at which the sweep triggers. In the PRE-SET position, the Trigger Level control will have little effect because R-143, a 1K resistor, shunts the attenuator, R-145, 1 meg, and R-141, 150K. Any signal above a minimum level will trigger the sweep when the TRIGGER INPUT switch is at PRE-SET.

V-26, the trigger multivibrator, is a Schmitt trigger which uses a pentode for the input section to provide greater gain, making faster switching times possible. The purpose of this circuit is to put out a square wave at the frequency of the incoming signal. The square wave is differentiated by C-63 (20 µµf) and R-160 (4.7K) of V-27, producing a sharp pulse for triggering V-27, the sweep gate tube.

In the quiescent state, the grid of V-26 is positive; V-26A conducts and its plate voltage drops. This drop in voltage is applied to the grid of V-26B. At the same time, the cathode voltage of V-26B has risen because of current flow through R-155, the common cathode resistor. V-26B is cutoff and remains in this condition until a negative signal is applied to the grid of V-26A, cutting off V-26A.

The plate of V-26A now goes to B+ potential, raising the grid of V-26B. The decrease of current in V-26A lowers the cathode potential, further increasing conduction of V-26B. Because of the high gain of the circuit, the change takes place very quickly. The circuit remains in this condition until the negative signal is removed.

R-157, TRIGGER LEVEL CENTERING, determines the point at which V-26B will flip, thereby controlling the sensitivity of the circuit. It also determines the range of the TRIGGER LEVEL control and is set to permit triggering at a minimum signal level. C-62, the trimmer across R-152, provides high frequency compensation.

## SWEEP AND TRIGGER CIRCUIT BIBLIOGRAPHY

TIME BASES by Puckle. Jarrold & Sons Ltd. 2nd edition, 1951

PULSE AND DIGITAL CIRCUITS by Millman & Taub. McGraw Hill, 1956.

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PRINCIPLES OF RADAR. MIT Radar Staff.

## THE SWEEP CIRCUIT

The sweep generator provides accurately calibrated, linear, sweep voltages. Linearity is obtained by adding an incremental voltage to the charging voltage applied to the sweep timing capacitors. This has the effect of extending the linear portion of the voltage vs. time characteristic of the charging curve of a capacitor, as shown in the following diagram. The incremental voltage is supplied by a bootstrap arrangement in which the cathode of V-30B, the circuit containing the sweep timing capacitors and resistors, is tied directly to the screen of V-30A, the sweep cathode follower.

For each sweep range, the correct capacitor and resistor are selected by section A, B and C of the TIME/CM switch, S-4. Provision for an external capacitor (above 1$\mu$f) makes speeds slower than 1 sec/cm possible. R-192 and R-193, the ganged VARIABLE front panel control provides sweep speeds at values between the ranges of the TIME/CM switch.

The sweep is controlled by a gate voltage, generated by V-27, a bistable, cathode-coupled multivibrator. Negative pulses from the trigger multivibrator are applied to the grid of V-27A while positive pulses are removed to the diode, CR-13. A negative pulse cuts off V-27A and turns on V-27B, applying a gate of negative voltage to the grids of V-29A (unblanking amplifier) and V-29B (sweep gate tube). V-29A and B cut off simultaneously so that the sweep begins at the same instant a step of positive voltage from the plate of V-29A unblanks the CRT.

E-13, 14 and 15, NE-2 neon regulators, supply the needed DC voltage drop while making up an AC path with minimum attenuation of the gate signal. R-181, the GATE ADJUST, sets the gate signal with reference to ground, but has no effect on the height of the gate. R-181 is adjusted for reliable gate action—complete cutoff alternated with full saturation of V-29.

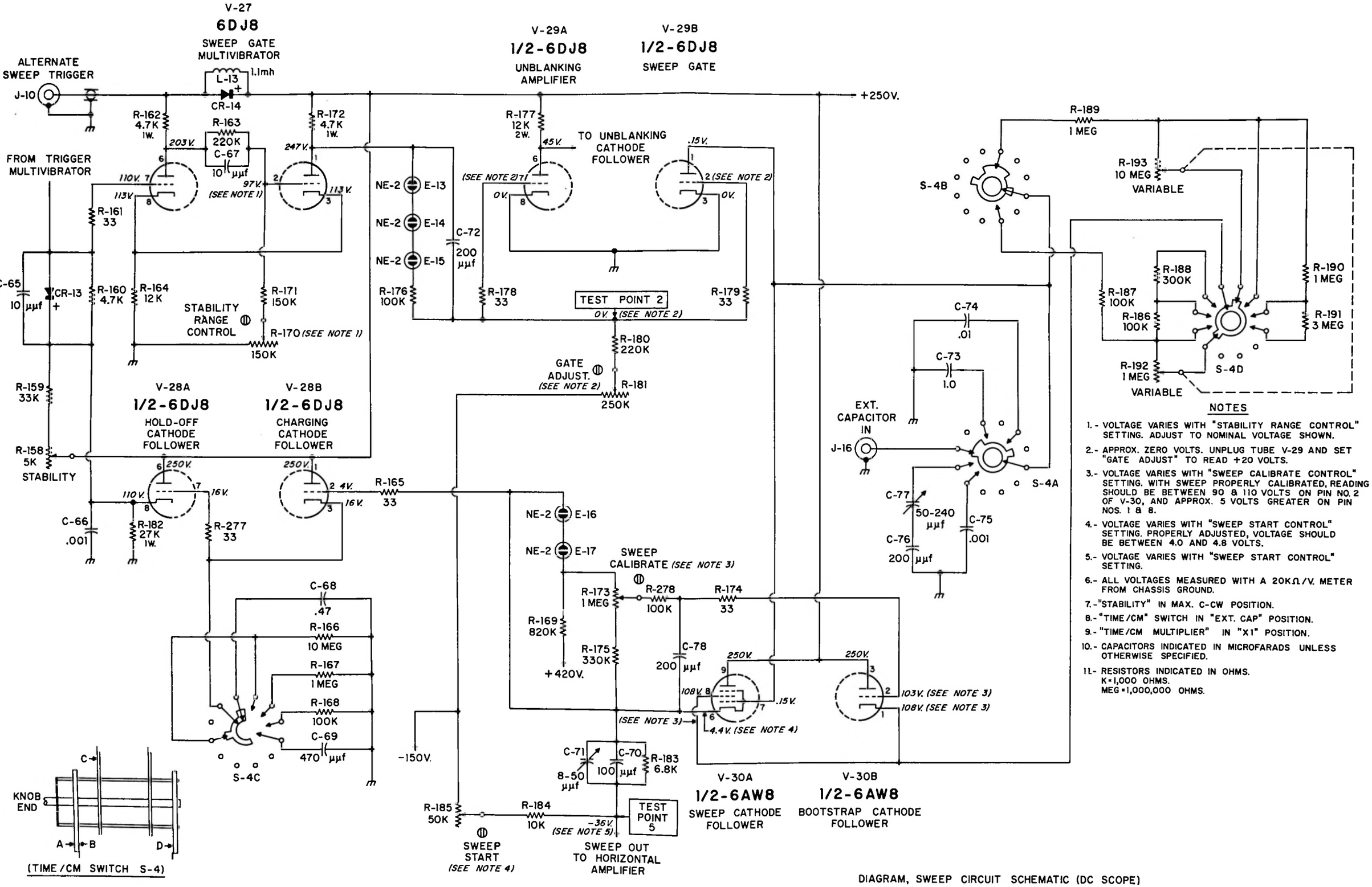
When V-29B is cutoff, the sweep begins because V-29B acts as a switch across the timing capacitor. When it cuts off, the capacitor begins to charge. The charging current flows through tubes 30A and B, providing sweep voltage which is taken off the cathode of V-30A.

R-173, SWEEP CALIBRATOR, varies the slope of the sweep sawtooth by setting the charging voltage. E-16, 17, provide a constant DC voltage tapped by R-173 to supply the desired charging voltage. R-175, SWEEP START, sets the DC level at which the sweep begins, fixing the position of the undeflected spot at the left of the screen.

Part of the sweep sawtooth is applied to V-28, the holdoff cathode follower, and then to the grid of V-27A, the sweep gate multivibrator. When this positive voltage reaches sufficient amplitude, V-27 flips into its other stable state with V-27A conducting, V-27B cutting off and plate voltage rising. Now V-29A and B saturate, turning off the sweep and blanking the CRT. The timing capacitor quickly discharges and another sweep cycle would immediately be initiated by an incoming negative pulse at V-27A, were it not for the action of the holdoff circuit.

The holdoff circuit prevents immediate decay of the positive voltage at the V-27A grid, to provide sufficient time for the sweep circuit to return to the quiescent condition before the next sweep cycle starts. Sweep voltage, applied to V-28B, charges one of the holdoff capacitors in the cathode circuit of this tube. Charging time is very short because only the low resistance of a cathode follower is in the charge path. When the sweep cuts off, this capacitor must discharge through one of the holdoff resistors, a time factor selected by S-4D of the TIME/CM switch. The grid of V-27A remains positive until the holdoff capacitor discharges. Then the V-27 multivibrator is ready to flip again and put out a gate of negative voltage which turns on the sweep. The exact time at which this occurs is controlled by the incoming negative sync pulses.

R-170 stability range control, and R-158, front panel STABILITY control set the operating levels of V-27 for stable sync. L-13 and CR-14 are used only with the dual trace preamplifier and are shorted out by a capacitor in the wide-band and high-gain preamplifiers. L-13 is a ringing coil and CR-14 damps the ringing curve to provide a single pulse for sync use in dual trace applications.




NOTES

1. - VOLTAGE VARIES WITH "STABILITY RANGE CONTROL" SETTING. ADJUST TO NOMINAL VOLTAGE SHOWN.
2. - APPROX. ZERO VOLTS. UNPLUG TUBE V-29 AND SET "GATE ADJUST" TO READ +20 VOLTS.
3. - VOLTAGE VARIES WITH "SWEEP CALIBRATE CONTROL" SETTING. WITH SWEEP PROPERLY CALIBRATED, READING SHOULD BE BETWEEN 90 & 110 VOLTS ON PIN NO. 2 OF V-30, AND APPROX. 5 VOLTS GREATER ON PIN NOS. 1 & 8.
4. - VOLTAGE VARIES WITH "SWEEP START CONTROL" SETTING. PROPERLY ADJUSTED, VOLTAGE SHOULD BE BETWEEN 4.0 AND 4.8 VOLTS.
5. - VOLTAGE VARIES WITH "SWEEP START CONTROL" SETTING.
6. - ALL VOLTAGES MEASURED WITH A 20KΩ/V. METER FROM CHASSIS GROUND.
7. - "STABILITY" IN MAX. C-CW POSITION.
8. - "TIME/CM" SWITCH IN "EXT. CAP" POSITION.
9. - "TIME/CM MULTIPLIER" IN "X1" POSITION.
10. - CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
11. - RESISTORS INDICATED IN OHMS.
K = 1,000 OHMS.
MEG = 1,000,000 OHMS.

DIAGRAM, SWEEP CIRCUIT SCHEMATIC (DC SCOPE)

## THE HORIZONTAL AMPLIFIER

The horizontal amplifier is designed to pass the highest internally-derived sweep frequency (100kc) without distortion. It converts the single-ended output from the sweep generator to push-pull output which drives the horizontal deflection plates of the crt. The amplifier can also be fed by an external signal, introduced at the EXT. SIGNAL jack. Input, external or internal, is selected by the AMPLIFIER GAIN switch which also selects the desired attentuation.

In the EXTERNAL position, R-202 and R-200 make up a 10:1 voltage divider. In the X10 external position, the entire external signal is applied to the grid of V-31A, the input cathode follower. In the X1 position, only 1/10 of the signal (that developed across R-200) is applied to the grid of V-31A.

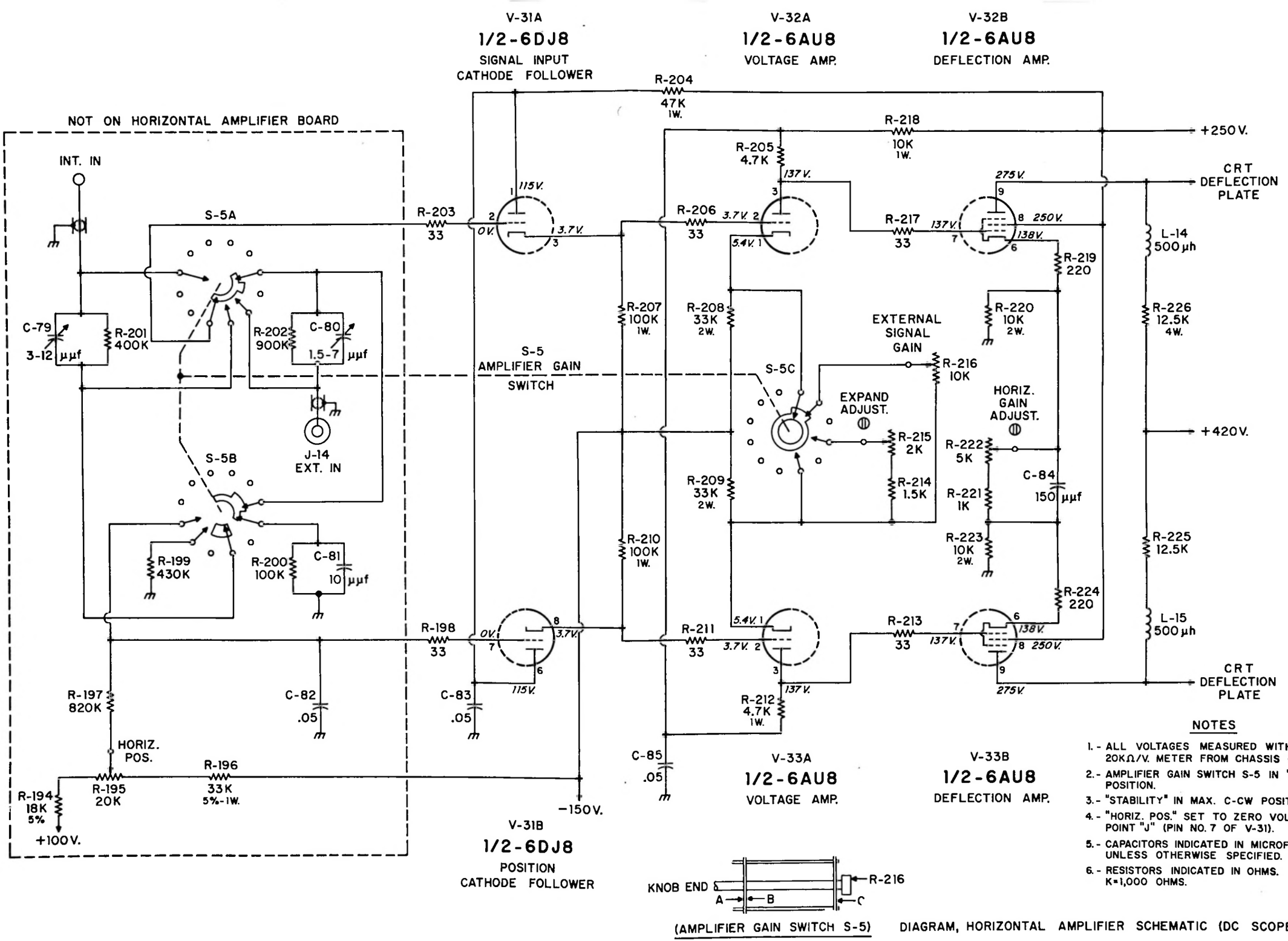
For the INTERNAL positions of this switch, the signal is developed across R-201 and R-200, a 5:1 voltage divider. In the X1 position, only the signal across R-200 is used. For the X5 and X20 positions, the entire signal across R-202 and R-200 is applied to V-31A. Additional gain for the X20 position is supplied by the next stage, V-32A and V-33A.

INPUT STAGE: V-31A and V-31B are operated as cathode followers to reduce the capacitive loading effects of the attenuator circuits. Signal is fed into V-31A and taken off the cathode for the next stage (V-32A, V-33A). V-31B receives no signal but fills two other functions: it supplies DC balance and is used for horizontal positioning. Its grid is connected to the center tap on the R-195 POSITION control. One leg of R-195 is connected to the +100 volt supply, the other to the −150 volt supply. In the Internal X1 position of the AMPLIFIER GAIN switch, R-199 is used to reduce the range of the POSITION control.

Phase splitting takes place in V-32A and V-33A. The cathodes are tied together, while signal is fed to the grid of V-32A (no signal appears at the grid of V-33A). Consider a positive-going signal at the grid of V-32A. Output at the plate will then be negative going. The cathode of this tube will vary in phase with this signal, as will the cathode of V-33A to which it is tied. Since no signal is present at the grid of V-33A, the positive going signal at the V-33A cathode has the effect of a negative going signal at the V-33A grid (all tube voltages are referred to the cathode). In turn the V-33A plate will be out of phase with its grid, resulting in positive going output at the same time the plate of V-32A is going negative.

The gain of this circuit is controlled by switching invariable resistors across cathode resistors R-208 and R-209. In the X20 position of the AMPLIFIER GAIN switch, the cathodes are directly connected so there is no attenuation of the signal and maximum gain is obtained. R-214 and the R-215 control provide the proper range for the X1 and X5 positions. The front panel control R-216, EXT. SIG. GAIN, provides variable gain for the X1 and X10 EXT. SIGNAL positions. Since the relative gain of V-32A and V-33A is different in each of these switch positions, the POSITION control must be readjusted slightly when the range is changed.

V-32B and V-33B are deflection amplifiers which supply voltage to drive the horizontal deflection plates. High-frequency compensation is provided by L-14, L-15, and also by C-84 which is part of a degenerative network in the cathode coupling circuit. When R-222, the HORIZ. GAIN ADJUST, is at minimum resistance, there is maximum coupling between the cathodes and maximum gain. Since the two cathodes are out of phase, maximum coupling between cathodes prevents each cathode from varying with its grid, thus allowing the grids to exert full control of each tube for maximum gain.







(AMPLIFIER GAIN SWITCH S-5)

NOTES

1. - ALL VOLTAGES MEASURED WITH A 20KΩ/V. METER FROM CHASSIS GROUND.
2. - AMPLIFIER GAIN SWITCH S-5 IN "X10 EXT." POSITION.
3. - "STABILITY" IN MAX. C-CW POSITION.
4. - "HORIZ. POS." SET TO ZERO VOLTS AT POINT "J" (PIN NO. 7 OF V-31).
5. - CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
6. - RESISTORS INDICATED IN OHMS. K=1,000 OHMS.

DIAGRAM, HORIZONTAL AMPLIFIER SCHEMATIC (DC SCOPE)

## THE TIME MARK CIRCUITS

The Time Marker Generator consists of 3 synchronized, free-running multivibrators (V-38, V-37, V-36) which supply crystal-controlled negative pulses at 100 kc, 10 kc, and 1 kc respectively.

Time Mark output, at the rate selected by the TIME MARK switch (S-6) is fed to V-34, the unblanking cathode follower. For the duration of the pulse, V-34 is cut off and the crt is blanked. When S-6 is in the OFF position, trigger amplifier output at the TRIGGER POLARITY switch is fed to the trigger multivibrator, V-26. Therefore, in the OFF position of S-6, the signal under study triggers the sweep. However, in all other positions of S-6, the TRIGGER POLARITY circuit is open and the trigger multivibrator, V-26, is fed by the selected Time Mark pulse. The necessary DC voltage for the grid of V-26 is obtained by adjusting R-229 (TIME MARK SYNC).

The 100 kc synchronized oscillator circuit consists of V-38, a free-running multivibrator, with a 100 kc crystal in the feedback path from the screen of V-38B to the grid of V-38A. The screen of V-38B serves as one plate of the multivibrator and supplies 100 kc Time Mark output. For stable synchronization of this stage, R-272 is adjusted to provide the exact time constant needed.

Electron coupling between screen and plate of V-38B supplies 100 kc output to synchronize the next stage, V-37. This method of coupling prevents interaction between the stages.

V-37 is the 10 kc count-down multivibrator, synchronized by 100 kc pulses from the plate of V-38. On the application of a negative pulse to the grid of V-37B, the tube cuts off and its screen goes positive, applying a positive pulse to the grid of V-37A. V-37A then conducts heavily and its plate voltage drops, making the grid of V-7B more negative. The multivibrator remains in this condition for 9 incoming pulses, the time it takes for C-102 to discharge sufficiently through R-269 and R-265 to allow V-37B to conduct again. R-265, the 10 kc adjust, is set for the exact time constant to allow stable sync and the proper count-down ratio. V-37B conducts and V-37A is cut off until the next pulse, which pulls the V-37B grid below cut off. Output, then, is a 10 kc pulse because V-37B conducts on only one out of each ten 100 kc input pulses.

Electron coupling between screen and plate of V-37B is used for isolation from the next stage, the V-36 1 kc count-down. This stage operates in a manner similar to the 10 kc count-down just described. Output is used both for Time Mark purposes and to provide a 1 kc sync pulse for the voltage calibrator, V-35.

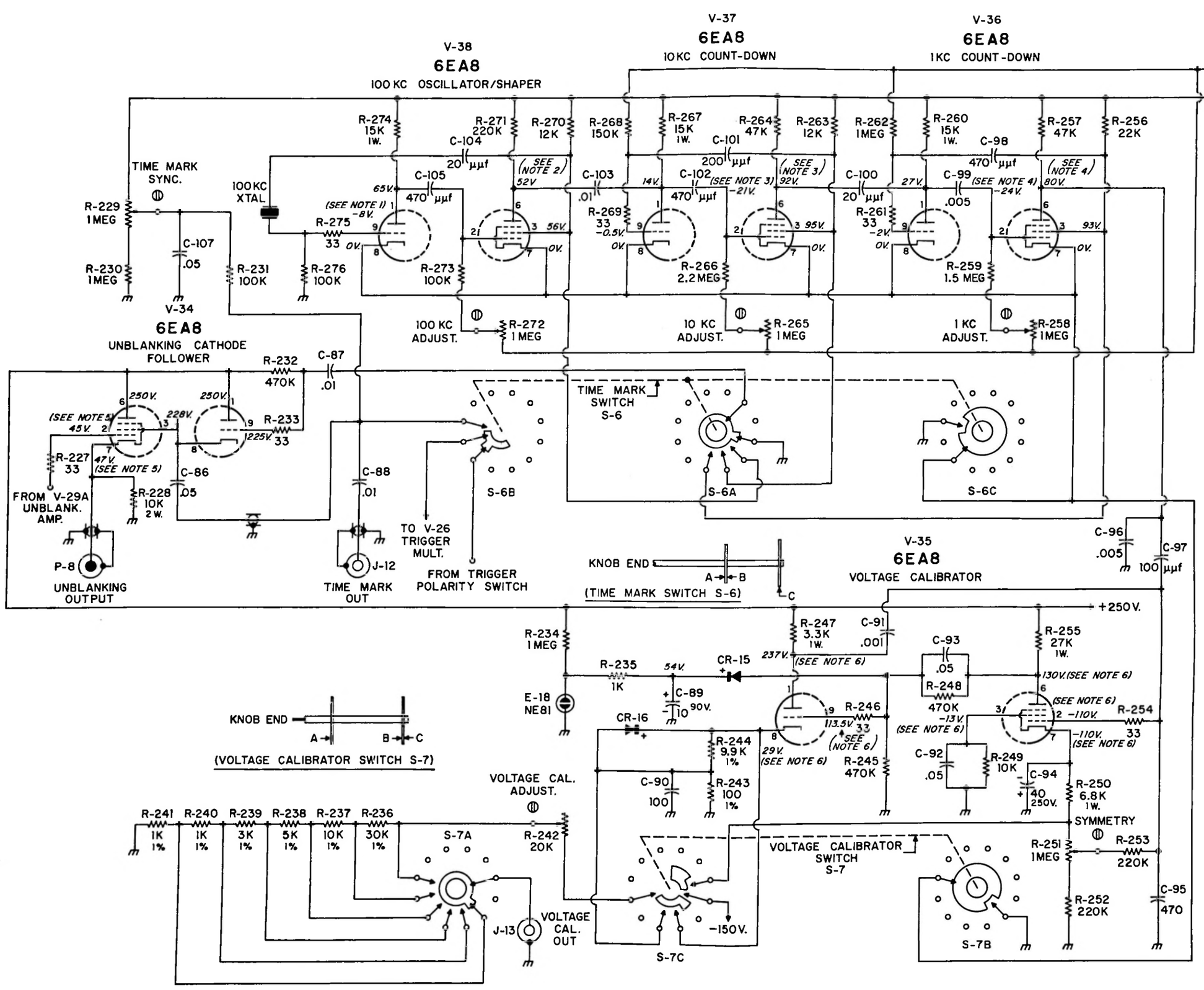
## VOLTAGE CALIBRATOR

The voltage calibrator uses a 6EA8 (V-35) in a multivibrator circuit, triggered by negative-going, 1 kc pulses from the crystal-controlled Time Marker. Synchronization is improved by use of C-96, a .005$\mu$f capacitor, which removes high-frequency components from the synchronizing wave shape.

On the application of a negative pulse to the grid of the V-35B pentode, this tube cuts off, increasing the plate voltage and applying a positive pulse to the grid of the V-35A triode. Now the triode conducts heavily, discharging C-91 through R-253, R-251 and R-252. This time constant (product of the value of C-91 and R-253, the tap of R-251 and R-252) can be varied with the SYMMETRY control, R-251, to achieve a 50% duty cycle. As C-91 discharges, the pentode grid voltage rises sufficiently to allow the tube to conduct.

Now the triode cuts off because the pentode plate has become negative with respect to ground and has applied a negative pulse to the grid of the triode, bringing grid and cathode down to ground. Notice that the pentode plate, although positive with respect to its cathode, is negative with respect to ground during conduction, because tube resistance of the conducting tube is considerably less than the value of the load resistor, R-255. R-255 and the triode plate resistance form a voltage divider between +250 and —150 volt line. The pentode continues to conduct until the next negative pulse cuts it off and turns on the triode section.

The CR-15 silicon diode and E-18, an NE-81 voltage regulator, are used to clamp the grid of the triode at approximately 55 volts, providing a voltage reference for calibrator output. Cathode voltage, used for calibrator output, is always close to grid voltage because the triode is operated as a cathode follower. When R-242, the CALIBRATE control is set for exactly 50 volts at the tap, calibrated voltages from .01 to 50 volts are available by switching the output to suitable points on the voltage dividers, R-236 through R-241. The output waveform is a 1 kc square wave.




## NOTES

1. - VOLTAGE DEPENDS ON CRYSTAL ACTIVITY.
2. - VOLTAGE VARIES WITH "100 KC ADJUST". POSITION CONTROL AT APPROX. 2 O'CLOCK.
3. - VOLTAGE VARIES WITH "10 KC ADJUST". POSITION CONTROL AT APPROX. 2 O'CLOCK.
4. - VOLTAGE VARIES WITH "1 KC ADJUST". POSITION CONTROL AT APPROX. 2 O'CLOCK.
5. - VOLTAGE INCREASES WHEN SWEEP IS TURNED ON (ADVANCING "STABILTY CONTROL" COUNTER-CLOCKWISE).
6. - VOLTAGE VARIES WITH "SYMMETRY CONTROL" POSITIONED AT MID-RANGE.
7. - ALL VOLTAGES MEASURED WITH A 20KΩ/V. METER FROM CHASSIS GROUND.
8. - "TIME MARK SWITCH" IN "OFF" POSITION.
9. - "CAL. MULTIPLIER" IN "X10" POSITION.
10. - "VOLTAGE CAL." VOLTS PEAK TO PEAK, 5.
11. - "TIME MARK SYNC." - APPROX. 90 VOLTS AT "TEST POINT 3".
12. - "STABILITY" IN MAX. C-CW POSITION.
13. - CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
14. - RESISTORS INDICATED IN OHMS. K=1,000 OHMS. MEG=1,000,000 OHMS.

DIAGRAM, TIME MARK & VOLTAGE CALIBRATOR SCHEMATIC (DC SCOPE)

## THE VERTICAL AMPLIFIER

### THE PREAMPLIFIER

Separate plug-in preamplifiers provide a choice of sensitivity, passband and special features, such as differential input or dual trace. The preamp supplies push-pull output for the vertical amplifier and includes the required attenuators and positioning controls. A 16-pin plug from the preamp mates with J-1 on the vertical chassis to supply input and to power the preamp.

### THE VERTICAL AMPLIFIER, MAIN UNIT

Designed for a passband of DC to 10 mc, the vertical amplifier is DC-coupled and push-pull throughout. The input stage (V-1, V-2) includes two controls which set operating voltages for this and following stages.

BIAS ADJUST, R-32, is set for a reading of 10 volts at the V-1, V-2 BIAS test jack (J-2). This value assures a voltage of +102 at the cathodes of V-1A and V-2A. Since the grids are at +100 volts DC through direct coupling to the preamp output tubes, a bias of −2 volts is obtained.

R-33, the DC BALANCE control, balances the screen voltages of V-1 and V-2. This control is adjusted to balance out any differences in the DC levels of the 2 vertical channels so that the trace will be centered in the no-signal condition. Adjustment is made by visual observation of the trace for vertical centering. V-1A and V-2A, voltage amplifiers, are coupled to succeeding stages through V-1B and V-2B, cathode followers.

An additional stage of gain for the deflection voltage is supplied by V-3 and V-4, push-pull amplifier with cathodes tied together by a variable degenerative network of R-16, the VERT GAIN CAL and C-3, the HF PEAKING CONTROL. When R-16 is at zero resistance, the cathodes are directly tied together. Gain will be at a maximum because signal present at one cathode will cancel signal present at the other cathode, allowing the grids to have fullest control of the tubes. As R-16 is increased, degeneration will increase — there will be a loss of gain because only part of the signal from one cathode will be available at the other cathode. Each cathode will then swing up or down with its own grid, resulting in an effective loss of signal.

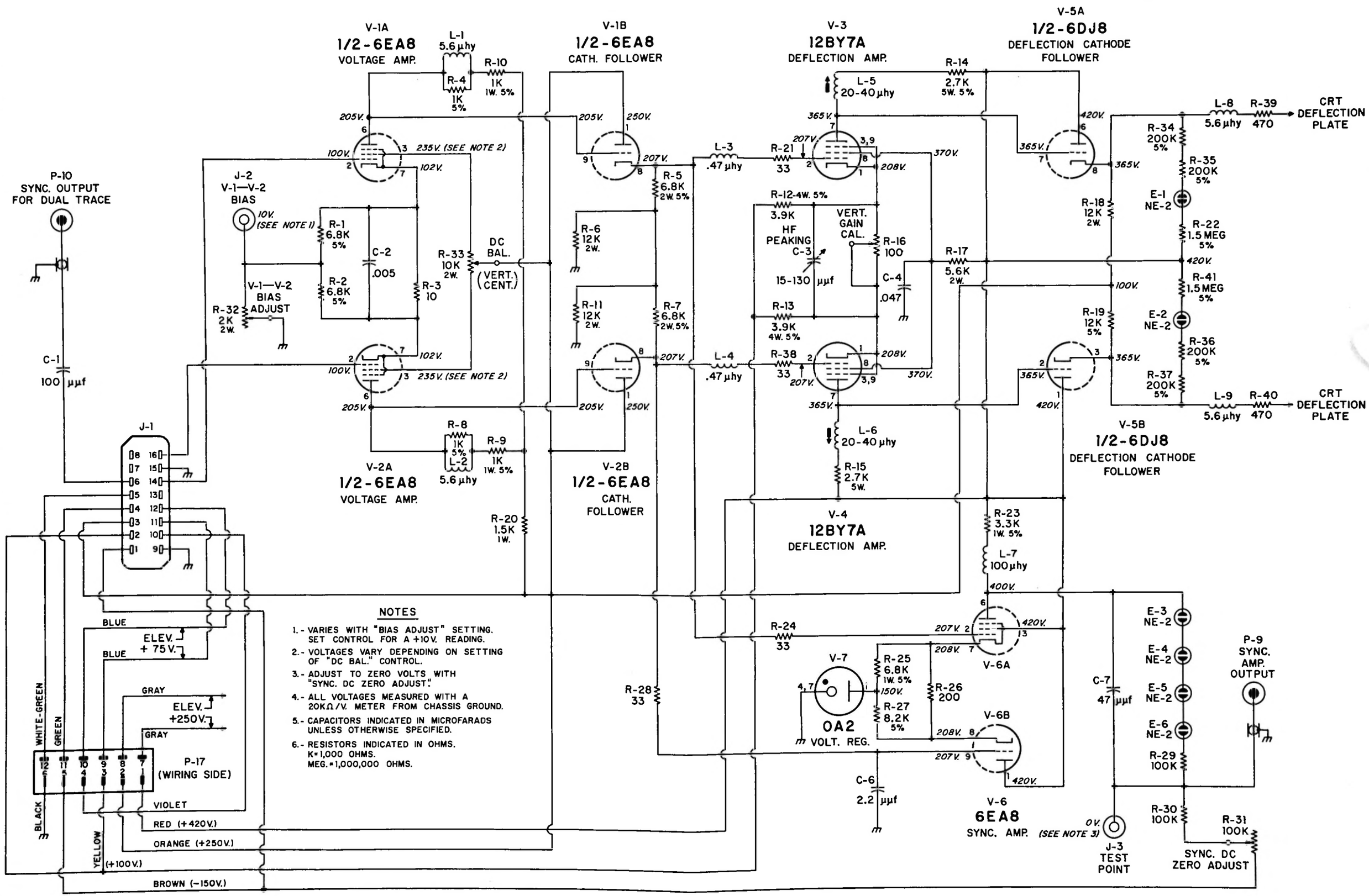
### HIGH-FREQUENCY COMPENSATION

Above 2 mc, the gain of V-3 and V-4 tends to drop off because of circuit and tube capacitances. High-frequency compensation is supplied by C-3 which provides a high-frequency bypass for R-16. Since R-16 controls the gain of the stage, C-3 must be readjusted each time R-16 is changed, to assure the correct amount of high-frequency compensation.

Peaking coils are used in each stage: L-1, L-3, and L-4 for V-1 and V-2; L-5 and L-6 for V-3 and V-4; and L-7 for V-6. L-5 and L-6 are pre-set to an optimum value (approximately 35 $\mu$hy).

V-5A and V-5B, cathode followers, supply low-impedance points for takeoff of deflection voltage, minimizing any capacitive effects of the deflection plates. If the signal to be displayed contains a DC component of considerable amplitude, the trace may be deflected off the face of the tube. In this case E-1 (or E-2 as the case may be) will glow, showing which way the trace has gone, and that vertical deflection voltage is present. These indicators serve as a guide to the adjustments needed at the preamp (vertical centering and range controls) for proper display.

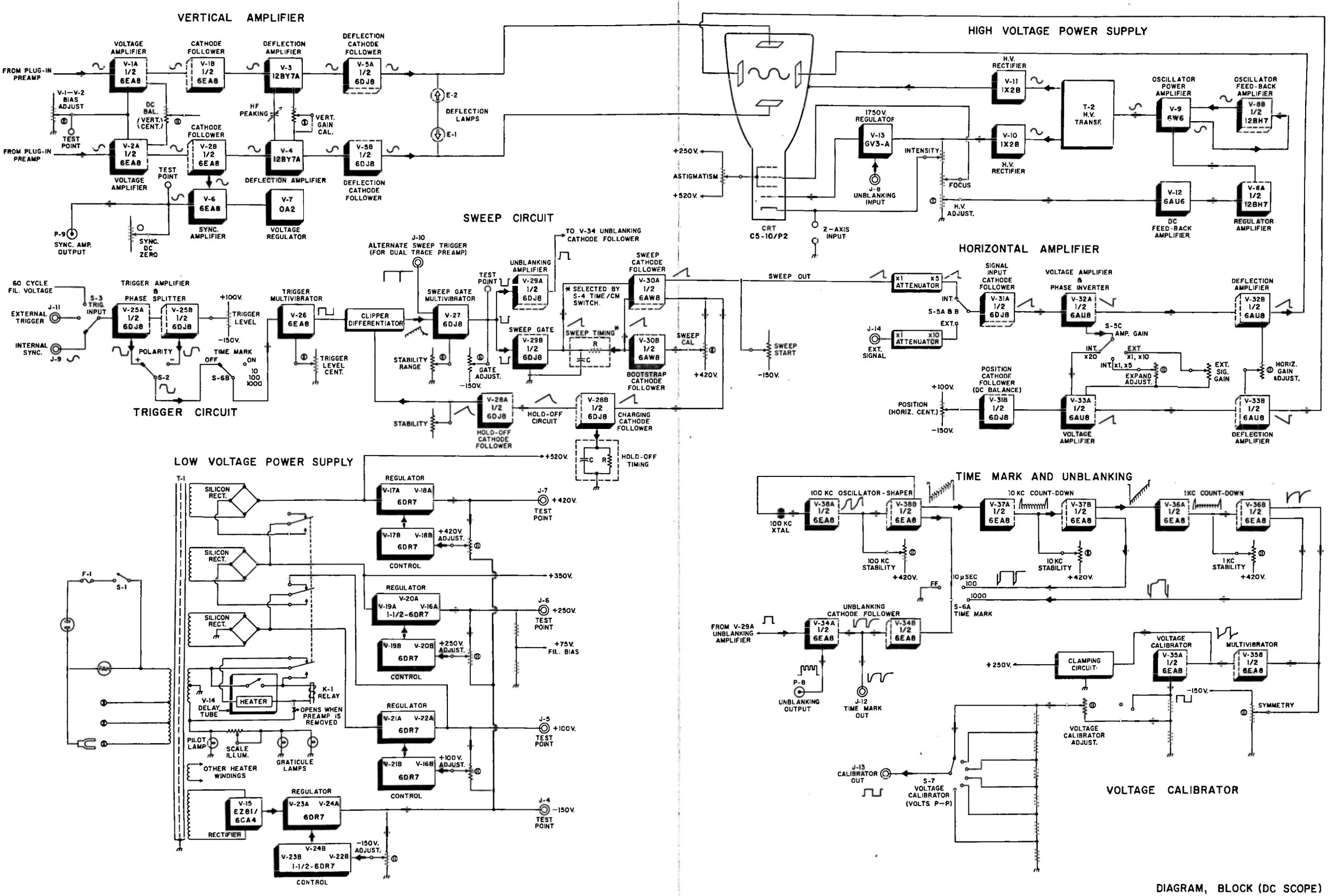
Signal for triggering the sweep is taken from V-1B and V-2B cathode followers and amplified in V-6A and V-6B. Since output for the trigger amplifier must be at 0 DC, a voltage divider is used between the plate of V-6A and the −150 v. DC supply, to obtain the needed voltage drop. However, attenuation of the AC signal is not desired. Therefore, NE-2 regulators, which present a low impedance to the AC signal, are used in this voltage divider. C-47 supplies HF compensation. R-31, the SYNC DC ZERO ADJUST has one leg connected to the −150 v. supply; the other leg is adjusted for 0 volts at the SYNC DC ZERO test point.




NOTES

1. - VARIES WITH "BIAS ADJUST" SETTING. SET CONTROL FOR A +10V. READING.
2. - VOLTAGES VARY DEPENDING ON SETTING OF "DC BAL." CONTROL.
3. - ADJUST TO ZERO VOLTS WITH "SYNC. DC ZERO ADJUST."
4. - ALL VOLTAGES MEASURED WITH A 20KΩ/V. METER FROM CHASSIS GROUND.
5. - CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
6. - RESISTORS INDICATED IN OHMS. K=1,000 OHMS. MEG.=1,000,000 OHMS.

DIAGRAM, VERTICAL AMPLIFIER SCHEMATIC (DC SCOPE)




DIAGRAM, BLOCK (DC SCOPE)

## KNIGHT INSTRUMENT GUARANTEE

Allied fully protects your Knight instrument purchase with this exclusive money-back guarantee. Your Knight instrument must meet with your complete satisfaction or your purchase price is refunded. Every Knight instrument is fully warranted against defects in material and workmanship for a period of 90 days from the date of original purchase.

If service is necessary, first write to TECHNICAL SERVICE at Allied Radio. Give the stock number, series number, date of purchase and describe the problem. We will reply promptly with pertinent data. Should it appear that work in our lab is necessary, we will send you packing instructions and a suitable shipping container.

To save shipping costs, try to isolate the trouble to a particular circuit and return only the affected section (vertical, horizontal or high-voltage). Service charges will be based on the length of time needed to repair the unit and catalog price of parts beyond the EIA 90-day warranty period.


39K178-2-750327-19-AG-1061