Model 150A/AR
Oscilloscope
Serial No. 40 thru 3189
150A/AR-901

— SPECIAL NOTE —

RACK MOUNT MODEL ONLY

With RACK MOUNT Model 150A's only, remove the two LARGE screws at the rear of the cabinet before installation. This permits the chassis to slide forward for servicing.

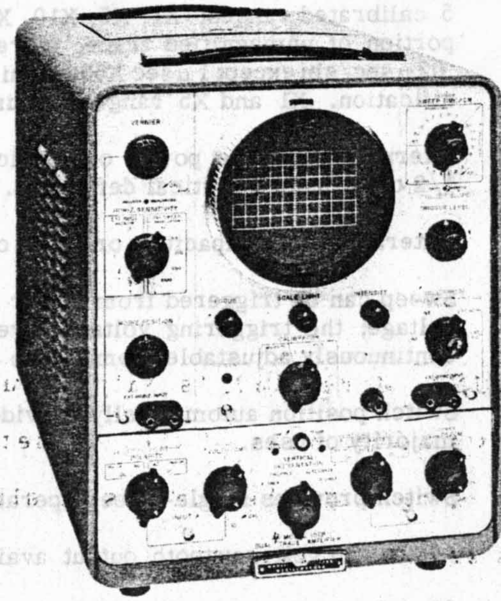
OPERATING AND SERVICING MANUAL

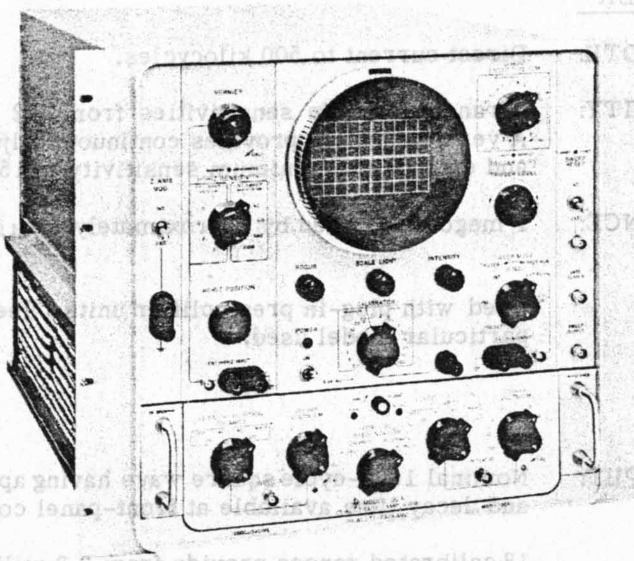
FOR

MODEL 150A/AR

HIGH FREQUENCY OSCILLOSCOPE

SERIAL 40 THROUGH 3189





275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

SPECIFICATIONS

SWEEP GENERATOR	
INTERNAL SWEEP:	24 calibrated ranges provide sweep times from 0.1 μsec/cm to 5 sec/cm; accurate to within 3%. A vernier control provides continuous adjustment of sweep speed between calibrated ranges and extends slowest sweep to 15 sec/cm.
MAGNIFICATION:	5 calibrated ranges; X1, X5, X10, X50 and X100 magnifies center portion of unmagnified trace, increases fastest sweep speed to .02 μsec/cm except 1 μsec X50 magnification and 2 μsec X100 magnification. X1 and X5 ranges retain accuracy of original sweep.
TRIGGERING:	Internal, from line power or vertical input signal which causes 1/2 cm or more vertical deflection. External, either capacitive or direct coupled, with 1/2V p-p or more.
TRIGGER POINT:	Sweep can be triggered from either a positive or a negative going voltage; the triggering voltage level if external sync signals is continuously adjustable from -30 to +30 volts. Switch position automatically provides optimum sync stability for majority of uses.
SINGLE SWEEP:	Switch provides single-sweep operation.
SAWTOOTH OUTPUT:	+20 to -20 volt sawtooth output available concurrent with sweep.
GATE OUTPUT:	20-volt positive pulse for duration of sweep.
HORIZONTAL AMPLIFIER	
BANDWIDTH:	Direct current to 500 kilocycles.
SENSITIVITY:	5 ranges provide sensitivities from 0.2 volt/cm to 5 volts/cm. A vernier control provides continuous adjustment between ranges and extends the minimum sensitivity to 15 volts/cm.
INPUT IMPEDANCE:	1 megohm shunted by approximately 27 μμf.
VERTICAL AMPLIFIER	Used with plug-in preamplifier units. See instruction manual for particular model used.
CALIBRATOR	
OUTPUT:	Nominal 1000-cycle square wave having approximately 1 μsec rise and decay time available at front-panel connector. 18 calibrated ranges provide from 0.2 millivolt to 100 volts peak-to-peak, accurate to within 3%.

CONTENTS

SPECIFICATIONS (CONT'D.)

CATHODE RAY TUBE

TYPE:	5AMP- mono-accelerator, flat face, available with P1, P2, P7 or P11 screen. 5000-volt accelerating potential.
FILTER SUPPLIED:	Compatible with phosphor, green with P1 and P2, amber with P7, and blue with P11.
GRATICULE:	10 cm long x 6 cm high marked in centimeter squares; 2 mm subdivisions on horizontal and vertical axes. Controlled edge lighting.
DEFLECTION PLATE CONNECTIONS:	Both screw and pin type terminals to receive wires or special connector assembly for connection to plates.
DEFLECTION SENSITIVITY:	20 volts/cm approximately.
INTENSITY MODULATION:	+20 volt pulse required to blank CRT trace of normal intensity.
REPLACEABILITY:	CRT bezel removes with 15° twist for replacement of graticule or for replacement of the CRT without removing the cabinet of the 150A or without removing the 150AR from the rack.
	CRT bezel provides firm mounting for standard oscilloscope cameras.

GENERAL

POWER REQUIREMENTS:	115/230 vac ±10%, 50/60 cps, approximately 500 watts.
DIMENSIONS:	Cabinet Mount: 13-3/4" wide, 17" high, 24-3/4" deep. Rack Mount: 19" wide, 15-3/4" high, 24-3/4" deep. Depth behind panel is 23 inches.
WEIGHT:	Cabinet Mount: Net 65 lbs., shipping 105 lbs. Rack Mount: Net 85 lbs., approximately.
PLUG-IN AMPLIFIERS:	Model 151A High Gain Amplifier, dc to 10 mc, 5 mv/cm. Model 152A Dual Trace Amplifier, dc to 10 mc, 50 mv/cm. Model 152B Dual Trace Amplifier, dc to 10 mc, differential input. Model 153A High Gain Differential Amplifier, dc to 500 kc, 1 mv/cm.
ACCESSORIES AVAILABLE:	Model 115A Testmobile, Model 116A Testmobile Storage Unit, Model AC-117A Accessory Storage Drawer, AC-83A Viewing Hood, 460B-95A, Oscilloscope adapter for connecting the output of a 460B Fast Pulse Amplifier to the 150A/AR Deflection Plates, AC-21A Probe, 10:1, specify grey or black lead, AC-21C Probe, 50:1, specify grey or black lead, AC-76A BNC to binding post adapter.
ACCESSORIES FURNISHED:	Two AC-21A Probes. Two AC-76A BNC to binding post adapters.

SECTION I
GENERAL DESCRIPTION

1-1 GENERAL INFORMATION

The Model 150A dc to 10 mc oscilloscope is a general purpose oscilloscope employing a 5 AMP- mono-accelerator type cathode ray tube with unitized, plug-in construction for maximum accessibility and flexibility. It can be used with either internal or external sweeps which can be either internally or externally synchronized. The horizontal amplifier incorporates magnification circuitry which is capable of expanding basic internal sweeps up to 100 times. The internal sweep range extends from .02 μsec/cm to 15 sec/cm.

The Model 150A uses a variety of vertical amplifier plug-in units to perform different functions. The various plug-in amplifiers available are described in the table of specifications.

Since operation of the rack model is similar to that of the cabinet model, the operation of the instrument will be described without regard to style of mounting.

1-2 DAMAGE IN TRANSIT

Should any shipping damage become evident refer to the "Claim for Damage in Shipment" paragraph on the warranty sheet in this manual.

1-3 POWER LINE VOLTAGES

The Oscilloscope is shipped from the factory wired for 115 volt ac line operation, unless otherwise specified. However, the instrument may also be operated from a 230 volt ac line source if the proper conversion is made to the power transformer. Refer to the conversion instructions in paragraph 1-7 and the appropriate schematic diagram in Section IV.

1-4 POWER CORD

The three conductor power cable supplied with the instrument is terminated in a polarized three prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin, added to a standard two-blade ac plug, which grounds the instrument chassis when used with the appropriate receptacle. An adapter should be used to connect the NEMA plug to a standard two contact output. When the adapter is used, the ground connection becomes a short lead from the adapter which should be connected to a suitable ground for the protection of operating personnel.

On the rack mount Model 150AR, the instrument is connected to the ac receptacle in the cabinet by means of a retracting coil cord. This permits the instrument to slide out of the cabinet while still in operation.

1-5 COOLING

The Model 150A employs a forced draft cooling system to maintain satisfactory operating temperatures within the case. The air intake and filter are located under the instrument case and adequate cooling will take place as long as the case is on the instrument and nothing obstructs the filter. Generally, the height of the cabinet feet provides such clearance. Thus, the Model 150A can be used in a confined bench set-up as long as the underside of the cabinet is clear, and ambient temperatures are not extreme.

1-6 OVERLOAD RELAY

The Model 150A has an overload relay which interrupts operation when:

1. Any series tube on the regulated dc heater string is removed while the instrument is on.
2. A plug-in vertical amplifier is removed while the instrument is on.
3. A short circuit or excessive loading of any positive-voltage supply occurs.

To reset the overload relay remove the cause, and turn the instrument off for one minute or more. The instrument may then be turned on again and operated normally.

1-7 230-VOLT OPERATION

The 150A is normally shipped from the factory with the dual primary windings of the two power transformers connected in parallel for use on 115-volt ac lines. The windings can easily be reconnected in series for use on 230-volt power, if desired. The primary connections to both power transformers are identical, and each requires the same change in connections. To reconnect the primary windings of T2 and T3 for use on 230 volts, on each transformer disconnect the jumpers which join terminals 1 to 4 and 2 to 5. Connect 10-ohm disk thermistors, RT301 to T2 and RT302 to T3, between terminals 4 and 5. Replace the 6-1/4 amp fuse with a 3-amp fuse and the 150A can now be operated from 230 volt lines with no change in operation.

SECTION II
OPERATING INSTRUCTIONS

2-1 INSTRUMENT SAFETY DEVICES

The Model 150A contains circuits which delay the application of dc operating voltages for approximately 30 seconds. This delay allows all tube heaters to reach operating temperature before power is applied to the instrument. In addition, protective relays are provided which disconnect the dc operating voltages when overloads or other potentially dangerous conditions occur. When the instrument is turned off these circuits require at least one minute to re-cycle. For this reason you should always wait at least one minute after turning the power switch off before turning it back on. If you do not allow adequate time the protective relays will lock out the operating voltages and the instrument will not come on. The protective circuits will operate whenever the plug-in amplifier, or any tube with a regulated dc heater supply is disconnected when the unit is turned on.

In addition this instrument is provided with a thermal cutout switch which opens the main power circuit if the internal temperature exceeds a safe value. If the instrument has been operating and suddenly goes off, the cutout may have operated. Remove the cause of the overheating and reset the cutout shown in Figure 2-10.

2-2 CONTROLS AND TERMINALS

The controls and terminals of both the cabinet and rack models operate identically. The controls and terminals of the central section of the rack mount model front panel are the same as those on the panel of the cabinet model. However, the controls and terminals inside the access hatch in the cabinet model are mounted on the front panel in the rack mount model. Directions in this manual refer to both models unless otherwise specified.

The illustrations that follow explain the operation of the controls and terminals for the various methods of operation. If the instrument does not function properly, refer to the Maintenance Section in this manual.

CAUTION

Turn the INTENSITY control to minimum before turning on the instrument and when the unit is not in actual use. Excess intensity, particularly with only a spot on the screen, can rapidly damage the cathode ray tube screen.

2-3 VERTICAL AMPLIFIERS

Vertical amplifiers for the Model 150A are built in the form of plug-in units for the bottom section of the oscilloscope. This permits selection of the proper vertical amplifier for a particular purpose. See the instruction manual for the particular plug-in amplifier in use for operating information.

2-4 AC OR DC COUPLING

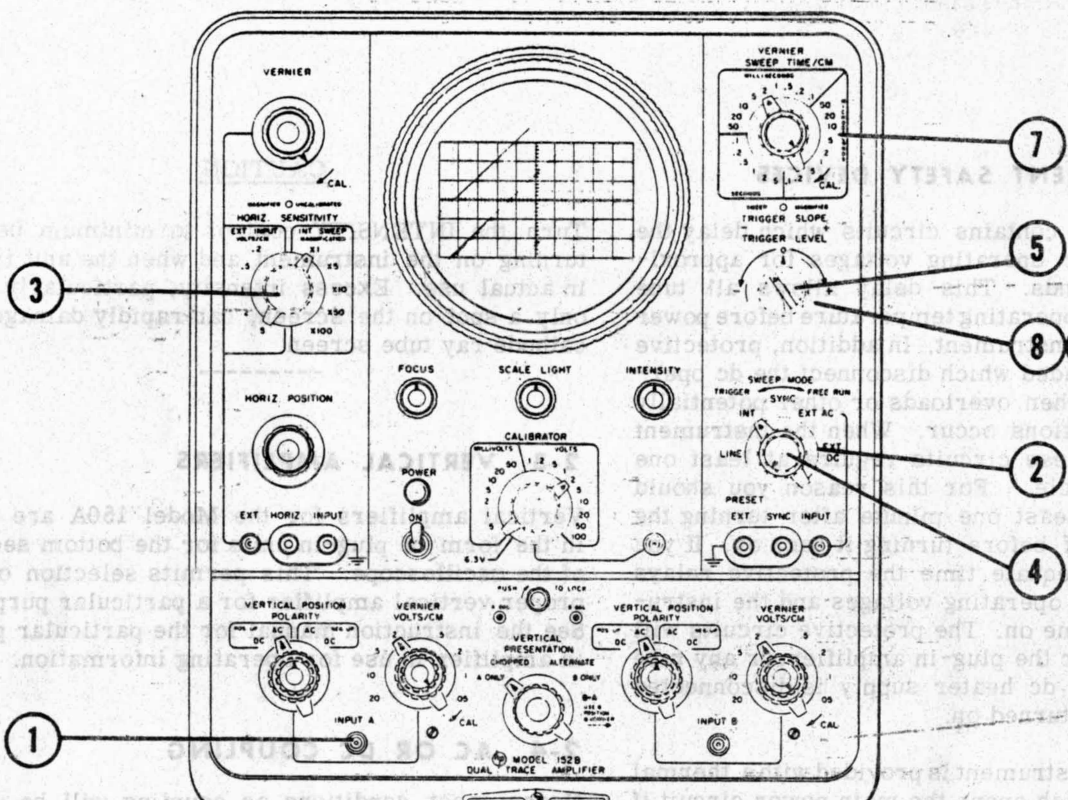
Under most conditions ac coupling will be used. It permits high gain to be employed without regard for the dc levels involved. In the AC position the input signal (vertical or external sync) is coupled to the instrument through a capacitor which removes the dc component from the input wave. Because of the low frequency cut-off of this circuit it is advisable to use dc coupling to view complex waves below approximately 200 cps. Use dc coupling to look at waveforms relative to a dc level. WHEN USING DC COUPLING THE POSITION OF THE TRACE ON THE SCREEN IS DETERMINED BY THE DC LEVEL. IF THE TRACE CANNOT BE ADJUSTED TO PLACE IT ON THE SCREEN, CHECK THE LEVEL TO DETERMINE IF THE INPUT STAGES ARE OVERLOADED.

2-5 AC-21 LOW-CAPACITY PROBES

The probe's alligator-clip jaws are opened by squeezing together the flanges on the probe body.

Typical step-by-step instructions for adjusting the probe for flat response are presented in Figure 2-5.

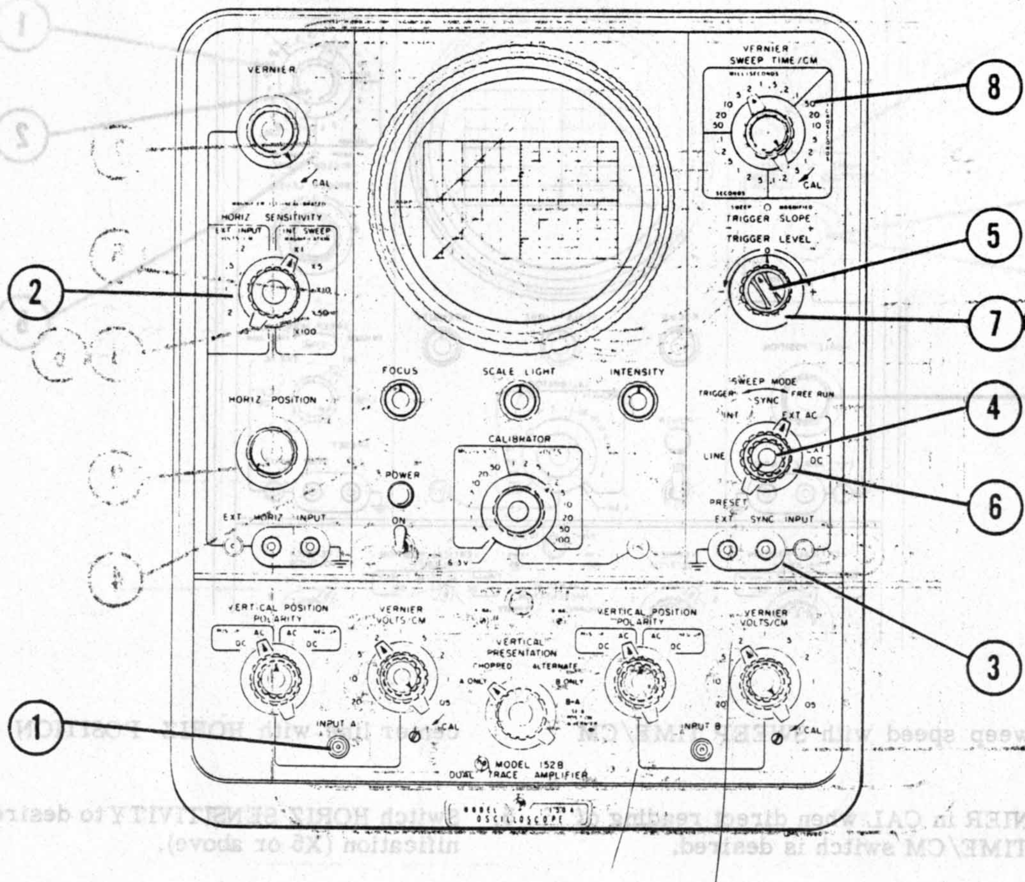
INTERNAL SWEEP - INTERNAL SYNCHRONIZATION



1. Connect vertical input signal to the plug-in amplifier.
2. Set SYNC selector to INT.
3. Set HORIZ. SENSITIVITY to INT. SWEEP X1
4. Set SWEEP MODE to PRESET.
5. Set TRIGGER SLOPE for triggering on positive or negative slope, as desired.
6. Set TRIGGER LEVEL to 0.
7. Select desired sweep speed with SWEEP TIME/CM switch.
8. Adjust TRIGGER LEVEL to start trace at desired level. In some cases, it may be necessary to switch SWEEP MODE from PRESET to an individual adjustment for the particular trace being viewed.

Figure 2-1.

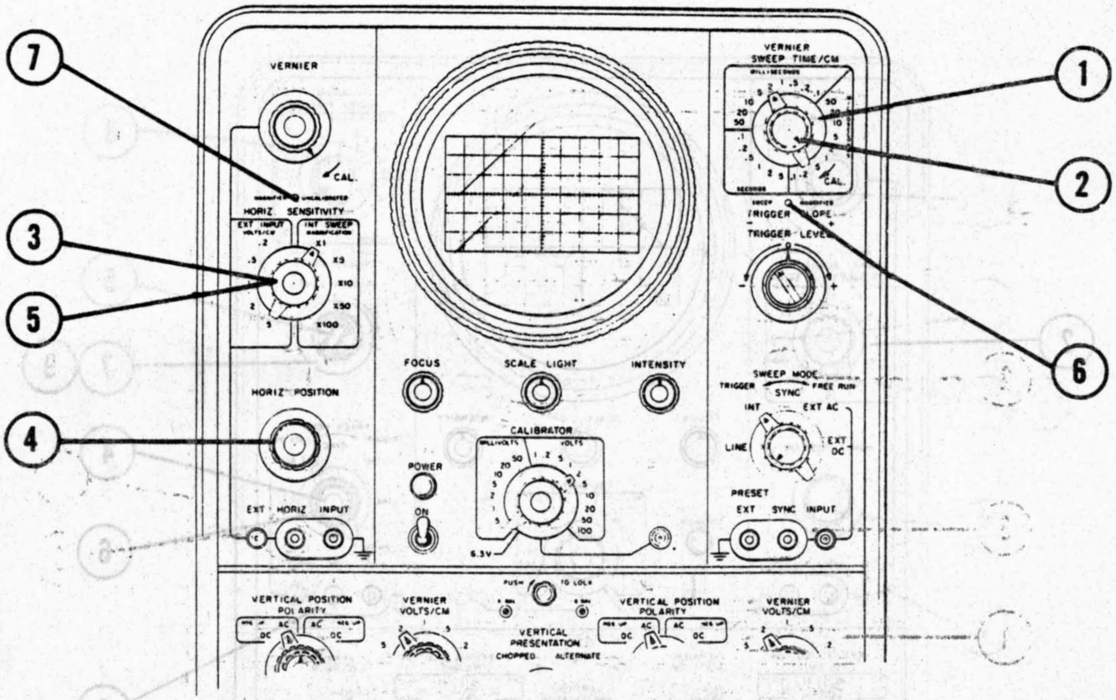
INTERNAL SWEEP - EXTERNAL SYNCHRONIZATION



1. Connect vertical input signal to the plug-in amplifier.
2. Set HORIZ. SENSITIVITY to INT SWEEP X1.
3. Connect external sync signal to EXT SYNC INPUT terminals.
4. Set SWEEP MODE to PRESET.
5. Set TRIGGER SLOPE for triggering on positive or negative slope, as desired.
6. Set SYNC selector to EXT AC or EXT DC, as required.
7. Set TRIGGER LEVEL to 0.
8. Select desired sweep speed with SWEEP TIME/CM switch.
9. Adjust TRIGGER LEVEL to start trace at desired level. In some cases it may be necessary to switch SWEEP MODE from PRESET to an individual adjustment for the particular trace being viewed.

Figure 2-2.

INTERNAL SWEEP MAGNIFICATION



1. Select sweep speed with SWEEP TIME/CM switch.

2. Set VERNIER in CAL when direct reading of SWEEP TIME/CM switch is desired.

3. Set HORIZ. SENSITIVITY to INT SWEEP X1 (X1 is the unmagnified sweep position).

4. Adjust horizontal position of trace. To magnify a portion of a wave or a particular wave in a train, place it under vertical graticule center line with HORIZ POSITION control.

5. Switch HORIZ SENSITIVITY to desired magnification (X5 or above).

6. SWEEP MAGNIFIED indicator will light.

7. If combination of sweep speed and degree of magnification exceeds maximum calibrated sweep speed (.02 μseconds/cm) the MAGNIFIER UNCALIBRATED indicator will light.

EXAMPLE

SWEEP TIME/CM = 0.5 μsec/CM
MAGNIFICATION = X50

Actual Sweep Time = 0.5 μsec/cm ÷ (X50)
= 0.01 μsec/cm

(MAGNIFIER UNCALIBRATED lamp will light. Increase sweep time or reduce degree of magnification.)

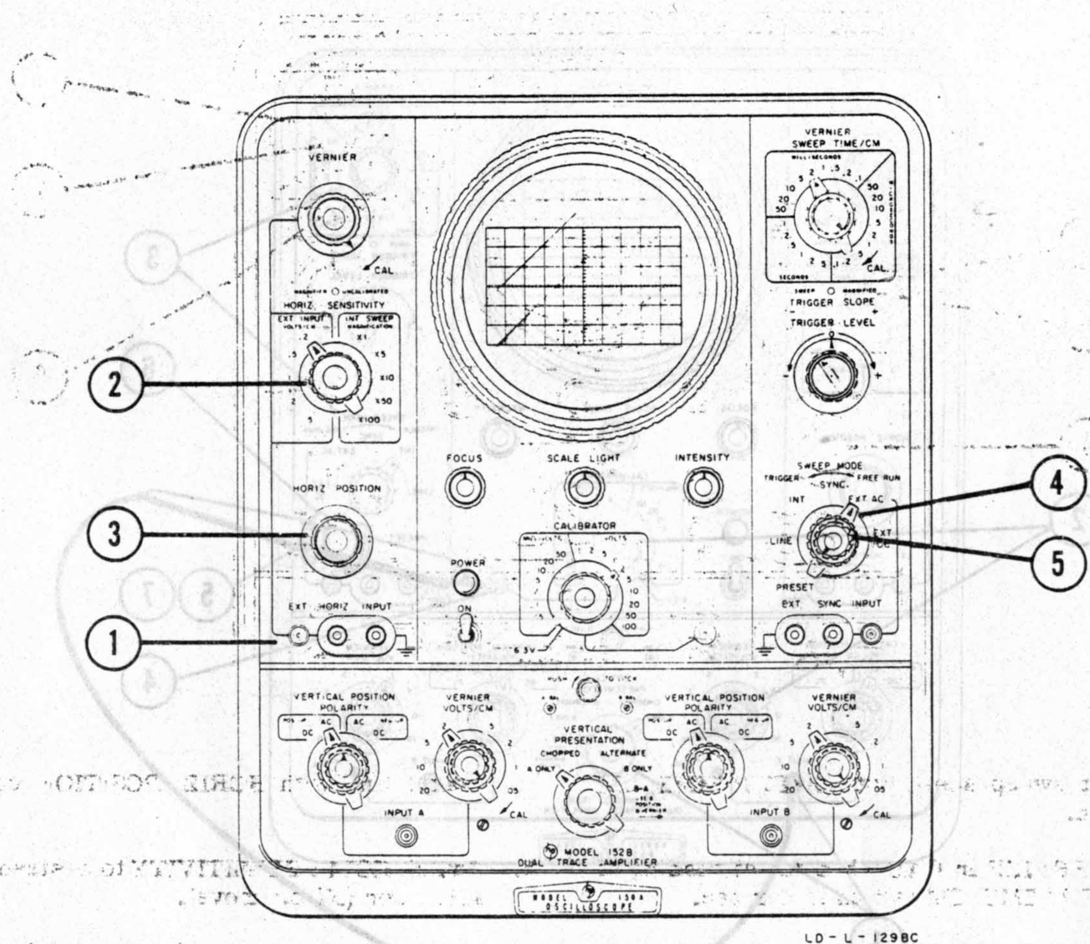
SWEEP TIME/CM = 0.5 μsec/CM
MAGNIFICATION = X10

Actual Sweep Time = 0.5 μsec/cm ÷ (X10)
= 0.05 μsec/cm

(Sweep time > 0.02 μsec/CM, MAGNIFIER UNCALIBRATED lamp stays off.)

Figure 2-3

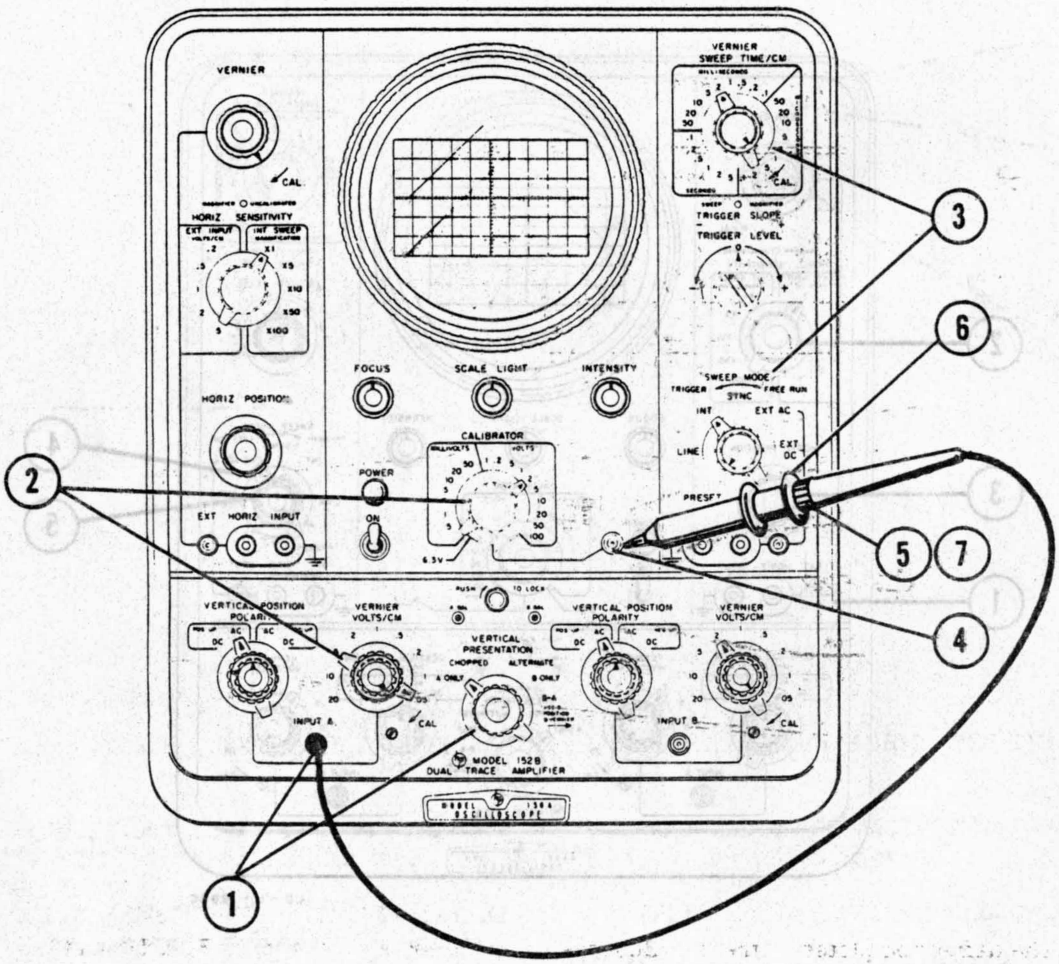
EXTERNAL HORIZONTAL INPUT



1. Insert external horizontal signal.
2. Select desired sensitivity on EXT. INPUT of HORIZ. SENSITIVITY control.
3. Adjust horizontal position.
4. Turn SYNC selector to an EXT. position.
5. Set SWEEP MODE just off PRESET.

Figure 2-4

ADJUSTING (hp) MODEL AC-21 PROBES



1. Connect the AC-21 Probe to the desired vertical input, and set the VERTICAL PRESENTATION selector to the corresponding input.

2. Set the CALIBRATOR selector to 2v. Set the vertical VOLTS/CM selector to .05.

3. Set the SWEEP TIME/CM selector to .5 MILLISECOND/CM: set the SYNC selector to INT: the SYNC control to PRESET.

4. Touch the probe to the CALIBRATOR connector and observe the 1-kc square wave.

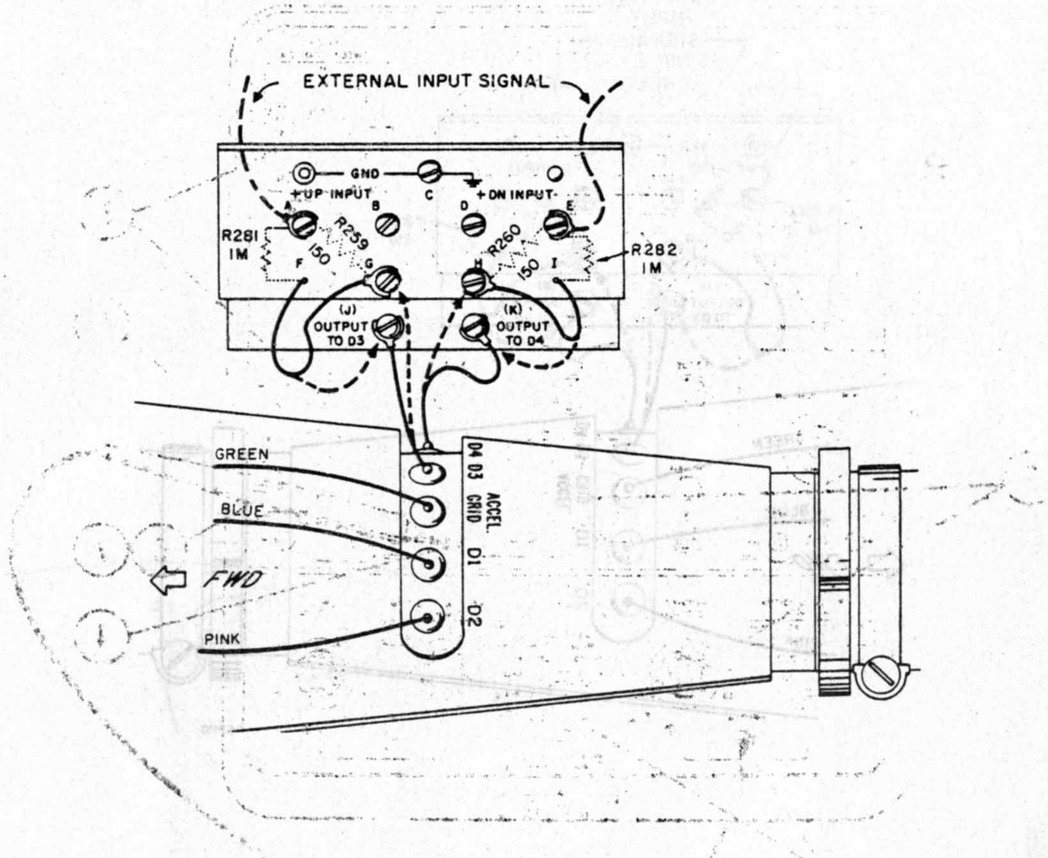
5. Loosen probe locknut by unscrewing.

6. Adjust probe to obtain flattest top on square wave by turning rear flange on probe.

7. Tighten locknut to retain adjustment.

Figure 2-5

DIRECT CONNECTION TO DEFLECTION PLATES



CAUTION - The deflection plates of the oscilloscope operate at a d-c potential of approximately +250 volts. Therefore, there can be no common chassis connection between the signal source and the oscilloscope. In most cases the signal source chassis will assume the deflection plate potential. Turn off the instrument before making connection to deflection plate terminals.

To connect an external signal directly to vertical deflection plates:

A. Balanced Input

1. Connect signal to terminals A and E.

2. Relocate leads from F, I, D3 and D4 as shown by dashed lines.

B. Single-Ended Input

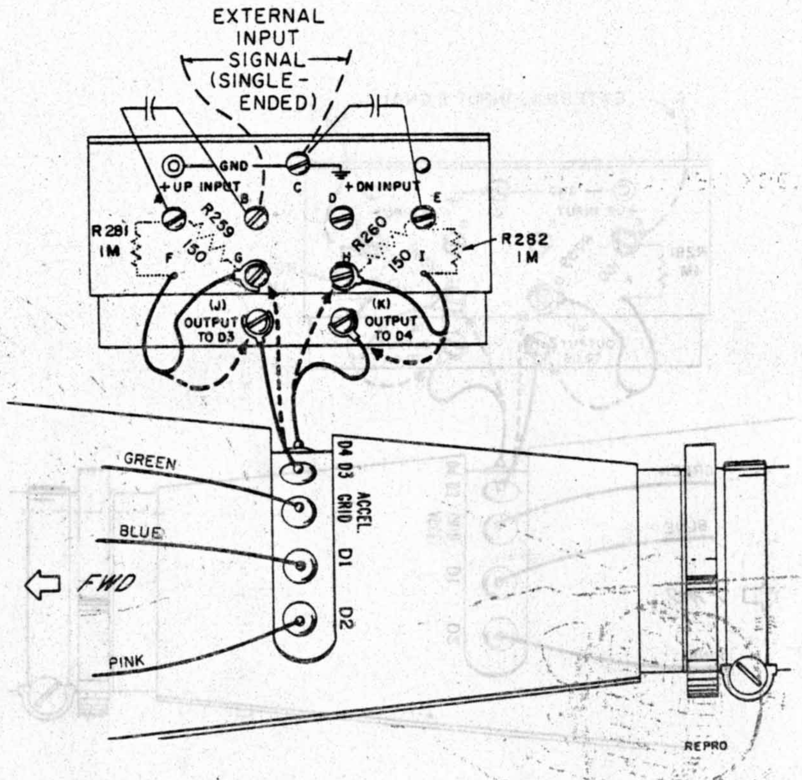
1. Connect the signal to A for +up deflection (to E for + down deflection).

2. Connect an appropriate bypass capacitor between C and E for + up deflection (between C and A for +down deflection). Signal source return connects to E or A, whichever is bypassed.

3. Relocate leads from F, I, D3 and D4 as shown by dashed lines.

Figure 2-6

CAPACITIVE CONNECTION TO DEFLECTION PLATES



CAUTION - Turn off instrument before making connection to deflection plate terminals.

To ac couple a signal to the vertical deflection plate:

A. Single-Ended Input

1. Connect external signal to B for + up deflection (to D for + down deflection) and the signal return to C.

2. Connect an appropriate bypass capacitor between C and E for + up deflection (between C and A for + down deflection).

3. Connect an appropriate d-c blocking capacitor between A and B for + up deflection (between D and E for + down deflection).

4. Relocate leads from F, I, D3 and D4 as shown by dashed lines.

B. Balanced Input

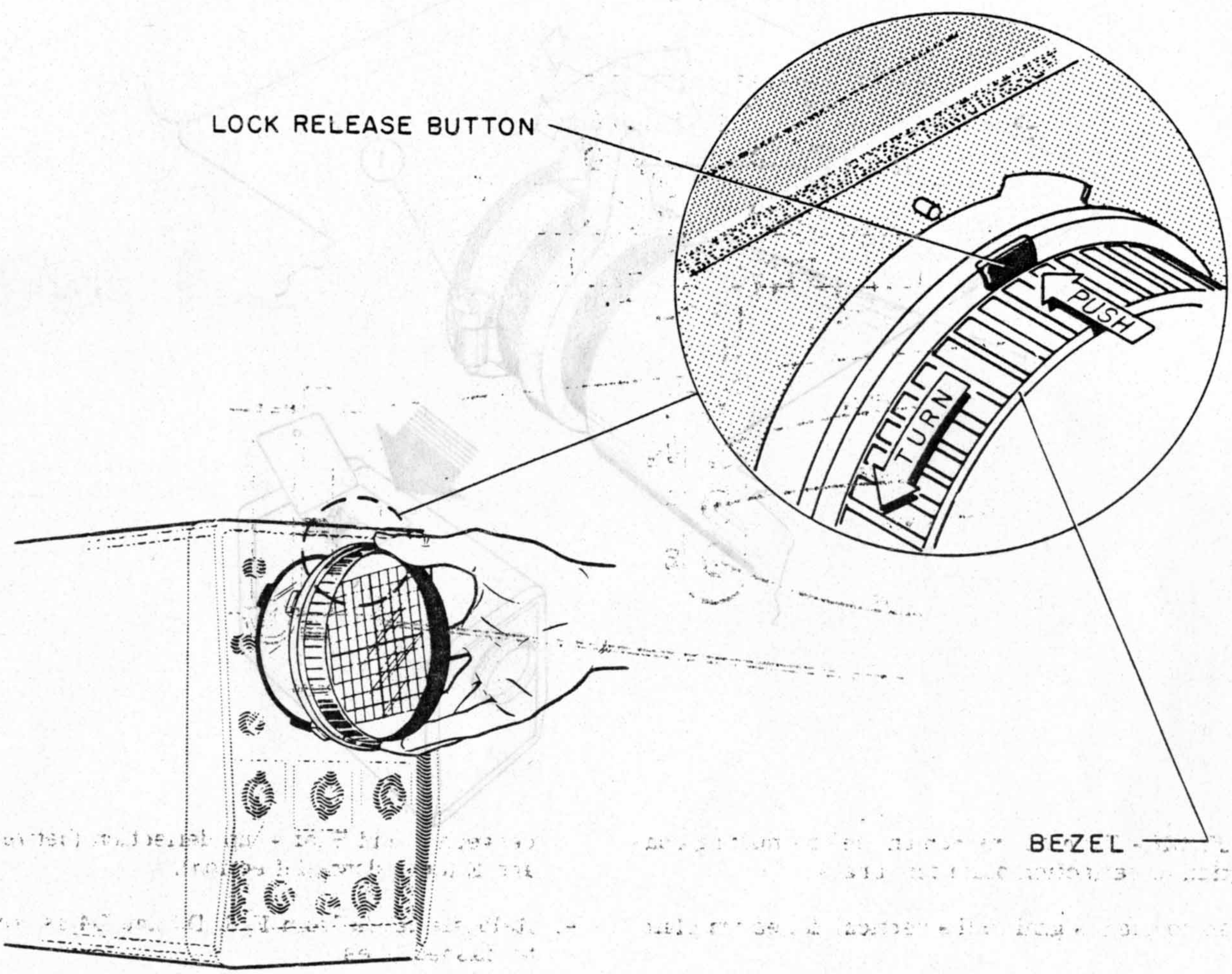
1. Connect external balanced signal to terminals B and D.

2. Connect appropriate d-c blocking capacitors between terminals A and B and between terminals D and E.

3. Relocate leads from F, I, D3 and D4 as shown by dashed lines.

Figure 2-7

REMOVING CRT BEZEL

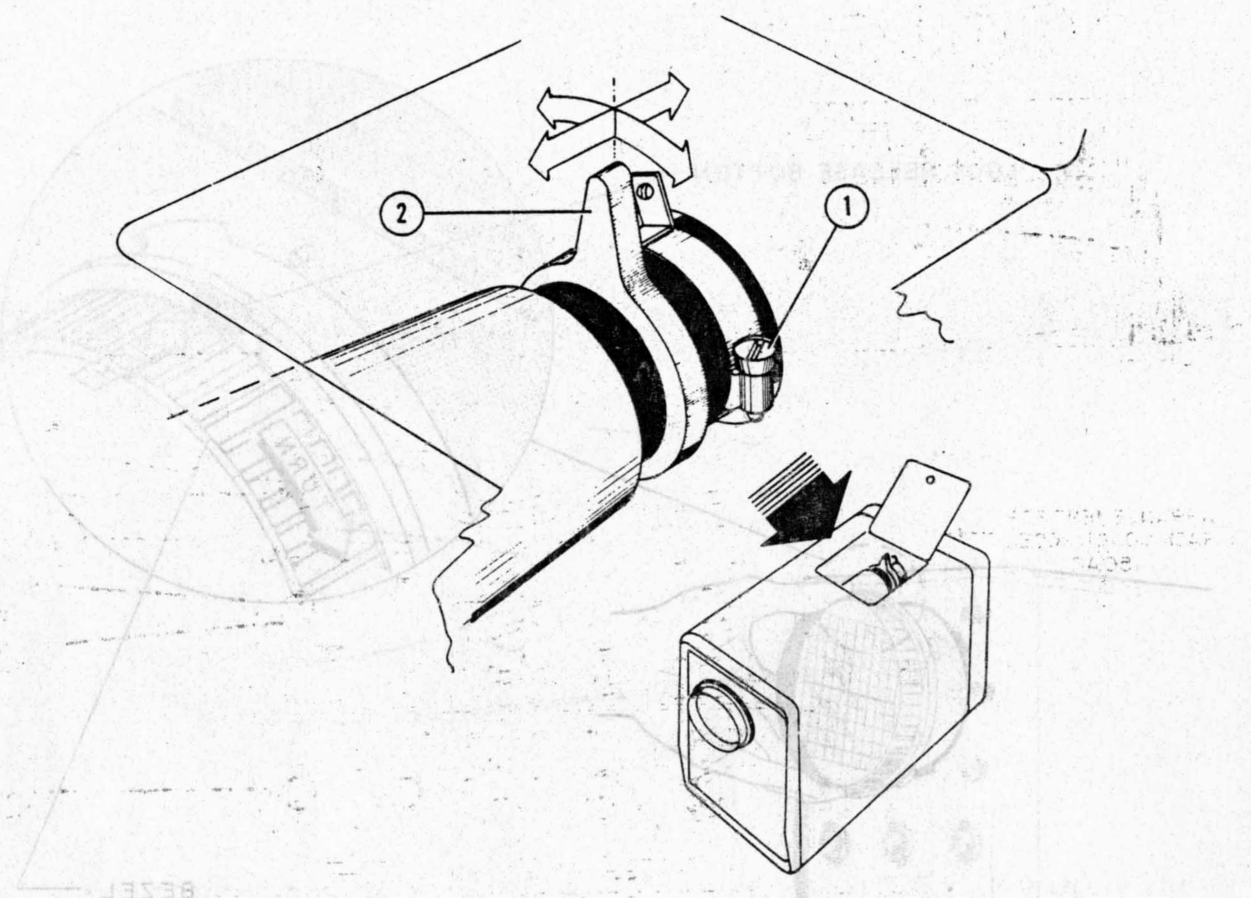


To remove bezel:

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

Figure 2-8

ALIGNING SCOPE TRACE WITH GRATICULE

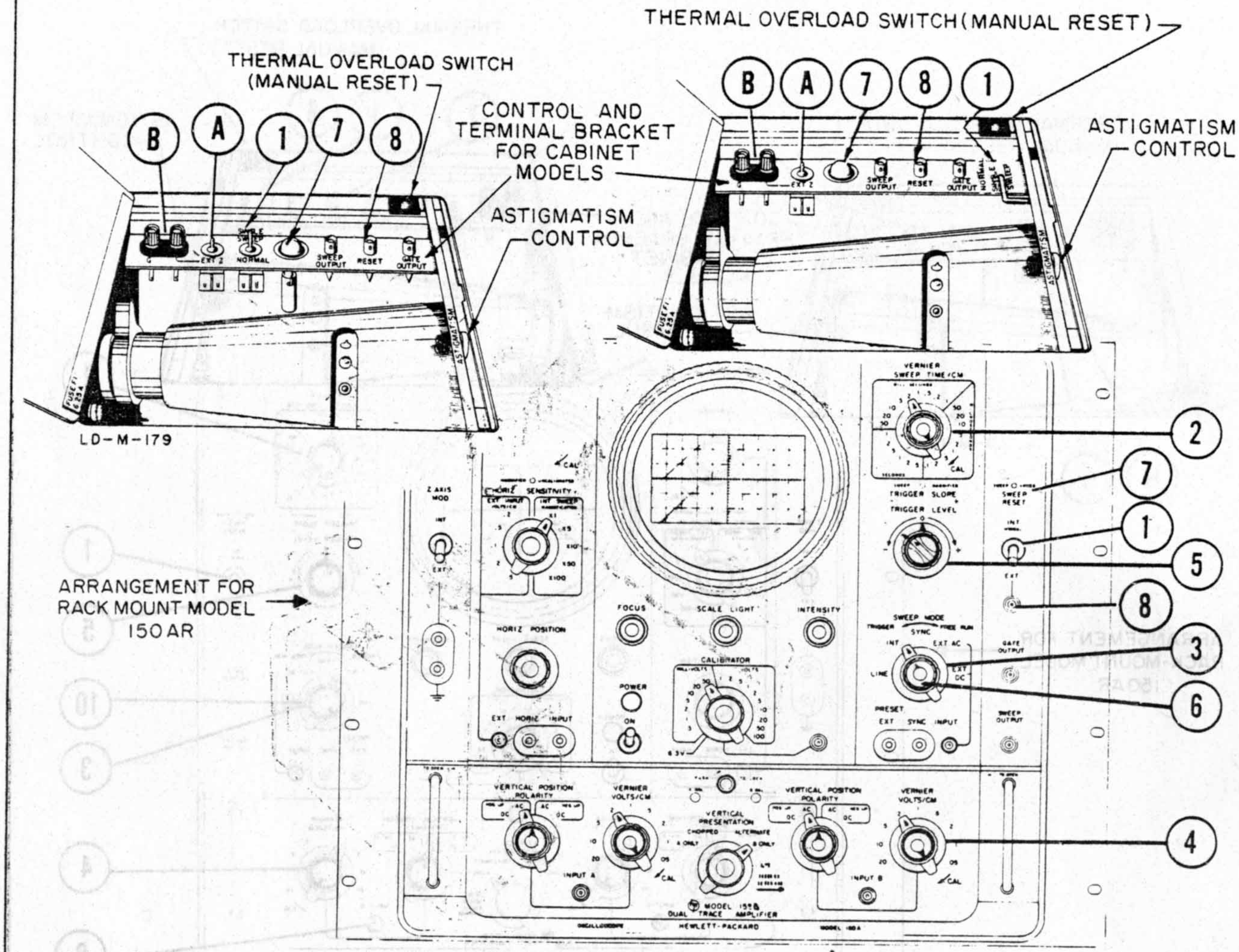


ALIGNMENT OF CATHODE RAY TUBE:

Lever (2) controls both radial and longitudinal positioning of CRT and is locked by clamp (1).

Figure 2-9

SINGLE SWEEP AND INTENSITY MODULATION OPERATION



1. Set selector switch to SINGLE OR EXT. sweep.

2. Select sweep speed.

3. Set SYN switch to INT. and SWEEP MODE to PRESET.

4. Select desired vertical sensitivity.

5. Adjust TRIGGER LEVEL to ZERO and SLOPE as desired. (In some applications it may be convenient to establish desired TRIGGER LEVEL in NORMAL operation.)

6. Switch SWEEP MODE control out of PRESET and back to PRESET to arm sweep circuit.

7. Indicator should light as soon as SWEEP MODE control is returned to PRESET. When input signal is received, sweep will fire once, indicator (7) will extinguish, and sweep will remain locked out until reset as described in step 6; or

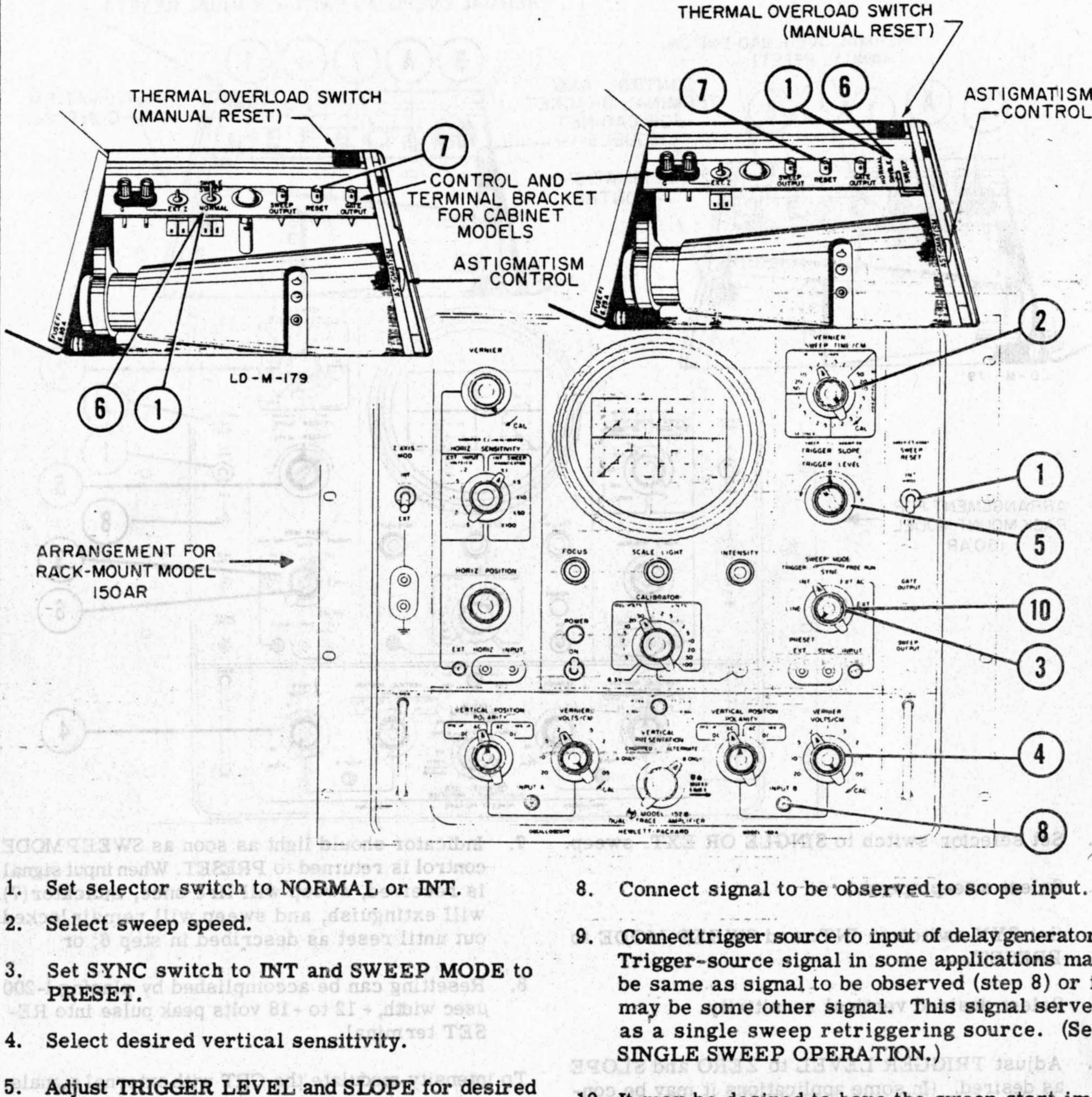
8. Resetting can be accomplished by placing 1-200 μsec width, + 12 to +18 volts peak pulse into RESET terminal.

To intensity modulate the CRT with external signals:

a) Set INT.Z - EXT.Z switch to EXT.Z.
b) Connect modulating signal to input terminals.
c) A positive voltage of 20 volts peak will blank the CRT trace from normal intensity. A negative input will brighten the trace.

Figure 2-10

DELAYED SWEEP OPERATION



1. Set selector switch to NORMAL or INT.

2. Select sweep speed.

3. Set SYNC switch to INT and SWEEP MODE to PRESET.

4. Select desired vertical sensitivity.

5. Adjust TRIGGER LEVEL and SLOPE for desired triggering.

6. Set selector switch to SINGLE SWEEP.

7. Connect output of DELAY GENERATOR to RESET terminal inside top access hatch.

8. Connect signal to be observed to scope input.

9. Connect trigger source to input of delay generator. Trigger-source signal in some applications may be same as signal to be observed (step 8) or it may be some other signal. This signal serves as a single sweep retriggering source. (See SINGLE SWEEP OPERATION.)

10. It may be desired to have the sweep start immediately at end of delay period instead of awaiting the arrival of signal to be observed. To accomplish this, follow steps 1 through 9, except that after step 6, set SWEEP MODE control to FREE RUN.

Figure 2-11

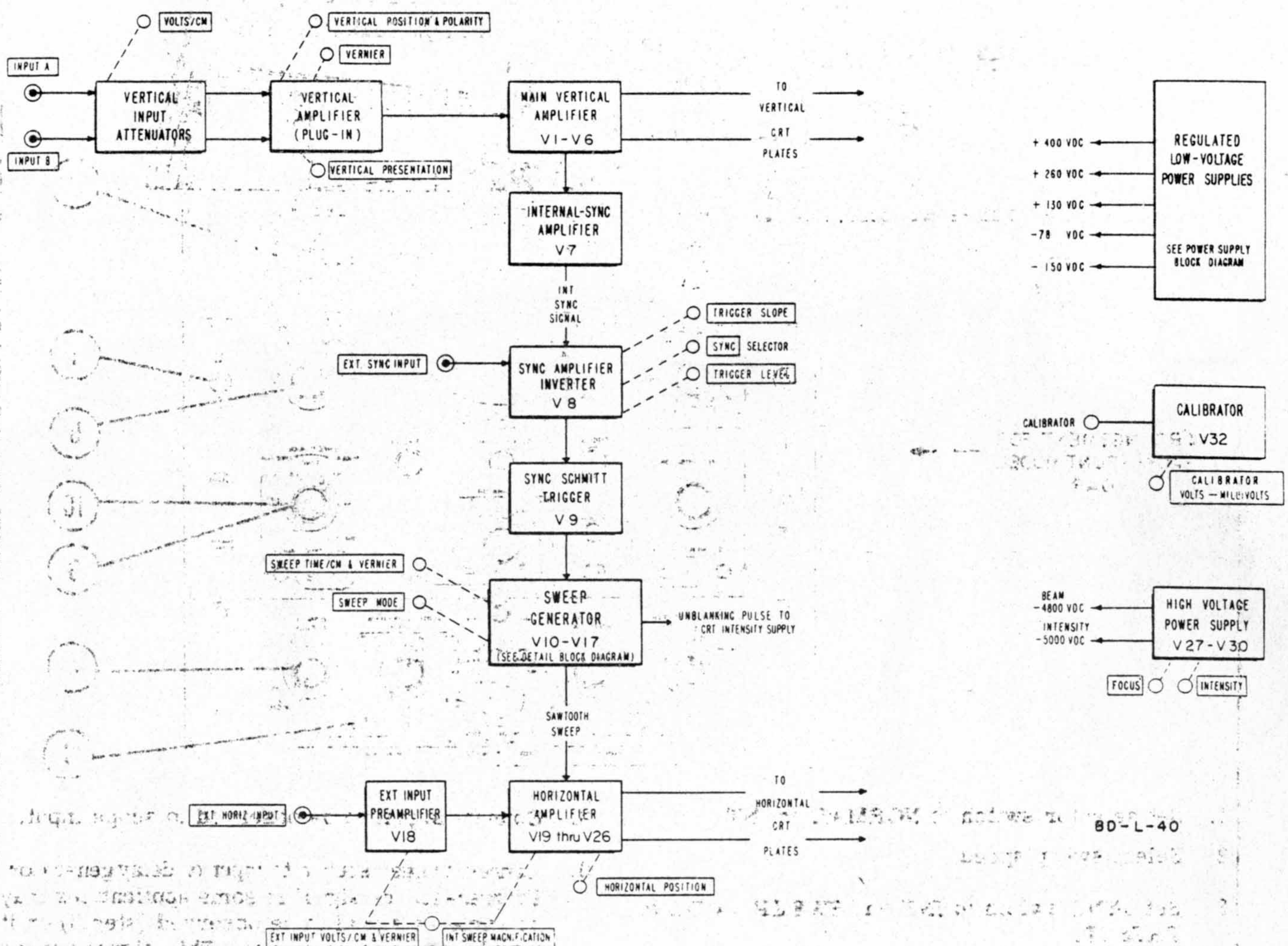


Figure 3-1. Block Diagram Complete Oscilloscope

SECTION III
THEORY OF OPERATION

3-1 OVER-ALL OPERATION

The block diagram in Figure 3-1 shows the basic signal circuits in the Model 150A Oscilloscope: the Vertical Amplifier, Horizontal Amplifier, Sweep Generator and Cathode Ray Tube.

a. Vertical Amplifier - The complete vertical amplifier receives the input signal, amplifies it, and drives the vertical deflection plates. It provides attenuation of the input signal if necessary; determines the direction of spot deflection for a given input signal polarity; determines the vertical position of the spot on the screen; supplies a signal for internal synchronization; and incorporates a 0.25 μsec delay in the input waveforms.

The complete Vertical Amplifier circuit is in separate parts: first the input attenuators, phase inverter, vertical position controls and amplifiers in the Vertical Amplifier Plug-In Unit, and second the intermediate and final amplifiers on the instrument chassis.

b. Horizontal Amplifier - The horizontal amplifier is driven either from the HORIZ. INPUT jack or from the internal sweep generator.

The complete Horizontal Amplifier consists of the main amplifier, and a preamplifier (used only for external signals applied to the HORIZ. INPUT connector). The preamplifier stage includes the VOLTS/CM portion of the HORIZ. SENSITIVITY selector switch and is not in use when the switch is set to one of the MAGNIFICATION positions. The MAGNIFICATION circuit of the HORIZ. SENSITIVITY selector is in the Main Horizontal Amplifier. The sawtooth sweep is applied directly to the Main Horizontal Amplifier while external signals are first applied to the HORIZ. SENSITIVITY switch and the preamplifier.

c. Sync Circuit - The Synchronizing Circuit receives a signal either from the Vertical Amplifier for internal synchronization, from the EXT. SYNC INPUT or from an internal power line source. The Sync Circuit amplifies all input signals, and determines the level and polarity which will start a sweep.

d. Sweep Generator - The Sweep Generator starts on receiving a sync pulse from the Sync Circuit and generates a sawtooth to drive the Horizontal Amplifier. The Feedback Integrator determines the basic sweep time per centimeter, and the SWEEP MODE control selects triggered or free-running operation. A SINGLE SWEEP switch provides either single or repetitive sweeps. The sweep generator also supplies unblanking pulses to the CRT, a timing signal (during each sawtooth flyback) to the Dual Channel Vertical Amplifier Plug-In Unit for ALTERNATE operation, and sweep and gate signals to output connectors.

e. The CRT - The CRT is a type 5AMP - mono-accelerator tube with the cathode operated at -4800 volts. The mono-accelerator anode makes possible a simple astigmatism adjustment (located inside the access hatch) which requires no resetting when adjusting the FOCUS or INTENSITY. The deflection plate terminals located on the periphery of the tube neck are connected through removable jumpers directly to the Main Vertical Amplifier, Horizontal Amplifier, and Astigmatism control.

3-2 VERTICAL AMPLIFIER

The signal from the plug-in vertical amplifier is coupled through a connector on the plug-in unit chassis to the Main Vertical Amplifier on the instrument chassis.

Input amplifiers V1 and V2 provide a maximum gain of approximately 20 db. The gain adjustment potentiometer R5 has a range of approximately 4 db obtained by varying V1 and V2 cathode circuit degeneration.

SECTION IV
MAINTENANCE

4-1 GENERAL INFORMATION

This section contains instructions for testing, adjusting and trouble-shooting the Model 150A Oscilloscope. If the instrument is operating, the Condensed Test and Adjustment Procedure, paragraph 4-3, is a fast method of checking the basic adjustments and operation. The Trouble-Shooting Procedure, paragraph 4-4, is a rapid means of isolating a section of the instrument that is not functioning. Paragraph 4-2 deals with the physical layout of the instrument and routine maintenance procedures.

Schematic Diagrams and the Table of Replaceable Parts are located at the end of this section.

The following test equipment is used for testing and adjusting the Model 150A Oscilloscope during manufacture. Equivalent test equipment may be used.

1) A test oscilloscope such as the ⓗⓟ Model 150A equipped with an ⓗⓟ Model 152 Dual Trace Amplifier.

2) A high impedance dc vacuum tube voltmeter calibrated to an accuracy of ±1%, such as an ⓗⓟ Model 410B with an ⓗⓟ Model 459A DC Voltage Multiplier.

3) A high impedance ac vacuum tube voltmeter, such as an ⓗⓟ Model 400D/H/L.

4) A variable power line transformer with a minimum rating of 7.5 amps, equipped with a voltmeter, accurate within 1 volt.

5) A square wave generator such as an ⓗⓟ Model 211A.

6) A sine wave oscillator with a maximum frequency of at least 50,000 cycles, such as an ⓗⓟ Model 200CD.

7) An accurate time mark generator suitable for sweep speed calibration.

8) A voltmeter calibration generator such as an ⓗⓟ Specification 23678.

9) A frequency response generator such as an ⓗⓟ Specification 23679.

4-2 ROUTINE SERVICING

Routine servicing covers air filter cleaning, cabinet removal, adjustments required when tubes are changed, and CRT replacement.

Each of the major sections of the instrument is located in a particular area. Figure 4-1 indicates the location of these sections. The Horizontal Amplifier and the Sweep Generator and Sync Amplifier sections will swing out when the instrument is out of the cabinet. These sections are held in place by fasteners near the panel.

A. CLEANING THE AIR FILTER

Inspect the air filter often when the Oscilloscope is in constant use.

The air-filter element in the 150A is a reuseable type. It is located in the bottom of the instrument cabinet and is removed by pulling straight down. In the rack mount pull the filters to the rear. To clean the filter element, wash in warm water and detergent, then recoat with an adhesive made for this purpose. Filter Coat No. 3 made by Research Products Corp., Madison 10, Wisconsin is suitable. If you have difficulty obtaining it, see your Hewlett-Packard Field Sales Engineer.

Apply Filter Coat No. 3 with the HANDIKOTER spray applicator directed at the intake side of the filter until visible baffles are liberally coated. Do not spray to the extent that adhesive runs or drips off the surface of the filter. Filter is now ready for service.

B. REMOVING THE CABINET

CAUTION

When the cabinet is removed, dangerous voltages are exposed. Observe adequate safety precautions.

TABLE 4-1. TUBE REPLACEMENT CHART (CONT'D)

Circuit Reference	Type	Function	Adjustment Required
		HORIZONTAL AMPLIFIER	
V18	6AN8 (6BQ7A)*	Ext. Horizontal Input Preamplifier	Adjust Preamplifier Gain, R178 and Preamplifier Balance, R185
V19	6DJ8(6BQ7A)*	Amplifier-Phase Inverter	Adjust Horizontal Gain R199 and Horizontal Balance, R189, R207
V20,21	6485	Push-Pull Amplifier	
V22	6DJ8 (6BQ7A)*	Cathode Followers	None
V23,24	6CL6	Output Amplifier	Adjust Horizontal Gain, R199 and Horizontal Balance, R189, R207
V25	6DJ8(6BQ7A)*	Output Cathode Follower	None
V26	6DJ8(6BQ7A)*	Capacitance Driver	
		HIGH VOLTAGE SUPPLY AND CRT CIRCUIT	
V27	6AU5GT	60 kc, High Voltage Oscillator	None
V28	6DJ8(6BQ7A)*	High Voltage Control Tube	Adjust High Voltage, R275, R267
V29	1X2B(3A2)**	High Voltage Rectifier	None
V30	1X2B(3A2)**	High Voltage Rectifier	
V31	5AMP	Cathode Ray Tube	Adjust Astigmatism, R283 Adjust Vertical Gain, R5; Horizontal Gain, R199 and Horizontal Balance, R189,R207
		CALIBRATOR	
V32	6U8	1 kc Multivibrator	None
		LOW VOLTAGE POWER SUPPLY	
V33,34,35	12B4A	+400 Volt Regulator	None
V36	6BH6	+400 Volt Control	
V37,38,39	12B4A	+260 Volt Regulator	
V40	6BH6	+260 Volt Control	
V41,42	12B4A	+130 Volt Regulator	
V43	6BH6	+130 Volt Control	
V44,45,46	12B4A	-150 Volt Regulator	
V47	6BH6	-150 Volt Control	Check -150 Volt Output
V48	5651	Power Supply Reference	
V49	12AX7	-78 Volt Control	Check -78 Volt Output
V50	12B4A	-78 Volt Regulator	None

* Replace with same tube type found in instrument. Tube types 6BQ7A, 6DJ8 and 6BK7 are not directly interchangeable.
**3A2 used in some instruments.

4-3 CONDENSED TEST AND ADJUSTMENT PROCEDURE

All the basic tests and adjustments are covered in the following Table 4-2. This procedure is for instruments that are functioning. If the instrument is not operating, refer to Paragraph 4-4, Trouble-Shooting Procedure.

TABLE 4-2. MODEL 150A CONDENSED TEST AND ADJUSTMENT PROCEDURE

TEST	EXTERNAL EQUIPMENT REQUIRED	PROCEDURE	ADJUST	NOTES
1. Low Voltage Power Supply	Dc vtvm with 1% accuracy	Measure all low voltage power supply outputs, should be within the following limits -- -150 ±4 volts - 78 ±2 volts +130 ±4 volts +260 ±8 volts +400 ±12 volts	Do not adjust if within limits. Adjust R379 for -150 and R382 for -78, repeat as necessary.	Check CALIBRATOR and SWEEP TIME calibration if -150 volt is adjusted.
2. Horizontal Amplifier Gain	None	Connect 10 volts from CALIBRATOR to EXT. HORIZ. INPUT. HORIZ. SENSITIVITY to unmarked vertical position.	Set R199 for 5.0 cm or 5.6 cm between spots. Set C80 or C82 (whichever is variable) to eliminate "tails" on spots.	(*) Depends on SWEEP GENERATOR timing components. Refer to SWEEP TIME/CM SWITCH DETAIL drawings.
3. Horizontal Amplifier Balance	None	No INPUT, no sweep, HORIZ. SENS. X100, position spot on screen. Switch to X5 and note spot location. Return to X100 and move spot to position noted in X5 with HORIZ. POSITION.	Center spot with R207. Switch to X1 and center spot with R189.	Check HORIZ. GAIN if adjustments are made. (*)
4. Plug-In Vertical Amplifier		See plug-in amplifier manual for balance and calibration adjustments.		
5. Main Vertical Amplifier Gain	Plug-in amplifier with accurately adjusted 20 db gain in 0.05 VOLTS/CM position.	Connect 0.2 VOLTS from CALIBRATOR to INPUT with VERT. SENS. on 0.05 VOLTS/CM and VERNIER in CAL.	Adjust R5 for exactly 4 cm vertical deflection.	(*)
6. Sync Circuits	Insulated dc voltmeter, 50 kc sine wave source, ac coupled test oscilloscope with 10:1 probe.	Connect dc voltmeter between pins 1 and 6 of V8 and with no external INPUT.	Adjust TRIGGER LEVEL for zero volts on meter.	(*)
		Connect 50 kc sine wave with 2 volt peak-to-peak amplitude to EXT. SYNC. INPUT. Calibrate test oscilloscope for 1 volt/cm and connect to junction of R65 and 82.	Adjust R66 and R72 for pips spaced exactly 1/2 volt above and 1/2 volt below center of waveform.	If parasitic oscillations present rotate R66 max. CCW. If no pips visible rotate R66 CW just short of oscillation then adjust R72 for pips. (*)
7. Sweep Amplitude and Start-Stop Trigger	Dc vtvm test oscilloscope with 10:1 probe.	With no INPUT set SWEEP TIME to 2 SEC/CM, EXT. AC SYNC, SWEEP MODE in FREE RUN. Connect vtvm between ground and pin 2 of V10.	Adjust R88 for -15 volt at end of sweep. This control is not present in all units.	If unable to set adjust R135 until able to set R88. (*)
		Move vtvm to pin 8 of V15.	Adjust R135 (R122 in some units) for -110 to -115V at end of sweep.	(*)
		Change SWEEP TIME to 0.1 MICROSECONDS/CM with VERNIER on CAL. and HORIZ. SENS. on X1. Remove vtvm and connect test oscilloscope probe to pin 8 of V15.	Adjust C40 for maximum amplitude with no distortion on negative tip.	
8. Sweep Preset	DC vtvm	With no INPUT set SWEEP TIME to 0.1 MILLISECONDS, SWEEP MODE in PRESET, and SYNC. selector to INT. Connect dc vtvm between ground and pin 2 of V10.	Slowly adjust R103 until sweep begins. Repeat several times and note voltage. Set R103 for 1.5 volts more positive than voltage level just before sweep starts.	(*)

(*) If you change a tube, see the Tube Replacement Chart, Table 4-1.

4-4 TROUBLE-SHOOTING PROCEDURE

The Model 150A Oscilloscope is composed of several basic sections or circuits. Repair and test time can be minimized by following a procedure that will isolate the section needing repair. It is important to isolate the problem before changing any internal adjustments. In the majority of cases, only a tube change will be required.

A. CHECK AC POWER CIRCUIT

All ac power circuits are normal if the fan will operate with the instrument turned on and connected to a suitable power source.

If the fan will not operate:

1) Check the power line fuse mounted near the base of the CRT. Access in cabinet models is through the top hatch and in rack models by sliding the instrument out of the rack.

The cause of a blown line fuse can usually be found in the low voltage regulator input circuits. Check silicon rectifiers, filter capacitors, etc.

2) Check the thermal overload on the top of the instrument at the rear of the hinged sweep generator chassis Access to the thermal overload is same as for the line fuse. To reset, push the small button.

The thermal overload will trip when the cabinet temperature exceeds approximately 150°F. A dirty or obstructed air filter or a high ambient temperature are the usual causes of excessive cabinet temperature.

B. CHECK DC LOW VOLTAGE CIRCUITS

Check dc voltages at marked test points on the CALIBRATOR AND HIGH VOLTAGE board at the top rear of the instrument.

If all voltages are correct, check the two fuses for the plug-in amplifier. These fuses are located at the rear of the opening for the plug-in amplifier.

If the voltages are incorrect, turn off power for a full minute and turn on again. If the instrument fails to come on the overload relay may have tripped. Check for a resistance of about 30 ohms between the -78 volt test point and ground with a plug-in amplifier installed and the line cord disconnected. A resistance of 1,000 ohms or more indicates an open heater. A heater-cathode short in any tube may operate the overload relay.

If you replace any tubes refer to Table 4-1, Tube Replacement Chart and Table 4-2, Condensed Test and Adjustment Procedure.

C. CHECK HIGH VOLTAGE CIRCUITS

If a spot or trace is visible on the face of the tube, the high voltage circuits are operating.

If a spot or trace is not present, short circuit the horizontal deflection plates of the CRT with an insulated clip lead. With a second clip lead short circuit the vertical deflection plates. This should produce a spot near the center of the CRT at some setting of the INTENSITY control. If not, check the high voltages on the High Voltage and Calibrator board at the test points marked CRT CATHODE and CRT GRID. The cathode should measure -4800 volts. With the INTENSITY control at minimum, the grid should measure approximately -5000 volts.

Resistors R261, 266, or 276 located on the High Voltage and Calibrator board, may cause incorrect high voltage. Check V28 if R261 is defective.

If you replace any tubes or components, refer to Table 4-1, Tube Replacement Chart and Table 4-2, Condensed Test and Adjustment Procedure.

D. CHECK HORIZONTAL AND VERTICAL AMPLIFIER

The Horizontal and Vertical Amplifiers are functioning properly when a spot on the face of the CRT can be easily and smoothly positioned by the horizontal and vertical position controls.

If a spot is not visible on the screen:

1) Short the horizontal deflection plates together; if this produces a spot that can be positioned and deflected by a vertical input, the vertical amplifier is functioning properly.

2) Short the vertical deflection plates together, if this produces a spot that can be positioned and deflected by a horizontal input, the horizontal amplifier is functioning properly.

The amplifiers in the instrument are direct coupled and balanced, and corresponding voltages in each side of the circuit must remain balanced to keep the spot on the screen. The settings of gain, balance and positioning controls can introduce unbalanced voltages and should be considered when checking an amplifier.

To check an inoperative amplifier, short circuit corresponding points in each stage until a point is reached where the spot does not return to the screen. For example, in the Horizontal Amplifier, if the spot is on the screen when the deflection plates are connected together, remove the jumper from between the deflection plates and connect it between the plate (pin 6) of V23 and the plate (pin 6 of V24). Work toward the input, shorting plate - to - plate, until a point is reached where the spot does not appear. This locates the unbalanced portion of the circuit.

E. CHECK SWEEP GENERATOR

1) Set the HORIZ. SENSITIVITY selector to X1 and the SWEEP MODE control maximum clockwise to FREE RUN . In cabinet models, set the SINGLE SWEEP-NORMAL switch at NORMAL ; or in rack models set the SWEEP RESET switch to INT.

2) A repetitive sweep should be obtained in each position of the SWEEP TIME/CM selector. If the generator is inoperative, try the following steps in the order listed.

NOTE

Turn the Model 150A Oscilloscope power off before removing or installing the tubes discussed in this procedure. All voltages are measured between ground and the indicated point with an ⓗⓟ Model 410B High Impedance Vacuum Tube Voltmeter.

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3) Check tubes V10 through V17, one at a time by substitution. Always replace the original tube if proper operation is not restored.

4) Check the adjustment of R135 (R122 in some units), SWEEP AMPLITUDE ADJ., by rotating through the entire range of adjustment.

a. If the generator operates at some setting, complete adjustment Number 7, described in Table 4-2.

b. If adjustment does not restore operation, set R135 near the mechanical center of the adjustment range.

5) Check the adjustment of R88 (not in all units), UPPER HYSTERESIS LIMIT ADJ., by rotating through the entire range of adjustment.

a. If the generator operates at some setting, complete adjustment Number 7, described in Table 4-2.

b. If adjustment does not restore operation, set R88 near the mechanical center of the adjustment range.

6) When the sweep generator will not "free run" the dc feedback loop can be opened and the generator forced into two specific conditions. Any analysis of voltage measurements, in these two conditions, will help in isolating the problem. The change in voltage between the two conditions is far more significant than the absolute voltages.

Table 4-3 contains the procedure for forcing the sweep generator as well as a tabulation of all the significant voltages.

4-5 DETAILED TEST AND ADJUSTMENT PROCEDURES

The complete test and adjustment procedures for the oscilloscope follow. In general, only one or two of the procedures will be needed and they can be done without completing all other tests.

A ten to fifteen minute warm-up and a check of the power supply output voltages is always recommended before making any other tests or adjustments.

The specifications for your instrument are given in the front of this manual. The following test procedure contains extra checks to help you analyze a particular instrument. These extra checks and the data they contain cannot be considered as specifications.

This detailed procedure is outlined in the Condensed Test and Adjustment Procedure, Table 4-2.

4-6 LOW VOLTAGE POWER SUPPLY

The low voltage power supply regulator circuits are located on an etched circuit board on the right side at the rear of the instrument. Figure 4-2 locates the adjustments on this board.

A. TEST LOW VOLTAGE POWER SUPPLY

CAUTION

After repair work in any power supply circuit, turn the intensity control full counterclockwise before applying power. Failure to do this may result in a damaged cathode ray tube.

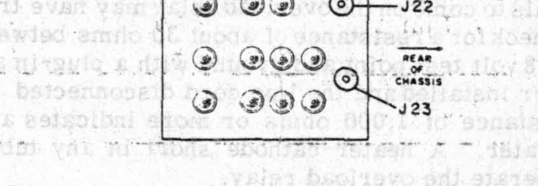

Figure 4-2. Low Voltage Power Supply Adjustments

TABLE 4-3. SWEEP GENERATOR FORCED VOLTAGES

Set oscilloscope controls as follows:

SWEEP TIME/CM - 10 MILLISECONDS
SWEEP MODE - - - - - - - - - - - - - FREE RUN (maximum clockwise)
HORIZ. SENSITIVITY - - - - - - - - - - - - - - - - - INT. SWEEP "X1"
SINGLE SWEEP-NORMAL (cabinet) - - - - - - - - - - - - - - - - NORMAL
or
SWEEP RESET (rack) - INT

REMOVE V17 and compare measured voltages with those listed below.

The "SWEEP RESET" condition is obtained by connecting V10 pin 2 to ground.

The "SWEEP COMPLETED" condition is obtained by disconnecting V10 pin 2 from ground.

MEASURE THE VOLTAGE AT	SWEEP RESET		SWEEP COMPLETED		AVERAGE ΔE
V11 pin 3	+47	± 5	+132	± 5	+ 85
8	+53	± 5	+135	± 5	+ 82
V12 pin 2	-25	± 5	+0.4	±0.2	+ 25
V13 pin 5	- 2	± 1	+ 3	± 1	+ 5
V14 pin 1	-2.5	±0.5	-0.5	± 1	+ 2
5	+165	±10	+ 30	±10	-135
V15 pin 8	- 2	± 1	-125	± 5	-123
V16 pin 1	+87	± 5	+160	±10	+ 73
7	-80	± 5	- 7	±10	+ 73

REPLACE V17, REMOVE V11 and compare measured voltages with those listed below.

The "SWEEP RESET" condition is obtained automatically.

The "SWEEP COMPLETED" condition is obtained by connecting V14 pin 1 to ground.

MEASURE THE VOLTAGE AT	SWEEP RESET		SWEEP COMPLETED		AVERAGE ΔE
V17 pin 2	- 70	± 5	0	± 3	+ 70
8	- 43	± 5	- 3	± 3	+ 40
V10 pin 2	Same as V17 pin 8				

B. ADJUST THE CALIBRATOR OUTPUT

1) Set the CALIBRATOR switch to the 6.3 V AC position and check the voltage at the calibrator output terminal; it should be approximately 6.3 volts rms.

2) Remove tube V32. Connect a dc vacuum tube voltmeter with a high input resistance to the CALIBRATOR output terminal.

3) Set CALIBRATOR to 100 volts output. Adjust R290 to set the dc voltage at the CALIBRATOR output terminal to +100 volts. If R290 adjustment range is not wide enough to permit setting this voltage, try replacing CR1 and/or CR2 diodes. Diode CR1 is located on the underside of the high voltage power supply and calibrator board at the top rear of the instrument. Diode CR2 is located on the CALIBRATOR switch.

4) The remaining voltages, measured with a dc voltmeter, should fall within ±3% of the indicated CALIBRATOR output. Checking the accuracy of the 50 through .1 volt ranges will verify all ranges.

5) Replace V32.

C. TEST THE CALIBRATOR GROUND CLAMP

1) The CALIBRATOR square wave symmetry should be better than 40-60%. Replacing V32 will usually restore symmetry.

2) Set CALIBRATOR to 1 VOLT and connect the CALIBRATOR output to the test oscilloscope vertical input.

3) Set the test oscilloscope for positive-up dc and a vertical deflection sensitivity of 1 volt per centimeter. Position the bottom of the square wave CALIBRATOR signal across the center of the test oscilloscope screen.

4) Rotate the CALIBRATOR to 20 VOLTS If the bottom of the square wave shifts vertically more than 1 centimeter, diode CR2 is defective and must be replaced. A certain amount of shift can be expected due to overload of the test oscilloscope vertical amplifier.

4-8 HORIZONTAL AMPLIFIER

The horizontal amplifier is located on the left side of the instrument on a swing out chassis. The chassis is locked in place by a captive fastener, or a screw near the center of the board next to the panel. Physical location and numbering of the Horizontal Amplifier adjustments has varied with production. Assembly No. 150A-65B is shown in Figure 4-4A, Assembly No. 150A-65F is shown in Figure 4-4B.

A. ADJUST HORIZONTAL AMPLIFIER GAIN

Gain adjustment is keyed to Sweep Generator timing components. Refer to the different SWEEP TIME/CM SWITCH DETAIL drawings (Figure 4-12A, 4-12B and 4-12C) and compare circuits to find one that agrees with the oscilloscope being adjusted. Circuit configuration and notes on the switch drawings indicate proper setting for gain adjustment.

1) Set the HORIZ. SENSITIVITY control to the unmarked vertical test position.

2) Set the CALIBRATOR to 10 VOLTS and connect to the EXT. HORIZ. INPUT.

3) Slowly adjust R199 to give a horizontal deflection of 5.0 or 5.6 centimeters. It will be necessary to adjust the HORIZ. POSITION control to keep the spots centered.

4) Adjust C80 or C82 (whichever is variable) to eliminate any overshoot or undershoot on the spots. Proper adjustment produces well defined spots with no "tails."

5) Disconnect all cables.

B. ADJUST HORIZONTAL AMPLIFIER BALANCE

1) Set the HORIZ. SENSITIVITY control to X100 and adjust the HORIZ. POSITION to bring the spot to the approximate center of the CRT. Keep the INTENSITY low to avoid burning the phosphor.

2) Switch to the X5 range and note the location of the spot. Switch back to X100 and return the spot to the location noted when on the X5 range using the HORIZ. POSITION control

3) Center the spot with R207.

4) Switch from X5 to X1 and note the spot shift. Adjust R189 for minimum spot shift when switching between X1 and X5.

5) Repeat paragraphs 4-8A and 4-8B until both balance and gain are correct.

C. TEST HORIZONTAL AMPLIFIER FOR HUM

1) Set the HORIZ. SENSITIVITY switch to XI, stop

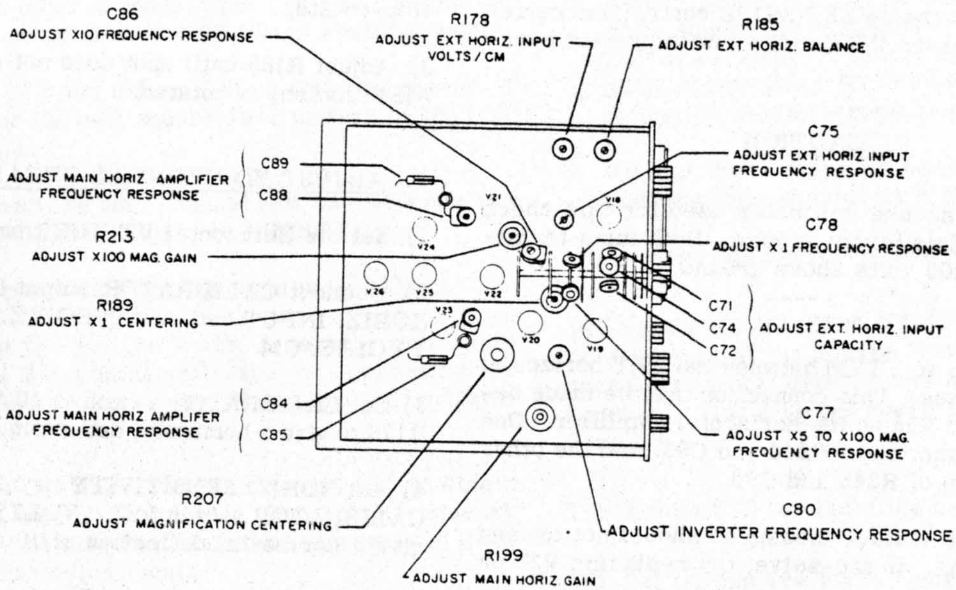

Figure 4-4A. Horizontal Amplifier Adjustments
Assembly No. 150A-65B

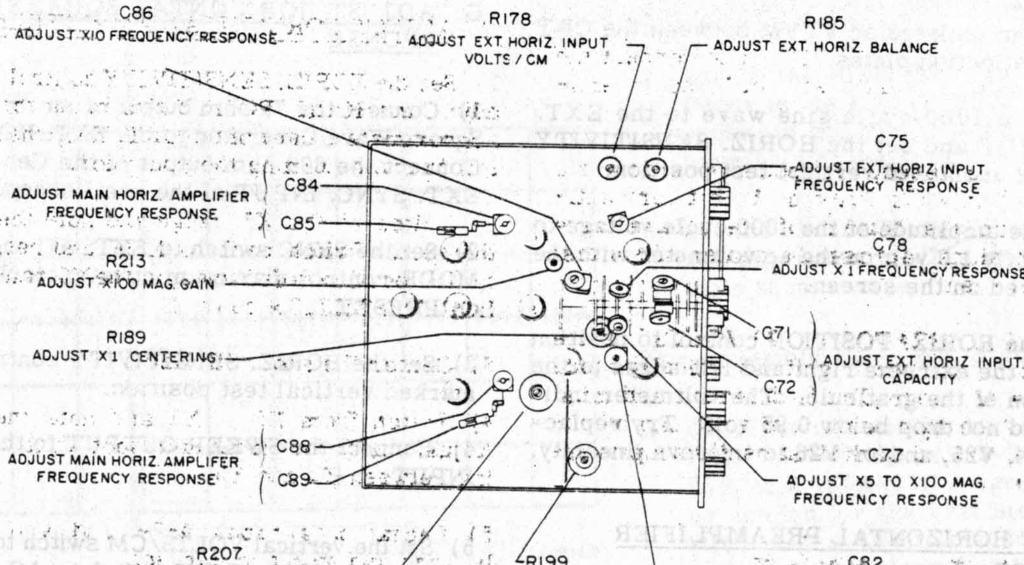

Figure 4-4B. Horizontal Amplifier Adjustments
Assembly No. 150A-65F

c. Attach Alignment Attenuator to EXT. HORIZ. INPUT and adjust C74 for the best possible square wave.

19) Switch the HORIZ. SENSITIVITY to 2 VOLTS/CM and set the Square Wave Generator amplitude for maximum or approximately 3 centimeters.

20) Adjust C71 and C72 to obtain the best possible square wave.

21) Disconnect all cables and test instruments.

4-9 MAIN VERTICAL AMPLIFIER

The main vertical amplifier is located on the left side of the instrument near the terminals on the neck of the cathode ray tube. Figure 4-6 shows the location of all adjustments on the amplifier.

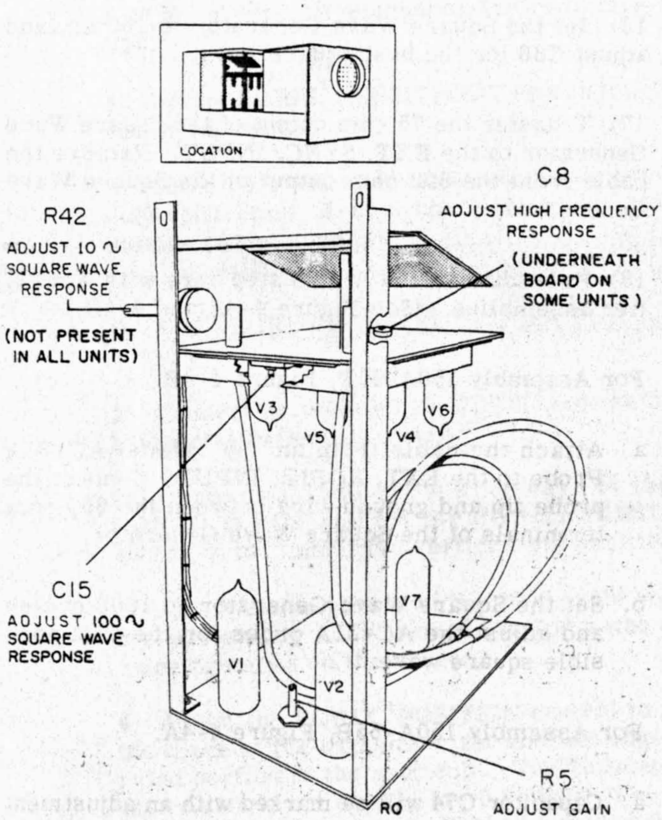

Figure 4-6. Main Vertical Amplifier Adjustments

A. ADJUST PLUG-IN AMPLIFIER

You should set the Balance and Calibration of the plug-in amplifier before continuing. Follow the instructions that are given in the Operating Instructions for the plug-in amplifier used.

B. TEST VERTICAL AMPLIFIER FOR LINEARITY

CAUTION

The voltmeter used for this check must not be grounded. The voltmeter case is 400 volts above ground.

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1) Connect a 400 cps signal to the plug-in vertical amplifier.

2) Connect an isolated ac voltmeter between the vertical deflection plates of the CRT.

3) Set the SWEEP MODE control full counterclockwise but not on PRESET. Adjust the HORIZ. POSITION and VERTICAL POSITION controls to center the vertical trace. Keep intensity low.

4) Adjust VERTICAL POSITION for a maximum voltmeter indication. The center of the oscilloscope pattern should be within 1 centimeter of the graticule vertical center. Set the amplitude of the input signal to obtain a 1.0 volt indication on the voltmeter.

5) Adjust the trace to the top and bottom of the graticule. Note the voltmeter indication in both positions. The voltage should not drop below 0.95 volts. A voltage drop of more than 5% is usually caused by V5 and/or V6.

C. TEST VERTICAL AMPLIFIER FOR DRIFT

1) Center a low intensity spot on the face of CRT with the line voltage set at 102 volts.

2) Vary the power line voltage between 102 and 128 volts and closely observe spot for any shift in vertical position.

3) Spot shift should not exceed 0.5 centimeters. Excessive shift is usually caused by V1 and/or V2.

D. ADJUST VERTICAL AMPLIFIER GAIN

A 2 volt peak-to-peak (0.707 rms volt sine wave) input signal to the main vertical amplifier will produce a 4 centimeter peak-to-peak deflection when R5 is properly adjusted. Before starting the following procedure the voltage gain of the plug-in amplifier should be adjusted to exactly 10 (20 db) with the VOLT/CM selector set to ".05".

1) Connect a 400 cps sine wave signal to the vertical input of the plug-in amplifier.

2) Set the input signal level to 300 millivolts peak-

to peak (0.106 rms volt sine wave). Set the oscilloscope vertical VOLTS/CM to 0.05 and VERNIER to CAL.

3) Adjust R5 for a peak-to-peak deflection of 6 centimeters.

E. ADJUST VERTICAL AMPLIFIER SQUARE-WAVE RESPONSE

1) Set POLARITY to POS. UP-AC, TRIGGER SLOPE to + , SYNC. to INT , and SWEEP TIME/CM to 0.2 MICROSECONDS

2) Set vertical VOLTS/CM at 0.05 and vertical VERNIER at CAL.

3) Connect a 100 kc square wave from the 75-ohm output of an ⓗ Model 211A Square Wave Generator to the vertical input of the plug-in amplifier. Adjust the square wave generator output level to obtain a 6 centimeter peak-to-peak pattern.

4) Adjust C8 for the best rise time along the leading edge of the square wave. Crest variation should not exceed 0.12 centimeters (± 2%).

5) Set the square wave generator to 100 cps.

6) Switch POLARITY to POS. UP-DC and SWEEP TIME/CM to 2 MILLISECONDS.

7) Adjust C15 (when variable) for best possible square wave.

8) Set Square Wave Generator to 10 cps.

9) Switch SWEEP TIME/CM to 20 MILLISECONDS.

10) Adjust R42 for best possible square wave.

F. TEST INTERNAL SYNC AMPLIFIER

1) Connect a 1-kc sine wave signal to the vertical amplifier input.

2) Set the SYNC. selector to INT . Adjust the oscilloscope controls to display the sine wave signal with a vertical deflection of 6 centimeters peak-to-peak.

3) Connect an ac voltmeter between ground and the long bare wire at the bottom of the sweep generator board. The voltage on this wire should be at least 5 volts rms, if not check V7 in the main vertical amplifier.

G. TEST VERTICAL AMPLIFIER BANDWIDTH

1) Connect a frequency response generator to the vertical input. Set this generator to 1 MC and adjust the amplitude to produce a peak-to-peak deflection of 4 centimeters. This deflection must be vertically centered on the graticule.

2) Increase the generator frequency until the peak-to-peak deflection has decreased to 2.8 centimeters. Maintain generator output at the level established in step 1. This is a drop of 3 db and should occur at a frequency above 10 mc. If this drop occurs at a frequency below 10 mc, clean the CRT deflection plate connecting pins and clips. In addition, dress the two yellow leads between the amplifier and the CRT neck connectors as far from each other and surrounding metal as possible.

If the above steps do not improve the bandwidth, it may be necessary to replace V5 and/or V6, or to recheck the plug-in amplifier frequency response in another oscilloscope.

4-10 SWEEP GENERATOR AND SYNC CIRCUITS

The Sweep Generator and Sync Circuits are located on the right side of the instrument on a swing out chassis. The chassis is held in place by a captive fastener or a screw located in the center of the board near the panel.

A. ADJUST SYNC CIRCUITS

1) Connect a dc voltmeter between plate pins 1 and 6 of V8 inverter amplifier tube. These points each have a blue wire from the TRIGGER SLOPE switch connecting to them. The voltmeter must be isolated from ground.

2) Remove any external connection to EXT. SYNC. INPUT jacks and set SYNC. selector switch to EXT. AC.

3) Rotate the TRIGGER LEVEL control to obtain an indication of zero volts on the dc voltmeter.

4) The TRIGGER LEVEL control must not be moved until R66 and R72 have been adjusted.

5) Connect a 50 kc sine wave signal with an amplitude of 2 volts peak-to-peak to the EXT. SYNC. INPUT jack or terminals.

6) Calibrate the test oscilloscope with probe to have

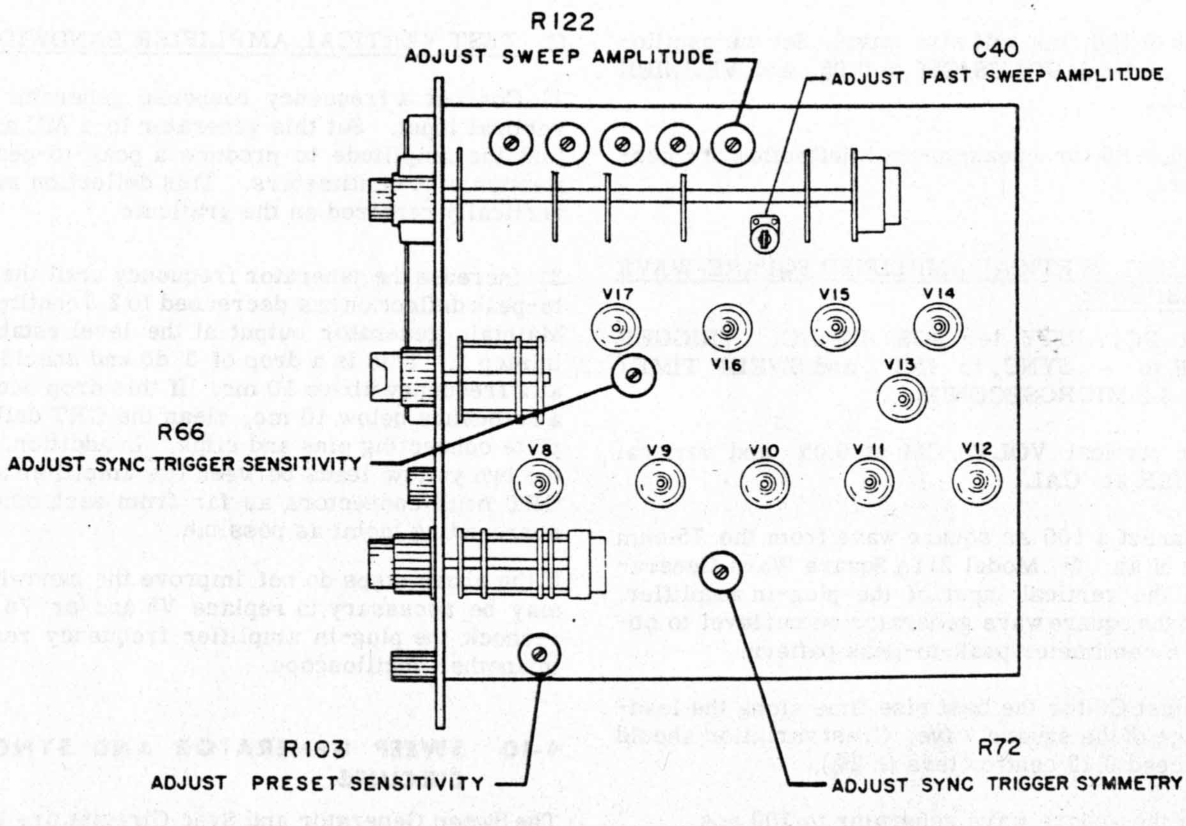


Figure 4-7A. Sweep Generator Adjustments

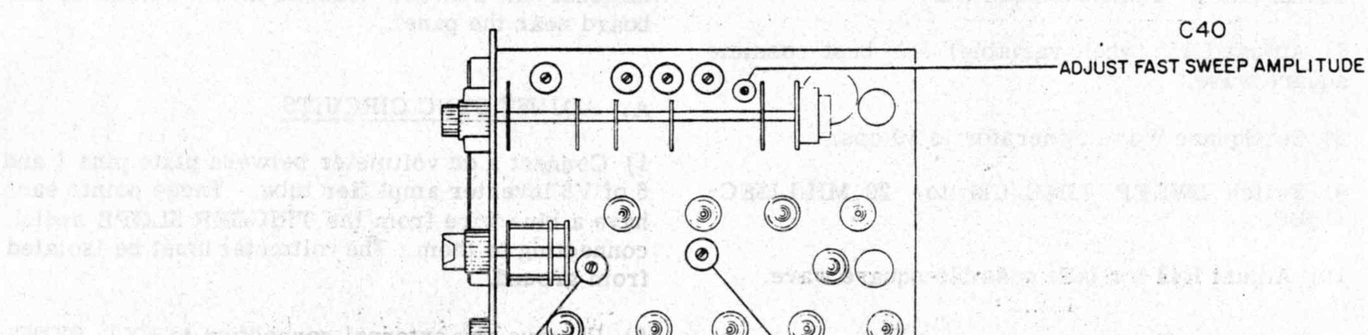


Figure 4-7B. Sweep Generator Adjustments a vertical deflection sensitivity of 1 volt per centimeter.

7) Connect test oscilloscope probe to junction of R65 and arm of S2 TRIGGER SLOPE switch (use ac coupling). This point can be identified as the connector approximately midway between tubes V9 and V17 to which a green wire from the TRIGGER SLOPE switch is connected. If high frequency oscillations are present, rotate R66 maximum counterclockwise.

8) Refer to Figures 4-7 and 4-8. Adjust potentiometer R66 and R72 for pips vertically spaced exactly 1 volt apart on the displayed sine wave. In addition, the pips must be exactly 0.5 volt above and below the center of the wave. The upper pip must be on the positive slope portion of the sine wave and the lower on the negative slope.

These two controls interact but pip vertical separation is primarily controlled by R66 and vertical position of both pips by R72. Repeated adjustments of both controls may be required.

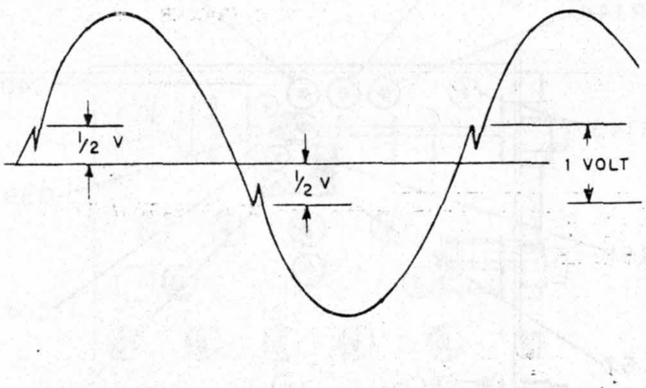


Figure 4-8. Sync Trigger Hysterisis Limits

If pips are not visible, set R66 as far clockwise as possible without introducing oscillation and then slowly rotate R72 until the pips appear.

B. ADJUST START-STOP TRIGGER AND SWEEP AMPLITUDE

1) With no input to the oscilloscope, set the SYNC selector to EXT. AC.

2) Set the SWEEP TIME/CM to 2 SECONDS/CM and rotate SWEEP MODE maximum clockwise to FREE RUN.

3) This step is for Sweep Generator Assemblies No. 150A-65 E, L or LR only. See Figure 4-7B.

a. Connect a dc VTVM between ground and pin 2 of V10. The voltmeter indication will swing between approximately -40 and -15 volts.

b. Adjust R88 to obtain -15 volts at the end of the sweep. If unable to set R88, rotate R135 until R88 may be set properly.

4) Connect the dc VTVM between ground and pin 8 of V15. The violet wire terminated above V15 connects to pin 8.

5) The voltmeter indication will rise and fall with the sweep. Adjust R122 or R135 (see Figure 4-7) until the end of the sweep occurs between -110 and -115 volts.

6) Set the SWEEP TIME/CM to .1 MICROSECONDS, SWEEP VERNIER to CAL. and HORIZ. SENSITIVITY to X1. Connect the test oscilloscope to pin 8 of V15 through a low capacity probe and observe the sweep waveform. Adjust C40 for maximum undistorted amplitude. Undesirable distortion will appear at the most negative point on the waveform.

C. ADJUST SWEEP PRESET

1) Disconnect any external vertical input to oscilloscope. Set SWEEP TIME/CM switch to .1 MILLISECONDS and SWEEP MODE control maximum counterclockwise to PRESET. Set SYNC. selector to INT.

2) Connect the dc voltmeter between ground (+) and pin 2 (-) of V10. Slowly adjust R103 until the sweep generator begins to free-run. The voltmeter indication will increase, as R103 is rotated, to a maximum and then suddenly drop, when the sweep generator begins to free-run.

Repeat this several times and note the average maximum voltmeter indication. The exact value of this voltage is not critical and will vary with individual characteristics of tubes V10 and V11.

3) Set R103 to give a voltmeter indication exactly 1.5 volts less negative than the maximum noted before the sweep began to free-run. For example: if the maximum voltage noted was -37 volts, R 103 should be set for -35.5 volts.

D. ADJUST SWEEP CALIBRATION

Physical location of the variable capacitors for Sweep Calibration has varied with production. Compare the configurations shown in Figure 4-9 to find

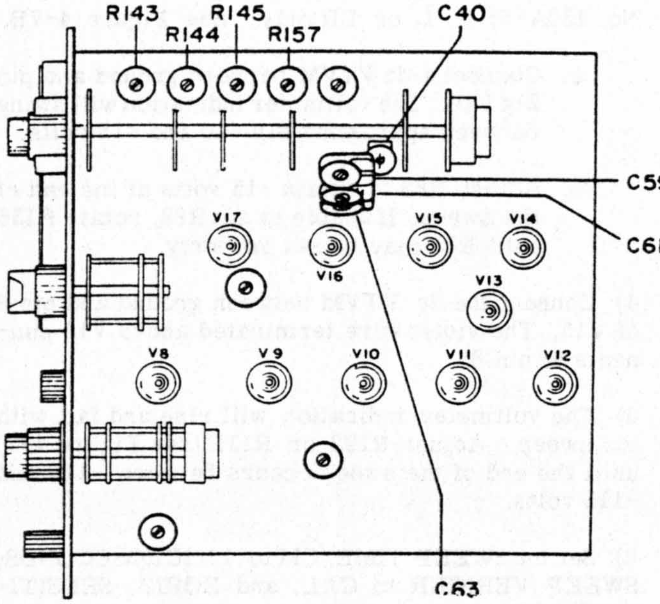


Figure 4-9A

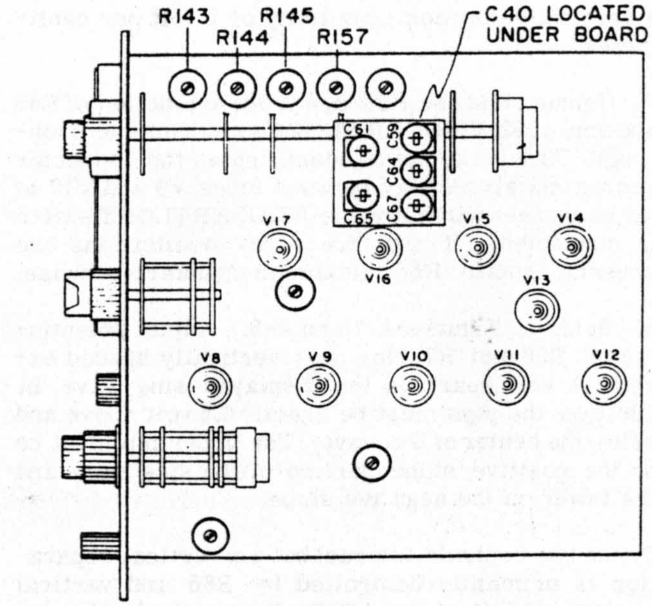


Figure 4-9B

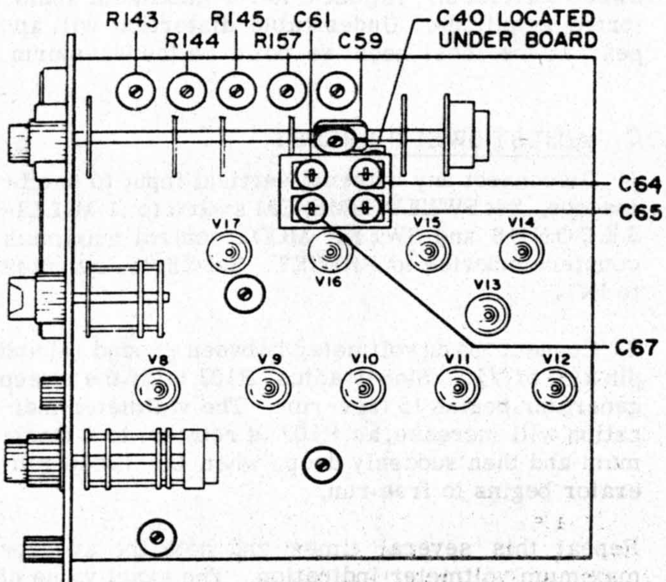


Figure 4-9C

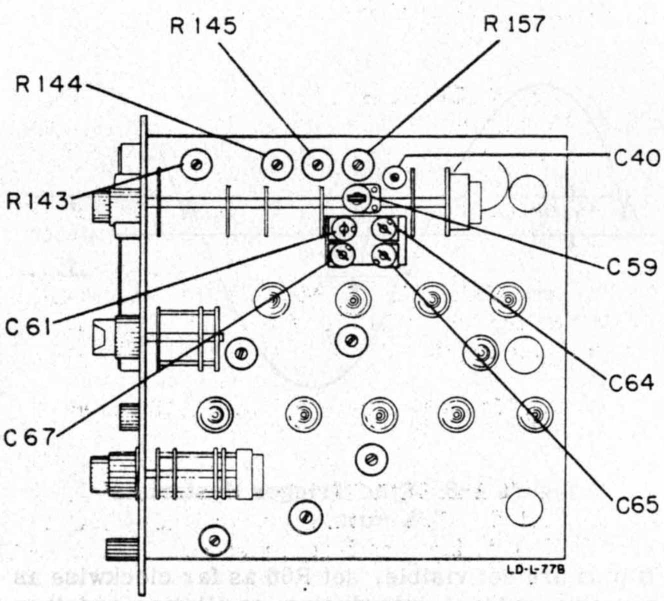


Figure 4-9D

Figure 4-9. Sweep Calibration Adjustments

one that agrees with the oscilloscope being adjusted.

1) Set the SWEEP TIME/CM switch to 0.1 MICRO-SECONDS, VERNIER to CAL., HORIZ. SENSITIVITY to X5, and the SWEEP MODE maximum clockwise to FREE RUN.

2) Connect the output of a Marker Generator to the vertical input.

3) Set the Marker Generator for a 10 mc sine wave output and adjust the oscilloscope controls for a steady display 5 to 6 centimeters high.

4) Adjust C67 (C63 in Figure 4-9A) so two cycles of the sine wave are 10 centimeters long.

5) Set the HORIZ. SENSITIVITY switch to X1.

6) Adjust C78, located on the Horizontal Amplifier chassis, so each cycle of the sine wave is exactly one centimeter long. If the total sweep length is less than 10 centimeters, check the sweep length adjustment C40.

NOTE

Skip Steps 7, 8, and 10 if Sweep Switch has configuration shown in Figure 4-9A.

7) Set the Marker Generator for a 5 mc sine wave.

8) Set the SWEEP TIME/CM to 0.2 MICROSECONDS and adjust C65 so each cycle of the sine wave is exactly one centimeter long.

9) Set the Marker Generator for 1 microsecond pips and rotate the SWEEP MODE into PRESET.

10) Set the SWEEP TIME/CM switch to 0.5 MICROSECONDS and adjust C64 until the pips are exactly 2 centimeters apart.

11) Set the SWEEP TIME/CM switch to 1 MICROSECONDS and adjust C61 to space the pips exactly 1 centimeter apart.

12) Set the Marker Generator for 10 microsecond pips.

13) Set the SWEEP TIME/CM switch to 10 MICROSECONDS and adjust C59 to space the pips exactly 1 centimeter apart.

14) Set the Marker Generator for 100 microsecond pips.

15) Set the SWEEP TIME/CM switch to 0.1 MILLISECONDS and adjust R157 to space the pips exactly 1 centimeter apart.

16) Set the Marker Generator for 5 microsecond pips.

17) Set the HORIZ. SENSITIVITY switch to X5, X10, X50, and X100. This should produce pips spaced every 0.25, 0.5, 2.5, and 5 centimeters.

If the expanded sweep ranges are out of calibration, set the HORIZ. SENSITIVITY to X100 and adjust R213, located on the Horizontal Amplifier chassis, to space the pips exactly 5 centimeters apart.

Return the HORIZ. SENSITIVITY switch to X1.

18) Set the Marker Generator for 1 millisecond pips.

19) Rotate the sweep VERNIER control from one extreme to the other. Pip spacing should change from 10 centimeters to between 2.9 and 3.3 centimeters. If the spacing is less than 2.9 centimeters, connect a 120,000 ohm or higher resistor in parallel with the VERNIER control. If the spacing is more than 3.3 centimeters, reduce the value of R147 which is in series with the VERNIER control.

20) Set the SWEEP TIME/CM switch to 1 MILLISECONDS and adjust R145 to space the pips exactly 1 centimeter apart.

21) Set the Marker Generator for 10 millisecond pips.

22) Set the SWEEP TIME/CM switch to 10 MILLISECONDS and adjust R144 to space the pips exactly 1 centimeter apart.

23) Set the Marker Generator for 100 millisecond (0.1 second) pips.

24) Set the SWEEP TIME/CM switch to 0.1 SECOND and adjust R143 to space pips exactly 1 centimeter apart.

E. TEST SINGLE SWEEP OPERATION

1) Set the SWEEP TIME/ CM switch at 10 MILLISECONDS or longer.

2) Set TRIGGER LEVEL to 0 and SYNC. to INT . Apply a signal with a frequency of 1 mc. or below. Adjust signal amplitude to obtain 4 centimeters peak-to-peak vertical deflection.

3) Set the NORMAL-SINGLE SWEEP (SWEEP RESET, INT-EXT) switch to SINGLE SWEEP (EXT) .

4) Rotate the SWEEP MODE control maximum clockwise, then counterclockwise into PRESET. A single sweep will be obtained on switching into PRESET.

5) Rotate SWEEP MODE off of PRESET, lamp I6 should go on. Continued clockwise rotation of this control should produce one sweep after which lamp I6 will be off. Leave the SWEEP MODE control rotated maximum clockwise.

The spot should return to the sweep starting point. This may be determined by temporarily increasing intensity.

6) It should be possible to complete steps 4 and 5 with the SWEEP TIME/CM switch in any position. As the sweep time is shortened it becomes progressively difficult to see the trace.

THE REMAINING STEPS CHECK SINGLE SWEEP OPERATION BY USING AN EXTERNAL PULSE TO RESET THE SWEEP.

7) Connect the positive sync output from an ⓗ Model 212A Pulse Generator to oscilloscope vertical input.

8) Set the Pulse Generator for a positive output pulse and connect output to oscilloscope RESET connector.

9) Set the Pulse Generator for a 500 per second repetition rate and a 3 microsecond pulse width.

10) Set the NORMAL SINGLE SWEEP (SWEEP RESET, INT-EXT) switch to NORMAL (INT), the TRIGGER SLOPE to +, and SWEEP TIME/CM to 0.2 MICROSECONDS. Adjust vertical VOLTS/CM to 20 with VERNIER at CAL.

11) Set TRIGGER LEVEL to obtain a display of the 212A sync pulse.

12) Set the SINGLE SWEEP-NORMAL switch for SINGLE SWEEP and the 212A pulse position control for maximum delay.

13) Advance the Pulse Generator output from minimum until the sync output pulse is displayed on the oscilloscope. Usually the amplitude of this pulse will be approximately 10 volts peak-to-peak. The start of the oscilloscope sweep and the start of the pulse should approximately coincide and should not change with a change in the Pulse Generator pulse delay time.

14) Disconnect all instruments and return the SINGLE SWEEP-NORMAL switch to NORMAL.

F. <u>TEST OPERATION OF MAGNIFIED AND UNCALIBRATED LIGHTS</u>

1) The SWEEP MAGNIFIED light should be ON with the HORIZ. SENSITIVITY control in the X5, X10, X50, and X100 position.

2) The MAGNIFIER UNCALIBRATED light should be ON with SWEEP TIME/CM and the HORIZ. SENSITIVITY control set to the combinations shown in Table 4-5.

3) If lights fail to operate as above, switches may be defective or connectors from SWEEP TIME/CM and HORIZ. SENSITIVITY switches may be disconnected or transposed.

TABLE 4-5. MAGNIFIER UNCALIBRATED LIGHT

HORIZONTAL SENSITIVITY	.1	.2	.5	1	2
X10	ON				
X50	ON	ON	ON	ON	
X100	ON	ON	ON	ON	ON

SWEEP TIME - MICROSECOND/CM

G. <u>TEST GATE OUTPUT WAVEFORM</u>

1) Set the SWEEP TIME/CM switch to .1 MICROSECONDS and the SWEEP MODE to FREE RUN.

2) Connect a test oscilloscope through a low capacity probe to the GATE OUTPUT connector. The test oscilloscope should be set for positive up deflection.

3) This waveform should be a nonsymmetrical square wave with a peak-to-peak amplitude of 60 to 70 volts. Ripple on the top of the waveform should not exceed 2% of the total amplitude.

4) The square wave rise time should be less than approximately 0.15 microseconds, and the decay time should be less than approximately 0.7 microseconds.

5) Overshoot in the waveform may be due to CR3 being defective.

H. <u>TEST SWEEP OUTPUT WAVEFORM</u>

1) Attach the test oscilloscope to the SWEEP OUTPUT connector.

2) The sweep output waveform should have a peak amplitude of at least 40 volts and may be considerably higher.

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.

6. Relays shown in condition prevailing during normal instrument operation.

7. ‡ indicates a selected part. See parts list.

8. * Value adjusted at factory. Part may be omitted.

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
Hm	=	heater mid-tap	NC	=	no external connection to socket
IS	=	internal shield	△	=	indefinite reading due to circuit (See 2.)

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, such as t for triode and p for pentode.

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

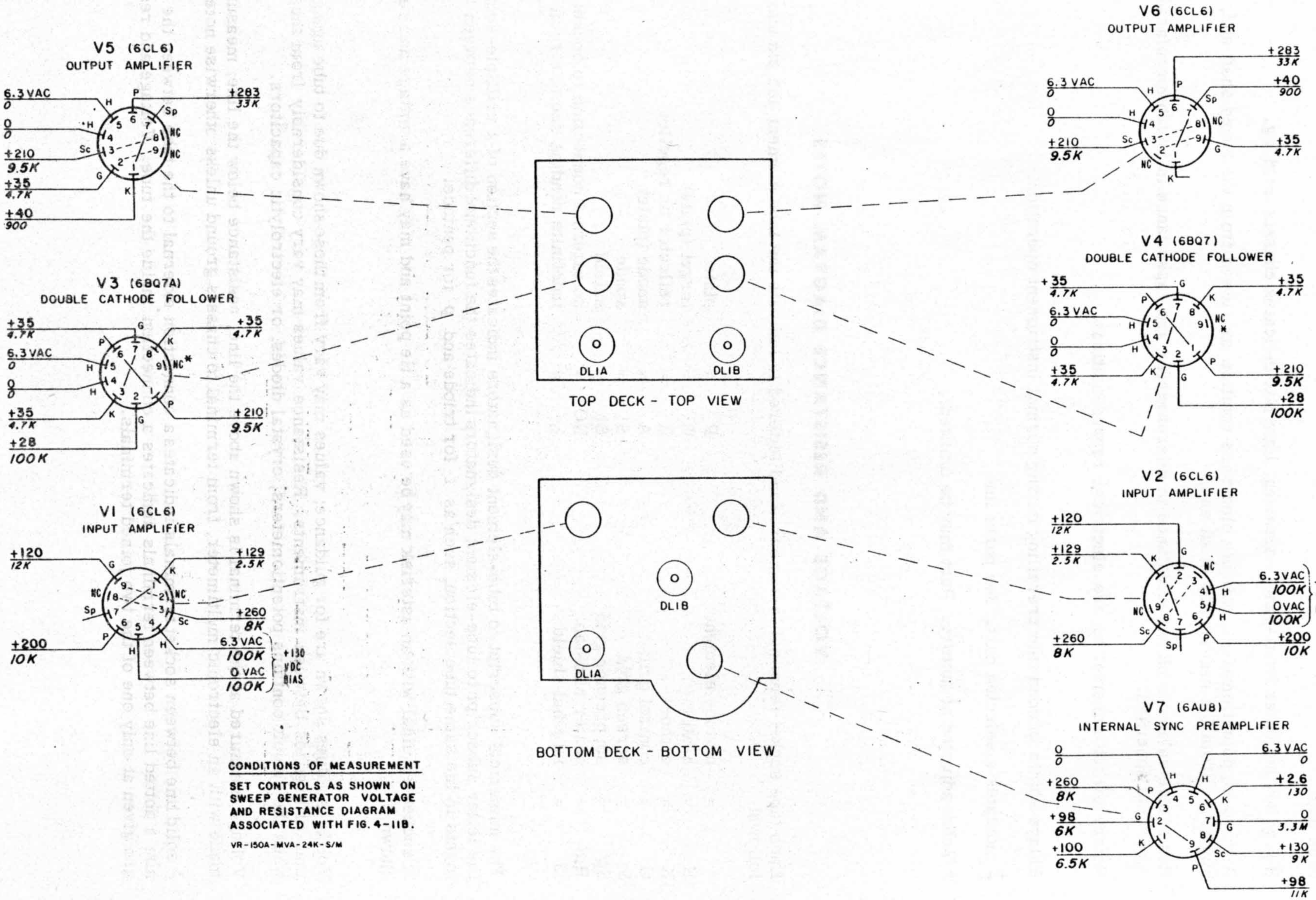
2. Voltages values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit contains potentiometers, crystal diodes, or electrolytic capacitors.

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.

MAIN VERTICAL AMPLIFIER

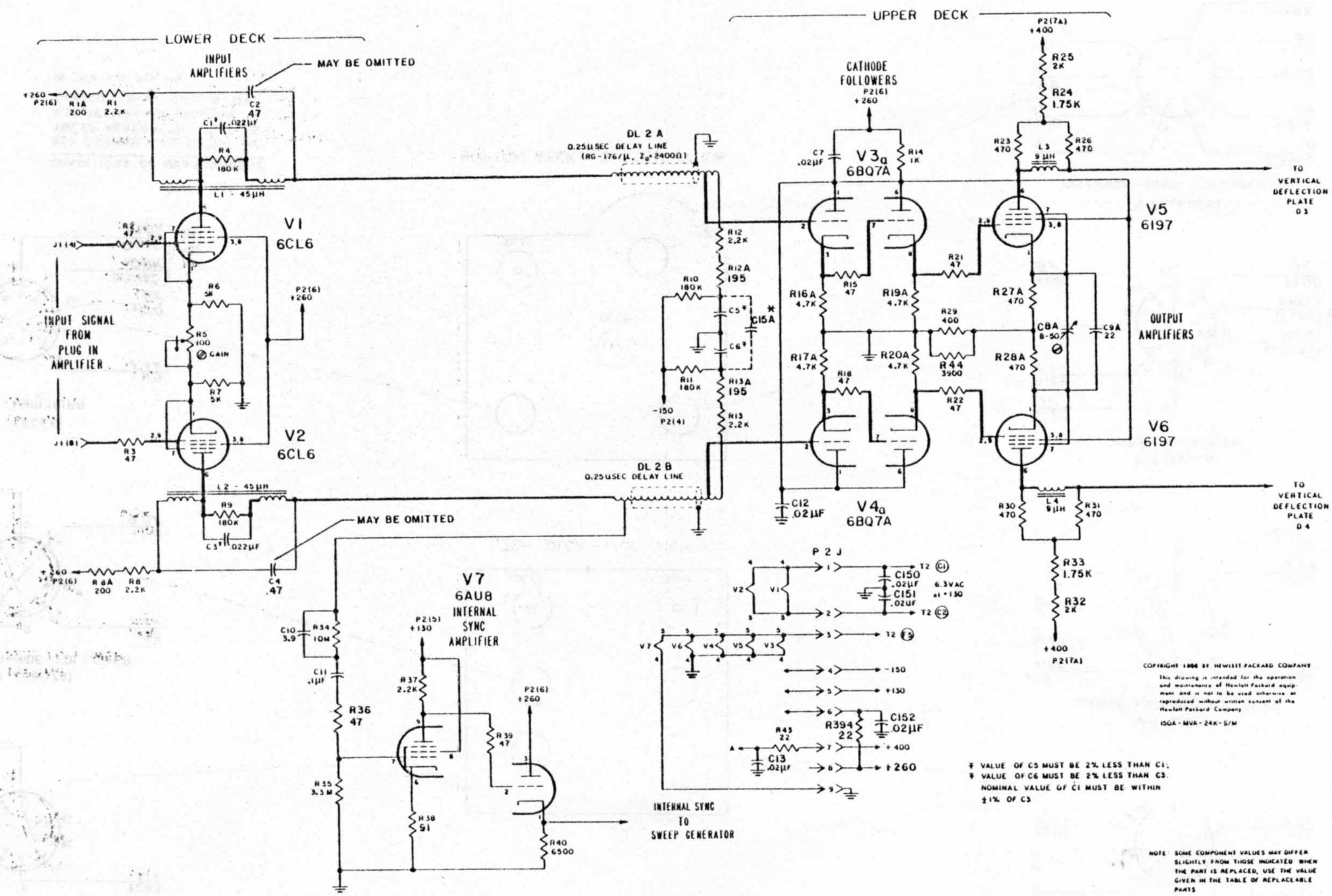
VOLTAGE - RESISTANCE DIAGRAM



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-MVA-24K-S/M



‡ VALUE OF C5 MUST BE 2% LESS THAN C1;
‡ VALUE OF C6 MUST BE 2% LESS THAN C3.
NOMINAL VALUE OF C1 MUST BE WITHIN ±1% OF C3

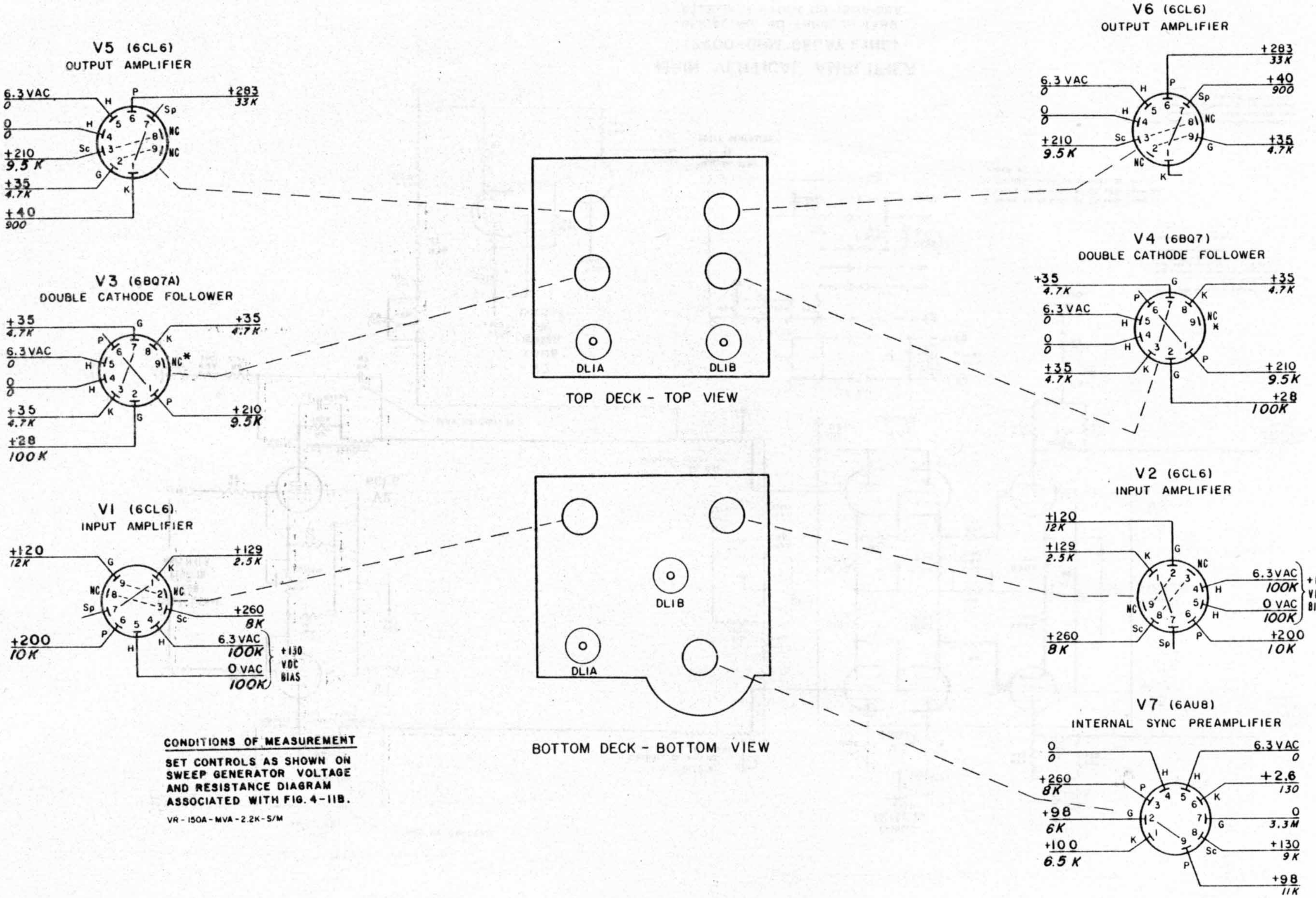
NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS

150A-MVA-24K-S/M

MAIN VERTICAL AMPLIFIER
(2400-OHM DELAY LINE)
SERIAL NO. 40 THROUGH 1389
ASSEMBLY STOCK NO. 150A-58A

MAIN VERTICAL AMPLIFIER

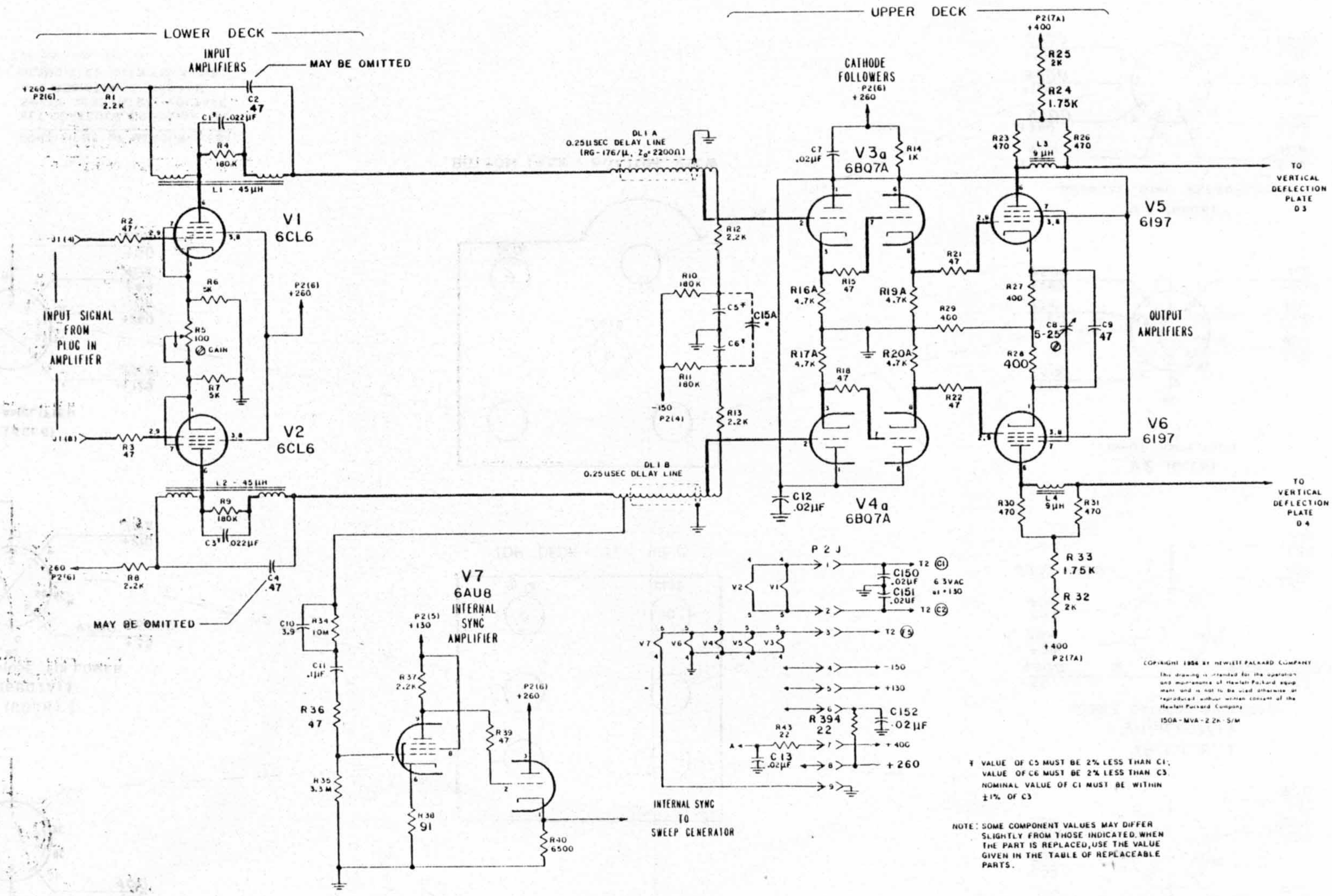
VOLTAGE - RESISTANCE DIAGRAM



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-MVA-2.2K-S/M



<F VALUE OF C5 MUST BE 2% LESS THAN C1; VALUE OF C6 MUST BE 2% LESS THAN C3. NOMINAL VALUE OF C1 MUST BE WITHIN ±1% OF C3

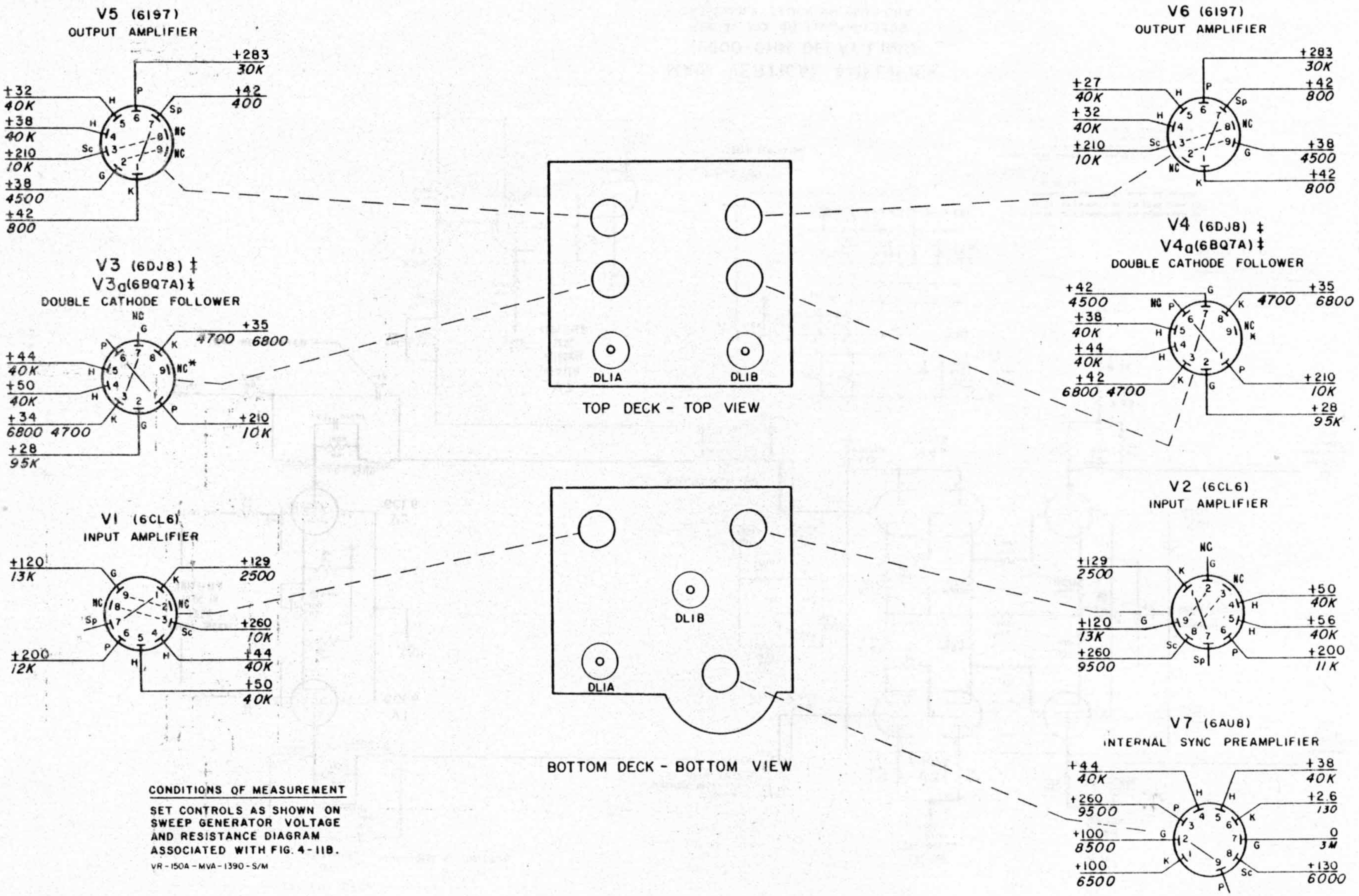
NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED. WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

150A-MVA-2.2K-S/M

MAIN VERTICAL AMPLIFIER
(2200-OHM DELAY LINE)
SERIAL NO. 40 THROUGH 1389
ASSEMBLY STOCK NO. 150A-58A

MAIN VERTICAL AMPLIFIER

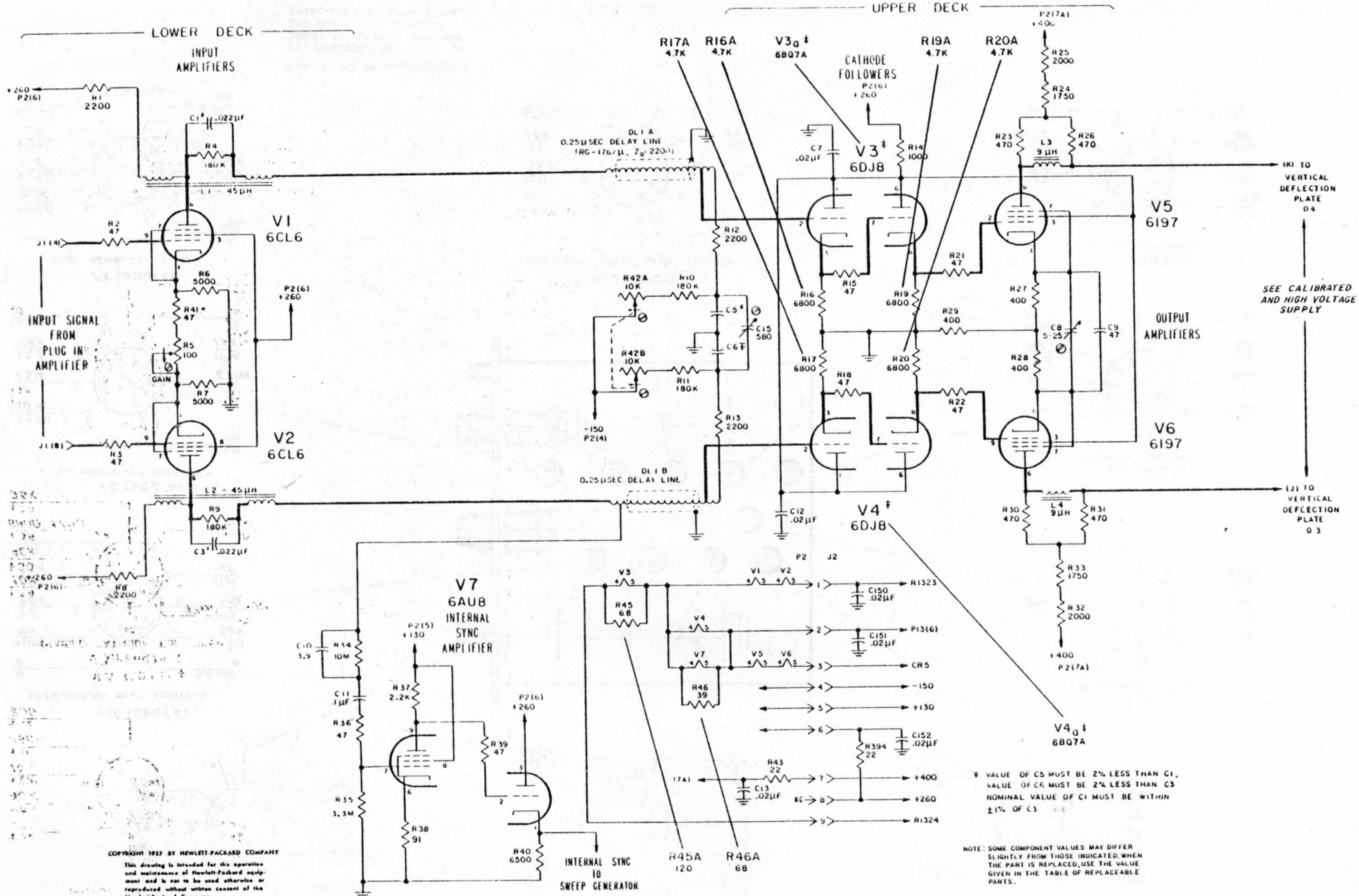
VOLTAGE - RESISTANCE DIAGRAM



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-MVA-1390-S/M



‡ VALUE OF C5 MUST BE 2% LESS THAN C1, VALUE OF C6 MUST BE 2% LESS THAN C3 NOMINAL VALUE OF C1 MUST BE WITHIN ±1% OF C3

NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED, WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

COMPONENT VALUES PRINTED IN RED ARE FOR INSTRUMENTS WITH 6BQ7A TUBES

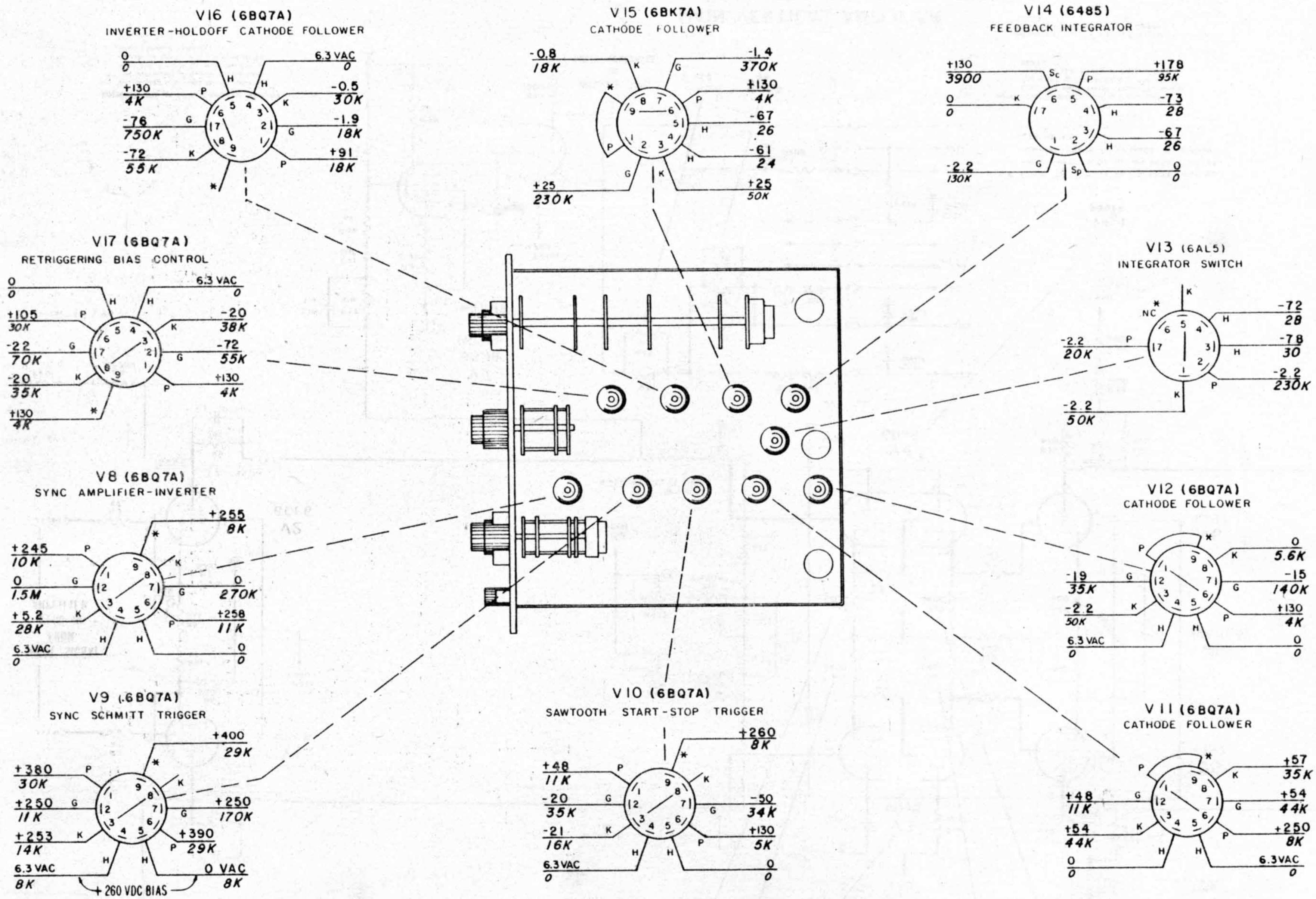
150A-MVA-1390-S/M

MAIN VERTICAL AMPLIFIER

SERIAL NO. 1390 AND ABOVE
ASSEMBLY STOCK NO. 150A-58B

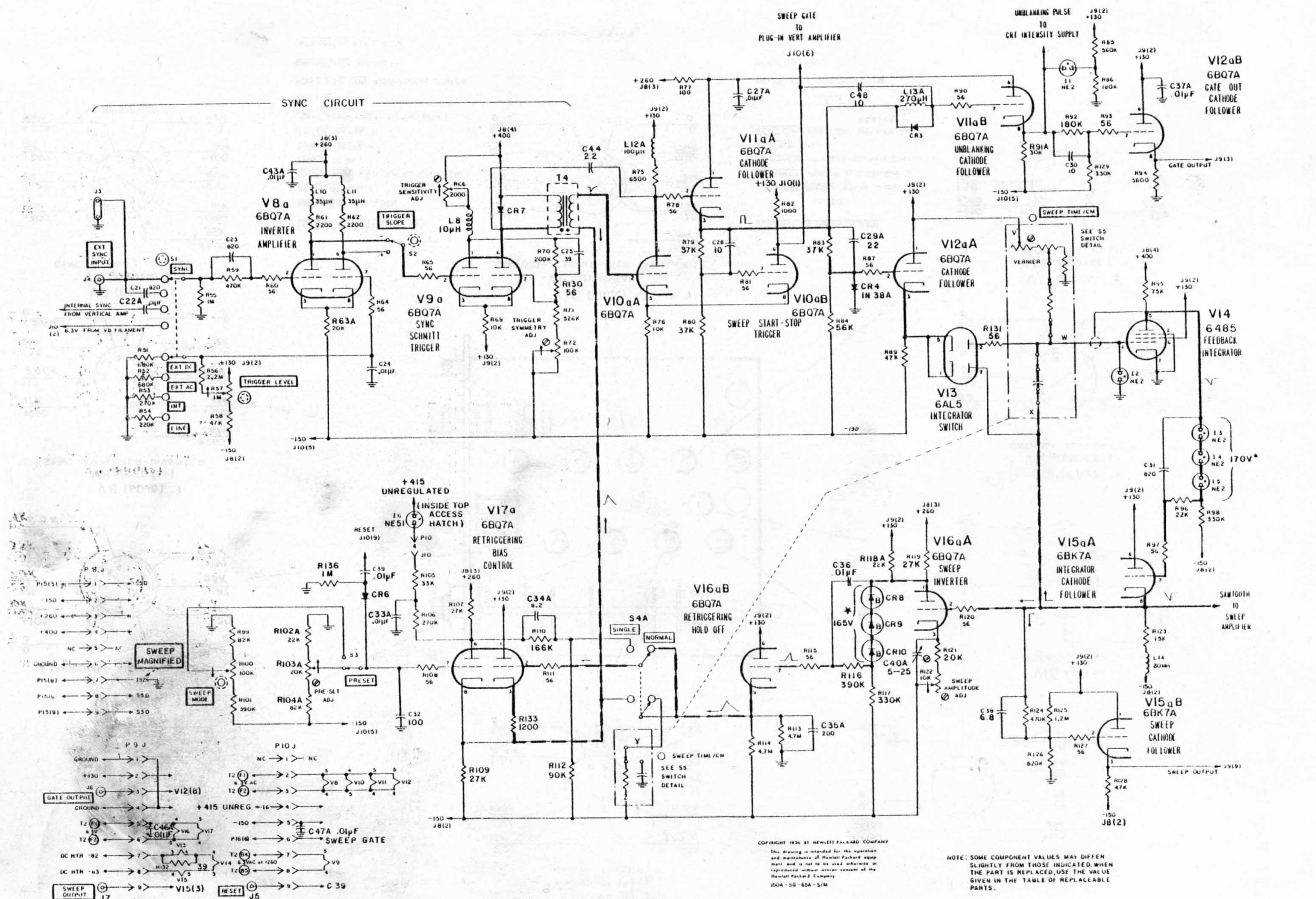
SWEEP GENERATOR

VOLTAGE-RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.



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150A-SG-65A-S/M

NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED. WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

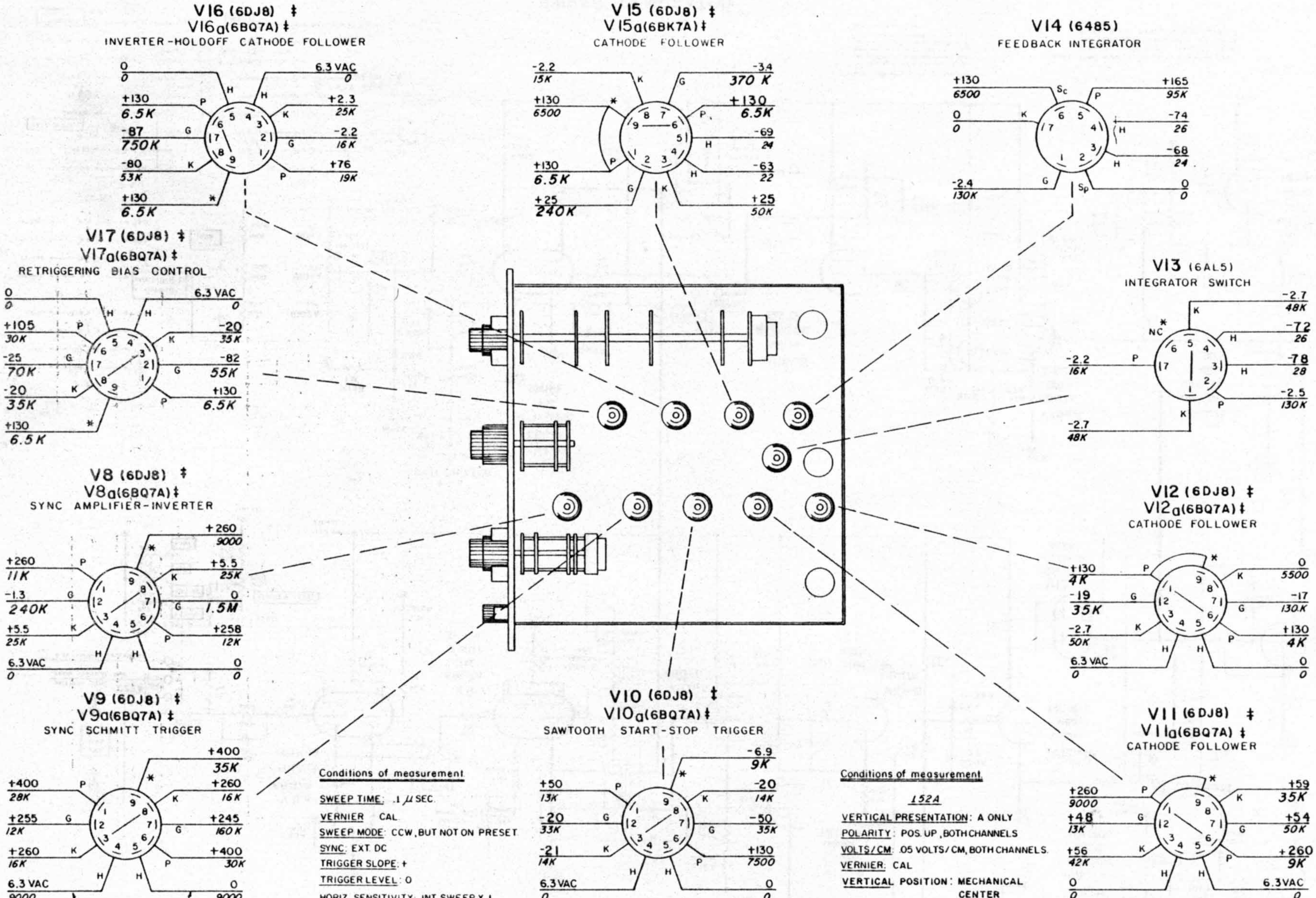
★ NOMINAL VALUE

SWEEP GENERATOR

SWEEP GENERATOR ASSEMBLY 150A-65A

SWEEP GENERATOR

VOLTAGE-RESISTANCE DIAGRAM (VIEWED FROM UNDERSIDE)



Conditions of measurement

SWEEP TIME: .1 μSEC.
VERNIER: CAL.
SWEEP MODE: CCW, BUT NOT ON PRESET
SYNC: EXT. DC
TRIGGER SLOPE: +
TRIGGER LEVEL: 0
HORIZ. SENSITIVITY: INT. SWEEP X 1
VERNIER: CAL.
HORIZ. POSITION: MECHANICAL CENTER
CALIBRATOR: 100 VOLTS
INTENSITY: FULL CCW

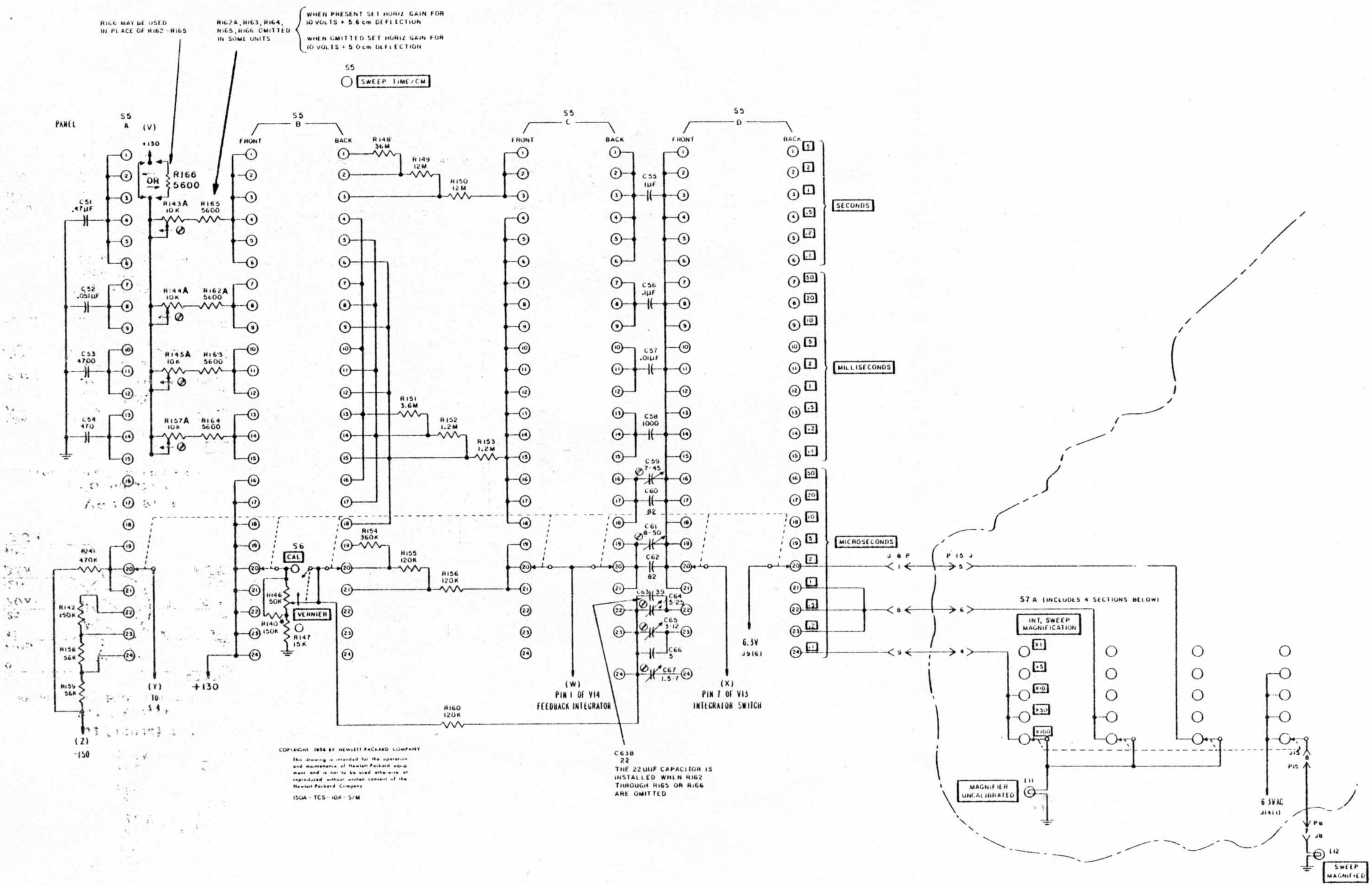
Conditions of measurement

152A

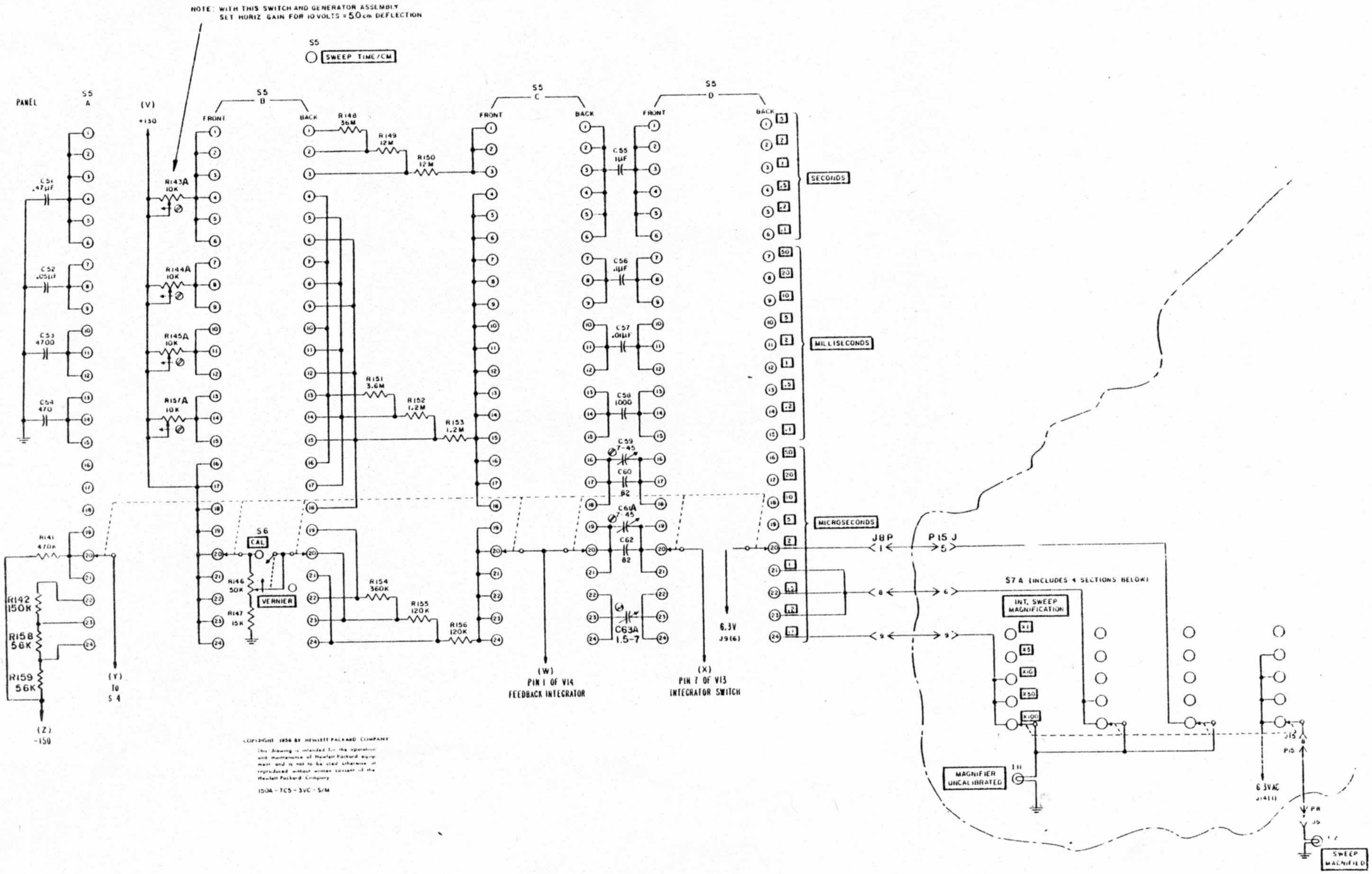
VERTICAL PRESENTATION: A ONLY
POLARITY: POS. UP, BOTH CHANNELS
VOLTS/CM: .05 VOLTS/CM, BOTH CHANNELS.
VERNIER: CAL
VERTICAL POSITION: MECHANICAL CENTER

151A

VOLTS/CM: .005 VOLTS/CM
VERNIER: CAL.

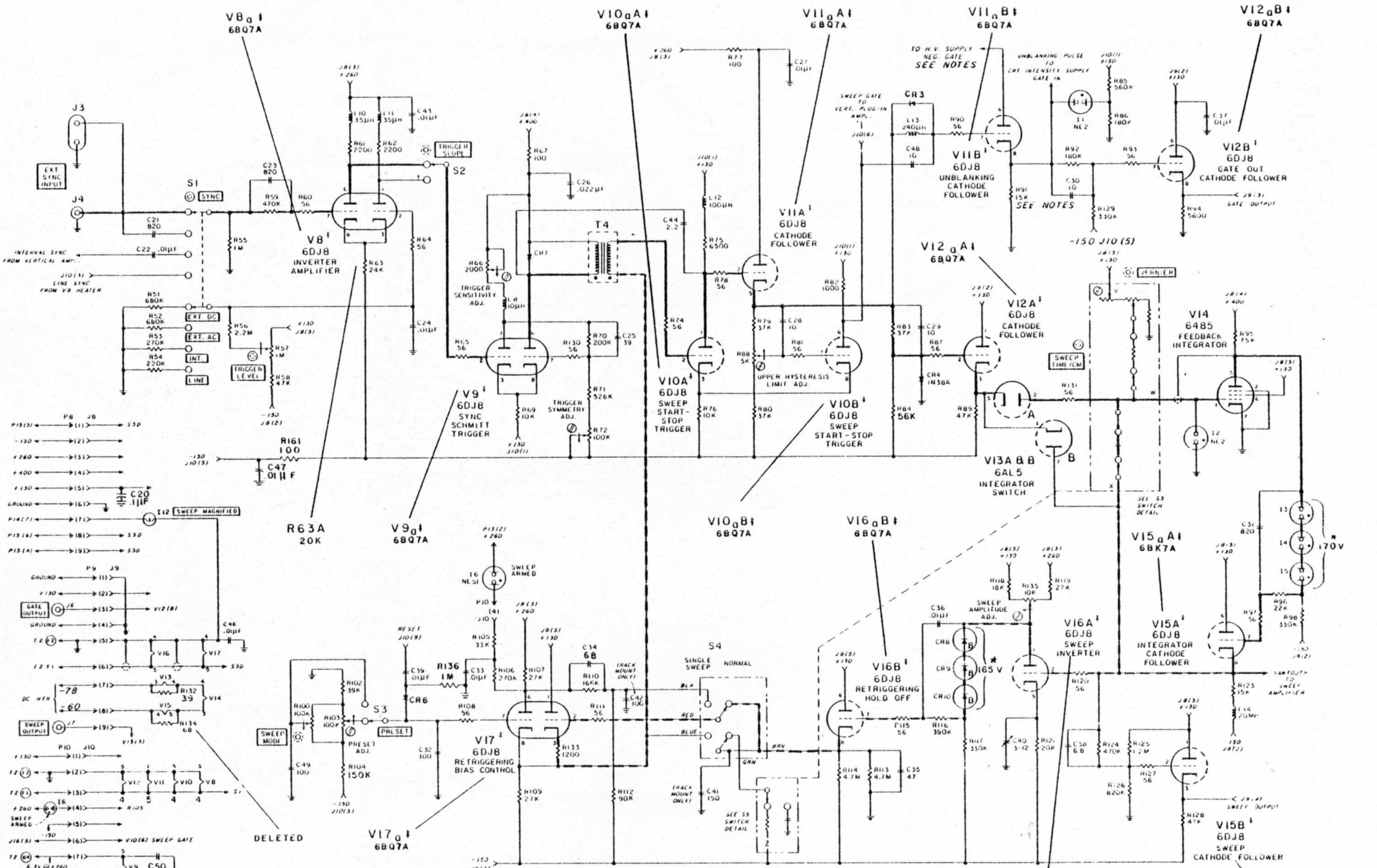


SWEEP TIME/CM SWITCH DETAIL
(SWITCHES WITH 5 VARIABLE CAPACITORS)
FOR SWEEP GENERATOR ASSEMBLIES WITH
10K TIMING POTENTIOMETERS



150A - TC5 - 3VC - S/M

SWEEP TIME/CM SWITCH DETAIL
(SWITCHES WITH 3 VARIABLE CAPACITORS)



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150A-SG-65E/L/LR S/M

COMPONENT VALUES PRINTED IN RED ARE FOR INSTRUMENTS WITH 6BQ7A TUBES

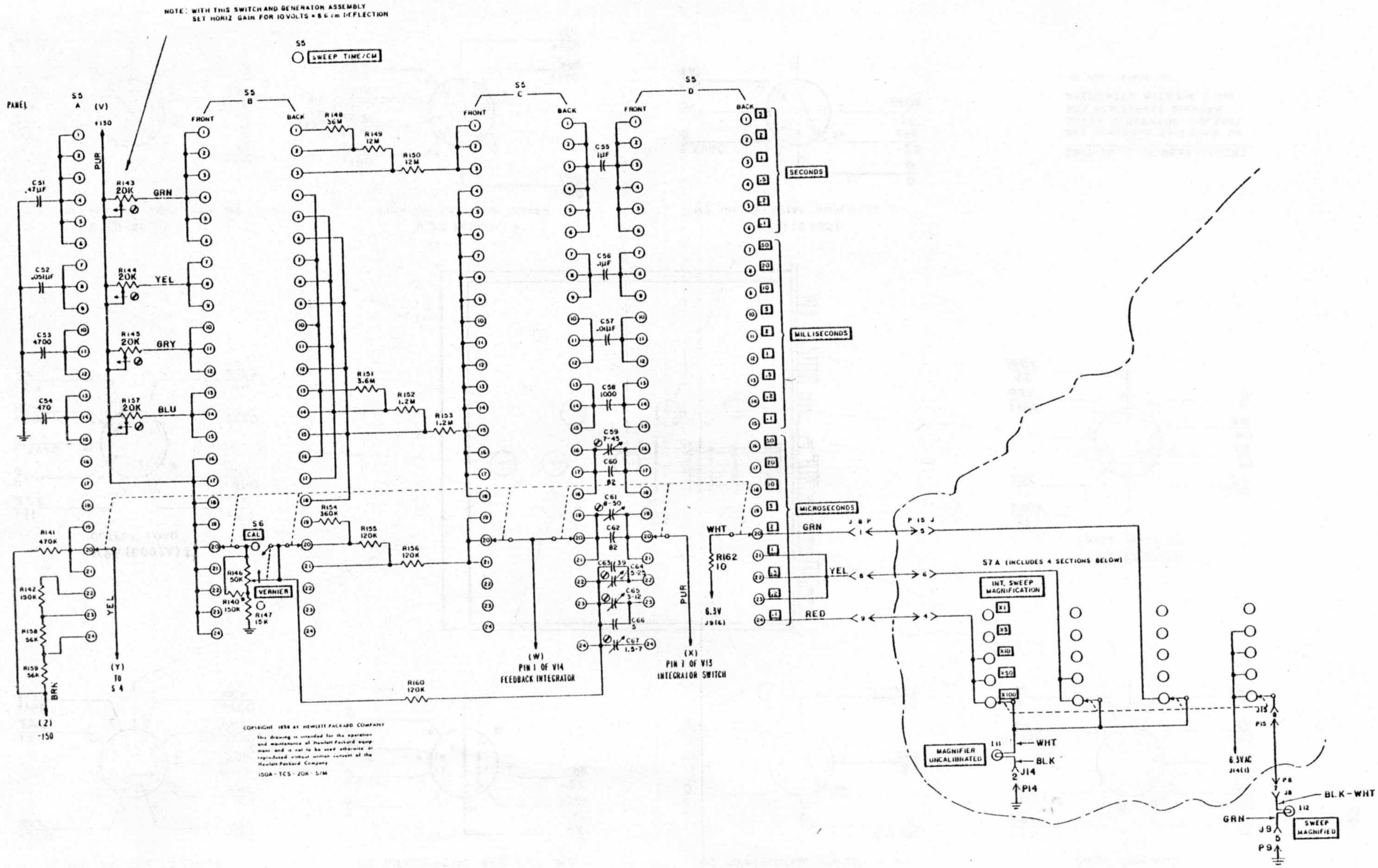
NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED, WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

★ NOMINAL VALUE

SWEEP GENERATOR

SWEEP GENERATOR ASSEMBLY 150A-65E, 150A-65L, 150A-65LR

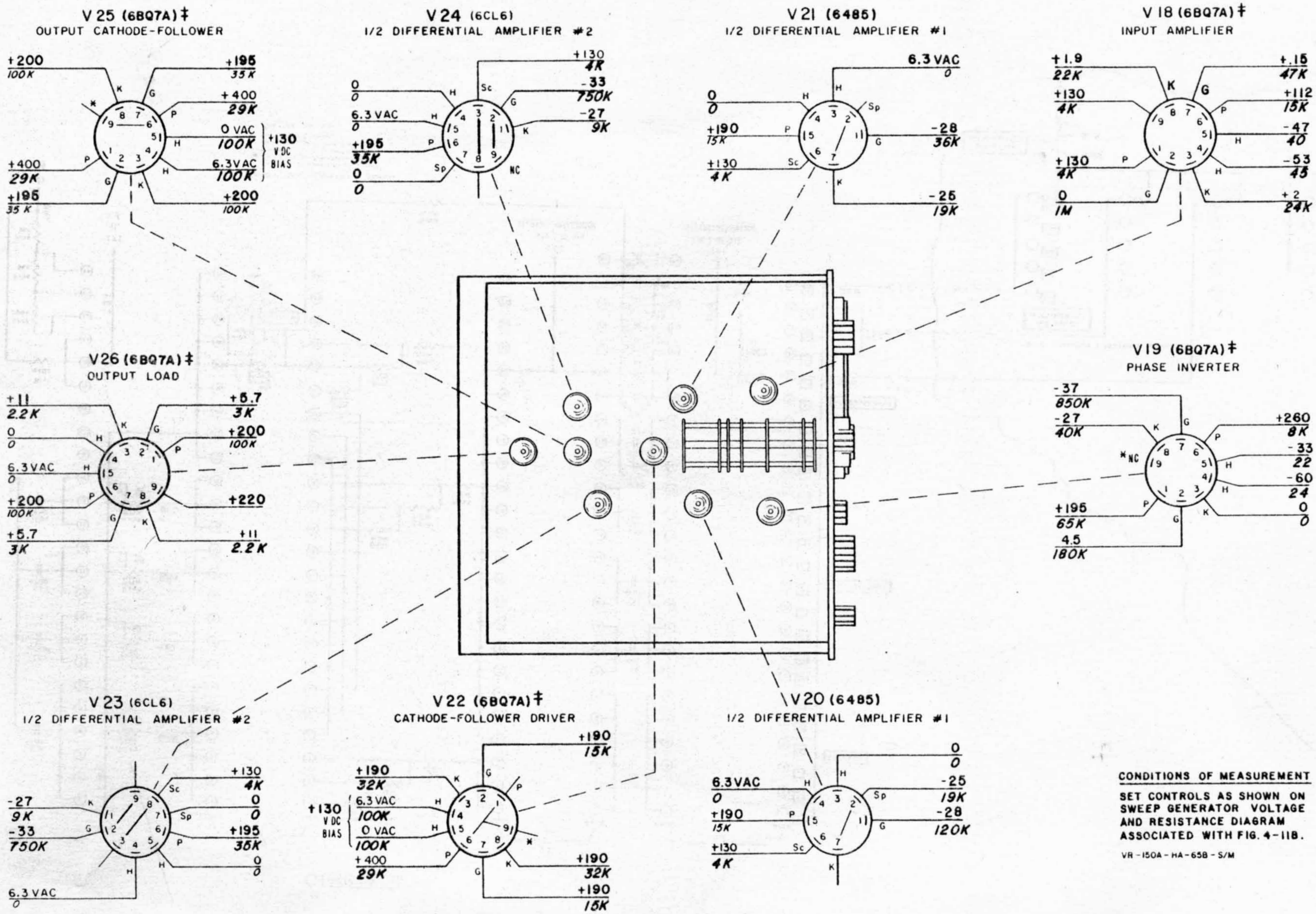
ALTERNATE CONNECTIONS FOR V11B PLATE CIRCUIT OR CATHODE CIRCUIT ARE SHOWN IN FIGURE 4-[illegible]



SWEEP TIME/CM SWITCH DETAIL
(SWITCHES WITH 5 VARIABLE CAPACITORS)
FOR SWEEP GENERATOR ASSEMBLIES WITH
20K TIMING POTENTIOMETERS

HORIZONTAL AMPLIFIER

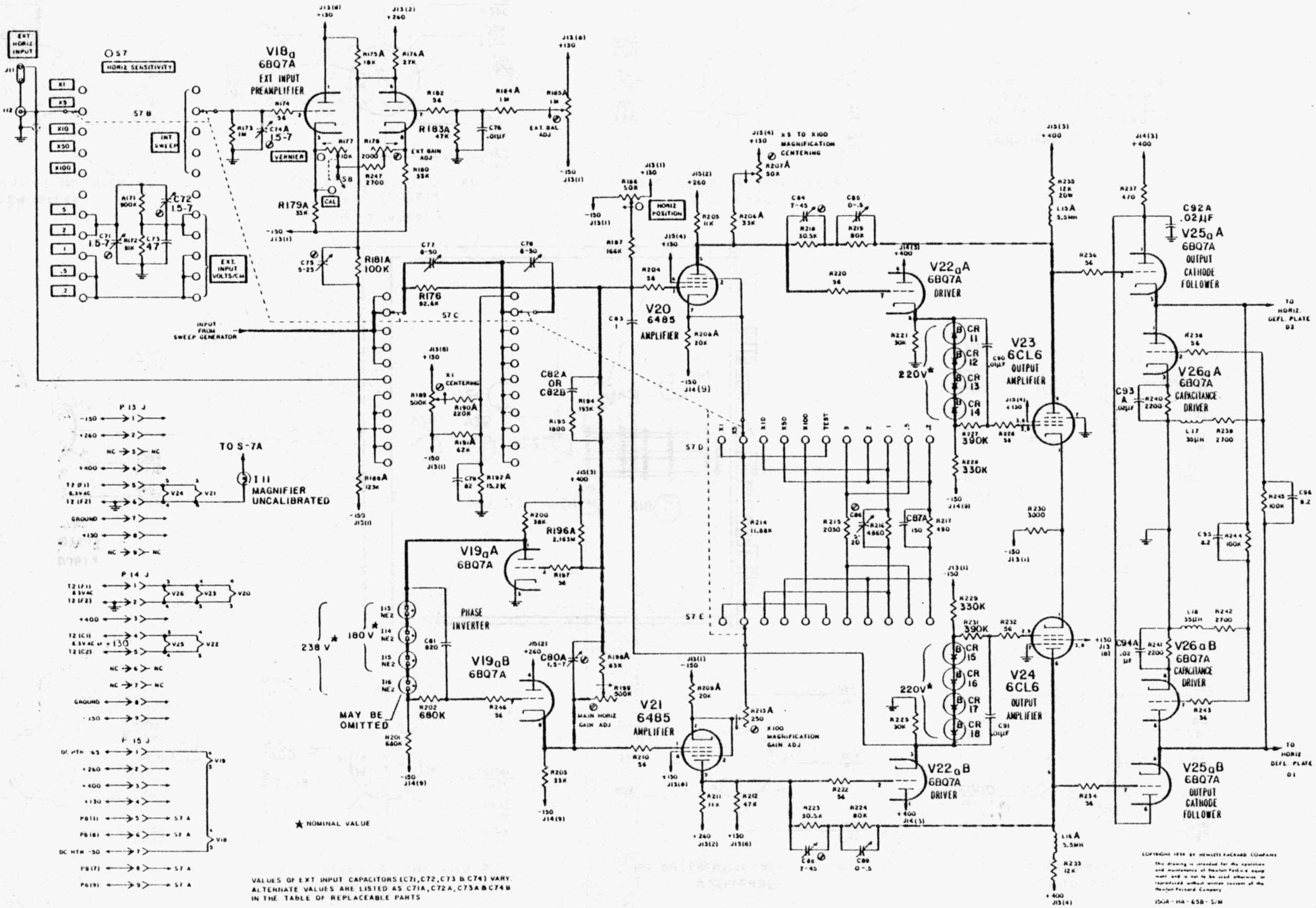
VOLTAGE - RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-HA-65B-S/M



VALUES OF EXT INPUT CAPACITORS (C71, C72, C73 & C74) VARY. ALTERNATE VALUES ARE LISTED AS C71A, C72A, C73A & C74B IN THE TABLE OF REPLACEABLE PARTS

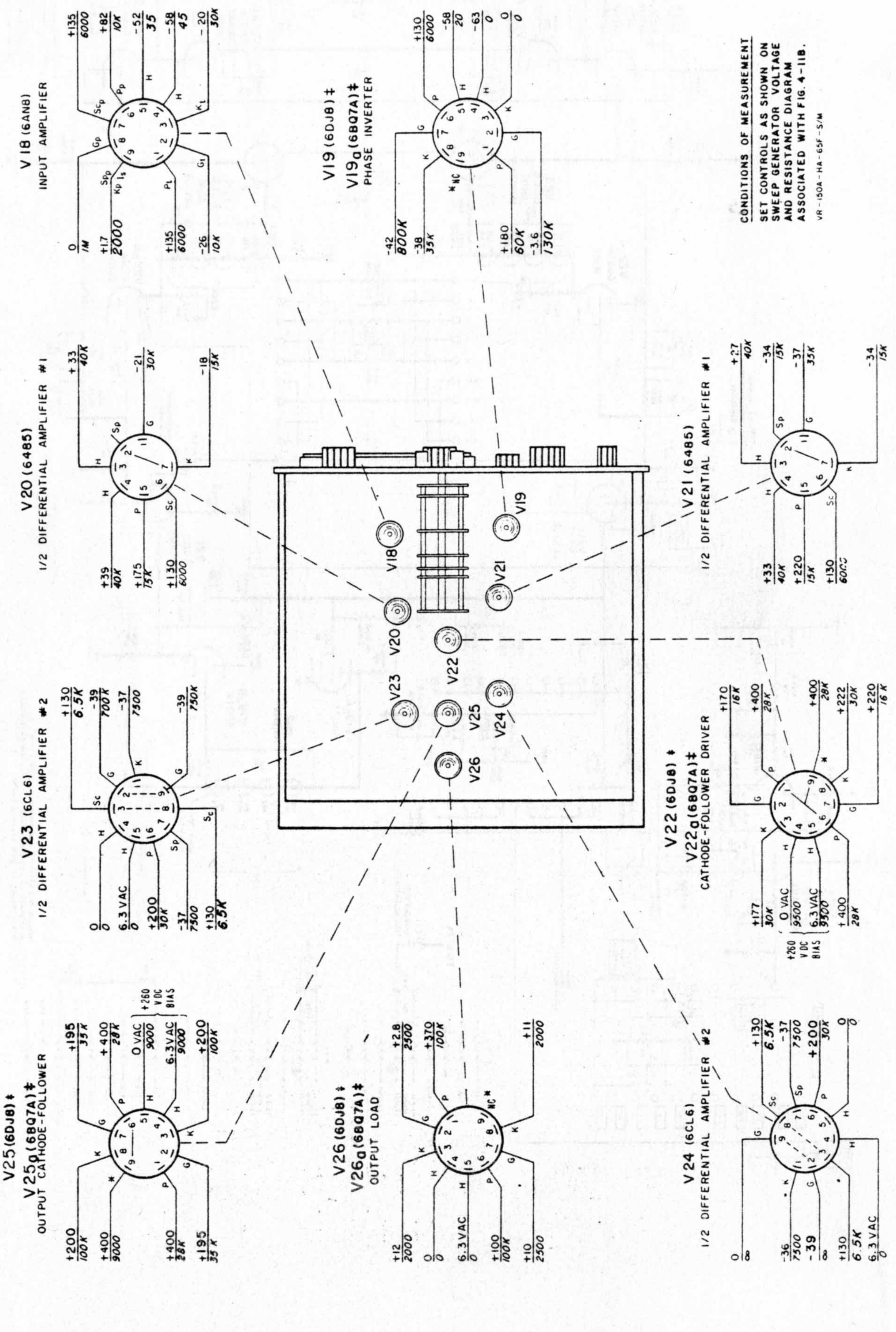
NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED. WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

HORIZONTAL AMPLIFIER

HORIZONTAL AMPLIFIER ASSEMBLY 150A-65B

HORIZONTAL AMPLIFIER

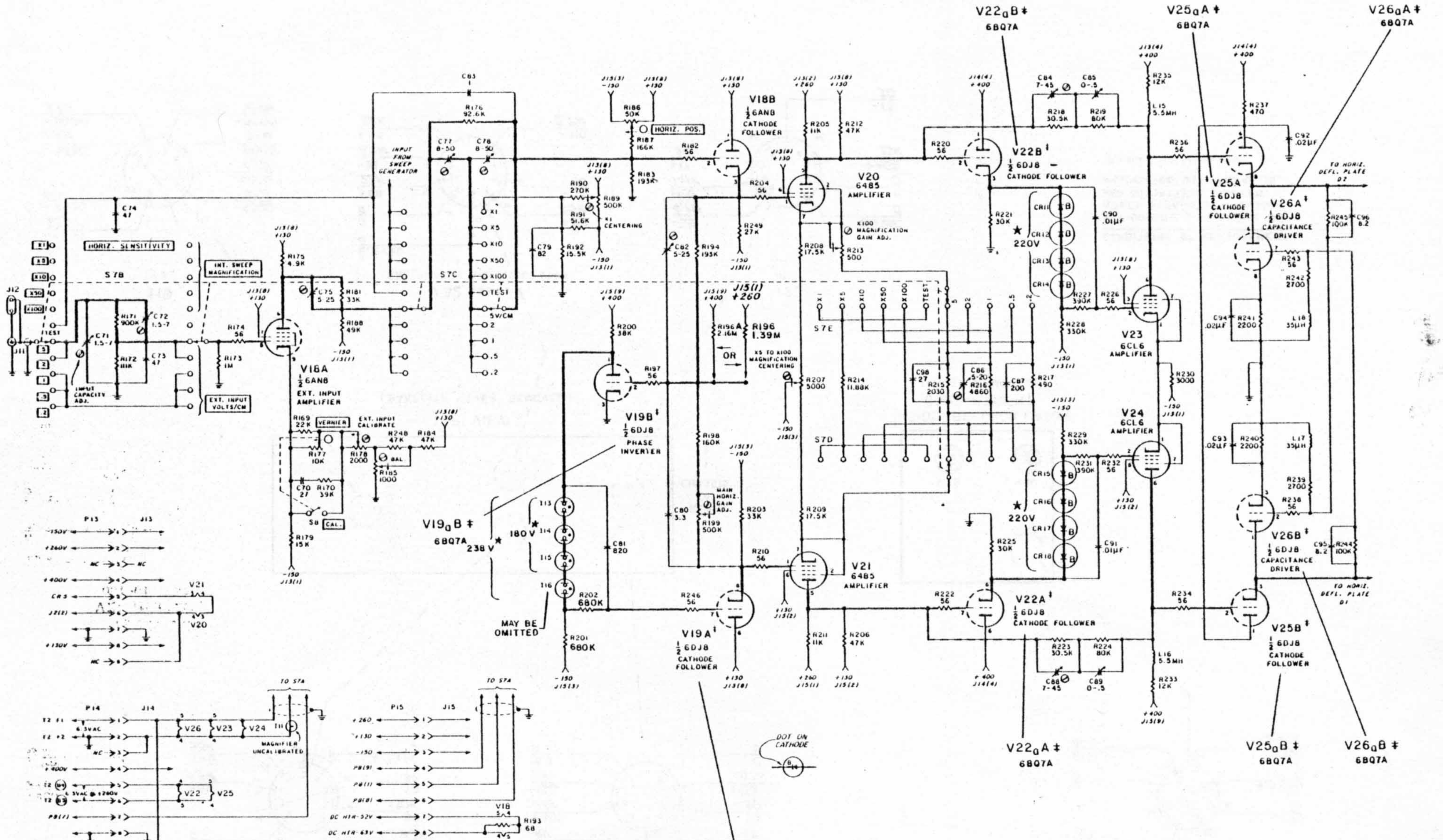
VOLTAGE - RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-HA-65F-S/M



NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED, WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

★ NOMINAL VALUE

COMPONENT VALUES PRINTED IN RED ARE FOR INSTRUMENTS WITH 6BQ7A TUBES

150A-HA-65F-S/M

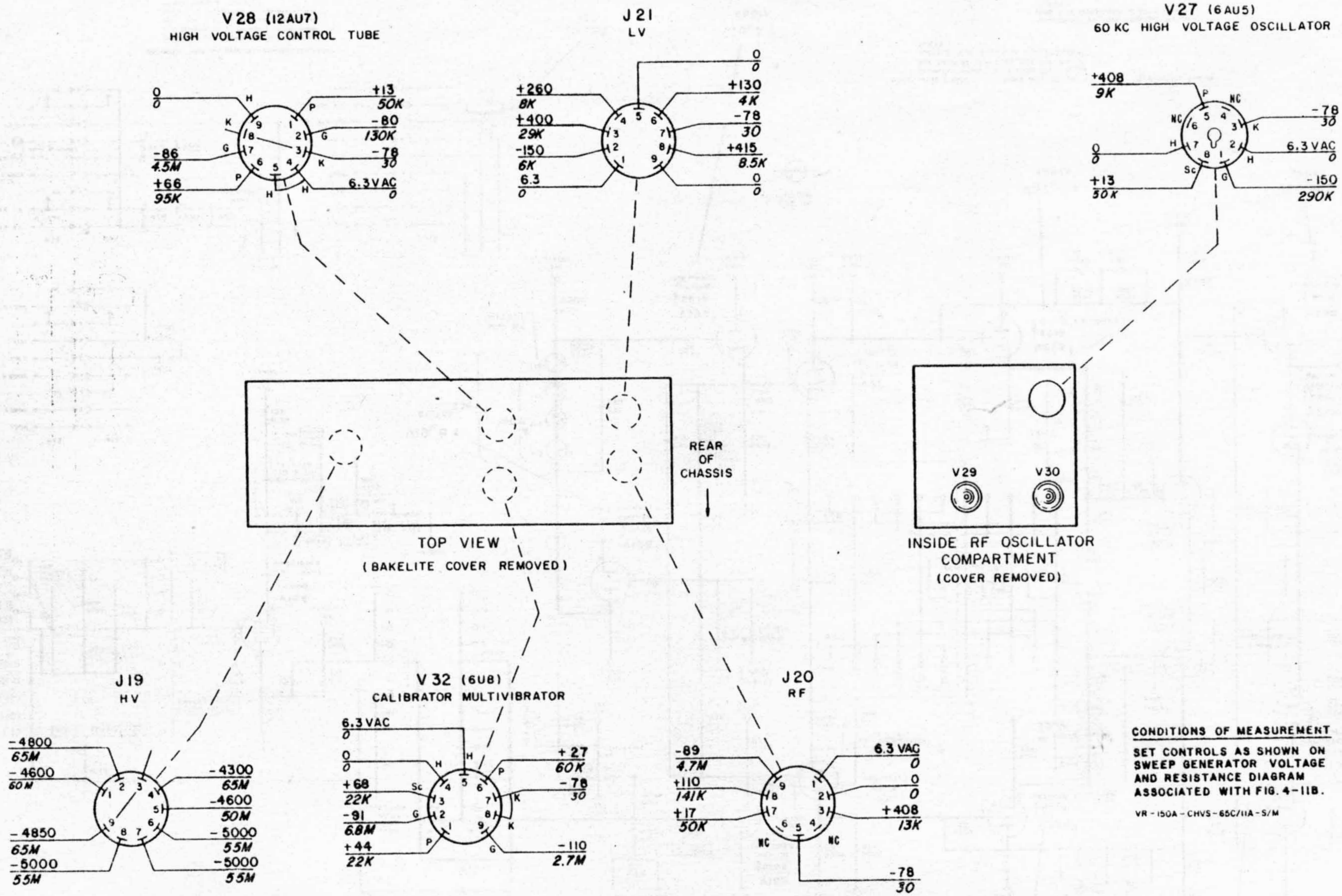
HORIZONTAL AMPLIFIER

HORIZONTAL AMPLIFIER ASSEMBLY 150A-65F

S/N 113

CALIBRATOR AND HIGH VOLTAGE REGULATED POWER SUPPLY

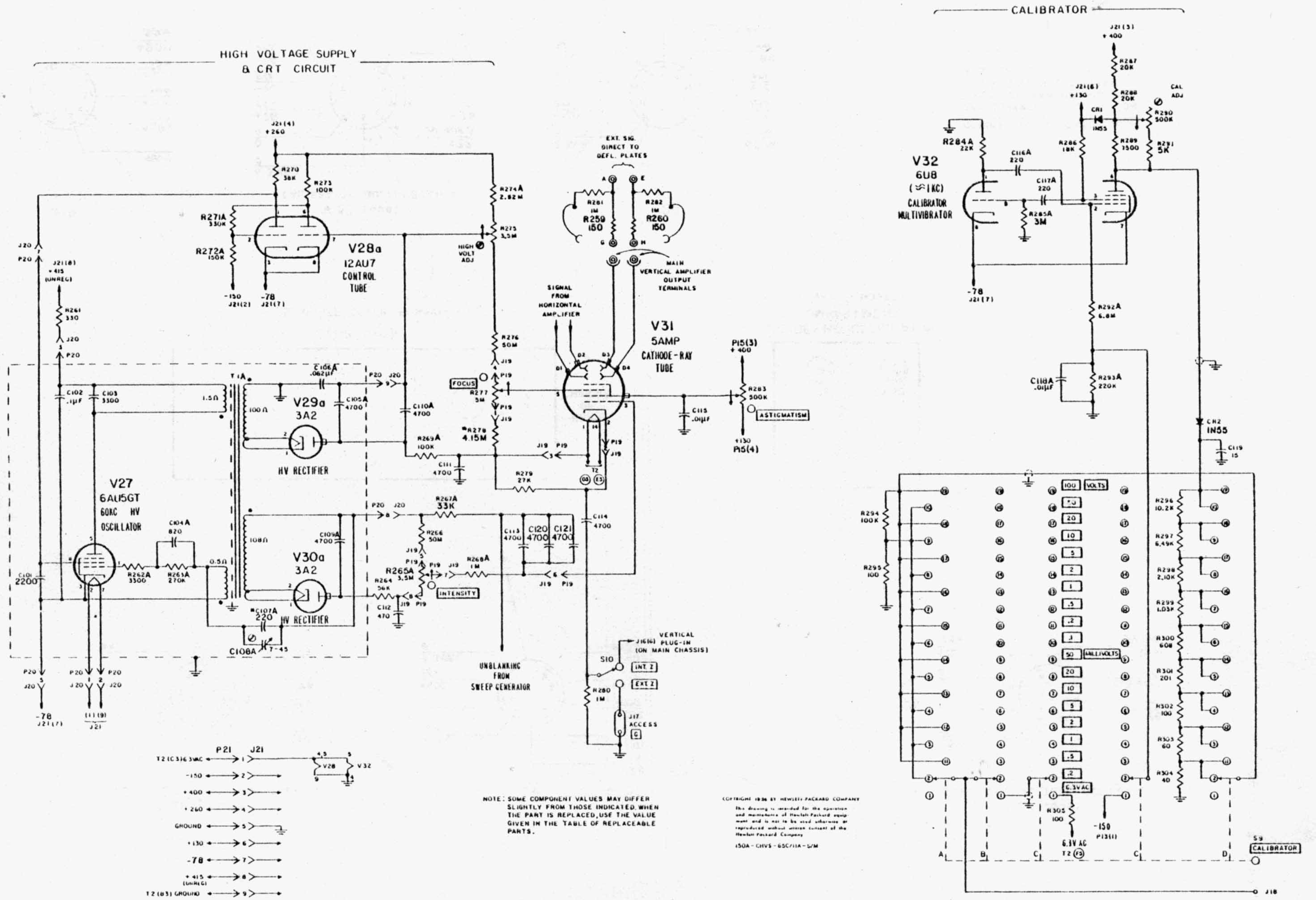
VOLTAGE - RESISTANCE DIAGRAM



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-CHVS-65C/11A-S/M

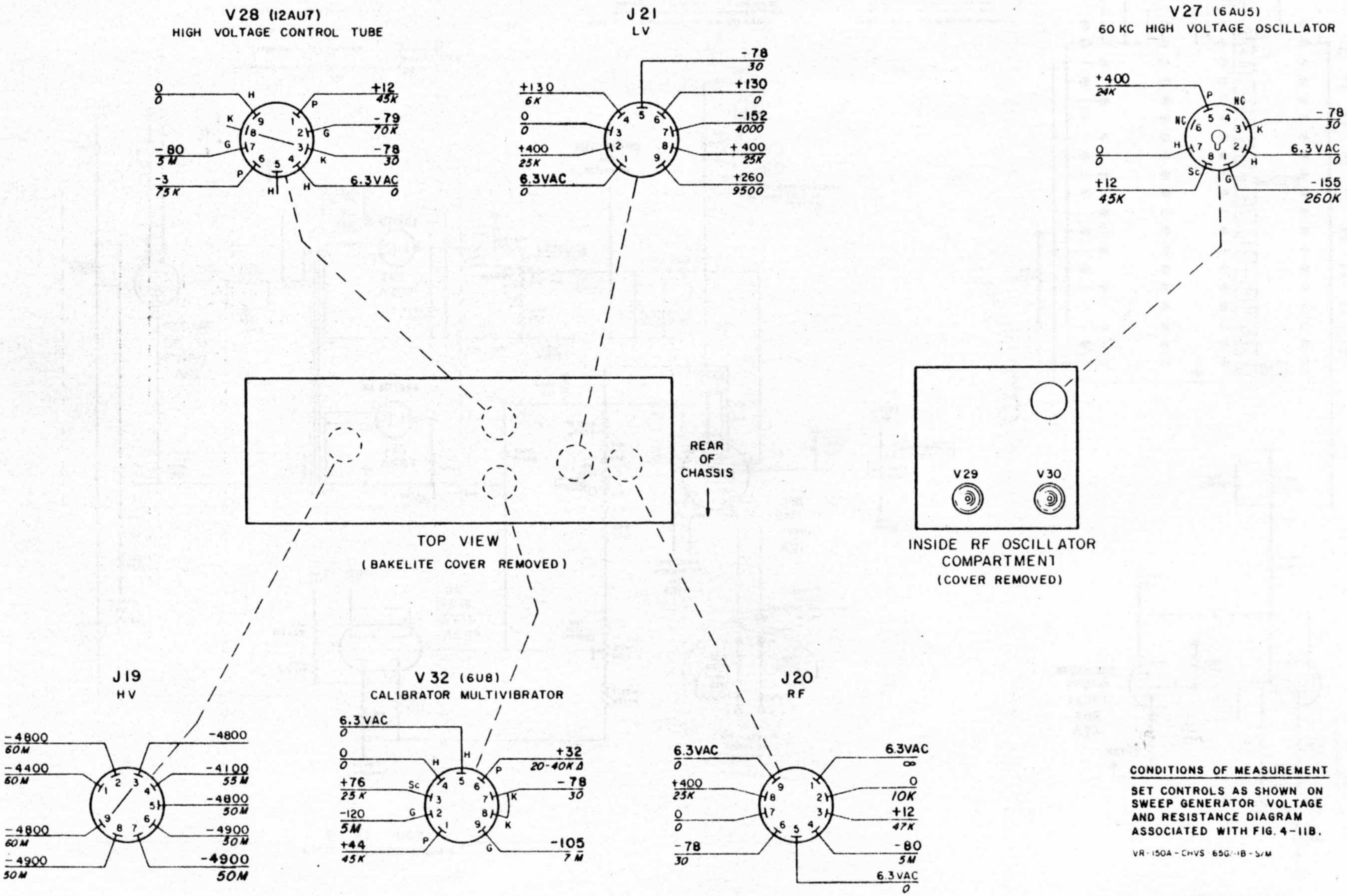


CALIBRATOR AND HIGH VOLTAGE SUPPLY

CALIBRATOR AND HIGH VOLTAGE ASSEMBLY 150A-65C
HIGH VOLTAGE AND RECTIFIER ASSEMBLY 150A-11A

CALIBRATOR AND HIGH VOLTAGE REGULATED POWER SUPPLY

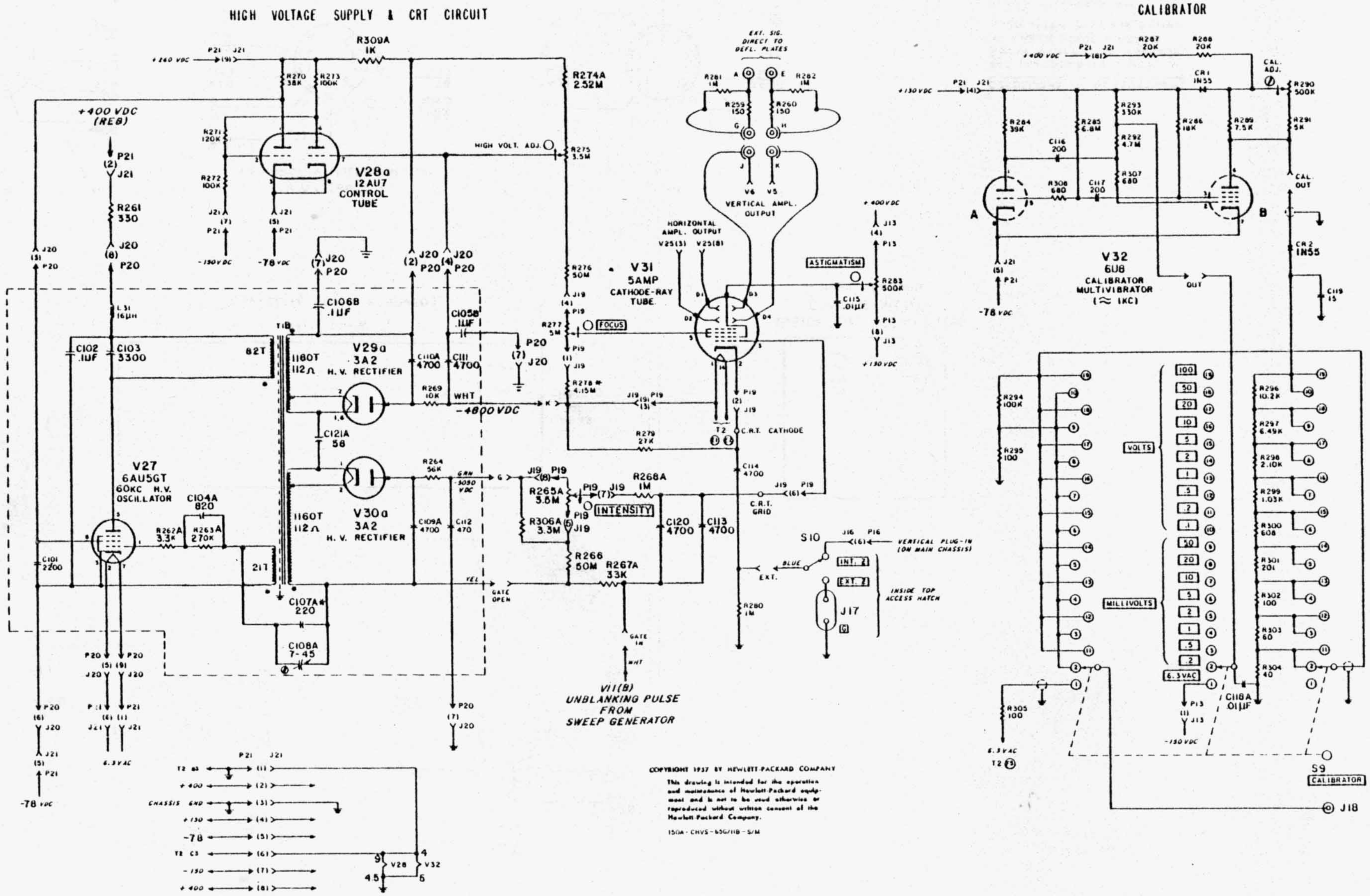
VOLTAGE – RESISTANCE DIAGRAM



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-CHVS 65G-1B-S/M



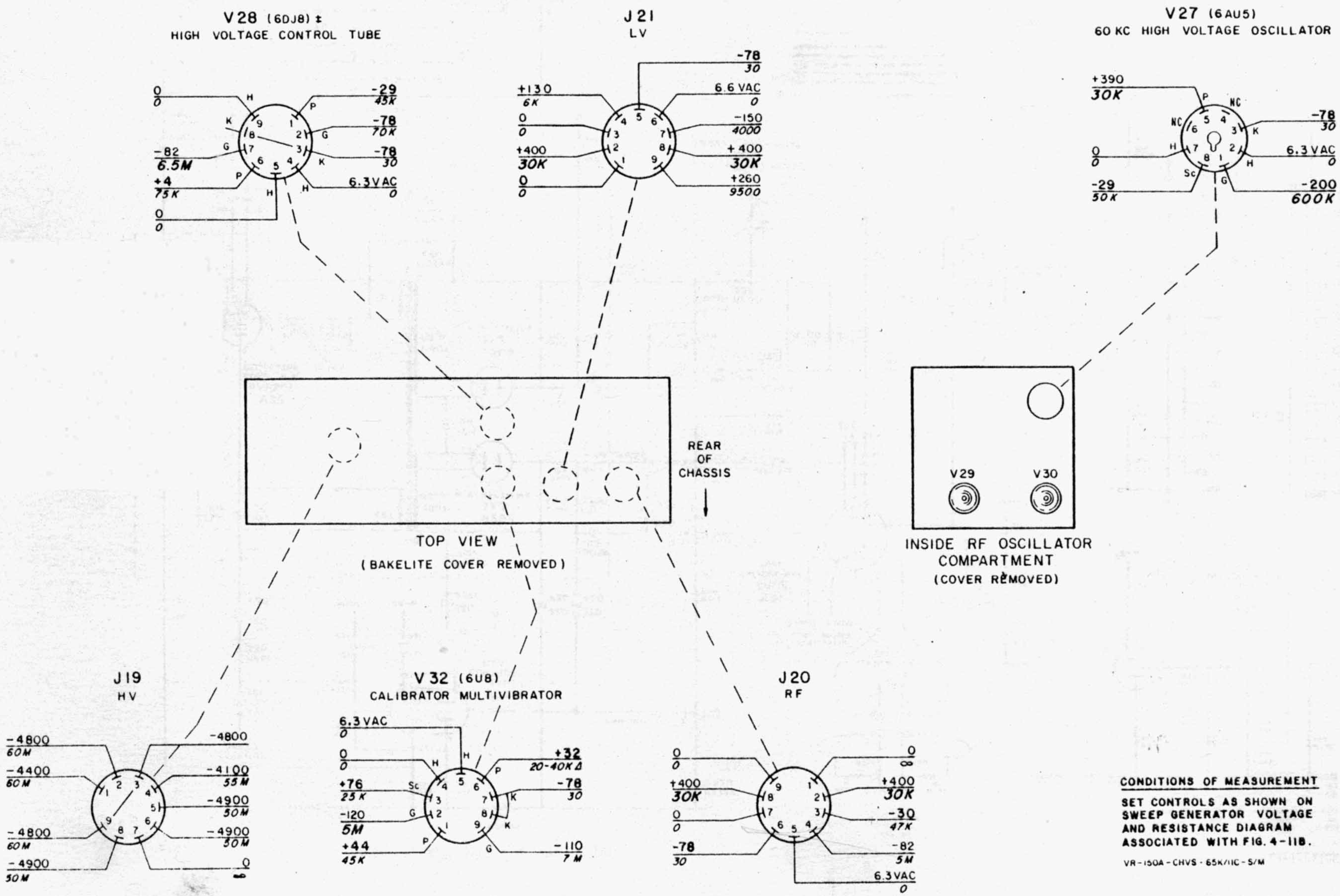
150A - CHVS - 65G/11B - S/M

CALIBRATOR AND HIGH VOLTAGE SUPPLY

CALIBRATOR AND HIGH VOLTAGE ASSEMBLY 150A - 65G
HIGH VOLTAGE AND RECTIFIER ASSEMBLY 150A - 11B

CALIBRATOR AND HIGH VOLTAGE REGULATED POWER SUPPLY

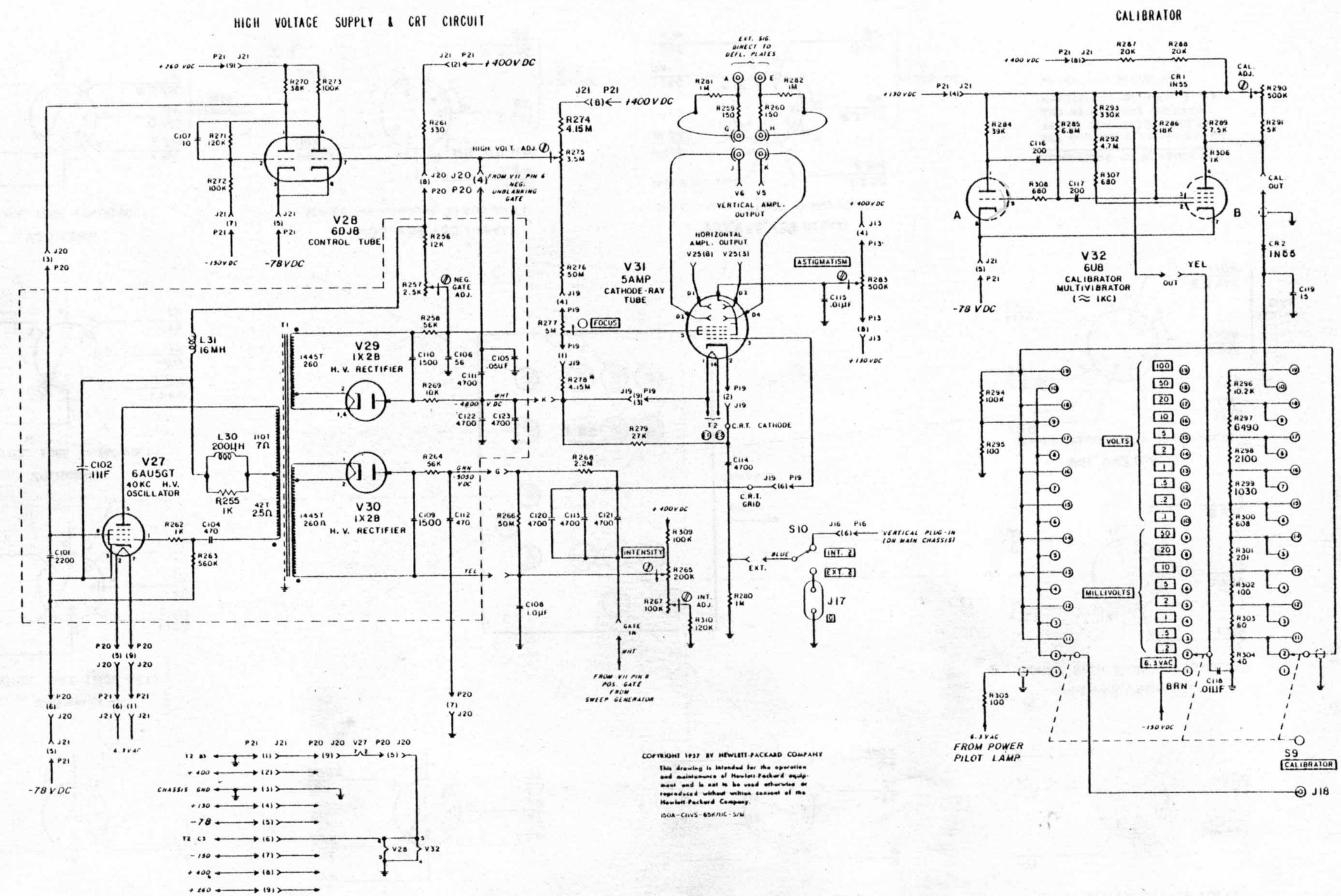
VOLTAGE – RESISTANCE DIAGRAM



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-CHVS-65K/IIC-S/M



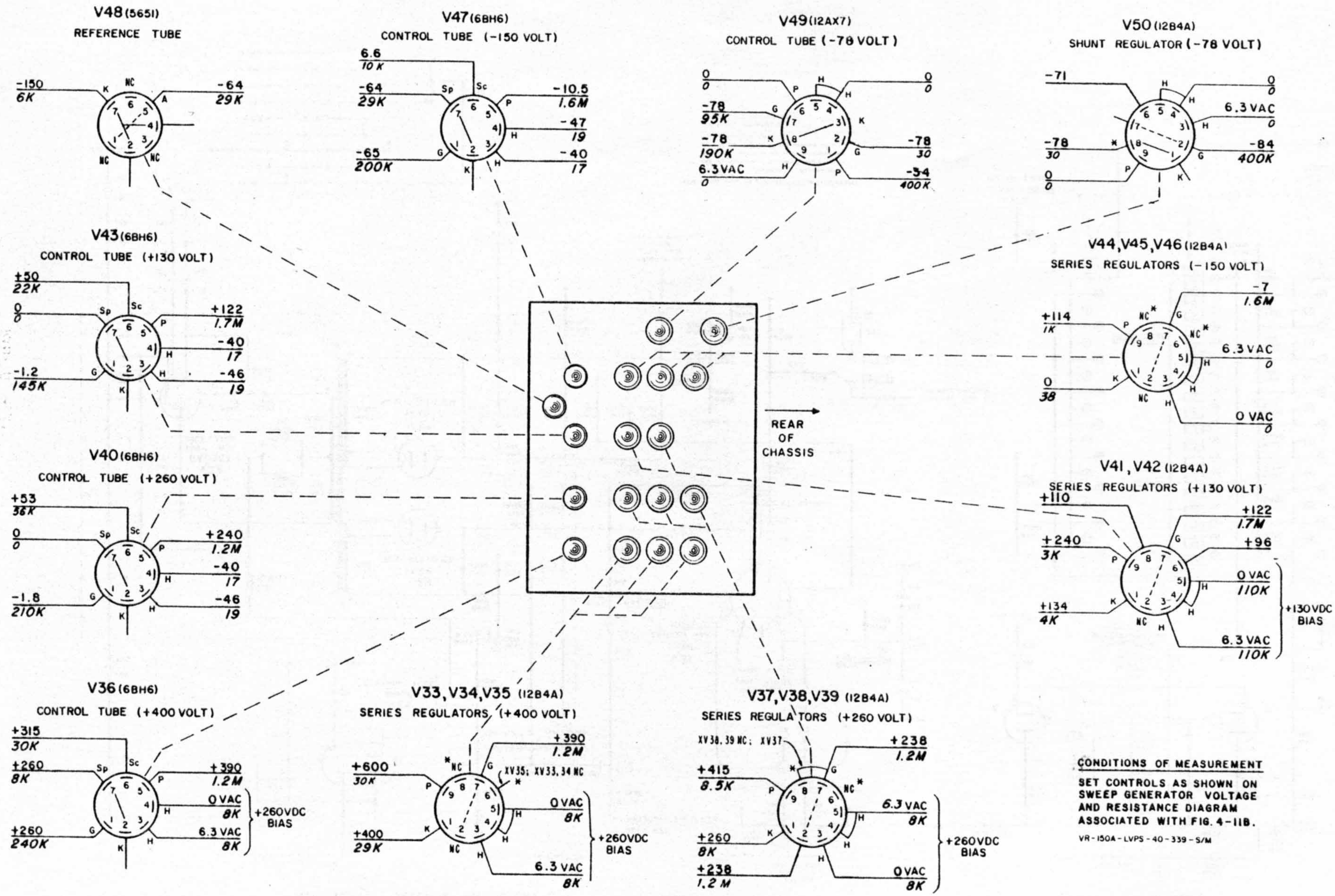
150A-CHVS-65K/11C-S/M

CALIBRATOR AND HIGH VOLTAGE SUPPLY

CALIBRATOR AND HIGH VOLTAGE ASSEMBLY 150A-65K
HIGH VOLTAGE AND RECTIFIER ASSEMBLY 150A-11C

LOW VOLTAGE POWER SUPPLY

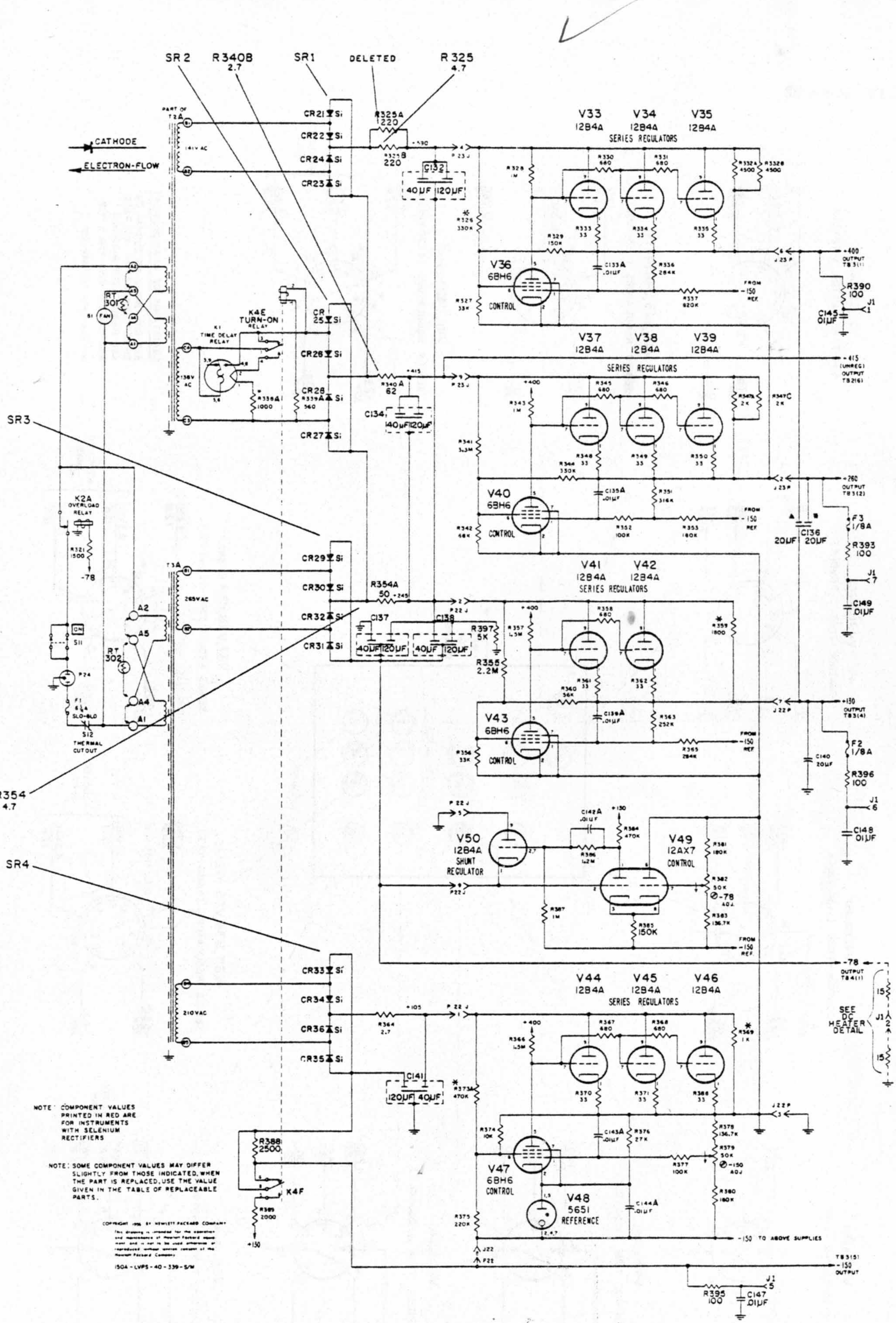
VOLTAGE – RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-LVPS-40-339-S/M

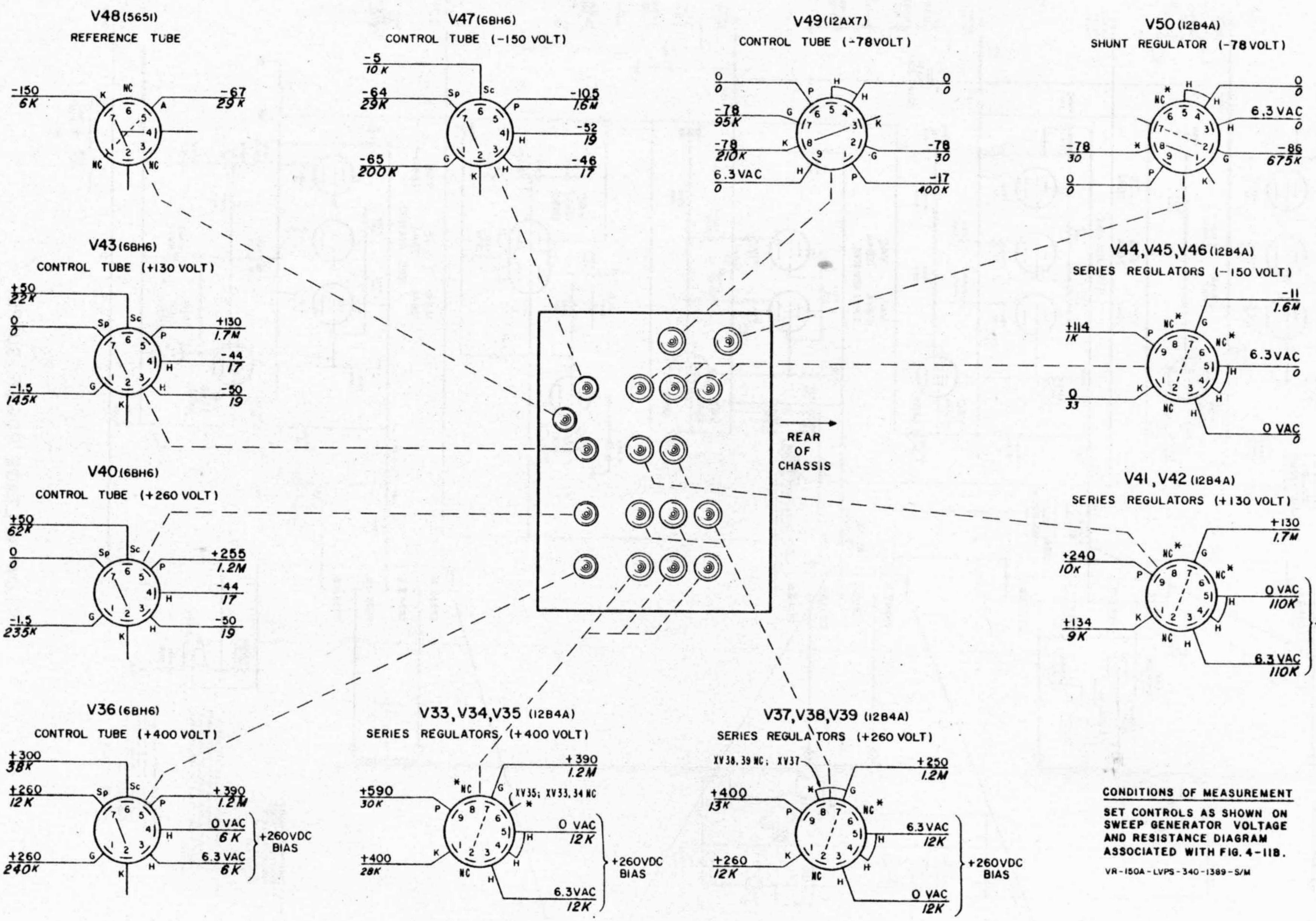


LOW VOLTAGE POWER SUPPLY

SERIAL NO. 40 THROUGH NO. 339

LOW VOLTAGE POWER SUPPLY

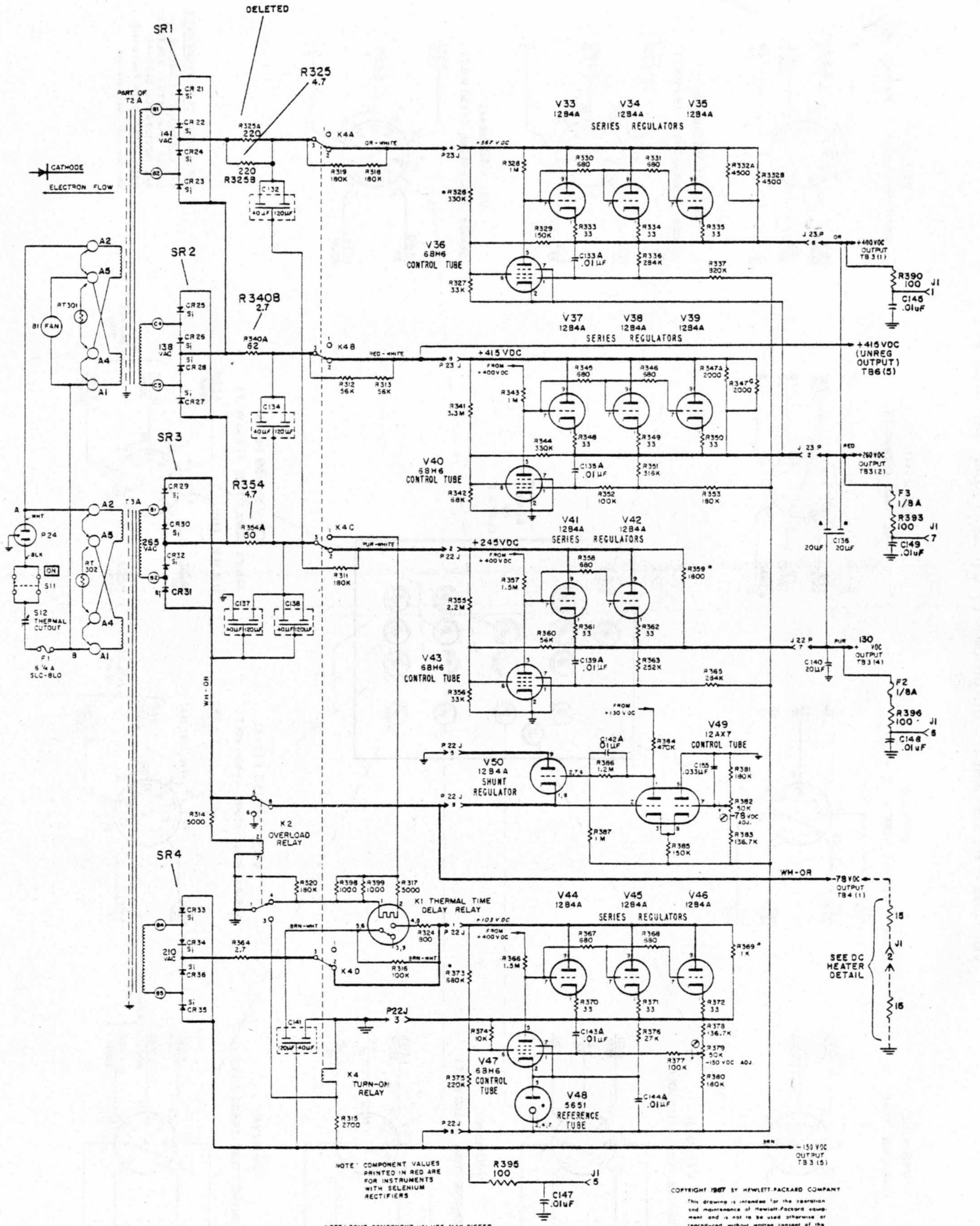
VOLTAGE – RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

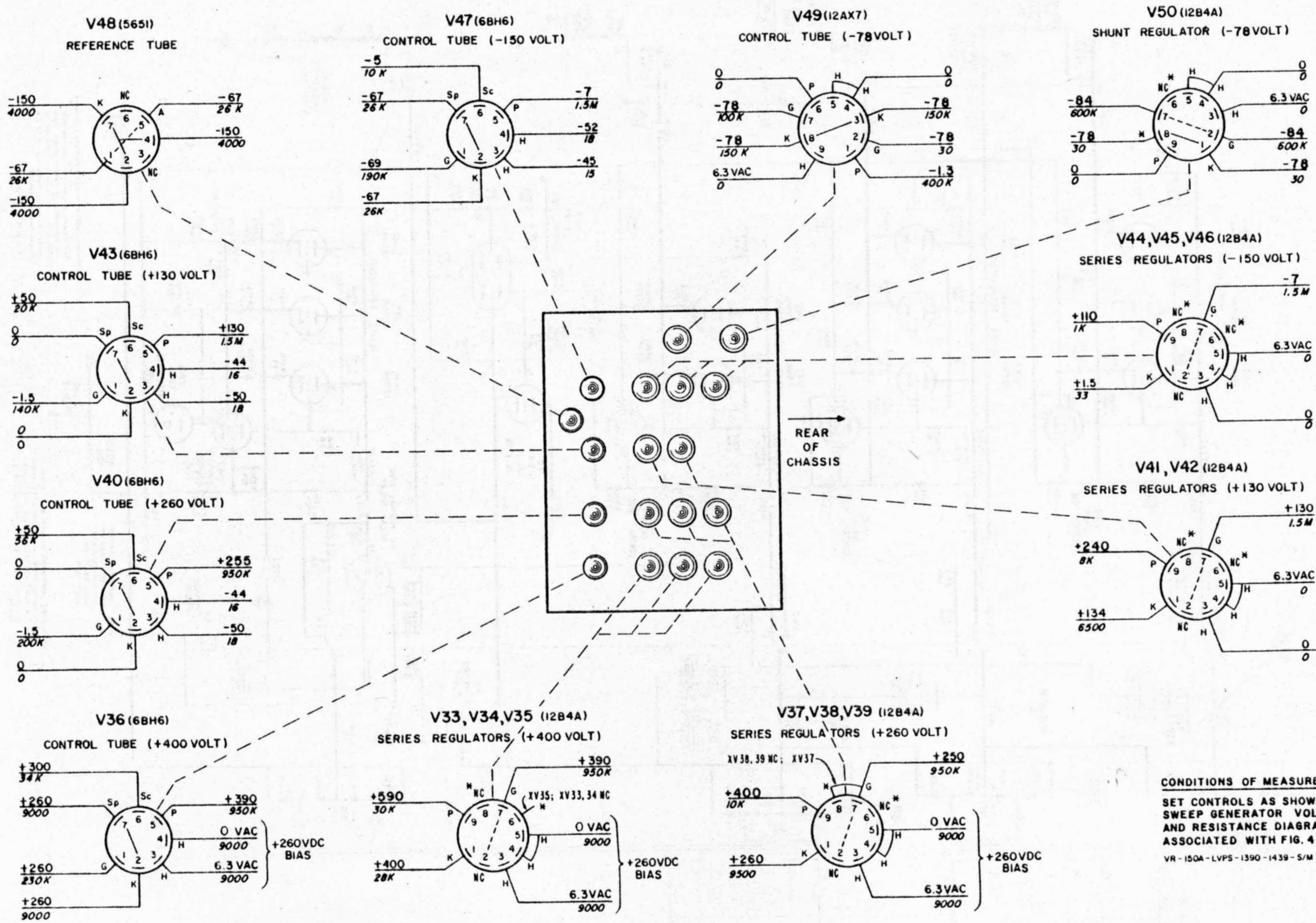
VR-150A-LVPS-340-1389-S/M



LOW VOLTAGE POWER SUPPLY

LOW VOLTAGE POWER SUPPLY

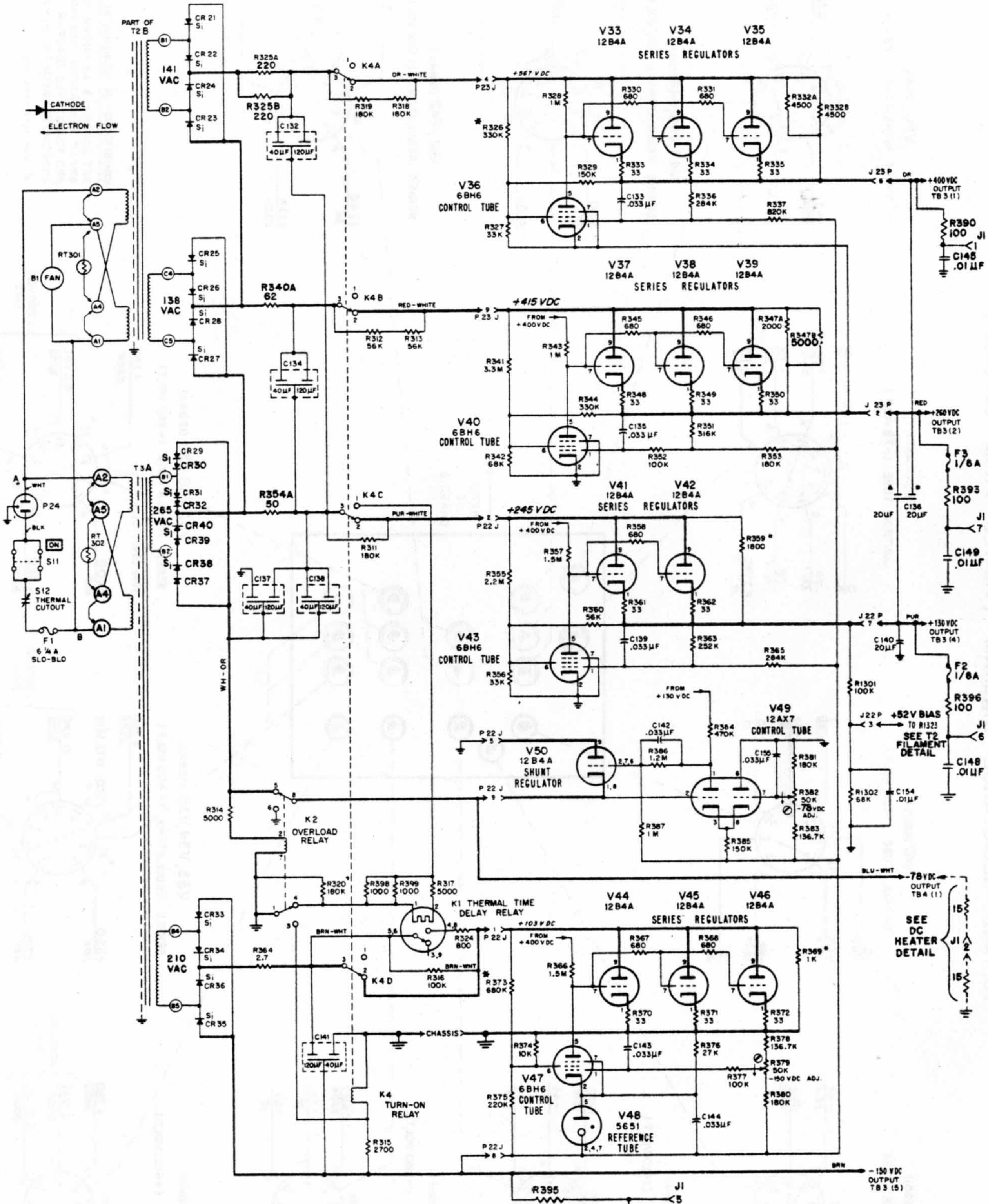
VOLTAGE – RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-LVPS-1390-1439-5/M



NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED. WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

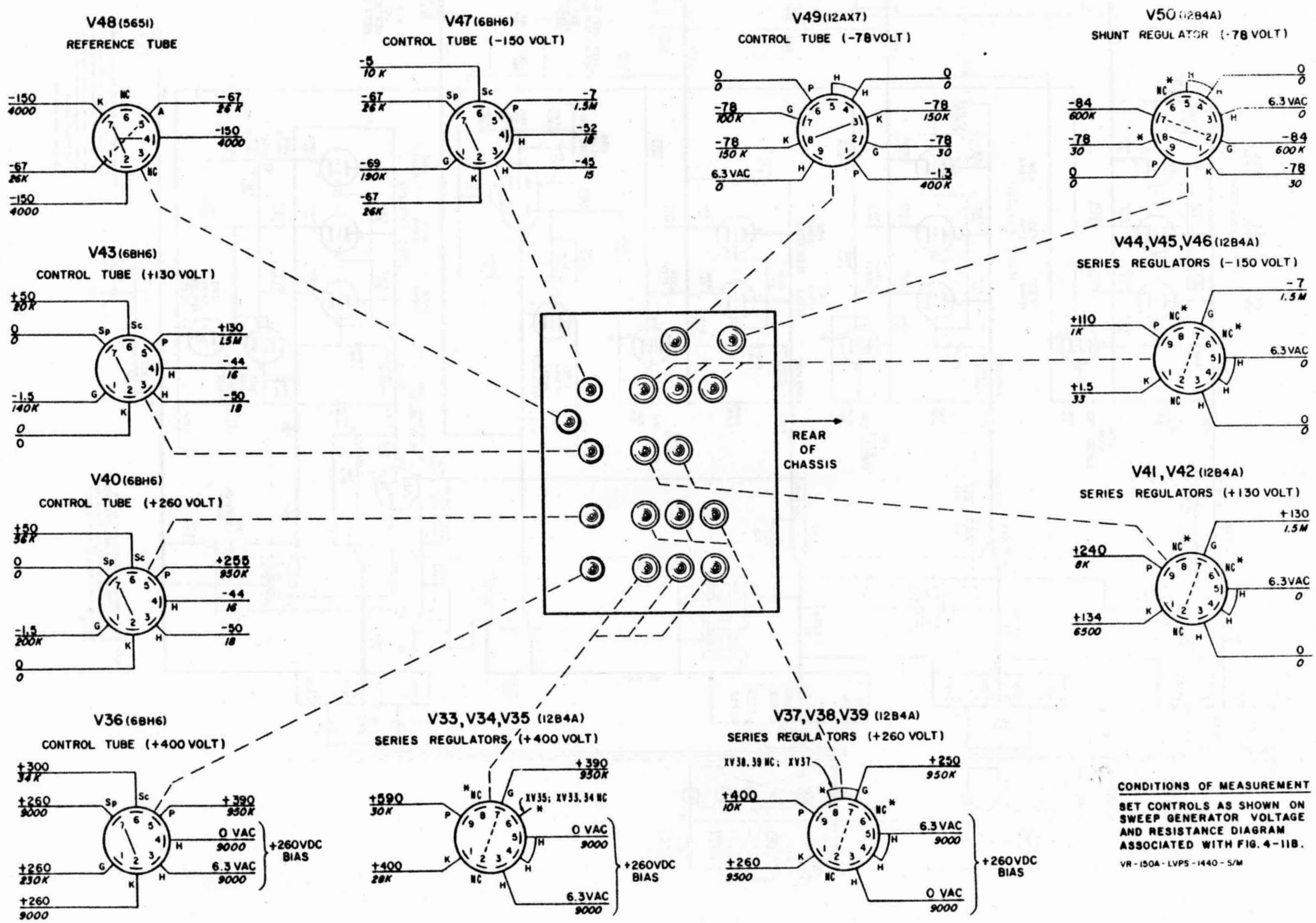
150A-LVPS-1390-1439-S/M

LOW VOLTAGE POWER SUPPLY

SERIAL NO. 1390 THROUGH NO. 1439

LOW VOLTAGE POWER SUPPLY

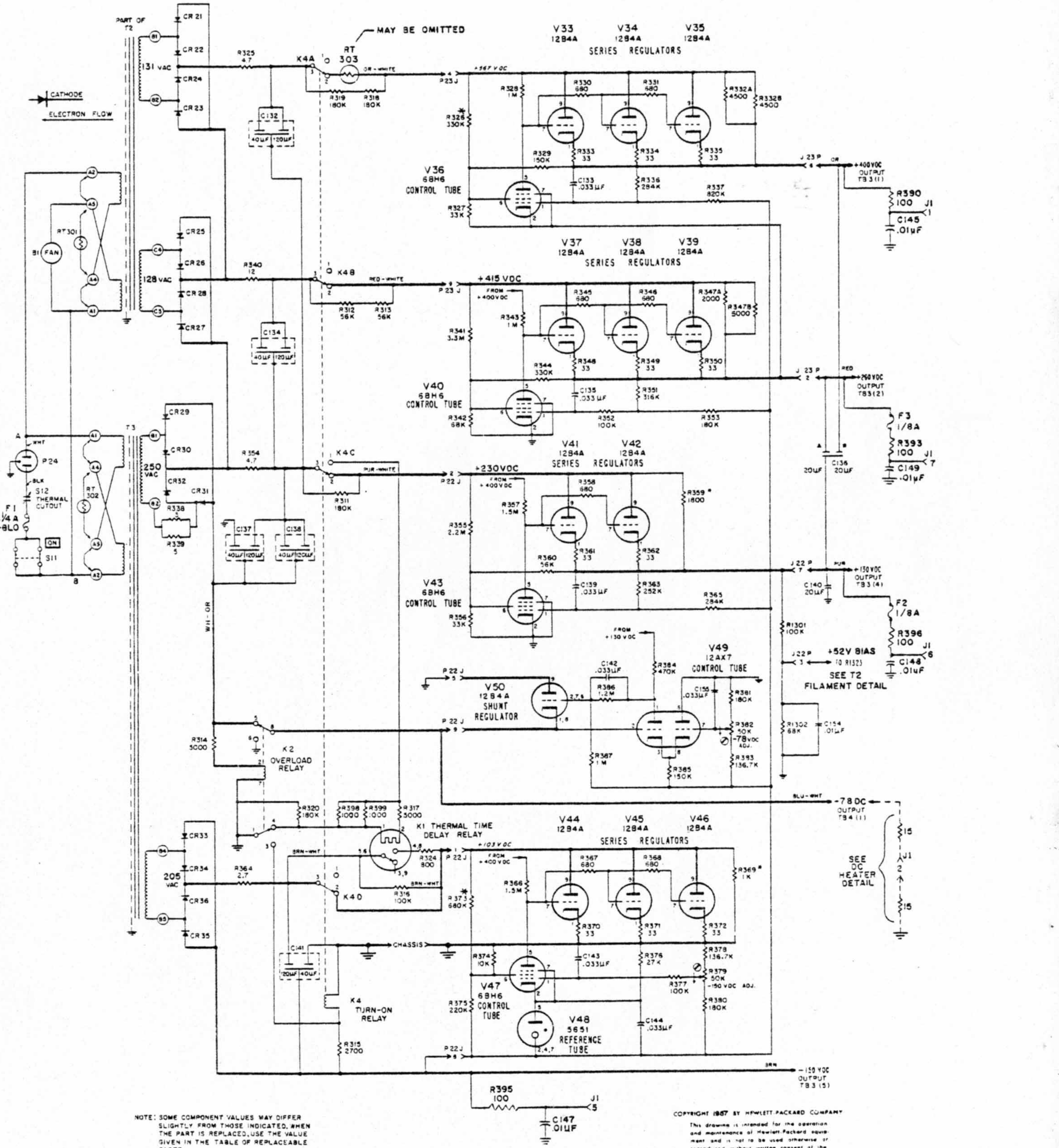
VOLTAGE – RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)



CONDITIONS OF MEASUREMENT

SET CONTROLS AS SHOWN ON SWEEP GENERATOR VOLTAGE AND RESISTANCE DIAGRAM ASSOCIATED WITH FIG. 4-11B.

VR-150A-LVPS-1440-S/M



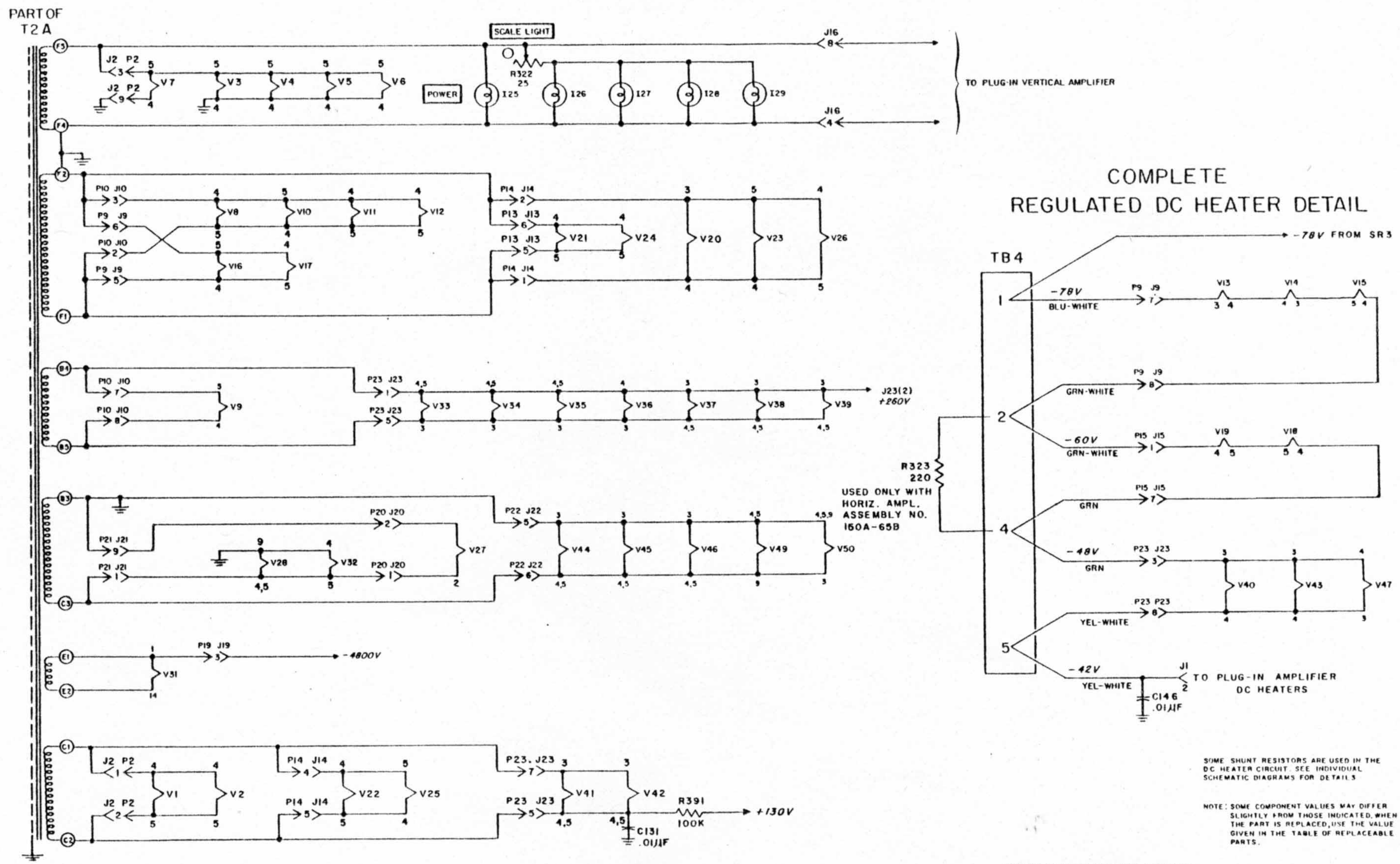
NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED. WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

LOW VOLTAGE POWER SUPPLY

SERIAL NO.1440 AND ABOVE

COMPLETE AC HEATER DETAIL

COMPLETE REGULATED DC HEATER DETAIL



SOME SHUNT RESISTORS ARE USED IN THE DC HEATER CIRCUIT. SEE INDIVIDUAL SCHEMATIC DIAGRAMS FOR DETAILS.

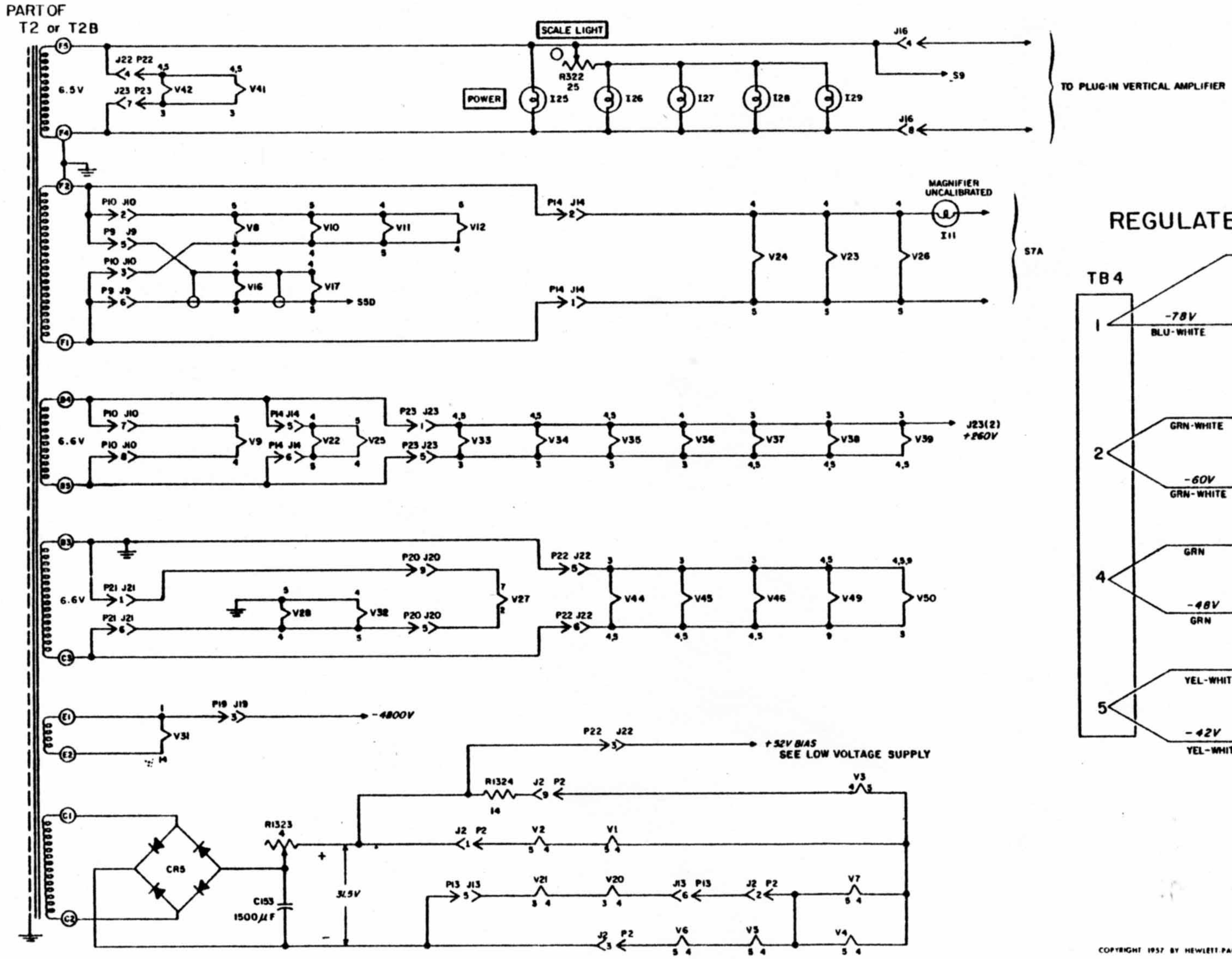
NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED, WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

150A-F-40-1389-S/M

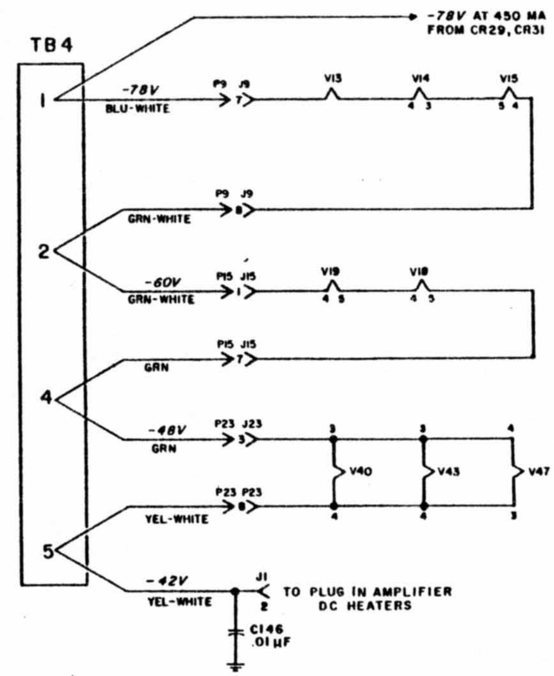
T2 FILAMENT DETAIL AND CONNECTORS

SERIAL NO. 40 THROUGH NO. 1389

T2 HEATER DETAIL



REGULATED DC HEATER DETAIL



SOME SHUNT RESISTORS ARE USED IN THE DC HEATER CIRCUIT. SEE INDIVIDUAL SCHEMATIC DIAGRAMS FOR DETAILS

NOTE: SOME COMPONENT VALUES MAY DIFFER SLIGHTLY FROM THOSE INDICATED. WHEN THE PART IS REPLACED, USE THE VALUE GIVEN IN THE TABLE OF REPLACEABLE PARTS.

150A-F-1390-S/M

T2 FILAMENT DETAIL AND CONNECTORS

SERIAL NO. 1390 AND ABOVE

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Readily available standard-components have been used in this instrument, whenever possible. However, special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. ⓗⓟ Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed give complete description, function, and location of part.

If there are any corrections for the Table of Replaceable Parts they will be listed on an Instruction Manual Change sheet at the front of this manual.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
B1	Fan Motor: 115 VAC, 60 Cycles	314-29				
B1A	Fan Blade: Aluminum, counterclockwise rotation, 5 blades	314-30				
C1	Capacitor: 0.022μf; not separately replaceable; part of a set of four matched capacitors (C1, C3, C5, C6)	150A-95D				
C2	Capacitor: fixed, titanium dioxide,).47μμf, ±5%, 500 vdcw	15-74				
C3	Part of C1					
C4	Capacitor: fixed, titanium dioxide, 0.47μμf, ±5%, 500 vdcw	15-74				
C5, C6	Part of C1					
C7	Capacitor: fixed, ceramic, 0.02μf, -0% +100%, 600 vdcw	15-85				
C8	Capacitor: variable, ceramic 5-25μμf, NPO temp coef	13-28				
C8A	Capacitor: variable, ceramic, 8-50μμf, N750 temp coef	13-23				
C9	Capacitor: fixed, mica, 47μμf, ±5%, 300 vdcw	14-74				
C9A	Capacitor: fixed, mica, 22μμf, ±5%, 500 vdcw	14-69				
C10	Capacitor: fixed, titanium dioxide, 3.9μμf, ±10%, 500 vdcw	15-126				
C11	Capacitor: fixed, mylar, 0.1μf, ±5%, 200 vdcw	16-103				
C12, C13	Capacitor: fixed, ceramic, 0.02μf, -0% +100%, 600 vdcw	15-85				
C14	Circuit reference not assigned					
C15	Capacitor: variable, mica, 110-580μμf, 175 vdcw	13-31				
C15A	Capacitor: fixed, electrical value selected at factory					
C16 thru C19	Circuit references not assigned					
C20	Capacitor: fixed, paper, 0.1μf, ±10%, 400 vdcw	16-35				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	℗ STOCK NO.				
C21	Capacitor: fixed, mica, 820μμf, ±10%, 500 vdcw	14-28				
C22	Capacitor: fixed, mylar, 0.01μf, ±5%, 200 vdcw	16-101				
C22A	Capacitor: fixed, ceramic, 0.01μf, ±20% 1000 vdcw	15-43				
C23	Capacitor: fixed, mica, 820μμf, ±10%, 500 vdcw	14-28				
C24	Capacitor: fixed, ceramic, 0.01μf, ±20% 1000 vdcw	15-43				
C25	Capacitor: fixed, mica, 39μμf, ±5%, 300 vdcw	14-70				
C26	Capacitor: fixed, paper, 0.022μf, ±10%, 600 vdcw	16-12				
C27	Capacitor: fixed, paper, 0.01μf, ±5%, 600 vdcw	16-51				
C27A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C28, 29	Capacitor: fixed, mica, 10μμf, ±10%, 500 vdcw	14-10				
C29A	Capacitor: fixed, mica, 22μμf, ±5%, 500 vdcw	14-69				
C30	Capacitor: fixed, mica, 10μμf, ±10%, 500 vdcw	14-10				
C31	Capacitor: fixed, silver mica, 820μμf, ±5%, 500 vdcw	15-104				
C32	Capacitor: fixed, mica, 100μμf, ±10%, 500 vdcw	14-73				
C33	Capacitor: fixed, paper, 0.01μf, ±5%, 600 vdcw	16-51				
C33A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C34	Capacitor: fixed, mica, 68μμf, ±10%, 500 vdcw	14-60				
C34A	Capacitor: fixed, titanium dioxide, 8.2μμf, ±10%, 500 vdcw	15-123				
C35	Capacitor: fixed, mica, 47μμf, ±5%, 300 vdcw	14-74				
C35A	Capacitor: fixed, silver mica, 200μμf, ±5%, 500 vdcw	15-103				
C36	Capacitor: fixed, mica, 0.01μf, ±10%, 300 vdcw	14-23				
C37	Capacitor: fixed, paper, 0.01μf, ±5%, 600 vdcw	16-51				
C37A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
C38	Capacitor: fixed, titanium dioxide, 6.8μμf, ±10%, 500 vdcw	15-148				
C39	Capacitor: fixed, paper, 0.01μf, ±5%, 600 vdcw	16-51				
C40	Capacitor: variable, ceramic, 3-12μμf, NPO temp coef	13-29				
C40A	Capacitor: variable, ceramic, 5-25μμf, NPO temp coef	13-28				
C41	Capacitor: fixed, mica, 150μμf, ±10%, 500 vdcw (rack mount only)	14-150				
C42	Capacitor: fixed, mica, 100μμf, ±10%, 300vdcw (rack mount only)	14-76				
C43	Capacitor: fixed, paper, 0.01μf, ±5%, 600 vdcw	16-51				
C43A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C44	Capacitor: fixed, titanium dioxide, 2.2μμf, ±10%, 500 vdcw	15-52				
C45	Circuit reference not assigned					
C46	Capacitor: fixed, paper, 0.01μf, ±5%, 600 vdcw	16-51				
C46A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C47	Capacitor: fixed, paper, 0.01μf, ±5%, 600 vdcw	16-51				
C47A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C48	Capacitor: fixed, ceramic, 10μμf, ±5%, 500 vdcw	15-30				
C49	Capacitor: fixed, mica, 100μμf, ±10%, 500 vdcw	14-73				
C50	Capacitor: fixed, paper, 0.01μf, ±20%, 400 vdcw	16-109				
C51	Capacitor: fixed, paper, 0.47μf, ±10%, 200 vdcw	16-37				
C52	Capacitor: fixed, paper, 0.051μf, ±10%, 200 vdcw	16-84				
C53	Capacitor: fixed, mica, 4700μμf, ±10%, 500 vdcw	14-44				
C54	Capacitor: fixed, mica, 470μμf, ±10%, 500 vdcw	14-62				
C55	Capacitor: fixed, mylar, 1.0μf, ±5%, 200 vdcw	16-102				
C56	Capacitor: fixed, mylar, 0.1μf, ±5%, 200 vdcw	16-103				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.				
C57	Capacitor: fixed, mylar, 0.01μf, ±5%, 200 vdcw	16-101				
C58	Capacitor: fixed, silver mica, 1000 $\mu\mu$f, ±5%, 500 vdcw	15-57				
C59	Capacitor: variable, ceramic, 7-45$\mu\mu$f, 500 vdcw	13-1				
C60	Capacitor: fixed, ceramic, 82$\mu\mu$f, ±5%, NPO temp coef	15-7				
C61	Capacitor: variable, ceramic, 8-50$\mu\mu$f, N750 temp coef	13-23				
C61A	Capacitor: variable, ceramic, 7-45$\mu\mu$f, 500 vdcw	13-1				
C62	Capacitor: fixed, ceramic, 82$\mu\mu$f, ±5%, NPO temp coef, 500 vdcw	15-7				
C63	Capacitor: fixed, mica, 39$\mu\mu$f, ±5%, 300 vdcw	14-70				
C63A	Capacitor: variable, ceramic, 1.5-7$\mu\mu$f; NPO temp coef	13-27				
C63B	Capacitor: fixed, mica, 22$\mu\mu$f, ±5%, 500 vdcw	14-69				
C64	Capacitor: variable, ceramic, 5-25$\mu\mu$f, NPO temp coef	13-28				
C65	Capacitor: variable, ceramic, 3-12$\mu\mu$f, NPO temp coef	13-29				
C66	Capacitor: fixed, ceramic, 5$\mu\mu$f, ±.5%, NPO temp coef, 500 vdcw	15-29				
C67	Capacitor: variable, ceramic, 1.5-7$\mu\mu$f, NPO temp coef	13-27				
C68,69	Circuit references not assigned					
C70	Capacitor: fixed, mica, 27$\mu\mu$f, ±5%, 300 vdcw	14-78				
C71	Capacitor: variable, ceramic, 1.5-7$\mu\mu$f, NPO temp coef	13-27				
C71A	Capacitor: variable, ceramic, 5-25$\mu\mu$f, NPO temp coef	13-28				
C72	Capacitor: variable, ceramic, 1.5-7$\mu\mu$f; NPO temp coef	13-27				
C72A	Capacitor: variable, ceramic, 5-25$\mu\mu$f, NPO temp coef	13-28				
C73	Capacitor: fixed, mica, 47$\mu\mu$f, ±10%, 500 vdcw	14-67				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
C73A	Capacitor: fixed, mica, 82$\mu\mu$f, ±10%, 500 vdcw	14-19				
C74	Capacitor: fixed, mica, 47$\mu\mu$f, ± 10%, 500 vdcw	14-67				
C74A	Capacitor: variable, ceramic, 1.5-7$\mu\mu$f, NPO temp coef	13-27				
C74B,75	Capacitor: variable, ceramic, 5-25$\mu\mu$f, NPO temp coef	13-28				
C76	Capacitor: fixed, ceramic, 0.01μf,±20%, 1000 vdcw	15-43				
C77,78	Capacitor: variable, ceramic, 8-50$\mu\mu$f; N750 temp coef	13-23				
C79	Capacitor: fixed, mica, 82$\mu\mu$f, ±10%, 500 vdcw	14-19				
C80	Capacitor: fixed, titanium dioxide, 3.3$\mu\mu$f,±10%, 500 vdcw	15-78				
C80A	Capacitor: variable, ceramic, 1.5-7$\mu\mu$f, NPO temp coef	13-27				
C81	Capacitor: fixed, mica, 820$\mu\mu$f,±10%, 500 vdcw	14-28				
C82	Capacitor: variable, ceramic, 5-25$\mu\mu$f, NPO temp coef	13-28				
C82A	Capacitor: fixed, titanium dioxide, 8.2$\mu\mu$f,±10%, 500 vdcw	15-123				
C82B	Capacitor: fixed, ceramic, 10$\mu\mu$f ±.5%, 500 vdcw	15-30				
C83	Capacitor: fixed, titanium dioxide, 1.0$\mu\mu$f,±10%, 500 vdcw	15-102				
C84	Capacitor: variable, ceramic, 7-45$\mu\mu$f, 500 vdcw	13-1				
C85	Capacitor: variable, clip, 0-.5$\mu\mu$f	150A-7A				
C86	Capacitor: variable, ceramic, 5-20$\mu\mu$f, 500 vdcw	13-20				
C87	Capacitor: fixed, mica, 200$\mu\mu$f,±10%, 500 vdcw	14-200				
C87A	Capacitor: fixed, mica, 150$\mu\mu$f,±10%, 500 vdcw	14-150				
C88	Capacitor: variable, ceramic, 7-45$\mu\mu$f, 500 vdcw	13-1				
C89	Capacitor: variable, clip 0-.5$\mu\mu$f	150A-7A				
C90,91	Capacitor: fixed, mica, 0.01μf , ±10%, 300 vdcw	14-23				
C92	Capacitor: fixed, paper, 0.02μf,±5%, 600 vdcw	16-52				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
C92A	Capacitor: fixed, ceramic disc 0.02μf, -0% +100%, 600vdcw	15-85				
C93	Capacitor: fixed, paper, 0.02μf, ±5%, 600 vdcw	16-52				
C93A	Capacitor: fixed, ceramic disc 0.02μf, -0% +100%, 600 vdcw	15-85				
C94	Capacitor: fixed, paper, 0.02μf, ±5%, 600 vdcw	16-52				
C94A	Capacitor: fixed, ceramic disc 0.02μf, -0% +100%, 600 vdcw	15-85				
C95, C96	Capacitor: fixed, titanium dioxide, 8.2μμ, ±10%, 500 vdcw	15-123				
C97	Circuit reference not assigned					
C98	Capacitor: fixed, mica, 27μμf, ±10%, 500 vdcw	14-17				
C99, C100	Circuit references not assigned					
C101	Capacitor: fixed, paper, 2200μμf, ±10%, 600 vdcw	16-22				
C102	Capacitor: fixed, paper, 0.1μf, ±10%, 600 vdcw	16-1				
C103	Capacitor: fixed, mica, 3300μμf, ±10%, 500 vdcw	14-64				
C104	Capacitor: fixed, mica, 470μμf, ±10%, 500 vdcw	14-62				
C104A	Capacitor: fixed, mica, 820μμf, ±10%, 500 vdcw	14-28				
C105	Capacitor: fixed, paper, 0.051μf, ±10%, 200 vdcw	16-84				
C105A	Capacitor: fixed, paper, 4700μμf, ±20%, 6000 vdcw	16-75				
C105B	Capacitor: fixed, paper, 0.1μf, ±10%, 600 vdcw	16-1				
C106	Capacitor: fixed, mica, 56μμf, ±10%, 500 vdcw	14-41				
C106A	Capacitor: fixed, paper, 0.082μf, ±10%, 600 vdcw	16-70				
C106B	Capacitor: fixed, paper, 0.1μf, ± 10%, 600 vdcw	16-1				
C107	Capacitor: fixed, mica, 10μμf, ±10%, 500 vdcw	14-10				
C107A	Capacitor: fixed, mica, 220μμf, ±5%, 500 vdcw	14-66				
C108	Capacitor: fixed, paper, 1μf, ±10%, 600 vdcw	17-12				
C108A	Capacitor: variable, ceramic, 7-45μμf, 500 vdcw	13-1				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
C109	Capacitor: fixed, paper H.V., 1500μμf, 6000 vdcw	16-132				
C109A	Capacitor: fixed, paper, 4700μμf,±20%, 6000 vdcw	16-75				
C110	Capacitor: fixed, paper H.V., 1500μμf, 6000 vdcw	16-132				
C110A, C111	Capacitor: fixed, paper, 4700μμf,±20%, 6000 vdcw	16-75				
C112	Capacitor: fixed, ceramic, 470μμf,±20%, 6000 vdcw	15-128				
C113, C114	Capacitor: fixed, paper, 4700μμf,±20%, 6000 vdcw	16-75				
C115	Capacitor: fixed, ceramic, 0.01μf,±20%, 1000 vdcw	15-43				
C116	Capacitor: fixed, silver mica, 200μμf,±5%, 500 vdcw	15-103				
C116A	Capacitor: fixed, silver mica, 220μμf,±5%, 500 vdcw	15-76				
C117	Capacitor: fixed, silver mica, 200μμf,±5%, 500 vdcw	15-103				
C117A	Capacitor: fixed, silver mica, 220μμf,±5%, 500 vdcw	15-76				
C118	Capacitor: fixed, paper, 0.01μf,±5%, 600 vdcw	16-51				
C118A	Capacitor: fixed, ceramic, 0.01μf,±20%, 1000 vdcw	15-43				
C119	Capacitor: fixed, mica, 15μμf, ±10%, 500 vdcw	14-15				
C120, C121	Capacitor: fixed, paper, 0.4700μμf,±20%, 6000 vdcw	16-75				
C121A	Capacitor: fixed, mica, 56μμf,±10%, 500 vdcw	14-41				
C122, C123	Capacitor: fixed, paper, 0.4700μμf,±20%, 6000 vdcw	16-75				
C124 - C130	Circuit references not assigned					
C131	Capacitor: fixed, ceramic, 0.01μf,±20%, 1000 vdcw	15-43				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
C132	Capacitor: fixed, electrolytic, 2 sections, 120 x 40μf, 400 vdcw	18-51HP				
C133	Capacitor: fixed, paper, 0.033μf, ±10%, 400 vdcw	16-108				
C133A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C134	Capacitor: fixed, electrolytic, 2 sections, 120 x 40μf, 400 vdcw	18-51HP				
C135	Capacitor: fixed, paper, 0.033μf, ±10%, 400 vdcw	16-108				
C135A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C136	Capacitor: fixed, electrolytic, 4 section, 20μf, each section 450 vdcw	18-42HP				
C137, C138	Capacitor: fixed, electrolytic, 2 sections, 120 x 40μf, 400 vdcw	18-51HP				
C139	Capacitor: fixed, paper, 0.033μf, ±10%, 400 vdcw	16-108				
C139A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C140	Capacitor: fixed, electrolytic, 4 section, 20μf, each section 450 vdcw	18-42HP				
C141	Capacitor: fixed, electrolytic, 2 sections, 120 x 40μf, 400 vdcw	18-51HP				
C142	Capacitor: fixed, paper, 0.033μf, ±10%, 400 vdcw	16-108				
C142A	Capacitor: fixed, ceramic, 0.01μf, ±20% 1000 vdcw	15-43				
C143	Capacitor: fixed, paper, 0.033μf, ±10%, 400 vdcw	16-108				
C143A	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				
C144	Capacitor: fixed, paper, .033μf, ±10%, 400 vdcw	16-108				
C144A and C145 thruC149	Capacitor: fixed, ceramic, 0.01μf, ±20%, 1000 vdcw	15-43				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.				
C150-C152	Capacitor: fixed, ceramic disc; 0.02μf,-0%+100%, 600 vdcw	15-85				
C153	Capacitor: fixed, electrolytic, 1 section, 1500μf, 50 vdcw	18-61HP				
C154	Capacitor: fixed, paper, 0.01μf,±5%, 600 vdcw	16-51				
C155	Capacitor: fixed, paper, 0.033μf,±10%, 400 vdcw	16-108				
CR1,CR2	Crystal diode: type 1N55	212-1N55				
CR3	Crystal diode	212-G11A				
CR4	Crystal diode: type 1N38A	212-1N38A				
CR5	Rectifier: selenium, bridge	212-125				
CR6,CR7	Crystal diode	212-G11A				
CR8,thru CR10	Breakdown diodes: selected set of three	G-172A				
CR11 thru CR18	Breakdown diodes: 2 selected sets of four	G-172B				
CR19, CR20	Circuit references not assigned					
CR21-CR28	Rectifier: silicon, 400 v PIV	212-126				
CR29-CR32	Rectifier: silicon, 500 v PIV	212-141				
CR33-CR36	Rectifier: silicon, 400 v PIV	212-126				
CR37-CR40	Rectifier: silicon, 500 v PIV	212-141				
DL1A, DL1B	Delay lines: matched pair 2200 ohms	150A-16AF				
DL2A, DL2B	Delay lines: matched pair 2400 ohms	150A-16A				
F1	Fuse: cartridge, 6.25 amp, 'slow blow' (115 v operation) Fuse: cartridge, 3.2 amp, 'slow blow' (230 v operation)	211-61 211-45				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.					
F2, F3	Fuse cartridge, 1/8 amp, 'fast blow'	211-67					
I1, I2	Indicator: neon, type NE2	211-43					
I3, I4	Indicator: neon, selected, blue coding, NE2	G-84B					
I5	Indicator: neon, selected, green coding, NE2	G-84D					
I6	Indicator: neon, glow, 1/25 W NE51	211-27					
I7 - I10	Circuit references not assigned						
I11, I12	Indicator: incandescent, 6 v type 51	211-70					
I13-I16	Indicator: neon, selected, blue coding, NE2	G-84B					
I17-I24	Circuit references not assigned						
I25	Lamp: pilot, #47	211-47					
I26 thru I29	Lamp: graticule, #47	211-47					
J1	Connector: 8 pin, blue ribbon, plug-in amplifier, main vertical signal in-put	125-6					
J2	Connector: 9 pin min, main vertical power in-put	120-10					
J3	EXT SYNC INPUT: Insulator Binding Post: red Binding Post: black	AC-54A AC-10D AC-10C					
J4	Connector: type BNC, EXT SYNC INPUT	125-9					
J5, J6, J7	Connector: type BNC, SWEEP RESET, GATE OUTPUT, SWEEP OUTPUT	125-UG1094/U					
J8 thru J10	Connector: 9 pin min, SWEEP GEN. POWER INPUT	G-76D					
J11	Connector: type BNC, EXT HORIZONTAL INPUT	125-9					
J12	EXT HORIZONTAL INPUT: Insulator: Binding post: red Binding post: black	 AC-54A AC-10D AC-10C					
J13, J14, J15	Connector: 9 pin min, HORIZONTAL AMP POWER INPUT	G-76D					

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
J16	Connector: 8 pin, blue ribbon, plug-in amplifier, MAIN VERTICAL SIGNAL IN-PUT	125-6				
J17	Z AXIS MODULATION INPUT:					
	Insulator:	AC-54A				
	Binding post: red	AC-10D				
	Binding post: black	AC-10C				
J18	CALIBRATOR OUTPUT:					
	Insulator:	AC-54D				
	Binding post: red	AD-10D				
J19 thru J23	Connector: 9 pin min: Calib and HV bd to CRT Calib and HV bd to HV power supply Calib and HV bd power input (2) L.V. Regulator	G-76D				
K1	Relay: thermal, time delay	49-24				
K2	Relay: overload, DPDT, coil 115 vdc	49-28				
K2 A	Relay: overload, DPDT, coil, 26.5 vdc	49-10				
K3	Circuit reference not assigned					
K4	Relay: turn-on, 4 PDT coil 115 vdc	49-26				
K4A thru K4D	Part of K4					
K4E	Relay: turn-on, DPDT, coil 115 vdc	49-23				
K4F	Part of K4E					
L1, L2	Coil Assy: bridged "T", 45 μh ferrite core	150A-60J				
L3, L4	Coil, R. F.: 9μh	150A-60D				
L5 thru L7	Circuit references not assigned					
L8	Coil: choke, 10μh,±10%	48-54				
L9	Circuit reference not assigned					
L10, L11	Coil, R.F.: 35μh,±10%	48-42				
L12	Coil: R.F., 100μh	150A-60K				
L12A	Coil: R.F., 100μh	150A-60A				
L13	Coil: 240μh	150A-60L				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
L13A	Coil: 270μh	150A-60G				
L14	Coil, R.F.: 20mh	150A-60E				
L15	Coil, R.F.: 5.5mh	150A-60M				
L15A	Coil, R.F.: 5.5mh	150A-60B				
L16	Coil, R.F.: 5.5mh	150A-60M				
L16A	Coil, R.F.: 5.5mh	150A-60B				
L17, 18	Coil, R.F.: 35μh, ±10%	48-42				
L19 - L29	Circuit references not assigned					
L30	Coil, R.F.: 200μh	48-34				
L31	Coil, R.F.: 16mh	48-5				
P1	This circuit reference not assigned					
P2	Plug: 9 pin, min, short MAIN VERTICAL POWER	150A-95F				
P3, P7	Circuit references not assigned					
P8, P9, P10	Plug: 9 pin min, long, SWEEP GEN POWER INPUT	150A-95E				
P11, P12	Circuit references not assigned					
P13,P14, P15	Plug: 9 pin min long; HORIZ AMP POWER INPUT	150A-95E				
P16 thru P18	Circuit references not assigned					
P19	Plug Assy: Calib and HV bd to CRT (HV)	150A-95T				
P20, thru P23	Plug: 9 pin min long; Calib and HV bd to HV power supply Calib and HV bd power input L.V. regulator (2)	150A-95E				
P24	Plug: 3 wire, NEMA; AC power cord	812-56				
R1	Resistor: fixed, metal film, 2200 ohms, ±1%, 4 W	334-2.2K				
R1A	Resistor: fixed, composition, 200 ohms, ±5%, 1/2 W	23-200-5				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.			
R2, R3	Resistor: fixed, composition, 47 ohms,±10%, 1/2 W	23-47			
R4	Resistor: fixed, composition, 180,000 ohms, ±1% 1/2 W	33-180K			
R5	Resistor: variable, 100 ohms,±20%, .2 W	210-166			
R6, R7	Resistor: fixed, metal film, 5000 ohms,±5%, 5 W	335-5K-5			
R8	Resistor: fixed, metal film, 2200 ohms,±1%, 4 W	334-2.2K			
R8A	Resistor: fixed, composition, 200 ohms,±5%, 1/2 W	23-200-5			
R9 thru R11	Resistor: fixed, composition, 180,000 ohms,±1%, 1/2 W	33-180K			
R12	Resistor: fixed, deposited carbon, 2200 ohms,±1%, 1/4 W	30-2.2K			
R12A	Resistor: fixed, deposited carbon, 195 ohms,±1%, 1/8 W	30-195			
R13	Resistor: fixed, deposited carbon, 2200 ohms,±1%, 1/4 W	30-2.2K			
R13A	Resistor: fixed, deposited carbon, 195 ohms,±1%, 1/8 W	30-195			
R14	Resistor: fixed, wirewound, 1000 ohms,±10%, 10 W	26-17			
R15	Resistor: fixed, composition, 47 ohms,±10%, 1/2 W	23-47			
R16	Resistor: fixed, composition, 6800 ohms,±10%, 1 W	24-6800			
R16A	Resistor: fixed, composition, 4700 ohms,±10%, 1 W	24-4700			
R17	Resistor: fixed, composition, 6800 ohms,±10%, 1 W	24-6800			
R17A	Resistor: fixed, composition, 4700 ohms,±10%, 1 W	24-4700			
R18	Resistor: fixed, composition, 47 ohms,±10%, 1/2 W	23-47			
R19	Resistor: fixed, composition, 6800 ohms,±10%, 1 W	24-6800			

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R19A	Resistor: fixed, composition, 4700 ohms, ±10%, 1 W	24-4700				
R20	Resistor: fixed, composition, 6800 ohms, ±10%, 1 W	24-6800				
R20A	Resistor: fixed, composition, 4700 ohms, ±10%, 1 W	24-4700				
R21, 22	Resistor: fixed, composition, 47 ohms, ±10%, 1/2 W	23-47				
R23	Resistor: fixed, composition, 470 ohms, ±5%, 1/2 W	23-470-5				
R24	Resistor: fixed, metal film, 1750 ohms, ±5%, 7 W	337-1750-5				
R25	Resistor: fixed, metal film, 2000 ohms, ±5%, 7 W	337-2K-5				
R26	Resistor: fixed, composition, 470 ohms, ± 5%, 1/2 W	23-470-5				
R27	Resistor: fixed, metal film, 400 ohms, ±5%, 3 W	333-400-5				
R27A	Resistor: fixed, metal film, 470 ohms, ±5%, 4 W	334-470-5				
R28	Resistor: fixed, metal film, 400 ohms, ±5%, 3 W	333-400-5				
R28A	Resistor: fixed, metal film, 470 ohms, ±5%, 4 W	334-470-5				
R29	Resistor: fixed, metal film, 400 ohms, ±5%, 3 W	333-400-5				
R30, 31	Resistor: fixed, composition, 470 ohms, ±5%, 1/2 W	23-470-5				
R32	Resistor: fixed, metal film, 2000 ohms, ±5%, 7 W	337-2K-5				
R33	Resistor: fixed, metal film, 1750 ohms, ±5%, 7 W	337-1750-5				
R34	Resistor: fixed, composition, 10 megohms, ±10%, 1/2 W	23-10M				
R35	Resistor: fixed, composition, 3.3 megohms, ±10%, 1/2 W	23-3.3M				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R36	Resistor: fixed, composition, 47 ohms, ±10%, 1/2 W	23-47				
R37	Resistor: fixed, composition, 2200 ohms, ±10%, 1 W	24-2200				
R38	Resistor: fixed, composition, 91 ohms, ±5%, 1/2 W	23-91-5				
R39	Resistor: fixed, composition, 47 ohms, ± 10%, 1/2 W	23-47				
R40	Resistor: fixed, metal film, 6500 ohms, ±5%, 3 W	333-6500-5				
R41	Resistor: fixed, composition, 47 ohms, ±10%, 1/2 W	23-47				
R42A/B	Resistor: variable, composition, dual tandem, 10,000 ohms, ±20%, each section	210-202				
R43	Resistor: fixed, composition, 22 ohms, ±10%, 1/2 W	23-22				
R44	Resistor: fixed, composition, 3900 ohms, ±10%, 1/2 W	23-3900				
R45	Resistor: fixed, composition, 68 ohms, ±10%, 2 W	25-68				
R45A	Resistor: fixed, composition, 120 ohms, ±10%, 1 W	24-120				
R46	Resistor: fixed, composition, 39 ohms, ±10%, 2 W	25-39				
R46A	Resistor: fixed, composition, 68 ohms, ±10%, 2 W	25-68				
R47 thru R50	Circuit references not assigned					
R51, 52	Resistor: fixed, composition, 680,000 ohms, ±10%, 1/2 W	23-680K				
R53	Resistor: fixed, composition, 270,000 ohms, ±10%, 1/2 W	23-270K				
R54	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2 W	23-220K				
R55	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.
R56	Resistor: fixed, composition, 2.2 megohms, ±10%, 1/2W	23-2.2M
R57	Resistor: not separately replaceable; part of S2	
R58	Resistor: fixed, composition, 47,000 ohms, ±10%, 1/2 W	23-47K
R59	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W	23-470K
R60	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56
R61, 62	Resistor: fixed, composition, 2200 ohms, ±10%, 1 W	24-2200
R63	Resistor: fixed, metal film, 24,000 ohms, ±10%, 4 W	334-24K
R63A	Resistor: fixed, metal film, 20,000 ohms, ±10%, 4 W	334-20K
R64, 65	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56
R66	Resistor: variable, composition, linear taper, 2000 ohms, ±30%, 1/3 W	210-133
R67	Resistor: fixed, composition, 100 ohms, ±10%, 1/2 W	23-100
R68	Circuit reference not assigned	
R69	Resistor: fixed, metal film, 10,000 ohms, ±5%, 3 W	333-10K-5
R70	Resistor: fixed, deposited carbon, 200,000 ohms, ±1%, 1/2 W	33-200K
R71	Resistor: fixed, composition, 526,000 ohms, ±1%, 1 W	31-526K
R72	Resistor: variable, composition, 100,000 ohms, ±30%, 1/4 W	210-138
R73	Circuit reference not assigned	
R74	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56
R75	Resistor: fixed, metal film, 6500 ohms, ±5%, 3 W	333-6500-5

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.
R76	Resistor: fixed, metal film, 10,000 ohms, ±5%, 4 W	334-10K
R77	Resistor: fixed, composition, 100 ohms, ±10%, 1/2 W	23-100
R78	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56
R79, 80	Resistor: fixed, composition, 37,000 ohms, ±1%, 1 W	31-37K
R81	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56
R82	Resistor: fixed, composition, 1000 ohms, ±10%, 1/2 W	23-1000
R83	Resistor: fixed, composition, 37,000 ohms, ±1%, 1 W	31-37K
R84	Resistor: fixed, composition, 56,000 ohms, ±10%, 1 W	24-56K
R85	Resistor: fixed, composition, 560,000 ohms, ±10%, 1/2 W	23-560K
R86	Resistor: fixed, composition, 180,000 ohms, ±10%, 1/2 W	23-180K
R87	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	23-56
R88	Resistor: variable, composition, linear taper, 5000 ohms, ±30%, 1/3 W	210-134
R89	Resistor: fixed, composition, 47,000 ohms, ±10%, 2 W	25-47K
R90	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56
R91	Resistor: fixed, metal film, 15,000 ohms, ±5%, 4 W	334-15K-5
R91A	Resistor: fixed, metal film, 30,000 ohms, ±10%, 4 W	334-30K
R92	Resistor: fixed, composition, 180,000 ohms, ±10%, 1/2 W	23-180K
R93	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.				
R94	Resistor: fixed, composition, 5600 ohms, ±10%, 1/2 W	23-5600				
R95	Resistor: fixed, metal film, 75,000 ohms, ±10%, 7 W	337-75K				
R96	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2 W	23-22K				
R97	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	23-56				
R98	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2 W	23-330K				
R99	Resistor: fixed, composition, 82,000 ohms, ±5%, 1/2 W	23-82K				
R100	Resistor: not separately replaceable; part of S1, includes S3					
R101	Resistor: fixed, composition, 390,000 ohms, ±10%, 1/2 W	23-390K				
R102	Resistor: fixed, composition, 39,000 ohms, ±10%, 1/2 W	23-39K				
R102A	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2 W	23-22K				
R103	Resistor: variable, composition, 100,000 ohms, ±30%, 1/4 W	210-138				
R103A	Resistor: variable, composition, 20,000 ohms, ±20%, 1/4 W	210-136				
R104	Resistor: fixed, composition, 150,000 ohms, ±10%, 1/2 W	23-150K				
R104A	Resistor: fixed, composition, 82,000 ohms, ±5%, 1/2 W	23-82K				
R105	Resistor: fixed, composition, 33,000 ohms, ±10%, 1/2 W	23-33K				
R106	Resistor: fixed, composition, 270,000 ohms, ±10%, 1/2 W	23-270K				
R107	Resistor: fixed, composition, 27,000 ohms, ±10%, 2 W	25-27K				
R108	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R109	Resistor: fixed, composition, 27,000 ohms, ±10%, 2 W	25-27K				
R110	Resistor: fixed, deposited carbon, 166,000 ohms, ±1%, 1 W	31-166K				
R111	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R112	Resistor: fixed, composition, 90,000 ohms, ±10%, 1 W	31-90K				
R113, R114	Resistor: fixed, composition, 4.7 megohms, ±10%, 1/2 W	23-4.7M				
R115	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R116	Resistor: fixed, composition, 390,000 ohms, ±10%, 1/2 W	23-390K				
R117	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2 W	23-330K				
R118	Resistor: fixed, composition, 18,000 ohms, ±10%, 1/2 W	23-18K				
R118A	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2 W	23-22K				
R119	Resistor: fixed, composition, 27,000 ohms, ±10%, 2 W	25-27K				
R120	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R121	Resistor: fixed, metal film, 20,000 ohms, ±5%, 3 W	333-20K-5				
R122	Resistor: variable, composition, 10,000 ohms, ±20%, 1/4 W	210-135				
R123	Resistor: fixed, metal film, 15,000 ohms, ±5%, 4 W	334-15K-5				
R124	Resistor: fixed, composition, 470,000 ohms, ±10%, 1/2 W	23-470K				
R125	Resistor: fixed, composition, 1.2 megohms, ±10%, 1/2 W	23-1.2M				
R126	Resistor: fixed, composition, 820,000 ohms, ±10%, 1/2 W	23-820K				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R127	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	23-56				
R128	Resistor: fixed, composition, 47,000 ohms, ±10%, 2 W	25-47K				
R129	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2 W	23-330K				
R130 R131	Resistor: fixed, composition, 56 ohms,±10%, 1/2 W	23-56				
R132	Resistor: fixed, composition, 39 ohms, ±5%, 2 W	25-39-5				
R133	Resistor: fixed, composition, 1200 ohms, ±10%, 1/2 W	23-1200				
R134	Resistor: fixed, composition, 68 ohms, ±10%, 2 W	25-68				
R135	Resistor: variable, composition, 10,000 ohms, ±5%, 3 W	210-135				
R136	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				
R137, R138, R139	Circuit references not assigned					
R140	Resistor: fixed, composition, 150,000 ohms, ±10%, 1/2 W	23-150K				
R141	Resistor: fixed, composition, 470,000 ohms, ±10%, 1/2 W	23-470K				
R142	Resistor: fixed, composition, 150,000 ohms, ±10%, 1/2 W	23-150K				
R143	Resistor: variable, composition, 20,000 ohms, ±20%, 1/4 W	210-136				
R143A	Resistor: variable, composition, 10,000 ohms, ±20%, 1/4 W	210-135				
R144	Resistor: variable, composition, 20,000 ohms, ±20%, 1/4 W	210-136				
R144A	Resistor: variable, composition, 10,000 ohms, ±20%, 1/4 W	210-135				
R145	Resistor: variable, composition, 20,000 ohms, ±20%, 1/4 W	210-136				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R145A	Resistor: variable, composition, 10,000 ohms, ±20%, 1/4 W	210-135				
R146	Resistor: variable, composition, linear taper, 50,000 ohms, ±30%, 1/2 W, includes S6 BO*	210-153				
R147	Resistor: fixed, composition, 15,000 ohms, ±10%, 1/2 W	23-15K				
R148	Resistor: fixed, deposited carbon, 36 megohms, ±1%, 2 W	32-36M				
R149, R150	Resistor: fixed, deposited carbon, 12 megohms, ±1%, 1 W	31-12M				
R151	Resistor: fixed, deposited carbon, 3.6 megohms, ±1%, 1/2 W	33-3.6M				
R152, R153	Resistor: fixed, deposited carbon, 1.2 megohms, ±1%, 1/2 W	33-1.2M				
R154	Resistor: fixed, deposited carbon, 360,000 ohms, ±1%, 1/2 W	33-360K				
R155, R156	Resistor: fixed, deposited carbon, 120,000 ohms, ±1%, 1/2 W	33-120K				
R157	Resistor: variable, composition, 20,000 ohms, ±20%, 1/4 W	210-136				
R157A	Resistor: variable, composition, 10,000 ohms, ±20%, 1/4 W	210-135				
R158, R159	Resistor: fixed, composition, 56,000 ohms, ±10%, 1/2 W	23-56K				
R160	Resistor: fixed, deposited carbon, 120,000 ohms, ±1%, 1/2 W	33-120K				
R161	Resistor: fixed, composition, 100 ohms, ±10%, 1/2 W	23-100				
R162	Resistor: fixed, composition, 10 ohms ±10%, 1 W	24-10				
R162A, 163 R164, 165, R166	Resistor: fixed, composition, 5600 ohms, ±10%, 1/2 W	23-5600				
R167, 168	Circuit references not assigned					
R169	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2 W	23-22K				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R170	Resistor: fixed, composition, 39,000 ohms, ±10%, 1/2 W	23-39K				
R171	Resistor: fixed, deposited carbon, 900,000 ohms, ±1%, 1/2 W	33-900K				
R172	Resistor: fixed, deposited carbon, 111,000 ohms, ±1%, 1/2 W	33-111K				
R173	Resistor: fixed, deposited carbon, 1 megohm, ±1%, 1/2 W	33-1M				
R174	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	23-56				
R175	Resistor: fixed, composition, 4900 ohms, ±1%, 1 W	31-4900				
R175A	Resistor: fixed, composition, 18,000 ohms, ±10%, 1 W	24-18K				
R176	Resistor: fixed, composition, 92,600 ohms, ±1%, 1/2 W	33-92.6K				
R176A	Resistor: fixed, composition, 27,000 ohms, ±10%, 2 W	25-27K				
R177	Resistor: variable, composition, 10,000 ohms, ±30%, 1/2 W, includes S8	210-161				
R178	Resistor: variable, composition, 2000 ohms, ±30%, 1/3 W	210-133				
R179	Resistor: fixed, metal film, 15,000 ohms, ±5%, 4 W	334-15K-5				
R179A, R180	Resistor: fixed, composition, 33,000 ohms, ±10%, 2 W	25-33K				
R181	Resistor: fixed, composition, 33,000 ohms, ±10%, 2 W	31-33K				
R181A	Resistor: fixed, deposited carbon, 100,000 ohms, ±1%, 1 W	31-100K				
R182	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R183	Resistor: fixed, deposited carbon, 193,000 ohms, ±1%, 1 W	31-193K				
R183A	Resistor: fixed, composition, 47,000 ohms, ±10%, 1/2 W	23-47K				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.				
R184	Resistor: fixed, composition, 47,000 ohms, ±10%, 2 W	25-47K				
R184A	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				
R185	Resistor: variable, composition, linear taper, 1000 ohms, ±30%, 2 W	210-206				
R185A	Resistor: variable, composition, linear taper, 1 megohm, ±30%, 1/4 W	210-139				
R186	Resistor: variable, 50,000 ohms, ±5%, 3 W	210-169				
R187	Resistor: fixed, deposited carbon, 166,000 ohms, ±1%, 1 W	31-166K				
R188	Resistor: fixed, composition, 49,000 ohms, ±1%, 1 W	31-49K				
R188A	Resistor: fixed, deposited carbon, 123,000 ohms, ±1%, 1 W	31-123K				
R189	Resistor: variable, composition, linear taper, 500,000 ohms, ±30%, 1/4 W	210-146				
R190	Resistor: fixed, composition, 270,000 ohms, ±10%, 1/2 W	23-270K				
R190A	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2 W	23-220K				
R191	Resistor: fixed, deposited carbon, 51,600 ohms, ±1%, 1 W	31-51.6K				
R191A	Resistor: fixed, deposited carbon, 62,000 ohms, ±1%, 1 W	31-62K				
R192	Resistor: fixed, deposited carbon, 15,500 ohms, ±1%, 1/2 W	33-15.5K				
R192A	Resistor: fixed, deposited carbon, 15,200 ohms, ±1%, 1 W	31-15.2K				
R193	Resistor: fixed, composition, 68 ohms, ±10%, 2 W	25-68				
R193A	Resistor: fixed, composition, 150 ohms, ±10%, 1/2 W	23-150				
R194	Resistor: fixed, deposited carbon, 193,000 ohms, ±1%, 1 W	31-193K				
R195	Resistor: fixed, composition, 1800 ohms, ±10%, 1/2 W	23-1800				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R196	Resistor: fixed, deposited carbon, 1.39 megohms, ±1%, 1/2 W	33-1.39M				
R196A	Resistor: fixed, deposited carbon, 2.163 megohms, ±1%, 1 W	31-2.163M				
R197	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R198	Resistor: fixed, composition, 160,000 ohms, ±1%, 1 W	31-160K				
R198A	Resistor: fixed, deposited carbon, 83,000 ohms, ±1%, 1 W	31-83K				
R199	Resistor: variable, composition, linear taper, 500,000 ohms, ±30%, 1/4 W	210-146				
R200	Resistor: fixed, metal film, 38,000 ohms, ±10%, 4 W	334-38K				
R201, R202	Resistor: fixed, composition, 680,000 ohms, ±10%, 1/2 W	23-680K				
R203	Resistor: fixed, composition, 33,000 ohms, ±10%, 2 W	25-33K				
R204	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R205	Resistor: fixed, metal film, 11,000 ohms, ±5%, 4 W	334-11K-5				
R206	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W	24-47K				
R206A	Resistor: fixed, composition, 33,000 ohms, ±10%, 2 W	25-33K				
R207	Resistor: variable, composition, linear taper, 5000 ohms, ±20%, 1/2 W	210-122				
R207A	Resistor: variable, composition, linear taper, 50,000 ohms, ±20%, 1/3 W	210-124				
R208	Resistor: fixed, metal film, 17,500 ohms, ±1%, 2 W	332-17.5K				
R208A	Resistor: fixed, metal film, 20,000 ohms, ±1%, 2 W	332-20K				
R209	Resistor: fixed, metal film, 17,500 ohms, ±1%, 2 W	332-17.5K				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R209A	Resistor: fixed, metal film, 20,000 ohms, ±1%, 2 W	332-20K				
R210	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R211	Resistor: fixed, metal film, 11,000 ohms, ±5%, 4 W	334-11K-5				
R212	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W	24-47K				
R213	Resistor: variable, potentiometer, 500 ohms, ±20%, 1/4 W	210-203				
R213A	Resistor: variable, potentiometer, 250 ohms, ±20%, 1/4 W	210-176				
R214	Resistor: fixed, deposited carbon, 11,880 ohms, ±1%, 1/2 W	33-11.88K				
R215	Resistor: fixed, deposited carbon, 2030 ohms, ±1%, 1/2 W	33-2030				
R216	Resistor: fixed, composition, 4860 ohms, ±1%, 1/2 W	33-4860				
R217	Resistor: fixed, deposited carbon, 490 ohms, ±1%, 1/2 W	33-490				
R218	Resistor: fixed, deposited carbon, 30,500 ohms, ±1%, 1 W	31-30.5K				
R219	Resistor: fixed, deposited carbon, encapsulated, 80,000 ohms, ±1%, 1 W	150A-26A				
R220	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R221	Resistor: fixed, metal film, 30,000 ohms, ±10%, 4 W	334-30K				
R222	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R223	Resistor: fixed, deposited carbon, 30,500 ohms, ±1%, 1 W	31-30.5K				
R224	Resistor: fixed, deposited carbon, encapsulated, 80,000 ohms, ±1%, 1 W	150A-26A				
R225	Resistor: fixed, metal film, 30,000 ohms, ±10%, 4 W	334-30K				
R226	Resistor: fixed, composition, 56 ohms, ±10% 1/2 W	23-56				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R227	Resistor: fixed, composition, 390,000 ohms, ±10%, 1/2 W	23-390K				
R228, R229	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2 W	23-330K				
R230	Resistor: fixed, wirewound, 3000 ohms, ±10%, 20 W	27-45				
R231	Resistor: fixed, composition, 390,000 ohms, ±10%, 1/2 W	23-390K				
R232	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R233	Resistor: fixed, wirewound, 12,000 ohms, ±10%, 20 W	27-44				
R234	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R235	Resistor: fixed, wirewound, 12,000 ohms, ±10%, 20 W	27-44				
R236	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R237	Resistor: fixed, composition, 470 ohms, ±10%, 1/2 W	23-470				
R238	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R239	Resistor: fixed, composition, 2700 ohms, ±10%, 1/2 W	23-2700				
R240, R241	Resistor: fixed, composition, 2200 ohms, ±10%, 1/2 W	23-2200				
R242	Resistor: fixed, composition, 2700 ohms, ±10%, 1/2 W	23-2700				
R243	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R244, R245	Resistor: fixed, composition, 100,000 ohms, ±10%, 2 W	25-100K				
R246	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W	23-56				
R247	Resistor: fixed, composition, 2700 ohms, ±10%, 1/2 W	23-2700				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R248	Resistor: fixed, composition, 47,000 ohms, ±10%, 1/2 W	23-47K				
R249	Resistor: fixed, composition, 27,000 ohms, ±10%, 2 W	25-27K				
R250 thru R254	Circuit references not assigned					
R255	Resistor: fixed, composition, 1000 ohms, ±10%, 1/2 W	23-1000				
R256	Resistor: fixed, metal film, 12,000 ohms, ±5%, 3 W	333-12K-5				
R257	Resistor: variable, composition, 2500 ohms, 1/2 W	210-98				
R258	Resistor: fixed, composition, 56,000 ohms, ±10%, 1/2 W	23-56K				
R259, R260	Resistor: fixed, composition, 150 ohms, ±10%, 1/2 W	23-150				
R261	Resistor: fixed, composition, 330 ohms, ±10%, 1/2 W	23-330				
R262	Resistor: fixed, composition, 1000 ohms, ±10%, 1/2 W	23-1000				
R262A	Resistor: fixed, composition, 3300 ohms, ±10%, 1/2 W	23-3300				
R263	Resistor: fixed, composition, 560,000 ohms, ±10%, 1/2 W	23-560K				
R263A	Resistor: fixed, composition, 270,000 ohms, ±10%, 1/2 W	23-270K				
R264	Resistor: fixed, composition, 56,000 ohms, ±10%, 1/2 W	23-56K				
R265	Resistor: variable, composition, 200,000 ohms, ±20%	210-19				
R265A	Resistor: variable, composition, 3.5 megohms, ±30%, 1/2 W	210-150				
R266	Resistor: fixed, deposited carbon, 50 megohms, ±10%, 2 W	26-81				
R267	Resistor: variable, composition, linear taper, 100,000 ohms, ±20%, 1/3 W	210-82				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R267A	Resistor: fixed, composition, 33,000 ohms, ±10%, 1/2 W	23-33K				
R268	Resistor: fixed, composition, 2.2 megohms, ±10%, 1/2 W	23-2.2M				
R268A	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				
R269	Resistor: fixed, composition, 10,000 ohms, ±10%, 1/2 W	23-10K				
R269A	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2 W	23-100K				
R270	Resistor: fixed, metal film, 38,000 ohms, ±10%, 4 W	334-38K				
R271	Resistor: fixed, composition, 120,000 ohms, ±10%, 1/2 W	23-120K				
R271A	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2 W	23-330K				
R272	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2 W	23-100K				
R272A	Resistor: fixed, composition, 150,000 ohms, ±10%, 1/2 W	23-150K				
R273	Resistor: fixed, composition, 100,000 ohms, ±10%, 2 W	25-100K				
R274	Resistor: fixed, deposited carbon, 4.15 megohms, ±1%, 1 W	31-4.15M				
R274A	Resistor: fixed, deposited carbon, 2.52 megohms, ±1%, 1 W	31-2.52M				
R275	Resistor: variable, composition, 3.5 megohms, ±30%, 1/4 W	210-144				
R276	Resistor: fixed, wirewound, 50 megohms, ±10%, 2 W	26-81				
R277	Resistor: variable, composition, 5 megohms, ±30%, 1/2 W	210-159				
R278	Resistor: fixed, deposited carbon, 4.15 megohms, ±1%, 1 W	31-4.15M				
R279	Resistor: fixed, composition, 27,000 ohms, ±10%, 1/2 W	23-27K				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R280, R281, R282	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				
R283	Resistor: variable, composition, linear taper, 500,000 ohms, ±20%	210-20				
R284	Resistor: fixed, composition, 39,000 ohms, ±10%, 1 W	24-39K				
R284A	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2 W	23-22K				
R285	Resistor: fixed, composition, 6.8 megohms, ±10%, 1/2 W	23-6.8M				
R285A	Resistor: fixed, composition, 3 megohms, ±5%, 1/2 W	23-3M-5				
R286	Resistor: fixed, composition, 18,000 ohms, ±10%, 1 W	24-18K				
R287, R288	Resistor: fixed, metal film, 20,000 ohms, ±5%, 3 W	333-20K-5				
R289	Resistor: fixed, deposited carbon, 7500 ohms, ±1%, 1 W	31-7500				
R290	Resistor: variable, composition, linear taper, 500,000 ohms, ±30%, 1/4 W	210-146				
R291	Resistor: fixed, deposited carbon, 5000 ohms, ±1%, 1 W	31-5000				
R292	Resistor: fixed, composition, 4.7 megohms, ±10%, 1/2 W	23-4.7M				
R292A	Resistor: fixed, composition, 6.8 megohms, ±5%, 1/2 W	23-6.8M-5				
R293	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2 W	23-330K				
R293A	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2 W	23-220K				
R294	Resistor: fixed, deposited carbon, 100,000 ohms, ±1%, 1 W	31-100K				
R295	Resistor: fixed, deposited carbon, 100 ohms, ±1%, 1/2 W	33-100				
R296	Resistor: fixed, deposited carbon, 10,200 ohms, ±1%, 1 W	31-10.2K				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R297	Resistor: fixed, deposited carbon, 6490 ohms, ±1%, 1/2 W	33-6.49K				
R298	Resistor: fixed, deposited carbon, 2100 ohms, ±1%, 1/2 W	33-2.10K				
R299	Resistor: fixed, deposited carbon, 1030 ohms, ±1%, 1/2 W	33-1.03K				
R300	Resistor: fixed, deposited carbon, 608 ohms, ±1%, 1/2 W	33-608				
R301	Resistor: fixed, deposited carbon, 201 ohms, ±1%, 1/2 W	33-201				
R302	Resistor: fixed, deposited carbon, 100 ohms, ±1%, 1/2 W	33-100				
R303	Resistor: fixed, deposited carbon, 60 ohms, ±1%, 1/2 W	33-60				
R304	Resistor: fixed, deposited carbon, 40 ohms, ±1%, 1/2 W	33-40				
R305	Resistor: fixed, composition, 100 ohms, ±10%, 1/2 W	23-100				
R306	Resistor: fixed, composition, 1000 ohms, ±10%, 1/2 W	23-1000				
R306A	Resistor: fixed composition, 3.3 megohms, ±10%, 1/2 W	23-3.3M				
R307, R308	Resistor: fixed, composition, 680 ohms, ±10%, 1/2 W	23-680				
R309	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2 W	23-100K				
R309A	Resistor: fixed, composition, 1000 ohms, ±10%, 1/2 W	23-1000				
R310	Resistor: fixed, composition, 120,000 ohms, ±10%, 1/2 W	23-120K				
R311	Resistor: fixed, composition, 180,000 ohms, ±10%, 1 W	24-180K				
R312, R313	Resistor: fixed, composition, 56,000 ohms, ±10%, 2 W	25-56K				
R314	Resistor: fixed, deposited carbon, 5000 ohms, ±1%, 1 W	31-5000				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R315	Resistor: fixed, composition, 2700 ohms, ±10%, 1 W	24-2700				
R316	Resistor: fixed, composition, 100,000 ohms, ±10%, 2 W	25-100K				
R317	Resistor: fixed, metal film, 5000 ohms, ±1%, 4 W	334-5K				
R318, R319	Resistor: fixed, composition, 180,000 ohms, ±10%, 2 W	25-180K				
R320	Resistor: fixed, composition, 180,000 ohms, ±10%, 1 W	24-180K				
R321	Resistor: fixed, wirewound, 1500 ohms, ±10%, 10 W	26-87				
R322	Resistor: variable, wirewound, 25 ohms, ±10%, 3 W	210-167				
R323	Resistor: fixed, composition, 220 ohms, ±10%, 1 W	24-220				
R324	Resistor: fixed, wirewound, 800 ohms, ±5%, 40 W	27-23				
R325	Resistor: fixed, composition, 4.7 ohms, ±10%, 1 W	24-4.7				
R325A, R325B	Resistor: fixed, composition, 220 ohms, ±10%, 2 W	25-220				
R326	Resistor: fixed, composition, 330,000 ohms, ±10%, 1 W. Electrical value adjusted at factory.	24-330K				
R327	Resistor: fixed, composition, 33,000 ohms, ±10%, 1/2 W	23-33K				
R328	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				
R329	Resistor: fixed, composition, 150,000 ohms, ±10%, 1/2 W	23-150K				
R330, R331	Resistor: fixed, composition, 680 ohms, ±10%, 1/2 W	23-680				
R332	Circuit reference not assigned					
R332A, B	Resistor: fixed, wirewound, 4500 ohms, ±5%, 30 W	27-41				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.				
R333, R334, R335	Resistor: fixed, composition, 33 ohms, ±10%, 1/2 W	23-33				
R336	Resistor: fixed, deposited carbon, 284,000 ohms, ±1%, 1 W	31-284K				
R337	Resistor: fixed, deposited carbon, 820,000 ohms, ±1%, 1 W	31-820K				
R338	Resistor: fixed, wirewound, 5 ohms, ±10%, 2 W	26-33				
R338A	Resistor: fixed, composition, 1000 ohms, ±10%, 1 W	24-1000				
R339	Resistor: fixed, wirewound, 5 ohms, ±10%, 2 W	26-33				
R339A	Resistor: fixed, composition, 560 ohms, ±10%, 2 W	25-560				
R340	Resistor: fixed, composition, 12 ohms, ±10%, 2 W	25-12				
R340A	Resistor: fixed, wirewound, 62 ohms, ±5%, 10 W	26-91				
R340B	Resistor: fixed, composition, 2.7 ohms, ±10%, 1 W	24-2.7				
R341	Resistor: fixed, composition, 3.3 megohms, ±10%, 1/2 W	23-3.3M				
R342	Resistor: fixed, composition, 68,000 ohms, ±10%, 1/2 W	23-68K				
R343	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				
R344	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2 W	23-330K				
R345, R346	Resistor: fixed, composition, 680 ohms, ±10%, 1/2 W	23-680				
R347	Circuit reference not assigned					
R347A	Resistor: fixed, wirewound, 2000 ohms, ±5%, 40 W	27-40				
R347B	Resistor: fixed, wirewound, 5000 ohms, ±5%, 12 W	27-19				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.				
R347C	Resistor: fixed, wirewound, 2000 ohms, ±5%, 40 W	27-40				
R348 thru 350	Resistor: fixed, composition, 33 ohms, ±10%, 1/2 W	23-33				
R351	Resistor: fixed, deposited carbon, 316,000 ohms, ±1%, 1 W	31-316K				
R352	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2 W	23-100K				
R353	Resistor: fixed, deposited carbon, 180,000 ohms, ±1%, 1/2 W	33-180K				
R354	Resistor: fixed, composition, 4.7 ohms, ±10%, 1 W	24-4.7				
R354A	Resistor: fixed, wirewound, 50 ohms, ±10%, 10 W	26-27				
R355	Resistor: fixed, composition, 2.2 megohms, ±10%, 1/2 W	23-2.2M				
R356	Resistor: fixed, composition, 33,000 ohms, ±10%, 1/2 W	23-33K				
R357	Resistor: fixed, composition, 1.5 megohms, ±10%, 1/2 W	23-1.5M				
R358	Resistor: fixed, composition, 680 ohms, ±10%, 1/2 W	23-680				
R359	Resistor: fixed, wirewound, 1800 ohms, ±5%, 30 W	27-42				
R360	Resistor: fixed, composition, 56,000 ohms, ±10%, 1/2 W	23-56K				
R361, R362	Resistor: fixed, composition, 33 ohms, ±10%, 1/2 W	23-33				
R363	Resistor: fixed, deposited carbon, 252,000 ohms, ±1%, 1/2 W	33-252K				
R364	Resistor: fixed, composition, 2.7 ohms, ±10%, 1 W	24-2.7				
R365	Resistor: fixed, deposited carbon, 284,000 ohms, ±1%, 1 W	31-284K				
R366	Resistor: fixed, composition, 1.5 megohms, ±10%, 1/2 W	23-1.5M				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
R367, R368	Resistor: fixed, composition, 680 ohms, ±10%, 1/2 W	23-680				
R369	Resistor: fixed, wirewound, 1000 ohms, ±5%, 40 W	27-37				
R370, R371, R372	Resistor: fixed, composition, 33 ohms, ±10%, 1/2 W	23-33				
R373	Resistor: fixed, composition, 680,000 ohms, ±10%, 1/2 W	23-680K				
R373A	Resistor: fixed, composition, 470,000 ohms, ±10%, 1/2 W	23-470K				
R374	Resistor: fixed, composition, 10,000 ohms, ±10%, 1/2 W	23-10K				
R375	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2 W	23-220K				
R376	Resistor: fixed, composition, 27,000 ohms, ±10%, 1 W	24-27K				
R377	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2 W	23-100K				
R378	Resistor: fixed, deposited carbon, 136,700 ohms, ±1%, 1/2 W	33-136.7K				
R379	Resistor: variable, composition, linear taper, 50,000 ohms, ±30%, 1/4 W	210-137				
R380, R381	Resistor: fixed, deposited carbon, 180,000 ohms, ±1%, 1/2 W	33-180K				
R382	Resistor: variable, composition, linear taper, 50,000 ohms, ±30%, 1/4 W	210-137				
R383	Resistor: fixed, deposited carbon, 136,700 ohms, ±1%, 1/2 W	33-136.7K				
R384	Resistor: fixed, composition, 470,000 ohms, ±10%, 1/2 W	23-470K				
R385	Resistor: fixed, composition, 150,000 ohms, ±10%, 1/2 W	23-150K				
R386	Resistor: fixed, composition, 1.2 megohms, ±10%, 1/2 W	23-1.2M				
R387	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	23-1M				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗ STOCK NO.			
R388	Resistor: fixed, wirewound, 2500 ohms, ±10%, 10 W	26-7			
R389	Resistor: fixed, wirewound, 2000 ohms, ±5%, 40 W	27-40			
R390	Resistor: fixed, composition, 100 ohms, ±10%, 1 W	24-100R			
R391	Resistor: fixed, composition, 100, 000 ohms, ±10%, 1/2 W	23-100K			
R392	Circuit reference not assigned				
R393	Resistor: fixed, composition, 100 ohms, ±10%, 1 W	24-100R			
R394	Resistor: fixed, composition, 22 ohms, ±10%, 1/2 W	23-22			
R395, R396	Resistor: fixed, composition, 100 ohms, ±10%, 1 W	24-100R			
R397	Resistor: fixed, wirewound, 5000 ohms, ±10%, 20 W	27-3			
R398, R399	Resistor: fixed, wirewound, 1000 ohms, ±5%, 40 W	27-37			
R400 thru R1300	Circuit references not assigned				
R1301	Resistor: fixed, composition, 100, 000 ohms, ±10%, 1/2 W	23-100K			
R1302	Resistor: fixed, composition, 68, 000 ohms, ±10%, 1/2 W	23-68K			
R1303 thru R1322	Circuit references not assigned				
R1323	Resistor: variable, wirewound, linear taper, 4 ohms, ±10%, 4 W	210-187			
R1324	Resistor: fixed, wirewound, 14 ohms, ±10%, 10 W	26-90			
RT301, RT302	Thermistor: disc type, 10 ohms, ±10%, at 25°C, supplied on instruments wired for 230V operation only.	211-73			
RT303	Thermistor: disc type, 1000 ohms, ±10%, at 25°C	211-81			

• TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	(hp) STOCK NO.				
S1	Switch: SYNC selector, SWEEP MODE, assembly For assembly 150A-65E 150A-65L 150A-65LR	150A-19G				
	For assembly 150A-65A	150A-19C				
S2	Switch: TRIGGER SLOPE (incl. R57)	150A-19B				
S3	Part of S1					
S4	Switch: SINGLE-SWEEP, NORMAL, toggle, DPDT	310-54				
S4A	Switch: SINGLE-SWEEP, NORMAL, slide, DPDT	310-183				
S5	Switch: SWEEP TIME/CM (incl. R146 and S6)	150A-19JK				
S6	Switch: sweep VERNIER - cal., part of R146					
S7	Switch: HORIZ. SENSITIVITY For assembly 150A-65F For assembly 150A-65B	 150A-19F 150A-19D				
S8	Part of R177					
S9	Switch: CALIBRATOR	150A-19E				
S10	Switch: INT/Z-EXT/Z	310-12				
S11	Switch: AC POWER, toggle DPDT	310-54				
S12	Switch: thermal	310-194				
SR1, SR2, SR3, SR4	Rectifier, selenium: Replace with Silicon Rectifier Kit	150A-95Q				
T1	Transformer: high voltage	150A-11C-1				
T1A	Transformer: high voltage, part of 150A-11A, not replaceable.					
T1B	Transformer: high voltage, part of 150A-11B, not replaceable.					
T2	Transformer: power	910-65				
T2A	Transformer: power	910-142				
T2B	Transformer: power	910-160				
T3	Transformer: power	910-164				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	-hp- STOCK NO.				
T3A	Transformer: power	910-143				
T4	Transformer: SYNC pulse	150A-60I				
V1, V2	Tube, electron: 6CL6	212-6CL6				
V3	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V3A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V4	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V4A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V5, V6	Tube, electron: 6197	212-6197				
V7	Tube, electron: 6AU8	212-6AU8				
V8	Tube, electron: 6DJ/ECC88 See NOTE below	G-73Z				
V8A	Tube, electron: 6BQ7A See NOTE below	G-73M				
V9	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V9A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V10	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V10A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V11	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V11A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V12	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V12A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V13	Tube, electron: 6AL5	212-6AL5				
V14	Tube, electron: 6485	212-6485				
V15	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V15A	Tube, electron: 6BK7A See NOTE below	G-73V				
V16	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
	NOTE: Tubes selected for best performance will be supplied by -hp- stock number, but tubes meeting RETMA standards will normally result in the instrument operating within specifications.					

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	STOCK NO.				
V16A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V17	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V17A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V18	Tube, electron: 6AN8	212-6AN8				
V18A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V19	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V19A	Tube, electron: 6 BQ7A See NOTE below	G-73L				
V20, V21	Tube, electron: 6485	212-6485				
V22	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V22A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V23, V24	Tube, electron: 6CL6	212-6CL6				
V25	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V25A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V26	Tube, electron: 6DJ8/ECC88 See NOTE below	G-73Y				
V26A	Tube, electron: 6BQ7A See NOTE below	G-73L				
V27	Tube, electron: 6AU5GT	212- 6AU5GT				
V28	Tube, electron: 6DJ8/ECC88	212-6DJ8				
V28A	Tube, electron: 12AU7	212-12AU7				
V29	Tube, electron: 1X2B	212-1X2B				
V29A	Tube, electron: 3A2	212-3A2				
V30	Tube, electron: 1X2B	212-1X2B				
V30A	Tube, electron: 3A2	212-3A2				
V31	Tube, cathode ray: 5 AMP- (phosphor types available 1, 2, 7, 11, please specify)	212-5AMP				
	NOTE: Tubes selected for best performance will be supplied by -hp- stock number, but tubes meeting RETMA standards will normally result in the instrument operating within specifications.					

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.			
V32	Tube, electron: 6U8	212-6U8			
V33 thru V35	Tube, electron: 12B4A	212-12B4A			
V36	Tube, electron: 6BH6	212-6BH6			
V37 thru V39	Tube, electron: 12B4A	212-12B4A			
V40	Tube, electron: 6BH6	212-6BH6			
V41, V42	Tube, electron: 12B4A	212-12B4A			
V43	Tube, electron: 6BH6	212-6BH6			
V44, V45, V46	Tube, electron: 12B4A	212-12B4A			
V47	Tube, electron: 6BH6	212-6BH6			
V48	Tube, electron: 5651	212-5651			
V49	Tube, electron: 12AX7	212-12AX7			
V50	Tube, electron: 12B4A	212-12B4A			
Z1	Main vertical amplifier assembly: Serial 40 thru 1389 Serial 1390 and above	 150A-58A 150A-58B			
Z2	Sweep Generator Assembly: Serial 1690 and above Serial 1390 thru 1689 Serial 40 thru 1389 NOTE: When replacing Assemblies 150A-65A (Single Sweep-Normal Switch is a slide switch mounted on the etched circuit board) Order Kit	 150A-65L 150A-65LR 150A-65LR 150A-95R			
Z3	Horizontal amplifier assembly: Serial 40 thru 1389 Serial 1390 and above	 150A-65B 150A-65F			
Z4	Calibrator and high voltage assembly: Serial 40 thru 1389 Serial 1390 thru 1689 Serial 1690 and above	 150A-65C 150A-65G 150A-65K			

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	ⓗⓟ STOCK NO.				
Z5	Low Voltage Regulator Assembly					
	Serial 1390 and above	150A-65H				
	Serial 40 through 1389	150A-65D				
Z6	High voltage and rectifier assembly:					
	Serial 40 thru 1389	150A-11A				
	Serial 1390 thru 1689	150A-11B				
	Serial 1690 and above	150A-11C				
	MISCELLANEOUS					
	Adapter: BNC to binding post	AC-76A				
	Bezel assembly:					
	with green filter	150A-84A				
	with amber filter	150A-84B				
	with blue filter	150A-84C				
	Bezel assembly: CRT (less filter and graticule)	150A-95N				
	Clip: for CRT neck terminals	150A-76C				
	Extender, plug-in: (for servicing plug-in vertical amplifier)	150A-95L				
	Fuseholder	140-16				
	Filter, air, for cabinet mount	314-32				
	Filter, air, for Rack mount	314-42				
	Filter, green: for CRT	150A-83B				
	Filter, blue: for CRT	150A-83D				
	Filter, amber: for CRT	150A-85E				
	Graticule: for CRT	150A-83C				
	Jewel: small lucite (for magnifier lights)	150A-37A				
	Knob: sweep time/cm, sync	G-74Q				
	Knob: VERNIER, SWEEP MODE	G-74AU				
	Knob: TRIGGER LEVEL	G-74L				
	Knob: TRIGGER SLOPE	G-74AT				
	Knob: VERNIER, HORIZONTAL POSITION	G-74K				

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	⊕ STOCK NO.				
	Knob: HORIZ. SENSITIVITY, CALIBRATOR	G-74N				
	Knob: FOCUS, SCALE LIGHT, INTENSITY	G-74D				
	Lampholder: less jewel	145-23				
	Jewel: for lampholder	145-23A				
	Probe Assembly: 10 to 1, specify 5' grey, 5' or 10' black	AC-21A				
	Probe Assembly: 50 to 1, specify 5' grey, 5' or 10' black	AC-21C				
	Socket, tube: 7 pin miniature, for printed circuits	120-48				
	Socket, tube: 9 pin miniature, for printed circuits	120-49				
	Socket: 9 pin miniature for V29 and V30	150A-11A-4				
	Socket, tube: 14 pin for CRT Assembly	150A-52B				
	Socket, tube: 9 pin miniature for V23 and V24	120-44				
	Shock mount (for fan)	149-37				
	Tube Clamp mounting ring for 9 pin etched circuit sockets	G-52F				
	Tube clamp mounting ring for 7 pin etched circuit sockets	G-52E				

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

MANUAL CHANGES

MODEL 150A

OSCILLOSCOPE

Manual Serial 40 through 3189

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Number	Make Manual Changes
40 through 3189	ERRATA

Instrument Serial Prefix	Make Manual Changes

ERRATA:

J18: Change to binding post: red; ⓗ Stock No. AC-10D.

K4E: Change coil description to 115 VAC.

R325A, B: Change R325A to resistor, fixed, wirewound, 110 ohms $\pm 10\%$, 10W; ⓗ Stock No. 26-130. Delete R325B.

Section IV, Page 22, Under G, (TEST GATE OUTPUT WAVEFORM):
Correct the first sentence in step 3) as follows: "This waveform should be a nonsymmetrical square wave with a peak-to-peak amplitude of <u>20</u> to <u>30</u> volts.