

OPERATING AND SERVICING MANUAL

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MODEL 130A

OSCILLOSCOPE

Serial 125



HEWLETT-PACKARD COMPANY

275 Page Mill Road • Palo Alto, California, U.S.A.

PRELIMINARY OPERATING INSTRUCTIONS
FOR

MODEL 130A

OSCILLOSCOPE

Serial 125

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HEWLETT-PACKARD COMPANY
275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U. S. A.

130A000

ADJUST TO OBTAIN STATIONARY POSITION WHEN **VERT. SENSITIVITY** **VERNIER** IS TURNED FROM MIN. TO MAX.

ADJUST VERTICAL POSITION

SET TO **DC** (DIRECT-COUPLED INPUT) FOR DC SIGNALS, SET TO **AC** (CAPACITY COUPLED INPUT) FOR AC SIGNALS.

SELECT DESIRED VERTICAL INPUT SENSITIVITY ($\pm 5\%$) WITH **VERNIER** SET TO **CAL**.
SET TO **CAL** TO CHECK SENSITIVITY

ADJUST VERTICAL SENSITIVITY BETWEEN STEPS OF **VERTICAL SENSITIVITY** SELECTOR

VERTICAL INPUT. BALANCED INPUT CAN BE USED ON 1-20 MV/CM RANGES.

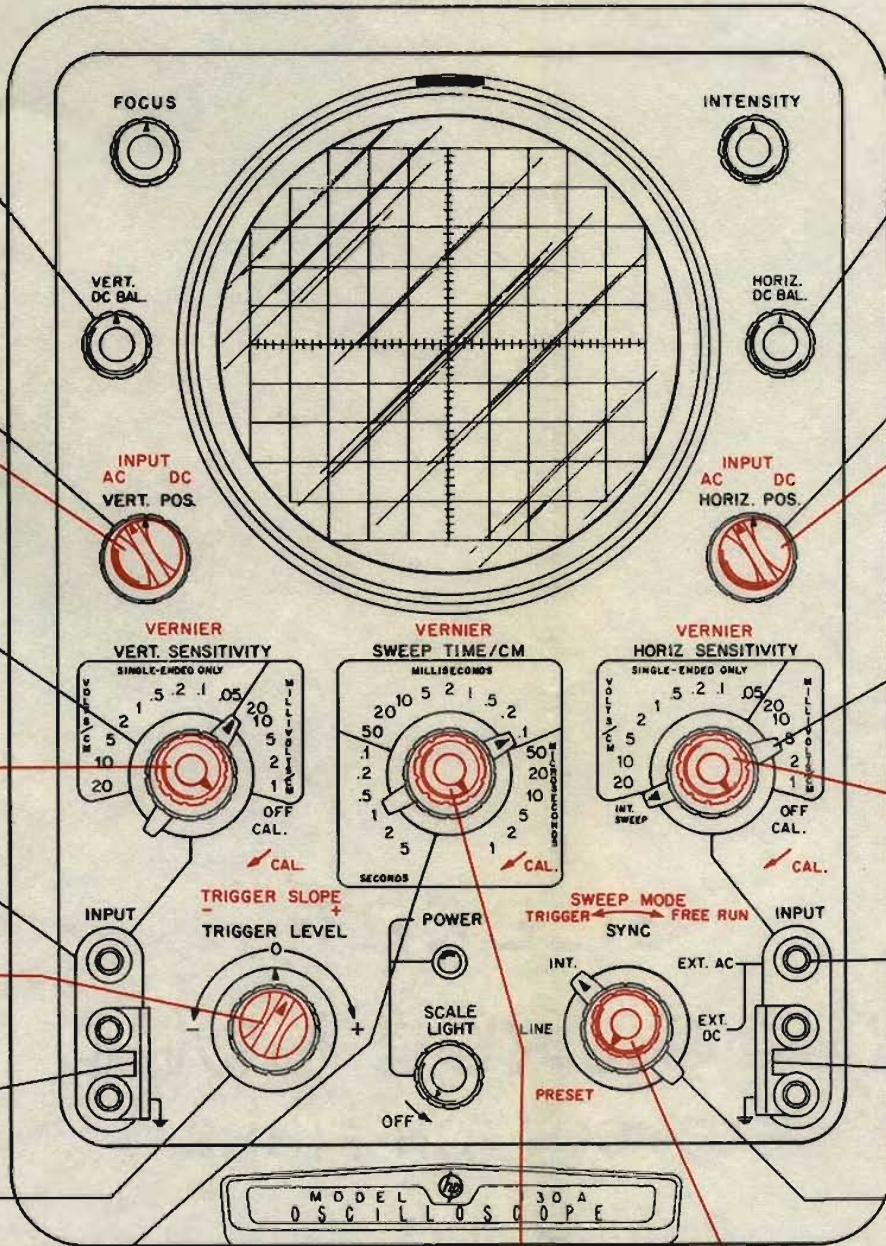
SET TO TRIGGER SWEEP FROM EITHER POSITIVE OR NEGATIVE SLOPE OF SYNC SIGNAL.

REMOVE SHORTING BAR FOR BALANCED INPUT.

ADJUST TO START SWEEP AT DESIRED VOLTAGE OF SYNC SIGNAL OR, IF NECESSARY, ADJUST TO STABILIZE SWEEP WITH **SWEEP MODE** IN **PRE-SET**

SELECT TIME/CM OF INTERNAL SWEEP ($\pm 5\%$) WITH **VERNIER** SET TO **CAL**

ADJUST SWEEP TIME/CM BETWEEN STEPS OF **SWEEP TIME/CM** SELECTOR



FOCUS

INTENSITY

VERT. DC BAL.

HORIZ. DC BAL.

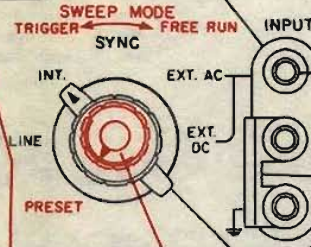
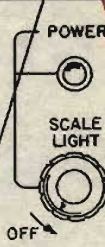
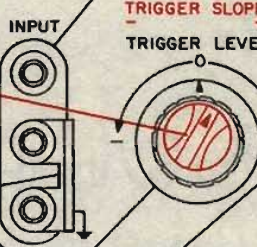
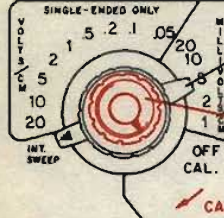
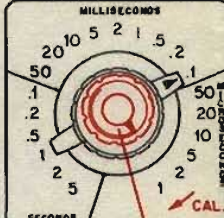
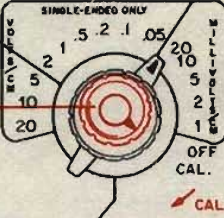
INPUT AC DC VERT. POS.

INPUT AC DC HORIZ. POS.

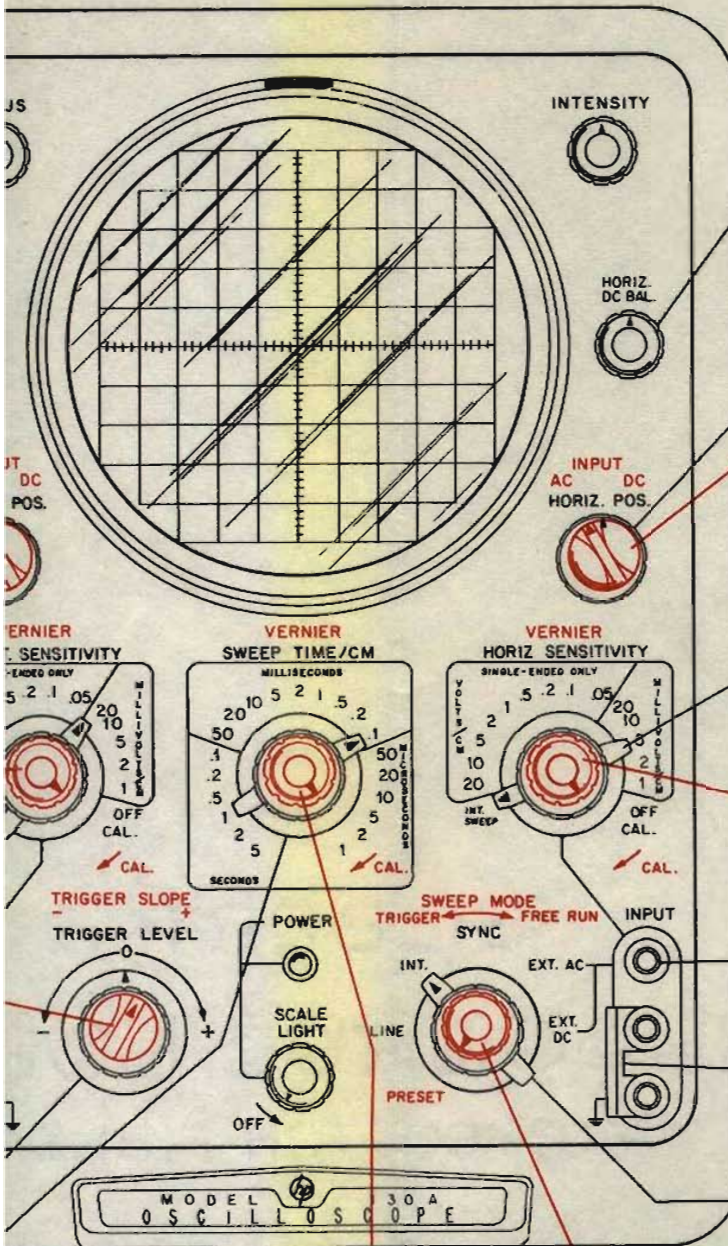
VERNIER
VERT. SENSITIVITY
SINGLE-ENDED ONLY

VERNIER
SWEEP TIME/CM
MILLISECONDS

VERNIER
HORIZ SENSITIVITY
SINGLE-ENDED ONLY



MODEL 30A
OSCILLOSCOPE



ADJUST TO OBTAIN STATIONARY POSITION WHEN **HORIZ. SENSITIVITY** **VERNIER** IS TURNED FROM MIN. TO MAX.

ADJUST HORIZONTAL POSITION.

SET TO **DC** (DIRECT-COUPLED INPUT) FOR DC SIGNALS; SET TO **AC** (CAPACITY-COUPLED INPUT) FOR AC SIGNALS.

SET TO **INT. SWEEP** TO OPERATE INTERNAL SWEEP. SELECT DESIRED HORIZONTAL INPUT SENSITIVITY ($\pm 5\%$) WITH **HORIZ. SENSITIVITY** SET TO **CAL**. SET TO **CAL** TO CHECK SENSITIVITY

ADJUST HORIZONTAL SENSITIVITY BETWEEN STEPS OF **HORIZ. SENSITIVITY** SELECTOR

SWEEP OR SYNCHRONIZING INPUTS. TO SYNC SCOPE, SET **HORIZ. SENSITIVITY** TO **INT. SWEEP**. BALANCED INPUT CAN BE USED ON 1-20 MV/CM RANGES.

REMOVE SHORTING BAR FOR BALANCED INPUT.

SELECT CHARACTER OF SYNC SIGNAL DESIRED.

SET TO **PRE-SET** FOR BEST SYNC STABILITY OR TO **FREE-RUN** AS DESIRED.

OF INTERNAL SWEEP
ER SET TO **CAL**

ADJUST SWEEP TIME /CM BETWEEN STEPS OF **SWEEP TIME/CM** SELECTOR

130A SPECIFICATIONS

———— SWEEP GENERATOR ————

INTERNAL SWEEP: 21 calibrated ranges provide sweep speeds from 1 μ -sec/cm to 5 sec/cm, accurate to within 5%.
A vernier control provides continuous adjustment of sweep speed between calibrated ranges and extends slowest sweep to approximately 15 sec/cm.

SYNCHRONIZATION: Internal, from line power or vertical input signal having 1/2 cm or more deflection.
External, either capacitively or directly coupled from signals of 1/2 volt peak-to-peak or more.

SYNC CONTROL: Sweep can be triggered from either a positive- or a negative going voltage; the triggering voltage level of external sync signals is continuously adjustable from -30 to +30 volts.
Switch position, "Preset", automatically provides optimum sync stability for majority of uses.

———— VERTICAL AND HORIZONTAL AMPLIFIERS ————

BANDWIDTH: Direct current to 300 kilocycles.

SENSITIVITY: 14 calibrated ranges provide sensitivities from 1 millivolt/cm to 20 volts/cm, accuracy $\pm 5\%$. A vernier control provides continuous adjustment between calibrated ranges and extends the minimum sensitivity to approximately 50 volts/cm.

COMMON MODE REJECTION: Rejection at least 40 db. Common mode signal must not exceed 1.5 volts.
(Balanced input only)

INPUT IMPEDANCE

Single Ended: 1 megohm shunted by approximately 50 μ mf.

Balanced input (on 1, 2, 10, and 20 mv/cm ranges only): 2 megohms shunted by approximately 25 μ mf.

———— CALIBRATOR ————

OUTPUT: Fixed amplitude 1000-cycle square wave automatically fed to vertical and horizontal amplifier inputs when switched to CAL.

———— CATHODE RAY TUBE ————

TYPE: 5AQP mono-accelerator, flat face, available with P1, P7 or P11 screen. 3000-volt accelerating potential.

DEFLECTION PLATE CONNECTIONS: Screw terminals in rear access receive wires for connection to plates.

INTENSITY MODULATION: Terminals inside rear access to receive +20 pulse for blanking CRT trace of normal intensity.

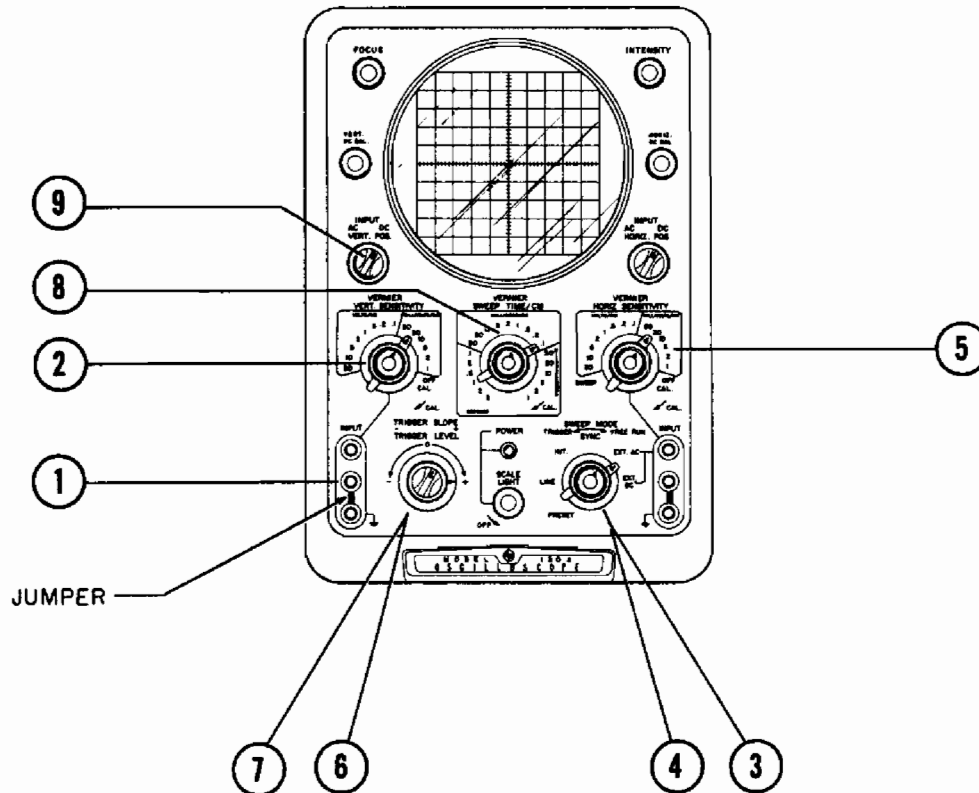
REPLACEABILITY: CRT bezel removes with 15° twist for replacement of graticule or CRT from the front panel.
CRT bezel provides firm mounting for standard oscilloscope cameras.

POWER REQUIREMENTS: 115/230 VAC $\pm 10\%$, 50/400 cycles; approximately 175 watts.

SIZE: 9-3/4" wide x 15-1/4" high x 20" deep.

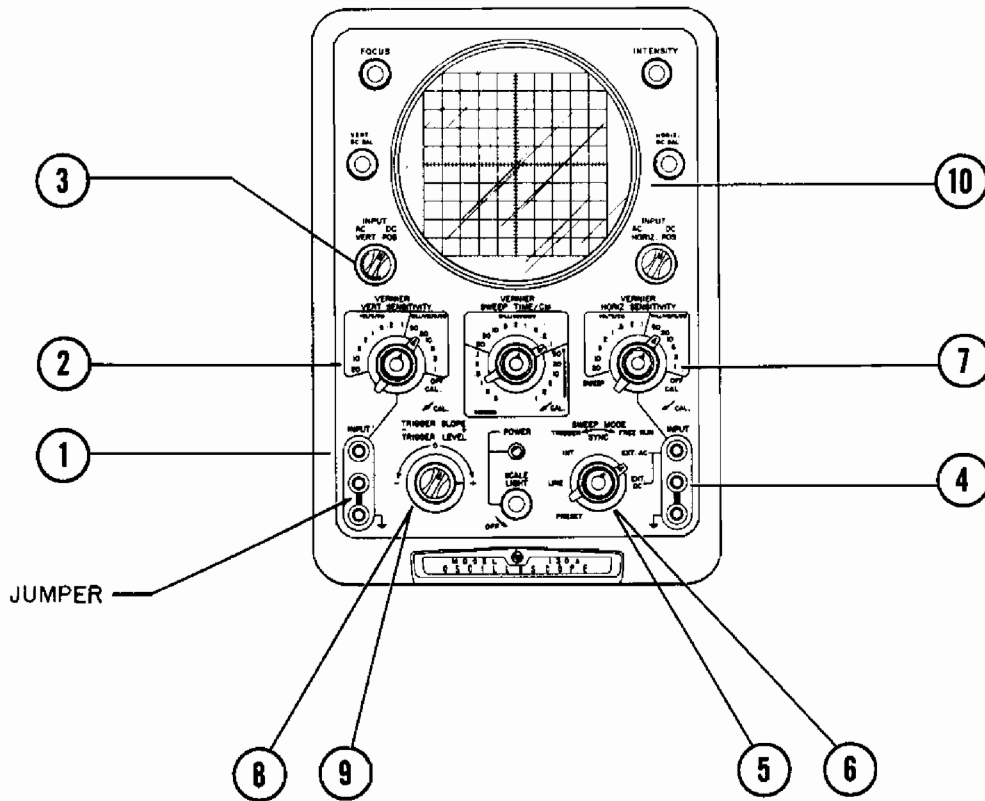
WEIGHT: Approximately 39 lbs. net.

INTERNAL SWEEP — INTERNAL SYNCHRONIZATION



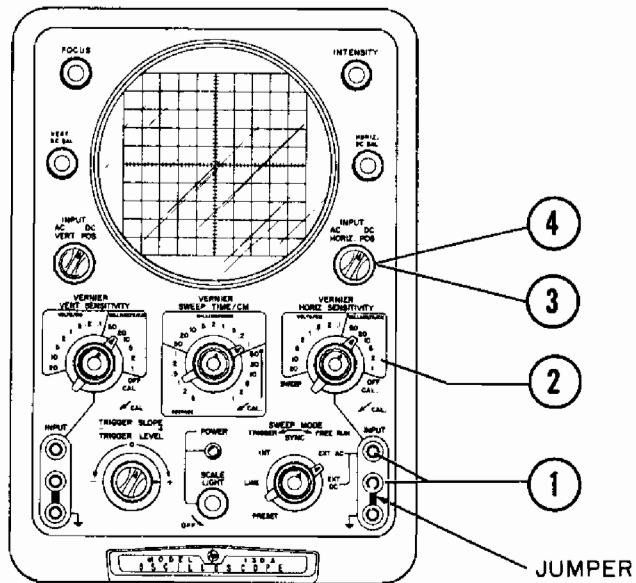
- | | |
|--|---|
| <ol style="list-style-type: none"> 1. Place vertical input signal across INPUT. You can use a balanced input on the 1 to 20 mv/cm ranges of the VERT SENSITIVITY switch by removing the ground jumper on INPUT terminal. 2. Adjust VERT SENSITIVITY for desired VOLTS/CM deflection. 3. Set SYNC to INT. 4. Set SWEEP MODE to PRESET. 5. Set HORIZONTAL SENSITIVITY to SWEEP. In other positions this control becomes the | <ol style="list-style-type: none"> external horizontal input attenuator, and the internal sweep generator is de-energized. 6. Put TRIGGER LEVEL control to ZERO. 7. Set TRIGGER SLOPE for triggering on positive or negative slope of input wave as desired. 8. Select desired sweep speed. 9. In most cases use AC position for vertical input coupling. See paragraph 2-4. |
|--|---|

INTERNAL SWEEP — EXTERNAL SYNCHRONIZATION



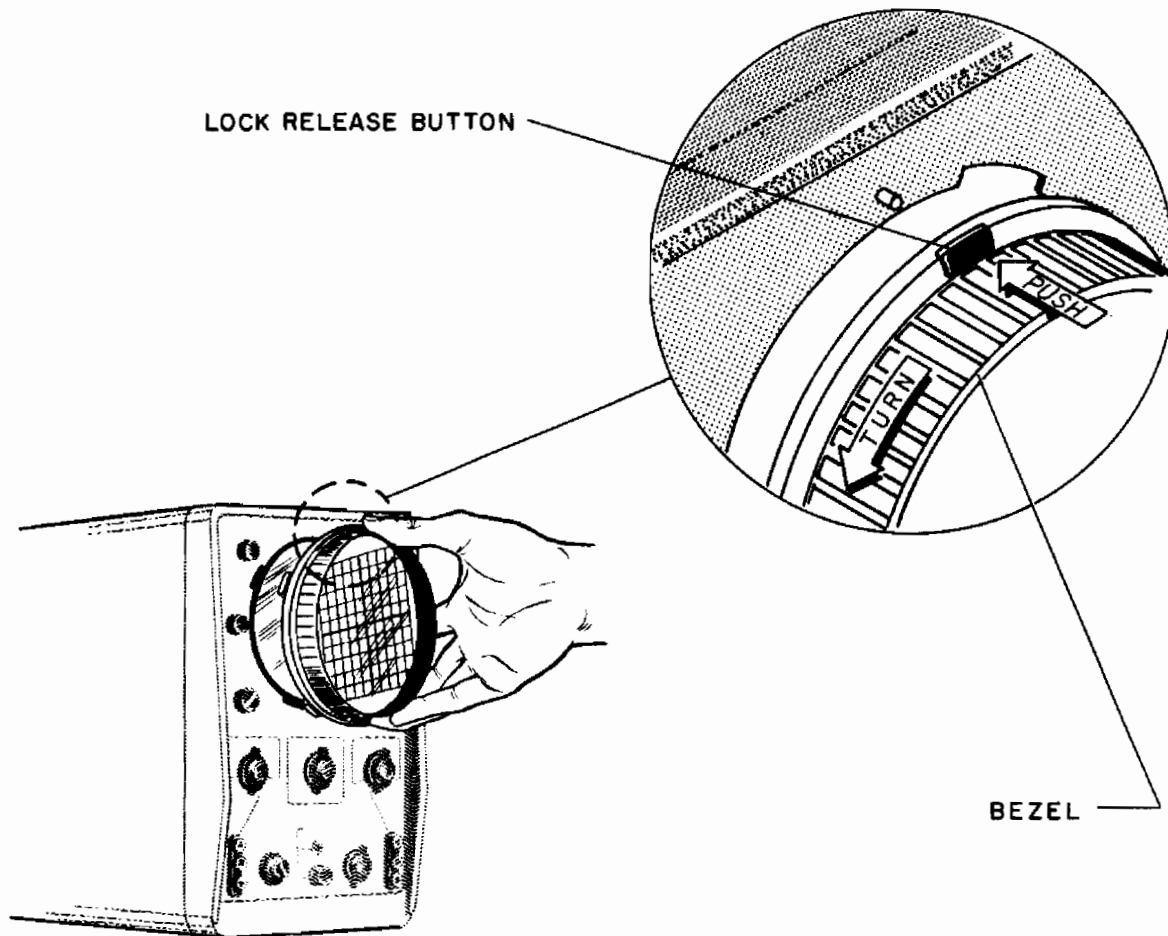
1. Place vertical signal into INPUT. You can use a balanced input on the 1 to 20 mv/cm ranges of the VERT SENSITIVITY control (2) by removing the ground jumper on the INPUT terminal.
2. Adjust VERT SENSITIVITY for desired VOLTS/CM deflection.
3. In most cases set for AC coupling. See paragraph 2-4.
4. Place external synchronizing signal across horizontal INPUT.
5. Switch SYNC selector to EXT AC or DC as desired. See paragraph 2-4.
6. Set SWEEP MODE to PRESET.
7. Switch HORIZ SENSITIVITY to SWEEP.
8. Adjust TRIGGER LEVEL to ZERO.
9. Adjust TRIGGER SLOPE to trigger sweep on positive or negative slope of input wave as desired.
10. Select desired sweep speed with SWEEP TIME C/M switch.

EXTERNAL HORIZONTAL INPUT



1. Place external horizontal signal to INPUT. Balanced input may be used on 1-20 mv/cm ranges of HORIZ. SENSITIVITY control by removing ground jumper on INPUT.
2. Select desired horizontal sensitivity. This control is a horizontal input attenuator when not in the INT SWEEP position, and all internal-sweep controls are de-energized.
3. Select desired input coupling. Paragraph 2-4.
4. Adjust horizontal position of signal.

REMOVING CRT BEZEL

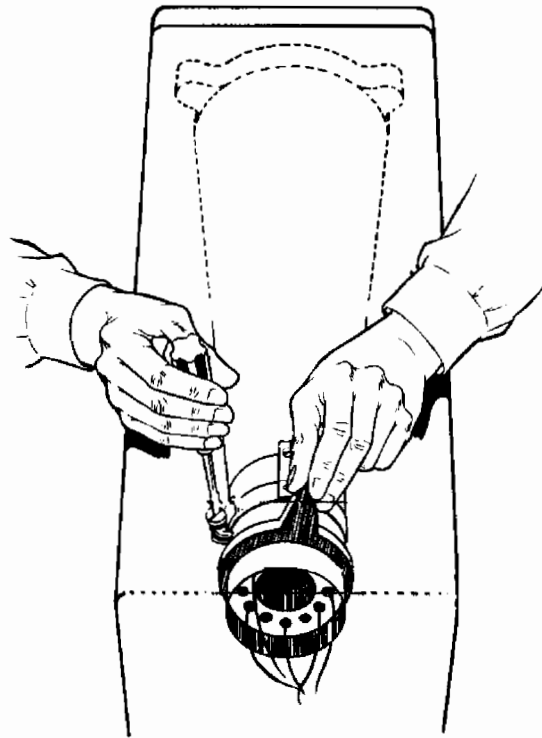


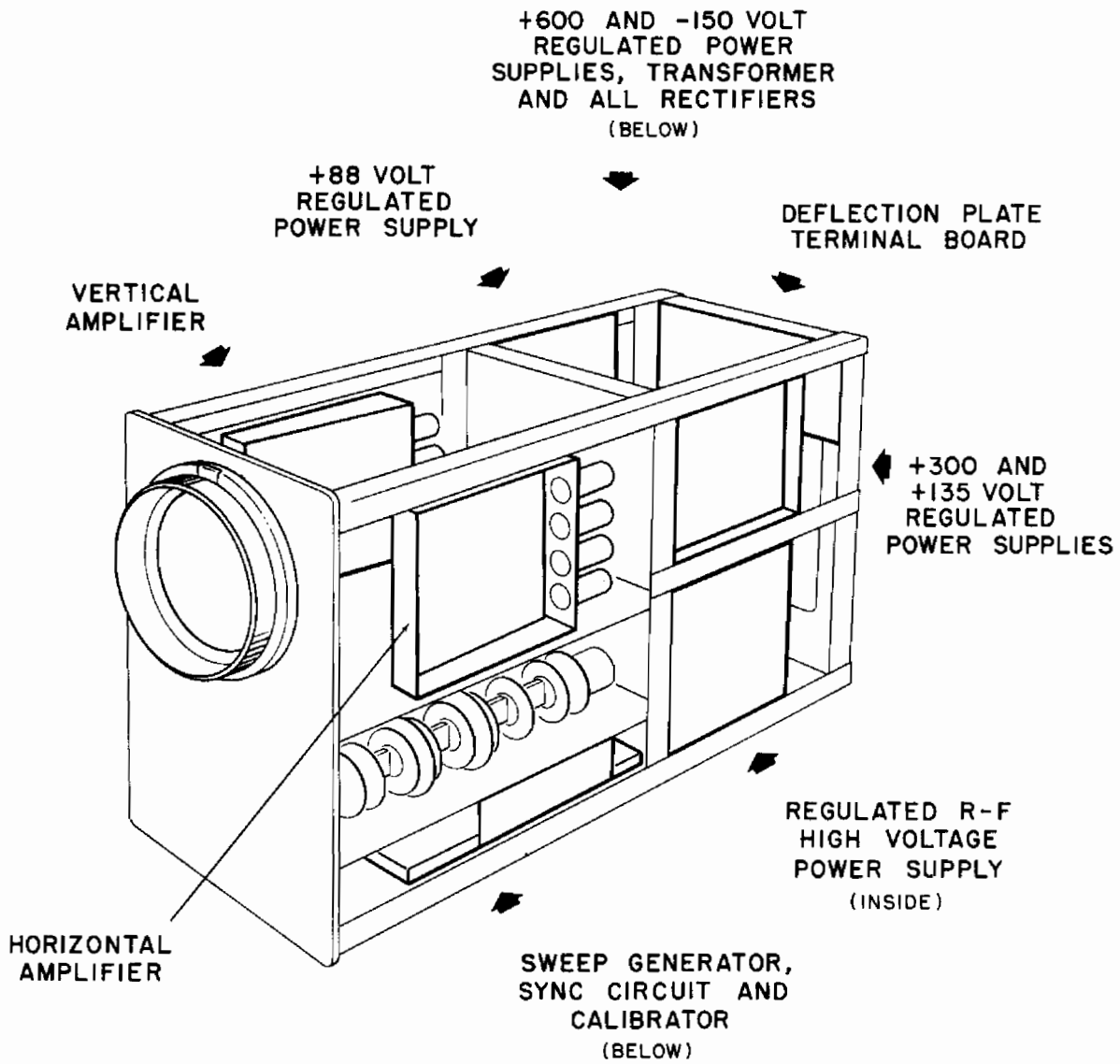
The CRT bezel contains the filter and graticule shields; it has also been designed to accept oscilloscope camera equipment without adapters of any kind. To change filters or cathode ray tubes the bezel must be removed.

To remove bezel:

1. Depress lock release button, and twist bezel counter clockwise about 15 degrees.
2. Pull bezel straight from panel as shown.

ALIGNING SCOPE TRACE WITH GRATICULE





SECTION IV
MAINTENANCE

4-1 INTRODUCTORY

This section contains instructions for adjusting and servicing the 130A Oscilloscope. The 130A is constructed so that each of the major circuit sections is physically located on a single etched circuit board, except for portions of the power supplies which utilize three separate chassis. The material in this section is divided as the circuit sections, each section has a complete set of adjustment instructions, and at the rear of the manual, a schematic and a voltage-resistance diagram. The material in this section is as follows:

- 4-2 Removing the Cabinet
- 4-3 Connecting for 230-Volt Power Lines
- 4-4 Servicing Etched Circuits
- 4-5 Tube Replacement Chart
- 4-6 Isolating Troubles to Major Sections
- 4-7 Adjusting the Low-Voltage Power Supplies
- 4-8 Adjusting the RF High-Voltage Power Supply
- 4-9 Replacing and Adjusting the CRT
- 4-10 Checking the Calibrator
- 4-11 Adjusting the Vertical Amplifier
- 4-12 Adjusting the Horizontal Amplifier
- 4-13 Adjusting the Preset Sensitivity of the Sweep Generator
- 4-14 Adjusting the Sweep Generator

4-2 REMOVING THE CABINET

The 130A chassis and panel are removed from the cabinet by removing the two retainer screws on the rear of the cabinet and sliding the chassis forward out of the cabinet.

SERVICING PRINTED CIRCUIT BOARDS

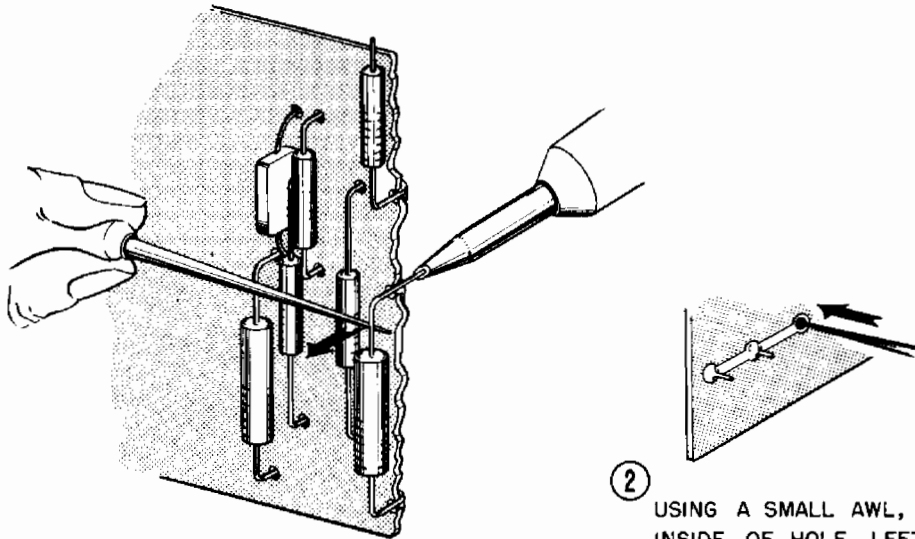
CAUTION

When servicing printed circuits DO NOT push or pull wires in such a way as to raise the printed wiring from the board.

When soldering leads, use 50 watt iron or smaller. Apply heat sparingly to the leads on the part to be replaced, not to the printed wiring on the board.

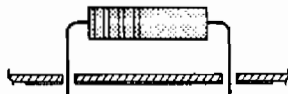
Before installing new parts, clean holes to receive new part without forcing. Have new leads tinned and if necessary fluxed to receive solder quickly with a minimum of heat and without residue.

- ① APPLY HEAT SPARINGLY TO LEAD OF PART TO BE REPLACED. REMOVE PART FROM BOARD AS IRON HEATS THE LEAD.



- ② USING A SMALL AWL, CAREFULLY CLEAN INSIDE OF HOLE LEFT BY OLD PART.

- ③ BEND CLEAN LEADS ON NEW PART AND CAREFULLY INSERT THROUGH HOLES ON BOARD.



- ④ HOLD PART AGAINST BOARD AND SOLDER LEADS.

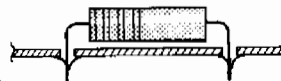


Diagram showing how to replace parts mounted on printed circuit boards

4-3 CONNECTING FOR 230-VOLT POWER LINES

The 130A is normally shipped from the factory with the dual primary windings of the power transformer connected in parallel for use on 115-volt a-c lines. The windings can easily be reconnected in series for use on 230-volt power if desired. To reconnect the primary windings of T2 for use on 230 volts disconnect the jumpers which join terminals A1 to A3 and A2 to A4. Connect a jumper between terminals A2 and A3. Replace the 2-amp slow-blow fuse with a 1-1/4-amp slow-blow fuse and the 130A can now be operated from 230-volt lines with no change in operation.

4-4 SERVICING ETCHED CIRCUITS

Figure 4-2 illustrates how to replace electrical parts on etched circuits.

When servicing etched circuits, DO NOT push or pull wires in such a way as to raise the wiring from the board.

When soldering leads on the etched board, use a 50 watt iron or smaller. Apply heat sparingly to the leads on the part to be replaced, not to the wiring on the board.

Before installing new parts, clean hole to receive new part without forcing. Have new leads tinned and if necessary fluxed to receive solder quickly with a minimum of heat and without residue.

4-5 TUBE REPLACEMENT CHART

The following chart lists all the tubes in the 130A with their functions and adjustments required when replacing tubes. The heaters of some of the tubes in the 130A are operated in series from a regulated d-c voltage obtained from the Low-Voltage Power Supply. This series heater string is shown in one piece on the Low-Voltage Power Supply schematic diagram; the actual connections through each circuit are shown individually on the schematic of the circuit. When replacing tubes during trouble shooting, if one of the series tubes is pulled, it will turn off all other tubes in the string.

TUBE REPLACEMENT CHART

DESIGNATION	TUBE TYPE	FUNCTION	CHECK OR ADJUSTMENTS NECESSARY
V1	12AU7	VERT. AMPL. Phase Inverter Amplifier	Adjust Bal Gain and C23 (para. 4-11)
V2	6211	Differential Amplifier	Adjust Bal Gain and C23 (para. 4-11)
V3	12AT7	Differential Amplifier	Adjust Gain, C23 and C21 (para. 4-11)
V4	6BQ7	Differential Amplifier	Adjust Gain, C23 and C21 (para. 4-11)
V5	12AU7	HORIZ. AMPL. Phase Inverter Amplifier	Adjust Bal, Gain and C59 (para. 4-12)
V6	6211	Differential Amplifier	Adjust Bal, Gain and C59 (para. 4-12)
V7	12AT7	Differential Amplifier	Adjust Gain, R96, C49, C53, C55, C57, C59 (para. 4-12)
V8	6BQ7	Differential Amplifier	Adjust Gain, R96, C49, C53, C55, C57, C59 (para. 4-12)
V9	6BQ7A	SWEEP GENERATOR Trigger Amplifier	No adjustment required
V10	12AT7	Trigger Generator	No adjustment required
V11	6BQ7A	Sweep Start-Stop Trigger	Adjust Preset, Sweep Length (paras. 4-13 and 4-14)
V12	6BC7	a. Diode Clamp b. Integrator Switch c. Integrator Switch	No adjustment required
V13	6AW8	a. Integrator Cathode Follower b. Feedback Integrator	Check Sweep Calib. (para. 4-14)
V14	12AX7	a. Retriggering Hold Off b. Retriggering Bias Control	Adjust Preset (para. 4-13)
V15	12AU7	a. Gate Out Cathode Follower b. Clamp	No adjustment required
V16	6BQ7	Calibrator Multivibrator	No adjustment required - Check Symmetry
V17	6AQ5	HIGH VOLTAGE POWER SUPPLY Oscillator	No adjustment required
V18	1X2B	High Voltage Rectifier	No adjustment required
V19	1X2B	High Voltage Rectifier	No adjustment required
V20	6BQ7A	Control Tube	Readjust High Voltage (para. 4-8)
V21	5AQP	CRT	Adjust gain of VERT. and HORIZ. amplifiers (para. 4-11 and 4-12)
V22	12B4	600-volt Series Regulator	No adjustment required
V23	6BH6	600-volt Control Tube	No adjustment required
V24	6BW4	300-volt Rectifier	No adjustment required
V25-V26	12B4	300-volt Series Regulators	No adjustment required
V27	6AW8	a. 300-volt Control Tube b. 135-volt Cathode Follower	No adjustment required
V28-V29	12B4	+88-volt Series Regulators	Adjust L.V. Supply if necessary (para. 4-7)
V30	6BH6	+88-volt Control tube	Adjust L.V. Supply if necessary (para. 4-7)
V31	6X4	-150-volt Rectifier	Adjust L.V. Supply if necessary (para. 4-7)
V32	12B4	-150-volt Series Regulator	Adjust L.V. Supply if necessary (para. 4-7)
V33	6BH6	-150-volt Control Tube	Adjust L.V. Supply if necessary (para. 4-7)
V34	5651	Reference Tube	Adjust L.V. Supply if necessary (para. 4-7)
SR2	212-122	+88-volt Rectifier	Adjust L.V. Supply if necessary (para. 4-7)

4-6 ISOLATING TROUBLE TO MAJOR SECTIONS

In any case of trouble shooting, attempt operation of the various sections of the oscilloscope and determine which major section contains the circuit failure. Proceed in the following manner.

- a. Check the Low-Voltage Power Supply voltages as described in paragraph 4-7.
- b. Check the High-Voltage Power Supply voltages as described in paragraph 4-8. Turn both VERT. SENSITIVITY and the HORIZ. SENSITIVITY input selectors to off, and center the position controls to obtain a spot. Note the action of the intensity and focus controls. If the spot does not appear, measure the deflection plate voltages.
- c. Check the Vertical Amplifier by switching to CAL, and note the resultant deflection which should be exactly 6 centimeters.
- d. Check the Horizontal Amplifier in the same manner as the Vertical Amplifier.
- e. Check the Sweep Generator. With the SWEEP MODE control, attempt free-running; then set to stop the free-running.

When a defective section is found, see that all the tubes are lighted; check by replacement or with a tube checker; then measure voltages. Refer to the Voltage Resistance Diagrams and the Tube Replacement Chart for assistance with changing tubes and measuring voltages and resistances in each circuit.

The two sides of the direct-coupled, push-pull circuits are normally balanced and cause the spot to be stationary in the center of the scope screen. A fault in either side usually unbalances the circuit and causes the spot to move off the screen. To bring the spot back, short together the control grids (or the plates) of the two sides of one stage starting at the last stage. This eliminates signals of all types, d-c unbalance, jitter, etc. which originate prior to the shorted points. If shorting the two halves of a stage together does not bring the spot on the screen and hold it motionless, a subsequent circuit is faulty. By continuing this process through the amplifier trouble can be isolated to a small circuit area.

4-7 ADJUSTING THE LOW-VOLTAGE POWER SUPPLIES

The complete, low-voltage power supply provides five, separately-regulated output voltages: -150 vdc, +88 vdc, +135 vdc, +300 vdc and +600 vdc. The low-voltage supplies have only one

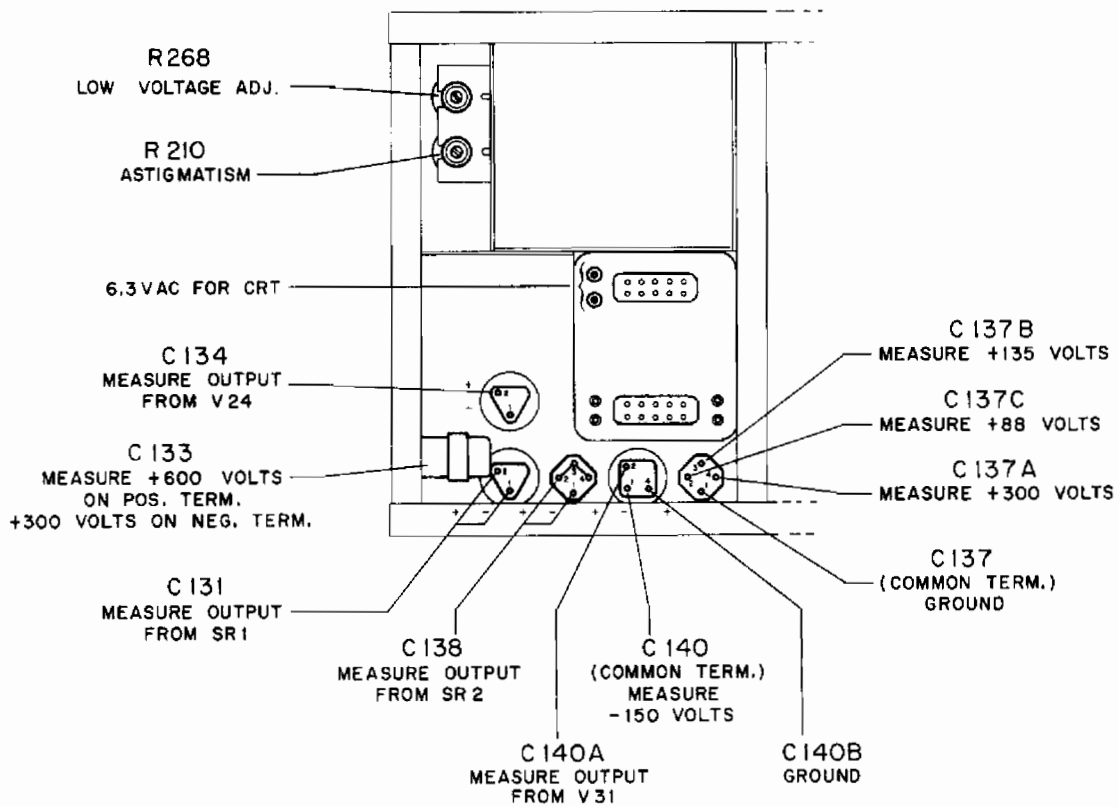


FIGURE 4-3 POWER SUPPLY MEASUREMENT POINTS

adjustment which sets the +88-volt filament supply. There are no separate adjustments for the -150-volt, +135-volt, +300-volt and +600-volt regulated supplies. All the remaining voltages depend upon correct adjustment of the +88-volt supply and also upon having the correct output voltage from the -150-volt supply.

All regulated voltages can be conveniently measured on the rear, left-hand corner of the hp 130A, see Fig. 4-3. To adjust the +88-volt supplies refer to Figure 4-3, and proceed as follows:

- a. Remove the 130A from the cabinet; turn on and allow to warm up for five minutes.
- b. With an accurate d-c voltmeter, measure the d-c voltage between the +88-volt measuring point and chassis.
- c. If necessary, adjust R268 to obtain +88 volts.
- d. Measure the d-c voltage and the chassis between the -150, the +135, the +300 and the +600 volt outputs. The voltages of these supplies are fixed by 1% resistors and should be within 3% of their specified voltages.

4-8 ADJUSTING THE RF HIGH-VOLTAGE POWER SUPPLY

Be careful when adjusting the high-voltage CRT cathode supply; the voltages for the CRT cathode, control grid, and filaments are -2600 volts to chassis. Use a high-voltage, high impedance probe such as Model 459A DC Resistive Voltage Multiplier with the 410B Voltmeter.

The r-f high-voltage supply provides two separately rectified output voltages (-2600 and approx. -2800 volts) from a single 40-kc oscillator. The -2600-volt output, as measured at pin 2 of the CRT (V21) is regulated and is adjusted by potentiometer R204. The -2800 volt output is measured at the control grid (pin 3) of the CRT with the INTENSITY control set for minimum brightness. The probe of the hp 459A may be inserted into the CRT socket to make these measurements. The -2800-volt output will vary as the -2600-volt output is adjusted.

To adjust the beam-supply voltage proceed as follows:

- a. Remove the instrument from the cabinet. Turn on and allow to warm up for five minutes.
- b. Check the output of the low-voltage power supply (see paragraph 4-7).
- c. Connect a d-c voltmeter between ground and pin 2 of the CRT V21.

- d. If necessary, adjust R204, accessible through rear hole in RF Oscillator housing, to obtain -2600 volts.
- e. Measure the d-c voltage at pin 3 of the CRT V21 .
- f. To measure the 40-kc ripple on the -2800-volt output:
- g. With the 130A turned off, connect the vertical input through a high-voltage capacitor to pin 2 of the CRT. After connection, turn back on.
- h. Set the VERT.SENSITIVITY selector to 0.5 VOLTS/CM; set the HORIZ. SENSITIVITY selector to OFF.
- i. Read the peak-to-peak deflection caused by the ripple on the -2800 volt supply. If this voltage is greater than 2 volts peak-to-peak C115 requires adjustment.
- j. To adjust C115 turn off the 130A and remove the r-f supply unit from the instrument.
- k. Remove the shield can from the r-f supply and attach the supply to the rear of the 130A as shown in Figure 4-10.
- l. Connect an a-c voltmeter (or the vertical input of the oscilloscope) through a high-voltage capacitor to pin 4 of J7.
- m. Turn on the 130A and using an insulated tuning wand adjust C115 to obtain a minimum reading on the voltmeter, or a minimum deflection of the trace on the oscilloscope.
- n. Turn the equipment off and replace the r-f supply in its cover and reinstall the unit in the 130A.

4-9 REPLACING AND ADJUSTING THE CRT

WARNING

HANDLE THE CATHODE RAY TUBE CAREFULLY. Implosion causes broken pieces to travel forward, out of the tube.

CAUTION

Turn the INTENSITY control to minimum when first applying power to a CRT. The phosphor can be damaged quickly by too much brightness.

To replace the cathode-ray tube, refer to Figures 2-4 and 2-5 and proceed as follows:

- a. Remove the 130A from the cabinet.
- b. Loosen the clamp on the CRT socket (see Fig. 2-5).
- c. Remove the front-panel bezel (see Figure 2-4).
- d. With a screwdriver loosen the CRT base from the socket. Free the CRT from the socket by pressing on the center of the tube base with one hand while supporting the front of the CRT with the other.
- e. Remove the CRT through the front panel.
- f. Insert the replacement CRT through the front panel and seat in socket.
- g. Replace front-panel bezel.
- h. Position the socket assembly so that the face of the CRT is seated on the bezel. Tighten the clamp just enough to hold the CRT in place.
- i. Set the INTENSITY control to the max. ccw position. Turn the 130A on and allow to warm up.
- j. Set the SWEEP MODE control to FREE RUN.
- k. Adjust the INTENSITY control to obtain a weak trace; adjust the FOCUS control for a sharp trace, and with the vertical position control, center the trace vertically.
- l. Align trace with graticule using the alignment handle at rear of CRT (see figure 2-5).
- m. Making certain the CRT face is against the bezel, tighten the clamp on the CRT socket.
- n. Readjust the astigmatism control as follows: set the VERTICAL SENSITIVITY to CAL. Adjust the focus and the astigmatism simultaneously for the best overall focus, or for optimum sharpness in any desired area.
- o. Check the gain calibration of the Vertical and Horizontal Amplifiers by setting the VERTICAL and HORIZONTAL SENSITIVITY selectors to CAL, and if necessary, adjusting R50 to obtain 6 cm vertical deflection and R111 to obtain 6 cm horizontal deflection of the trace, see paragraph 4-11B and 4-12B.

4-10 CHECKING THE CALIBRATOR

The output voltage from the CALIBRATOR is approximately a 1000-cycle/sec. square wave which is 0 volts during the off period and +120 mv peak during the on period. The peak positive voltage is set by a precision voltage divider located on the sweep generator deck and is dependent upon the correct setting of the +88 volt supply. This square-wave can be measured by an average-responding a-c voltmeter. To measure the 120-millivolt CALIBRATOR output, proceed as follows:

- a. Remove the 130A from the cabinet; turn on and allow to warm up for five minutes.
- b. Set the HORIZ. SENSITIVITY selector to CAL.
- c. Measure the +88 volt output; if necessary, adjust R268 to obtain exactly +88 volts.
- d. Measure the square-wave voltage at V15B, Pin 8 with an average-reading, rms calibrated, a-c voltmeter such as the hp 400 series. The rms voltage must be 66 millivolts \pm the accuracy of the a-c voltmeter. A 10% variation in the symmetry of the square-wave will cause a 1% error in meter reading. If the rms voltage is not within $\pm 3\%$ check the symmetry of the calibrator square wave which should be better than $\pm 5\%$. If necessary, select a 6BQ7 for V16 which will meet this condition.

If the voltage is still wrong, change V15 (12AU7) then measure R160 and R161. Replace the defective component.

4-11 ADJUSTING THE MAIN VERTICAL AMPLIFIER

The Vertical Amplifier contains three sets of adjustments as follows:

- | | |
|-------|--|
| 4-11A | Vertical Balance Adjustment |
| 4-11B | Vert. Ampl. Gain and Freq. Resp. Adjustments |
| 4-11C | Vert. Sens. Selector Freq. Resp. Adjustments |

Each procedure is an independent one and can be performed without affecting other adjustments. All adjustments are located in the vicinity of the Vertical Amplifier assembly or on the VERT. SENSITIVITY selector switch.

4-11A VERTICAL BALANCE ADJUSTMENT

The two sides of direct-coupled, push-pull circuits must be balanced to produce zero signal output. Because of differences in tubes and components, this balance must be established by bucking out any signal generated by differences between the two sides of the amplifier. Two balance adjustments are provided, the front panel adjustment to compensate for small shifts in balance during operation, and a chassis adjustment which makes the range of the panel adjustment appropriate for any particular set of tubes. The chassis Bal. Adj. potentiometer shifts the cathode bias of the two sides of the Phase Inverter in opposite directions and balance the d-c voltage at the grids of the following stage. The adjustment is made so that the spot will remain motionless when the gain of the amplifier is changed. Note that the Bal. Adj. and VERT. BAL. potentiometers are the same kind of adjustment as the VERT. POS. adjustment.

To adjust the vertical balance, refer to Fig. 4-4 and proceed as follows:

- a. Pull the 130A chassis from the cabinet far enough to gain access to the Bal. Adj. pot. R17. Turn on and allow to warm up for at least five minutes.
- b. Set the VERT. SENSITIVITY selector to off. Set the HORIZ. SENSITIVITY selector to INT. SWEEP and adjust the SWEEP MODE control to obtain a free running trace.
- c. Turn the VERT. DC BAL. control to the mechanical center of its range.
- d. Center the trace with the VERT. and HORIZ. POS. controls.
- e. Short the VERT. INPUT terminals. Set the VERT. SENSITIVITY selector to 1 MILLIVOLT/CM.
- f. If necessary, adjust R17 (Bal. Adj.) to return the trace to the center of the graticule.

4-11B VERT. AMPL. GAIN AND FREQ. RESP. ADJUSTMENTS

The Vertical Amplifier has one basic gain and two frequency response adjustments, one, C23, which is dependent upon the setting of the Gain Calibrate Adj. control and must be adjusted whenever the gain is set. These adjustments are in the amplifier itself, and are separate from the input attenuator adjustments which must be adjusted after the basic amplifiers have been

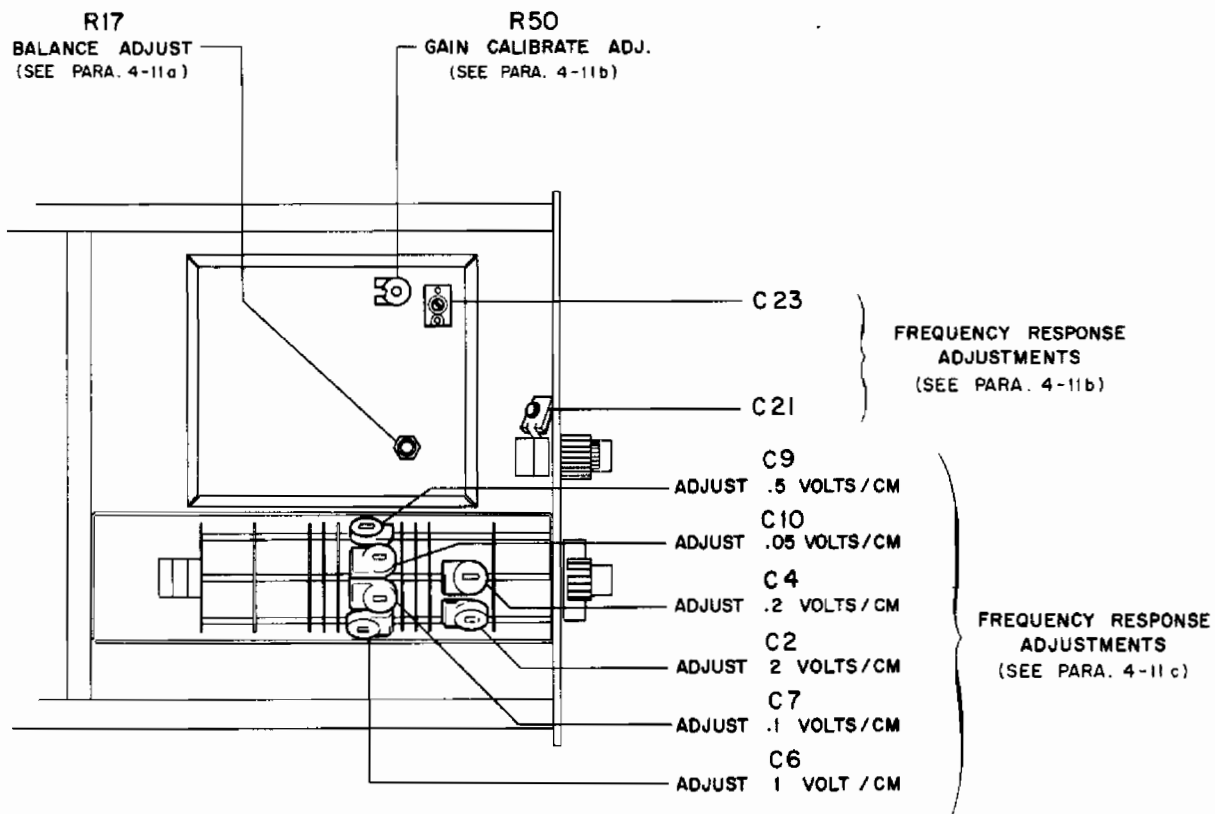


FIG. 4-4 VERTICAL AMPLIFIER ADJUSTMENTS

correctly set. The two frequency response adjustments set the response of the two last stages in the amplifier (last one first) to obtain the best square wave shape when viewing a 50 kc square wave. To adjust the Vertical Amplifier gain and frequency response adjustments, refer to Fig. 4-4 and proceed as follows:

- a. Pull the 130A chassis about half way out of the cabinet to gain access to the adjustments. Turn on and allow to warm up for at least five minutes.
- b. Set the VERT. SENSITIVITY selector to CAL. and turn the VERNIER control clockwise to CAL. (Switch must snap.)
- c. Adjust R50, Gain Calibrate Adj. to obtain exactly 6 centimeters deflection.
- d. Set the VERT. SENSITIVITY selector to 20 MILLIVOLTS /CM. Set the SYNC selector to INT., the SWEEP MODE control to PRESET, and the TRIGGER LEVEL control to 0.
- e. Connect a 50 kc square wave to the VERT. INPUT terminals and adjust the square wave amplitude to obtain a vertical deflection of approximately 6-8 cm. Set the SWEEP TIME/CM selector to display approximately 8 cycles.
- f. Short together the cathodes of V3 (accessible at the ends of the VERT. POS. control) with a jumper and adjust C23 to obtain the best square wave.
- g. Remove the short between the cathodes of V3 and adjust C21 to obtain the flattest possible square wave.

4-11C VERTICAL SENSITIVITY SELECTOR FREQUENCY RESPONSE ADJUSTMENT

The vertical input attenuator has a total of five attenuator sections, arranged in various groupings to provide the desired attenuation (see schematic diagram). Each section has one or two frequency response adjustments. When there are two, note that one affects another voltage divider and not the one on which it is drawn. All are adjusted to obtain the best wave shape when viewing a 5-kc square wave on the 130A. The adjustments are located on the VERT. SENSITIVITY selector switch and must be made in

the following order because of the interaction mentioned above, refer to Fig. 4-4 and proceed as follows:

- a. Remove the 130A from the cabinet; turn on and allow to warm up for five minutes.
- b. Set the VERT. SENSITIVITY selector to the .05 VOLTS/CM position.
- c. Connect a square wave generator to the VERT. INPUT. Adjust the square wave generator output to obtain 6 cm vertical deflection.
- d. Set the SWEEP TIME/CM selector to obtain a display of approximately 6 square waves.
- e. Adjust C10 to obtain the best shaped square wave.
- f. Proceed with the following adjustments for the remaining VOLTS/CM ranges, each time adjusting the square wave generator output amplitude to obtain 6 cm deflection on the scope.

.1 VOLT/CM range, adjust C7	
.2	C4
.5	C9
1.0	C6
2.0	C2

4-12 ADJUSTING THE HORIZONTAL AMPLIFIER

The Horizontal Amplifier contains four sets of adjustments as follows:

- 4-12A Horizontal Balance Adjustment
- 4-12B Horizontal Amplifier Frequency Response and Gain Adjustments
- 4-12C Sweep Attenuator and Linearity Adjustments
- 4-12D Horiz. Sensitivity Selector Frequency Response Adjustment

The Balance Adjustment and the Sensitivity Selector Adjustments are independent, and their settings affects no other adjustments.

The Horiz. Amplifier frequency response and gain will affect the settings of, and must be adjusted before, the Sweep Attenuator and Linearity adjustments, and the HORIZ. SENSITIVITY selector adjustments.

4-12A HORIZONTAL BALANCE ADJUSTMENT

The two sides of direct-coupled, push-pull circuits must be balanced to produce zero signal output. Because of differences in tubes and components, this balance must be established by bucking out any signal generated by differences between the two sides of the amplifier. Two balance adjustments are provided, the front panel adjustment to compensate for small shifts in balance during operation, and a chassis adjustment which makes the range of the panel adjustment appropriate for any particular set of tubes. The chassis Bal. Adj. potentiometer shifts the cathode bias of the two sides of the Phase Inverter in opposite directions and balances the d-c voltage at the grids of the following stage. The adjustment is made so that the spot will remain motionless when the gain of the amplifier is changed. Note that the BAL. Adj. and HORIZ. DC potentiometers are the same kind of adjustment as the HORIZ. POS. adjustment.

To adjust the horizontal balance, refer to Fig. 4-5 and proceed as follows:

- a. Pull the 130A chassis from the cabinet far enough to gain access to the Bal. Adj. pot. Turn on and allow to warm up for at least five minutes.
- b. Set the VERTICAL and HORIZONTAL SENSITIVITY selector to OFF.
- c. Turn the HORIZ. DC BAL. control to the mechanical center of its range.
- d. Center the spot with the VERT. and HORIZ. POS. controls.
- e. Short the HORIZ. INPUT terminals and set the HORIZ. SENSITIVITY selector to 1 MILLIVOLT/CM.
- f. If necessary, adjust R77 (Bal. Adj. on the horizontal amplifier etched circuit) to return the spot to the center of the graticule.

4-12B HORIZONTAL AMPLIFIER FREQUENCY RESPONSE AND GAIN ADJUSTMENTS

The Horizontal Amplifier has four basic frequency response adjustments and one gain adjustment. Two of these frequency response adjustments affect the response of the amplifier when it is used in the INT. SWEEP position of the HORIZ. SENSITIVITY selector, the other two affect the frequency response of the amplifier when it is used to amplify external signals. One adjustment,

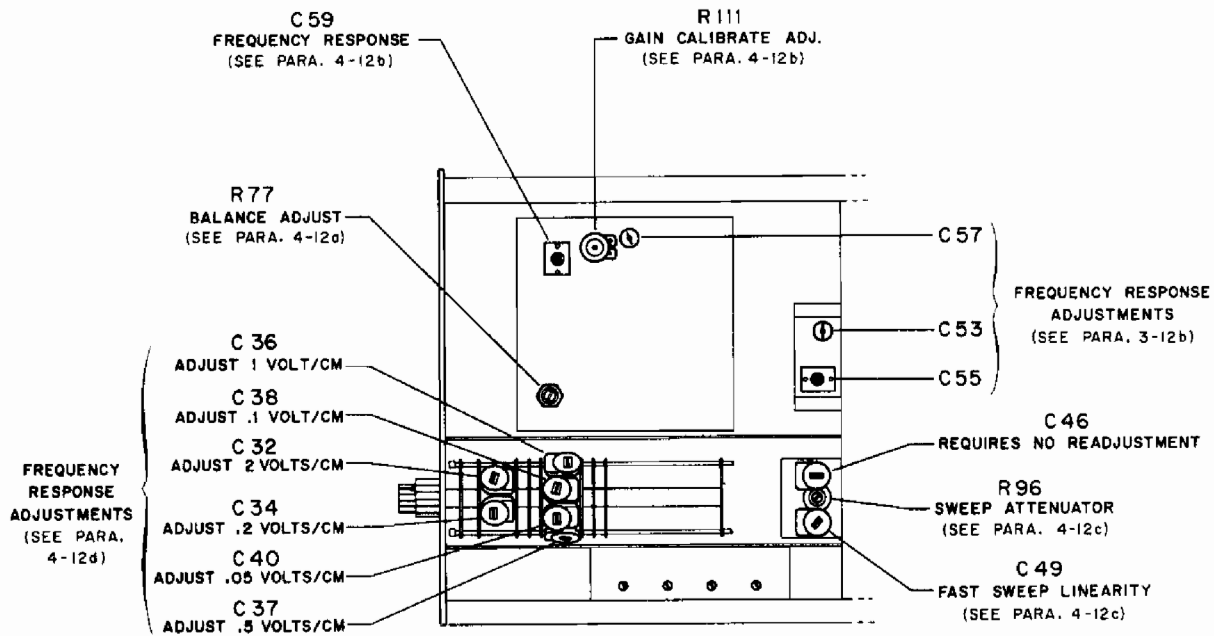


FIG. 4-5 HORIZONTAL AMPLIFIER ADJUSTMENTS

C59, is dependent upon the setting of the Gain Calibrate Adj. and must be adjusted when the gain is set. All the adjustments are in the last two stages of the amplifier and must be correctly set before adjusting the frequency response of the HORIZ. SENSITIVITY selector switch. The frequency response adjustments are made to obtain the best 50 KC square wave shape on the oscilloscope screen. To adjust the Horizontal Amplifier frequency response and gain refer to Figure 4-5 and proceed as follows:

- a. Remove the 130A from the cabinet, turn it on its right side, and swing out the Sweep Generator etched circuit board. Disconnect the blue-white lead which connects to the board with a malco connector.
- b. With a clip lead connect the output of the Sweep Generator (V13, pin 1) to the VERT. INPUT.
- c. Set the HORIZ. SENSITIVITY selector to INT. SWEEP.
- d. Set the SYNC selector to EXT., the TRIGGER LEVEL control to 0, the VERT. SENSITIVITY selector to 10 VOLTS/CM, and the VERT. INPUT selector to AC.
- e. Connect a 50 KC square wave signal to V7A, pin 7 and to the HORIZ. INPUT.
- f. Turn on the 130A and allow it to warm up for at least five minutes.
- g. Adjust the amplitude of the square wave generator to obtain approximately 6-8 cm. deflection and set the SWEEP TIME/CM selector to display 3 or 4 cycles of the square wave.
- h. Short the cathodes of V7 together (accessible at the ends of the HORIZ. POS. control) and adjust C57 on the Horizontal Amplifier etched circuit board for the flattest square wave presentation on the scope.
- i. Remove the short from the cathodes of V7 and adjust C53 on the small card to the rear of the Horizontal Amplifier for the best square wave presentation.
- j. Disconnect the 50 KC square wave generator from V7 pin 7 and set the HORIZ. SENSITIVITY selector and VERNIER to CAL.
- k. Adjust R111 to obtain exactly 6 cm. horizontal deflection.

- l. Reconnect the 50 KC square wave generator to V7 pin 7 and set the HORIZ. SENSITIVITY selector to 20 MILLIVOLTS /CM.
- m. To operate the Sweep Generator with the HORIZ. SENSITIVITY selector set off of INT. SWEEP, connect a clip lead between the purple lead on the TRIGGER LEVEL control (-150 volts) and the junction of R138 and C78 on the sweep generator etched circuit board near the front right hand corner when viewed from the bottom.
- n. Synchronize the sweep generator from the square-wave generator by connecting the square-wave output (use the sync output, if available) to pin 7 of the Trigger Amplifier V9. Excessive sync amplitude will cause distortion.
- o. Short the cathodes of V7 together as in step h. and adjust C59 on the Horizontal Amplifier etched circuit board for the flattest square wave presentation. Remove the short on V7.
- p. Adjust C55 on the small card to the rear of the Horizontal Amplifier for the flattest square-wave presentation. Remove the clip lead between the sweep output and the VERT. INPUT and the clip lead between the TRIGGER LEVEL control to the junction of R138 and C78. Reconnect the blue-white lead to the Sweep Generator etched circuit board.

4-12C SWEEP ATTENUATOR AND FAST SWEEP LINEARITY ADJUSTMENT

The sweep attenuator controls the sawtooth amplitude driving the Horizontal Amplifier when the HORIZ. SENSITIVITY selector is in the INT. SWEEP position. The linearity adjustment compensates for tube and stray capacities to keep the sweep attenuator flat.

- a. Set the SWEEP TIME/CM selector to 1 MILLISECOND and the VERNIER control to CAL; set the HORIZ. SENSITIVITY selector to INT. SWEEP; set the SYNC SELECTOR to INT.
- b. Connect a time marker generator to the VERT. INPUT. Set the marker generator to obtain 1 millisecond markers. An accurate sine- or square-wave generator can be used in place of the time marker generator with some sacrifice of accuracy.
- c. Adjust R96, on the small card at the rear of the HORIZ. SENSITIVITY switch, to align the time markers with the scope graticule markings. At the same time, adjust the

HORIZ. POS. control to maintain the first time marker at the first graticule mark.

- d. Set the SWEEP TIME/CM selector and the time marker generator to 1 MICROSECOND and adjust C98 on the SWEEP TIME/CM selector switch (second from the compression type capacitor, C94) to obtain 10 time markers across the graticule; disregard non-linearity at this time. Adjust C49, to the rear of the horizontal amplifier, to obtain uniform spacing of the time markers. Readjust C98 to align the time markers with the graticule markings. It may be necessary to refine the adjustment of C49 and C98 several times to obtain a uniform 1 centimeter spacing of the time markers.

4-12D HORIZ. SENSITIVITY SELECTOR FREQUENCY RESPONSE ADJUSTMENT

The horizontal input attenuator has a total of five attenuator sections, arranged in various groupings to provide the desired attenuation (see schematic diagram). Each section has one or two frequency response adjustments. When there are two, note that one affects another voltage and not the one on which it appears. All are adjusted to obtain the best wave when viewing a 5 KC square wave on the 130A. The adjustments are located on the HORIZ. SENSITIVITY selector switch and must be made in the following order because of the interaction mentioned above. Refer to Figure 4-5 and proceed as follows:

- a. Remove the 130A from the cabinet; turn it on its right side, and swing out the Sweep Generator etched circuit board. Disconnect the blue-white lead which connects to the board with a malco connector.
- b. With a clip lead connect the output of the sweep generator (V13, pin 1) to the VERT. INPUT.
- c. Set the HORIZ. SENSITIVITY selector to .05 VOLTS/CM.
- d. To operate the Sweep Generator with the HORIZ. SENSITIVITY selector set off of INT. SWEEP, connect a clip lead between the purple lead on the TRIGGER LEVEL control (-150 volts) and the junction of R138 and C78 on the Sweep Generator etched circuit board near the front right hand corner when viewed from the bottom.
- e. Turn on the 130A and allow it to warm up for five minutes.

- f. Connect a square wave generator to the HORIZ. INPUT. Adjust the square wave generator output to obtain approximately 10 cm horizontal deflection.
- g. Set the SWEEP TIME/CM selector to display approximately 6-8 cycles.
- h. Adjust C40 to obtain the best square wave.
- i. Proceed with the following adjustments for the remaining VOLTS/CM ranges, each time adjusting the square wave generator output to obtain 10 cm deflection.
 - .1 VOLT CM range, adjust C38 for the best square wave.
 - .2 C34
 - .5 C37
 - 1. C36
 - 2. C32

4-13 ADJUSTING PRESET SENSITIVITY

The preset adjustment is a potentiometer in the grid circuit of V14B, Retriggering Bias Control, which sets the d-c voltage at the grid of V11A, Sweep Start-Stop Trigger, to a level which gives stable operation of V11 and dependable triggering.

To adjust preset refer to figure 4-6 and proceed as follows:

- a. Pull the 130A about halfway out of the cabinet to gain access to the adjustment. Turn on and allow to warm up for at least five minutes.
- b. Set the HORIZ. SENSITIVITY selector to INT. SWEEP and the SWEEP MODE control to PRESET.
- c. Turn R144, Preset Adj., (located below the Horiz. Sensitivity selector switch) clockwise until the sweep free runs then turn R144 counterclockwise until free running just stops.
- d. Record the d-c voltage on the arm of R144.
- e. Set the SYNC selector to LINE and adjust the TRIGGER LEVEL control to obtain a triggered sweep.
- f. Turn R144 counterclockwise until the sweep stops; record the voltage on the arm of R144.

NOTE

The difference of the voltages obtained in steps d and f should be 6 volts ± 1 volt. This voltage is the amplitude of the negative trigger pulses from V10.

- g. Adjust the voltage at the arm of R144 to be the average of the voltages measured in steps d and f.

4-14 SWEEP GENERATOR ADJUSTMENTS

The Sweep Generator contains two sets of adjustments which are independent of each other, but are dependent upon the correct adjustment of the Horizontal Amplifier, see paragraph 4-12C. These adjustments are as follows:

- 4-14A SWEEP TIME/CM Selector Calibration
- 4-14B Sweep Length Adjustment

These adjustments control the rate of rise and the amplitude of the sawtooth voltage formed by the Sweep Generator.

4-14A SWEEP TIME/CM CALIBRATION

The SWEEP TIME/CM selector is calibrated by three variable capacitors for the fast sweeps and three potentiometers for the slow sweeps. The sawtooth sweep in the 130A is very linear on all ranges, and the final accuracy will be limited almost entirely by reading error, the care and the equipment used in making these adjustments. Each adjustment calibrates three consecutive ranges, except R181 which calibrates the six slowest sweep times. Each adjustment is independent and any one can be reset without affecting the others. To calibrate the SWEEP TIME/CM selector ranges, refer to Figure 4-6 and proceed as follows:

- a. Remove the 130A from the cabinet and lay it on its right side. Turn on the 130A and allow it to warm up for at least five minutes.
- b. Set the HORIZ. SENSITIVITY selector to INT. SWEEP and the SWEEP TIME/CM VERNIER to CAL.
- c. Set the SYNC selector to INT, and connect the output of a time-marker generator to the VERT. INPUT.
- d. Set the SWEEP TIME/CM selector and the time-marker generator as indicated below and make the following adjustments to align the markers with the centimeter calibrations on the graticule. Adjust the HORIZ. POS. control

SWEEP TIME/CM ADJUSTMENTS
(SEE PARA 4-14 a)

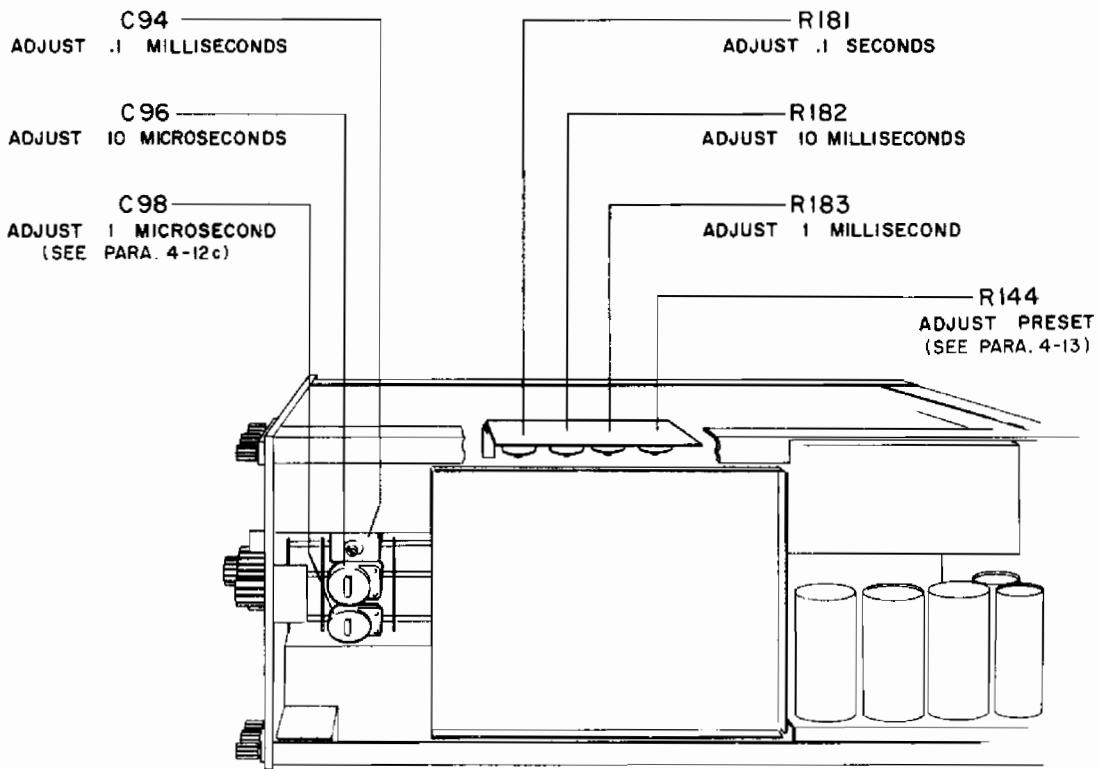


FIGURE 4-6 SWEEP GENERATOR ADJUSTMENTS

to align the first time marker with the first graticule mark.

SWEEP TIME/CM and Time Mark Generator	Adjust
1 MICROSECOND	C98
Note: If the sweep is non-linear see paragraph 4-12C.	
10 MICROSECONDS	C96
.1 MILLISECOND	C94
1 MILLISECOND	R 183
10 MILLISECONDS	R 182
.1 SECOND	R 181

Note: If the time mark generator used does not have .1 second markers, set the SWEEP TIME/CM to a slower sweep and use a stop watch for this adjustment.

4-14B SWEEP LENGTH ADJUSTMENT

The Sweep Length adjustment is a potentiometer R148, which controls the amount of the sawtooth voltage reaching the Sweep Start-Stop Trigger, V11. Reducing the amplitude of the sawtooth reaching V11 causes the sawtooth output and the sweep length to increase. The sweep length is made as short as possible and still be at least 10 cm long under the most adverse conditions to reduce flicker to a minimum. The Sweep Length adjustment is located on the Sweep Generator etched circuit board. To adjust sweep length, proceed as follows:

- a. Remove the 130A from the cabinet and turn it on its right side.
- b. Turn on the 130A and allow it to warm up for at least five minutes.
- c. Set the SYNC selector to INT., the SWEEP TIME/CM selector to 1 MILLISECOND, the HORIZ. SENSITIVITY selector to INT. SWEEP, and the SWEEP MODE control to PRE-SET.

- d. Connect a 20 to 500 KC signal to the VERT. INPUT and adjust the TRIGGER LEVEL control for the shortest sweep. The higher the frequency of the input signal, the less the effect of the TRIGGER LEVEL control. The TRIGGER LEVEL control is able to affect sweep length since the amplitude of the voltage necessary to fire the Trigger Generator and therefore the time at which the Trigger Generator fires is controlled by the d-c voltage on the input grid of the Trigger Generator.
- e. Adjust R148 to obtain a trace approximately 10.3 cm long.

SCHEMATIC DIAGRAM NOTES

1. Heavy solid line shows main signal path; heavy dashed line shows control, secondary signal, or feedback path.
2. Heavy box indicates front-panel engraving; light box indicates chassis marking.
3. Arrows on potentiometers indicate clockwise rotation as viewed from the round shaft end, counterclockwise from the rectangular shaft end.
4. Resistance values in ohms, inductance in microhenries, and capacitance in micromicrofarads unless otherwise specified.
5. Rotary switch schematics are electrical representations; for exact switching details refer to the switch assembly drawings.
6. Relays shown in condition prevailing during normal instrument operation.

VOLTAGE AND RESISTANCE DIAGRAM NOTES

1. Each tube socket terminal is numbered and lettered to indicate the tube element and pin number, as follows:

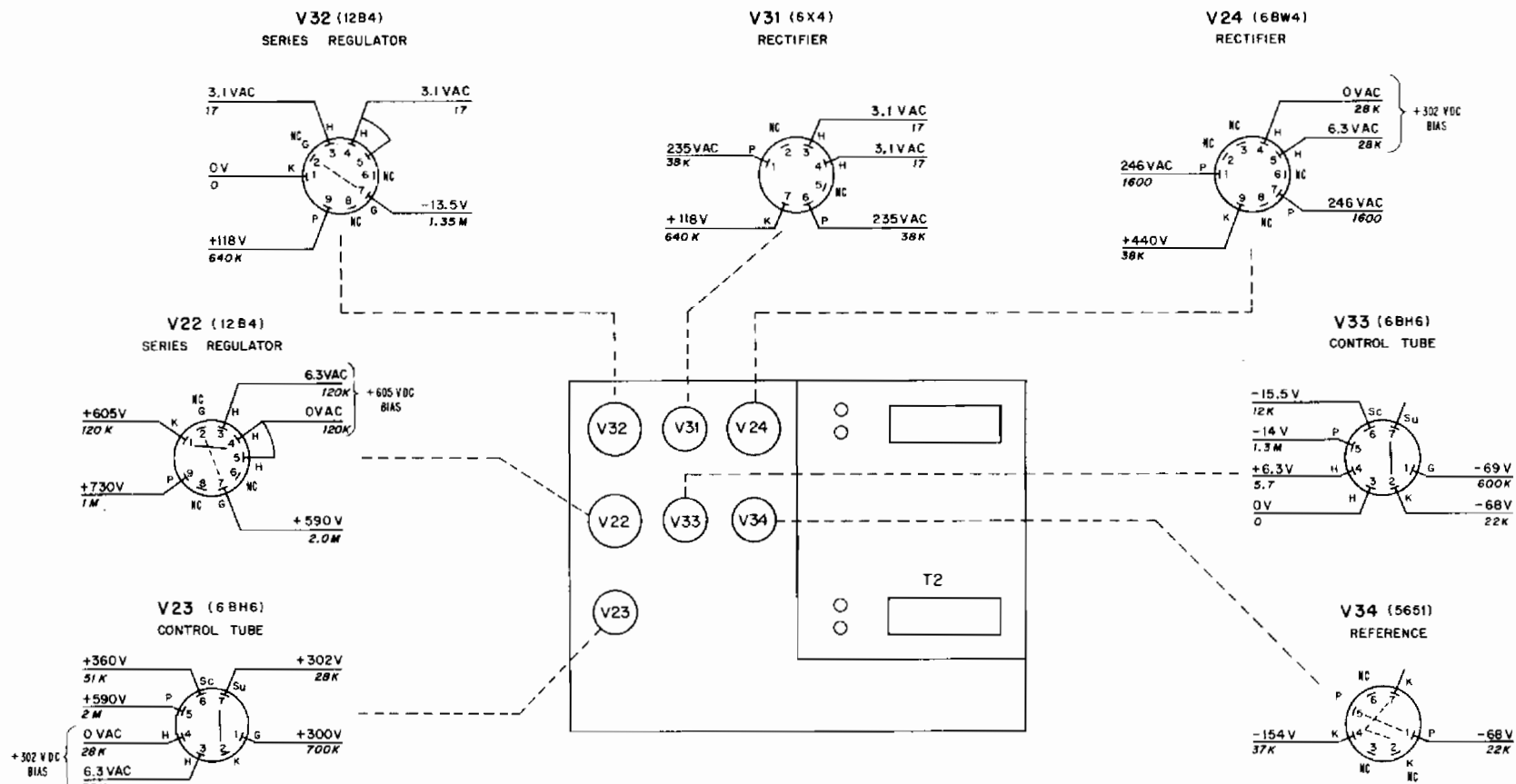
* = no tube element	P = plate
H = heater	T = target (plate)
K = cathode	R = reflector or repeller
G = control grid	A = anode (plate)
Sc = screen grid	S = spade
Sp = suppressor grid	Sh = shield
	NC = no external connection to socket

The numerical subscript to tube-element designators indicates the section of a multiple-section tube; the letter subscript to tube-element designators indicates the functional difference between like elements in the same tube section.

A socket terminal with an asterisk may be used as a tie point and may have a voltage and resistance shown.

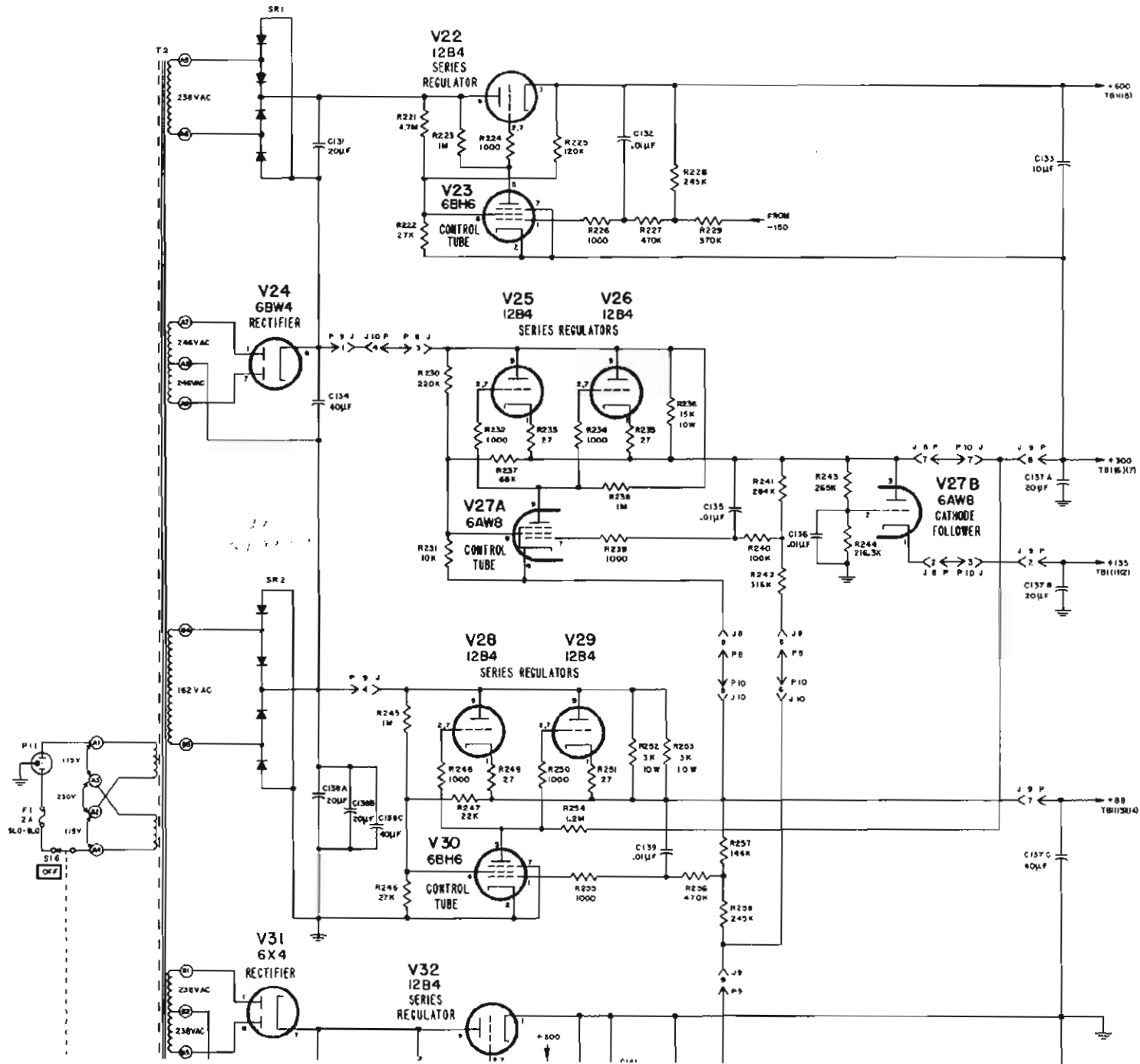
2. Voltages values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit contains potentiometers, crystal diodes, or electrolytic capacitors.
3. Voltage measured at the terminal is shown above the line, resistance below the line; measurements made with an electronic multimeter, from terminal to chassis ground unless otherwise noted.
4. A solid line between socket terminals indicates a connection external to the tube between the terminals; a dotted line between terminals indicates a connection inside the tube. Voltage and resistance are given at only one of the two joined terminals.

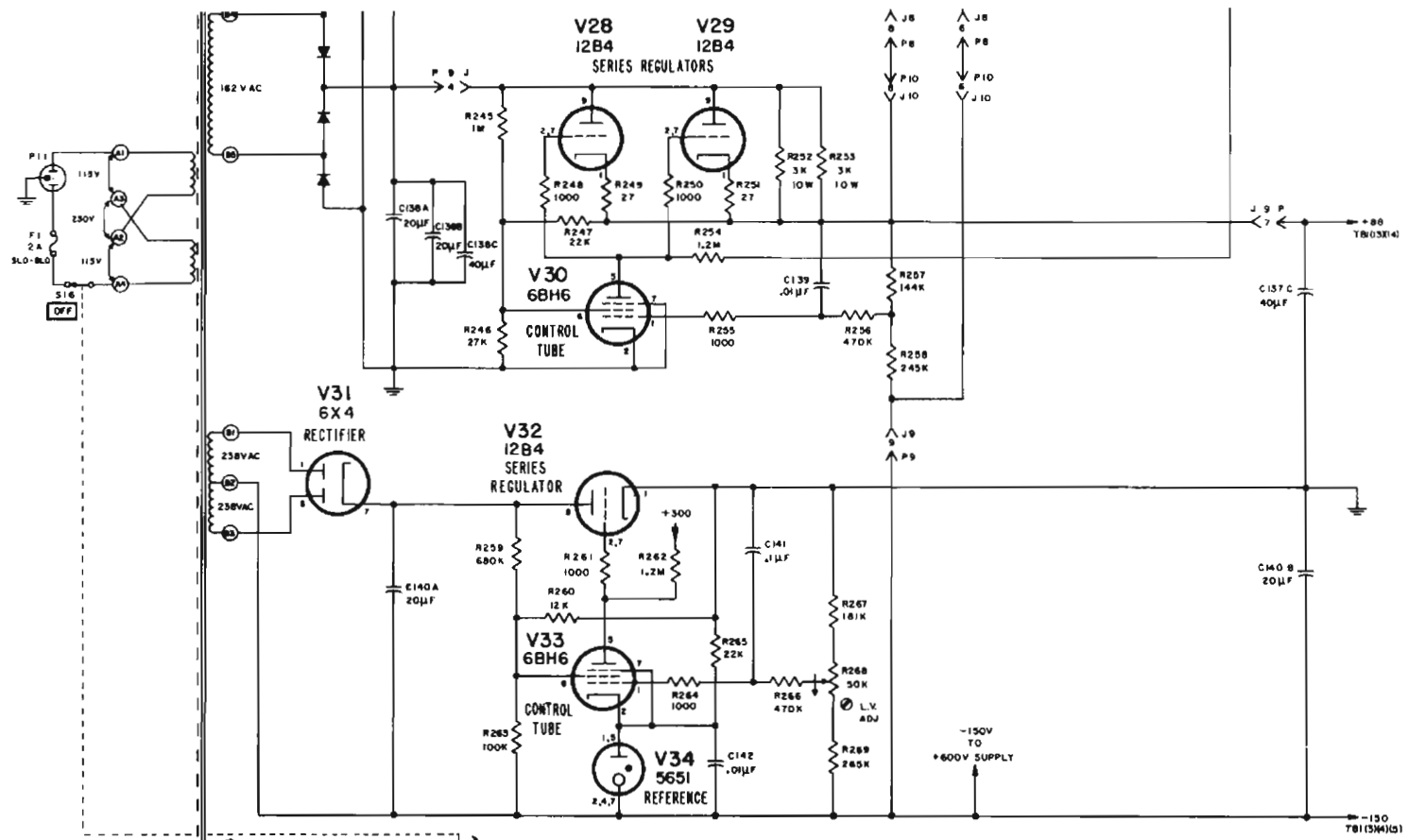
**+600 V & -150 V REGULATED POWER SUPPLIES, POWER TRANSFORMER AND ALL RECTIFIERS
VOLTAGE - RESISTANCE DIAGRAM**



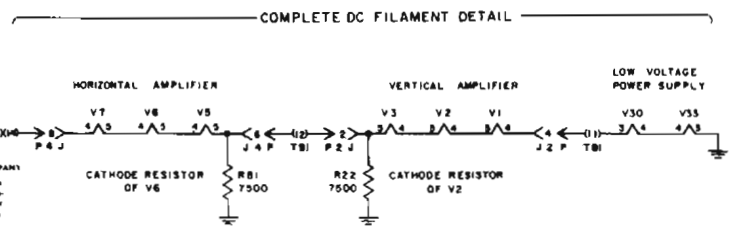
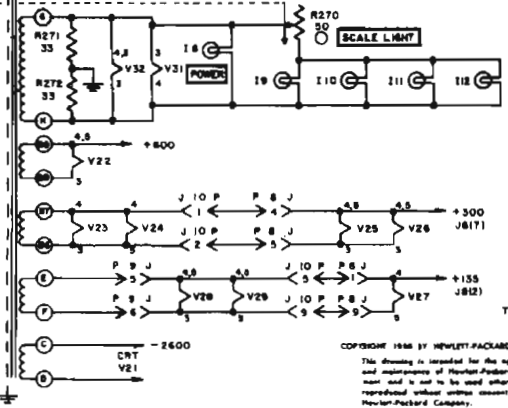
LOW VOLTAGE POWER SUPPLY

581





NOTE
 1. ONLY POWER SUPPLY FILAMENT DETAIL AND COMPLETE DC FILAMENT DETAIL SHOWN - OTHER FILAMENT DETAILS ARE SHOWN ON APPROPRIATE SCHEMATIC.



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hp MODEL 130A
POWER SUPPLY
 SERIAL 125 & ABOVE

+ 88 V POWER SUPPLY REGULATOR

VOLTAGE - RESISTANCE DIAGRAM

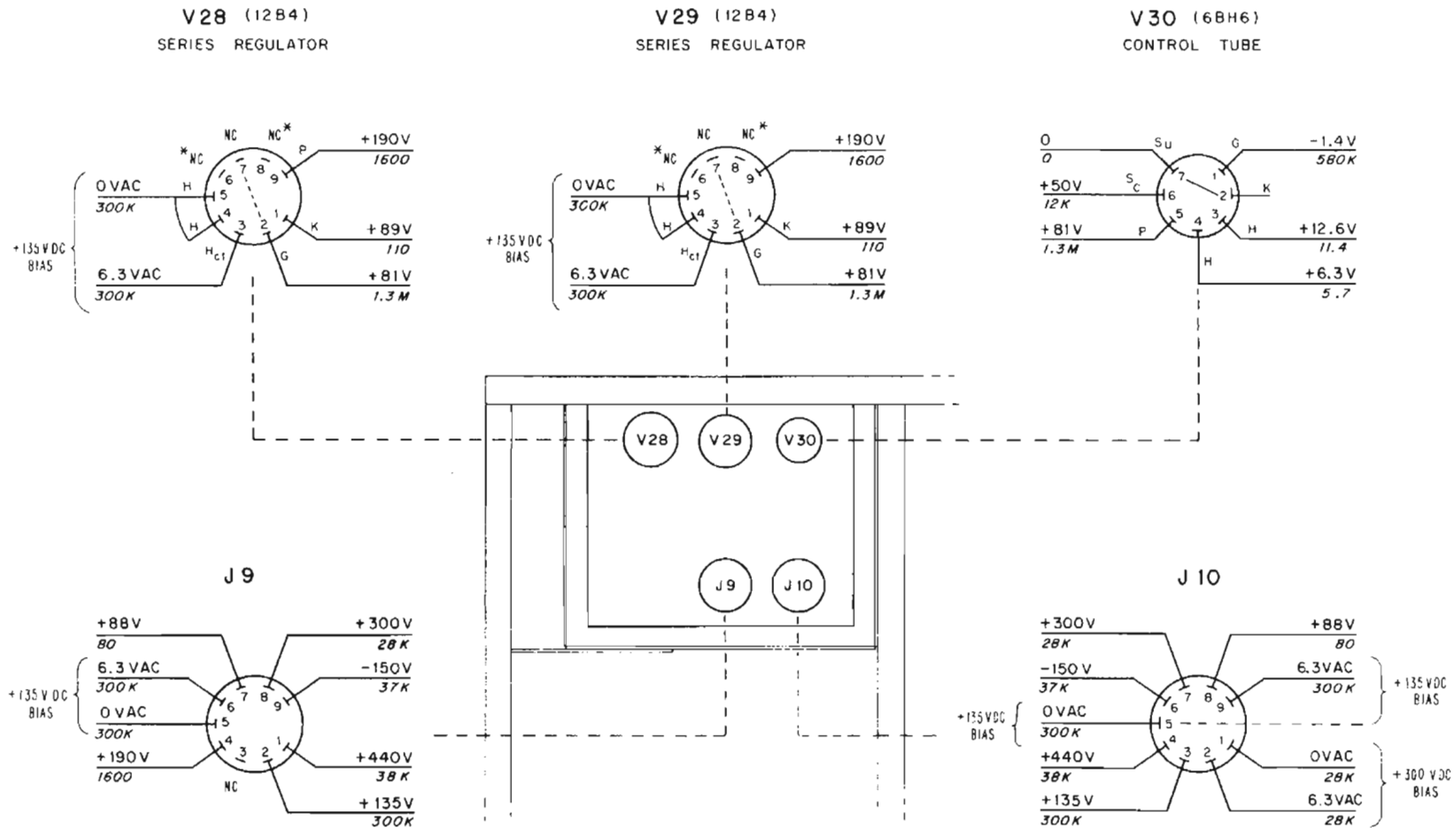


FIGURE 4-8

+300V & +135V POWER SUPPLY REGULATORS

VOLTAGE - RESISTANCE DIAGRAM

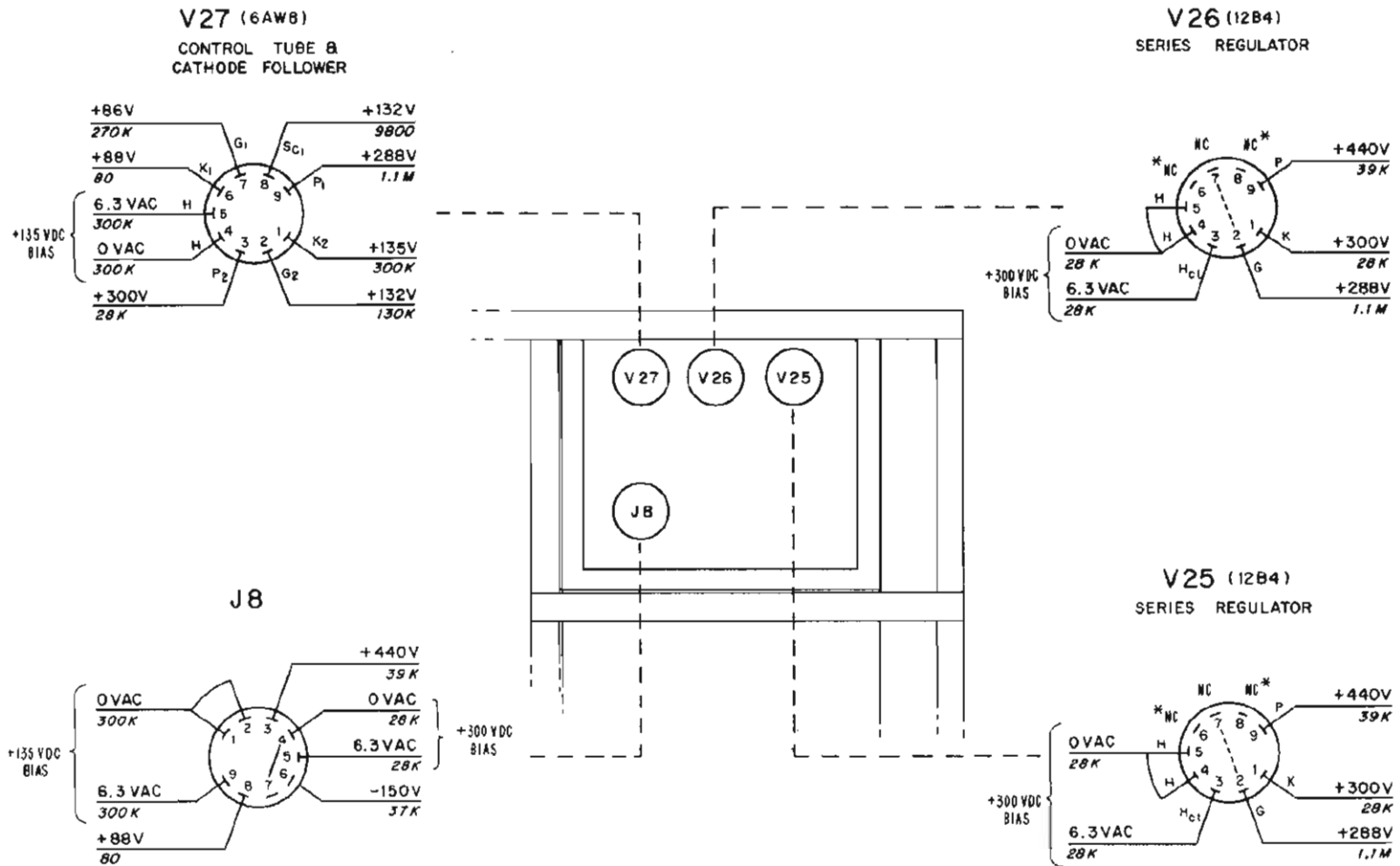


FIGURE 4-9

HIGH VOLTAGE POWER SUPPLY VOLTAGE - RESISTANCE DIAGRAM

CAUTION:

BOXED VOLTAGES MEASURED WITH VOLTMETER HAVING 12,000 MEGOHMS INPUT IMPEDANCE.

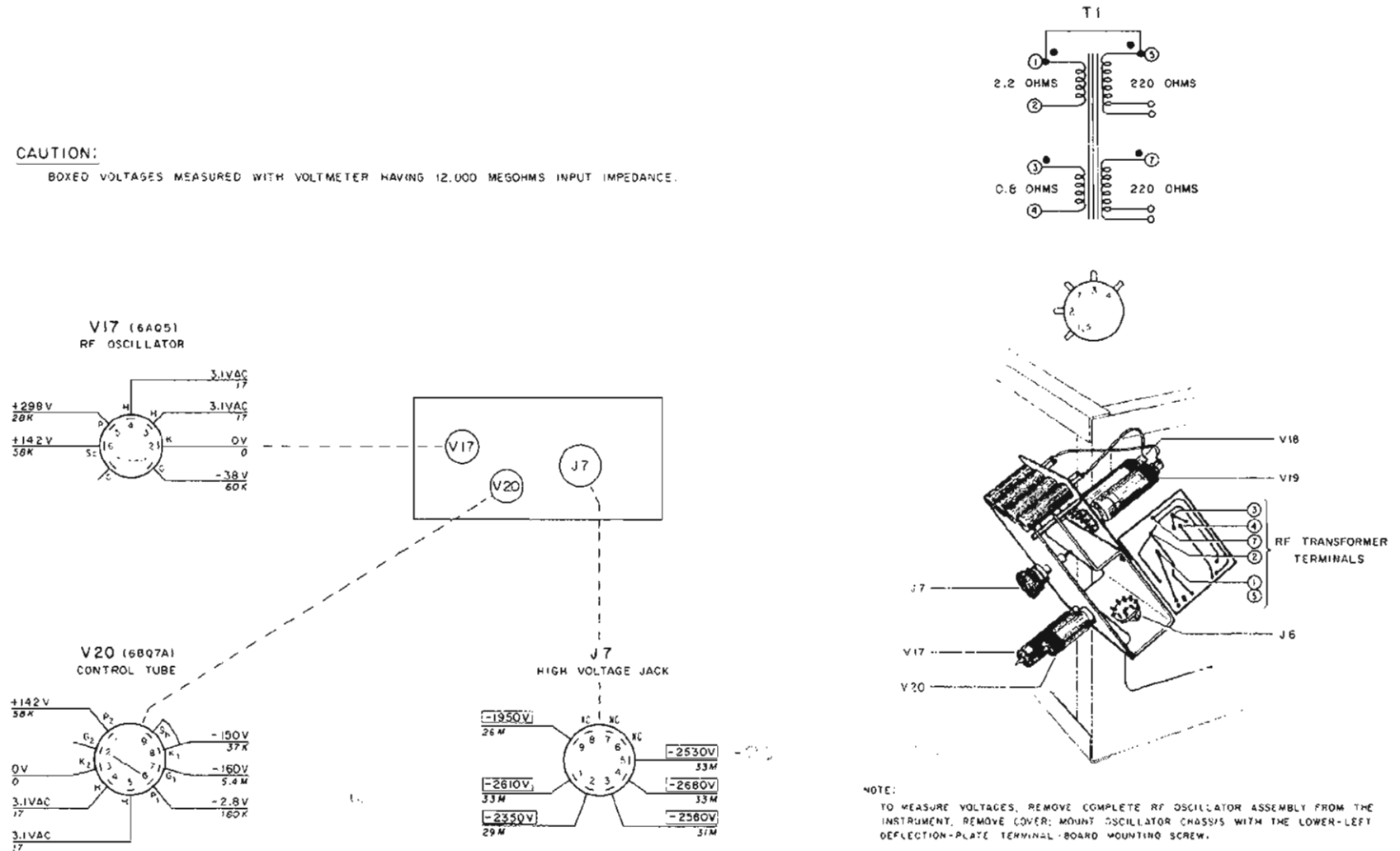
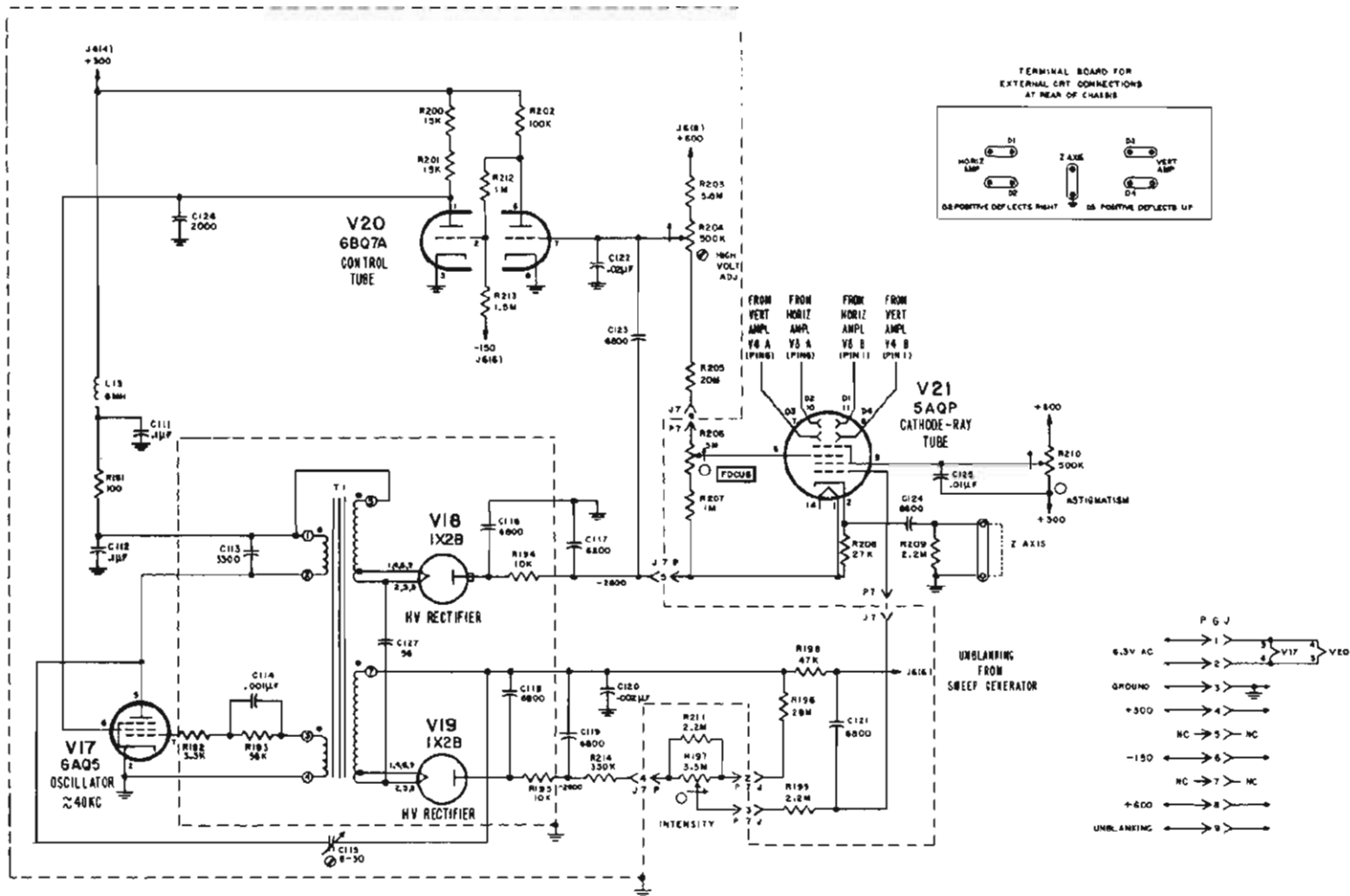


FIGURE 4-10

HIGH VOLTAGE POWER SUPPLY
AND CRT CIRCUIT



hp MODEL 130A
HIGH VOLTAGE SUPPLY & CRT CIRCUIT
 SERIAL 125 & ABOVE

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VERTICAL AMPLIFIER

VOLTAGE - RESISTANCE DIAGRAM

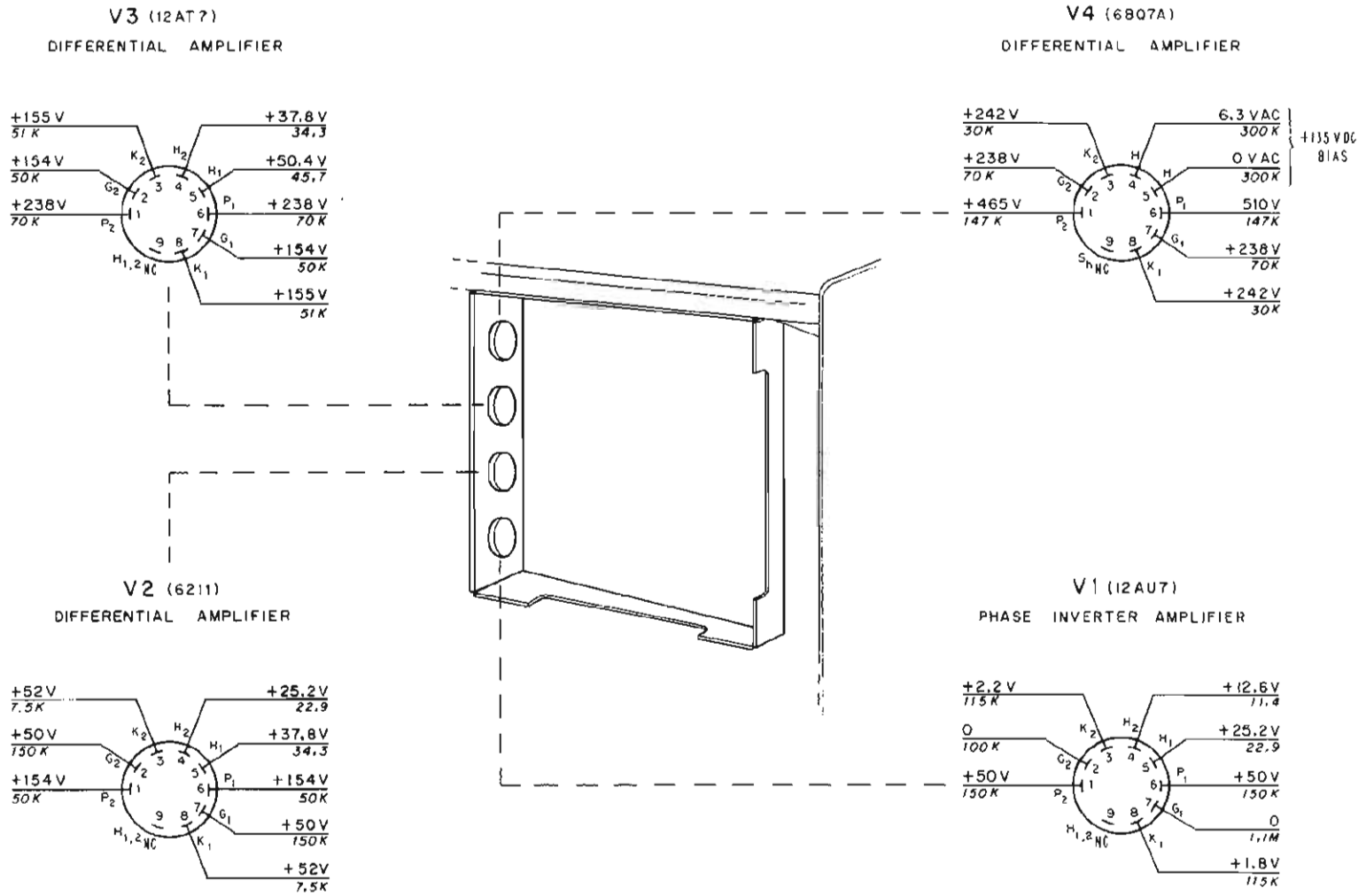
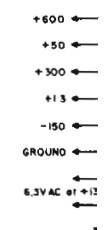
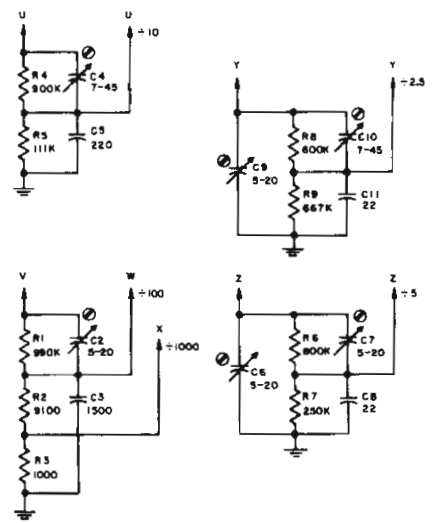
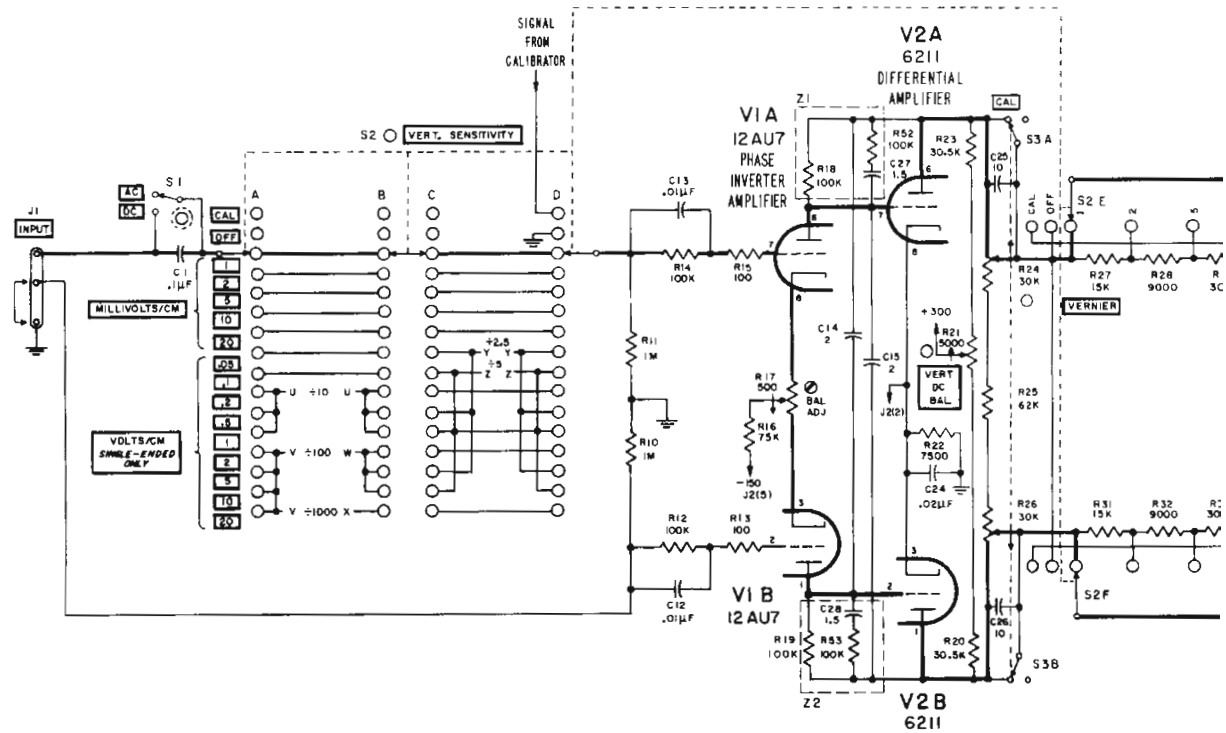
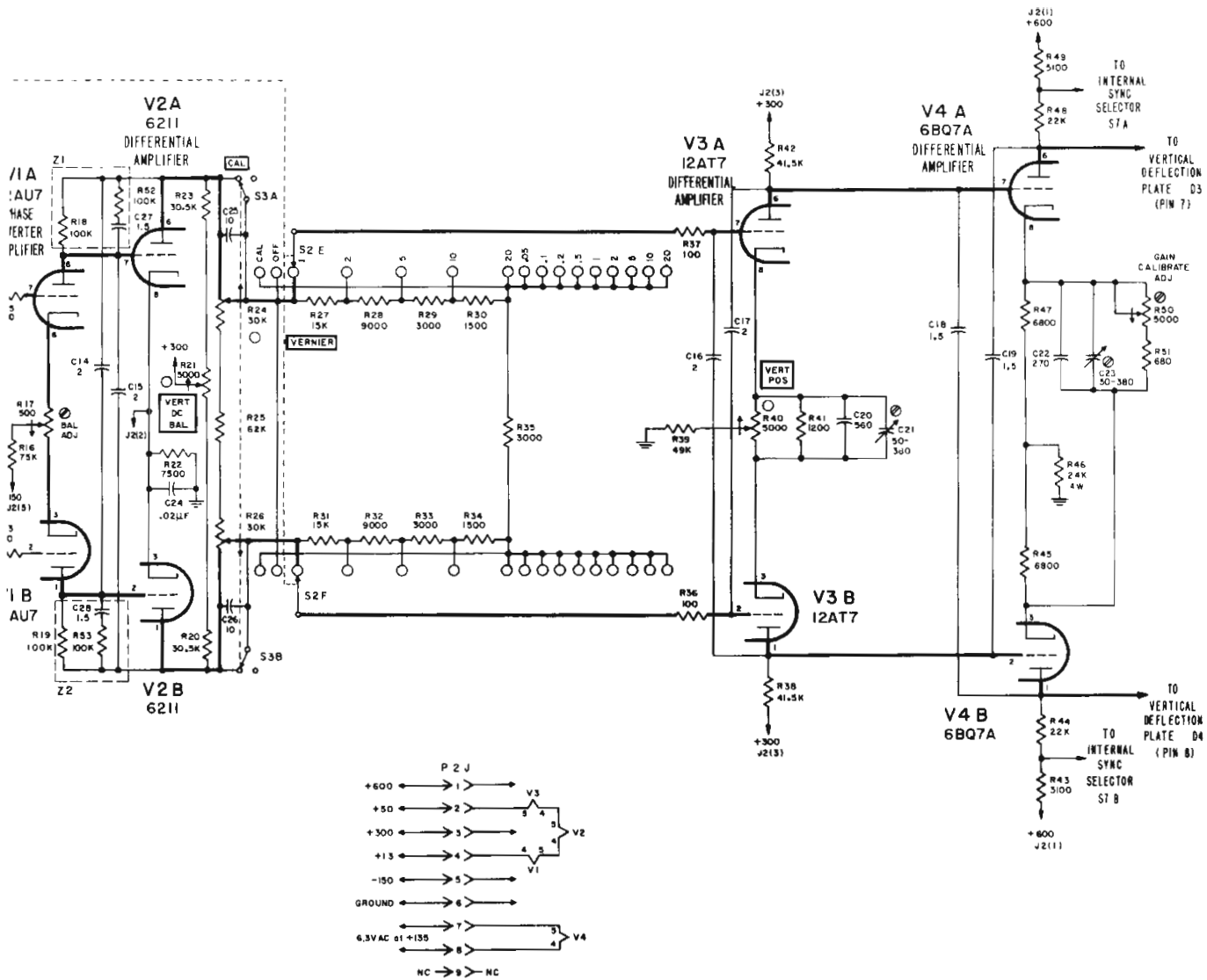


FIGURE 4-11

VERTICAL AMPLIFIER



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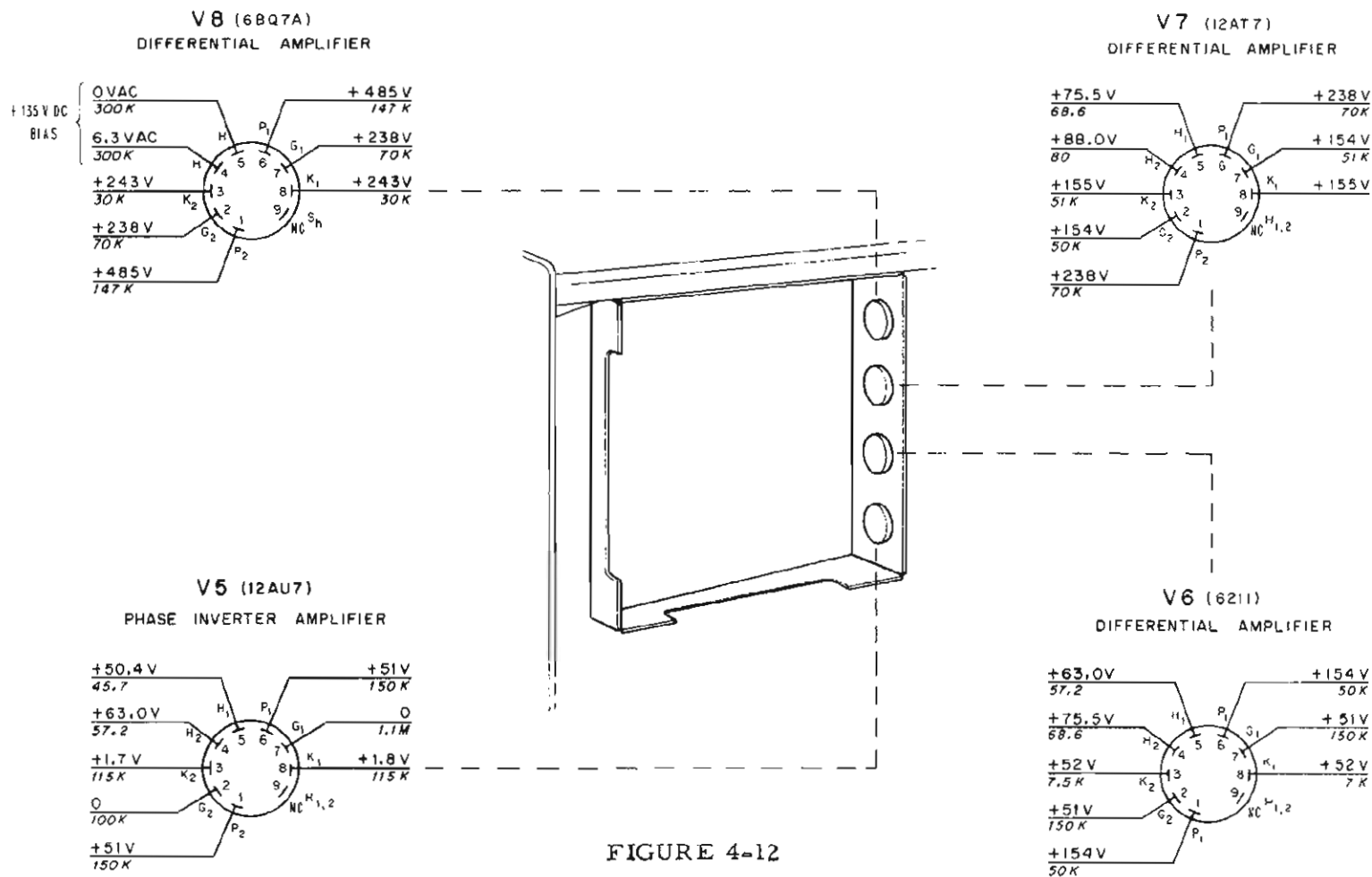


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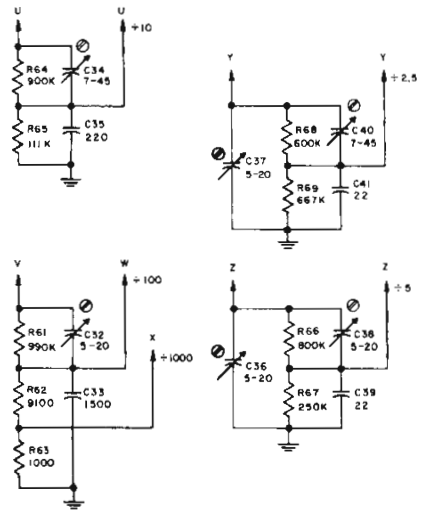
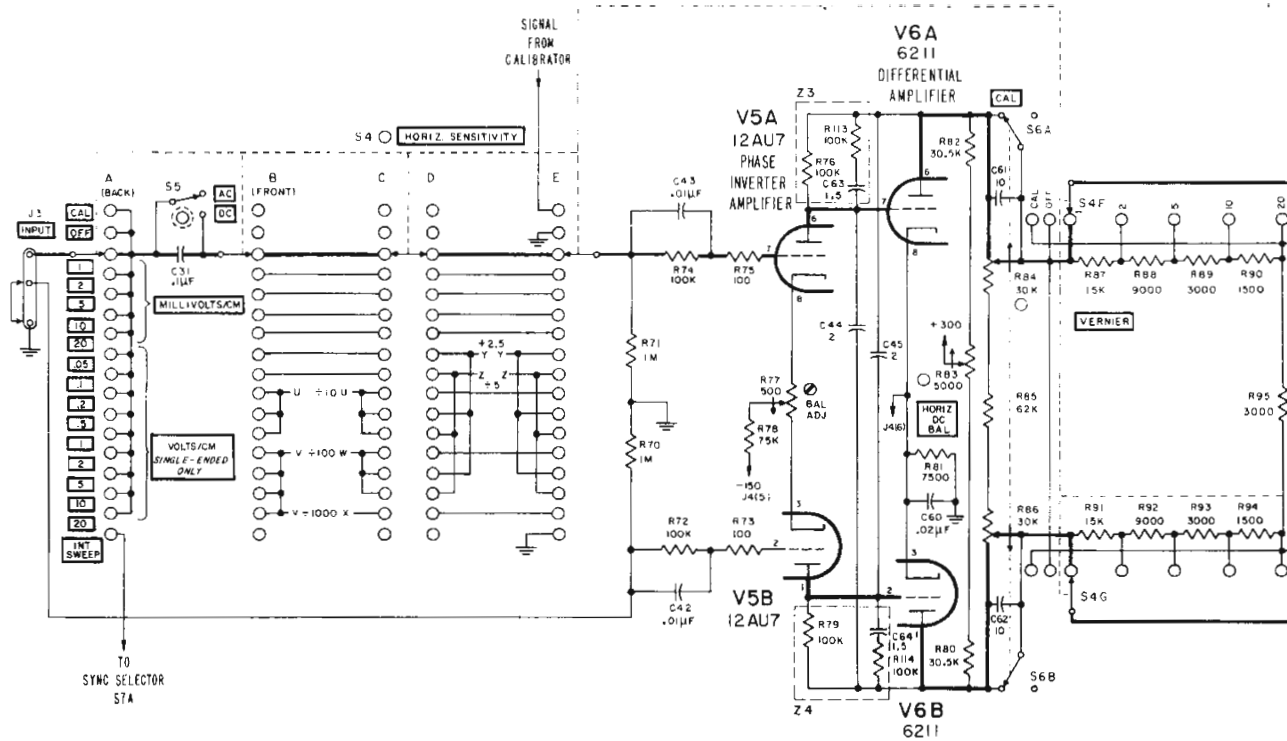
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HORIZONTAL AMPLIFIER

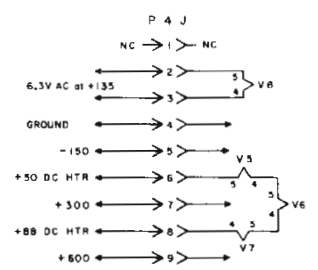
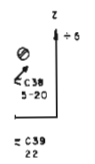
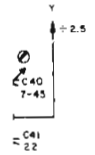
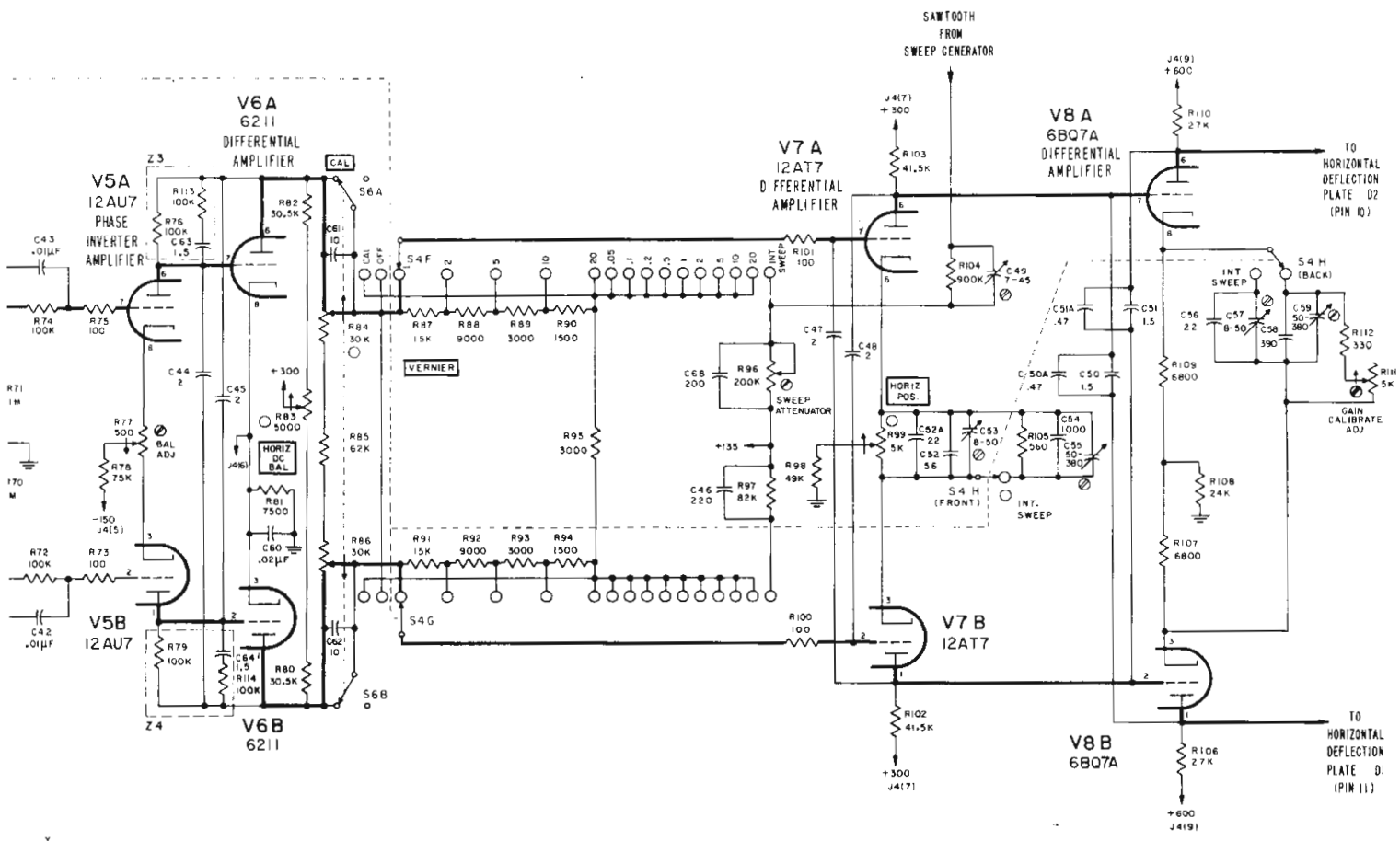
VOLTAGE - RESISTANCE DIAGRAM



HORIZONTAL AMPLIFIER



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hp MODEL 130A
HORIZONTAL AMPLIFIER

SWEEP GENERATOR AND CALIBRATOR VOLTAGE - RESISTANCE DIAGRAM

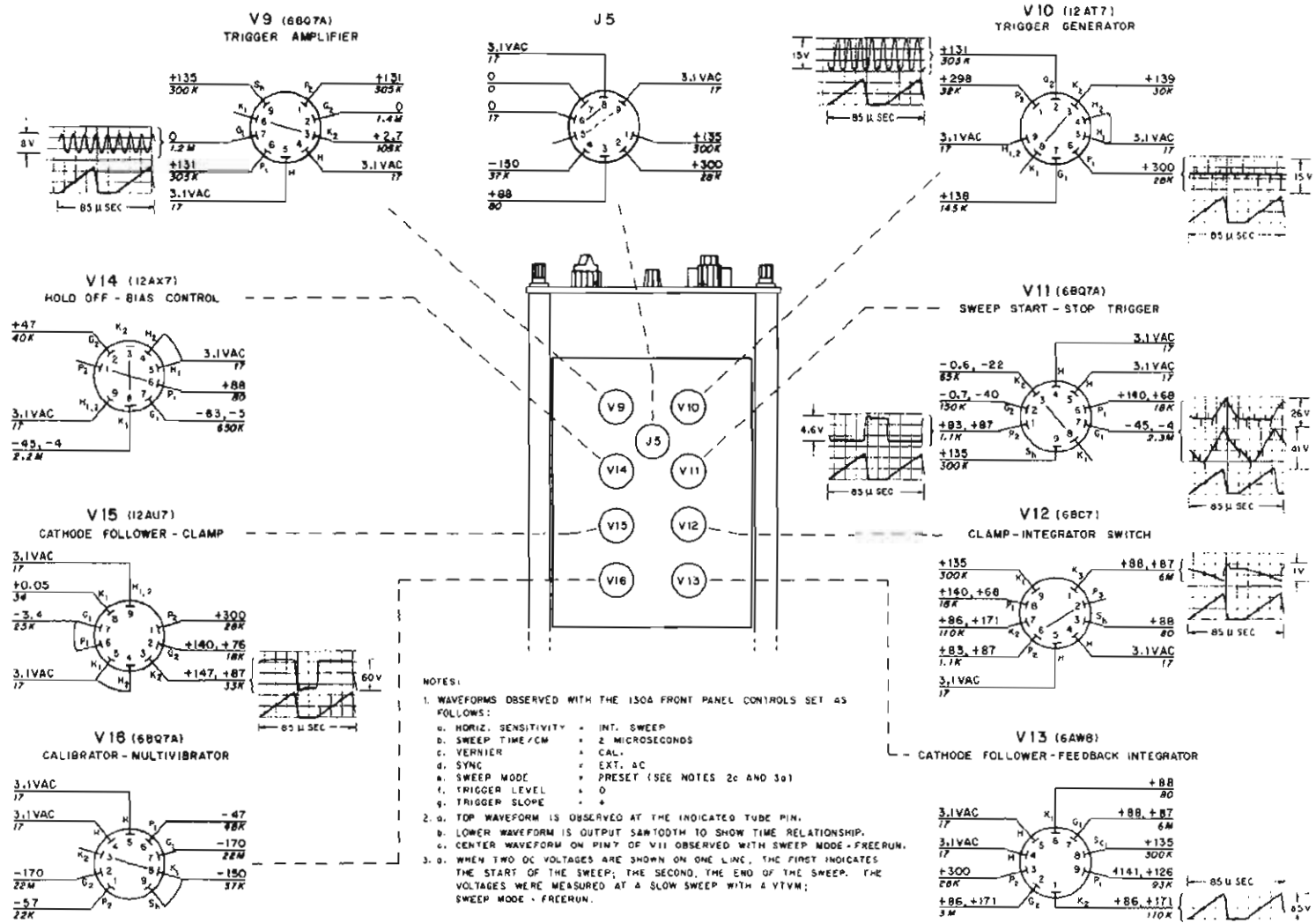
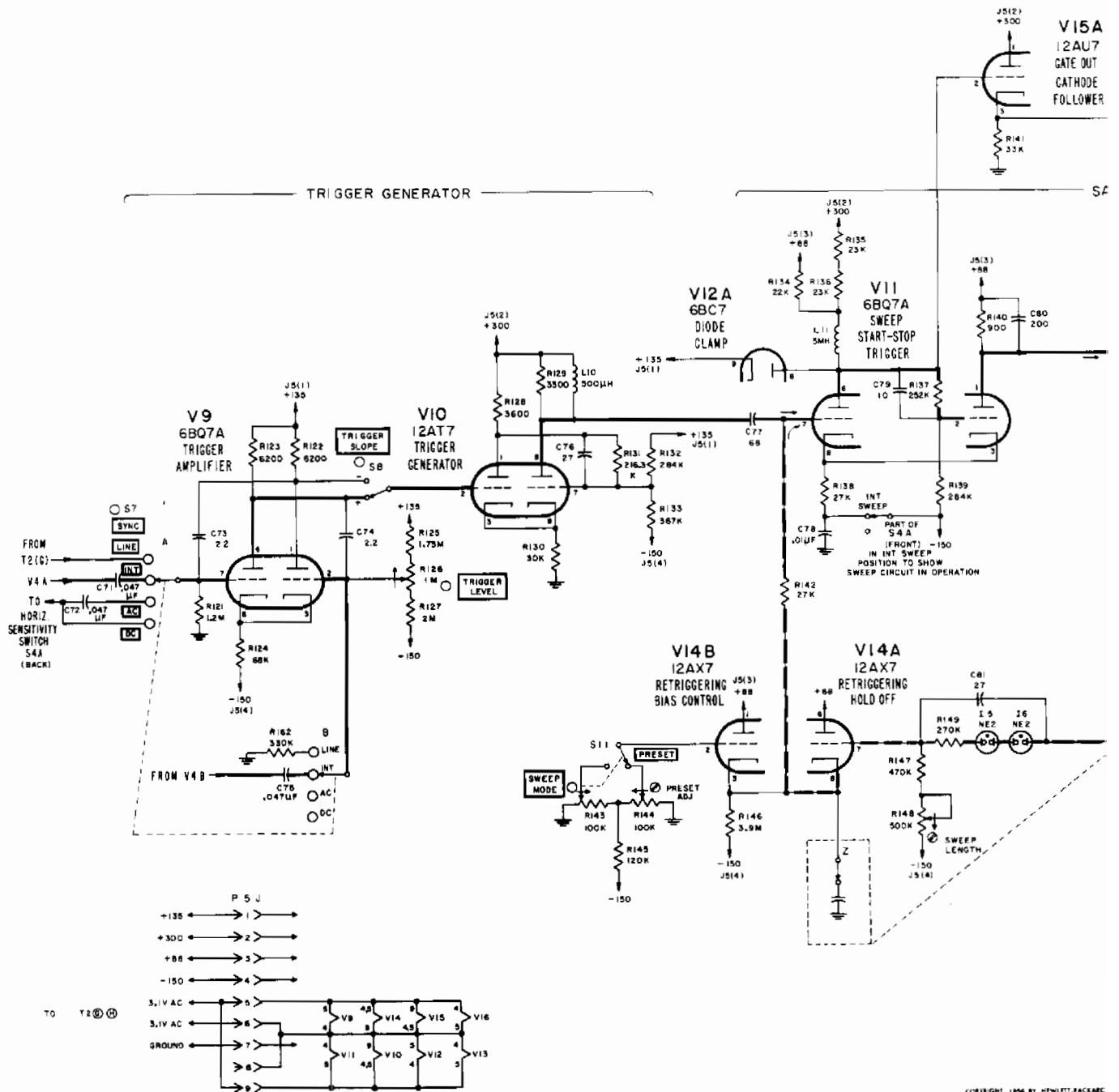


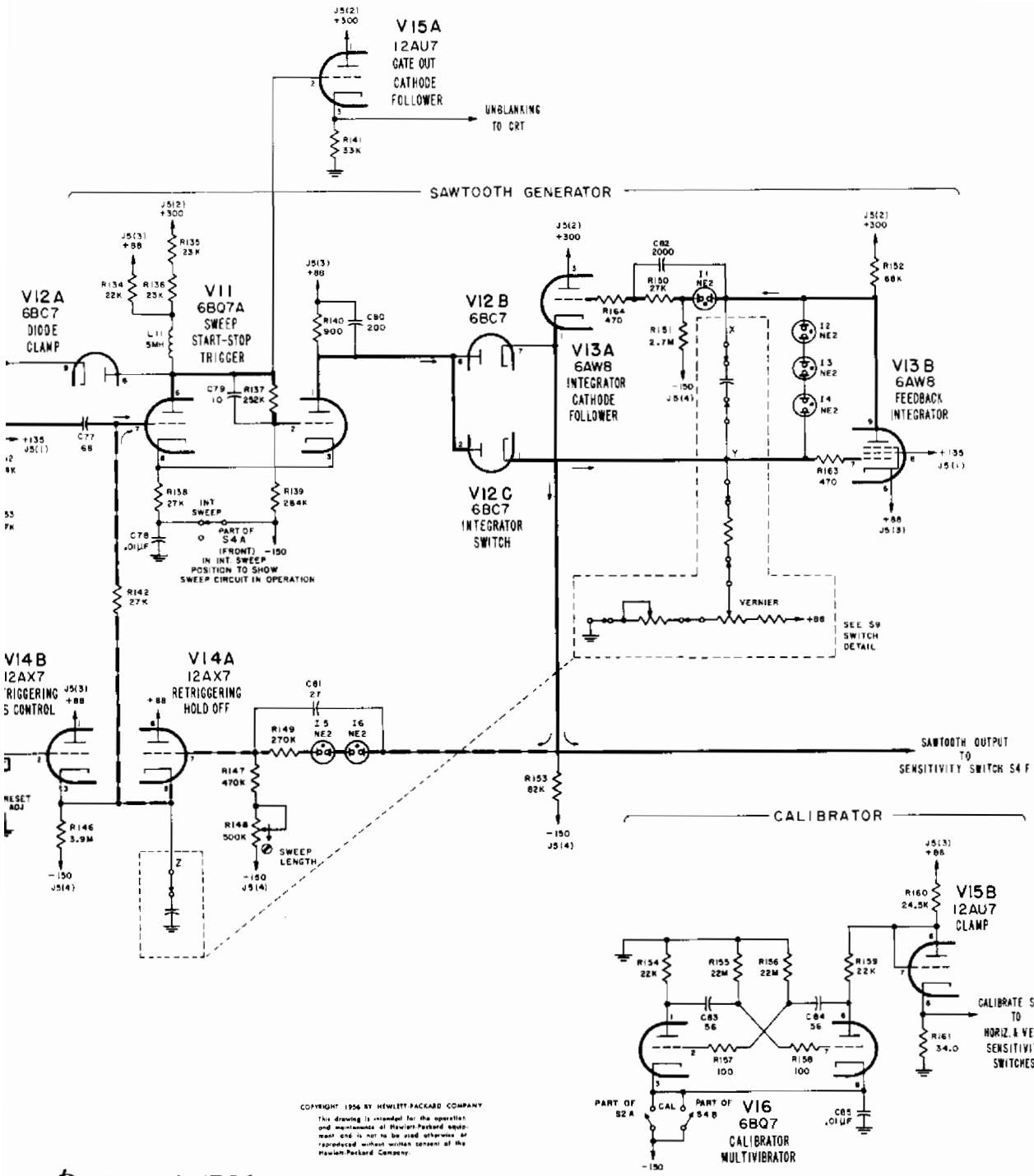
FIGURE 4-13

SWEEP GENERATOR



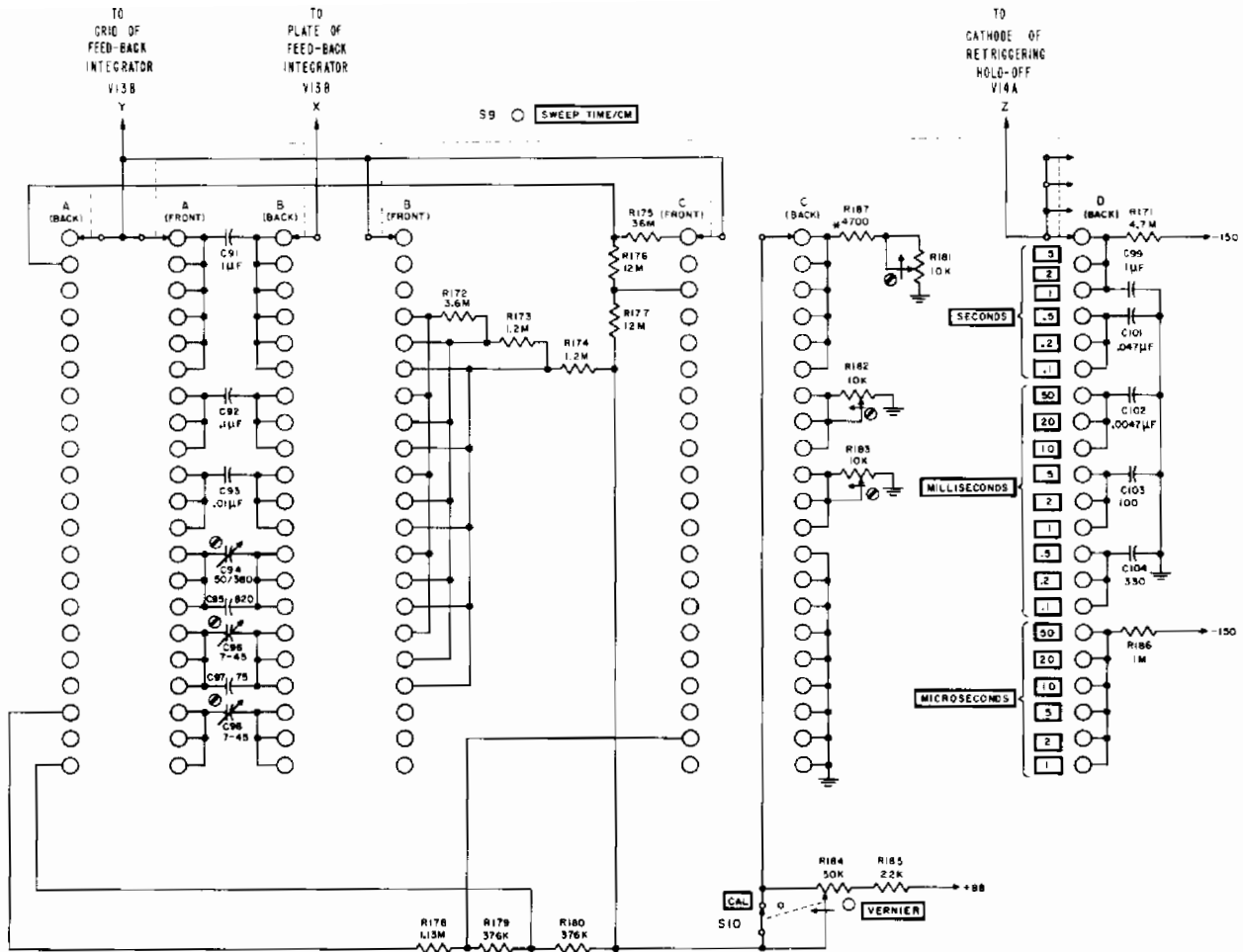
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hp MODEL 130A
SWEEP GENERATOR
 SERIAL 125 & ABOVE



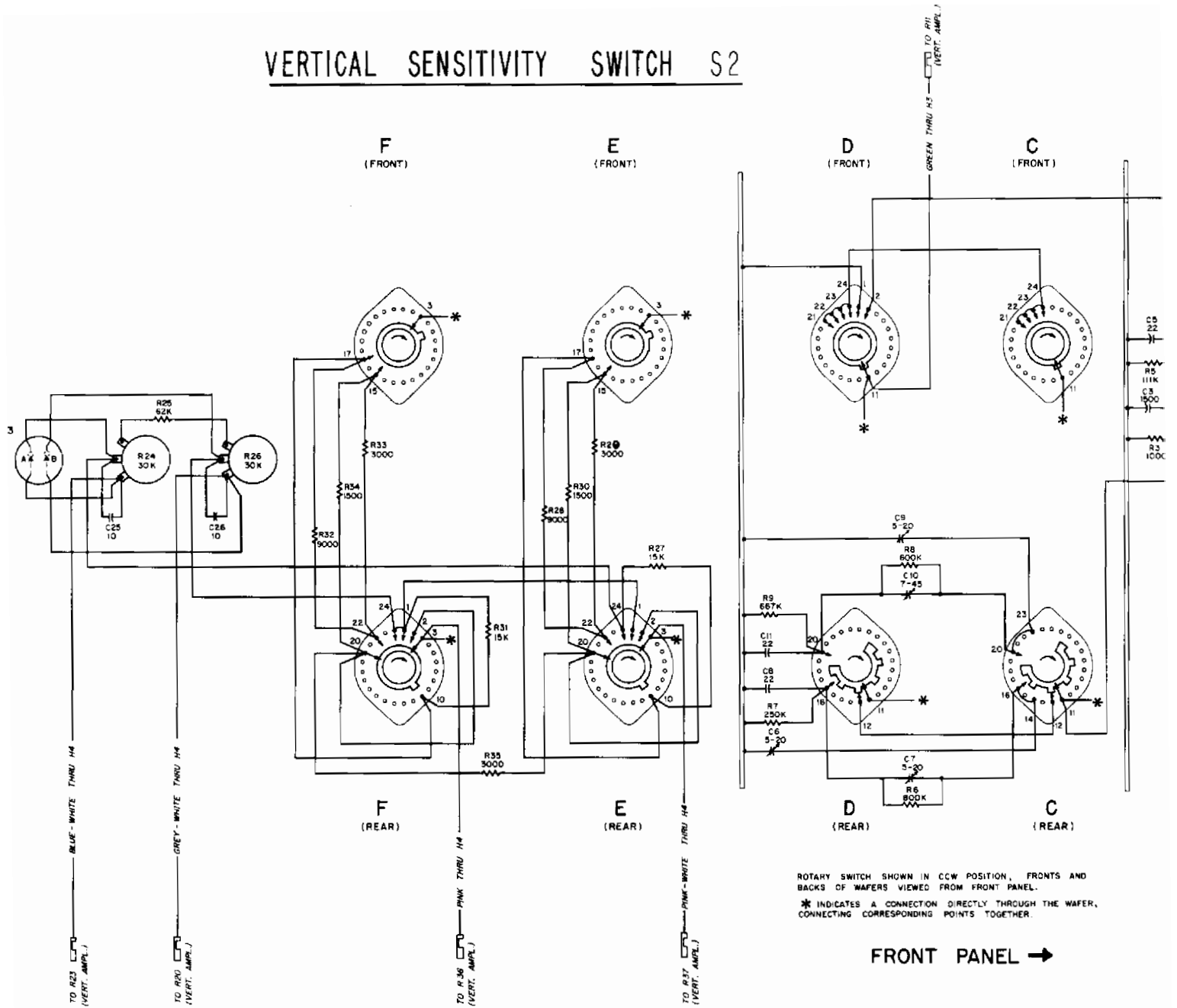
hp MODEL 130A
SWEEP GENERATOR
SERIAL 125 & ABOVE

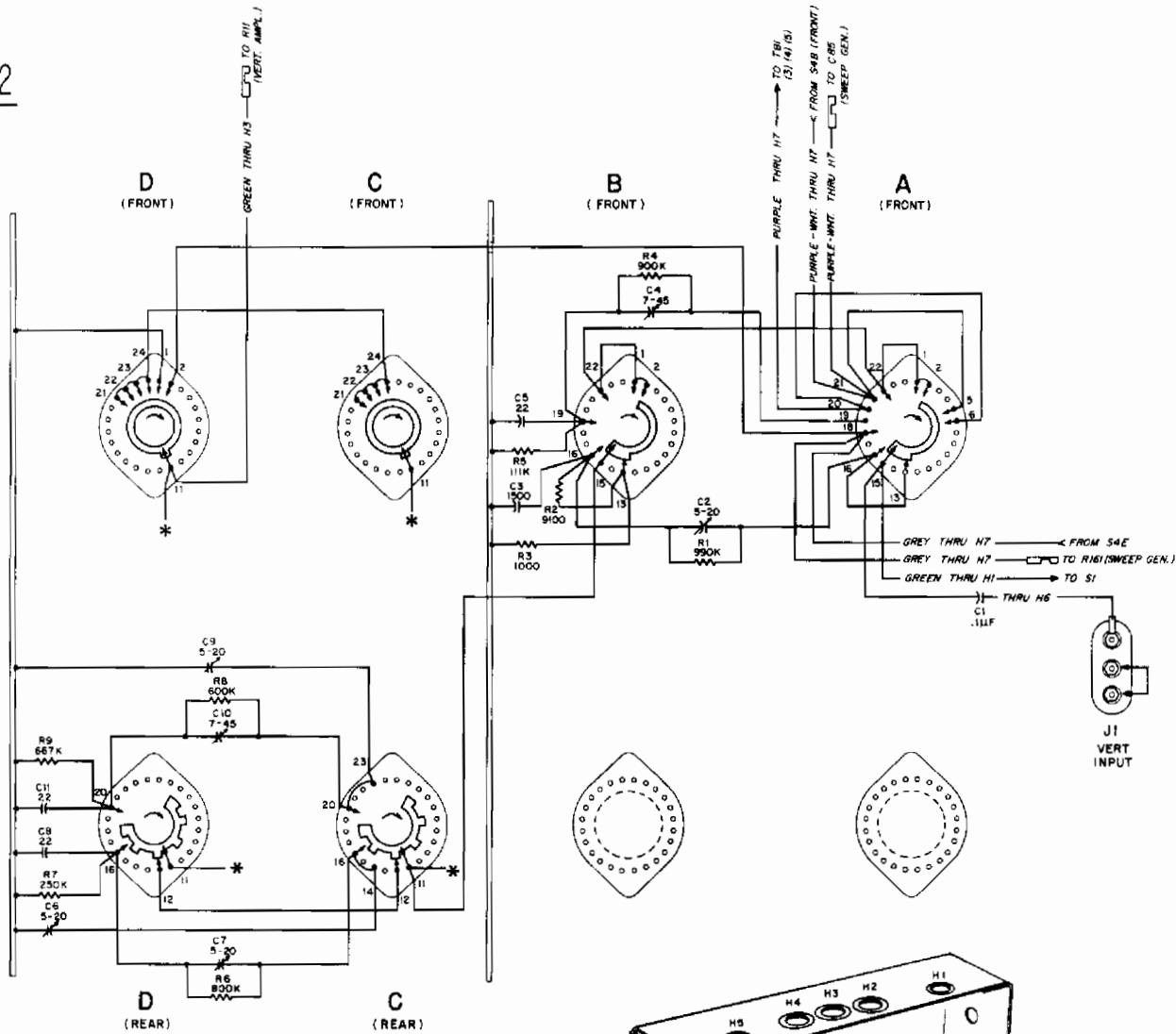
SWEEP TIME/CM SWITCH



hp MODEL 130A
SWEEP TIME/CM SWITCH
SERIAL 125 & ABOVE

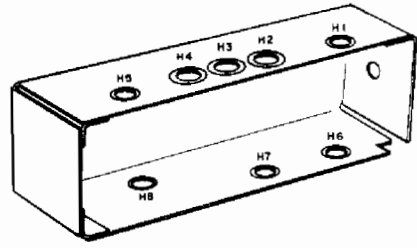
VERTICAL SENSITIVITY SWITCH S2



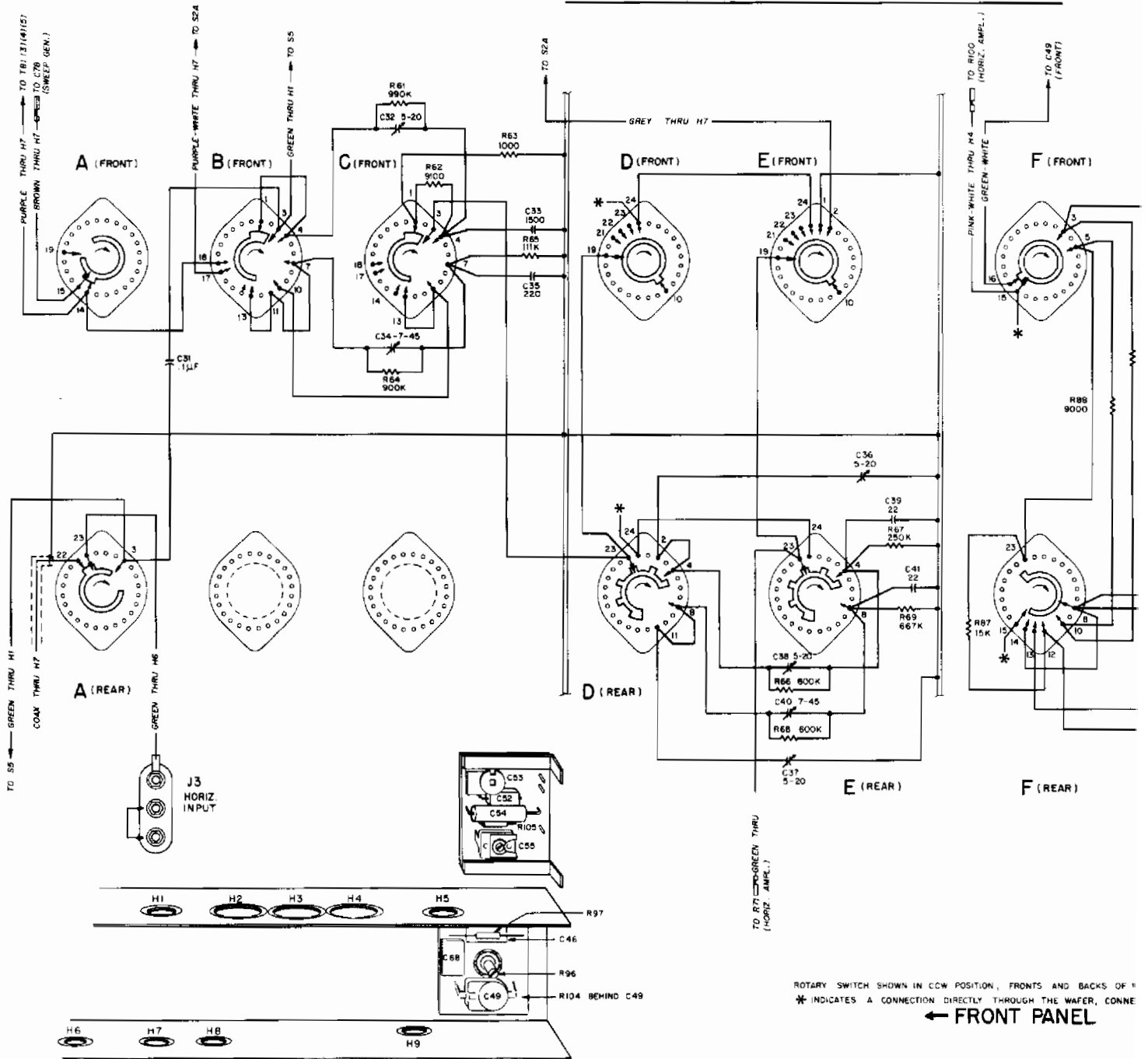


ROTARY SWITCH SHOWN IN CCW POSITION; FRONTS AND BACKS OF WAFERS VIEWED FROM FRONT PANEL.
 * INDICATES A CONNECTION DIRECTLY THROUGH THE WAFER, CONNECTING CORRESPONDING POINTS TOGETHER.

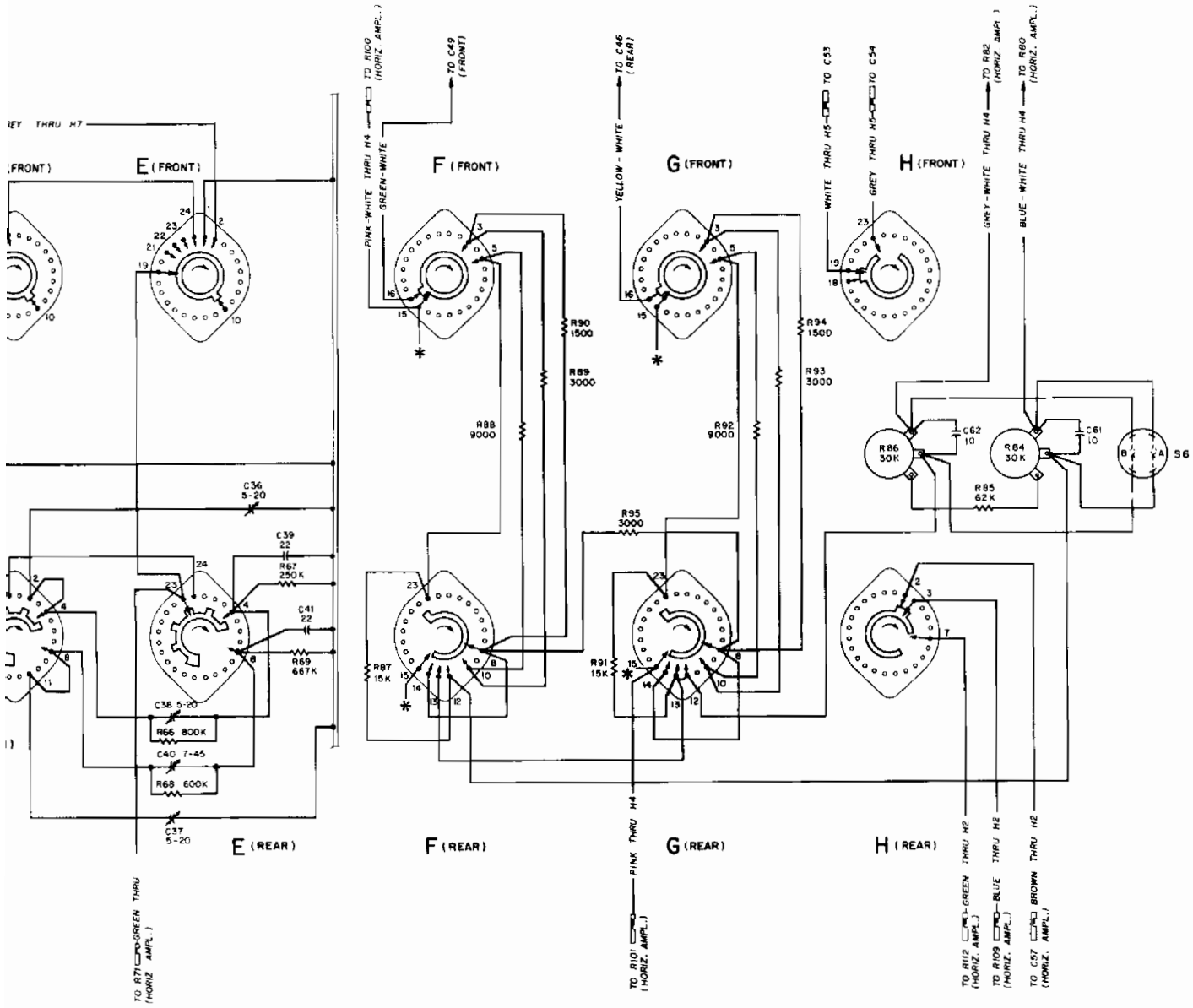
FRONT PANEL →



HORIZONTAL SENSITIVITY SWITCH S4

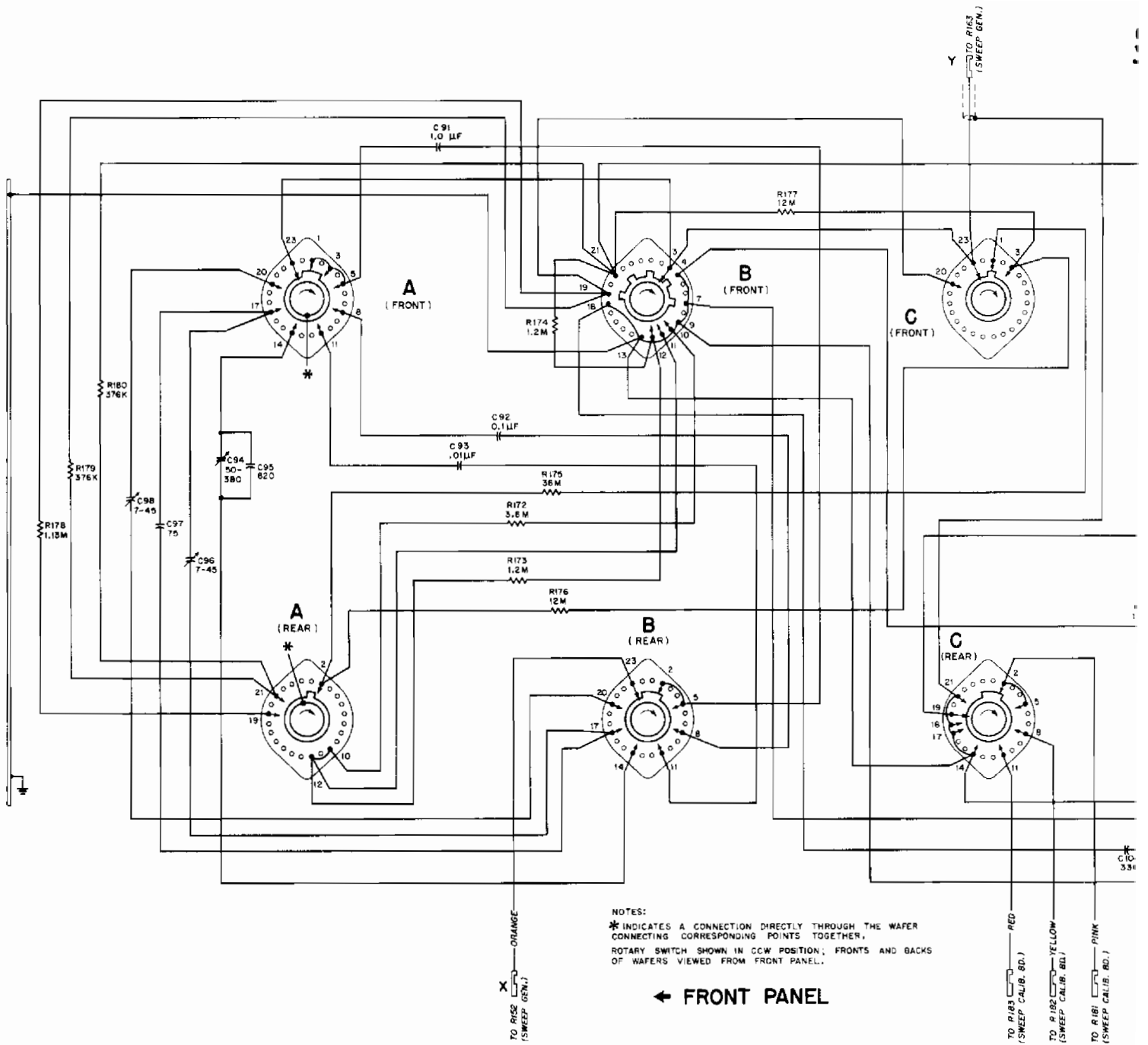


INTERNAL SENSITIVITY SWITCH S4

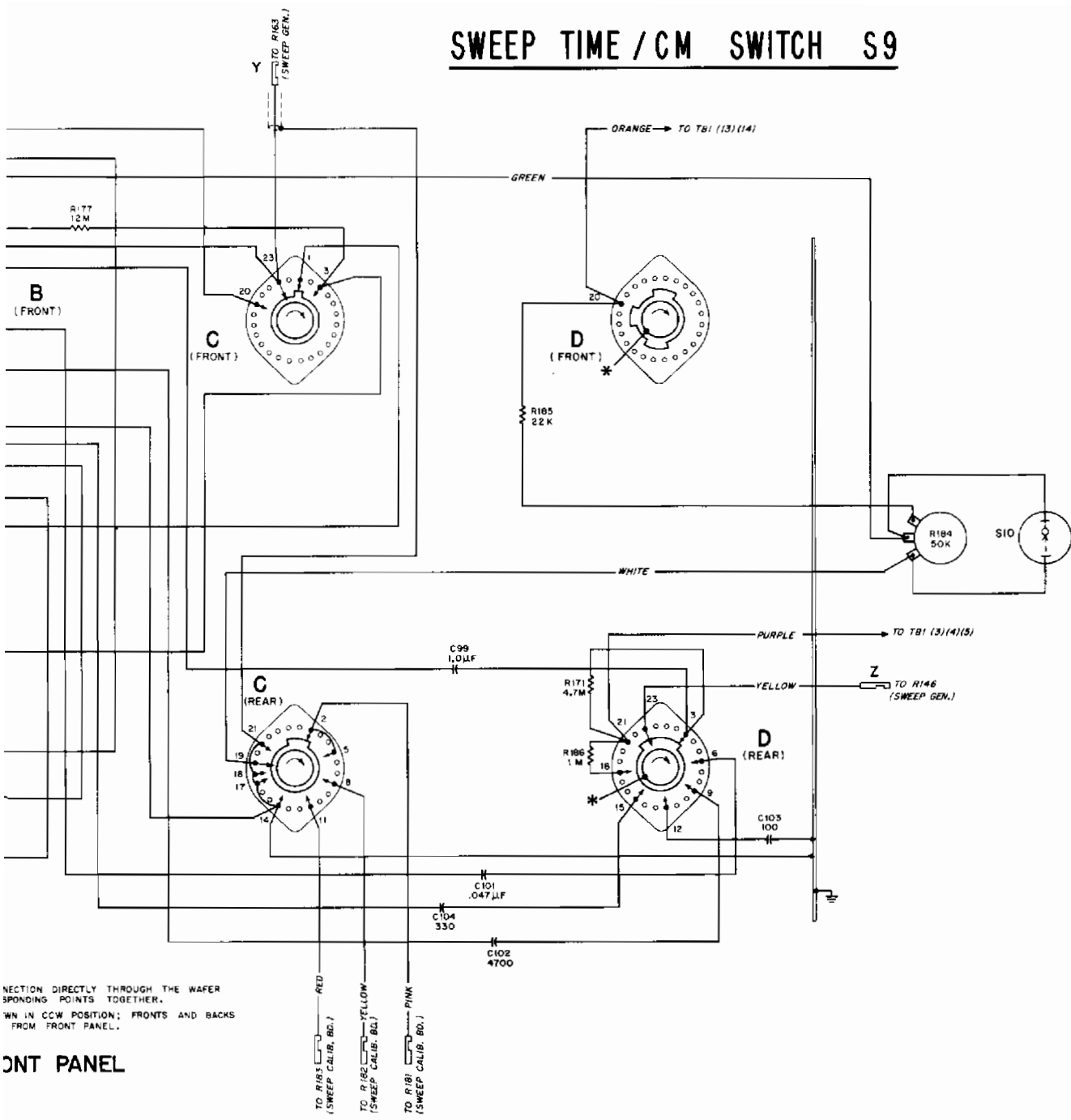


49
 ROTARY SWITCH SHOWN IN CCW POSITION; FRONTS AND BACKS OF WAFERS VIEWED FROM FRONT PANEL.
 * INDICATES A CONNECTION DIRECTLY THROUGH THE WAFER, CONNECTING CORRESPONDING POINTS TOGETHER.

← FRONT PANEL



SWEEP TIME / CM SWITCH S9



FRONT PANEL