INSTRUCTION MANUAL

Serial Number ____________

TYPE 556 OSCILLOSCOPE

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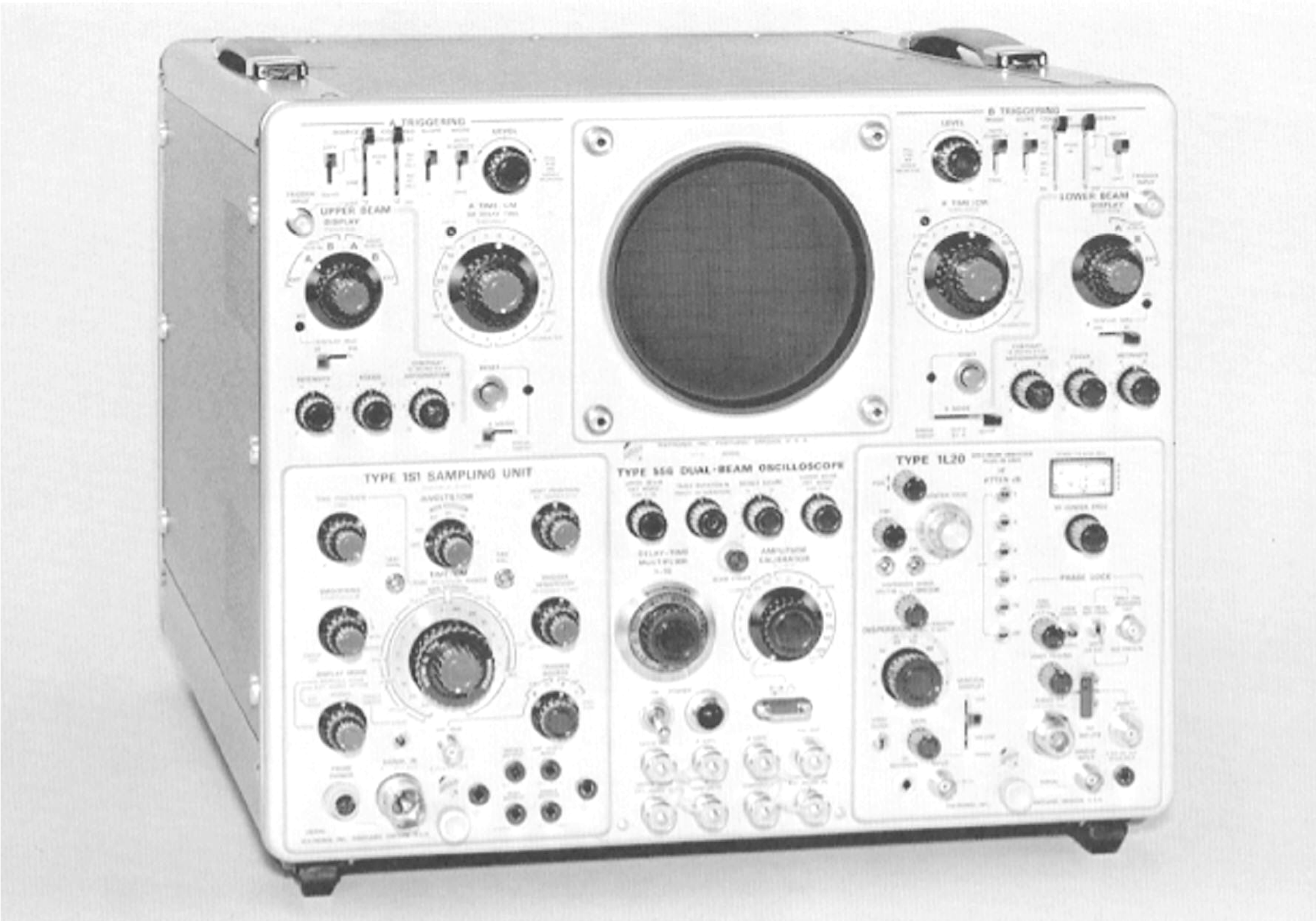
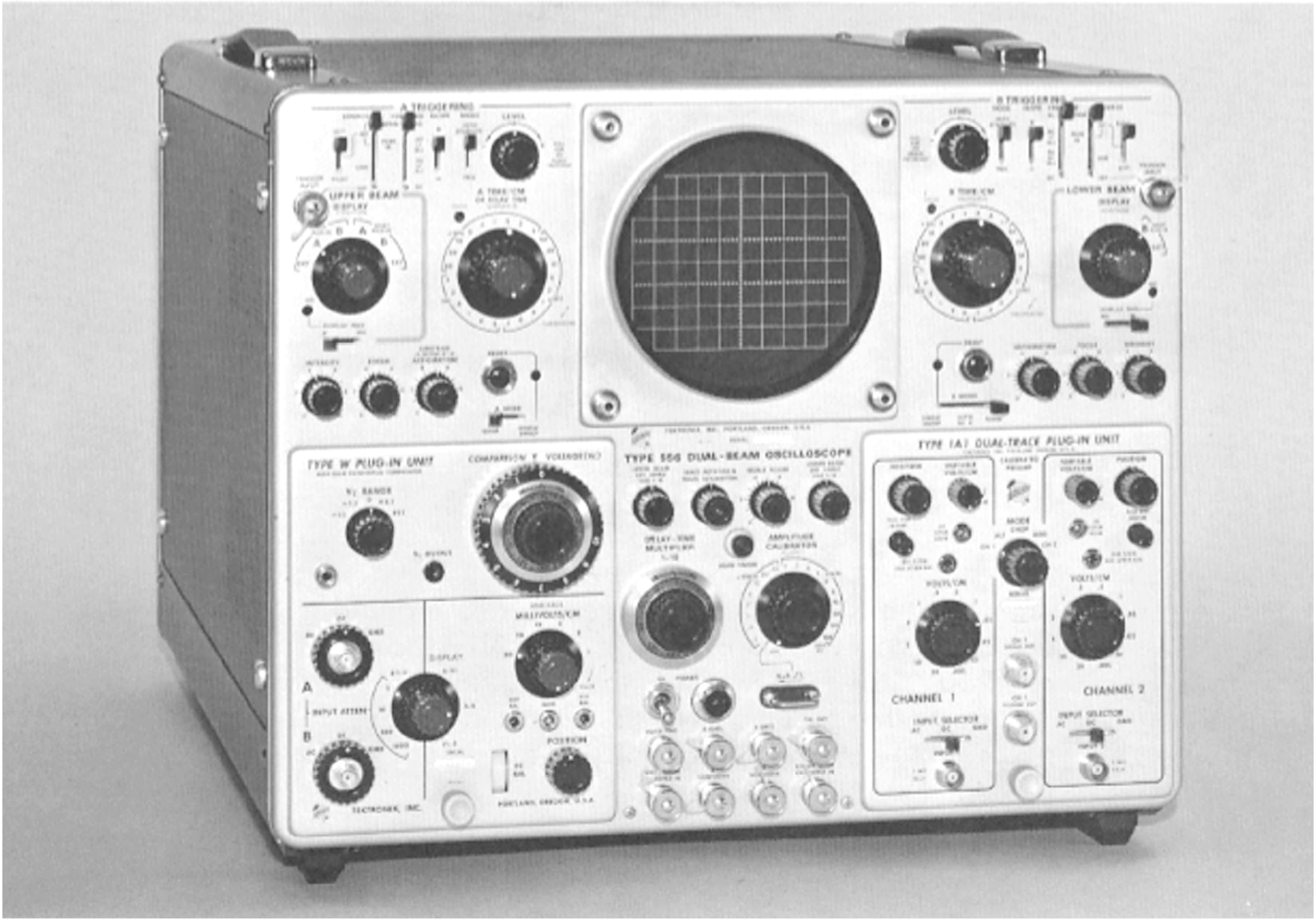


Serial number 2000 and up.



SECTION 1
CHARACTERISTICS

Change information, if any, affecting this section is found at the rear of the manual.

Introduction

The Type 556 Oscilloscope—is a versatile dual-beam laboratory type instrument providing accurate voltage and time measurements in the DC to 50 MHz frequency range. Two complete horizontal and vertical deflection systems permit completely indepentent operation of the two beams.

The Upper Beam can display the signal from either the left or right vertical plug-in unit and may be controlled by either the A or B time base or an external signal. The Lower Beam displays the signal from the right plug-in and the sweep is controlled by the B time base or an external signal. The left and right plug-in compartments accept all letter series and 1-series plug-ins.

Special circuits within the oscilloscope provide selection of an accurate, continuously-variable delay when using the B sweep. The B sweep may be delayed by the A sweep from 0.1 μs to 50 s (calibrated) after application of a trigger pulse. This feature permits the delayed B sweep to expand a selected portion of the undelayed A sweep, thereby providing precise time measurements and detailed observation of the signal. Both the delayed and undelayed sweeps can be presented simultaneously on the oscilloscope screen. The Upper Beam trace has an intensified zone indicating the portion of the signal being displayed by the B sweep and Lower Beam.

The instrument is designed to operate over an ambient temperature range of 0° C to +50° C. Performance specifications that are given in the center column apply over this temperature range after a warmup time of 20 minutes. Supplemental information describing a characteristic or a feature is also included in this portion of the manual.

VERTICAL AMPLIFIERS

Characteristics	Performance Specification	Supplemental Information
Frequency Response	DC to ≥50 MHz at 3 dB down with a 1-series plug-in unit having a risetime of 3.12 ns or less.	
Risetime		≤6.25 ns. Indicated risetime of 6.93 ns with a Test Load Plug-In Unit (Tektronix Part No. 067-0521-00) having a risetime of 3 ns.
Transient Response on Screen	≤2.25% peak overshoot, rounding, ringing or tilt.	Applies to all three vertical modes with Test Load Plug-In Units.
Gain Change with Line Voltage Change	≤1% from 147 VAC peak to 178 VAC peak.	
Trace Drift with Line Voltage Change	±2 mm from 147 VAC peak to 178 VAC peak.	

A & B SWEEP GENERATORS

Calibration Accuracy 5 s/cm to 0.1 μs/cm	±3% of displayed time between two points displayed within the middle 8 cm.	
×10 Magnified Display	±5% of displayed time between any two points ≥1 cm apart displayed within the middle 8 cm.	Calibrated from 4 cm to 70 cm from sweep start. Extends fastest sweep rate to 10 ns/cm.
Variable Time/Cm Range	≥2.5:1.	Extends slowest sweep to approximately 12.5 s/cm.
Sweep Length	10.5 cm ±0.5 cm	At 1 ms/cm.

VARIABLE TIME DELAY

Delay Time Accuracy 5 s/cm to 1 μs/cm	±1% of indicated delay time ±2% of A TIME/CM setting + fixed delay of ≤150 ns in system.	1% of A TIME/CM setting corresponds to 1 minor division on the DELAY-TIME MULTIPLIER dial.
0.5 μs/cm to 0.1 μs/cm	±1% of indicated delay time ±5% of A TIME/CM setting + fixed delay of ≤150 ns in system.	For additional information refer to Fig. 2-10 in the Operation Instructions.

Characteristics	Performance Specification	Supplemental Information
Incremental Delay Time Accuracy 5 s/cm to 1 μs/cm	±1% of indicated incremental delay time ±4% of A TIME/CM setting.	Incremental Delay Time is the difference between two delay time readings.
0.5 μs/cm to 0.1 μs/cm	±1% of indicated incremental delay time ±7% of A TIME/CM setting.	For additional information refer to Page 2-24 in the Operating Instructions.
Short Term Jitter	≤1 part in 20,000 of the available delay time.	

EXTERNAL HORIZONTAL AMPLIFIERS

Ext. Horizontal Deflection Factor	≤0.1 V/cm with DISPLAY MAG in ×10 position.	
Transient Response	±3% peak overshoot, rounding, ringing or tilt.	
Variable Range	≥10:1	
Frequency Response	DC to ≥400 kHz at 3 dB down. VARIABLE control set fully cw.	
Maximum Input Voltage	50 V combined DC + peak AC.	With DISPLAY MAG in ×10 position.
Input C		Approximately 65 pF.

A & B TRIGGERING FEATURES

Characteristic	Feature
Source	Internal Normal (from left or right trigger pick-off circuit within the vertical amplifier), Internal Plug-In (from one of the channels in the left or right Type 1A1 or 1A2 Plug-In Unit), Line and External.
Coupling	Capacitive (AC), low-frequency reject (AC LF REJ), high-frequency reject (AC HF REJ) or direct (DC).
Slope	Triggering on positive-or-negative-going portion of triggering signal.
Mode: Auto Stability	Free runs sweep in absence of a triggering signal; instrument can be triggered on signals ≥30 Hz.
Triggered	Triggered at an adjustable level.
Jitter	≤2 ns.
LEVEL Control Range: Normal	≥ ±2 V.
×10 Increase	≥ ±20 V.
External Trigger Input: R & C	Approximately 1 megohm paralleled by approximately 35 pF.
Volts	50 V maximum (DC plus peak AC).

A & B TRIGGERING SENSITIVITY

Trigger Coupling/Source		To 10 MHz	To 50 MHz
AC: INT NORM		≤ 2 mm display amplitude above 60 Hz.	≤ 1 cm display amplitude.
EXT		≤ 0.2 V above 60 Hz.	≤ 0.4 V.
AC LF REJ: INT NORM	≥ 3 cm display amplitude at 30 Hz.	≤ 2 mm display amplitude above 2.5 kHz.	≤ 1 cm display amplitude.
EXT	≥ 3 V at 30 Hz.	≤ 0.2 V above 2.5 kHz.	≤ 0.4 V.
AC HF REJ: INT NORM	≤2 mm display amplitude from 60 Hz to 60 kHz, ≥1 cm at 6 MHz.		
EXT	≤0.2 V from 60 Hz to 60 kHz, ≥1 V at 6 MHz.		
DC INT NORM		≤ 3.5 mm display amplitude.	≤ 2 cm display amplitude.
EXT		≤ 0.2 V.	≤ 0.4 V.
INT PLUG IN	Characteristics that apply for the EXT trigger input also apply to the Int Plug-In interconnection (pin 5 of plug-in connectors J11 and J12).		

AMPLITUDE CALIBRATOR

Characteristic	Performance Specification	Supplemental Information
Voltage Accuracy	±2%.	
5 mA Current Loop Accuracy	±2%.	
Repetition Rate	1 kHz ±25%	
Duty Cycle	45% to 55%.	
Risetime	≤ 1.5 μs.	70 pF load.
Terminated Voltage Accuracy	One-half indicated voltage ±2% when terminated into 50 ohms ±0.1%.	Applies to AMPLITUDE CALIBRATOR switch positions from 0.2 mV to 0.2 V only.

Z AXIS INPUTS

Sensitivity		10 V P to P causes noticeable modulation intensity.
Input R at DC		1 megohm ±10%.

FRONT-PANEL OUTPUT SIGNALS

A GATE	≥ 8 V positive-going pulse.	With baseline at zero volts. Time coincident with the A sweep. Maximum current is 10 mA. Recommended load resistance ≥1 kΩ.
B GATE	≥ 8 V positive-going pulse.	With baseline at zero volts. Time coincident with the B sweep. Maximum current is 10 mA. Recommended load resistance ≥1 kΩ.
DLY'D TRIG	≥ 7 V positive-going pulse into a ≥1 kΩ load.	Pulse occurs at the end of the A sweep delay period.
A SAWTOOTH	≥ 9 V/cm.	Has the same time duration as the A sweep. Recommended load resistance ≥30 kΩ.
B SAWTOOTH	≥ 9 V/cm.	Has the same time duration as the B sweep. Recommended load resistance ≥30 kΩ.
Line Frequency	50 Hz to 60 Hz	400 Hz with special fan modification.
Power Consumption		≈840 W maximum. ≈1 kVA maximum.
Thermal Protection		An automatic resetting thermal cutout interrupts instrument power if internal temperature exceeds safe operating level.

POWER SOURCE REQUIREMENTS

For serial numbers 2000 and up			
Regulating Range Selection:	AC RMS Operating Range (≤2% harmonic distortion of the input power waveform)	AC Peak Operating Range (>2% harmonic distortion[1])	A Line Voltage Selector assembly facilities selection of a regulating range compatible with the actual line voltage.
115 Volts			
LO	90 to 110 V	127 to 156 V	
M	104 to 126 V	147 to 178 V	
HI	112 to 136 V	158 to 192 V	
230 Volts			
LO	180 to 220 V	254 to 311 V	
M	208 to 252 V	294 to 356 V	
HI	224 to 272 V	316 to 384 V	

[1]**Crest Factor** $= \frac{\text{Peak V}}{\text{RMS V}} =$ **between 1.30 and 1.414.**

Characteristic	Performance Specification		Supplemental Infromation
For serial numbers 100-1999			
Normal Line:	AC RMS Operating Range (≤2% harmonic distortion of the input power waveform)	AC Peak Operating Range (>2% harmonic distortion[1])	
115 VAC Nominal	100 to 130 V	142 to 183 V	Normally wired at the factory for this voltage unless directed otherwise.
230 VAC Nominal	200 to 260 V	284 to 366 V	
Low Line: 104 VAC Nominal	90 to 117 V	127 to 165 V	
208 VAC Nominal	180 to 234 V	254 to 330 V	

CRT AND DISPLAY

Characteristic	Information
Tube Type	T5560-31-1. Dual-Beam, round, glass envelope. Tektronix Part No. 154-0500-00.
Phosphor	P31 standard. Others available on special order.
Accelerating Potential	Approximately 10 kV; gun potential is 2 kV.
Scan Area	≥6 cm vertical by 10 cm horizontal per beam. Beams can be overlapped in a 4 cm area.
Graticule Type	Internal. 8 cm vertical by 10 cm horizontal. Each major division is 1 cm; four corners are omitted.
Graticule Illumination	Variable edge lighting.
Internal Unblanking	DC-coupled to CRT control grids from the Sweep Generators.
Orthogonality	Within ±1%.
Trace Rotation Range	Sufficient to align traces with their respective graticule lines.
Beam Finder	Limits traces within graticule area.

ELECTROMAGNETIC INTERFERENCE

Electromagnetic Interference	Meets interference specifications of MIL-I-6181D over the following frequency ranges: Radiated (with CRT mesh filter, cabinet covers and BNC connector covers installed)—150 kHz to 1 GHz; conducted (power line)—150 kHz to 25 MHz.

MECHANICAL CHARACTERISTICS

Construction	Aluminum alloy chassis, panel and cabinet. Glass laminate etched circuit boards.
Finish	Anodized front panel. Blue vinyl-finished cabinet and rear panel.
Overall Dimensions:	Measured at maximum points; 15 inches high, 16-7/8 inches wide, 24 inches deep.

[2]**Crest Factor** $= \frac{\text{Peak V}}{\text{RMS V}}$ **= between 1.30 and 1.414.**

ENVIRONMENTAL CHARACTERISTICS

The Type 556 has been designed to operate over a temperature range of 0° C to +50° C, altitude up to 15,000 feet. The non-operating storage temperature range is —40° C to +65° C, altitude up to 50,000 feet. After storage at either extreme, the instrument must be allowed at least 4 hours time for all components to return to the ambient temperature range 0° C to +50° C before operating.

Further information on environmental test procedures may be obtained by contacting your local Tektronix Field Office or representative.

ACCESSORIES

Standard accessories supplied with the Type 556 can be found on the last pullo-ut page of the Mechanical Parts List Illustrations. For optional accessories see the Tektronix, Inc. catalog.

SECTION 3
CIRCUIT DESCRIPTION

Change information, if any, affecting this section is found at the rear of the manual.

Introduction

This section of the manual contains a functional description of the instrument circuitry. A general discussion of display logic, with accompanying diagrams, preceeds the detailed functional circuit analysis.

DISPLAY LOGIC

The display logic system used to connect deflection signals to the dual independent vertical and horizontal deflection circuits provides the instrument with a versatility that permits accommodation of diverse applications. The two beams may be deflected by signals from several sources. In general, the signal source options are as follows:

Upper Beam—Vertical deflection by signals from either plug-in unit. Horizontal deflection by sweep signals from either A or B time base generator or by signals from an external source (EXT HORIZ IN).

Lower Beam—Vertical deflection by signals from the right plug-in only. Horizontal deflection by sweep signals from either A or B time base generator (Time-base B only for serial numbers 1999 and below) or by signals from an external source.

Table 3-1 lists some typical applications with examples of signal source selections. The figure number listed with an application refers to the illustration that shows the major circuit interconnections for the selected signal source opions.

FUNCTIONAL BLOCK DIAGRAMS

To provide a basis for this discussion, six functional block diagrams (Fig. 3-1 through 3-6) are used to demonstrate how the major circuit blocks are connected when a particular operating mode is set up. There are many other combinations that can be shown, depending on the setting of the controls and the plug-in units used, but these six modes are intended to provide the fundamental information needed for quickly analyzing the internal operation of the Type 556 before studying the individual circuits in detail.

First Basic Mode (Fig. 3-1)

In this mode of operation the Type 556 is operating as two completely independent systems. A signal applied to the left plug-in unit is coupled to the Left Vertical Input Amplifier. At this point a portion of the signal is taken off to provide normal internal push-pull triggering signals to the A Sweep Trigger circuit. This circuit converts the triggering of the A Sweep Generator.

With the Upper Beam DISPLAY switch set to LEFT PLUG-IN A, the sawtooth from the A Sweep Generator is applied to the Upper Beam Horizontal Amplifier. This amplifier provides push-pull drive to the Upper Beam horizontal deflection plates.

TABLE 3-1

Application	Signal Source Selection			
	Upper Beam		Lower Beam	
	Vertical	Horizontal	Vertical	Horizontal
Two indepent display systems. Fig. 3-1.	Left	A sweep	Right	B sweep
Signals from one plug-in displayed at two sweep rates. Figs. 3-2, 3-4 and 3-6.	Right	A sweep	Right	B sweep
Signals from two plug-ins displayed at a common sweep rate.	Left	B sweep	Right	B sweep
Dual X-Y displays.	Left	External	Right	External
Combined X-Y and Y-T (time-base) displays. Fig. 3-3.	Right	External	Right	B sweep
Dual multi-trace displays. Fig. 3-5.	Right	A sweep	Right	B sweep
B sweep delayed by A sweep. Fig. 3-6.	Right	A sweep	Right	B sweep

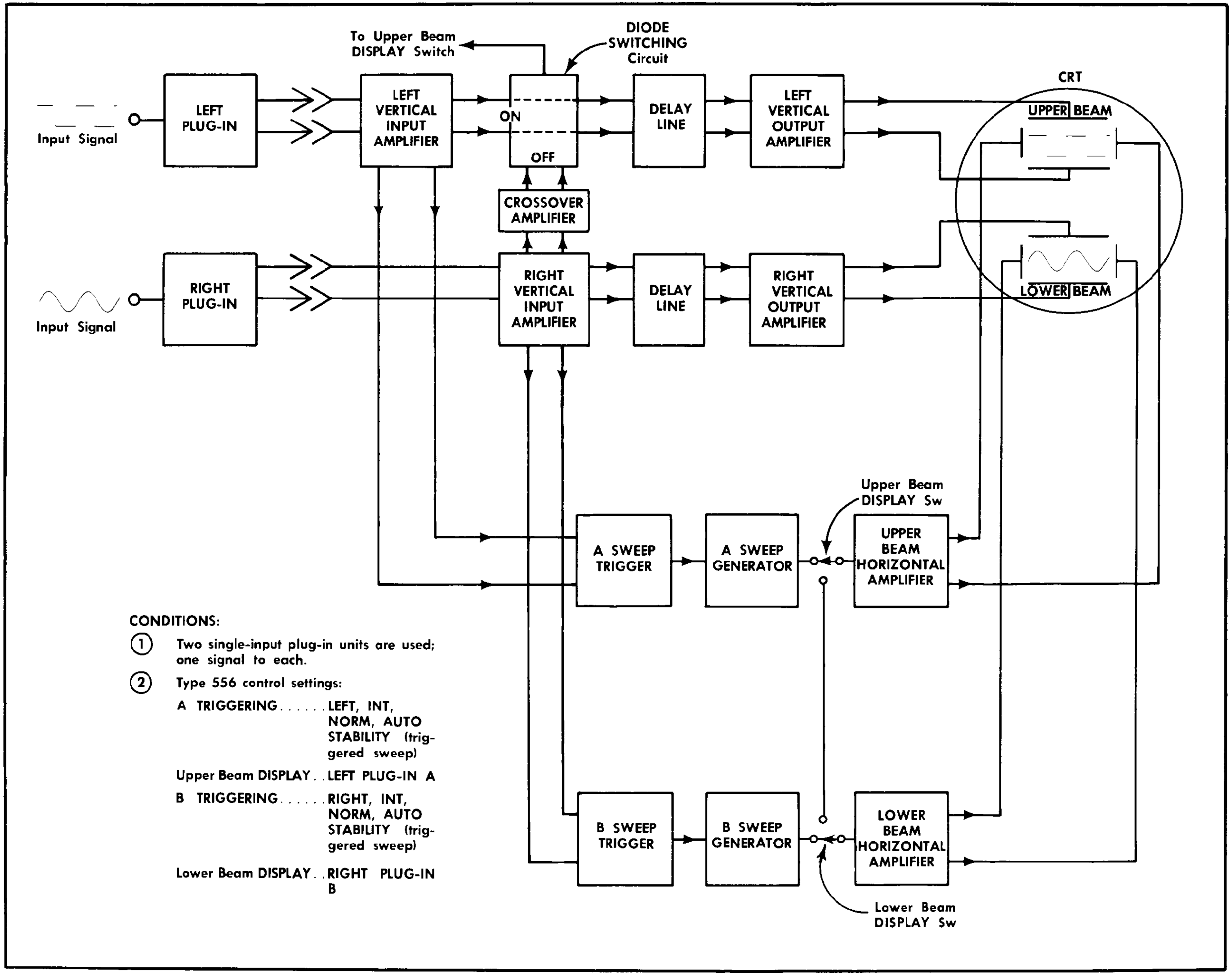


Fig. 3-1. The Type 556 operating as two completely independent deflection systems (one for each beam).

Going back to the Left Vertical Input Amplifier block, the left vertical signal is also applied to the Diode Switching circuit. With the Upper Beam DISPLAY switch set as given, the Diode Switching circuit connects the signal to the left vertical Delay Line. Any signal from the right plug-in is blocked by the "off" diodes in the Diode Switching circuit.

The Delay Line is a specially braided 186-ohm line which delays the application of the left plug-in signal to the Left Vertical Output Amplifier for 170 ns. This amount of delay provides time for unblanking the Upper Beam and starting the horizontal sweep before the vertical signal reaches the Upper Beam vertical deflection plates. Thus, it is possible to display the leading edge of a single fast-rising pulse. The Delay Line has a constant characteristic impedance along its length and requires no adjustment.

The signal applied to the right plug-in drives the Lower Beam deflection plates and B Sweep Trigger in the same manner as described for the Upper Beam system. In like manner, the B Sweep Trigger circuit triggers the B Sweep Generator. The sawtooth output is applied to the Lower Beam Horizontal Amplifier which in turn is used to drive the Lower Beam horizontal deflection plates.

Second Basic Mode (Fig. 3-2)

This mode shows the Type 556 operating as two interconnected vertical deflection systems with independent horizontal deflection systems. The main advantage of this mode is that only one probe need be used for coupling the signal to the Type 556, and yet maximum flexibility is obtained in displaying the signal on both beams. Use of one probe will minimize circuit loading of the device under test as compared to using separate probes at the same test point.

The vertical signal to be displayed by both beams is applied to the right plug-in. At the Right Vertical Input Amplifier the signal is taken off in the usual manner for application to the A and B Sweep Trigger circuits. The trigger circuits trigger their respective Sweep Generator circuits. The A Sweep Generator and Upper Beam Horizontal Amplifier circuits drive the Upper Beam horizontal deflection plates. Similarly, the B Sweep Generator and Lower Beam Horizontal Amplifier circuits drive the Lower Beam horizontal deflection plates. The sweep rate for the one beam can be controlled independent of the other. Thus, the displays shown in Fig. 3-2, for example, can be obtained by setting one sweep rate twice as fast as the other.

Also, from the Right Vertical Input Amplifier the signal goes through a Crossover Amplifier to the Diode Switching circuit. With the Upper Beam DISPLAY switch set to RIGHT PLUG-IN A, the diodes for the right plug-in signal are turned on and the signal goes through the left vertical Delay Line and Left Vertical Output Amplifier to the Upper Beam vertical deflection plates. The signal from the left plug-in is blocked by the "off" diodes in the Diode Switching circuit.

To provide a vertical display on the Lower Beam, the right plug-in signal goes through the Right Vertical Input Amplifier, right vertical Delay Line and Right Vertical Output Amplifier to the Lower Beam vertical deflection plates.

Since the left plug-in is not used in this mode for display purposes, it can be used to amplify a low-amplitude triggering signal for application to the A and B Sweep Trigger circuits. To use this trigger, set the A and B Triggering SOURCE switches to LEFT, INT, NORM.

Third Basic Mode (Fig. 3-3)

Under the conditions given in Fig. 3-3, the Type 556 is operating as two interconnected vertical systems and two independent horizontal deflection systems. In this mode, however, the Upper Beam Horizontal Amplifier is driven externally to obtain an Upper Beam X-Y display of the right plug-in and external horizontal input signals. The Lower Beam is used in a conventional manner to display the right plug-in signal amplitude against time.

Since the A Sweep Trigger and A Sweep Generator circuits are not used to obtain the displays, these circuits can be used for other purposes, if desired. For example, the A Sweep Generator block shows that its output signals are available. In addition, the left plug-in and Left Vertical Input Amplifier blocks are available for other uses as mentioned in the Second Basic Mode description.

Fourth Basic Mode (Fig. 3-4)

Fig. 3-4 shows the Type 556 operating as two interconnected vertical and horizontal deflection systems. Here the right plug-in signal is applied to the vertical deflection plates of both beams and the B Sweep circuit is used to provide dual-beam horizontal deflection.

Horizontal deflection of the beams can be controlled individually by using the DISPLAY MAG switches. To obtain the displays shown, the Upper Beam DISPLAY MAG switch is set to ×1 and the Lower Beam DISPLAY MAG switch is set to ×10.

As described previously, the blocks that are not used for obtaining the displays can be used for other purposes.

Fifth Basic Mode (Fig. 3-5)

In this mode of operation the Type 556 is operating as two interconnected vertical deflection systems. The dual-trace right plug-in unit provides the vertical deflection for both beams. Both Sweep Generators and Horizontal Amplifiers provide independent horizontal deflection drive for their respective beams.

With the dual-trace unit operating in the alternate mode, the Alternate Trace Logic circuit is used to produce one alternate sync pulse per slower sweep. For example, assume that both Sweep Generators are triggered simultaneously by the right plug-in channel 1 signal and both sweeps have started. Also, assume that the A Sweep is set to run several times slower than B Sweep. Under these conditions, the B Sweep Generator will generate several sweeps while the A Sweep is still running up. But, each time the B Sweep resets no alternate sync pulses are produced during the A Sweep runup.

As soon as the A Sweep ends, however, the A Sweep Inhibit gate keeps the A Sweep from starting again until the B Sweep can reset once again. As the B Sweep resets, the combined condition of A Sweep off and B Sweep resetting causes the Alternate Trace circuit to produce one alternate sync pulse that is applied to the dual-trace unit. The

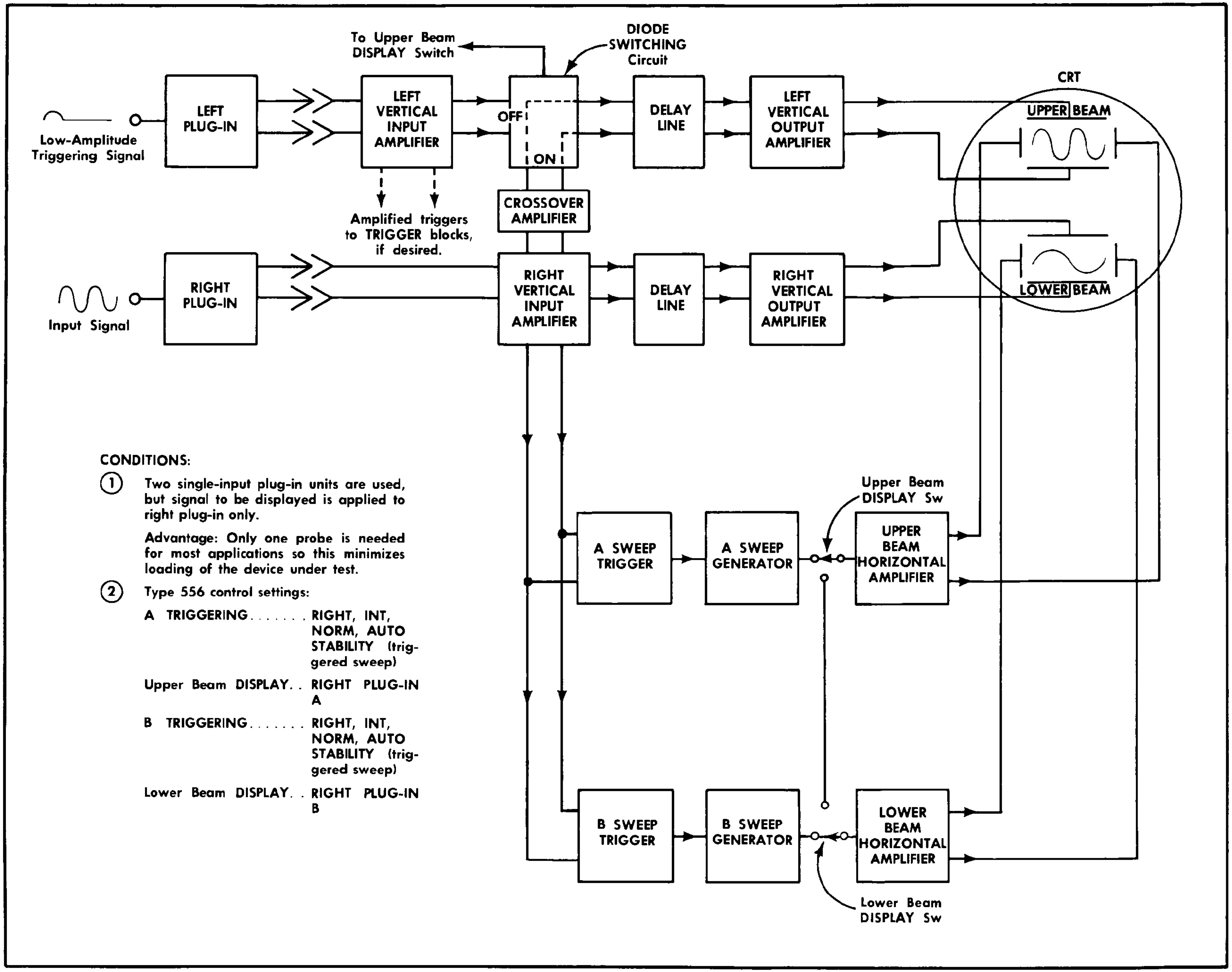


Fig. 3-2. The Type 556 operating as two interconnected vertical deflection systems and two completely independent horizontal deflection systems.

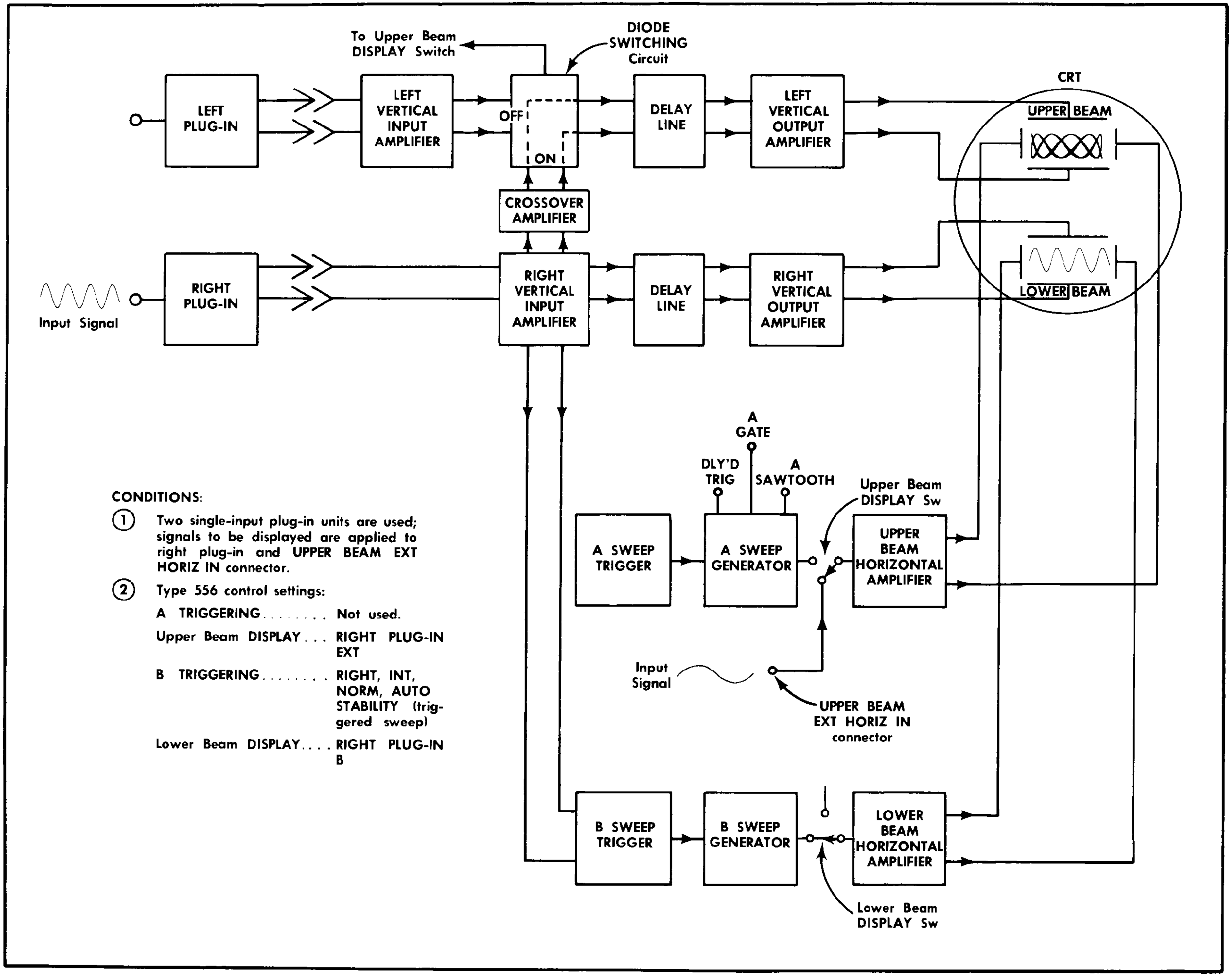


Fig. 3-3. The Type 556 operating as two interconnected vertical deflection systems and two completely independent horizontal deflection systems. Upper Beam Horizontal Amplifier is driven externally to obtain an X-Y display and the Lower Beam is driven by the B Sweep.

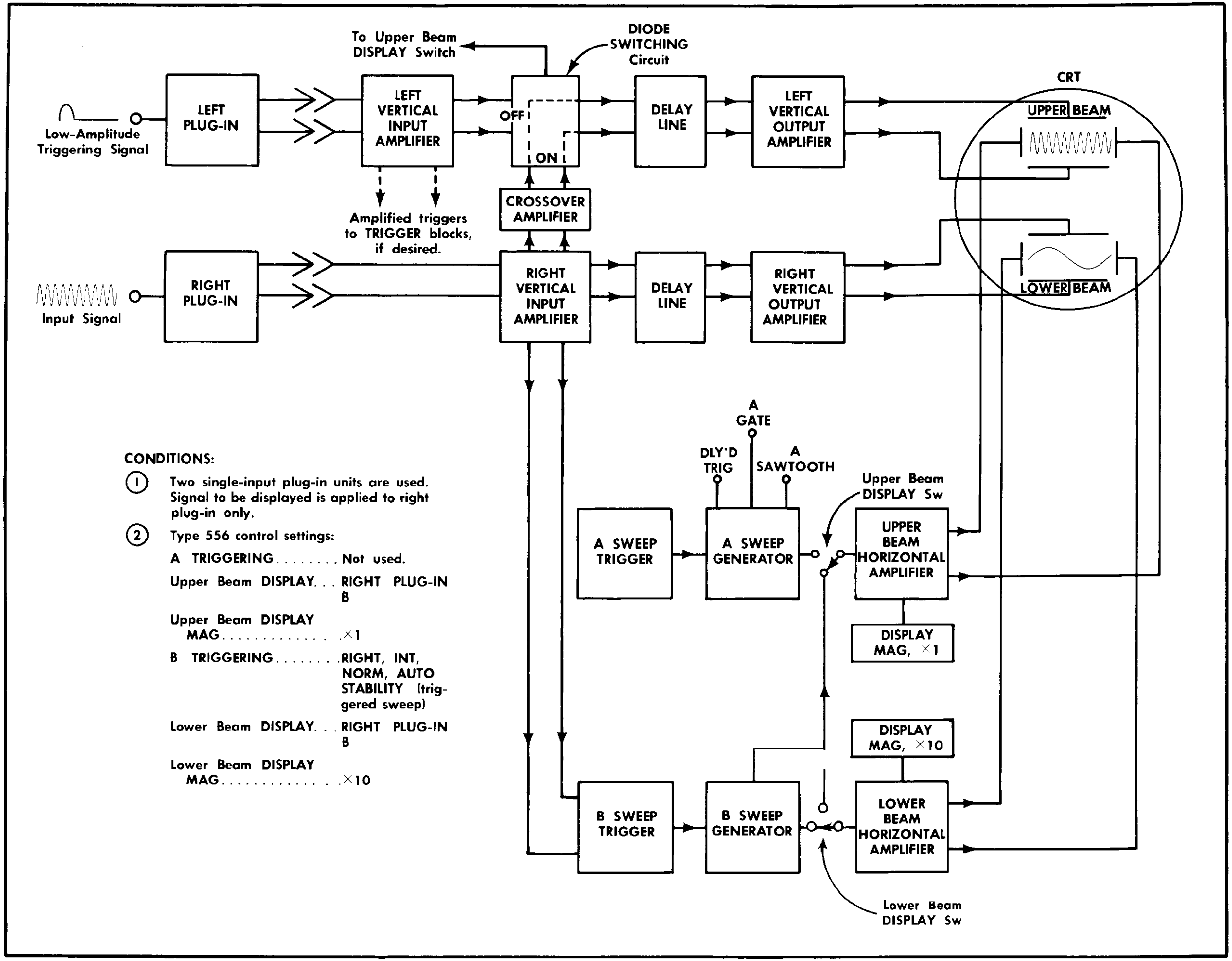


Fig. 3-4. The Type 556 operating as two interconnected vertical and horizontal deflection systems.

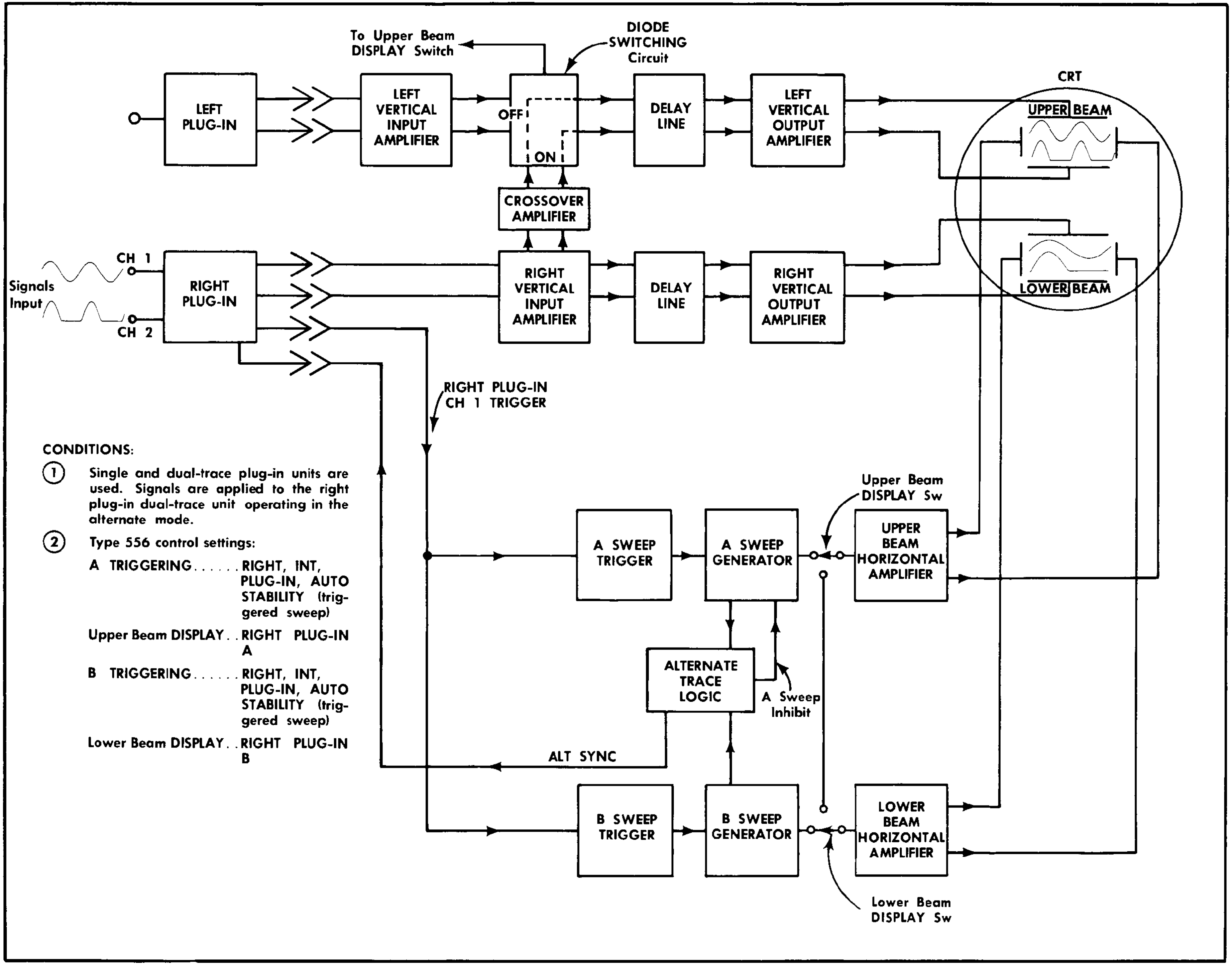


Fig. 3-5. The Type 556 operating as two interconnected vertical deflection systems and two independent horizontal deflection systems. The A Sweep Inhibit gate assures that only one Alt Sync pulse per slower sweep is obtained to alternate the right plug-in.

alternate sync pulse switches the plug-in unit to channel 2. Both sweeps start again and deflect their respective beams so a dual-beam display of channel 2 is obtained.

If the B Sweep is the slower sweep, the A Sweep will run only once and is locked out by the A Sweep Inhibit gate until the B Sweep resets. Since the A Sweep is the only one which is locked out in each case, best results are obtained by running the B Sweep at the same rate or faster than the A Sweep. This same operating characteristic applies if a single-channel plug-in unit is used.

As shown in Fig. 3-5, the A and B Triggering switches are set to RIGHT, INT, PLUG-IN. In these positions the channel 1 trigger is applied from the right plug-in to both Sweep Trigger circuits and the internal triggering signal from the Left and Right Vertical Input Amplifiers are not used. Thus, use of the channel 1 trigger permits the channel 1 input signal to be used as the time reference for channel 2.

If the dual-trace unit is set for chopped-mode operation, (not shown in Fig. 3-5) the plug-in sends chopped blanking pulses via the Chopped Blanking Amplifier and CRT Cathode Selector switches to the CRT cathodes to blank out the traces during the channel-switching intervals.

Sixth Basic Mode (Fig. 3-6)

For the conditions given in Fig. 3-6, the Type 556 is operating as two interconnected vertical deflection systems with the right plug-in signal displayed by both beams. The horizontal deflection systems are operating independently since each beam is driven by its respective Sweep Generator and Horizontal Amplifier. In this (Delayed B Sweep) mode of operation, where the B MODE switch is set to DLY'D BY A and the B Triggering is automatic, the B Sweep starts automatically after the A Sweep delay time.

If the right plug-in triggering signals from the Right Vertical Amplifier are applied to the B Sweep Trigger circuit and the B Triggering controls are set for triggered operation, the B Sweep will not start automatically after the delay time but must be triggered by a right plug-in internal triggering signal. Once triggered, the B Sweep will run. Delay time is determined by the A TIME/CM switch in the A Sweep Generator circuit and the DELAY-TIME MULTIPLIER control in the Delay Pickoff circuit. To prevent the A Sweep from running again until the B Sweep can reset, the B Gate is applied to an Inverter stage in the Alternate Trace Logic circuit. The inverted B Gate is used as an A Sweep Inhibit gate to lock out the A Sweep. When the sweeps reset, the A Sweep will run again when triggered by the right plug-in signal and the cycle is repeated.

Referring to Fig. 3-6 again, this same mode of operation can be changed easily to single-sweep B delayed mode by setting the A MODE switch to SINGLE SWEEP. When triggered, the A Sweep will run only once, the B Sweep will run automatically after the delay time and the sweeps will not start again until the A MODE RESET button is pressed and the A Sweep is triggered to repeat the cycle.

CIRCUIT ANALYSIS

The following circuit analysis of the Type 556 is keyed to detailed block diagrams that are provided in this portion of the manual. These diagrams give the names of the individual stages and show how they are connected together to form a major circuit. The major circuits from which the detailed block diagrams are derived, are shown on the schematic diagrams located on the pullout pages in the Diagrams section.

Each schematic diagram has been assigned a reference diagram number in a diamond frame; for example, Left Vertical Amplifier ⟨1⟩. These numbers are used throughout the detailed block and schematic diagrams as references to point out where a circuit on one diagram ties into the circuit on another diagram. When reading through the description, refer to the schematic diagrams for electrical values of components, voltages, waveforms and other detailed information as needed.

As supplemental information to the detailed blocks provided in this section, there are two more block diagrams provided on pullout pages in the Diagrams section. These diagrams show the interrelationship of blocks throughout the vertical and horizontal systems.

LEFT VERTICAL AMPLIFIER ⟨1⟩

Input Cathode Follower, V3

The push-pull output of the left plug-in, with a fixed DC level of about +67.5 V, is applied to the Input Cathode Follower V3 stage (see Fig. 3-7) via pins 1 and 3 of the plug-in connector J11.

Letter-series plug-in units, when inserted into the oscilloscope, actuate the transient-response compensation switch SW105. This switch connects a series network, C100 and R100, across the input to V3A and V3B. The network compensates for the slight difference in transient response that exists between the letter- and 1-series vertical plug-in units. Since the switch is mechanically actuated by the plug-in, no attention on the part of the operator is required.

Resistors R1 and R101, connected in series with the grids of V3A and V3B, are parasitic suppressors. V3A and V3B are two halves of a 12AT7 twin-triode tube. The cathodes of the tube are returned to ground through the DC BALANCE control R5. This control adjusts the bias voltages of V3A and V3B so that the CRT trace will come to graticule center with V3A and V3B grids connected together.

The heaters of V3 and V661 (see Heater Wiring diagram) are part of a series heater circuit which receives power from the +100-V DC supply. V3 and V661 heaters drop the voltage 25 V to provide 75 V at 150 mA to the remaining portion of the heater string located in the left plug-in unit. The DC voltage supply to the plug-in heaters eliminates hum modulation of the cathodes and stablizes the tube gain.

Protection diodes D4 and D104 prevent V3 cathodes from going below +61 V. This voltage is set by a 39 V zener, D6, connected between the anodes of the diodes and the +100 V supply. D4 and D104 are normally back-biased, but if the cathode voltages should attempt to decrease below +61 V, the diodes will conduct and clamp the cathodes, thus preventing any further decrease in cathode voltage. Zener D6 is also connected to a voltage divider network. At the junction of R6 and R7 the voltage is about +50 V which is used as the low-impedance voltage source for the Diode Switch-

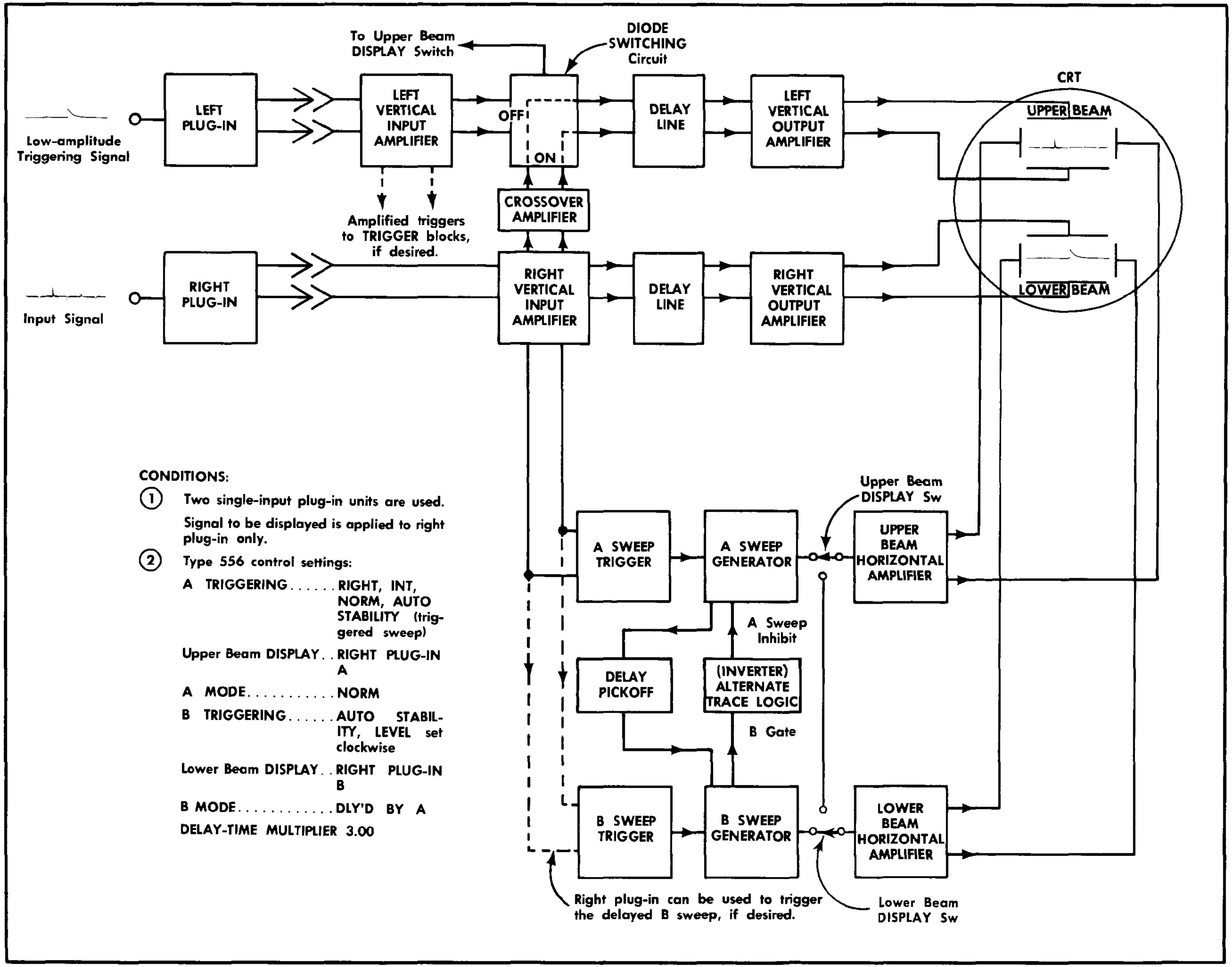


Fig. 3-6. The Type 556 operating as two interconnected vertical deflection systems and two independent horizontal deflection systems. The B Sweep starts automatically after A Sweep delay time. If B Sweep is set for triggered operation (dashed lines to B Sweep Trigger), B Sweep runs when triggered by signal occurring after delay time.

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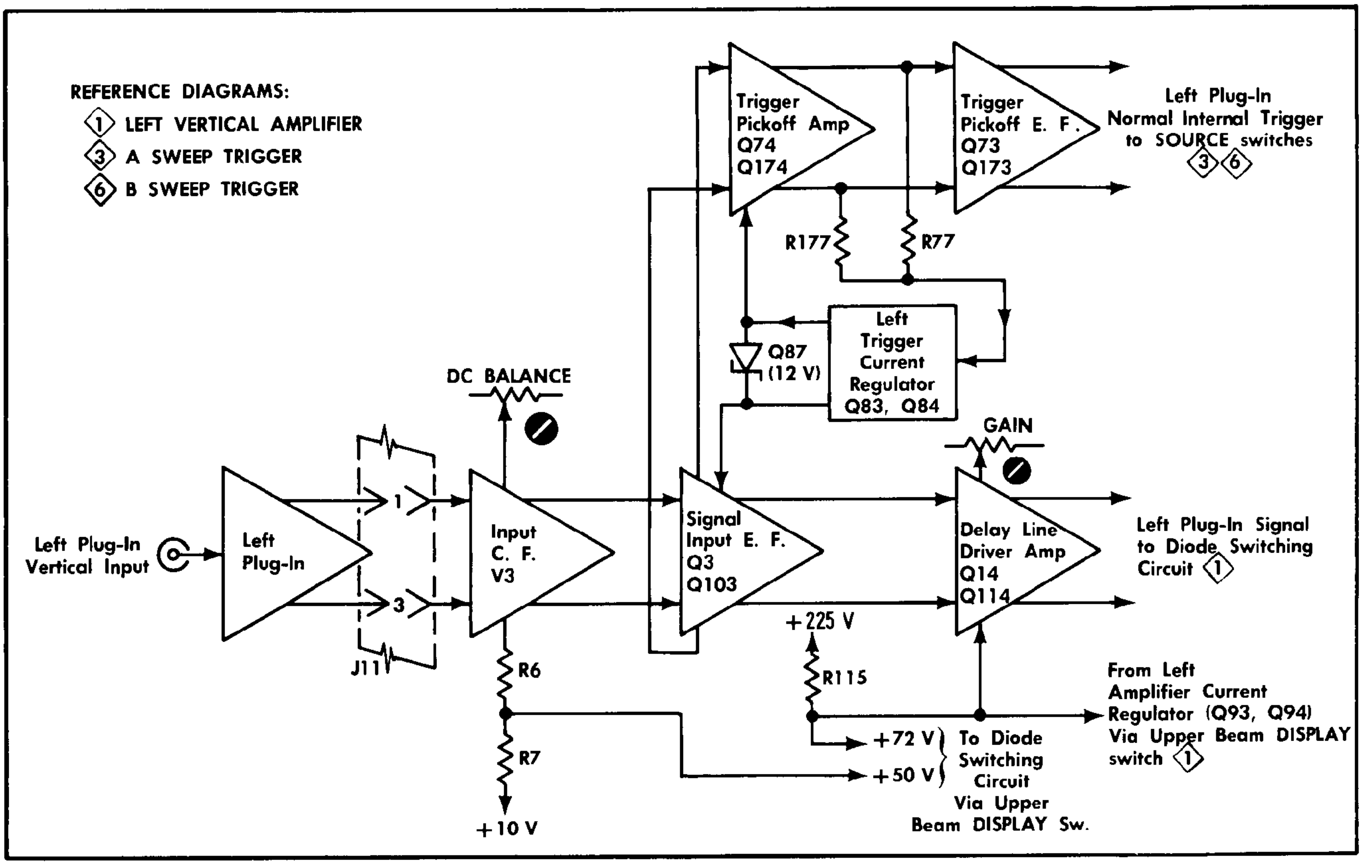

Fig. 3-7. Partial block diagram of Left Vertical Amplifier.

ing stage to be described later. Diodes D8, D108, D9 and D109 (for SN 100-1999, D7, D8, and D108) provide protection for certain transistors in the stages that follow.

Signal Input Emitter Follower, Q3 and Q103

The push-pull left plug-in signal from the Input C. F. stage is applied to the Signal Input E. F. (Q3, Q103) stage. For signal purposes, this stage is an emitter follower since the output is taken from its emitters. However, the collector circuits operate in a cascode configuration with the Trigger Pickoff Amplifiers (Q74, Q174).

To compensate for variations between plug-in units in output DC level from the nominal +67.5 V, the output from the Trigger DC Collector Current Regulator stage (Q83, Q84) is applied to R9 and R109 in the emitter circuit of Q3 and Q103. Further details about the regulator stage are described later.

Trigger Pickoff Amplifier, Q74 and Q174

To obtain a push-pull triggering signal which is always available for normal internal triggering purposes when the SOURCE switch is set to LEFT, INT, NORM, the signal must be taken off ahead of the Diode Switching stage. This is accomplished by connecting the Trigger Pickoff Amplifier (Q74, Q174), in a cascode configuration with the Input E. F. stage.

The push-pull internal trigger output from Q74 and Q174 is applied to the Trigger Pickoff E.F. stage.

Trigger Pickoff Emitter Follower, Q73 and Q173

This stage provides low-impedance drive for the A and B Triggering SOURCE switches. When the SOURCE switches are set to LEFT, INT, NORM, the normal internal triggering signal with its regulated DC output level is coupled to the A and B Sweep Trigger circuits for use in triggering the A and B Sweep Generator circuits.

Left Trigger Current Regulator, Q83 and Q84

The regulator stage consisting of Q83 and Q84 with associated circuitry acts as a series bootstrap element that automatically regulates the common-mode DC collector currents so that collector voltage levels are held constant. This is particularly important when using the DC coupling mode of triggering. When using this mode, the DC levels at the collectors of Q74 and Q174 must be held at a nominal value to maintain proper DC levels at the emitters of Q73 and Q173 for application to the Sweep Trigger circuits.

If the plug-in output DC level is more or less than +67.5 V, this common-mode voltage change from the nominal value of of 67.5 V tends to cause a current change through Q3, Q103, Q74 and Q174. This current change tends to change the voltage at the collectors of Q74 and Q174. As a result, an error signal is developed at the junction of L77 and L177.

The error signal is applied to the base of Q83. This transistor operates as an emitter follower for the error signal which is then applied to the base of Q84. Transistor Q84 and associated circuitry acts as a series-element regulator in the emitter circuit of Q3 and Q103 comparing the error signal voltage to the +100 V supply. By resetting the emitter voltages of Q3 and Q103, current through the transistors is the same as if the plug-in output level were +67.5 V.

The regulating action of Q83 and Q84 causes the voltage at the junction of L77 and L177 to remain constant so the collector voltage of Q74 and Q174 are maintained at a nominal level for application to the bases of Q73 and Q173. Thus, with the plug-in unit Position control centered so the voltages at pins 1 and 3 of J11 are equal, the voltage at the emitters of Q73 and Q173 should be about +50 V.

The zener diode drop across D87 is used as a reference voltage for the bases of Q74 and Q174. Thus, the bases move up and down in phase with the junction of R9 and R109, but 12 volts removed by D87.

Delay Line Driver Amplifier, Q14 and Q114

The balanced Delay Line Amplifier stage, Q14 and Q114, is a push-pull stage which is actually connected in cascode with Q44 and Q144. An adjustable vertical GAIN control R12 is provided in the emitter circuit. Gain is adjusted by controlling the amount of degeneration. Variable capacitor C10 is adjusted to vary the time constant sufficiently to optimize the transient response.

The RC networks in the collectors of Q14 and Q114 are thermal time constant compensations. The push-pull signal from this stage provides signal current drive for the Diode Switching circuit and delay line.

In the LEFT PLUG-IN positions of the Upper Beam DISPLAY switch, the Left Amplifier Current Regulator, Q93 and Q94, provides a regulated current via R14 and R114 to the emitters of Q14 and Q114.

Diode Switching Circuit

Fig. 3-8 shows the operation of the Diode Switching circuit. This circuit permits passage of either the left or right plug-in signals to the Upper Beam vertical deflection plates. The Upper Beam DISPLAY switch is used to control the switching of the diodes.

The LEFT and RIGHT positions of the Upper Beam DISPLAY switch shown in Fig. 3-8 correspond to these front-panel positions: LEFT is any of the LEFT PLUG-IN positions and RIGHT corresponds to the RIGHT PLUG-IN positions. Assume the Upper Beam DISPLAY switch is set to the LEFT position. +72 V is applied from the collector circuit of Q94 (see Fig. 3-7) to the cathode junctions of D17 and D117 to turn these diodes off and turn on diodes D15 and D115. As a result the left plug-in signal passes through diodes D15 and D115 to the left-vertical delay line.

On the other hand, +50 V is applied to the cathode junctions of D19 and D119 to turn these diodes on and turn off diodes D16 and D116. Thus, diodes D16 and D116 prevent the right plug-in signal from being applied to the left-vertical delay line.

If the Upper Beam DISPLAY switch is set to the RIGHT position, just the opposite occurs. +50 V is applied to D17 and D117 and +72 V is applied from the collector circuit of Q94 to D19 and D119. Hence, all the previously on diodes are turned off and the off diodes are turned on. The left pulg-in signal is blocked by D15 and D115; D16 and D116 pass the right plug-in signal to the left-vertical delay line.

Right Plug-In Crossover E. F., Q23 and Q123

The right plug-in signal from the Signal Input E. F. (Q203, Q403) in the Right Vertical Amplifier circuit is applied at all times through 93-ohm coaxial cables to the Right Plug-In Crossover E. F. (Q23, Q123). Termination for the cable is provided by R20 and R120. Purpose of the emitter follower stage is to isolate the impedance of the cables from the input impedance of the Delay Line Driver Amplifier circuit. The input impedance of the right Plug-In Crossover, E. F. stage depends upon settings of the gain and peaking adjustments.

Right Plug-In Crossover Amplifier, Q34 and Q134

This stage is very similar to the Delay Line Driver Amplifier Q14 and Q114 described earlier. In the emitter circuit a CROSSOVER GAIN control R34 is provided to adjust the gain of the stage so the vertical deflection factor of the right plug-in signal amplitude to the Upper Beam vertical deflection plates is the same as that from the left plug-in unit.

Variable capacitors C19, C30 and C31 with R31 are adjusted for optimum transient response. These adjustments vary the high-frequency peaking in the emitter circuit.

In the RIGHT PLUG-IN positions of the Upper Beam DISPLAY switch, a regulator current is fed from the Left Amplifier Current Regulator (Q93, Q94) through the switch via R36 and R136 to the emitters of Q34 and Q134. In the LEFT PLUG-IN positions of the Upper Beam DISPLAY switch, R37 provides "keep alive" current for diodes D19 and D119.

Left Vertical Delay Line

Output from the left or right Delay Line Driver stages is applied through the Left Vertical Delay Line to the Output Driver Amplifier (Q44, Q144). The Delay Line delays the signal about 170 ns to give the Sweep Generator circuit time to initiate a sweep before the vertical signal reaches the Upper Beam vertical deflection plates.

R41-C41 and R141-C141 provide the output termination for the Delay Line; R18 provides the reverse termination. The center-tapped inductors, L18 and L118, at the input to the Delay Line and the collector-base capacitance of the delay line transistors form a T-section matching network. Impedance of the network can be varied by adjusting C17 in the LEFT PLUG-IN positions of the Upper Beam DISPLAY switch and C19 in the RIGHT PLUG-IN positions.

Output Driver Amplifier, Q44 and Q144

This stage forms the other portion of the cascode amplifier with the Delay Line Driver Amplifier Q14 and Q114. Net-

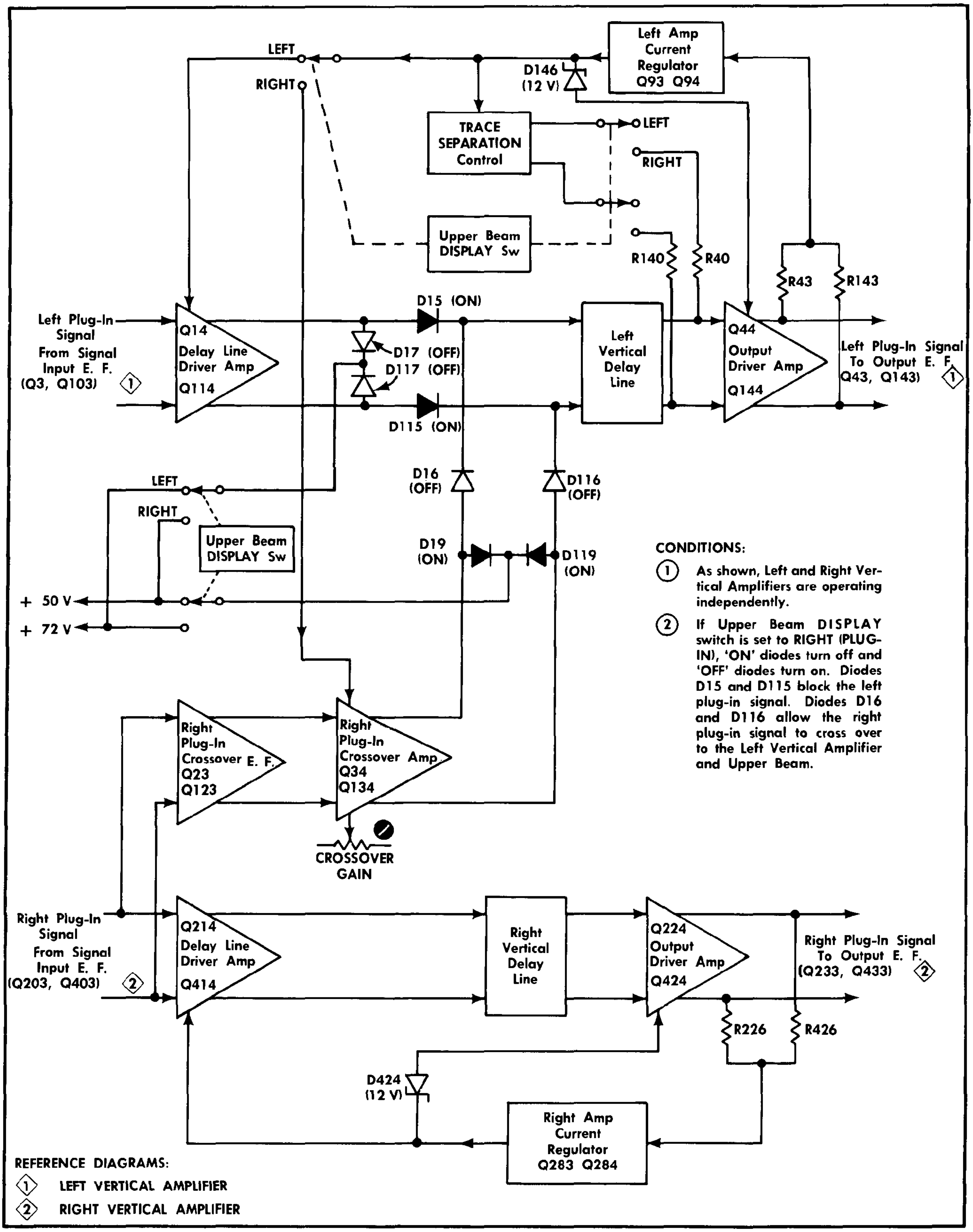

Fig. 3-8. Partial block-and-circuit diagram of Left and Right Vertical Amplifiers. The diodes are located in the Diode Switching circuit of the Left Vertical Amplifier.

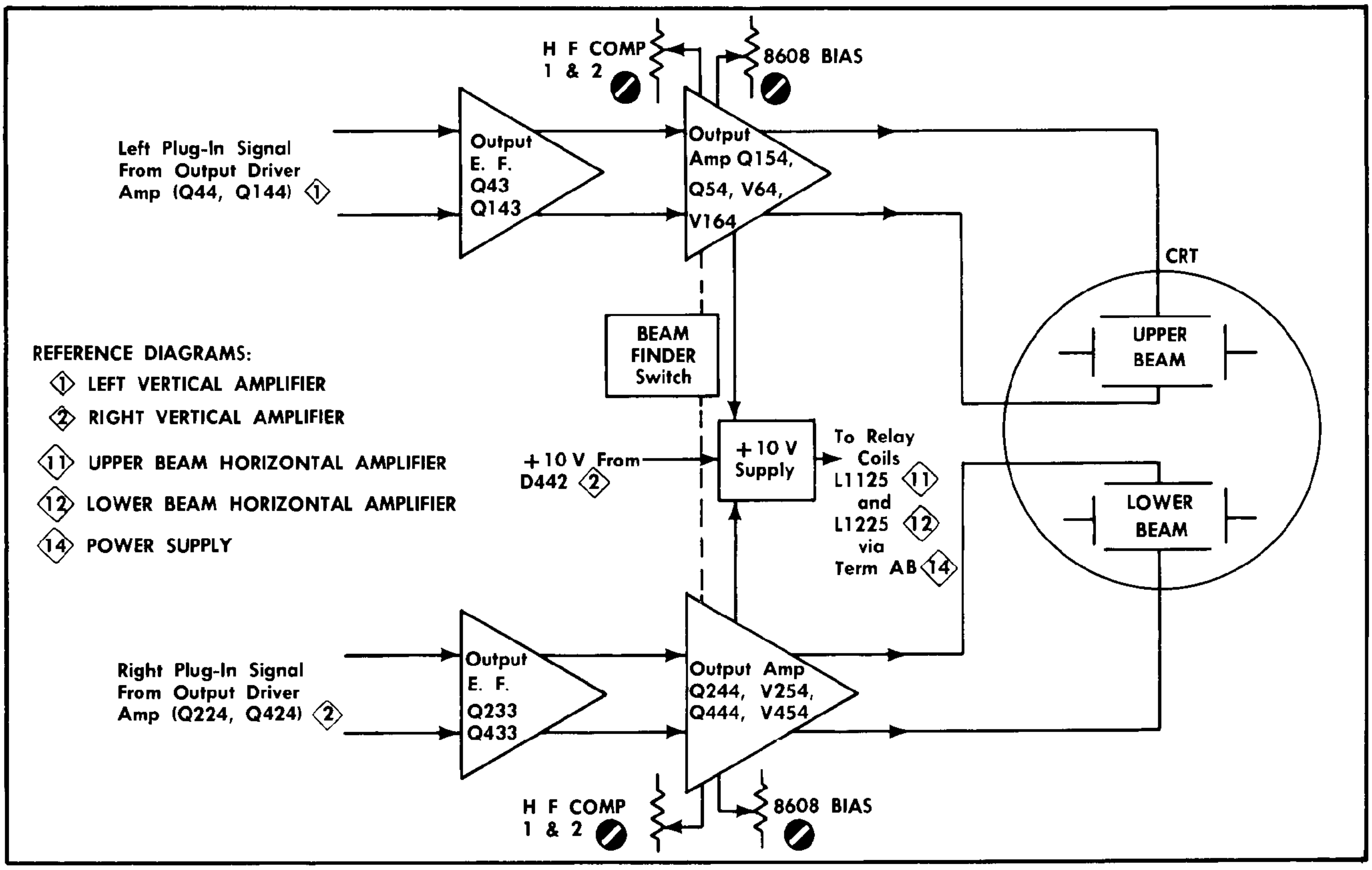

Fig. 3-9. Partial block diagram of Left and Right Vertical Output Amplifiers.

works C42-R42 and R142-C142 are temperature compensations for Q44 and Q144. L43 and L143 are adjustable T-coils for high-frequency peaking.

Zener D144 limits the base-collector voltage to about 22 V for protection purposes. Any change in DC level at the anode of D144 due to a change from nominal in output DC level of the plug-in is applied to the Left Amplifier Current Regulator, Q93 and Q94. D146 supplies base voltage to Q44 and Q144.

A TRACE SEPARATION control R182 is switched into the emitters of Q44 and Q144 when the Upper Beam DISPLAY switch is set to the RIGHT PLUG-IN positions allowing the Upper Beam to be positioned independently of the Lower Beam.

Left Amplifier Current Regulator, Q93 and Q94

This stage regulates the DC collector levels of Q44 and Q144 to compensate for any change in plug-in unit DC output level from the nominal value of +67.5 V.

For regulating purposes, if the DC level at the junction of R90 and R91 tends to change due to a change in current through Q44 and Q144, an error signal is developed and applied to the base of Q93. The emitter output from Q93 is applied to the base of Q94. Transistor Q94 serves as a DC current series regulator to control the emitter current of Q14 and Q114 when the Upper Beam DISPLAY switch is set to any of the LEFT PLUG-IN positions.

In the RIGHT PLUG-IN positions of the switch, the regulating current is applied to the Right Plug-In Crossover Amplifier (Q34 and Q134).

With the Upper Beam DISPLAY switch set to RIGHT PLUG-IN A, the right plug-in vertical Position control positions both beams simultaneously but cannot position one beam with respect to the other. However, the latter situation is solved by adding a TRACE SEPARATION control, R182, in the Q94 collector circuitry. The control varies the DC current through R180 more than through R184, or vice versa, so that the control acts as a vertical positioning control for the Upper Beam.

The positioning currents are applied via the Upper Beam DISPLAY switch through R40 and R140 to the emitter input circuit of Q44 and Q144. When the Upper Beam DISPLAY switch is set to any of the LEFT PLUG-IN positions these positioning currents are disconnected from R40 and R140 so the TRACE SEPARATION control has no effect on the Upper Beam. The control is disconnected at this time because the left plug-in Position control provides the normal vertical positioning range for the Upper Beam.

Output E. F., Q43 and Q143

This stage is an emitter follower for either the left or right plug-in signals from the Output Driver Amplifier (Q44, Q144), depending on the position of the Upper Beam DISPLAY switch.

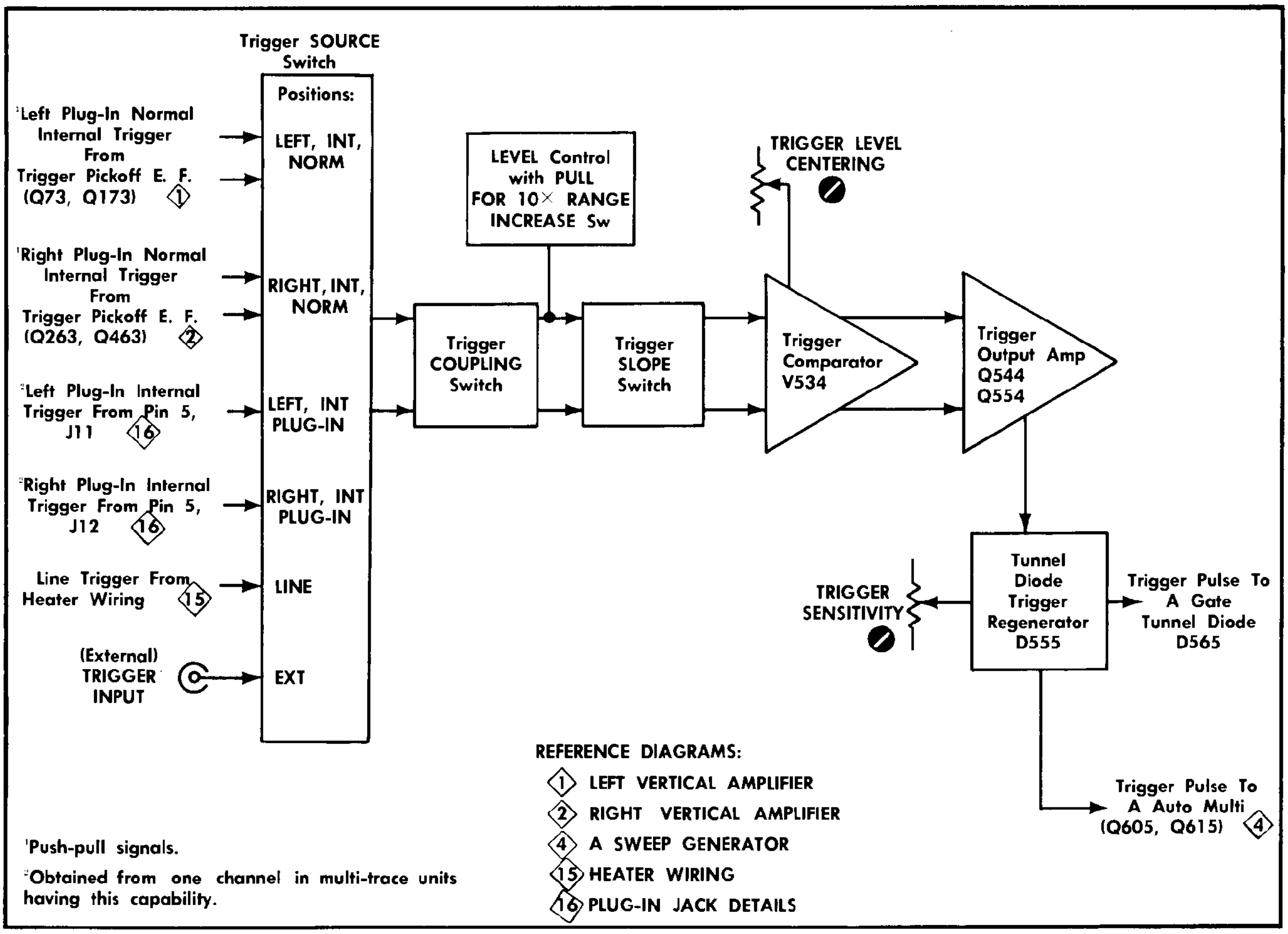

Fig. 3-10. Block diagram of the A Sweep Trigger.

To trace the signal, assume the Upper Beam DISPLAY switch is set to the LEFT PLUG-IN positions. The push-pull left plug-in signal is applied to the bases of Q43 and Q143 and the output signal at the emitters is used to drive the lower part (Q54, Q154) of the hybrid Output Amplifier stage.

Output Amplifier Q54, Q154, V64 and V164

The Output Amplifier stage operates in a hybrid cascode configuration to drive the Upper Beam vertical deflection plates and to raise the DC output level from about +50 V at the bases of the transistors to about +176 V at the deflection plates.

L64 and L164 are T-coils that provide high-frequency peaking in the stage. Other high-frequency compensation adjustments are HF COMP 1 (R52), HF COMP 2 (R54), C51, C53, C54 and C55.

The BEAM FINDER button, when pressed, disconnects R150 and R151 limiting the emitter current to Q54 and Q154. This restricts the dynamic operating range of the transistors limiting the trace to the Upper Beam display area. The BEAM FINDER switch SW155 also connects R62 and R162 in shunt with Q54 and Q154 maintaining current through V64 and V164 essentially constant, so that the average CRT deflection plate potential does not change. The BEAM FINDER switch SW155 performs a similar function in the Right Vertical Amplifier circuit. This same switch is used in the Upper and Lower Beam Horizontal Amplifier circuits to restrict the horizontal deflection simultaneously with the vertical deflection.

The +10 V in the emitter circuit of Q54 and Q154 is a supply voltage obtained from zener D442 in the Q244-Q444 emitter circuit of the Right Vertical Amplifier. This voltage goes to terminals AB in the Power Supply circuit for distribution to relay coils L1125 (Upper Beam Horizontal Amplifier) and L1225 (Lower Beam Horizontal Amplifier).

In the grid circuit of V64 and V164 there is an 8608 BIAS adjustment R69. This adjustment sets the collector voltage across Q54 and Q154 for correct thermal characteristics.

RIGHT VERTICAL AMPLIFIER ⟨2⟩

This circuit is the same as the Left Vertical Amplifier except for the crossover amplifier and TRACE SEPARATION control circuitry which have already been described.

A SWEEP TRIGGER ③

Trigger Source

The triggering signal source is selected with the SOURCE switch SW515. Six sources are available and they are all shown being applied to the SOURCE switch block in Fig. 3-10. The SOURCE switch block lists all the SOURCE switch positions. Each position is shown with its corresponding signal source.

Trigger Coupling

The COUPLING switch offers a means of accepting or rejecting certain frequency components of the triggering signal. In the AC and AC LF REJ positions, the DC component of a push-pull signal is blocked by coupling capacitors C501 and C502, and C525 or C526. In the AC position, frequency components below about 30 Hz will be attenuated. In the AC LF REJ position, frequency components below about 1.6 kHz will be attenuated.

The AC HF REJ position attenuates high-frequency components of the triggering signal. The signals are AC-coupled and are attenuated below about 60 Hz and above about 100 kHz. In the DC position, the push-pull normal internal triggering signal is DC-coupled to the triggering circuit via dividers R504-R505 and R520-R521. The no-signal DC level at the input to the dividers with the plug-in Position control centered is about +50 V. At the output of the dividers the voltage is about zero.

Trigger Level

The A Triggering LEVEL control R518 applies a DC voltage to one grid or the other of V534, depending on the position of the SLOPE switch. Purpose of the LEVEL control is to set the DC push-pull current through Q544 and Q554 to a point where the trigger signal current will cause tunnel diode D555 to switch states. Switching of the tunnel diode to its high state always occurs on the positive-going rising portion of the waveform at Q554 collector.

With the SLOPE switch set to + and the LEVEL control pushed inward as shown on the A Sweep Trigger schematic diagram, voltage range of the control at the grid of V534B is about ±2 V when measured using a DC-coupled oscilloscope having a 10-megohm input loading. When the control is pulled outward to the ×10 RANGE INCREASE position, R511 is bypassed and the voltage range is about ±20 V. If the LEVEL control knob is properly positioned on the shaft, the knob should point to 0 when voltage at the grid of V534B is zero.

Trigger Slope

The + and — positions of the SLOPE switch SW520 provide a means of inverting or not inverting the single-ended signal which is applied to the anode of D555. This is accomplished by switching the triggering signal at the grids of V534.

In the + position of the SLOPE switch, a positive-going incoming single-ended triggering signal applied to the junction of R526 and R528 will be applied to the grid of V534A. The signal will have the same polarity when applied to D555.

If the SLOPE switch is set to —, the signal will be applied to the grid of V534B and will be inverted when applied to D555 so D555 can switch on the falling (positive-going) portion of the displayed waveform. This is done so the positive-going trigger at the output of the A Sweep Trigger can be made to occur during either a positive-going or a negative-going portion of the triggering signal.

Trigger Comparator V534

The Trigger Comparator circuit consists of a cathode-coupled vacuum tube pair, V534A and V534B. In operation, the circuit is a push-pull amplifier which drives a Trigger Output Amplifier Q544 and Q554.

The A TRIGGER LEVEL CENTERING control R545 in the plate circuit of V534 is adjusted so the base voltages on Q544 and Q554 are equal when V534 grid voltages are zero. Coil L547 is energized when the COUPLING switch SW510 is set to the AC HF REJ position. The coil closes SW547 contacts to connect C547 across V534 output and limit the high-frequency push-pull response of the circuit.

Trigger Output Amplifier, Q544 and Q554

Push-pull signals from V534 are applied to the Trigger Output Amplifier stage, Q544 and Q554. The push-pull input signals are converted to single-ended output signals at the collector of Q554 for application to tunnel diode D555.

Tunnel Diode Trigger Regenerator D555

For discussion purposes, assume these conditions: The SLOPE switch is set to +, the LEVEL control is set in the + region, and the current through D555 is such that the tunnel diode is in its low state (see Fig. 3-11 for the characteristic

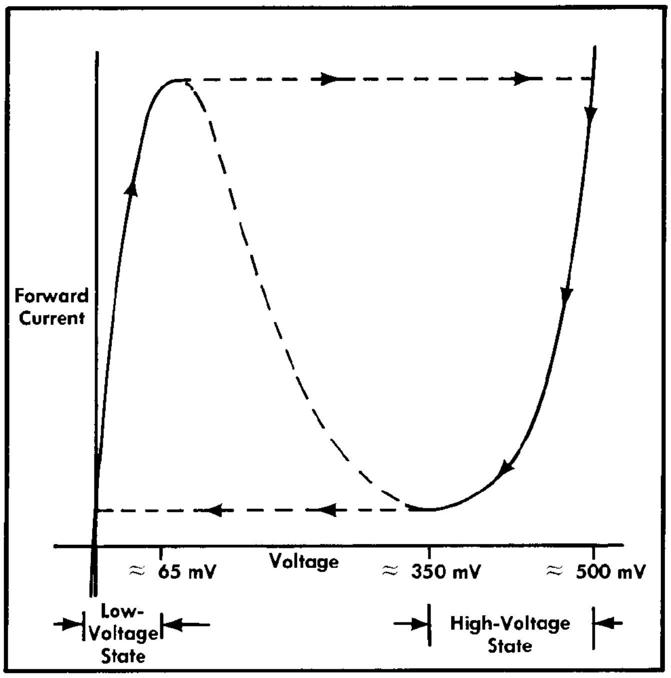

Fig. 3-11. Tunnel diode characteristics.

curve of a tunnel diode). When a positive-going trigger is applied to the grid of V534A, the trigger is negative-going at the base of Q554. Collector current of Q554 increases and this increased current flows through D555, causing D555 to switch to its high state. The sudden switching of D555 to its high state causes the tunnel diode to produce a positive-going trigger having a uniform amplitude and a fast rise for application to the Sweep Gate Tunnel Diode D565 and to the A Auto Multivibrator stage, Q605 and Q615.

When the positive-going trigger at the base of Q554 returns to the original starting level, decreased current through Q554 resets the tunnel diode to its low state. R553 and the A TRIGGER SENSITIVITY control R556 sets the load and bias on D555 so the tunnel diode has a small hysteresis but not small enough to switch states on internal noise or to self-oscillate.

B SWEEP TRIGGER ⟨6⟩

The B Sweep Trigger is similar to the A Sweep Trigger in every respect except the B Sweep Trigger drives the B Sweep Generator.

A SWEEP GENERATOR ⟨4⟩ and A SWEEP TIMING SWITCH ⟨5⟩

General

The A Sweep Generator produces seven simultaneous output signals controlled by four input signals (see Fig. 3-12). There are two more input signals but these control only a portion of the A Sweep Generator circuit when certain Upper Beam DISPLAY switch positions are used. The input signals are:

1. For triggered-sweep operation, a positive-going trigger from D555 in the A Sweep Trigger.

2. For auto-stability operation, a DC threshold level determined by the A Auto Multivibrator circuit, Q605 and Q615.

3. For single sweep operation, a positive-going reset pulse generated by operating the RESET button.

4. For RIGHT PLUG-IN A operation, a positive-going inhibit gate from the Alternate Trace Logic and Blanking Circuit.

5. In RIGHT PLUG-IN A, DLY'D BY A operation, a positive-going trace brightening pulse (restored to normal intensity during B sweep) from R799 in the B Sweep Generator circuit. This pulse controls the Upper Beam unblanking circuitry only. In addition, there is a positive-going inhibit gate coming from the Alternate Trace Logic and Blanking circuit.

6. In RIGHT PLUG-IN operation, a negative-going B gate during B sweep from Q763 and Q773 in the B Sweep Generator circuit. This gate pulse controls the Upper Beam unblanking circuitry only.

The output signals are:

1. Positive-going unblanking pulse applied to the CRT Circuit Upper Beam control grid.

2. Positive-going gate signal to the A GATE connector on the front panel.

3. Negative-going gate signal during the A Sweep to D1024 in the Alternate Trace Logic and Blanking circuit.

4. Positive-going A sawtooth signal to the Upper Beam Horizontal Amplifier via the Upper Beam DISPLAY switch.

5. Positive-going A sawtooth signal to the Delay Pickoff circuit.

6. Positive-going A sawtooth signal to pin 6 of J11. Used for driving a left plug-in spectrum analyzer capable of utilizing this signal.

7. Positive-going A sawtooth signal to the front-panel A SAWTOOTH connector.

8. Positive-going A sawtooth signal to the Lower Beam Horizontal Amplifier, via the Lower Beam DISPLAY switch.

To simplify the operational description of each stage shown in Fig. 3-12, the description initially assumes that the conditions are as follows:

1. The front-panel controls are set as follows:

A Triggering	LEFT, INT, NORM, TRIG; LEVEL control is set for triggered operation.
Upper Beam DISPLAY	LEFT PLUG-IN A
A MODE	NORM

2. The A Sweep Generator circuit is in its quiescent state ready to be triggered by a triggering pulse from D555.

3. The description for each stage begins with the stage in its quiescent state; i. e., the A Sweep Generator circuit is ready to be triggered. Then, the discussion proceeds to describe the operation as D555 triggers the sweep. Refer to Figs. 3-12, 3-13, 3-14 and the appropriate schematic diagrams when following the description. Other modes of operation, but only those of most importance where the input signal directly affects the stage, are briefly described last. All signal amplitudes and voltages stated in the text are approximate.

A Gate Tunnel Diode D565

During quiescence, tunnel diode D565 is in its low state. Bias current is set by R561, D562 and R563 connected to the +100 V supply.

To switch D565 to its high state, a positive-going trigger from D555 is required. The trigger is coupled through C560 to L560 and D561. C560 and L560 form a differentiating network to provide a very narrow trigger pulse to D565. Diode D560 clamps the junction of L560 and R560 at about +0.5 V.

Upon application of the trigger pulse, D565 switches to its high state and the A Sweep Generator circuit produces a sawtooth. At a point determined by the A SAWTOOTH AMPL control R678, the Holdoff Multi changes state, V625A returns D565 to its low state and holds D565 in the low state until holdoff capacitor C675 discharges to a point where V625A will allow D565 to accept another trigger. The output signal from D565 is a 350-mV positive-going gate applied to the base of Q564. Duration of the gate is equal to the ramp time of the sawtooth.

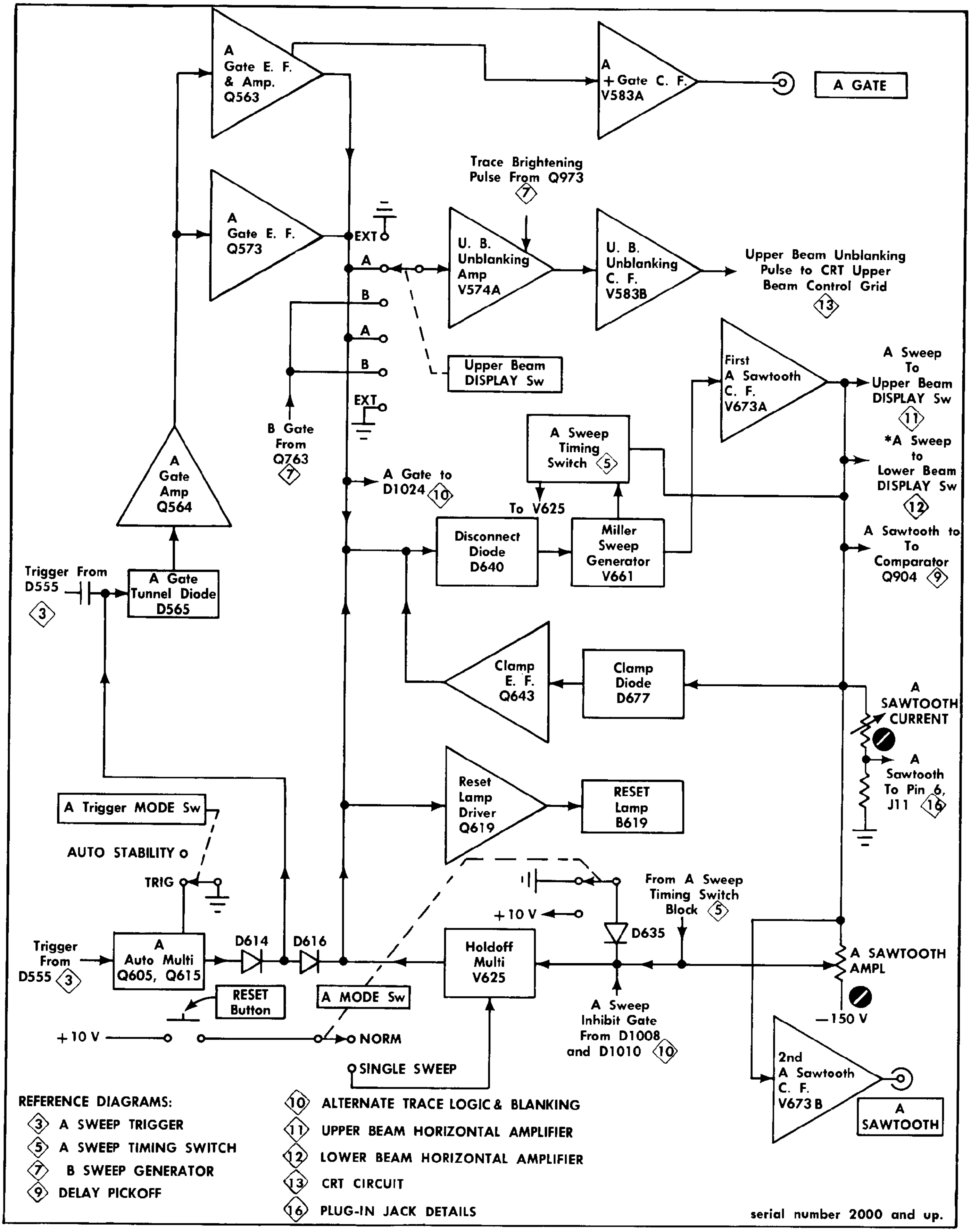

Fig. 3-12. Block diagram of the A Sweep Generator circuit.

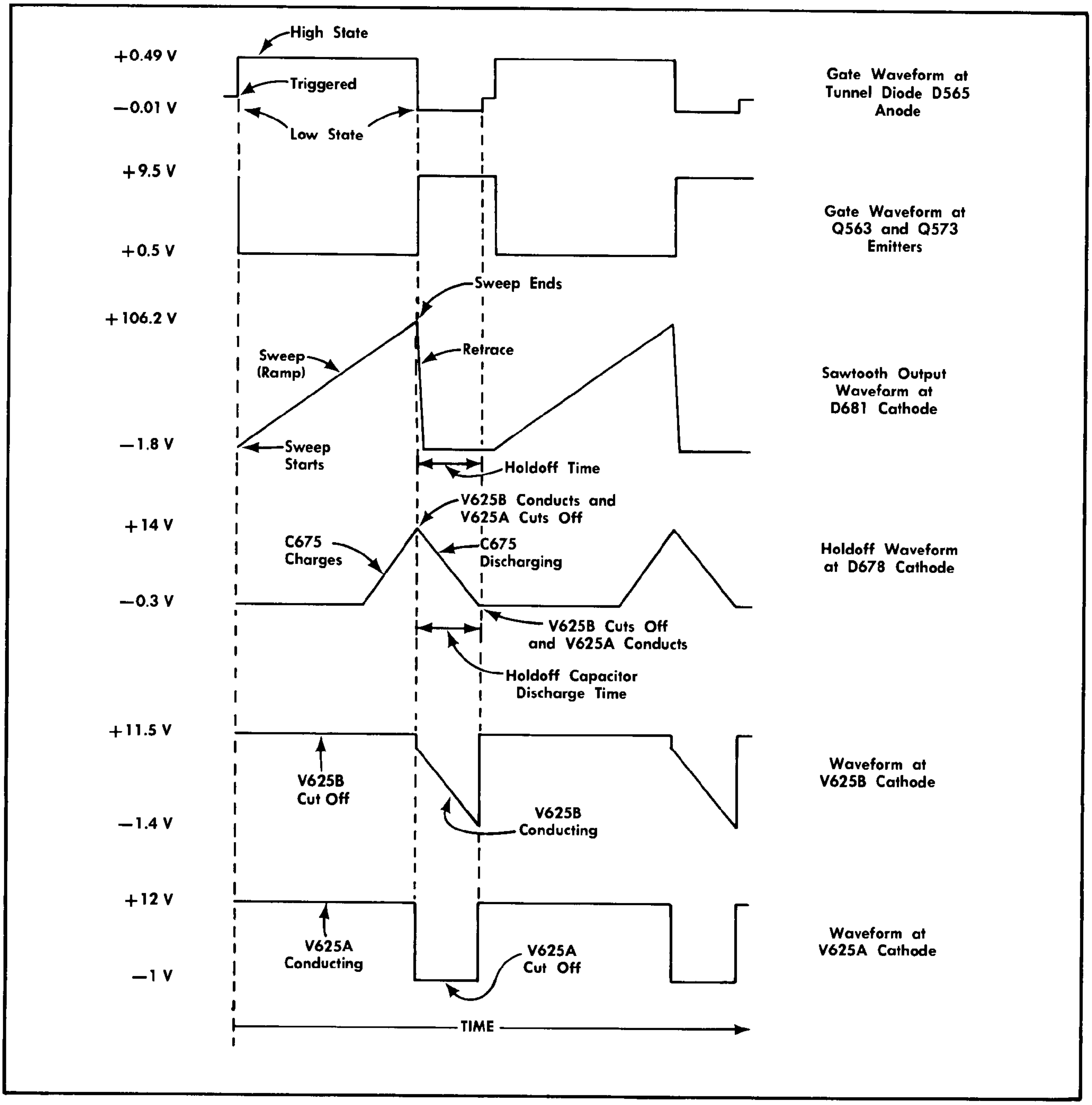

Fig. 3-13. Illustration showing time relationship of waveforms in the A Sweep Generator circuit starting at the quiescent voltage levels.

When the A Triggering MODE switch is set to AUTO STABILITY, and triggers from D555 are absent, the A Auto Multivibrator stage (Q605, Q615) sets the DC threshold level of D565 so the sweep cycle can be repeated to obtain a free-running sweep.

A Gate Amplifier Q564

In its quiescent state, Q564 is cut off. When a trigger is applied to D565 and the tunnel diode switches to its high state, D565 drives Q564 into saturation. Q564 remains saturated until D565 returns to the low state. The voltage waveform at Q564 collector is a 10.5 V negative-going gate applied to the bases of Q563 and Q573. Duration of the gate is equal to the ramp time of the sawtooth.

A Gate Emitter Follower and Amplifier Q563

The 10.5 V negative-going gate from Q564 collector is applied to the bases of Q563 and Q573. The following discussion describes the A Gate Emitter Follower Q563 stage. In its quiescent state, Q563 is cut off. When the gate is

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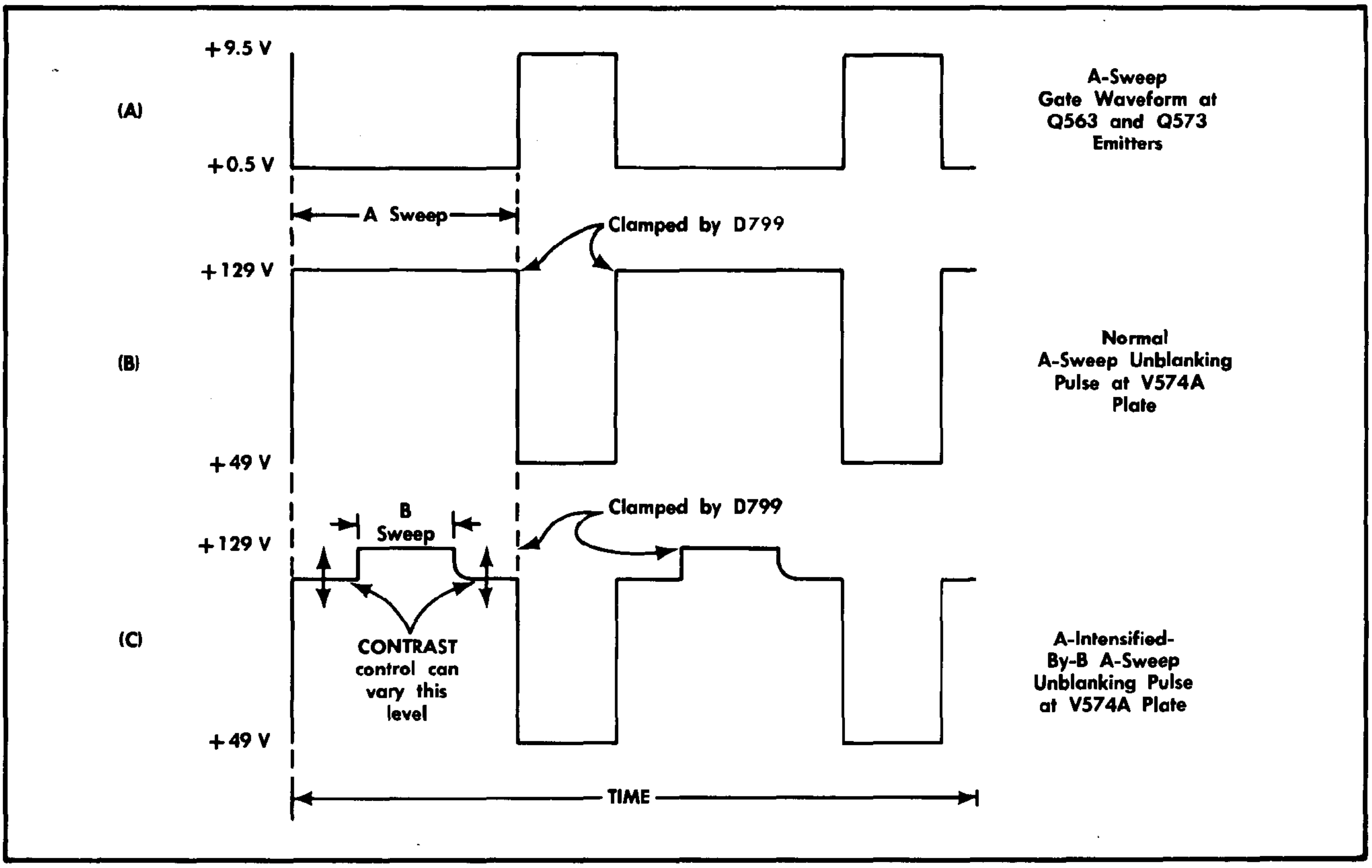


Fig. 3-14. Time-related waveforms showing how the CONTRAST control varies the non-intensified DC level of the A Sweep unblanking pulse.

applied, Q563 is driven into saturation until the gate ends. The emitter waveform from this stage has the same polarity as the input and the amplitude is about 9 volts. Purpose of the stage is to provide a fast-rise negative-going low-impedance drive to the following circuits (see Fig. 3-12).

1. When the Upper Beam DISPLAY switch is set to LEFT PLUG-IN A or RIGHT PLUG-IN A, the 9-V negative-going gate is applied to the Upper Beam Unblanking Amplifier V574A. The gate is then amplified and inverted for use in unblanking the Upper Beam.

2. The 9-V negative-going gate is applied to D1024 in the Alternate Trace Logic and Blanking circuit to provide drive to the logic circuit and then (during gate turn off) to produce an alternate-trace sync pulse that can be used by the left plug-in multi-trace unit.

3. The 9-V negative-going gate is applied to Disconnect Diode D640 to turn off the diode so a sweep sawtooth can be generated.

4. The waveform at the collector of Q563 is a positive-going 14-V +gate source for driving the grid circuit of V583A so this waveform is available at the A GATE connector every time the sweep runs. Diode D570 clamps the collector of Q563 so the gate cannot go higher than the diode bias above ground for the duration of the gate.

A Gate Emitter Follower Q573

Transistor Q573 with associated components is connected in a complementary circuit with Q563. The purpose of Q573 is to provide a fast-rise positive-going gate at the end of the sweep through its emitter follower action.

In its quiescent state, Q573 is conducting. When the gate is applied to its base, Q573 is driven into cutoff and remains in this state until the gate terminates. When the gate ends, Q573 is quickly turned on and this completes the cycle. The fast turn-on of Q573 is necessary for driving V1043A to obtain the proper alternate-trace sync pulse amplitude.

Disconnect Diode D640

Disconnect Diode, D640, is forward-biased and quiescently conducting current through Q573, R640 and R660. When tunnel diode D565 is triggered and switches to its high state, the 9-V negative-going gate from transistors Q563 and Q573 is applied to D640. The gate reverse biases D640 and the current through D640 is interrupted, and the Miller circuit generates a sawtooth. When the sweep terminates and the negative-going gate at Q563 emitter returns to its quiescent level, D640 is forward biased again, thus completing the cycle. Diode D641 is a protection diode for D640 and is normally not conducting.

Miller Sweep Generator V661 and A Sweep Timing Switch ⟨5⟩

In its quiescent state V661 is conducting heavily. When the negative-going gate reverse biases Disconnect Diode D640, timing capacitor C660 begins to charge through the timing resistor R660 and the VARIABLE control R662 (see A

Sweep Timing Switch diagram; more details about this diagram are given later).

As C660 begins to charge, a negative-going change in voltage occurs at the grid of V661, is amplified by a factor of about 200 and appears as a positive-going voltage at the plate of the tube. This amplified change is coupled back through V673A, D675 and D681 to the output side of timing capacitor C660. The coupled-back change tends to oppose any change at the grid side of the timing capacitor. This feedback action continues throughout the sawtooth rise, limiting the total negative excursion at the grid of V661 to less than 1 V.

With the grid of V661 held at nearly constant voltage level, the voltage across the timing resistor R660 remains essentially unchanged. Current through the resistor is therefore constant and the timing capacitor charges linearly. The resulting voltage change at the cathode of V673A, and hence, the output end of C660, is a linear positive-going sawtooth (about 105 V in amplitude at 1 ms/cm) that is capable of driving the following circuits:

1. Via LEFT PLUG-IN A and RIGHT PLUG-IN A positions of the Upper Beam DISPLAY switch to the base of Q1135 in the Upper Beam Horizontal Amplifier.

2. Via RIGHT PLUG-IN A position of the Lower Beam DISPLAY switch to the base of Q1235 in the Lower Beam Horizontal Amplifier.

3. To the grid of V904A in the Delay Pickoff circuit.

4. To pin 6 of the left plug-in jack J11 in the Plug-In Jack Details circuit, for use by Spectrum Analyzer plug-in units that are wired to accept this signal.

5. A sample sawtooth the grid of V625 in the Holdoff Multivibrator circuit (A Sweep Generator circuit).

6. A sawtooth to grid of V673B in the Second A Sawtooth C. F. (A Sweep Generator circuit).

The sweep rate (the rate at which the spot moves across the face of the CRT) is determined by the rate at which the timing capacitor and timing resistor permit the Miller Sweep Generator to run up. By means of the A TIME/CM switch SW660 (see A Sweep Timing Switch diagram), both the size of the capacitor being charged and the charging current can be selected to cover a wide range of sawtooth slopes (sweep rates). Note that SW660 is connected so that switching 8 capacitors and 6 resistors provides 24 different sweep rates, from 5 s/cm to 0.1 μs/cm without magnification. The A TIME/CM switch also selects the proper holdoff capacitor and discharge resistor for the sweep rate in use.

Adjustable capacitors C660G, C660H, and C660J are adjusted to obtain correct sweep timing at the fastest sweep rates.

Continuously variable uncalibrated sweep rates are provided by R662 and SW662 (mounted on and actuated by R662). When SW662 is switched to the uncalibrated position, the switch removes the short from around R662 and turns on the UNCAL neon B663. By turning VARIABLE control R662, the charging time of the timing capacitor selected by the A TIME/CM switch may be increased by at least 2.5 times the calibrated rate, thus providing continuously variable sweep rates.

First A Sawtooth Cathode Follower V673A

The First A Sawtooth Cathode Follower V673A stage isolates the output shunt capacitances and load from the circuitry associated with the Miller tube V661. The 105 volt positive-going sawtooth waveform at the grid of V673A produces the same waveform at the cathode for distribution to all points as described earlier.

Neon B670 is a protection device that prevents V673A grid from becoming too positive with respect to the cathode during warmup time when the oscilloscope is first turned on. The neon does not glow when the oscilloscope has warmed up.

Bootstrap capacitor C668 improves the operation of the Miller Sweep Generator circuit in developing rapidly rising runup waveforms. To make the output sawtooth signal start at about zero volts, zener diode D675 is used to overcome the difference between V673A cathode voltage level and the desired level at the junction of D681 and R681.

To allow the A Sweep Generator circuit to reset quickly when the sawtooth has terminated, diode D681 is back-biased during the sweep retrace time to disconnect the diode-cathode circuitry from V673A cathode circuit. Diode D681 is normally conducting during the sawtooth runup and remaining portion of the holdoff period. C681 and R681 form a compensation network. C681 is adjusted to obtain best sweep linearity at the start of the sweep sawtooth when calibrating the fastest sweep rates.

Clamp Emitter Follower Q643 and Clamp Diode D677

In their quiescent state, Q643 and D677 are conducting to provide a DC feedback loop. This assures stable quiescent conditions. When tunnel diode D565 is triggered and the 9-V negative-going gate from the emitter of Q563 is applied to the emitter of Q643, transistor Q643 cuts off and diode D677 is reverse biased. These are the conditions while the sawtooth is generated.

Second A Sawtooth Cathode Follower V673B

The sawtooth output from the cathode circuit of V673A is applied to the grid of V673B in the Second A Sawtooth Cathode Follower stage. The purpose of this stage is to make the sawtooth available at the front-panel A SAWTOOTH connector while isolating the external loading from the internal sawtooth voltage.

Holdoff Multivibrator V625

The Holdoff Multivibrator V625 circuit prevents D565 from being triggered during the retrace interval. That is, the holdoff circuit allows a finite time for the Miller Sweep Generator circuit to reach a steady-state condition after the completion of a sweep.

Due to the many modes of operation of this stage, each mode is described separately as follows:

1. Quiescent State—Conditions: (Assume the A MODE switch is set to NORM). V625A is conducting and V625B is cut off. V625A cathode resets at about +12 V. Diodes D614, D616, D624, D635 and D678 are reverse-biased; D627 and D629 are conducting.

2. D565 Triggered—When tunnel diode D565 is triggered, the Miller Sweep Generator produces the positive-going sawtooth as explained earlier. At a certain point on the sawtooth ramp (about zero volts on the sample appearing at the wiper arm of the A SAWTOOTH AMPL control R678), diode D678 conducts and holdoff capacitor C675 charges. The sawtooth continues to rise and is coupled through D678 to the grid circuit of V625B.

When the rising sawtooth voltage reaches about +14 V at D678 cathode (see Fig. 3-13), V625B conducts, V625A cuts off and V625A cathode drops from +12 V to about —1 V. D616 conducts and D565 is driven to its low state but cannot be triggered while V625A is cut off. The sweep terminates, the retrace interval begins, D678 reverse-biases, and C675 begins to discharge resistors R637 and R639 for the SEC and MSEC positions of the A TIME/CM switch.

During the sweep retrace and holdoff time the holdoff capacitor continues discharging without interruption and holds V625B in conduction while the Miller Sweep Generator circuit resets and reaches its steady-state condition. As long as V625B is conducting, V625A is cut off and D565 cannot be triggered.

Finally, C675 becomes discharged to a point where V625B cuts off and V625A conducts. V625A cathode rises from —1 V to +12 V, D616 reverse-biases and this completes the holdoff circuit cycle. D565 is ready to be triggered once again.

Holdoff time is determined by the size of the holdoff capacitor and resistors R637, R639. The A TIME/CM switch SW660 is used to change the time constant of the holdoff circuit simultaneously with the change of timing capacitors and resistors. In the μSEC positions of the A TIME/CM switch, R637 and R639 are shunted by R675 to speed up C675 discharge.

The A SAWTOOTH AMPL control R678 determines sweep length by controlling the voltage level at which the sawtooth-ramp sample starts, since the end of the sample is always fixed by the point at which V625B conducts.

3. Single-Sweep Operation—Assume these beginning conditions: A MODE switch SW625 is set to SINGLE SWEEP, no triggers are applied to D565, and the RESET button is not pressed. Diode D635 is conducting and holding V625B in conduction and V625A is cut off. Under these conditions, the sweep circuit cannot be triggered. However, if the RESET button is pressed, a positive-going pulse will be applied through D624 to the cathode of V625B sufficient to cut off V625B so the multivibrator switches states; i. e., V625B cuts off and V625A conducts. Now the sweep is ready to start when D565 is triggered.

4. Right Plug-In Multi-Trace Unit Set For Alternate-Mode of Operation—Conditions: A MODE and B MODE switches are set to NORM, Upper Beam DISPLAY switch SW185 is set to RIGHT PLUG-IN A, the right plug-in is set for multi-trace alternate mode of operation (see Fig. 3-5), and the B sweep is set for a slower sweep rate than the A sweep. With no triggers applied to D565, V625A is conducting and V625B is cut off.

When triggers are applied to D565 and D765 (in the B Sweep Generator circuit), both sweeps start. As the A sweep sawtooth reaches the point where V625B conducts and V625A cuts off, D565 resets to its low state and the A sweep terminates. At this point, a 10 volt positive-going inhibit gate (from D1008 and D1010 in the Alternate Trace Logic circuit), is applied to the grid of V625B. This inhibit gate, equal in duration to the time difference between the end of the A sweep and the end of the slower-running B sweep, holds V625B in conduction, preventing D565 from being triggered.

Then, as the B sweep ends, the inhibit pulse ends simultaneously with the B gate sweep and allows holdoff capacitor C675 to discharge to the point where V625B cuts off and V625A conducts, D565 is now ready to be triggered once again.

The purpose of the inhibit gate is to lock out the A sweep until the B sweep terminates. Then, the combined action of A sweep in its locked-out condition and the B sweep resetting causes the Alternate Trace Logic circuit to produce one alternate sync pulse for switching the plug-in to the next channel. Then, the cycle is repeated as both beams display the signal in the second channel. To summarize the action, the Alternate Trace Logic circuit allows the plug-in to switch channels only when the slower sweep has completed its runup.

If the B sweep is set faster than the A sweep, the B sweep cycle is repeated until the A sweep ends, then the inhibit gate occurring at this time and lasting until the B sweep ends keeps the A sweep locked out until the B sweep resets. The Alternate Trace Logic circuit does not produce any alternate sync pulses while the A sweep is running up but, as explained eariler, the combined condition of locked-out A sweep and the B sweep going through its resetting action causes only one alternate sync pulse to be produced.

5. B Sweep Delayed-By-A Mode of Operation—Conditions: A MODE switch is set to NORM, B MODE switch is set to DLY'D BY A and the Upper Beam DISPLAY switch is set to RIGHT PLUG-IN A (similar to Fig. 3-6). Assume that the B sweep is set to last longer than the A sweep, and both sweeps have ended.

With no triggers applied to D565, V625A is conducting and V625B is cut off. When a trigger is applied to D565, the A sweep starts running up. At a certain point on the sawtooth ramp, (determined by the setting of the DELAY-TIME MULTIPLIER control) a delayed trigger from the Delay Pickoff circuit is applied to the B Sweep Generator circuit.

Assume that the B sweep starts automatically upon application of the delayed trigger. The B Sweep runs up and simultaneously generates a negative-going B gate. The B Gate Inverter circuit Q1004 (see Alternate Trace Logic & Blanking diagram) inverts the gate so it is positive-going and about 10 V in amplitude. This +10-V gate is now referred to as an inhibit gate. This gate is applied to the grid circuit of V625B. When the A sweep ends and V625B goes into conduction, V625A cuts off and resets D565 to its low state.

The inhibit gate holds V625B in conduction until the A sweep ends and Holdoff Capacitor C675 discharges to a point that causes V625B to cut off and V625A to conduct. Thus, the inhibit gate holds the A sweep locked out until the B sweep ends to prevent the intensified portion of the Upper Beam display from extending into the start of the A sweep.

6. B Single-Sweep Mode of Operation—This mode is similar to B Sweep Delayed-By-A mode, except that the B MODE switch is set to SINGLE SWEEP. The DELAY-TIME MULTIPLIER control and delayed trigger are not used in this Mode. With the Upper Beam DISPLAY switch set to RIGHT PLUG-IN A, the Holdoff Multivibrator operates as in the previously described mode; that is, the inhibit gate locks out the A sweep until the B sweep ends.

Reset Lamp Driver Q619 and Reset Lamp B619

The Reset Lamp Driver Q619 circuit with B619 is mainly used for single-sweep operation, so this mode is described first.

Assume these conditions: The A MODE switch SW625 is set to SINGLE SWEEP, no triggers are applied to D565 and the RESET button is not pressed. Under these conditions, D635 holds V625B in conduction when the sweep ends and V625A is cut off. The cathode of V625A will be at —1 V. This voltage, applied to the base circuit of Q619, holds Q619 cut off and B619 is turned off.

When the RESET button is pressed, C622 charges quickly toward +10 V, resulting in a positive-going pulse which is applied through D624 to the cathode of V625B. The pulse is sufficient to turn off V625B and V625A conducts. The cathode of V625A rises from —1 V to +12 V, Q619 conducts, B619 turns on, and D565 is ready to accept a trigger.

When D565 is triggered, the negative-going gate at the emitter of Q563 turns off Q619 and B619; also, as described earlier, disconnect diode D640 is reverse-biased and the sawtooth is generated. When the sawtooth drives V625B into conduction, V625A cuts off and the sweep is terminated. This ends the cycle of operation until the RESET button is pressed again.

If the A MODE switch is set to the NORM position, the RESET button is disconnected and D635 anode is connected to ground. Thus, toward the end of the sweep, holdoff capacitor C675 is able to discharge to a point where V625B cuts off, V625A conducts and the sweep ends. Transistor Q619 conducts, B619 turns on and D565 is ready to be triggered. When D565 is triggered, Q619 and B619 turn off and the cycle of operation is repeated. It is normal for B619 to stay on when the sweep duty cycle is low (sweep holdoff time is relatively long).

A Auto Multivibrator, Q605 and Q615

Transistors Q605 and Q615 with associated circuit components form a triggered monostable multivibrator that has two modes of operation when the A Triggering MODE switch SW505 is set to AUTO STABILITY. The two modes are: (1) non-triggered, and (2) triggered. Mode 1 is described first because it is the normal state of the multivibrator.

Mode 1 (Non-triggered). Transistor Q605 is conducting and Q615 is cut off. C611 has charged to approximately 25 V, determined mostly by Zener diode D612. Diode D614 is conducting and its current adds to the current through D565. This extra current causes D565 to be held at a threshold level that enables the Holdoff Multivibrator to switch D565 to its high state at the end of each sweep holdoff period. Thus, the A Sweep Generator will go into a free-running mode when trigger signals are absent.

Mode 2 (Triggered). Assume that all the conditions given for Mode 1 are present and 100-Hz or faster triggers are applied to T555 from D555. (Ignore for the moment that these same triggers are also applied to D565.) Under these conditions, the multivibrator will be triggered and will run through its natural period. For the following discussion the period is the minimum time that it takes for the multivibrator to be triggered, switch states, and then return to its original triggerable state.

Differential triggers from the secondary of T555 are applied to the base of Q605. Only the negative-going portion of one of the triggers actually triggers the multivibrator, so this is the only portion discussed here. The negative-going trigger feeds through the base-emitter junction of Q605, drives Q615 into saturation and Q605 cuts off. The collector of Q605 rises exponentially as C604 charges through R604 and R605. Finally, a point is reached where the decreasing charge current lowers the base of Q615, causing this transistor to cut off and Q605 to conduct. This completes the first half-cycle.

With Q605 conducting and Q615 cut off, C604 goes through its recovery time and C611 starts charging through R610 and R611. C604 exponential discharge current raises the base of Q615 to a point that will enable one of the triggers, feeding through the base emitter junction of Q605, to drive Q615 into saturation and Q605 will cut off. As Q615 goes into saturation, C611 is quickly discharged through the low impedance of Q615. Thus, the natural period for the multivibrator is short enough to limit the charge time of C611 well below the threshold level so zener D612 never breaks down, D614 never conducts, and D565 returns to its low state. The A Sweep Generator will stop free running when it (sweep generator) completes its cycle. From this point on, as long as triggers are applied to D565 from D555, these same triggers will trigger the sweep.

As Q605 is turning on and Q615 is turning off, D604 conducts to limit the negative-going swing on the base of Q615 to about —0.6 V or less. The negative-going swing is developed by the drop in collector voltage as Q605 turns on and by C604 as it starts its recovery.

As Q615 is driven into saturation, D602 conducts to assure rapid turn on of Q615 and to clamp its emitter.

If the triggers from D555 are slowly decreased in repetition rate from 100 Hz toward 30 Hz, the period of the multivibrator will be longer and C611 will change further. As a result, C611 charge will approach the threshold level for D565.

If the time between triggers is reduced to longer than 50 ms (trigger repetition rate slower than 30 Hz), Q615 will remain in its cut off condition for a time sufficient to allow C611 to charge to the level mainly determined by D612. When this point is reached, D614 conducts and D565 returns to the threshold level that enables the A Sweep Generator to free run.

When the A Triggering MODE switch is set to the TRIG position, the switch grounds the collector of Q615 and disables the automatic stability feature of the Type 556.

Upper Beam Unblanking Amplifier V574A

When the Upper Beam DISPLAY switch SW185 is set to the LEFT PLUG-IN A or RIGHT PLUG-IN A positions and the B MODE switch SW825 is set to NORM or SINGLE SWEEP, an unblanking pulse is generated for use in driving the Upper Beam CRT control grid circuit so that the Upper Beam is unblanked during the A sweep time. The unblanking pulse is initiated when tunnel diode D565 switches to its high state and produces a 9-V negative-going gate at the Q563 emitter (see Fig. 3-14A).

The 9-V negative-going gate at the emitter of Q563 is connected through the Upper Beam DISPLAY switch to the control grid circuit of V574A. The gate rapidly drives V574A into cutoff and the plate rises from +49 V to about +129 V (see Fig. 3-14B). Thus, a positive-going pulse about 80 V in amplitude is produced at the plate and applied to the grid of V583B. When the sweep ends, D565 is driven into its low state, V574A resumes conduction, and the 80-V unblanking pulse is terminated.

Diode D574 is forward biased during the time V574A is in a quiescent state. The feedback loop established with D574 conducting provides a stable quiescent voltage level at the cathode of V573B. The negative-going gate signal that is applied to the V574A grid to generate the unblanking signal, also reverse biases D574 and interrupts the fedback loop.

When a negative-going gate signal is applied to V574's grid, its plate voltage will rise until D799 is forward biased. Diode D799 is located in the B sweep generator circuit. When the B MODE switch is set to either NORM or SINGLE SWEEP, the voltage at the cathode of D799 is established at approximately +127 VDC by D796 and its associated circuitry. The V574A plate voltage rise is clamped at approximately +129 volts. When the B MODE switch is set to DLY'D BY A, the reference voltage at the cathode of D799 may be varied by the conduction of Q794.

When the B MODE switch is set to DLY'D BY A, +100 VDC is applied to the Upper Beam CONTRAST control, R793 and to the Lower Beam CONTRAST control, R853. With the +100 volts applied to R793, the bias of Q794 may be adjusted to reduce the amplitude of the Upper Beam unblanking signal (diminishing the trace brightness level), except during the time when a B gate signal from the plate of V783A is applied to the base of Q794. The B gate signal overrides the effect of the DC voltage from R793, and the Upper Beam unblanking signal is returned to its normal amplitude. Returning the Upper Beam intensity to normal during B sweep time (Upper Beam DISPLAY set to A) permits viewing the amount of delay between the start of the A sweep and the B sweep.

With a B delayed by A application where the A sweep is displayed on the Lower Beam, R853 may be used to adjust the bias of Q854 to provide a contrast in the Lower Beam intensity between the A and B sweep times.

Since the instruments with serial numbers 100-1999 do not have the capability of displaying the A sweep on the Lower Beam, only the Upper Beam CONTRAST control is incorporated. The contrast circuitry for these instruments is described as follows:

Set the B MODE switch to the DLY'D BY A position and assume the following conditions: Upper Beam DISPLAY switch is set to RIGHT PLUG-IN A, Lower Beam DISPLAY switch is set to RIGHT PLUG-IN B, the B sweep is operating faster than the A sweep, and the DELAY-TIME MULTIPLIER dial is set for a reading of about 3.00. Using these conditions to describe the unblanking pulse shown in Fig. 3-14C, the A sweep unblanking pulse will be produced in the usual manner, except V574A plate DC level at cutoff is controlled two ways:

1. The B MODE switch SW825 connects one end of the CONTRAST control R796 to +100 V, D796 is forward biased and D799 is reverse biased when the B sweep is not running. Thus, the CONTRAST control, rather than D799, determines the plate DC level during V574A cutoff when the B sweep is not running.

2. However, when the B sweep runs, its unblanking pulse is applied to the base circuit of Q793. The unblanking pulse causes D799 to conduct, D796 reverse biases, and V574A plate DC level is clamped at +129 V for the duration of the B unblanking pulse.

Thus, the CONTRAST control varies the non-intensified portions of the A unblanking pulse and the B unblanking pulse is used to restore the intensified portion of the A unblanking pulse to its normal (original) level. That is, if the Upper Beam INTENSITY control setting was set for suitable trace brightness during normal A sweep operation, the intensified portion reaches this same level during A Intensified by B operation.

When the Upper Beam DISPLAY switch SW185 is set to the LEFT PLUG-IN B or RIGHT PLUG-IN B positions and the B MODE switch SW825 is set to any position, the B sweep unblanking pulse is applied via the Upper Beam DISPLAY switch to the control grid circuit of V574A. The pulse is used to unblank the CRT Upper Beam during the B sweep in the same manner described for normal A sweep operation.

When the Upper Beam DISPLAY switch is set to either of the EXT positions, V574A grid is grounded through R574 and R575 to unblank the Upper Beam for external horizontal input operation.

A Sweep Unblanking Cathode Follower V583B

The 80-V positive-going unblanking pulse at the plate of V574A is applied to the grid of V583B in the A Sweep Unblanking C. F. stage. The output pulse obtained at V583B cathode is the same as the input but at slightly lower amplitude (about 76 V). This 76 volt pulse is coupled from V583B cathode through a network (in the CRT Circuit) to the CRT Upper Beam control grid. The unblanking pulse turns on (unblanks) the beam during the sweep time.

Capacitor C583 connected from the cathode of V583B to the plate circuit of V574A is a bootstrap capacitor. At the instant the unblanking pulse goes positive, the bootstrap capacitor helps to drive the plate of V574A positive. This action assures rapid turn-on of the beam at the start of the sweep.

Diode D581, connected from the cathode of V583B to the plate circuit of V574A, is a bootstrap diode. D581 turns on the instant the unblanking pulse goes negative to help drive the cathode of V583B downward. This action assures rapid turnoff of the beam at the end of the sweep.

A +Gate Cathode Follower V583A

The 14 volt positive-going pulse at the collector of Q563 is used by the A +Gate Cathode Follower V583A to provide a +gate waveform to the A GATE front-panel connector on the Type 556.

In its quiescent state, the control grid of V583A rests at about —4.4 volts. When the sweep runs, the 14 V pulse at Q563 collector is applied to divider resistor R586 and R587. Amplitude of the pulse at the junction of R586 and R587 is about 13 volts. The pulse drives the grid from —4.4 V to about +8.6 V. The output waveform at the cathode rises from ground to about 11 V for application to the front panel A GATE connector.

B SWEEP GENERATOR ⟨7⟩ and B SWEEP TIMING SWITCH ⟨8⟩

The B Sweep Generator and B Sweep Timing Switch circuit operation is the same as the corresponding circuits used in the A sweep except as follows:

1. There is no inhibit gate applied to the Holdoff Multivibrator circuit V825, but similar action takes place in this circuit when the B MODE switch SW825 is set to the DLY'D BY A position. In this position of the switch +10 V is applied to the grid circuit of V825B. This holds the V825B section of the multivibrator in conduction after the B sweep ends so the next B sweep cannot be generated until a delayed trigger pulse switches the multivibrator.

The delayed trigger is a 10 V short-duration positive-going pulse obtained from Q933 in the Delay Pickoff circuit. The pulse is generated at a predetermined time during each A sweep. When the pulse is applied via the B MODE switch to the junction of C823 and R822, and through D824 to the cathode of V825B, the pulse drives V825B into cutoff and causes the multivibrator to switch states. V825B is now cut off, V825A is conducting, and the B sweep is ready to be triggered in either of two ways.

(a) If the B Triggering MODE switch SW705 is set to the AUTO STABILITY position and there is no trigger from the B Sweep Trigger circuit, the B Auto Multivibrator circuit (Q805 and Q815) sets D765 threshold level so the B sweep starts immediately.

(b) If the B Triggering MODE switch is set to the TRIG position, a trigger from the B Sweep Trigger circuit applied to D765 will trigger the sweep. The B sweep will run once, lock out, and will not reset until the next delayed trigger arrives.

2. The B SAWTOOTH SLOPE adjustment R861 (see B Sweep Timing Switch diagram) permits adjusting the B sawtooth slope to match the A sawtooth slope.

Instruments SN 100-1999 have these additional differences in their A and B circuits.

3. Diode D778 with emitter follower Q799 provides the clamping action for V774A plate when V774A is driven into cutoff by the B gate. Thus, the plate voltage level during cutoff is about +128 V and this is essentially the same level as described earlier when D578 clamped the plate of V574A in the A Sweep Generator circuit.

4. The B Sweep Unblanking Cathode Follower V783B applies the trace brightening pulse through Q793 to V574A plate circuit located in the A Sweep Generator circuit. For further information about the operation of Q793 with associated circuitry containing D799, D796 and the CONTRAST control R796, refer to the Upper Beam Unblanking Amplifier V574A description.

DELAY PICKOFF ⟨9⟩

Refer to Figs. 3-6 and 3-15, and the Delay Pickoff schematic diagram during the following discussion.

The Delay Pickoff circuit generates a 10 volt short-duration positive-going pulse that is delayed from the start of the A sweep by an amount determined by the settings of the A TIME/CM (OR DELAY TIME) switch and the DELAY-TIME MULTIPLIER dial. The comparator in the delay pickoff circuit continuously monitors the sawtooth ramp voltage from the A Sweep Generator circuit and compares the ramp voltage with a DC voltage level established by the DELAY-TIME MULTIPLIER dial.

When the ramp voltage biases V904A into conduction, the comparator switches tunnel diode D905 to its high state. The tunnel diode generates a trigger pulse that is delayed from the start of the A sweep by the time it takes the ramp voltage to rise to a value approximately equal to the voltage established by the DELAY-TIME MULTIPLIER dial setting.

The trigger pulse from the tunnel diode is applied via T905 to a monostable Delayed Trigger Multivibrator so the trigger is regenerated into a fast-rise, high-amplitude, short-duration delayed trigger. The delayed trigger is applied internally via the B MODE switch to the B Holdoff Multivibrator V825 for use in the delayed B sweep mode of operation. The trigger is also applied to the DLY'D TRIG front-panel connector where it is always available.

Assume the Type 556 circuits are set for these conditions:

1. The B sweep is set to run faster than the A sweep.

2. The B MODE switch is set to DLY'D BY A.

3. The A Sweep Generator has reset and is ready to be triggered.

4. The B Sweep Miller circuit has run up and reset, D765 is in its low state but cannot be triggered because the B MODE switch is applying +10 V to the grid circuit of V825B. The +10 V holds this half of the multivibrator in conduction to lock out the B sweep. (Only a delayed trigger can make the multivibrator switch states so that the B sweep can be triggered as mentioned earlier.)

5. The DELAY-TIME MULTIPLIER control is set for a dial reading of 3.00. This is equal to 30 volts on the 105-volt A sweep sawtooth ramp; or, 3 cm from the start of the sweep having a total length of 10.5 cm.

With the A Sweep ready to be triggered, the quiescent conditions for all stages in the Delay Pickoff circuit are as follows:

(a) V904B, Q908 and Q924 are conducting.

(b) V904A and Q933 are cut off.

(c) D905 is in its low-voltage state.

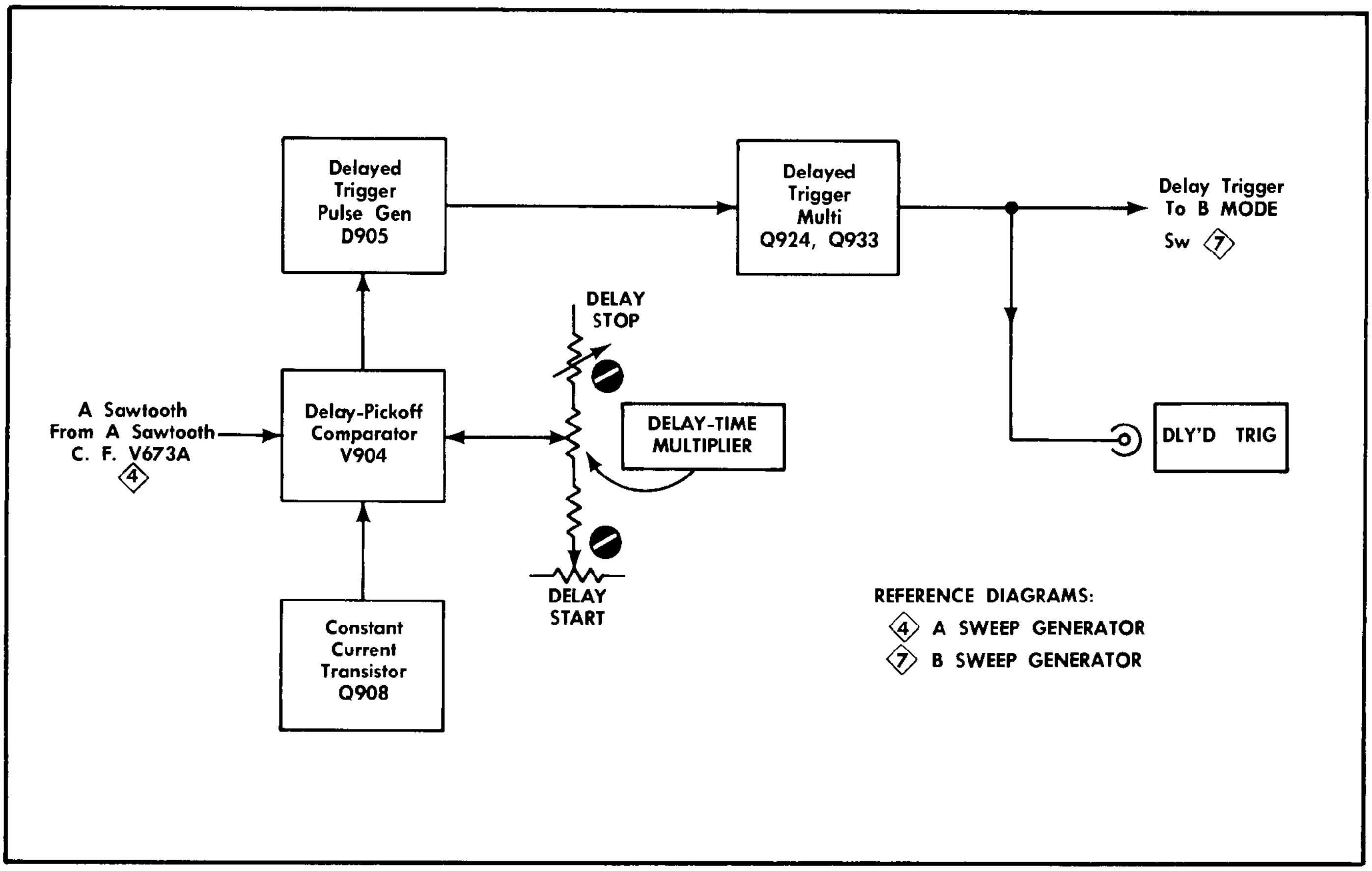


Fig. 3-15. Block diagram of Delay Pickoff circuit.

Constant Current Transistor Q908, Delay Pickoff Comparator V904 and Delayed Trigger Pulse Generator D905

Transistor Q908 is a constant-current source for V904A and V904B to keep the current through the Comparator relatively constant despite the large voltage swings applied to the grids. The base of Q908 is connected to ground and its collector rests at +34 volts. Emitter resistor R908 sets the current through Q908 and the Comparator at about 5 mA.

When the A sweep starts, the sawtooth ramp voltage is applied to the grid of V904A and the voltage selected by the wiper arm of the DELAY-TIME MULTIPLIER control R915 is applied to the grid of V904B. Assume the ramp voltage is increasing at the rate of 10 V/ms. Then, 3 ms after the sweep starts, the voltage on the grid of V904A will rise 30 V and will be equal to the voltage at the grid of V904B as set by the DELAY-TIME MULTIPLIER control.

At the point where V904A and B grids are equal, V904A conducts and draws current through R907 and tunnel diode D905. An increase in current through R907 results in a decrease through R909 and this push-pull current action causes D905 to switch to its high state. When D905 switches, a sharp trigger is developed in the primary of T905 and inductively coupled into the secondary. The dots above T905 windings on the schematic diagram indicate the + polarity end of the windings. To obtain a negative-going trigger to drive the base of Q924, the trigger is taken off at the negative end of the secondary winding.

When the sweep ends, V904A cuts off and returns D905 to its low state.

The Type 556 is calibrated so the major dial markings of the DELAY-TIME MULTIPLIER control correspond to the graticule divisions by correct adjustment of the DELAY START R918 and DELAY STOP R914 controls.

To eliminate ground-loop currents due to the remote location of the Delay Pickoff circuit, the coaxial shield of the cable from the A Sweep Generator is used as an isolated (from chassis) ground. The shield is connected to ground in the Delay Pickoff circuit through R900. V904B grid is referenced to the same isolated ground through C911.

Delay Trigger Multivibrator Q924 and Q933

The sharp negative-going trigger from T905 secondary is applied to the base of Q924. Transistor Q924 increases its conduction and Q933 turns on for the duration of the pulse. A fast positive-going trigger, rising from zero to +10 V, is produced at the emitter of Q933. This trigger is applied via the B MODE switch to the cathode circuit of V825B in the B Holdoff Multivibrator stage. The trigger causes V825B to cut off. V825A conducts to allow D765 to be triggered by the next trigger from the B Sweep Trigger or the B Auto Multivibrator (Q805 and Q815) to set D765 threshold level, depending on the settings of the B Triggering controls.

In addition, the trigger is applied to the DLY'D TRIG connector J935 on the front panel of the Type 556. This trigger is available for use in externally triggering other equipment.

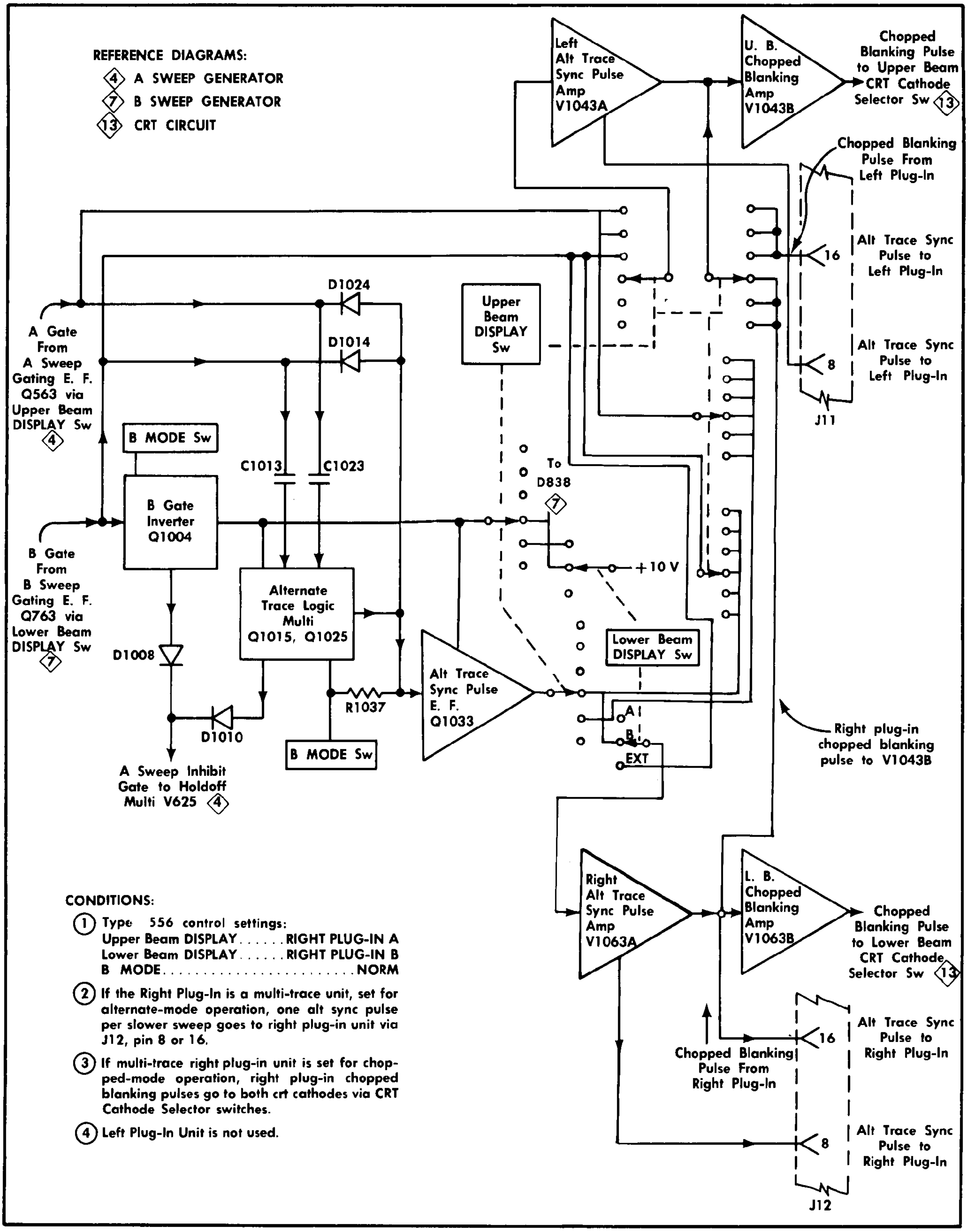


Fig. 3-16. Block diagram of Alternate Trace Logic and Blanking circuits for Type 556 instruments with serial number 2000 and up.

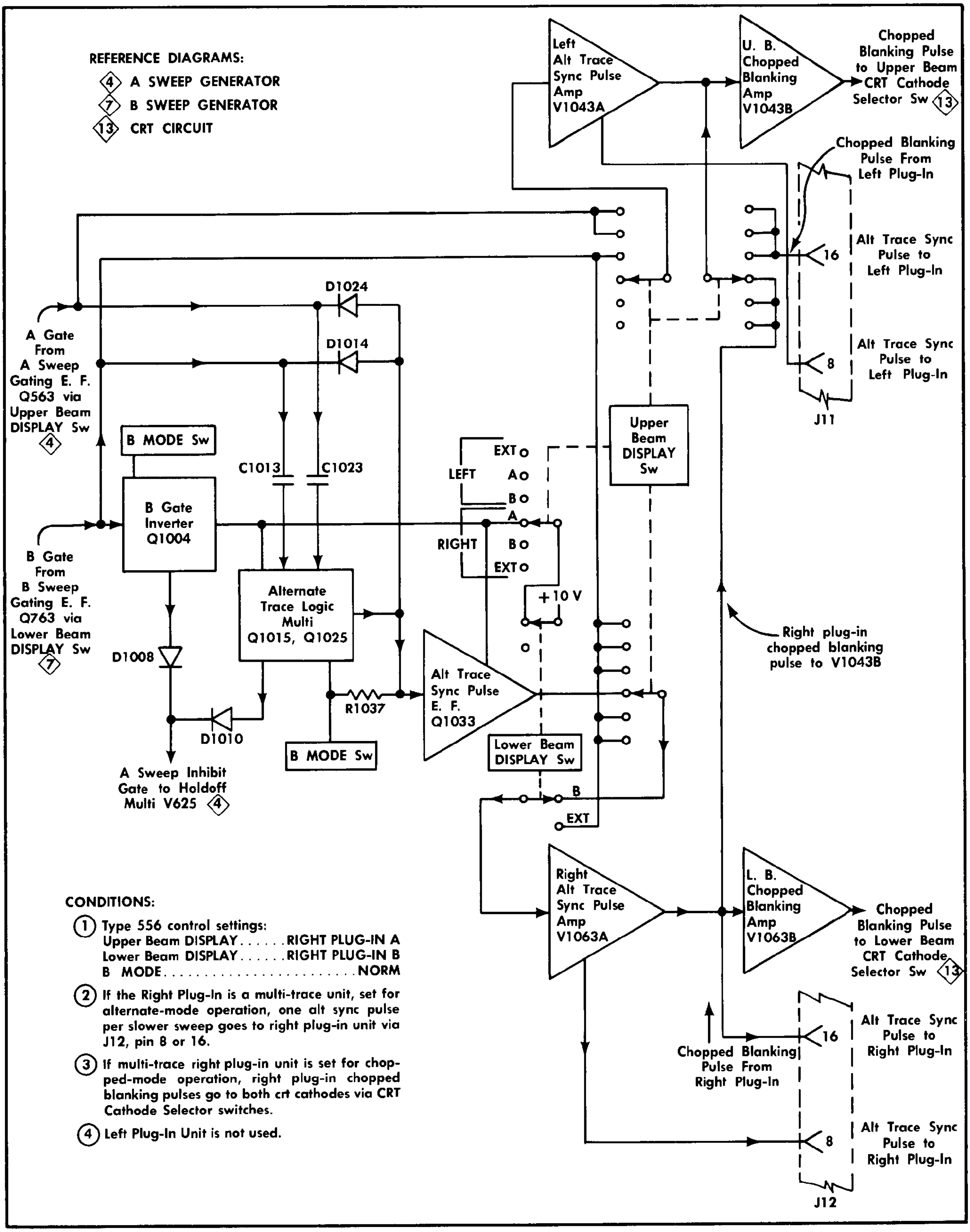


Fig. 3-17. Block diagram of Alternate Trace Logic and Blanking circuit for Type 556 instruments with serial numbers 100 to 1999.

ALTERNATE TRACE LOGIC & BLANKING (10)

Introduction

For this discussion, refer to the Alternate Trace Logic & Blanking schematic diagram (Fig. 3-16 and Fig. 3-17).

The Alternate Trace Logic & Blanking circuit can be divided into five smaller circuits according to purpose as follows:

1. **B Gate Inverter Q1004.** Purpose of this stage is to invert the negative-going B gate so the gate can serve as an inhibit gate for the A sweep during delayed-by-A and single-sweep operation. The inhibit gate locks out the A sweep until the B sweep ends to prevent the intensified portion of the Upper Beam display from folding over during right plug-in A display mode of operation.

2. **Alternate Trace Multivibrator, Q1015 and Q1025.** This stage provides the logic to operate a right plug-in multi-trace unit in the alternate mode during dual-beam operation. The sequence for proper logic is: Channel 1 (or A) signal is displayed simultaneously by both beams and then channel 2 (or B) signal is displayed by both beams, and so on.

3. **Alternate Trace Sync Pulse Emitter Follower Q1033.** This stage provides alternate trace sync pulse drive from D1014 and D1024 or Q1015 and Q1025 to V1063A.

4. **Alternate Trace Sync Pulse Amplifiers, V1043A and V1063A.** These stages amplify the alternate-trace sync pulses that are used to switch the channels in multi-trace plug-in units operating in the alternate mode. Channel switching occurs during the sweep retrace time.

5. **Chopped Blanking Amplifiers, V1043B and V1063B.** These stages amplify the chopped-blanking pulses coming from the multi-trace units operating in the chopped mode. These pulses blank the beams during the plug-in switching time from one channel to the next. Thus, the switching portions of the chopped display are not visible at normal settings of the INTENSITY controls.

B Gate Inverter Q1004

Operating conditions for this stage are: B MODE switch set to DLY'D BY A or SINGLE SWEEP, Upper Beam DISPLAY switch set to RIGHT PLUG-IN A, and the Lower Beam DISPLAY switch set to RIGHT PLUG-IN B. Assume the DELAY-TIME MULTIPLIER control and the B TIME/CM switch are set so the delayed B sweep terminates after the A sweep ends. Using these conditions while the B sweep is running, the 9 volt negative-going B gate from the Gating Emitter Follower Q763 in the B Sweep Generator circuit is applied through R1001 to the base of Q1004.

At the collector of Q1004 the gate pulse is a positive-going pulse about 10 V in amplitude. The pulse, now referred to as the inhibit gate, is applied through D1008 to the grid circuit of V625B in the A Holdoff Multivibrator stage of the A Sweep Generator circuit. When the A sweep ends, the inhibit gate holds the A sweep locked out until the B sweep ends.

If the right plug-in is a multi-trace unit that is set for alternate mode of operation, diodes D1014 and D1024 provide the logic for producing one alternate trace sync pulse per last sweep to end. To accomplish this logic, +100 V is applied to the collector circuits of Q1015 and Q1025 to disable the multivibrator stage and reverse bias D1021. As a result, diodes D1014 and D1024 are forward biased to permit the diodes to follow the DC levels of the incoming A and B gates.

When both sweeps are running concurrently, the gate from the last sweep that terminates is used to generate the alternate-trace sync pulse. For example, assume both sweeps are running; the DC level at the junction of D1014 and D1024 anodes will be at about the +1 V level and will remain at this level until the last sweep ends. As the last sweep ends, the positive-going portion of the DC level as it moves from +1 V to +10 V is used to generate the alternate-trace sync pulse required for switching the channels in the right plug-in multi-trace unit. Thus, for multi-trace delayed-sweep operation from the right plug-in unit operating in the alternate mode, there is always one A sweep and one B sweep per one alternate-trace sync pulse.

Alternate Trace Logic Multivibrator, Q1015 and Q1025

To establish the operating conditions for describing this circuit, assume the A and B MODE switches are set to NORM, the Upper Beam DISPLAY switch is set to RIGHT PLUG-IN A and the Lower Beam DISPLAY switch is set to RIGHT PLUG-IN B. Under these conditions, diodes D1024 and D1014 are reverse biased and not used; D1021 is always conducting.

Assume further that the sweeps have been triggered and are now running concurrently. With these conditions Q1025 is conducting and Q1015 is cut off. Diodes D1010, D1013 and D1028 are reverse biased; D1018 is conducting and clamps Q1015 collector at about −0.25 V. Diode D1023 is slightly forward biased and the collector of Q1025 is resting at about +10 V.

Assume the A sweep is ending first. As the A sweep ends and the A gate terminates (goes from +1 V to +10 V), the positive-going rise of this pulse is coupled through C1023 and D1023 to the base of Q1025. Transistor Q1025 is driven into cutoff and its collector is clamped at about +0.25 V by D1028.

With Q1025 cut off, the multivibrator action turns on Q1015, D1018 reverse biases and D1010 conducts to apply an inhibit gate to the A Holdoff Multivibrator stage. Thus, the A sweep is locked out and only the termination of the B gate can remove the inhibit gate and allow the A sweep to reset to its triggerable level; i. e., V625B is cut off and V625A is conducting in the A Holdoff Multivibrator stage to enable D565 to be triggered.

Assume the B sweep is now ending after the A sweep has ended. At the instant the B sweep ends, the B gate terminates and goes from +1 V to +10 V. The terminating B gate becomes a positive-going pulse when coupled through C1013 and this pulse drives Q1015 into cutoff. D1018 clamps the collector of Q1015 at −0.25 V. The multivibrator action causes Q1025 to conduct and D1028 reverse biases. As Q1015 goes into cutoff, D1010 is reverse biased and the inhibit gate is terminated to allow the A sweep to reset to its triggerable level. This completes one cycle of the multivibrator operation.

The signal generated at Q1025 collector is applied to the base of Q1033. The only portion of the signal that is used to produce an alternate-trace sync pulse is the portion generated when Q1025 turns on the instant the B sweep ends. This coincides with the combined condition of the A sweep locked out and the B sweep resetting. While the B sweep resets, the A sweep is allowed to reset and the alternate-trace sync pulse switches the right plug-in to the next channel. Thus, comparing this mode of operation to the operation of the B Gate Inverter stage previously described, the logic of the multivibrator circuit operation is such that the B sweep can run several times while there is only one A sweep and there will be only one alternate-trace sync pulse as shown in Fig. 3-18.

For the duration of the A sweep Q1025 is conducting and Q1015 is cut off. The positive-going portion of the B gate pulses, coupled through C1013 and D1013, will not base-trigger Q1015 because the transistor is already cut off. For the opposite situation, each time the B gate starts, the negative-going portion of the B gate pulses fail to reach the base of Q1015 because D1013 will not pass these pulses. As a result, Q1015 remains in cutoff while Q1025 is conducting and no alternate-trace sync pulses are generated while the A sweep is running.

Alternate Trace Sync Pulse Emitter Follower Q1033

This stage operates in conjunction with the B Gate Inverter and multivibrator stages to provide low-impedance sync pulse drive to V1063A.

Right Alternate Trace Sync Amplifier V1063A

With the Upper Beam DISPLAY switch set to RIGHT PLUG-IN A and the Lower Beam DISPLAY switch set to RIGHT PLUG-IN B, the alternate-trace sync pulse is applied to the grid circuit of V1063A. Coupling capacitor C1061 with R1060 forms a differentiating network for shaping the sync pulse. Diode D1062 clamps the negative-going portion of the pulse so only the positive-going portion is used as the sync pulse.

Both the cathode and plate circuits are completed through the switch connections in the right multi-trace plug-in unit operating in the alternate mode. In general, V1063A conducts only when the positive-going portion of the differential pulse is applied to the grid and the plug-in is operating in the alternate mode. V1063A is inoperative when operating in other modes. When V1063A is conducting, the alternate-trace sync pulse is either an amplified negative-going pulse when taken from the plate via pin 16 of J12, or is a small positive-going pulse when taken from the cathode via pin 8 of J12, if the tube is connected to operate as a cathode follower.

When the Upper Beam DISPLAY switch is set to any position except RIGHT PLUG-IN A, the B gate from the B Sweep Gating Emitter Follower Q763 is applied via the DISPLAY switch to the grid circuit of V1063A. Only the positive-going portion of the gate as it terminates is used to produce an alternate-trace sync pulse for switching the channels during the B sweep retrace time.

Left Alternate Trace Sync Pulse Amplifier V1043A

When the Upper Beam DISPLAY switch is set to LEFT PLUG-IN EXT or LEFT PLUG-IN A position, the A gate from the A Gate Emitter Follower Q563 is applied via the DISPLAY switch and C1041 to the grid circuit of V1043A. The function of the Left Alternate Trace Sync Pulse Amplifier stage is to provide an alternate-trace sync pulse via pin 8 or 16 of J11 to the left plug-in multi-trace unit during the sweep retrace time when the plug-in is operating in the alternate mode.

Operation of this stage is similar to the Right Alternate Trace Sync Pulse Amplifier stage. The sync pulse from V1043A is used to switch the channels in the left plug-in unit during the sweep retrace.

Lower Beam Chopped Blanking Amplifier V1063B

To avoid displaying the channel-switching portion of the vertical chopping signal when using a right plug-in multi-trace unit in the chopped mode, the beam is blanked during switching time between channels by the signal generated in the multi-trace unit. The negative-going chopped blanking pulses are connected to the junction of C1071 and R1065 through pin 16 of J12 of the right vertical interconnecting plug. The pulses are coupled through C1071 to the grid of the Lower Beam Chopped Blanking Amplifier tube V1063B. The signal is amplified and the inverted pulses are applied through the LOWER BEAM CHOPPED BLANKING position of the CRT Cathode Selector switch SW1345 (see CRT Circuit diagram) to the Lower Beam CRT cathode.

Note that the pulses applied to the junction of C1071 and R1065 are also applied through C1065 and a coaxial cable to the Upper Beam DISPLAY switch. When the switch is set to any of the RIGHT PLUG-IN positions, the negative-going chopped blanking pulses from the right plug-in unit are applied through the switch and coupled through C1051 to the grid of the Upper Beam Chopped Blanking tube V1043B for the purpose of blanking the Upper Beam display during the chopped-mode switching time between channels.

Upper Beam Chopped Blanking Amplifier V1043B

This amplifer serves the same purpose as the one for the Lower Beam; i. e., to provide chopped-mode blanking of the Upper Beam during chopped-mode switching between channels. When the Upper Beam DISPLAY switch is set to any of the RIGHT PLUG-IN positions, the chopped blanking pulses from the right plug-in are amplified by V1043B for application to the Upper Beam CRT cathode. The pulses to the CRT cathode are applied via the UPPER BEAM CHOPPED BLANKING position of the CRT Cathode Selector switch SW1395 (see CRT Circuit diagram).

When the Upper Beam DISPLAY switch is set to any of the LEFT PLUG-IN positions, the left plug-in chopped blanking pulses are used to blank the chopped-mode switching portion of the Upper Beam display. This occurs, of course, when the left plug-in is operating in the chopped mode. These pulses from the left plug-in are applied through pin 16 of J11 and

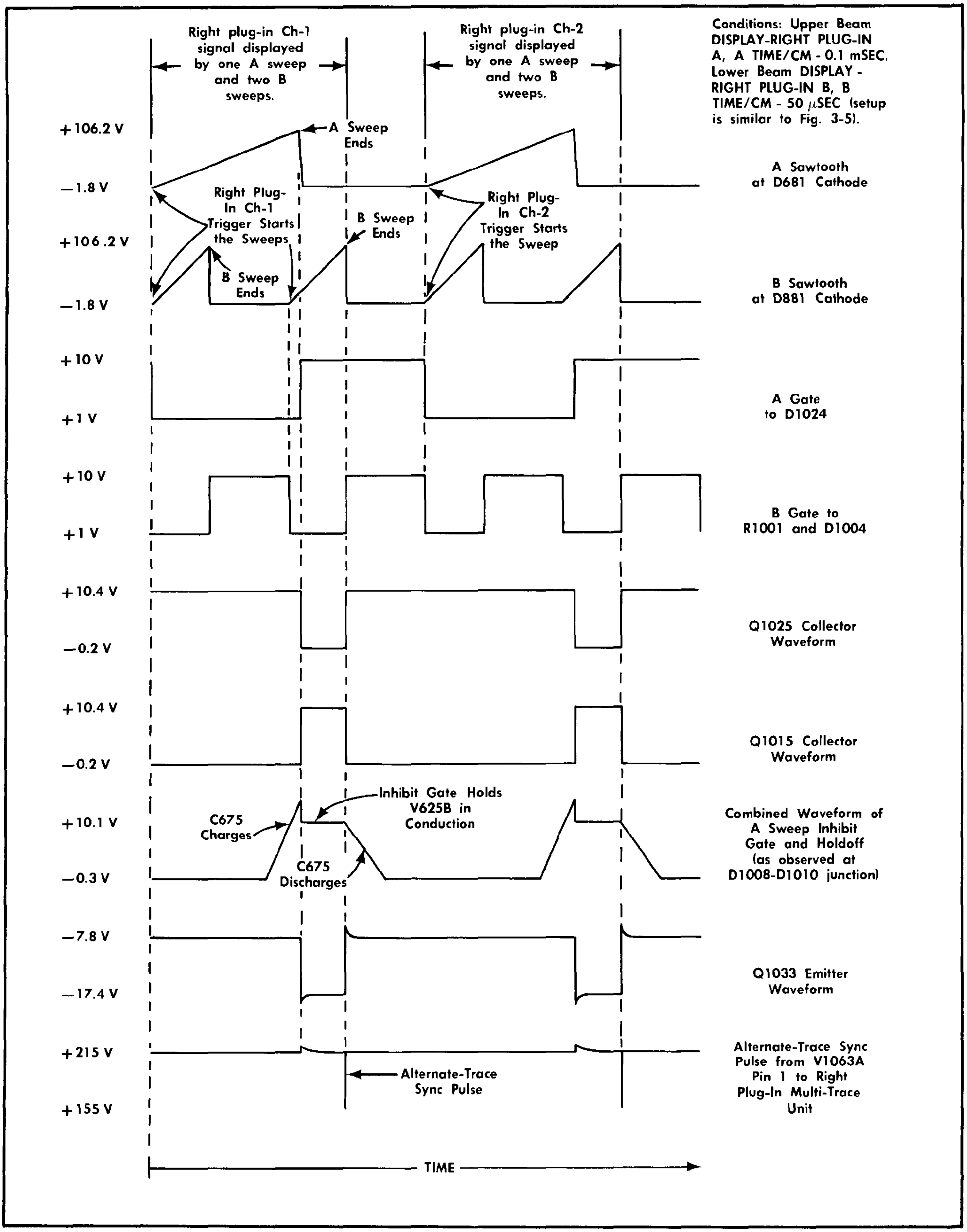


Fig. 3-18. Time-related waveforms showing how the A Sweep is locked out until the B Sweep ends. Note that only one alternate-trace sync pulse per slower sweep is generated for switching the channels in the right plug-in unit.

through C1051 to the grid of V1043B for amplification. The amplified and inverted pulses are applied through the UPPER BEAM CHOPPED BLANKING position of the CRT Cathode Selector SW1395 to the Upper Beam cathode of the CRT.

UPPER BEAM HORIZONTAL AMPLIFIER ⟨11⟩

The DC-coupled Upper Beam Horizontal Amplifier circuit (see Fig. 3-19) consists of Operational Amplifier Q1135, Q1145, Paraphase Amplifier Q1154-Q1164, push-pull Output Amplifier V1174-V1184, Capacitance Driver V1194, and External Horizontal Amplifier V1104.

The input signal for the Horizontal Amplifier is selected by the Upper Beam DISPLAY switch SW185. In the EXT positions the external signal, applied to the UPPER BEAM EXT HORIZ IN connector, is selected to drive the Upper Beam horizontal deflection plates. In the A positions of the switch the positive-going A sweep sawtooth provides the horizontal deflection, in the B positions the positive-going B sweep sawtooth provides the horizontal deflection.

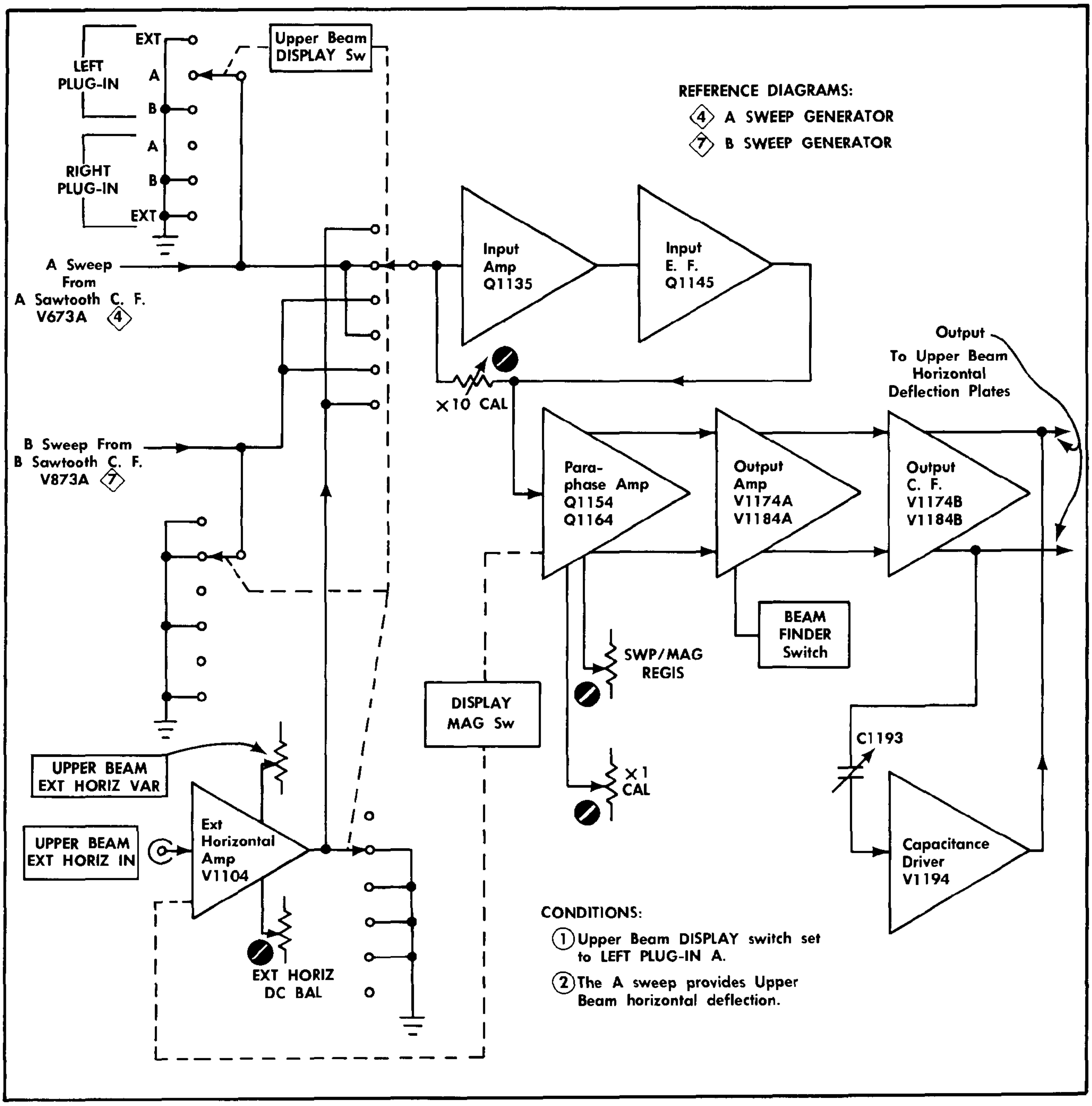


Fig. 3-19. Block diagram of the Upper Beam Horizontal Amplifier circuit.

Input Amplifier Q1135

The input signal selected by the Upper Beam DISPLAY switch, along with the DC positioning current from the horizontal POSITION controls R1136A and R1136B, is connected to the base of Q1135 in the Input Amplifier stage. This stage works together with Input Emitter Follower stage Q1145 to form an operational amplifier whose gain can be adjusted by the ×10 CAL control R1146 in the negative feedback loop. The Input Amplifier stage has a low input impedance and is current driven.

Horizontal positioning is provided by the POSITION controls, R1136A and R1136B. These controls are driven by the same shaft and they set the DC level of the input signal. Backlash coupling is used between the two sections of the POSITION control so both a coarse adjustment, R1136A, and a fine adjustment, R1136B, can be obtained by turning only one POSITION knob. Fine adjustment of the horizontal position is provided by R1136B operating in a 60° arc provided by the backlash coupling arrangement.

Negative feedback from the emitter of Q1145 to the base of Q1135 keeps the output impedance of the two stages low. The ×10 CAL adjustment provides a means of adjusting the amount of feedback, thereby controlling the gain when the DISPLAY MAG switch SW1120 is set to ×10.

Input Emitter Follower Q1145

The composite signal output (DC-positioning and signal current) from the collector of Q1135 is applied to a compensated divider network R1141, R1142 and C1141. The divider output is applied to the base of Q1145. Transistor Q1145 and associated components is an emittter follower, but the negative feedback to Q1135 makes the two transistors function as an operational amplifier. The output signal at the emitter of Q1145 is applied through D1151 to the base of Q1154. Diode D1151 is a protection diode. Resistor R1153 provides a bootstrap arrangement to restore the linearity of the sawtooth ramp. Zener D1144 sets the collector voltage at +25 V.

Paraphase Amplifier, Q1154 and Q1164

Transistors Q1154 and Q1164 with associated circuitry form a paraphase amplifier that converts the single-ended signal from the emittter of Q1145 into a push-pull output. The signal from Q1154 to Q1164 is coupled through the common emitter circuit. Gain of the stage is set by placing the DISPLAY MAG switch SW1120 to the ×1 position and adjusting the ×1 CAL control R1167 for proper 1 mSEC/CM sweep timing.

When the DISPLAY MAG switch SW1120 is set to the ×10 position, coil L1125 is energized to close its relay contacts (SW1125 on the Upper Beam Horizontal Amplifier diagram). These same contacts are closed when the Upper Beam DISPLAY switch SW1185 is set to either of the EXT positions. The contacts connect R1166 across the emitter resistors to decrease the emitter resistance of the stage and increase the display magnification by 10. To provide a front-panel indication that the DISPLAY MAG switch is set to ×10, SW1120 completes the circuit for B1120 so the incandescent lamp will turn on.

If switching the DISPLAY MAG switch between ×1 and ×10 causes a horizontal shift of the display, SWP/MAG REGIS control R1168 can be adjusted to prevent display shift.

Variable capacitor C1165 is adjusted for proper 0.1 μsec sweep timing when the DISPLAY MAG switch is set to ×10. Diode D1160 sets the base of Q1164 at about +0.5 V.

Output Amplifier V1174A and V1184A

The ramp voltage outputs from the collectors of Q1154 and Q1164 are applied to the control grids of V1174A and V1184A in the Output Amplifier stage. These two triodes amplify the ramp voltages, then the output is applied to the Output Cathode Followers, V1174B and V1184B.

To maintain the desired linearity at high sweep rates, part of the output is bootstrapped by the cathode followers through small variable capacitors C1172 and C1182. Diode D1182 conducts when the sweep resets to quickly return the beam to the left edge of the graticule.

BEAM LOCATE switch SW155, located in the cathode circuit of V1174A and V1184A, is a pushbutton switch. When pressed, the switch removes the short-circuit across R1179 to increase the common-cathode resistance and limit the current in the stage. The decrease in current limits the dynamic range of the stage so an off-screen display will appear on screen and the display location can be determined. B1178 is a protection neon that turns on during warm-up of the Type 556, thus limiting the grid-to-cathode voltages at that time.

Output Cathode Followers, V1174B and V1184B

The Output Cathode Follower stage, V1174B and V1184B, provides a low impedance push-pull drive to the Upper Beam horizontal deflection plates. Variable capacitors C1174 and C1184, together with stray capacitance across R1174 and R1184, form an adjustable high frequency feed-back network to obtain proper sweep waveshapes at high sweep rates.

Neons B1173 and B1183 limit grid-to-cathode voltage during the Type 556 warm up.

Capacitance Driver, V1194

The cathode of V1174B drives the left-hand deflection plate and, during the sweep, the cathode voltage should go linearly in a negative direction. At high sweep rates, when V1174B tries to drive the left-hand deflection plate negative, the deflection-plate capacitance and the output capacitance of cathode follower V1174B tend to distort the ideal linear ramp voltage into an RC discharge curve. To overcome this tendency toward non-linearity, the positive-going ramp voltage at the cathode of V1184B is applied through C1193 to the control grid of Capacitance Driver tube V1194.

The positive-going voltage on the grid of V1194 forces it into heavy conduction. The current supplied through the tube provides extra current to the cathode of V1174B and helps to discharge the capacitance in the V1174B output circuit. Since the CRT beam is blanked during the return trace, there is no need for a similar current driver for the cathode of V1184B.

External Horizontal Amplifier V1104

External signals for use in providing horizontal deflection of the Upper Beam are applied to the UPPER BEAM EXT HORIZ IN connector. In the ×1 position of the Upper Beam DISPLAY MAG switch SW1120, the signal is applied through the switch contacts and a compensated 10× attenuator to the grid of V1104A. The signal is attenuated 10× because the Paraphase Amplifier stage, Q1154 and Q1164, is already set for ×10 display magnification regardless of the Upper Beam DISPLAY MAG switch position. When the Upper Beam DISPLAY switch is set to either of the EXT positions, coil L1125 is energized, closing SW1125 relay contacts to provide the ×10 amplifer gain regardless of the DISPLAY MAG positions. Thus, to obtain a normal (×1) display, the X1 attenuator is used to reduce the amplitude of the signal by a factor of ten.

When the DISPLAY MAG switch is set to ×10, the signal is coupled directly (without attenuation) through the switch contacts to the grid of V1104A and the resulting horizontal deflection will appear as a ×10 magified display.

V1104A and V1104B form a cathode follower grounded-grid amplifier and the gain is controlled by adjusting the value of a coupling resistor connected in the cathode circuit. In this circuit, the variable coupling resistor is the UPPER BEAM EXT HORIZ VAR control R1108 which provides at least a 10:1 range of adjustment. The output of V1104B is applied through the DISPLAY switch to the base of Q1135.

Quiescent current through V1104B is adjusted with the EXT HORIZ DC BAL control R1110 to match the current through V1104A. With R1110 properly adjusted, there is no DC current flow in R1108 and R1105 with no signal applied. Thus, the UPPER BEAM EXT HORIZ VAR 1-10 control can be rotated without causing any horizontal shift in the position of the beam.

Variable capacitor C1115 provides a means of frequency-compensating the divider that is formed when the plate circuit of V1104B is connected to base circuit of Q1135.

LOWER BEAM HORIZONTAL AMPLIFIER ⟨12⟩

Except for differences in signal source selections, the Lower Beam Horizontal Amplifier circuit operates the same as the Upper Beam Horizontal Amplifier circuit. The signal source selections for the Lower Beam Horizontal Amplifier are: RIGHT PLUG-IN A, RIGHT PLUG-IN B and EXT.

Instruments with serial numbers 100-1999 do not have the RIGHT PLUG-IN A signal selection.

CRT CIRCUIT ⟨13⟩

The CRT in the Type 556 has two sets of vertical deflection plates and two sets of horizontal deflection plates, operated independently of each other. The CRT circuit consists of similar control circuits for the Upper Beam and the Lower Beam. The CRT Circuit consists of two major circuits that are similar to each other and controlled independently. One circuit is the Lower Beam and the other is the Upper Beam. However, the Lower Beam section contains additional circuits that control both beams. These are the high-voltage delay[1] and post-acceleration circuits. Fig. 3-20 is a block diagram that shows the Lower Beam CRT Circuit and those adjustments that are common to both beams. The CRT requires an accelerating potential of about 10,000 volts for both beams. Approximately 1850 volts of this is supplied by the CRT negative supply circuits and the remaining 8150 volts is provided by the Lower Beam post-acceleration circuit.

The —1850 volt supply for each beam consists of an oscillator, step-up transformer, rectifier and voltage regulator circuits. The description of these circuits refers to the Lower Beam section only but can be applied to the Upper Beam as well. Since the Lower Beam section contains additional circuits that affect both beams, these circuits are included in the description.

High-Voltage Oscillator V1300, Error Amplifier (V774B and V774C), and CRT Control-Grid Rectifier D1332

V1300 with associated circuitry comprises the high-voltage oscillator. V774B and V774C with their associated components are the error amplifiers. Output of the High-Voltage Oscillator is through T1301.

The High-Voltage Oscillator is a modified Armstrong circuit which operates at a frequency of about 35 kHz, determined mainly by the primary winding inductance of T1301 and the capacitance of C1303. Amplitude of the oscillator signal, and thus the amplitude of the rectified DC voltage is adjusted by changing the voltage on the control grid of V1300. This votage is controlled by the HIGH VOLTAGE adjustment R1332, through the Error Amplifier stage.

Transformer T1301 steps up the oscillator signal to the required voltage outputs. Diode D1332 provides half-wave rectification to produce the —1850 V. This negative DC high voltage is filtered by C1330, C1333, C1334 and R1339. Then it is applied to the CRT cathode and to a high-resistance voltage divider. The divider includes the FOCUS control R1336 and the HIGH VOLTAGE control R1332. When the HIGH VOLTAGE control R1332 is properly adjusted, the voltage at TP1340 is —1850 volts.

A portion of the —1850 V is fed back to the oscillator from the junction of R1331 and R1334 through the Error Amplifier stage for amplitude regulation. By comparing this voltage with the ground reference voltage at the cathode of V774C, any tendency of the rectified voltage to become more negative, for instance, would decrease the current through V774C and cause V774B grid to go less negative. This, in turn, would increase the current through V774B and R1302. With increased current through the resistors, the voltage at the control grid of V1300 goes more negative and thus would decrease the oscillator output amplitude to bring the rectifier output back to the correct value.

High Voltage Delay Q1334

The High Voltage Delay circuit consists of Q1334 and associated components. Purpose of this circuit is to gradually increase the high voltage while the instrument is warming up and the Lower Beam CRT circuit is stabilizing. The action of the delay circuit permits the Lower Beam to reach normal brightness at a slower rate than the Upper Beam.

[1]**Added in Type 556 SN 2000 and up.**

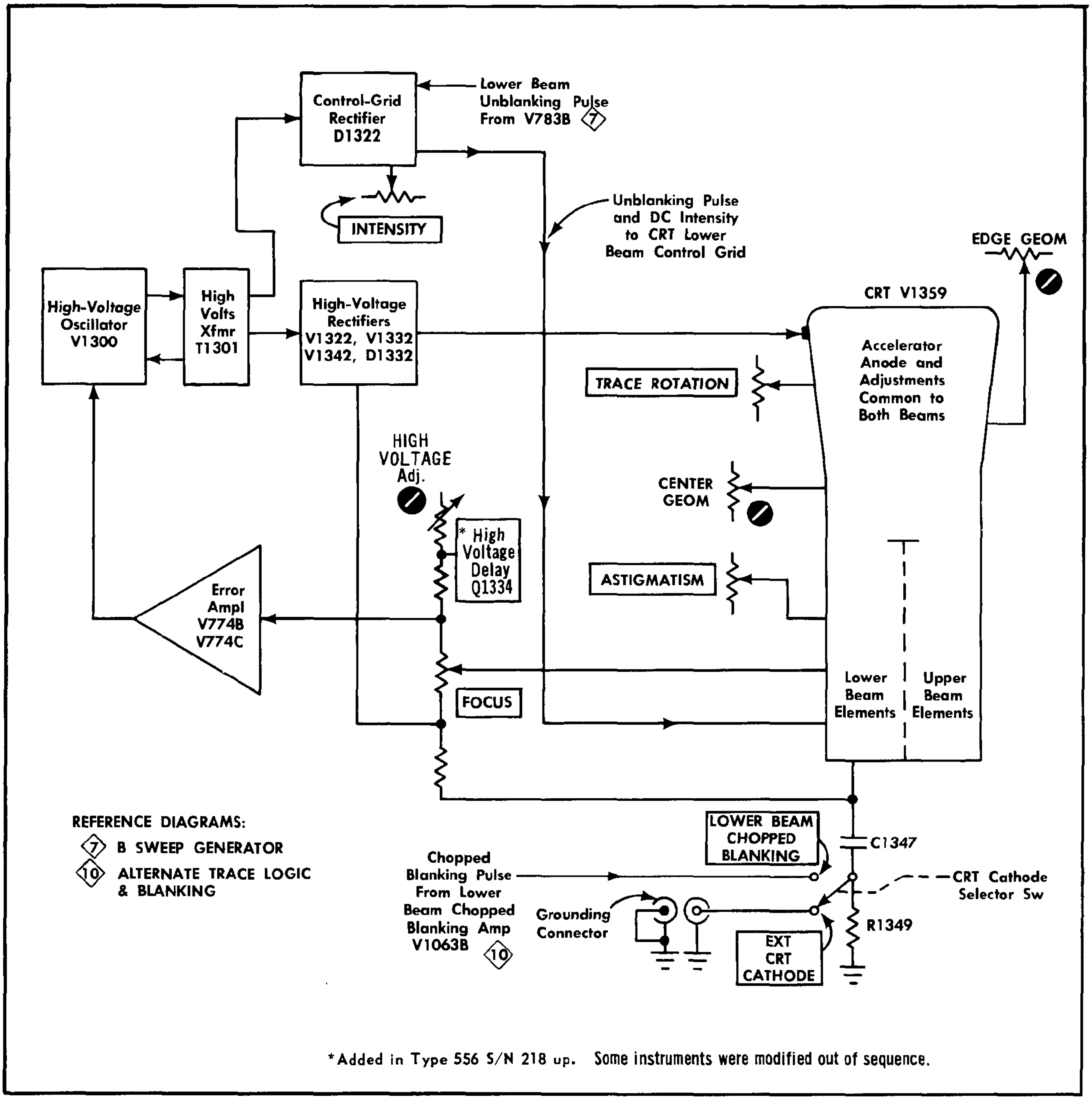


Fig. 3-20. Partial block diagram of CRT circuit showing the LowerBeam section and those adjustments that are common to both beams.

When the instrument is first turned on, Q1334 goes into saturation; D1334 and D1325 are reverse biased. The base current of Q1334 and the high-resistance path of R1323, R1325, R1326 and R1328 allow C1325 to change slowly. The change current keeps Q1334 froward biased and in saturation until the current begins to decrease as C1325 approaches full change. In about 20 seconds C1325 charge current has decreased to the point where D1325 becomes biased and Q1334 starts to come out of saturation.

As Q1334 comes out of saturation and starts to turn off, C1331 begins to charge. Charge current flows through the emitter-base junction of Q1334, and through resistors R1323, R1328 and R1329. As C1331 approaches full charge and the current decreases, Q1334 turns off and D1334 becomes biased. During the time that C1331 has been charging, the voltage level at the junction of R1330, R1331 and R1333 rises slowly, this action causes V774C grid voltage to go slowly less negative. Current through V774C increases, current through V774B decreases and V1300 control grid voltage goes less negative. As a result, the oscillator output amplitude is increased gradually as C1331 changes. Finally, when C1331 becomes fully charged, the voltages at TP1340 and the post-acceleration anode reach their normal level.

Total delay time is about 40 seconds. When the instrument is turned off, protection diode D1334 limits Q1334 emitter-to-base junction reverse bias by allowing C1325 to discharge through the diode.

Post-Acceleration Supply

A half-wave voltage tripler circuit, V1322, V1232 and V1342, rectifies the output from the associated secondary winding of T1301 to provide the dual-beam CRT post-acceleration potential of +8150 volts. Regulation of this voltage is provided through the transformer by regulation of the High-Voltage Oscillator V1300 output. Ground return for this supply is through the resistive helix inside the CRT to pin 9, through the R1392-R1393 divider resistors and to the +225-V and +100-V supplies.

CRT Control-Grid and Unblanking Circuit

As stated eariler, D1322 rectifies the high voltage from T1301 secondary winding (terminals 6 and 9). This rectified voltage provides the DC bias source for the CRT control grid. The front-panel Lower Beam INTENSITY control R1319 provides a means for manually adjusting the bias voltage applied to the Lower Beam CRT control grid and thus control the magnitude of the beam current. The range of the INTENSITY control varies the grid from about —1950 to —1870 volts.

As the control grid negative voltage is decreased (made less negative), the beam intensity is increased.

At the slower sweep rates the sweep unblanking signal from V783B in the B Sweep Generator circuit is applied through R1316, R1317, R1318, R1319 and R1320 to drive the Lower Beam control grid. The INTENSITY control R1319 is normally set so the Lower Beam does not light the phosphor of the CRT screen except during the positive portion of the sweep unblanking waveform.

At the fastest sweep rates, the stray capacitance of the floating control grid circuit makes it difficult for the grid to rise fast enough to unblank the CRT within the required time. A network consisting of R1316 and R1320 isolates the capacitive loading. By this arrangement, the fast leading edge of the unblanking pulse is coupled through C1321 and C1323 to the control grid of the CRT. For short-duration unblanking pulses such as those occurring at the fastest sweep rates, the DC levels on the rectifier D1322 and the associated secondary winding of T1301 are not appreciably affected. Longer unblanking pulses such as those that occur at the slower sweep rates, charges the stray capacitance in the control grid circuit through R1316. This pulls the floating grid up and holds the grid at the unblanked potential for the duration of the unblanking pulse.

CRT Circuit Controls and Connectors

Optimum size and shape of the upper beam as it is accelerated to the screen is obtained by adjusting the front-panel FOCUS and ASTIGMATISM controls. The FOCUS control R1366 provides the correct voltage for the second anode (focus ring) of the Upper Beam elements. Proper voltage for the third anode is obtained by adjusting the ASTIGMATISM control R1344. In order to obtain optimum spot size and shape, both the FOCUS and ASTIGMATISM controls are adjusted to provide the proper electronic lens configuration in the region of the second and third anodes. Spot intensity is adjusted by means of the front-panel INTENSITY control R1319. Varying the INTENSITY control changes the voltage on the CRT control grid, which in turn varies the density of the electron stream. Internal CENTER GEOM R1342 and EDGE GEOM R1391 controls adjust the isolation and edge shield voltages to minimize bowing of the display. The front-panel TRACE ROTATION control, R1390A and R1390B, permits minor adjustment in trace orientation. By adjusting the TRACE ROTATION control, the traces for both beams can be made parallel with the horizontal center lines on the internal graticule.

Lower Beam CRT Controls

The EXT CRT CATHODE BNC connector on the rear panel of the Type 556 provides an input for externally modulating the Lower Beam CRT cathode. The connector is normally grounded by a grounding cover. To intensity modulate the display from an external source, the grounding cover is disconnected from the BNC connector, the CRT Cathode Selector switch SW1345 is set to the EXT CRT CATHODE position, and the modulating signal is coupled to the Lower Beam CRT cathode through C1347.

When the Type 556 is used with multi-channel vertical plug-in units that provide multi-trace chopped blanking pulses, the blanking pulses are applied to the CRT Cathode Selector switch SW1345. With the plug-in unit operating in the chopped mode and SW1345 set to the LOWER BEAM CHOPPED BLANKING position, a positive pulse of about 20 volts amplitude is applied through C1347 to the cathode of the Lower Beam. At normal intensity levels, this pulse is sufficient to cut off the CRT during the time the channels in the plug-in unit are switched.

Upper Beam CRT Circuit

Except for the dual-beam post-acceleration supply and the high-voltage delay circuit included in the Lower Beam section, the Upper Beam CRT circuit is the same. For the Upper Beam, there is an additional signal which is combined with the unblanking pulse for controlling the trace unblanking levels. This additional signal, as explained earlier in the Upper Beam Unblanking Amplifier V574A description, restores the beam to its normal intensity level for the duration of the B sweep when using delayed-sweep mode of operation. This intensity level is referred to in this manual as the intensified portion of the Upper Beam display.

In delayed-sweep mode of operation, the front-panel CONTRAST control (see B Sweep Generator circuit) is used to control the brightness of the non-intensified portions of the trace and the INTENSITY control R1369 is used to set the overall level including the intensified portion of the display.

POWER SUPPLY and HEATER WIRING ⟨14⟩ ⟨15⟩

General

The low-voltage power supply provides the operating power for the instrument from four regulated supplies: —150 V, +100 V, +225 V and +350 V. Electronic regulation is used to provide stable output voltages. Each supply is fuse-protected against overloads.

An unregulated +6 volt supply is provided to operate the Reset Lamp Driver stages Q619 and Q819, and for powering the incandescent indicator lights B619 and B819. Unregulated 6.3 V and 12.6 V RMS AC voltages are provided for operating the tube filiments (including the dual-beam CRT), POWER pilot light and graticule lamps.. The 6.3 V is also the line triggering source for the A and B Sweep Trigger circuits.

All of the power-supply DC regulator circuits operate similarly. A sensing circuit compares a sample of the output voltage against a fixed reference voltage. Any difference between the output voltage and the reference produces an error signal which is amplified and applied to the series regulator transistors, causing the regulators to correct for the error and return the output to the proper value. Fig. 3-21 is a block diagram of the Power Supply circuit (Fig. 3-22 for SN 100-1999).

Power Transformer

The power transformer T1401 is enclosed in a special metal shield to reduce the effects of electromagnetic interference in the other circuits. The transformer windings ar shown schematically on the Power Supply diagram in Section 9.

When line voltage is applied to the instrument, the current path through the primary circuit is through line filter FL1400, POWER switch SW1402, thermal cutout TK1404, fuse F1401 or flses F1401 and F1402, and through both primary windings. When the instrument is configurated for a 115 volts (nominal) application, only fuse F1401 is used, with a 230 volts (nominal) application, fuse F1402 is added to the circuitry.

To provide optimum voltage regulation and correct DC voltage levels with any applied line voltage within the ranges of 90 to 136 VAC and 180 to 272 VAC, the primary is constructed as two identical windings, each with three taps to permit selection of different turns ratios. The desired transformer turns ratio is selected by positioning the Voltage and Range Selectors (located in the Line Voltage Selector Assembly). The two windings are connected in parallel when the Voltage Selector is set to 115 V and in series when the selector is set to 230 V. The position of the Range Selector (LO, M, HI) determines which taps on the two windings are selected.

For instruments with serial numbers 100-1999, the transformer primary circuit configuration is as follows:

One winding connects to terminals 1 and 3, the other connects to terminals 2 and 4. There are two more windings which may be used as voltage bucking or aiding windings. These are connected to terminals 5 and 6 for one winding and terminals 7 and 8 for the other winding. These windings along with the two main primary windings may be used to allow the instrument to run on nominal line voltages of 104, 115, 208, and 230 volts, depending upon how all the windings are connected. Square pin connectors on a power circuit board simplify the connections of leads and connectors when changing line-voltage operation.

Thermal cutout switch TK1404 is provided to protect the instrument from excessive heating. When its ambient temperature exceeds approximately 140°F, the thermal cutout switch will open the transformers primary circuit, Since the switch will close when its ambient temperature drops below its opening temperature, and restore line voltage to the primary, always set the POWER switch to OFF before attempting to remedy an overheated instrument condition.

The fan must be operative when power is applied to the instrument to adequately circulate the cooling air. Since the fan motor is connected across one of the primary windings. power is applied to the fan motor when it is applied to the primary windings and the fan rotation speed is not affected by changes to the transformers turns ratio.

The transformers output windings are the voltage source for five full wave rectifier circuits and one 6.3 VAC circuit.

DC VOLTAGE SUPPLIES SN 2000-up

—150 Volts Supply

A block diagram of this circuit is shown in Fig. 3-20. The —150 Volts Supply circuit contains a rectifier in the form of a diode bridge (D1482) connected to one of the secondary windings of T1401; a variable resistance network that contains the —150 volts output level adjustment R1498; a comparator circuit (Q1484 and Q1494) that senses any change in the output voltage level with respect to ground and two emitter followers (Q1504 and Q1513) that connects the output of the comparator circuit to 2 series regulator (Q1517). The series regulator circuit (Q1517) provides the necessary voltage compensations to maintain the output level at —150 volts.

Q1484 and Q1494 with their associated circuitry form the voltage comparator circuit. The constant plate to cathode voltage of glow discharge tube. V1482 is used to fix the voltage at the base of Q1484 with respect to the negative side of the rectifier bridge or output of the —150 supply. The base of Q1494 is connected to a variable resistance network that includes the —150 volts adjustment R1498. Since this resistance network is connected between the —150 supply circuits output and ground, the Q1494 base voltage level set by R1498 is referenced to ground. With the base voltage of Q1484 fixed with respect to the output voltage and the base voltage of Q1494 following any change in output voltage with respect to ground, the division of currents through Q1484 and Q1494 will vary with any output voltage change in respect to ground. The changes in the division of currents through the two transistors will cause voltage changes in both collector circuits, but only the voltage changes, or error signals, developed in the Q1494 collector circuit are coupled by the emitter follower circuits to the series regulator circuit.

During instrumnt calibration, the —150 volts adjustment, R1498, is set to establish a division of currents through Q1484 and Q1494. This produces a Q1494 collector voltage which sets the Q1504, Q1515 and Q1517 bias voltages, producing

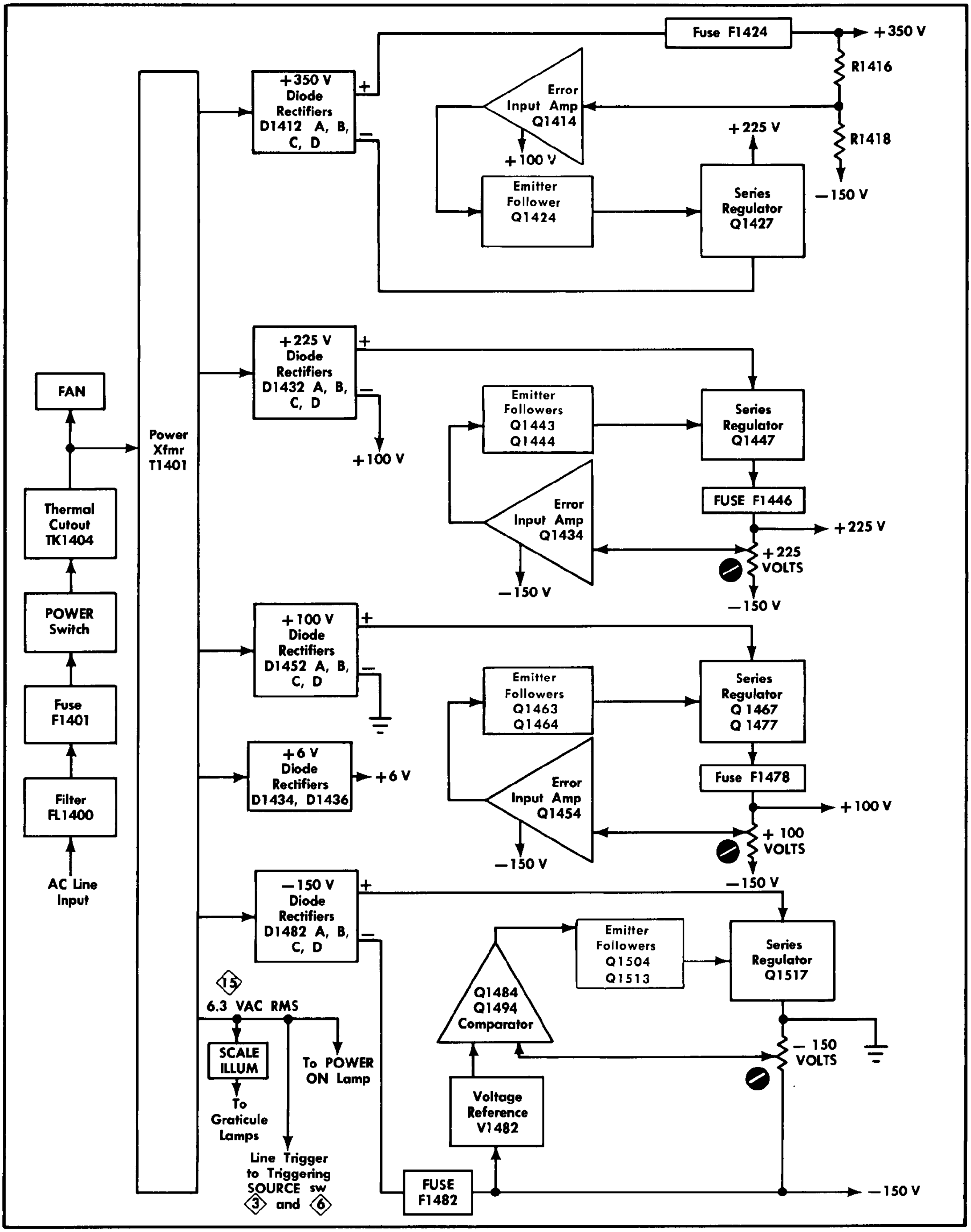


Fig. 3-21. Block diagram of Power Supply circuit and partial circuit of Heater Wiring for the Type 556 SN 2000 and up.

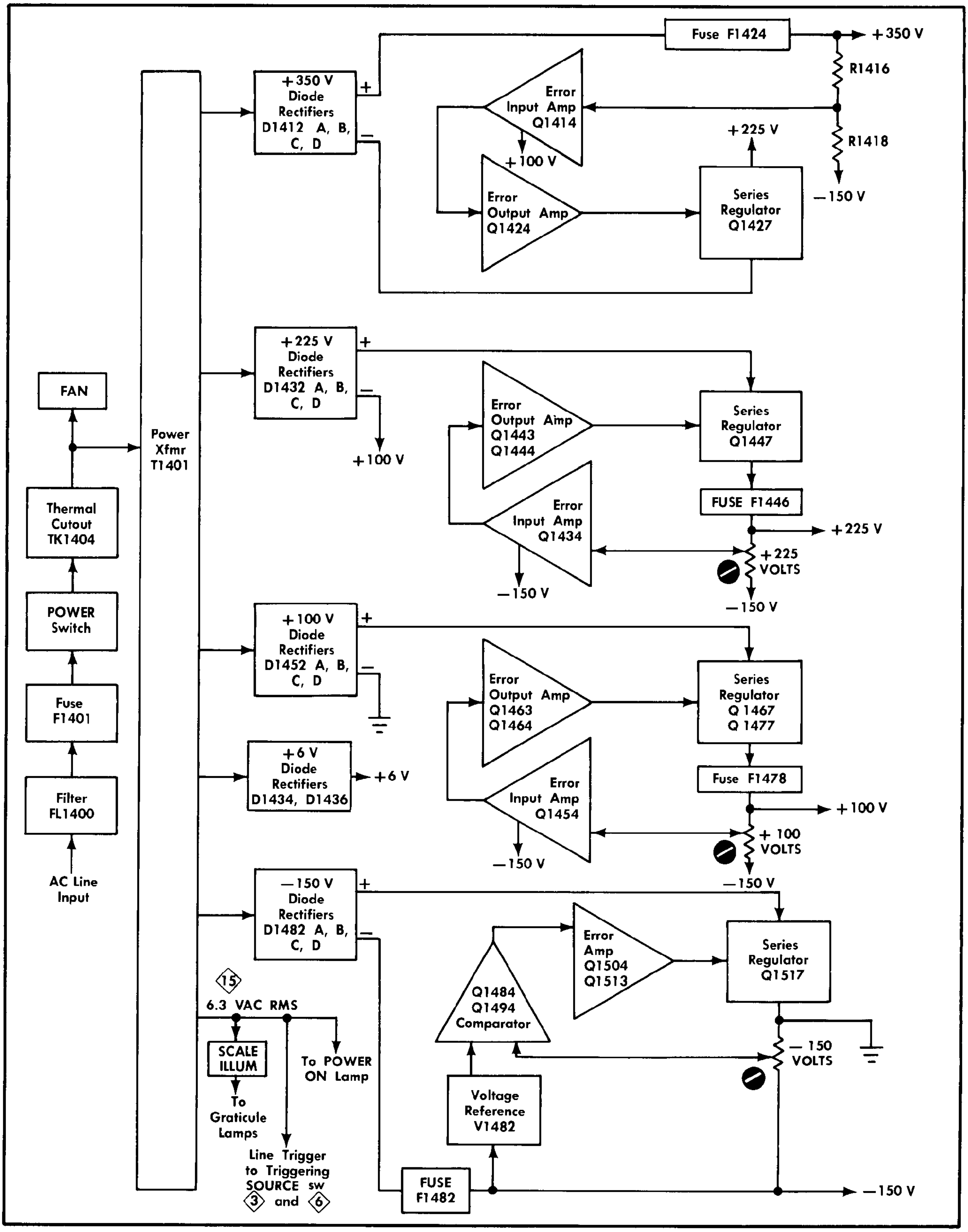


Fig. 3-22. Block diagram of Power Supply circuit and partial circuit of Heater Wiring for the Type 556 SN 100 to 1999.

a Q1517 collector to emitter drop which equals the difference between the rectifier output voltage and 150 volts. When the regulator circuitry is adjusted to produce —150 volts for a given rectifier output, any change in output voltage with respect to ground causes a bias change on Q1494 of opposite polarity to the output voltage, and of about one half the amplitude. For example, if the —150 volts output began to increase toward —151 volts, the voltage at the emitter of Q1494 would become more negative by approximately the unit of voltage change (due to the constant voltage across V1482), while the voltage at the base of Q1414 would become more negative by approximately one-half the unit of voltage change (due to the voltage divider action of the resistance network), resulting in an increase in forward bias of approximately one-half the unit of voltage change.

Q1504 and Q1513 with their associated circuitry form two emitter follower circuits. Error signals developed in the collector circuit of Q1494 are coupled to the base of Q1517 via these two emitter followers. The two emitter followers provide isolation between the error sensing circuit and the series regulator. The associated circuitry is configured to provide error signal limiting for regulator circuit protection and to provide phase shifting to prevent self-inflicted regulator circuit oscillations.

Q1517 and shunt resistor R1519 form a series regulator circuit. The circuit functions as a variable resistance in series with the —150 volt load circuits. Any change in the rectifier output voltage, whether due to line voltage or load current changes, is compensated by an equal change in voltage across the series regulator circuit.

Since the compensating changes in voltage across the series regulator are reactions to changes in the output voltage with respect to ground, there is a temporary change in output voltage during the regulator circuit reaction time. Filter capacitors C1498 and C1499, connected between the —150 volts output and ground, suppresses the effects of these voltage changes to a level negligible to the operation of the instrument.

Fuse 1482 will open when the current through it exceeds approximately .75 amperes. Since an excessive current must be present for a finite interval before F1482 will open, R1517 is provided to limit surge currents through Q1517 to a level within the transistor's dissipation capabilities.

+100 Volt Supply

The input to the +100 V supply is the output of the secondary winding connected to terminals 13 and 14 on the power transformer T1401 and the silicon diode bridge D1452. In addition to its other loads, the +100 V supply provides current to the +225 V supply and then through the 225 V supply to the 350 V supply. Also, the +100 V supply must provide a total current of 300 mA to two series strings of filaments (see the Heater Wiring diagram). The plug-in units become part of the series filament string. If the plug-in units are removed while the oscilloscope is operating, the +100 V supply is capable of remaining within its dissipation limits despite the 300 mA change in load.

The configuration of the +100 Volt Supply regulator circuit and its reaction to a change in output voltage is similar to the —150 Volts supply regulator circuit.

Q1454 with its associated circuitry forms the error sensing circuit. The base of Q1454 is connected to a resistance network that includes the +100 volt output adjustment R1459. Since R1459 is connected between the +100 Volt output and the regulated —150 Volt output, any change in the +100 volts with respect to the —150 Volts is applied as a change signal to the base of Q1454. D1450 provides thermal compensation for Q1454 and reference to ground.

Q1463 and Q1464 with their associated circuitry form a circuit similar in configuration and function to the circuit formed by Q1504 and Q1513 in the —150 Volt supply circuit.

Q1467 and Q1477 are connected in parallel and with the shunt resistors R1476, R1477 and R1478 form the series regulator circuit.

Fuse F1478 and current limiting resistors R1464 and R1469 protect the circuit from excessive currents.

+225 Volt Supply

The AC output of the secondary windings between terminals 15 and 16 is rectified by diode bridge D1432 and added to the +100 volt supply output to produce the +225 volts supply.

The +225 volts supply is similar in configuration and operation to the +100 volts supply. Q1434 with its associated circuitry forms the error sensing circuit. D1430 provides +100 reference and temperature compensation for Q1434 and R1430 is the +225 Volt output adjustment. Q1443 and Q1444 with their associated circuitry form the emitter follower circuits. Q1447 with the two shunt resistors R1445 and R1446 form the series regulator circuit. The regulating circuit is protected by fuse F1446 and current limiting resistors R1442 and R1443.

+350 Volt Supply

The AC output of the secondary windings between terminals 19 and 20 is rectiifed by diode bridge D1412 and added to the +225 volts supply through the series regulator (Q1427) to produce the +350 Volt supply.

Q1414 with its associated circuitry forms the error sensing circuit. The base of Q1414 is connected to the junction of two equal value resistors. Since these two resistors are connected between the +350 Volts output and the —150 Volt output, about one-half the amplitude of any change in the +350 Volts with respect to the regulated —150 Volts is applied to the base of Q1414.

Q1424 with its associated circuitry forms an emitter follower circuit that provides isolation between the error sensing circuit and the series regulator circuit. The output of Q1424 is the signal drive for Q1427 in the series regulator circuit.

Q1427 and shunt resistor R1427 form the series regulator circuit. Current limiting for Q1427 is provided by R1429.

In the event of a circuit malfunction, the +350 V supply circuitry is protected from excessive currents by F1424 and the output supply voltage is prevented from decreasing substantially below the +250 volts supply level by D1440.

The power supply circuits in instruments SN 100-1999 are configurated similarly to the circuits described above. They produce the same output supply voltages and the supply voltages and are regulated in essentially the same manner. In general, components in the two power supply configurations that have the same circuit designations, provide the same or a similar function. The notable circuit differences are, the transistors used in the four series regulator circuits are PNP germanium instead of NPN silicon; modified Darlington amplifiers instead of emitter follower circuits connect the output of the error sensing circuits to the series regulators in the −150, +100 and +250 Volt supplies and a voltage amplifier instead of an emitter follower connects the error sensing circuit to the series regulator in the +350 Volt supply.

CALIBRATOR ⟨17⟩

The Calibrator circuit in the Type 556 is a 1 kHz square-wave generator (see Fig. 3-23 and the Calibrator schematic) that provides both voltage and a 5 mA current output to the front-panel connectors. The voltage output is taken from the CAL OUT connector on the front panel, where either a square wave or a steady +100 V DC reference voltage is available.

By rotating the AMPLITUDE CALIBRATOR switch SW1630, the amplitude of the square wave output may be varied from 0.2 mV to 100 V peak to peak. The current output is applied to the loop marked 5 mA, with the arrow indicating conventional current flow. When the AMPLITUDE CALIBRATOR switch is set to the 100 V DC position, the loop has 5 mA DC flowing through it. When the switch is set to the 5 mAΩ position, the current through the link is in the form of a 1 kHz, 5 mA square wave.

CAUTION

The loop is designed for use with a snap-on current probe and does not unplug.

Calibrator Multivibrator, V1605A and V1605B

The square-wave generator is an astable multivibrator using two sections of a three-section tube. V1605A and V1605B are the multivibrator sections with the pentode section (V1605A) connected as a triode. The value of the plate load resistor R1605 is relatively lower than the value of V1605B plate load resistor R1615 so the current drawn through the sections during conduction will be nearly the same and constant current will be drawn from the −150 V supply.

When the amplitude calibrator is turned on, the multivibrator cathodes are returned through R1602 and R1601 to the −150 V supply. Capacitor C1602 bypasses any fast switching transients that may appear at the cathodes. The plate of V1605A operates from the +100 V supply while the plate of V1605B operates from the +225 V supply. The plate of V1605B swings from about −2 volts to about +143 volts. The output voltage from the plate of V1605B is coupled through R1620 and the CAL AMPL control R1628 to the grid of the cathode follower section, V1605C.

Calibrator Output Cathode Follower V1605C

The Calibrator Multivibrator stage switches the Calibrator Output Cathode Follower section, V1605C, between cutoff and conduction. During the negative portion of the multivibrator output waveform, the grid of V1605C is driven well below cutoff and its cathode rests at ground potential. During the positive portion of the waveform, V1605C is driven into conduction and the cathode potential is +100 V, set accurately by the CAL AMPL control R1628, the clamping action of D1620, and the precise setting of the +100 V supply.

Accurate adjustment of the CAL AMPL control is made by setting the AMPLITUDE CALIBRATOR switch SW1630 to 100 V DC and then adjusting R1628 for exactly +100 V output at

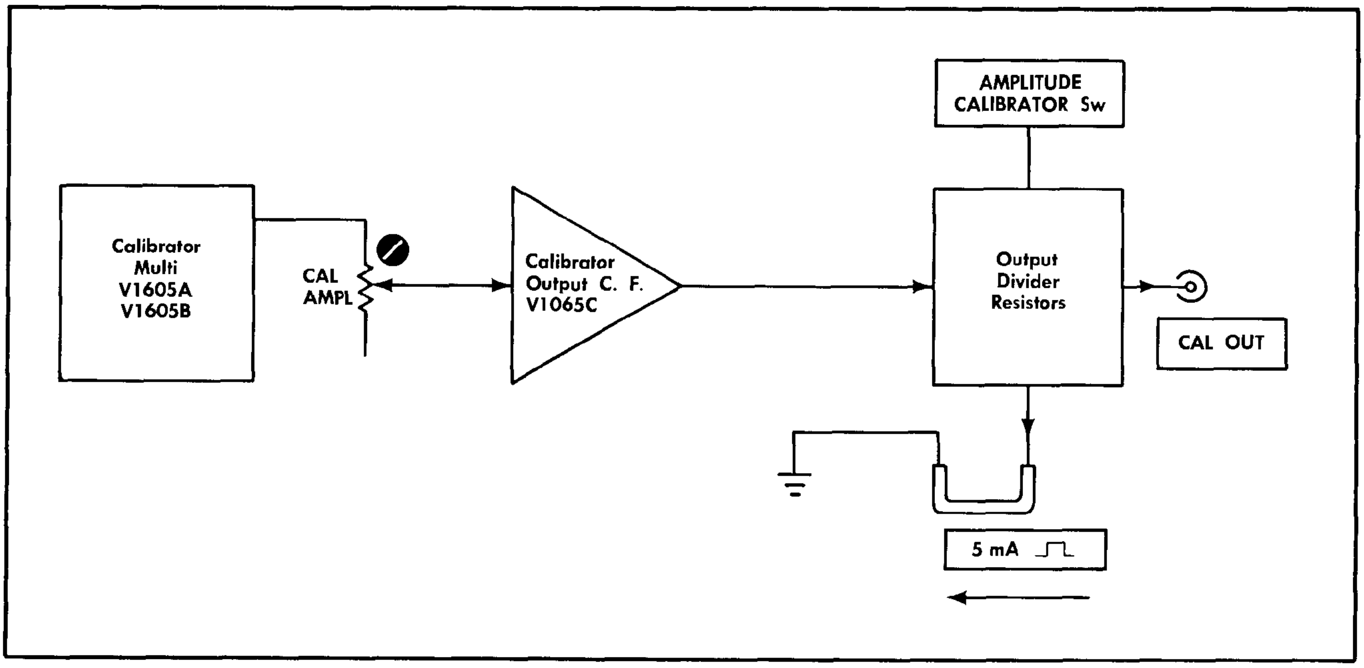


Fig. 3-23. Block diagram of the Calibrator circuit.

the CAL OUT connector. With the switch set to 100 V DC, the Calibrator Multivibrator stage is disabled because the cathode return circuit is disconnected from —150 V. Diode D1620 conducts and clamps the junction of R1620 and R1628 at about 0.6 V higher than the +100 V supply voltage. Thus, V1605C is held in conduction at the same level as that obtained when the multivibrator is operating and V1605B plate is at its most positive level. With V1605C grid held at a constant DC level and with the +100 V supply previously adjusted for proper output, the CAL AMPL control R1628 can be easily adjusted for exactly +100 V output at the CAL OUT connector.

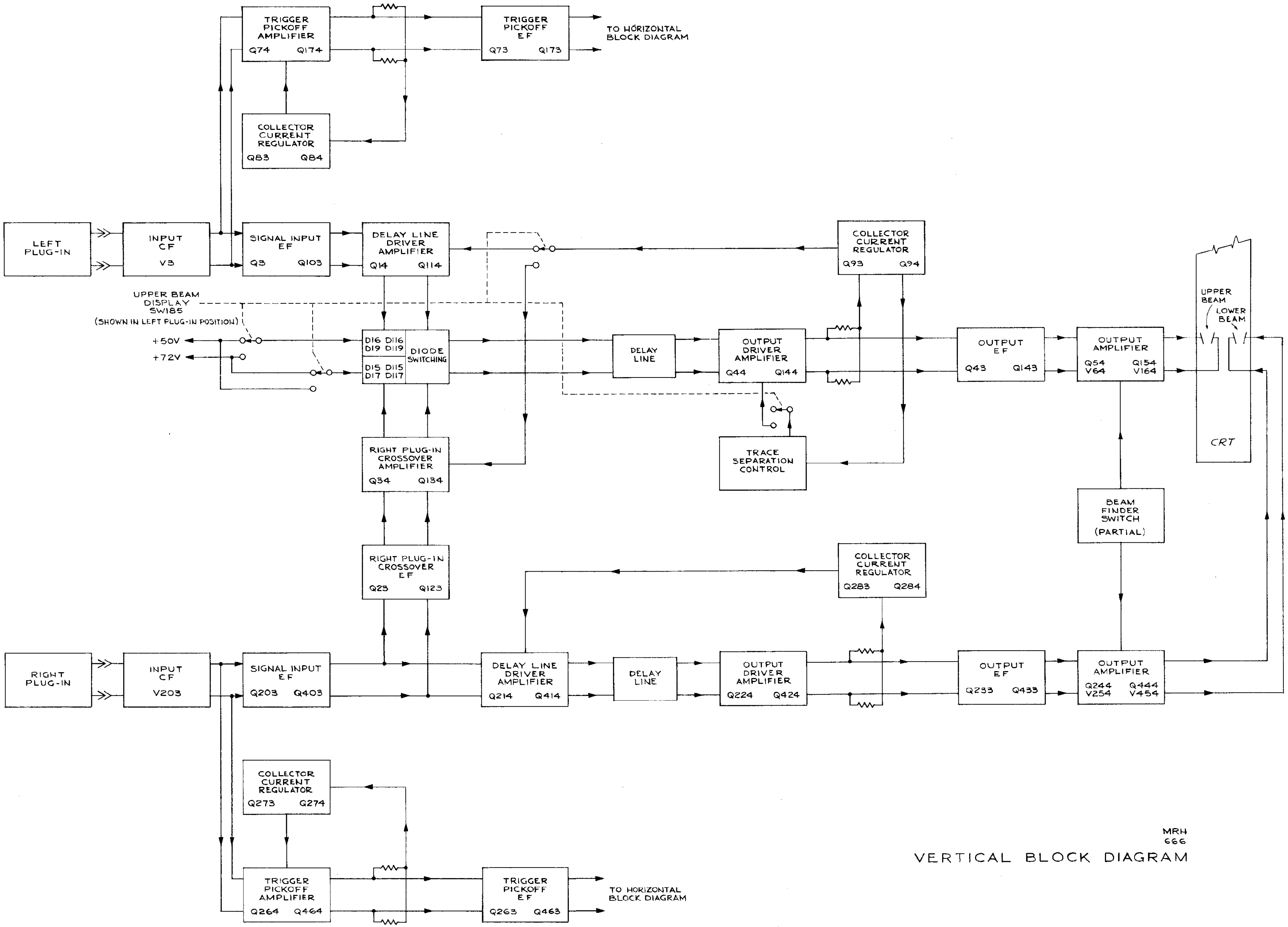
The network consisting of R1622, R1624 and C1624 prevents any ringing on the rising portion of the square wave.

Output Divider Resistors

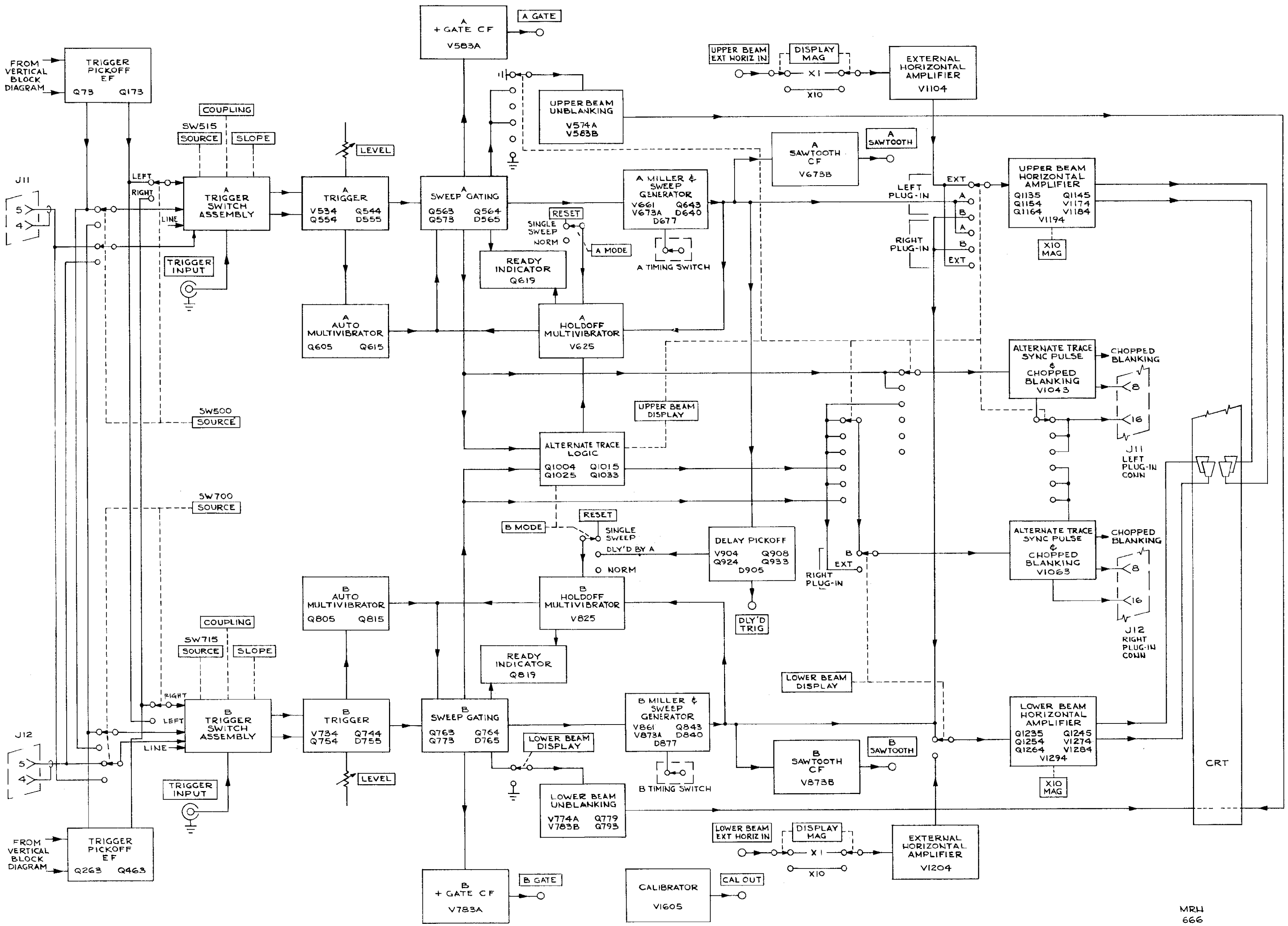
Cathode-follower section V1605C has a precision divider network for its cathode resistor. With the CAL AMPL control properly adjusted so the signal amplitude at the cathode of V1605C is exactly 100 V peak to peak, the divider network accurately divides the basic 100 V square wave to lower amplitudes in multiples of 1, 2 or 5 and provides an accurate 50-ohm output resistance when the AMPLITUDE CALIBRATOR switch is set to .2 VOLTS and below. If the 50-ohm output is terminated into a 50-ohm external load, the peak voltage across the external termination will be one-half that indicated by the switch setting.

The 100 V DC is available for use as a reference when the AMPLITUDE CALIBRATOR switch is set to 100 V DC. If the switch is set to the 5 mA position, an accurate 5 mA square wave is fed through the current loop. The accuracy of this current is established by the accurate 20 kΩ series resistance of divider resistors R1632 through R1640.

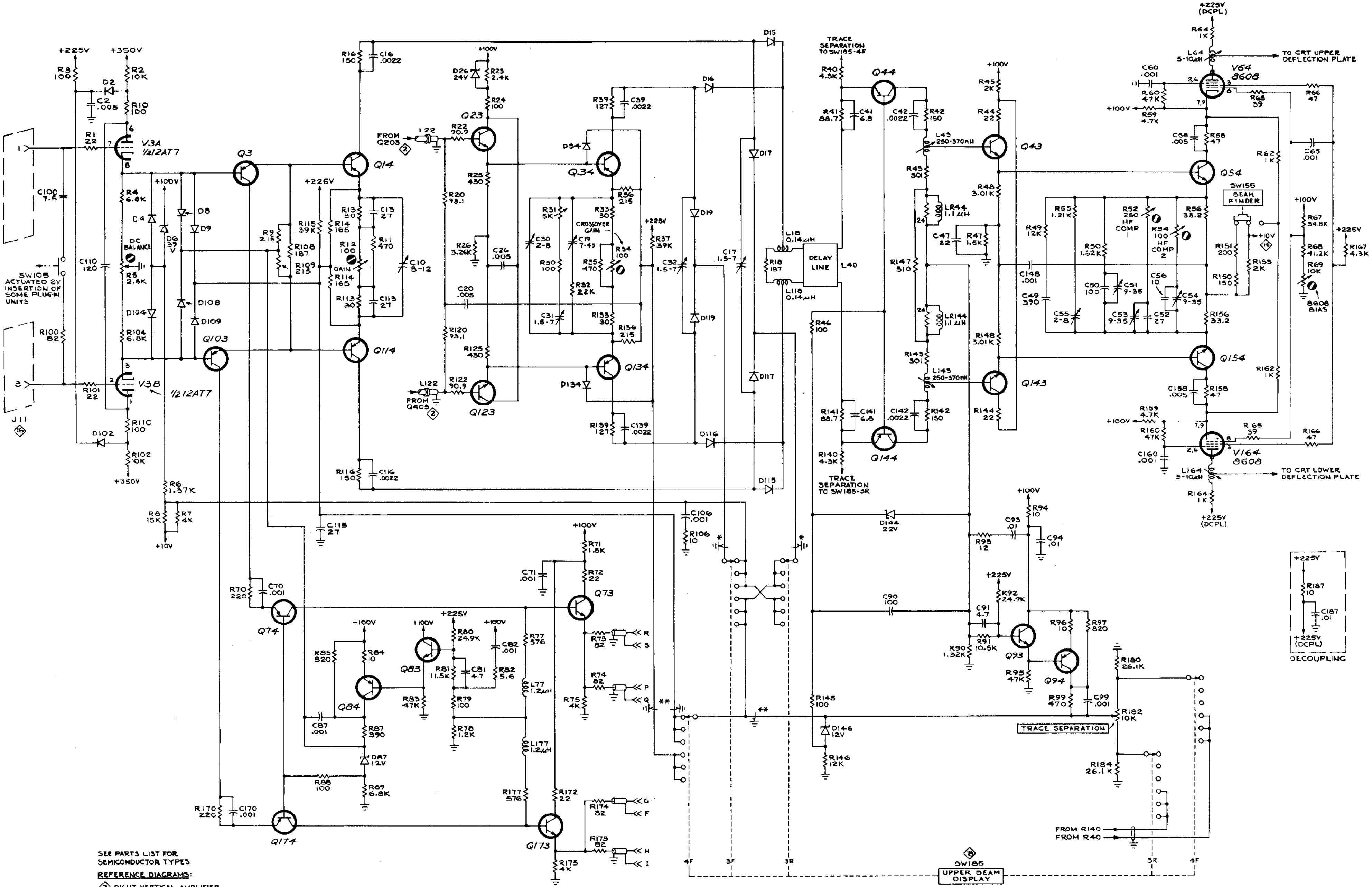
The 0.25 ohm resistor R1654, connected in series with the output divider resistors R1647 and R1650, minimizes possible ground current effects on the calibrator voltage accuracy; i. e., ground currents that may exist between the oscilloscope chassis and the chassis of some other device that is driven by the Amplitude Calibrator.



VERTICAL BLOCK DIAGRAM



HORIZONTAL BLOCK DIAGRAM



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:
- ② RIGHT VERTICAL AMPLIFIER
- ③ A SWEEP TRIGGER
- ⑥ B SWEEP TRIGGER
- ⑭ POWER SUPPLY
- ⑯ PLUG-IN JACK DETAILS
- ⑱ HORIZONTAL DISPLAY & MODE SWITCHING

* TWO WIRE SHIELDED CABLE

** THREE WIRE SHIELDED CABLE

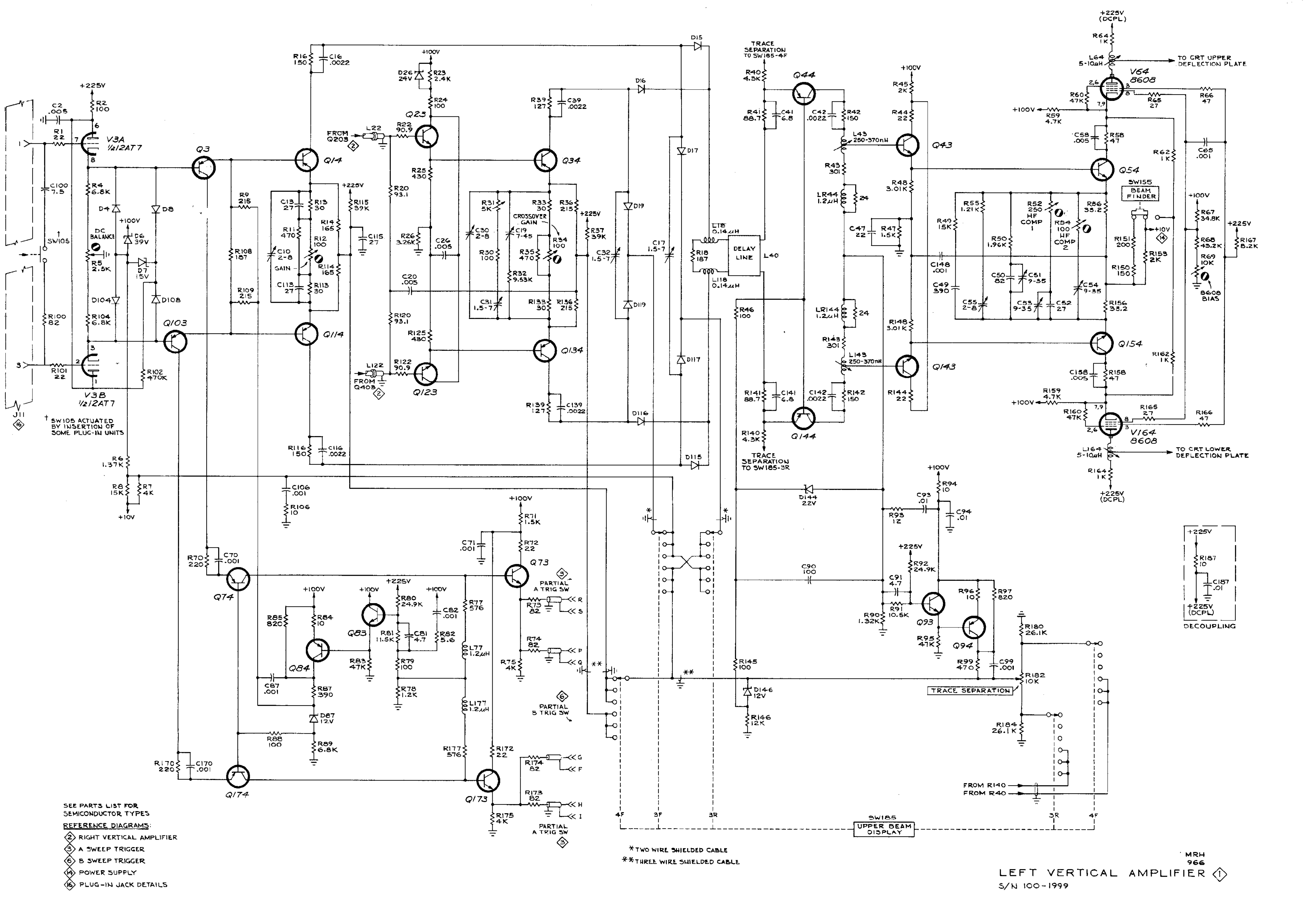
MRH 567

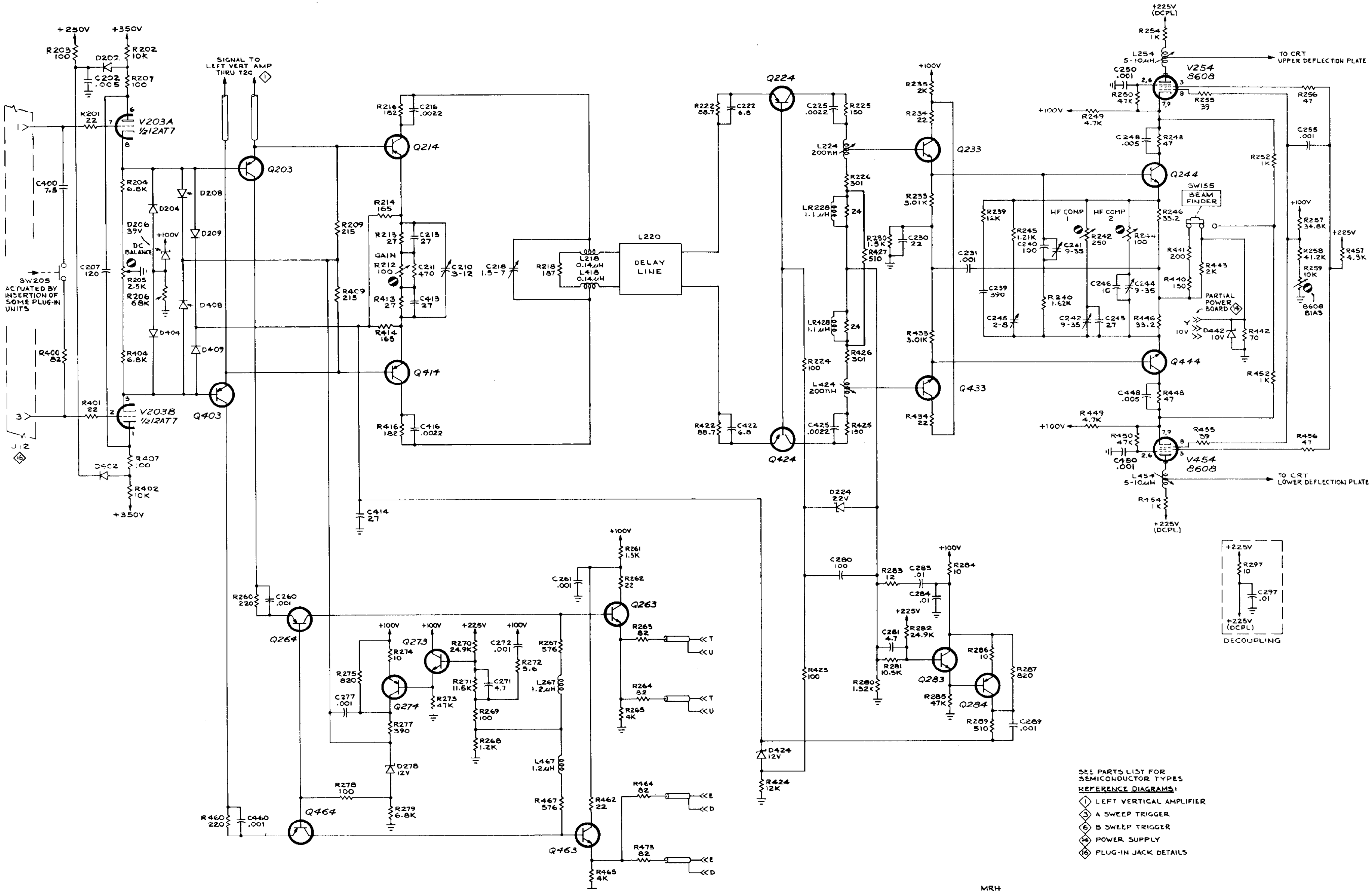
LEFT VERTICAL AMPLIFIER ①

S/N 2000 - UP

TYPE 556 OSCILLOSCOPE

A


SEE PARTS LIST FOR SEMICONDUCTOR TYPES
REFERENCE DIAGRAMS:
2 RIGHT VERTICAL AMPLIFIER
3 A SWEEP TRIGGER
6 B SWEEP TRIGGER
14 POWER SUPPLY
16 PLUG-IN JACK DETAILS
† SW105 ACTUATED BY INSERTION OF SOME PLUG-IN UNITS
* TWO WIRE SHIELDED CABLE
** THREE WIRE SHIELDED CABLE
DECOUPLING
TRACE SEPARATION
SW185 UPPER BEAM DISPLAY
TO CRT UPPER DEFLECTION PLATE
TO CRT LOWER DEFLECTION PLATE
DELAY LINE
MRH 966
LEFT VERTICAL AMPLIFIER 1
S/N 100-1999

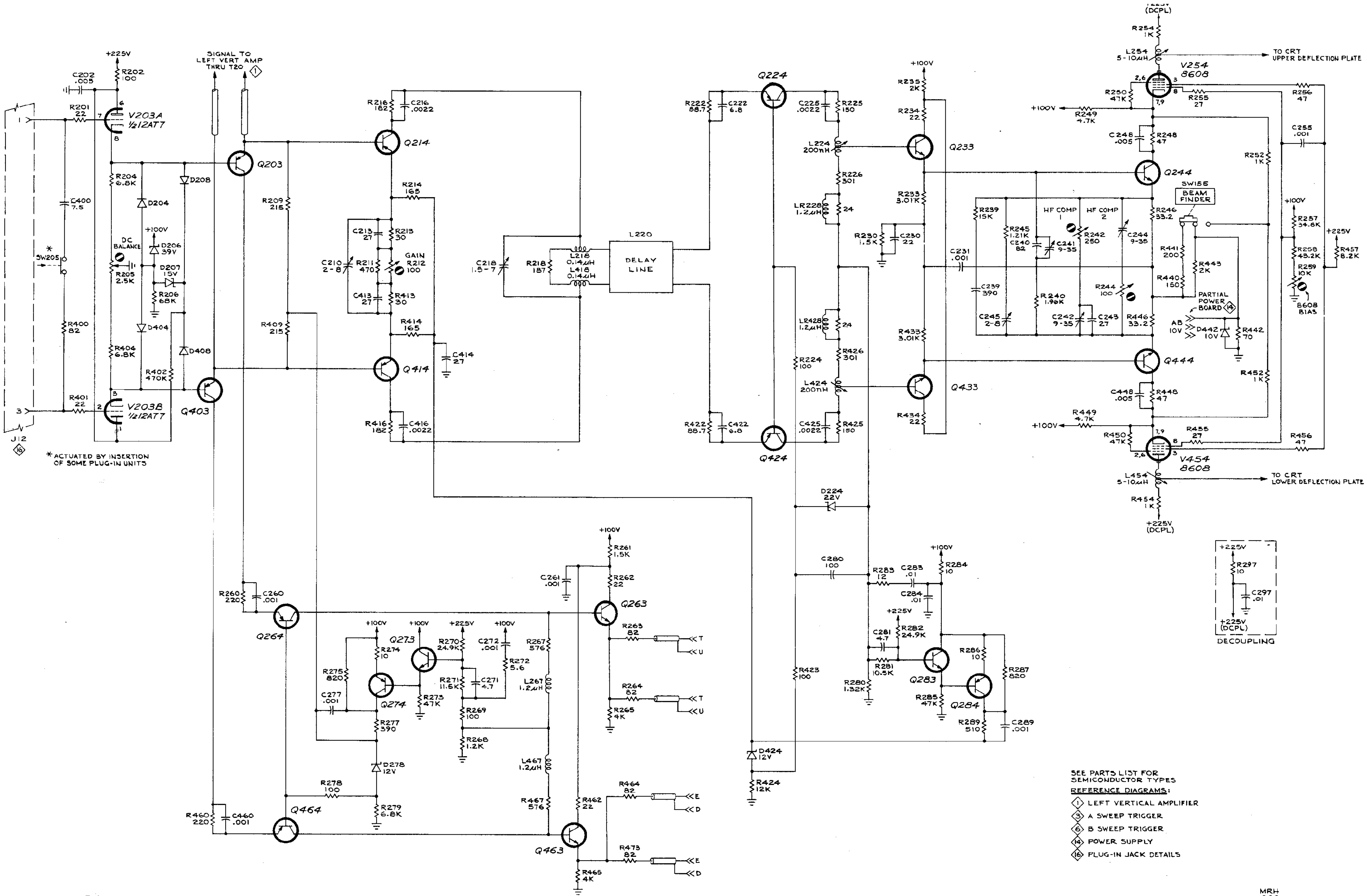


TYPE 556 OSCILLOSCOPE

RIGHT VERTICAL AMPLIFIER ②

S/N 2000 - UP

MRH
867



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

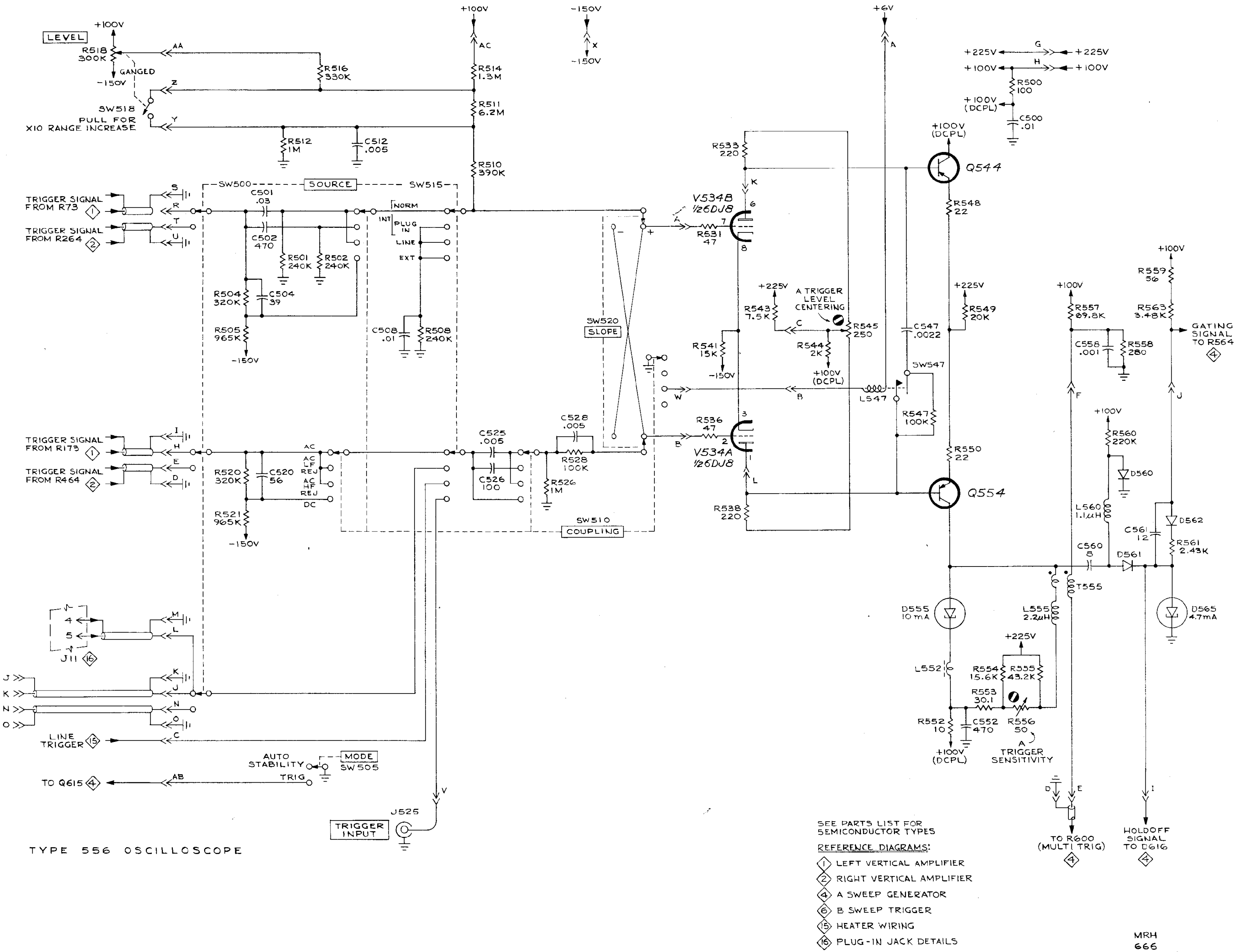
- (1) LEFT VERTICAL AMPLIFIER
- (3) A SWEEP TRIGGER
- (6) B SWEEP TRIGGER
- (14) POWER SUPPLY
- (16) PLUG-IN JACK DETAILS

TYPE 556 OSCILLOSCOPE

MRH 966

RIGHT VERTICAL AMPLIFIER (2)

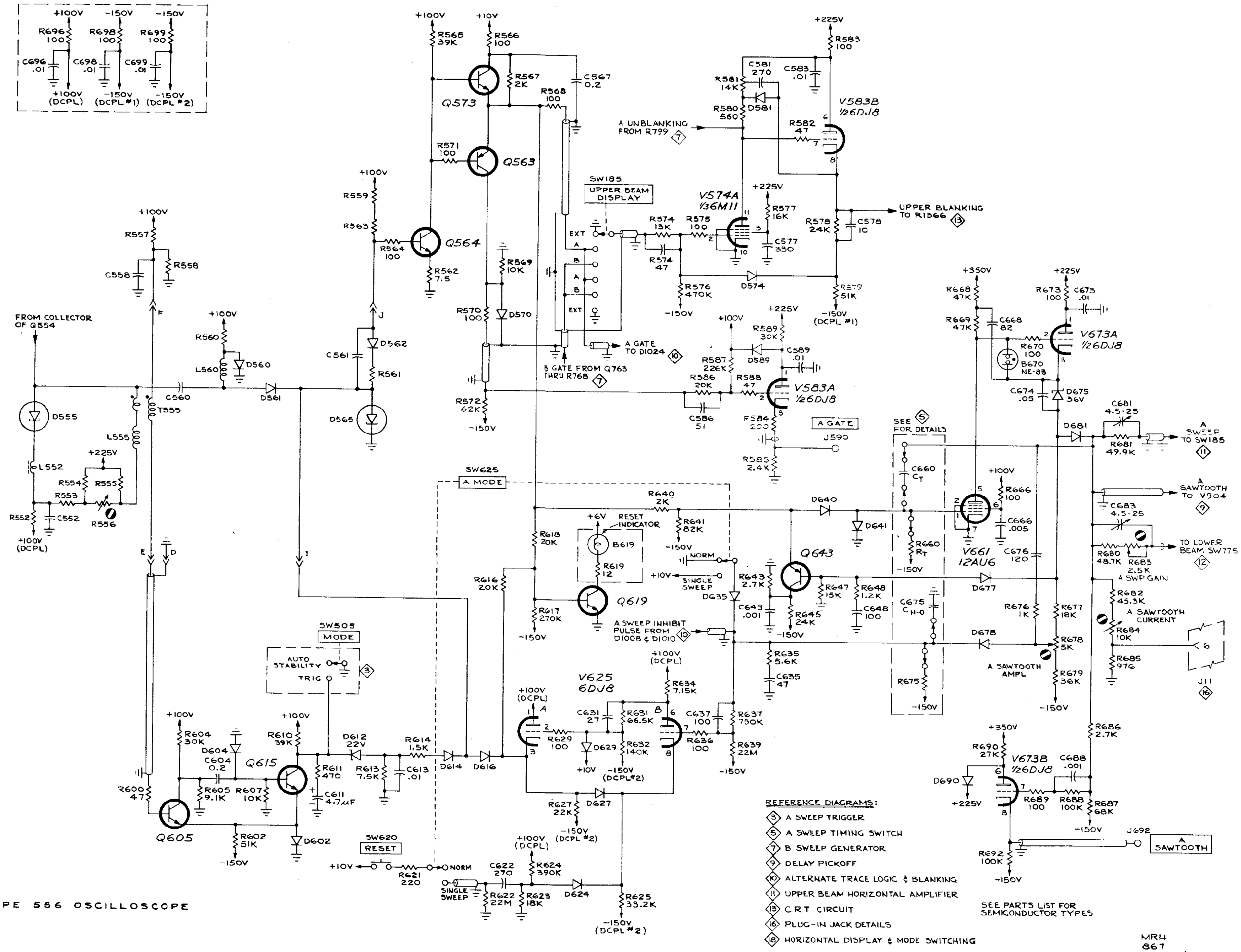
S/N 100-1999



TYPE 556 OSCILLOSCOPE

MRH
666

A SWEEP TRIGGER ③

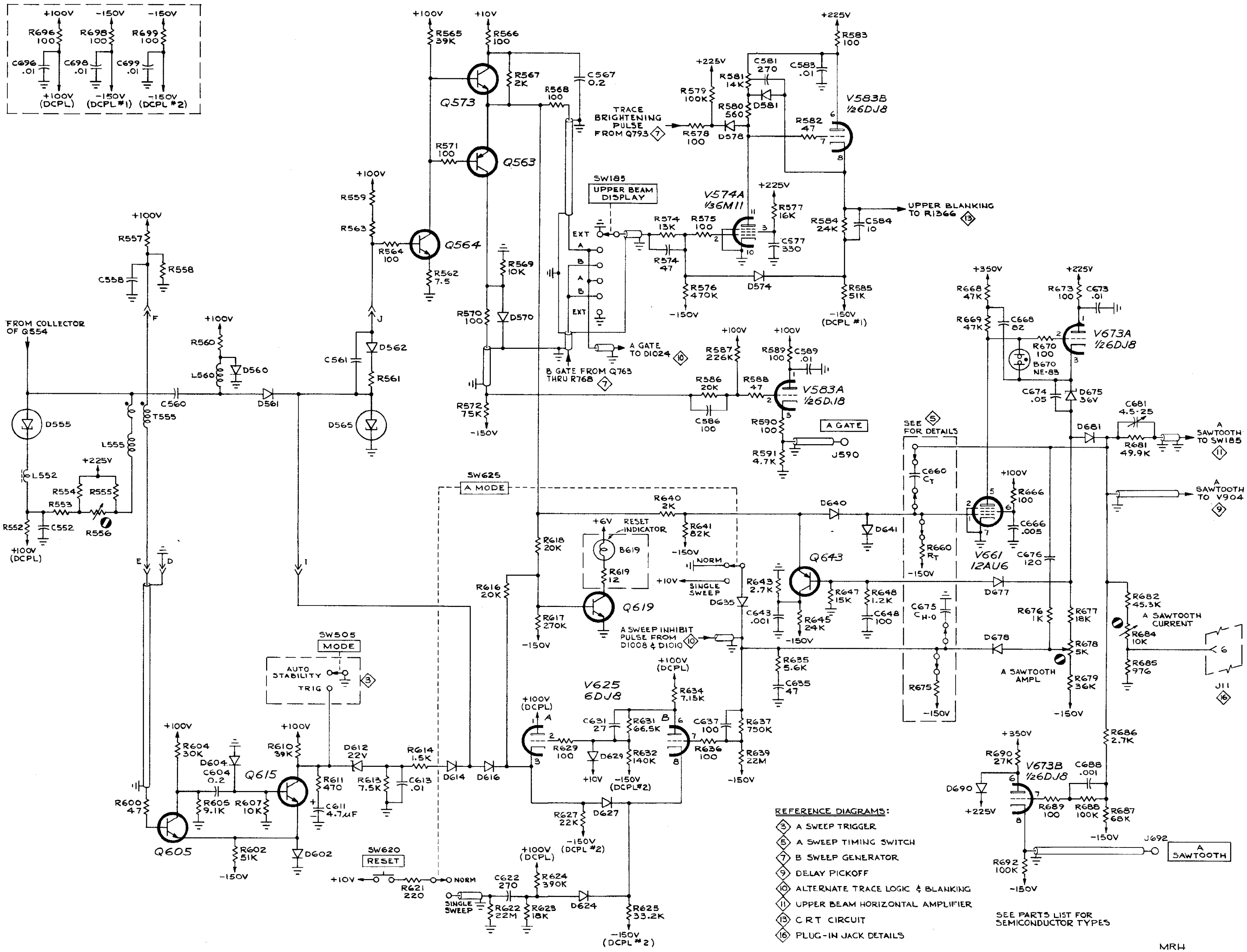


TYPE 556 OSCILLOSCOPE

A

A SWEEP GENERATOR 4

S/N 2000-UP



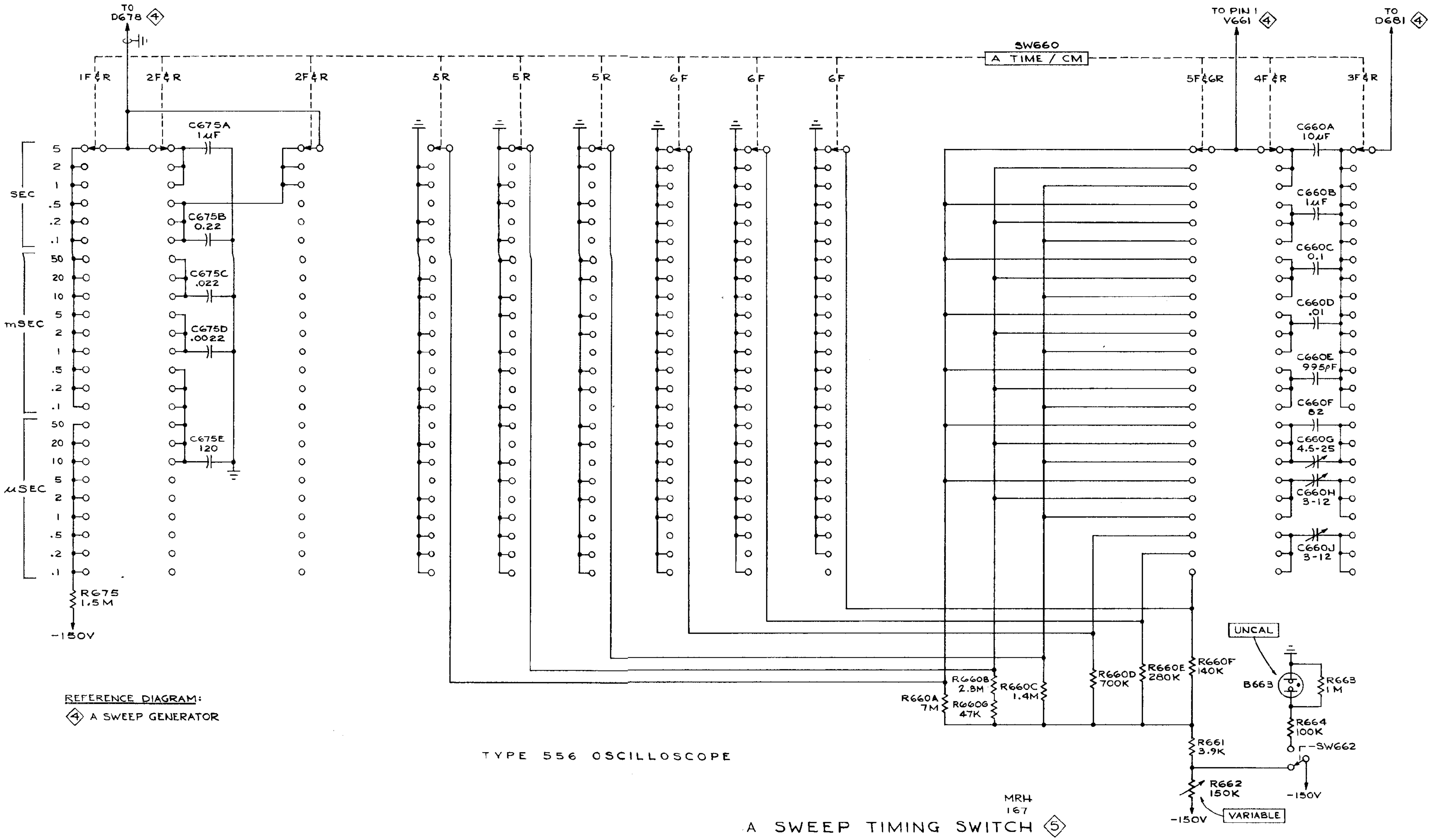
REFERENCE DIAGRAMS:

- 3 A SWEEP TRIGGER
- 5 A SWEEP TIMING SWITCH
- 7 B SWEEP GENERATOR
- 9 DELAY PICKOFF
- 10 ALTERNATE TRACE LOGIC & BLANKING
- 11 UPPER BEAM HORIZONTAL AMPLIFIER
- 13 CRT CIRCUIT
- 16 PLUG-IN JACK DETAILS

MRH
666

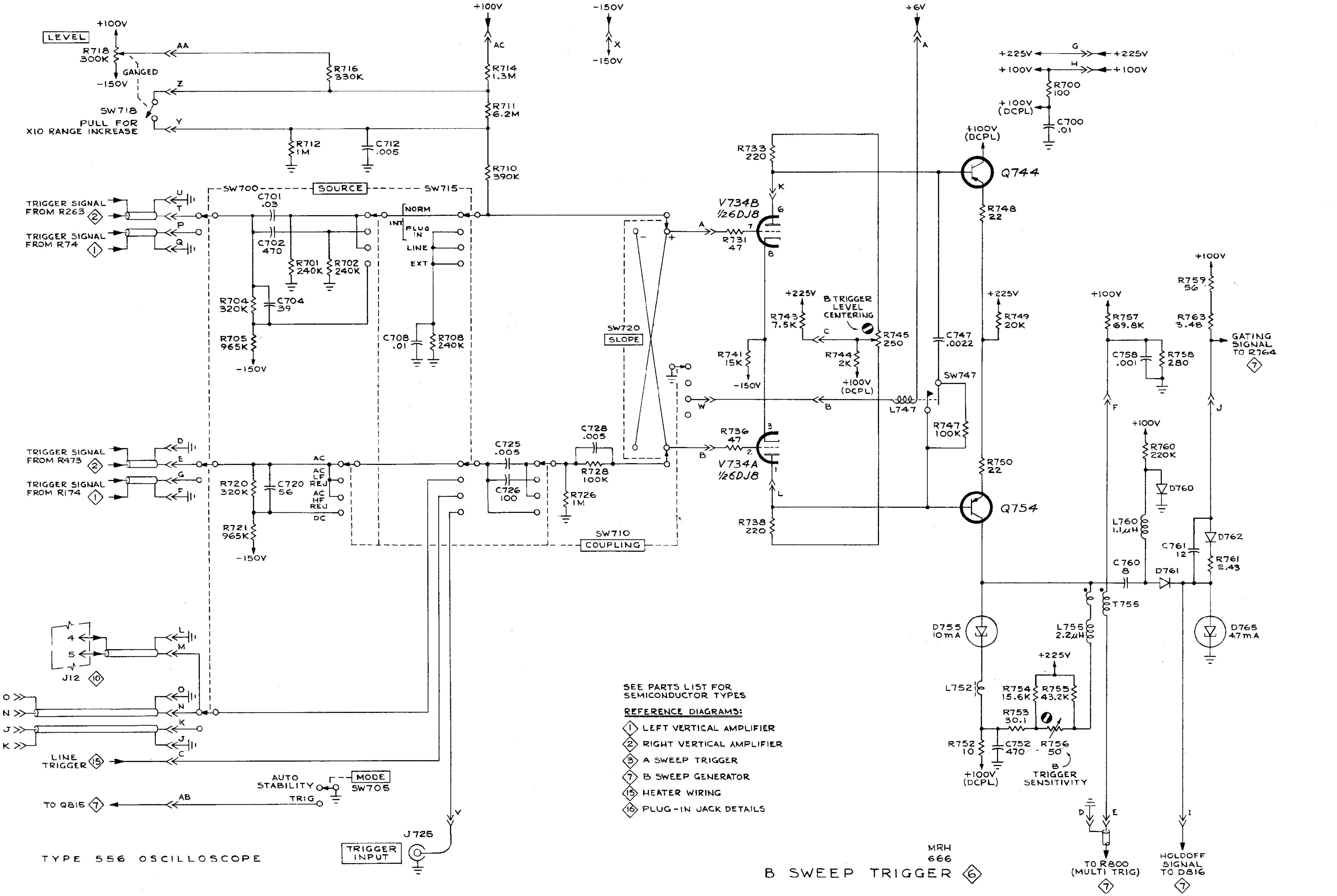
A SWEEP GENERATOR 4

S/N 100-1999



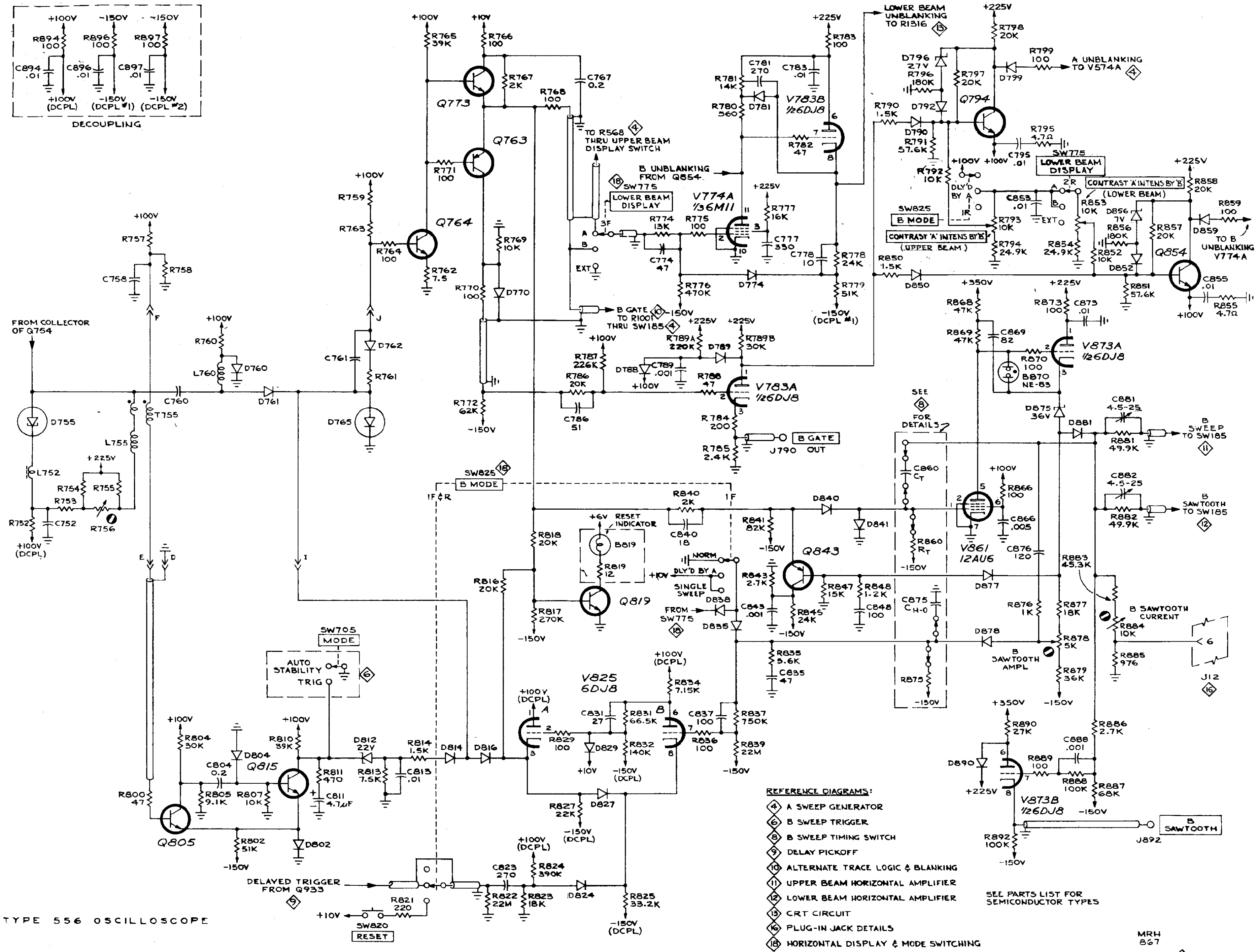
TYPE 556 OSCILLOSCOPE

A SWEEP TIMING SWITCH ⑤



TYPE 556 OSCILLOSCOPE

B SWEEP TRIGGER 6

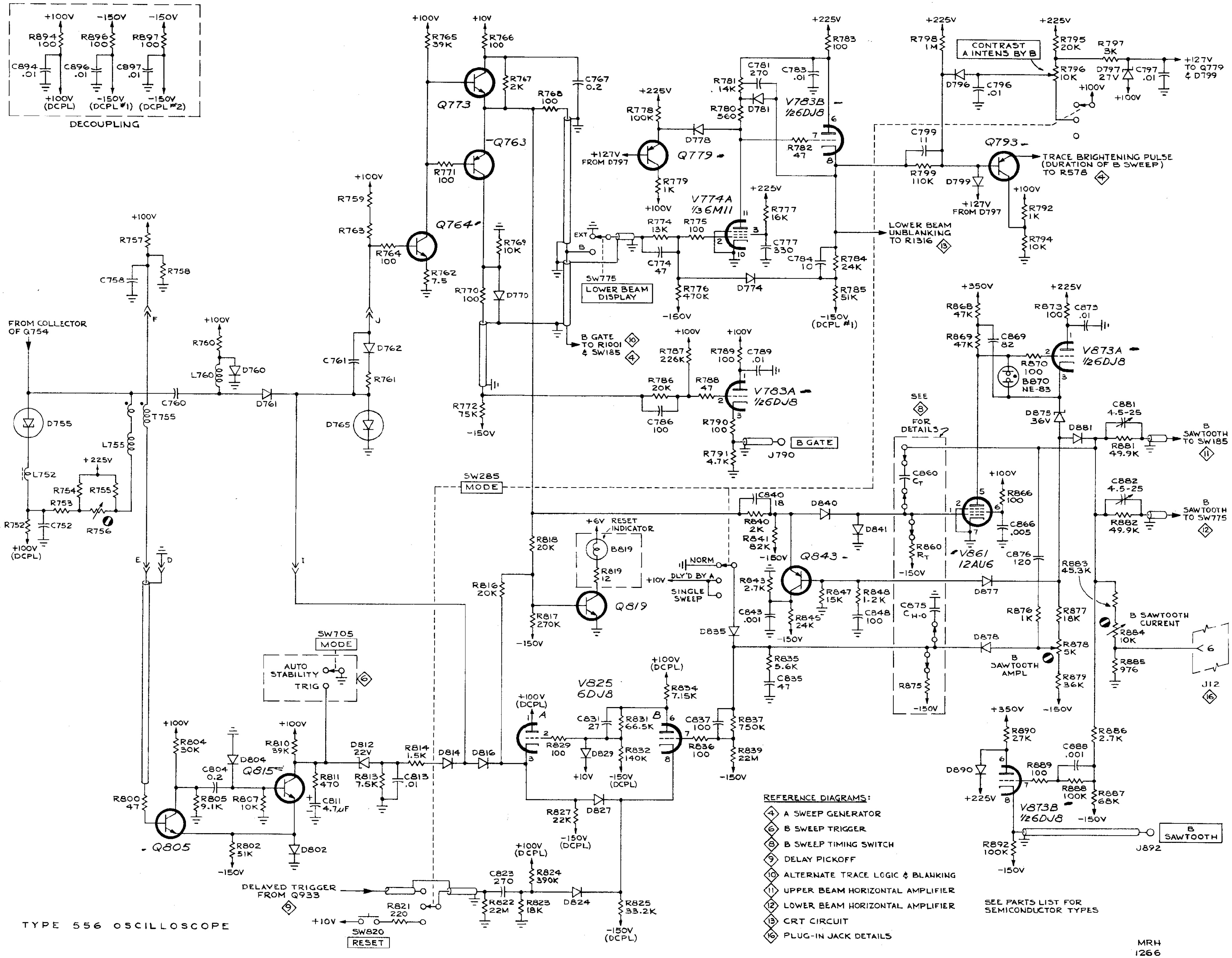


TYPE 556 OSCILLOSCOPE

A

B SWEEP GENERATOR 7

S/N 2000-UP



REFERENCE DIAGRAMS:
- ④ A SWEEP GENERATOR
- ⑥ B SWEEP TRIGGER
- ⑧ B SWEEP TIMING SWITCH
- ⑨ DELAY PICKOFF
- ⑩ ALTERNATE TRACE LOGIC & BLANKING
- ⑪ UPPER BEAM HORIZONTAL AMPLIFIER
- ⑫ LOWER BEAM HORIZONTAL AMPLIFIER
- ⑬ CRT CIRCUIT
- ⑯ PLUG-IN JACK DETAILS

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

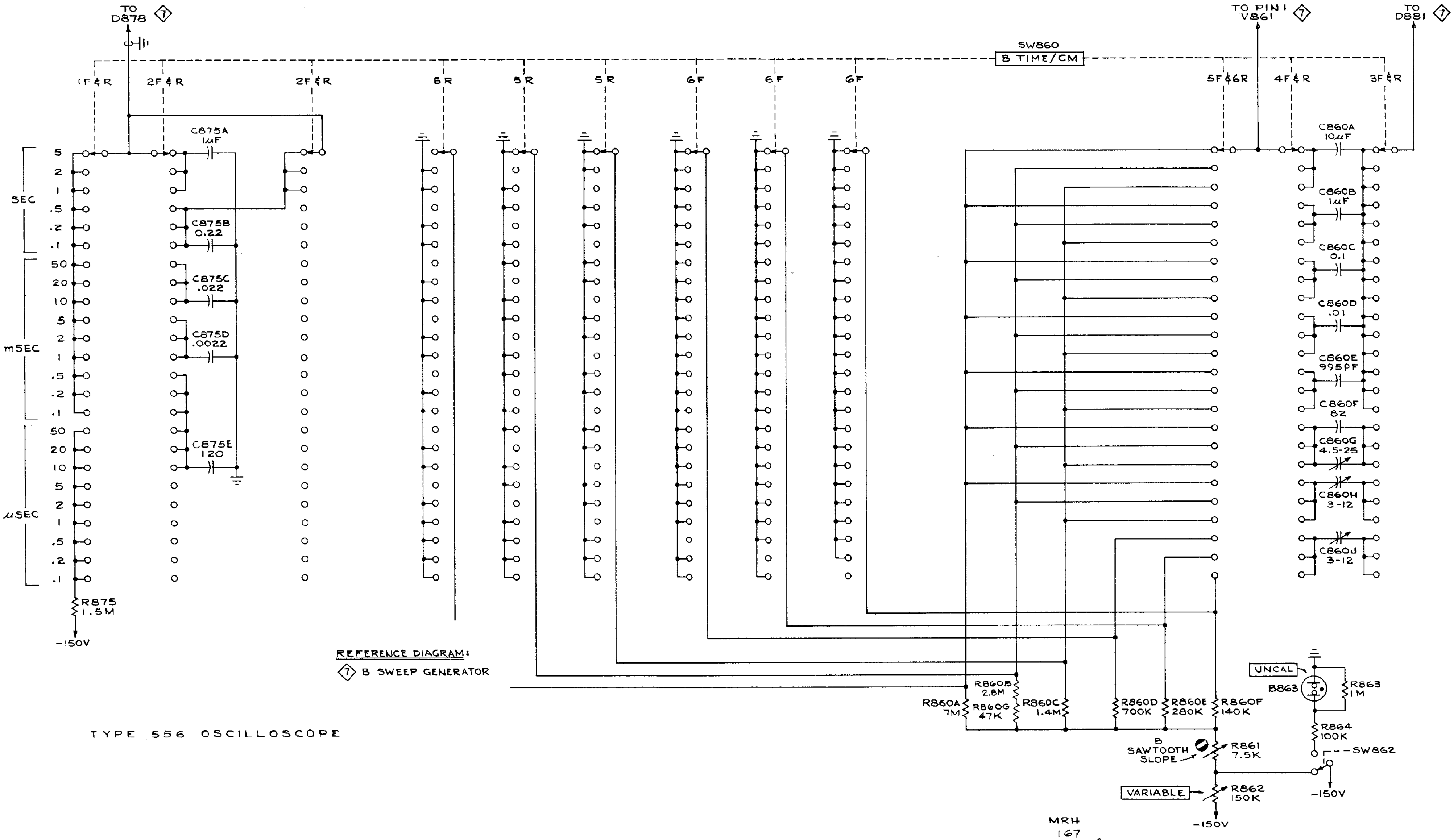
TYPE 556 OSCILLOSCOPE

MRH
1266

B SWEEP GENERATOR ⑦

S/N 100-1999

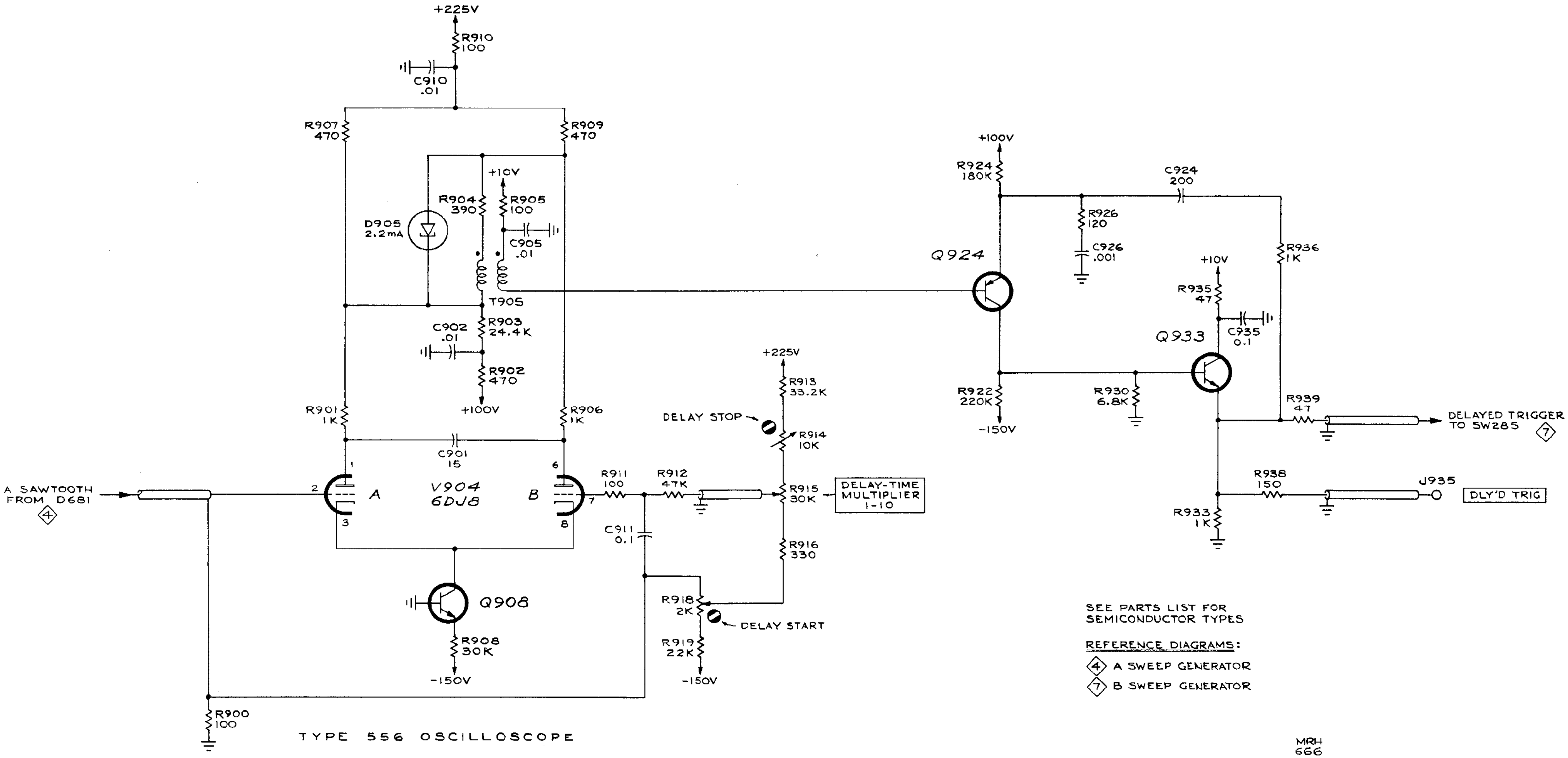
c



REFERENCE DIAGRAM:
7 B SWEEP GENERATOR

TYPE 556 OSCILLOSCOPE

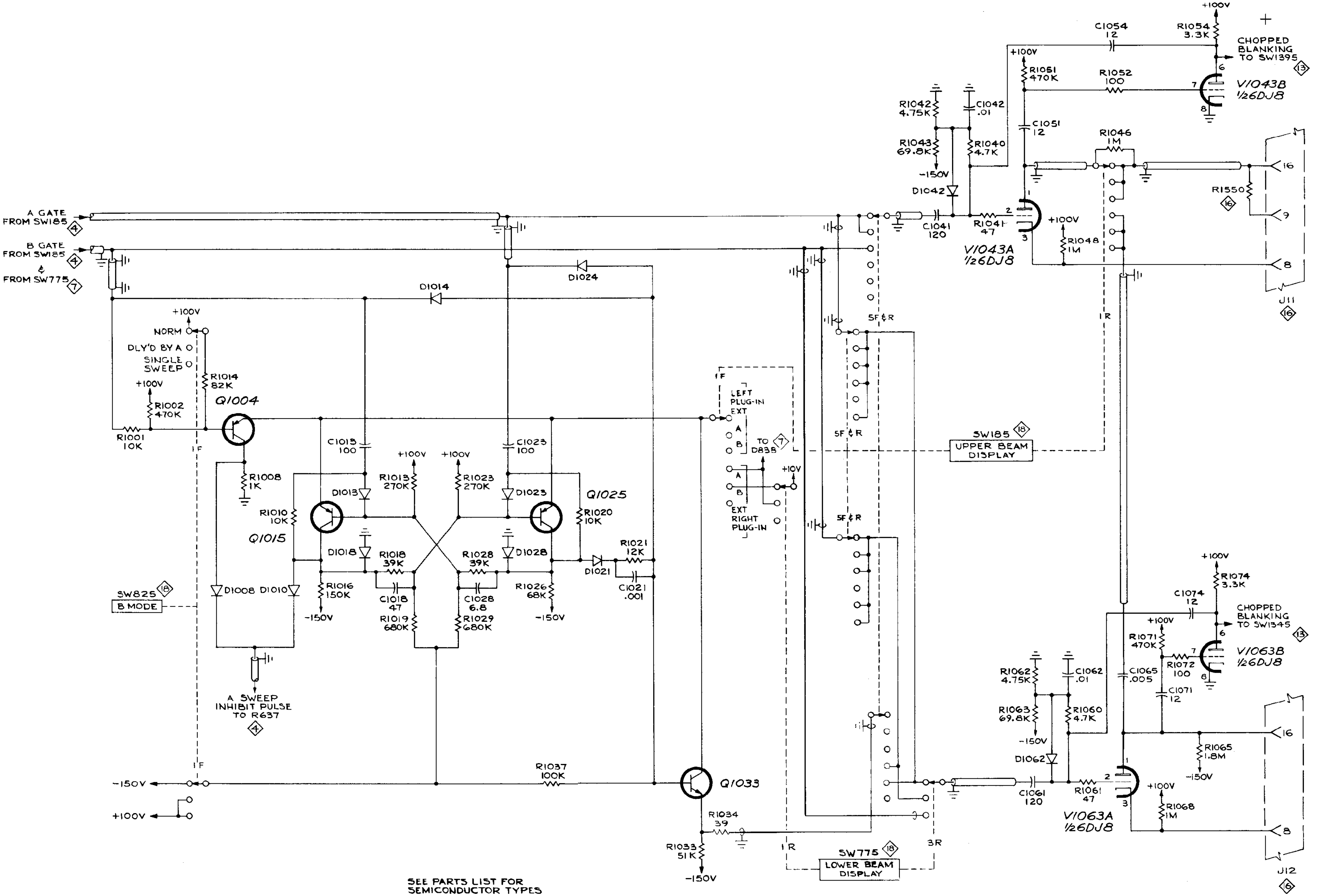
B SWEEP TIMING SWITCH 8



TYPE 556 OSCILLOSCOPE

MRH
666

DELAY PICKOFF 9



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

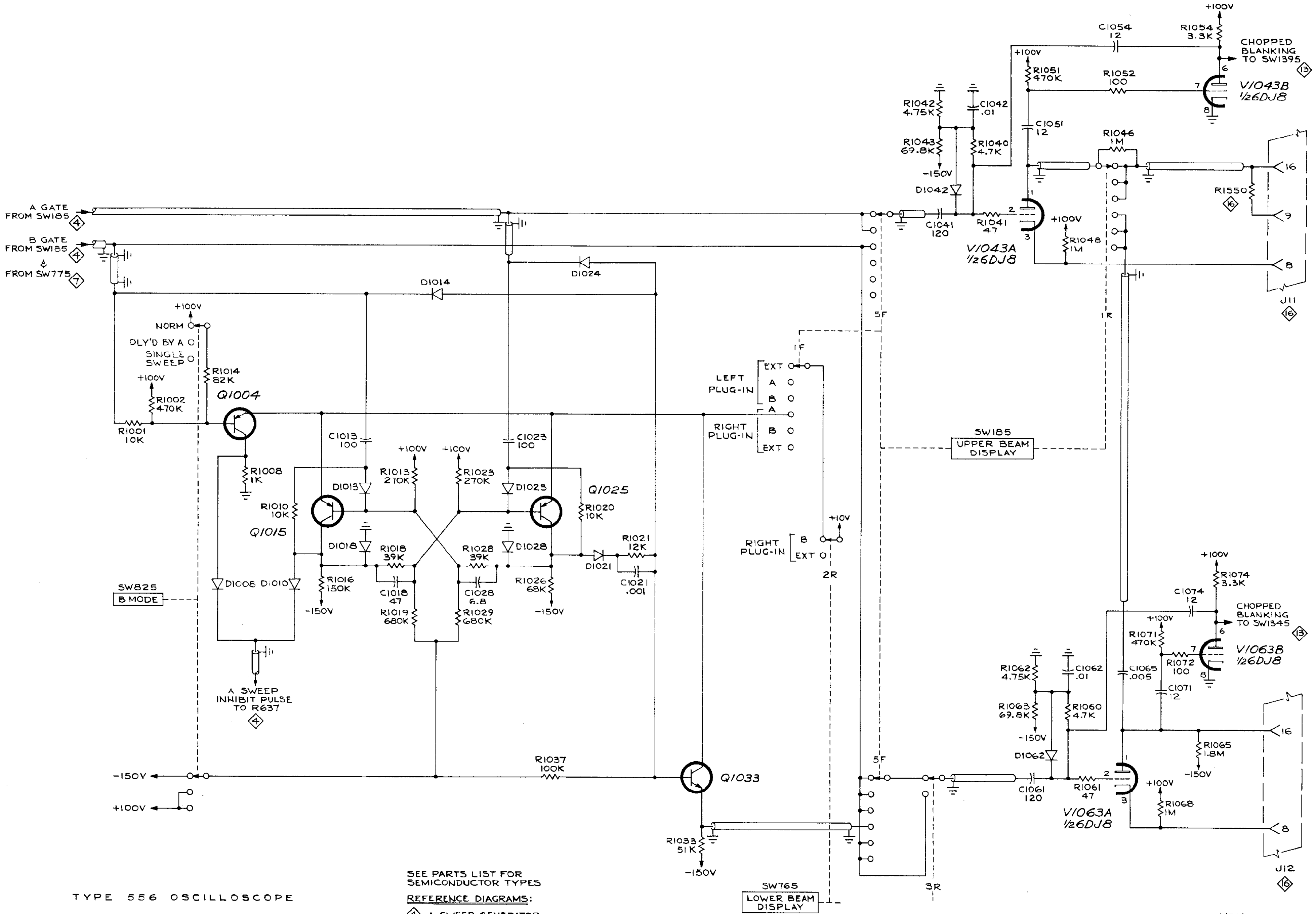
- 4 A SWEEP GENERATOR
- 7 B SWEEP GENERATOR
- 13 CRT CIRCUIT
- 16 PLUG-IN JACK DETAILS
- 18 HORIZONTAL DISPLAY & MODE SWITCHING

TYPE 556 OSCILLOSCOPE

MRH 367

ALTERNATE TRACE LOGIC & BLANKING 10

S/N 2000-UP



TYPE 556 OSCILLOSCOPE

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

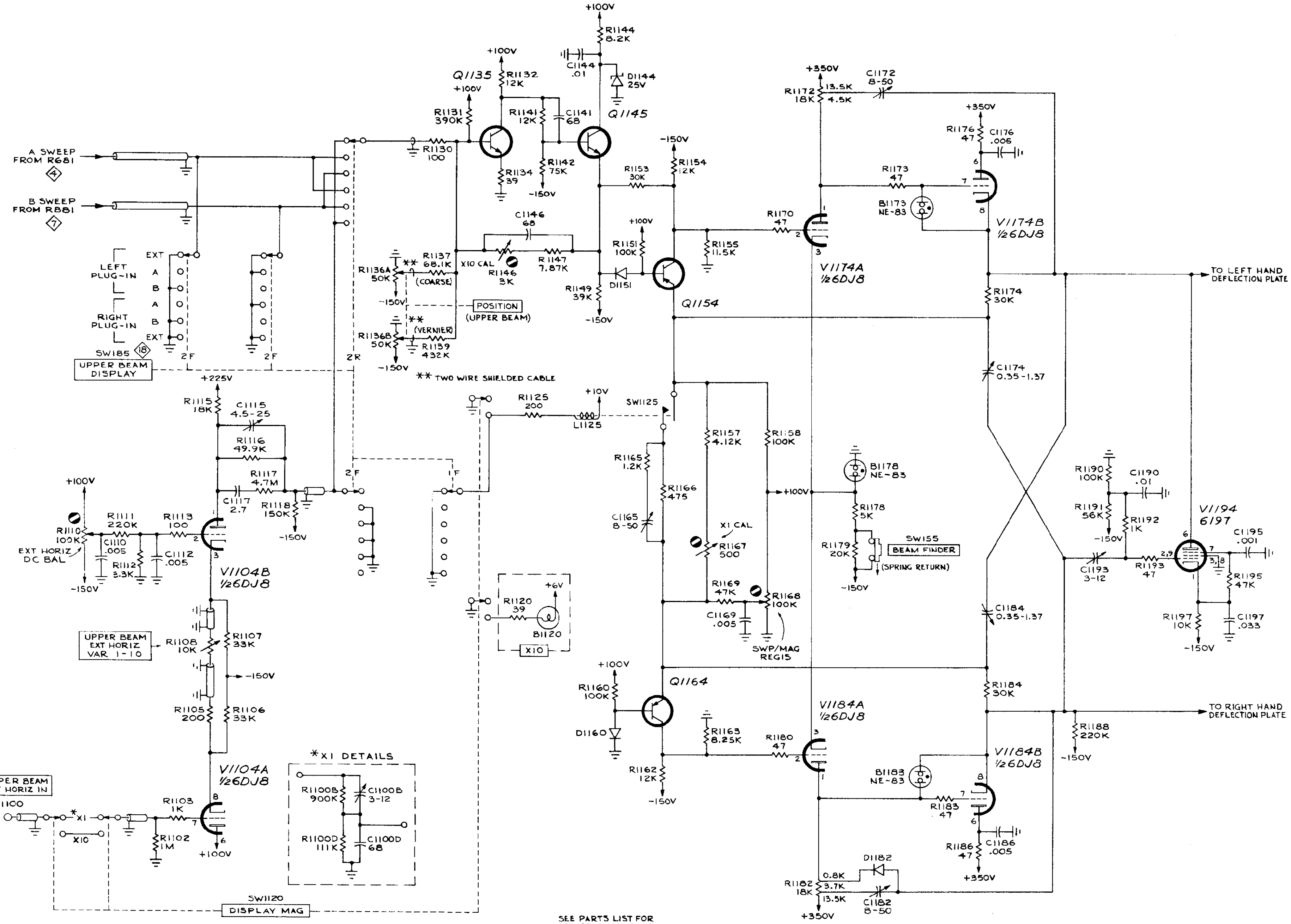
REFERENCE DIAGRAMS:

- 4 A SWEEP GENERATOR
- 7 B SWEEP GENERATOR
- 13 CRT CIRCUIT
- 16 PLUG-IN JACK DETAILS

MRH 666

ALTERNATE TRACE LOGIC & BLANKING 10

S/N 100-1999



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

4 A SWEEP GENERATOR

7 B SWEEP GENERATOR

18 HORIZONTAL DISPLAY & MODE SWITCHING

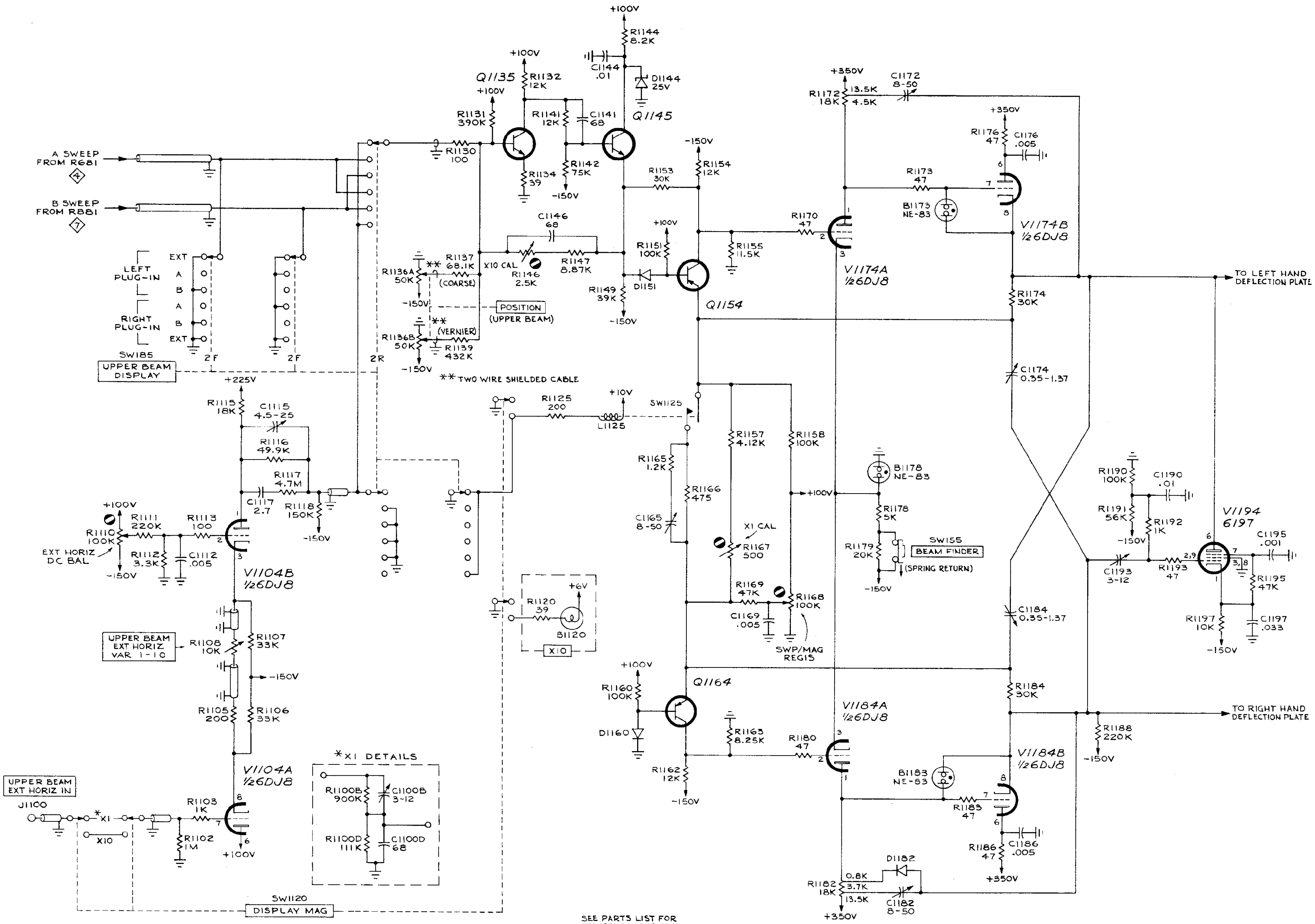
TYPE 556 OSCILLOSCOPE

MRH 867

A

UPPER BEAM HORIZONTAL AMPLIFIER 11

S/N 2000-UP



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

(4) A SWEEP GENERATOR

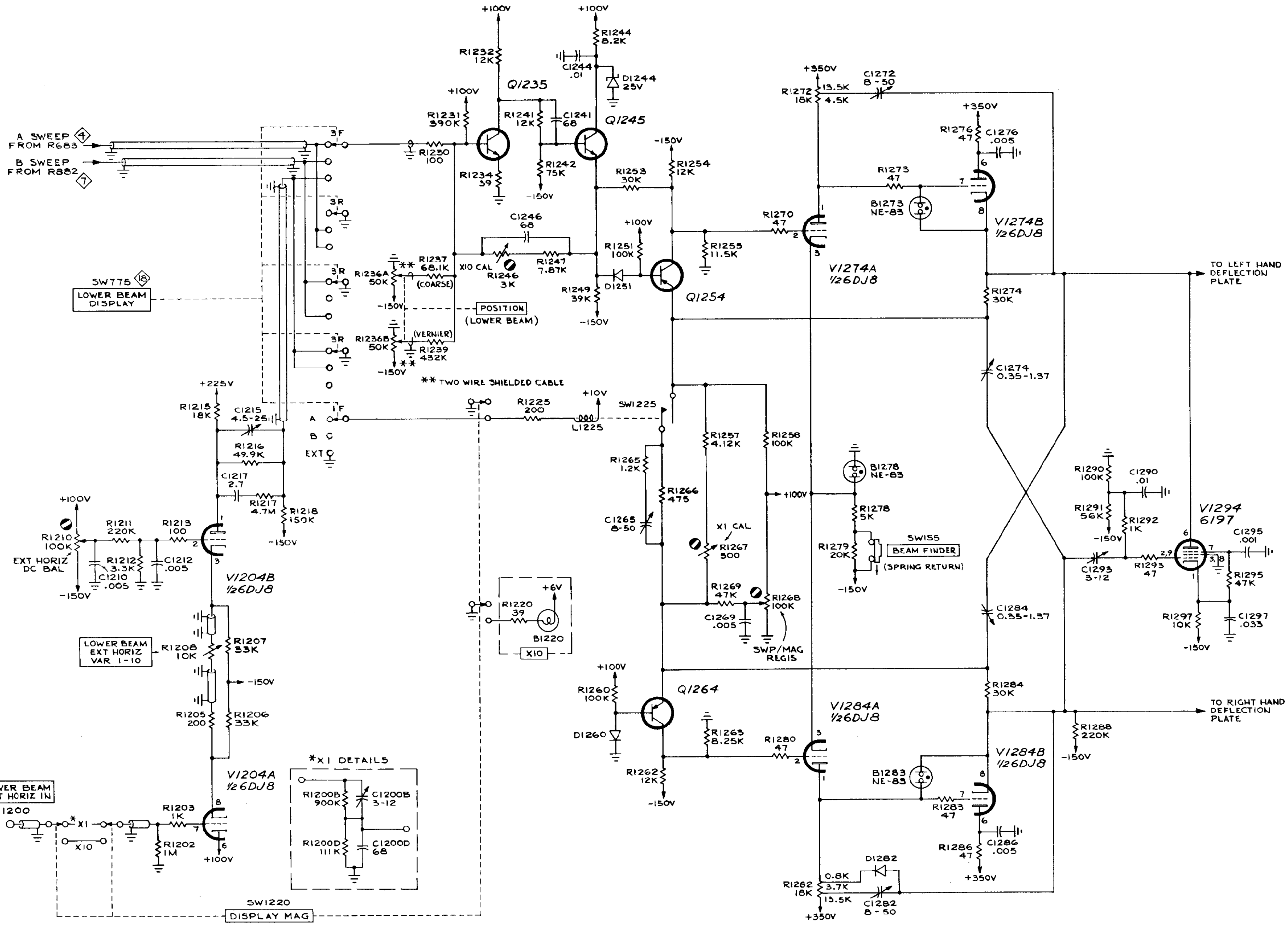
(7) B SWEEP GENERATOR

MRH
666

TYPE 556 OSCILLOSCOPE

UPPER BEAM HORIZONTAL AMPLIFIER (11)

S/N 100-1999



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAM:

7 B SWEEP GENERATOR

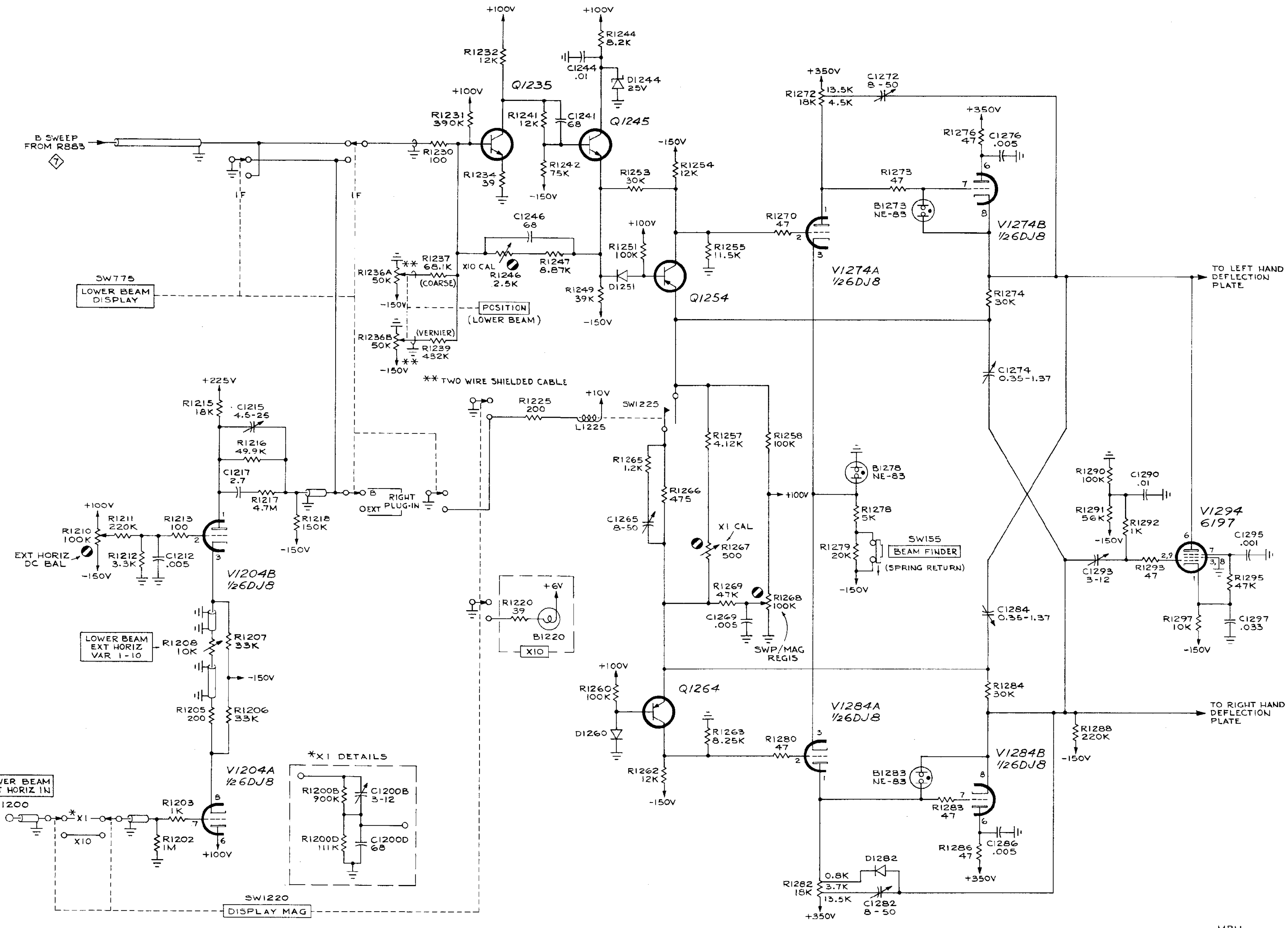
MRH
867

TYPE 556 OSCILLOSCOPE

LOWER BEAM HORIZONTAL AMPLIFIER 12

S/N 2000-UP

A



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAM:

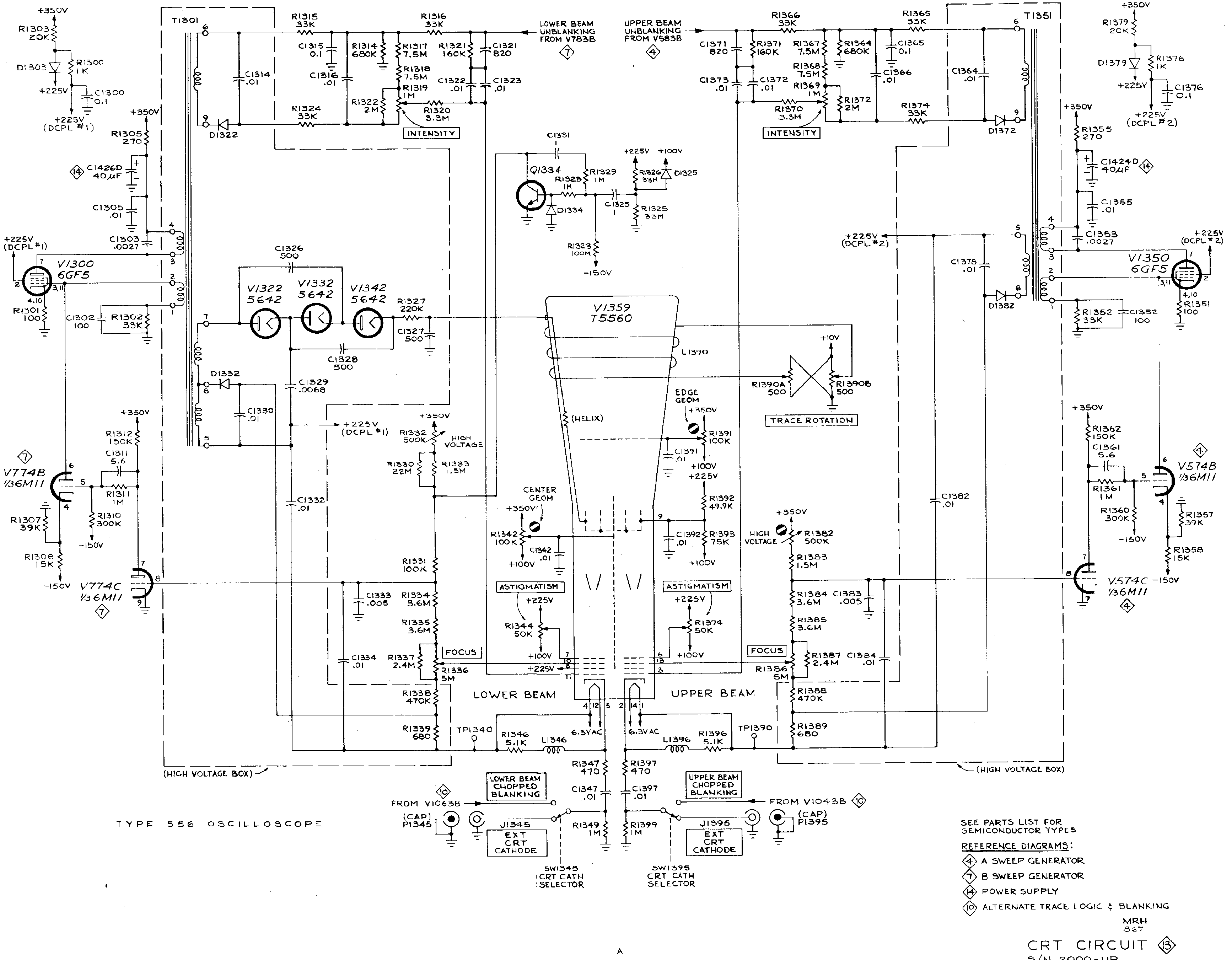
7 B SWEEP GENERATOR

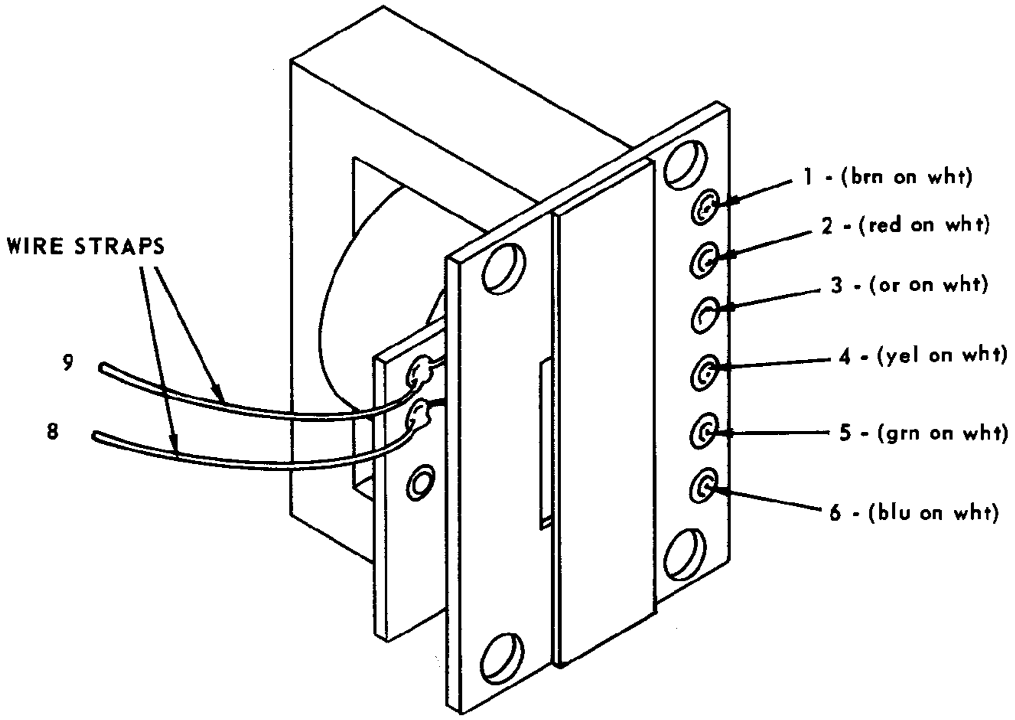
MRH 666

TYPE 556 OSCILLOSCOPE

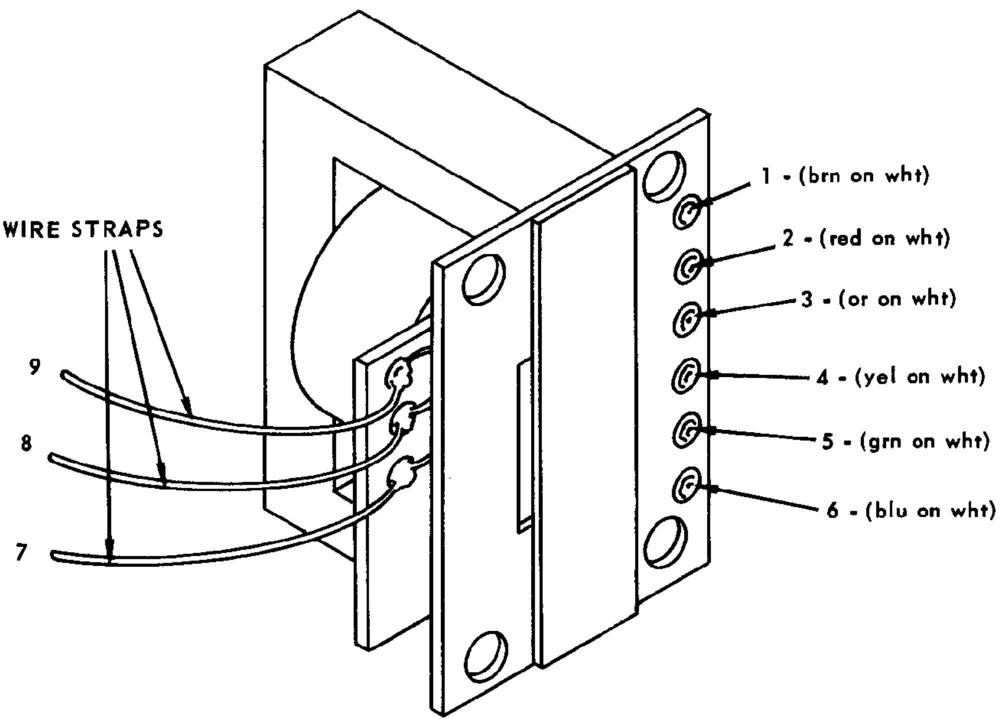
LOWER BEAM HORIZONTAL AMPLIFIER 12

S/N 100-1999

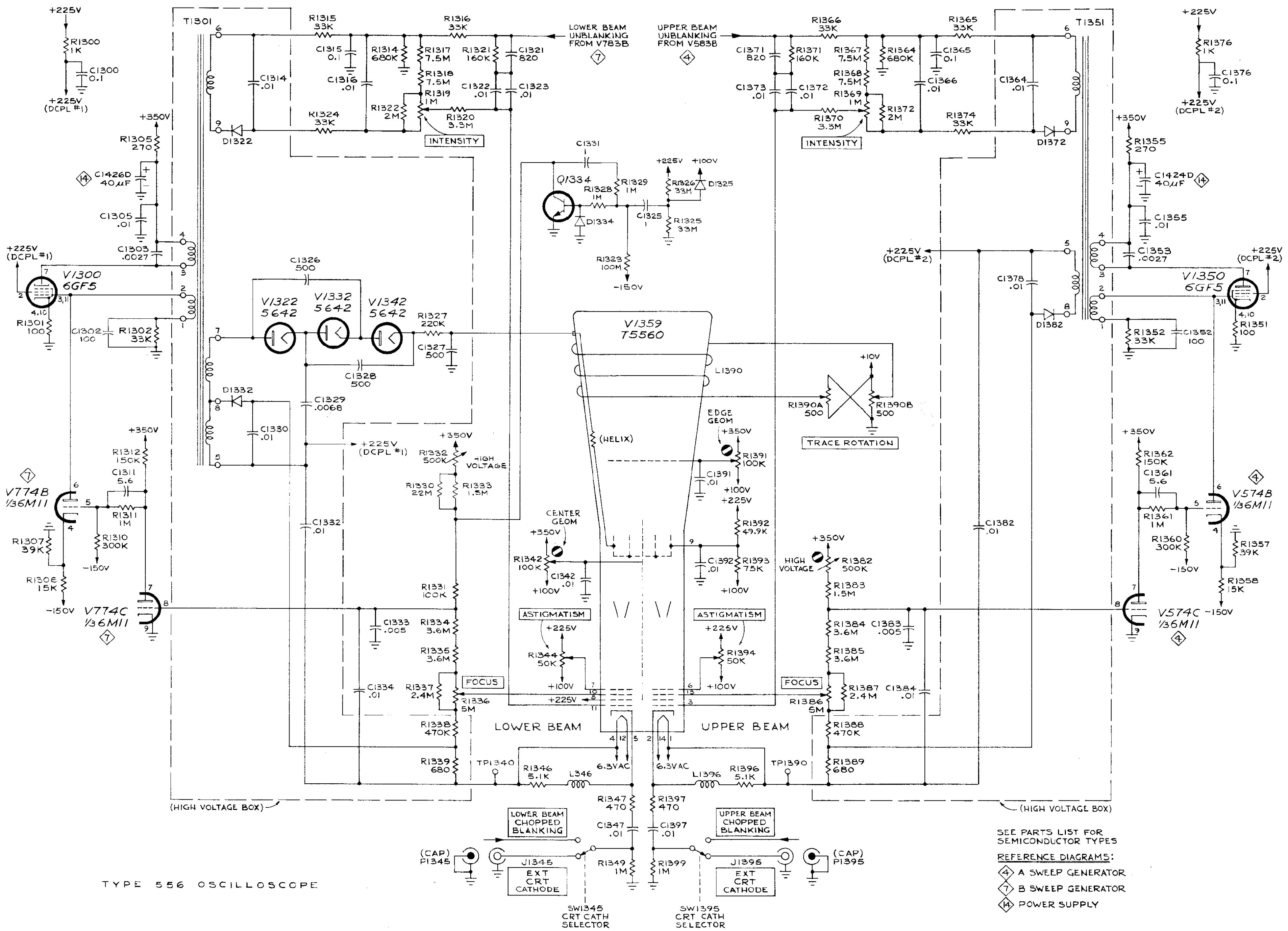

TYPE 556 OSCILLOSCOPE
T1301
T1351
LOWER BEAM UNBLANKING FROM V783B
UPPER BEAM UNBLANKING FROM V583B
INTENSITY
INTENSITY
V1300 6GF5
V1350 6GF5
V1322 5642
V1332 5642
V1342 5642
V1359 T5560
Q1334
L1390
(HELIX)
TRACE ROTATION
EDGE GEOM
CENTER GEOM
HIGH VOLTAGE
ASTIGMATISM
ASTIGMATISM
FOCUS
FOCUS
LOWER BEAM
UPPER BEAM
V774B 1/3 6M11
V774C 1/3 6M11
V574B 1/3 6M11
V574C 1/3 6M11
(HIGH VOLTAGE BOX)
(HIGH VOLTAGE BOX)
TP1340
TP1390
6.3VAC
6.3VAC
LOWER BEAM CHOPPED BLANKING
UPPER BEAM CHOPPED BLANKING
FROM V1063B
FROM V1043B
(CAP) P1345
(CAP) P1395
J1345 EXT CRT CATHODE
J1395 EXT CRT CATHODE
SW1345 CRT CATH SELECTOR
SW1395 CRT CATH SELECTOR
+225V (DCPL #1)
+225V (DCPL #2)
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
REFERENCE DIAGRAMS:
4 A SWEEP GENERATOR
7 B SWEEP GENERATOR
14 POWER SUPPLY
10 ALTERNATE TRACE LOGIC & BLANKING
MRH 867
CRT CIRCUIT 13
A



T1351
(Upper Beam)
TRANSFORMER DETAILS



T1301
(Lower Beam)
TRANSFORMER DETAILS



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

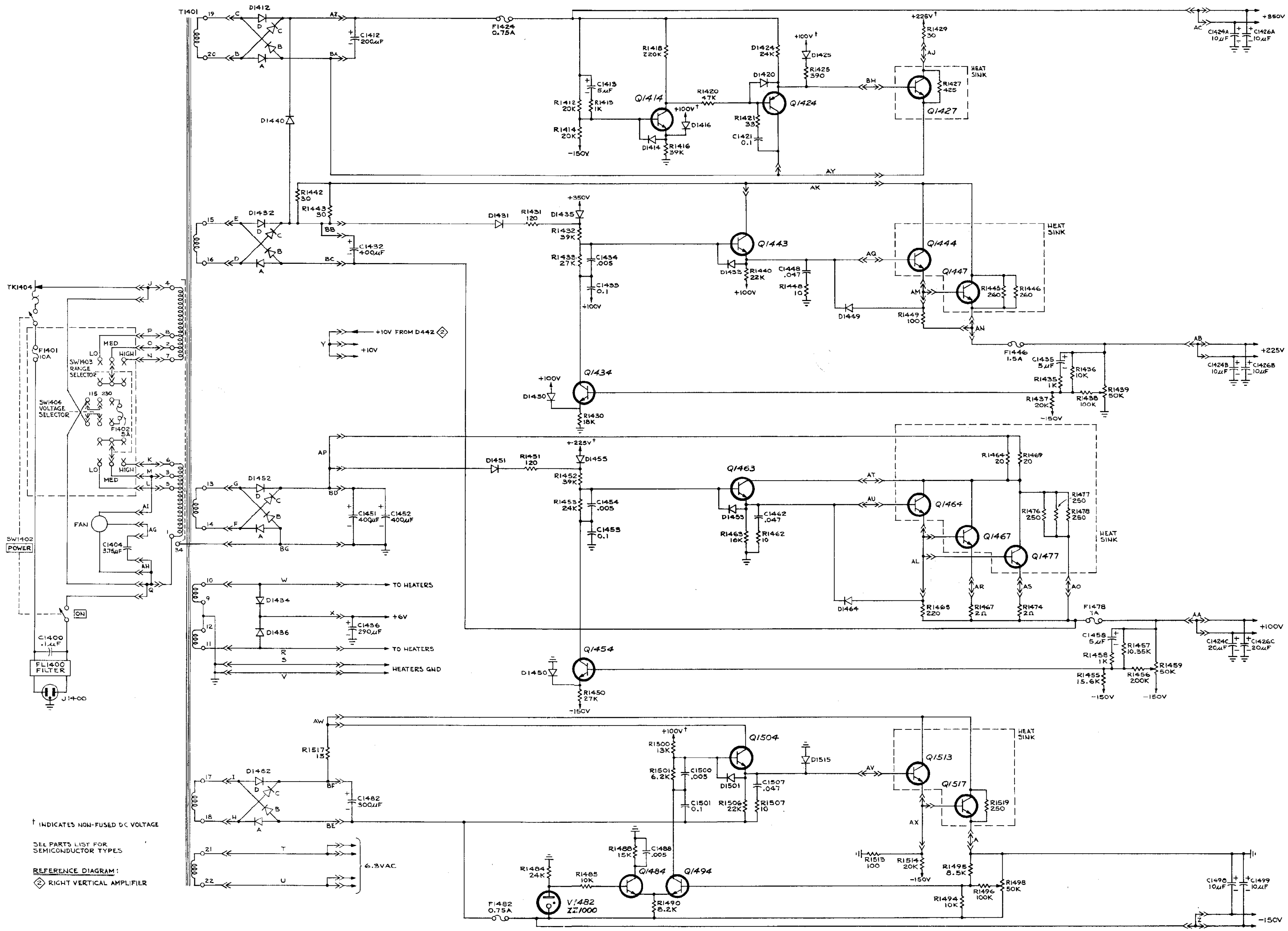
REFERENCE DIAGRAMS:

- ④ A SWEEP GENERATOR
- ⑦ B SWEEP GENERATOR
- ⑭ POWER SUPPLY

TYPE 556 OSCILLOSCOPE

MRH
966

CRT CIRCUIT ⑬
S/N 100-1999



† INDICATES NON-FUSED DC VOLTAGE

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

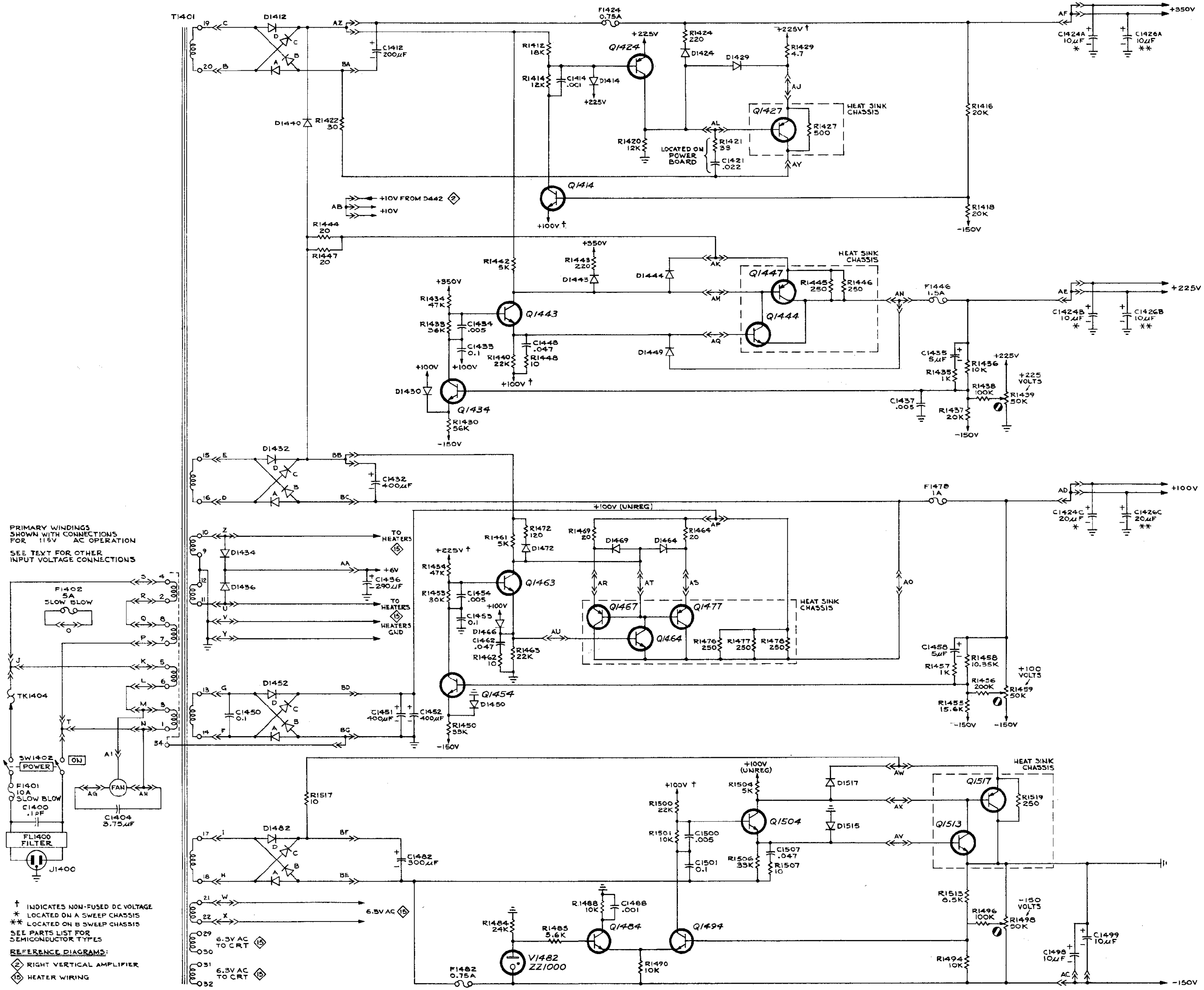
REFERENCE DIAGRAM:
② RIGHT VERTICAL AMPLIFIER

TYPE 556 OSCILLOSCOPE

A

POWER SUPPLY
S/N 2000-UP

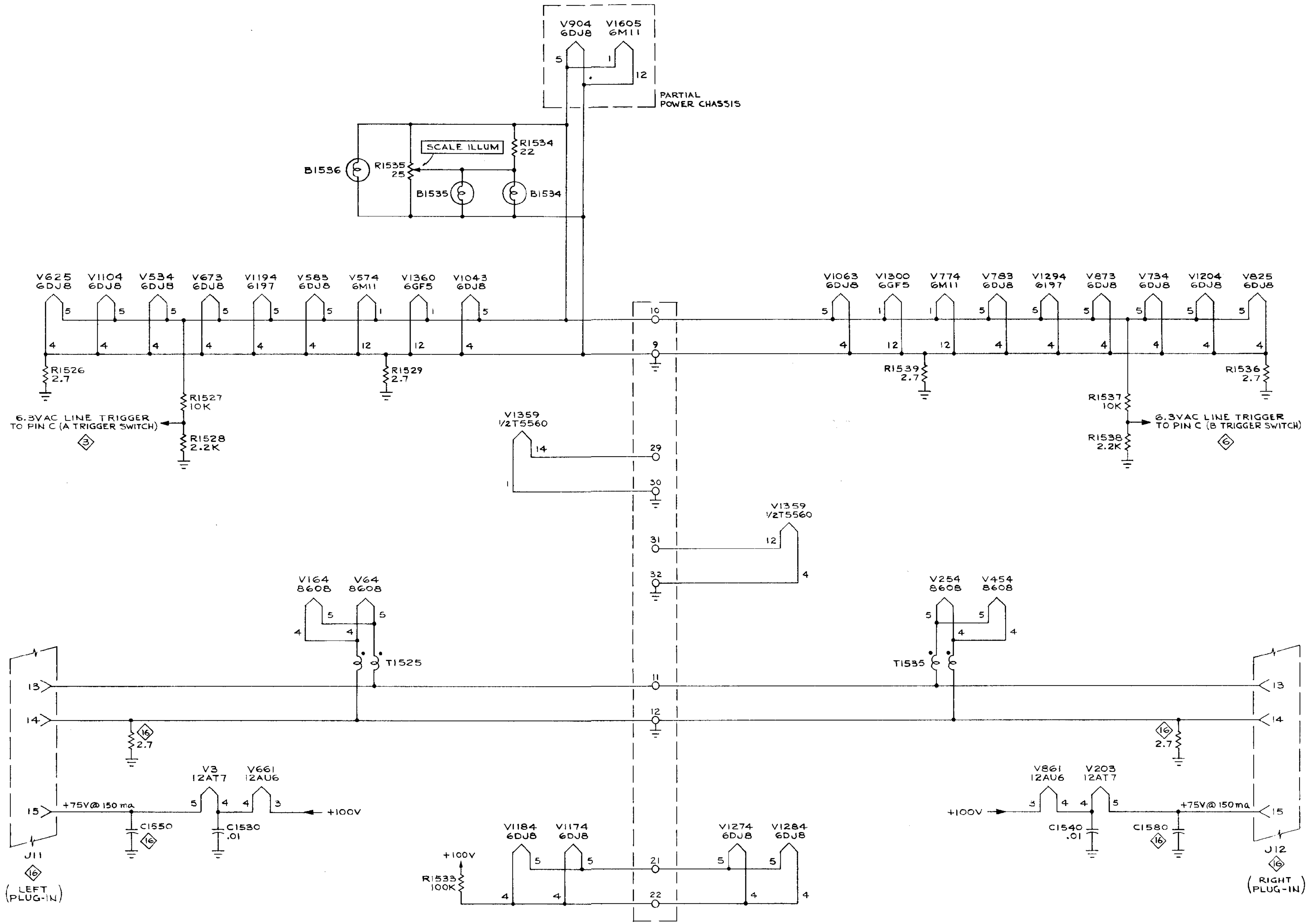
⑭ MRH 1067



MRH 1067

POWER SUPPLY ⑭

S/N 100-1999



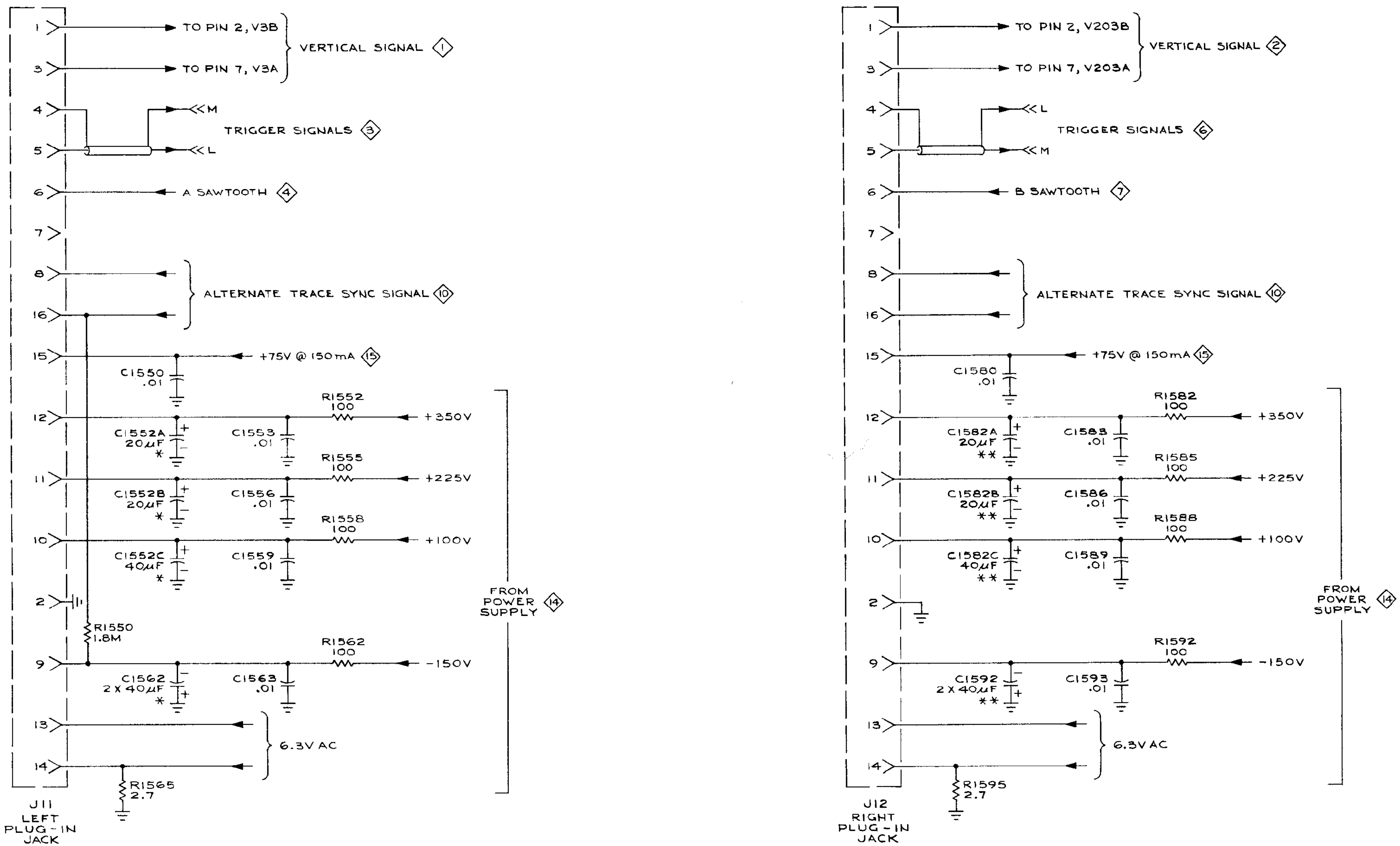
TYPE 556 OSCILLOSCOPE

REFERENCE DIAGRAMS:

- ③ A SWEEP TRIGGER
- ⑥ B SWEEP TRIGGER
- ⑯ PLUG-IN JACK DETAILS

MRH
666

HEATER WIRING ⑮



*LOCATED ON LEFT VERTICAL CHASSIS

**LOCATED ON RIGHT VERTICAL CHASSIS

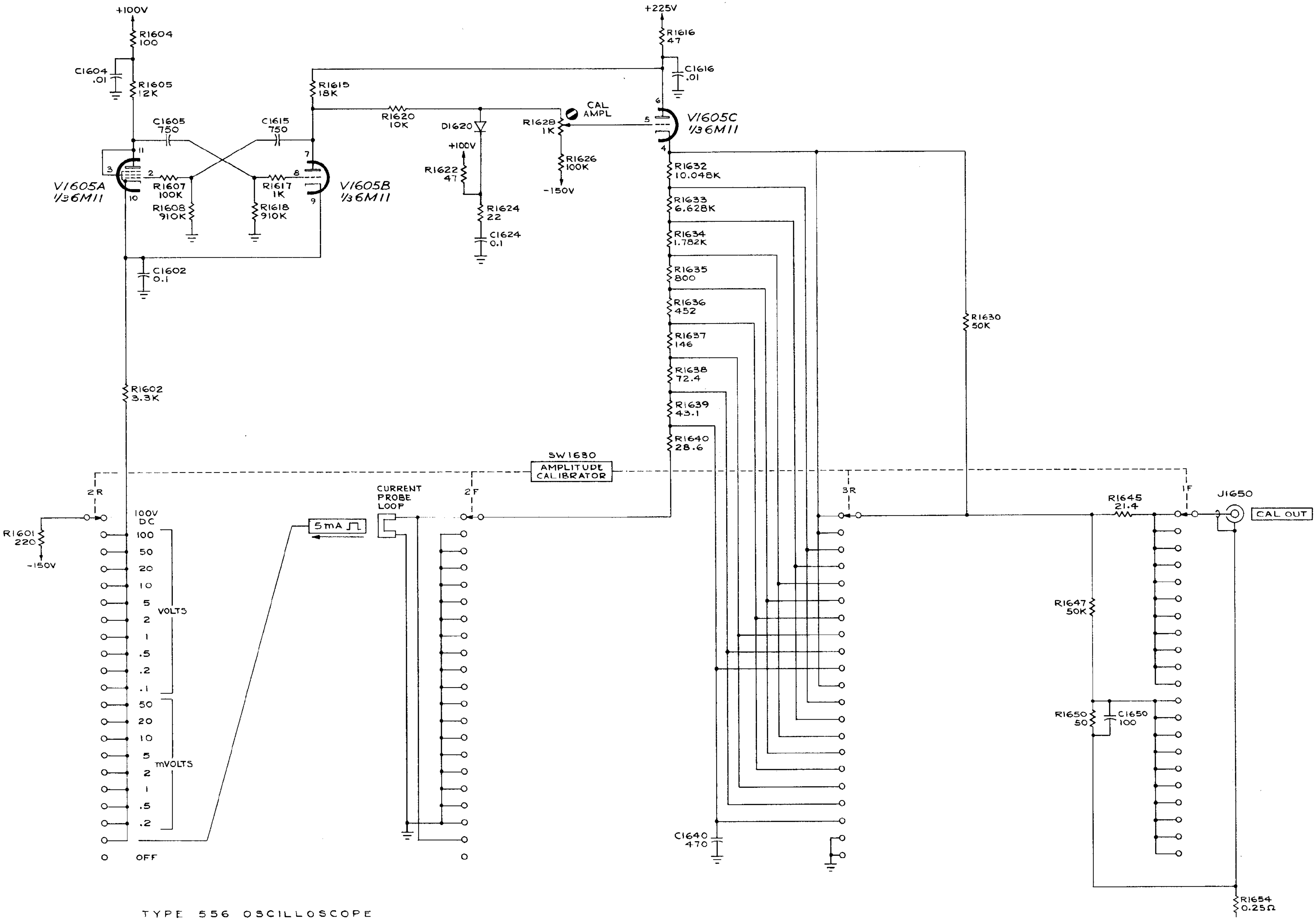
REFERENCE DIAGRAMS:

- ⟨1⟩ LEFT VERTICAL AMPLIFIER
- ⟨2⟩ RIGHT VERTICAL AMPLIFIER
- ⟨3⟩ A SWEEP TRIGGER
- ⟨4⟩ A SWEEP GENERATOR
- ⟨6⟩ B SWEEP TRIGGER
- ⟨7⟩ B SWEEP GENERATOR
- ⟨10⟩ ALTERNATE TRACE LOGIC & BLANKING
- ⟨14⟩ POWER SUPPLY
- ⟨15⟩ HEATER WIRING

TYPE 556 OSCILLOSCOPE

MRH
666

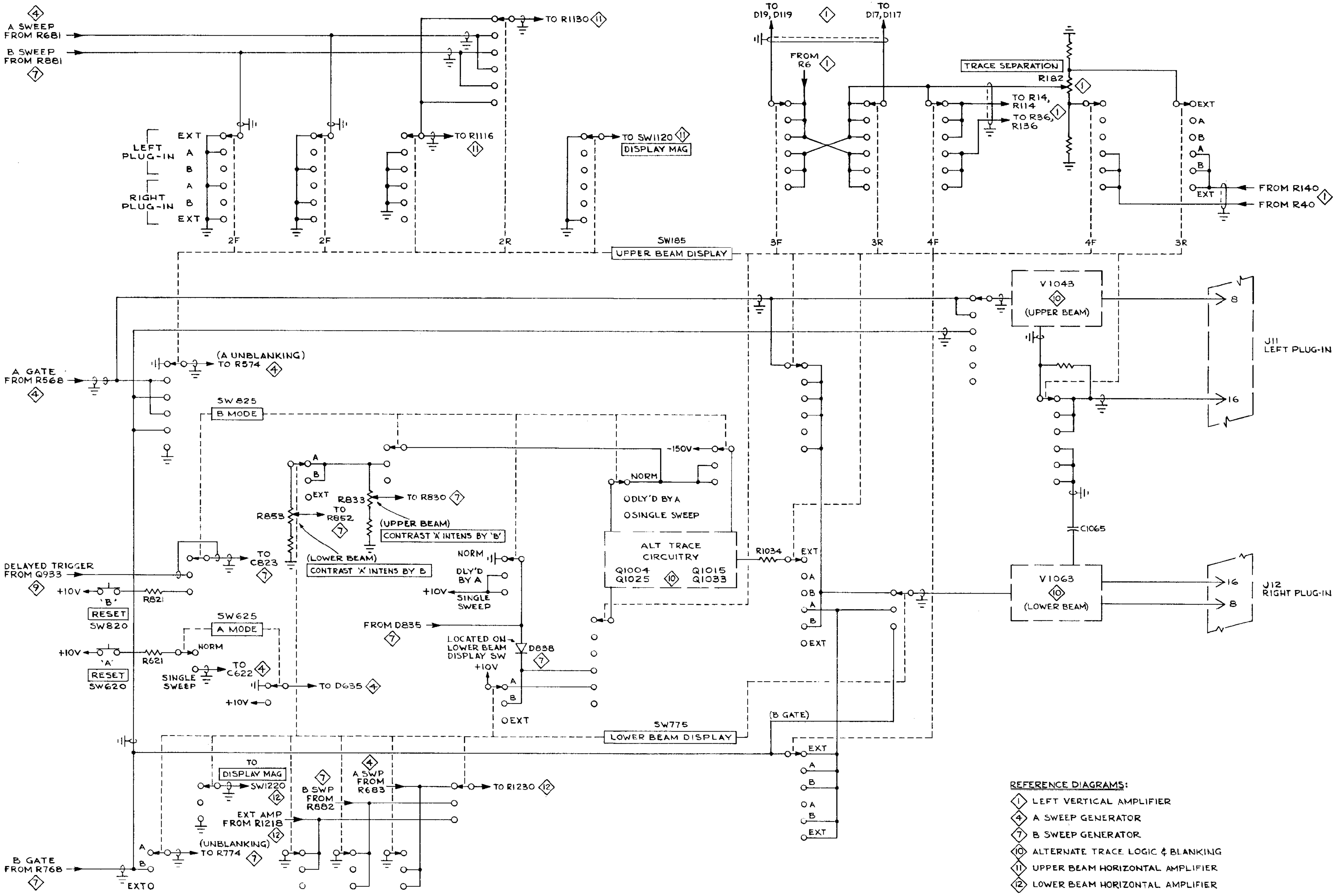
PLUG-IN JACK DETAILS ⟨16⟩



TYPE 556 OSCILLOSCOPE

MRH 666

CALIBRATOR 17



REFERENCE DIAGRAMS:

1. LEFT VERTICAL AMPLIFIER
4. A SWEEP GENERATOR
7. B SWEEP GENERATOR
10. ALTERNATE TRACE LOGIC & BLANKING
11. UPPER BEAM HORIZONTAL AMPLIFIER
12. LOWER BEAM HORIZONTAL AMPLIFIER

TYPE 556 OSCILLOSCOPE

HORIZONTAL DISPLAY & MODE SWITCHING 18

MRH 867

S/N 2000-UP

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

PARTS LIST CORRECTION

CHANGE TO:

R559	321-0245-00	3.48 kΩ	1/8 W	Prec	1%
R561	315-0560-00	56 Ω	1/4 W		5%
R563	323-0326-00	24.3 kΩ	1/2 W	Prec	1%
R759	321-0245-00	3.48 kΩ	1/8 W	Prec	1%.
R761	315-0560-00	56 Ω	1/4 W		5%
R763	323-0326-00	24.3 kΩ	1/2 W	Prec	1%

TYPE 556 TENT SN 2090

TYPE R556 TENT SN 1050

PARTS LIST CORRECTION

CHANGE TO:

R1319	311-0415-01
R1336	311-0121-01
R1369	311-0415-01
R1386	311-0121-01

M11,639/1067

PARTS LIST CORRECTION

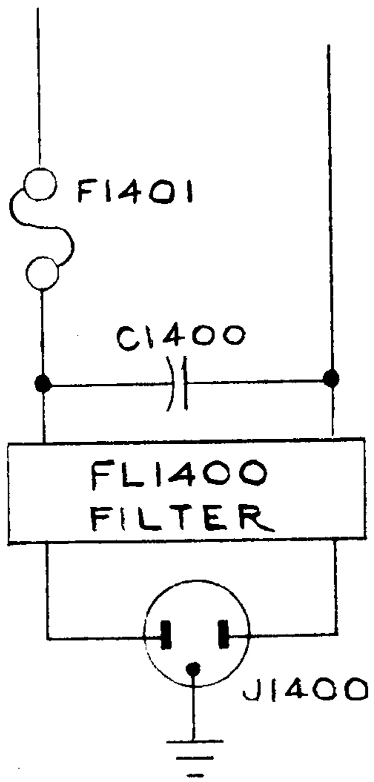
CHANGE TO:

FL1400	119-0135-03		

ADD:

C1400	285-0672-00	.1 µF	600 V

SCHEMATIC CORRECTION



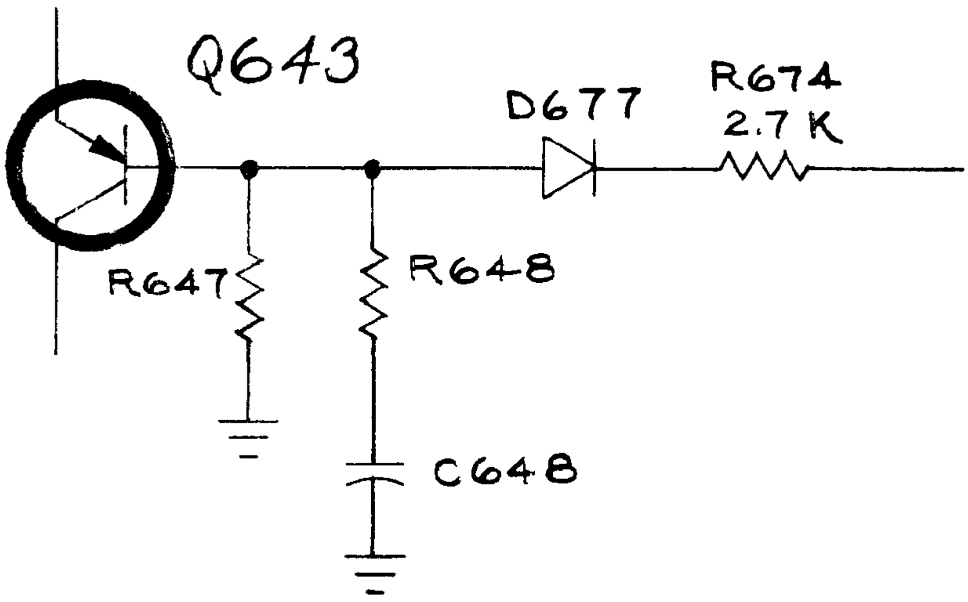
PARTIAL

POWER SUPPLY ⟨14⟩

PARTS LIST AND SCHEMATIC CORRECTION

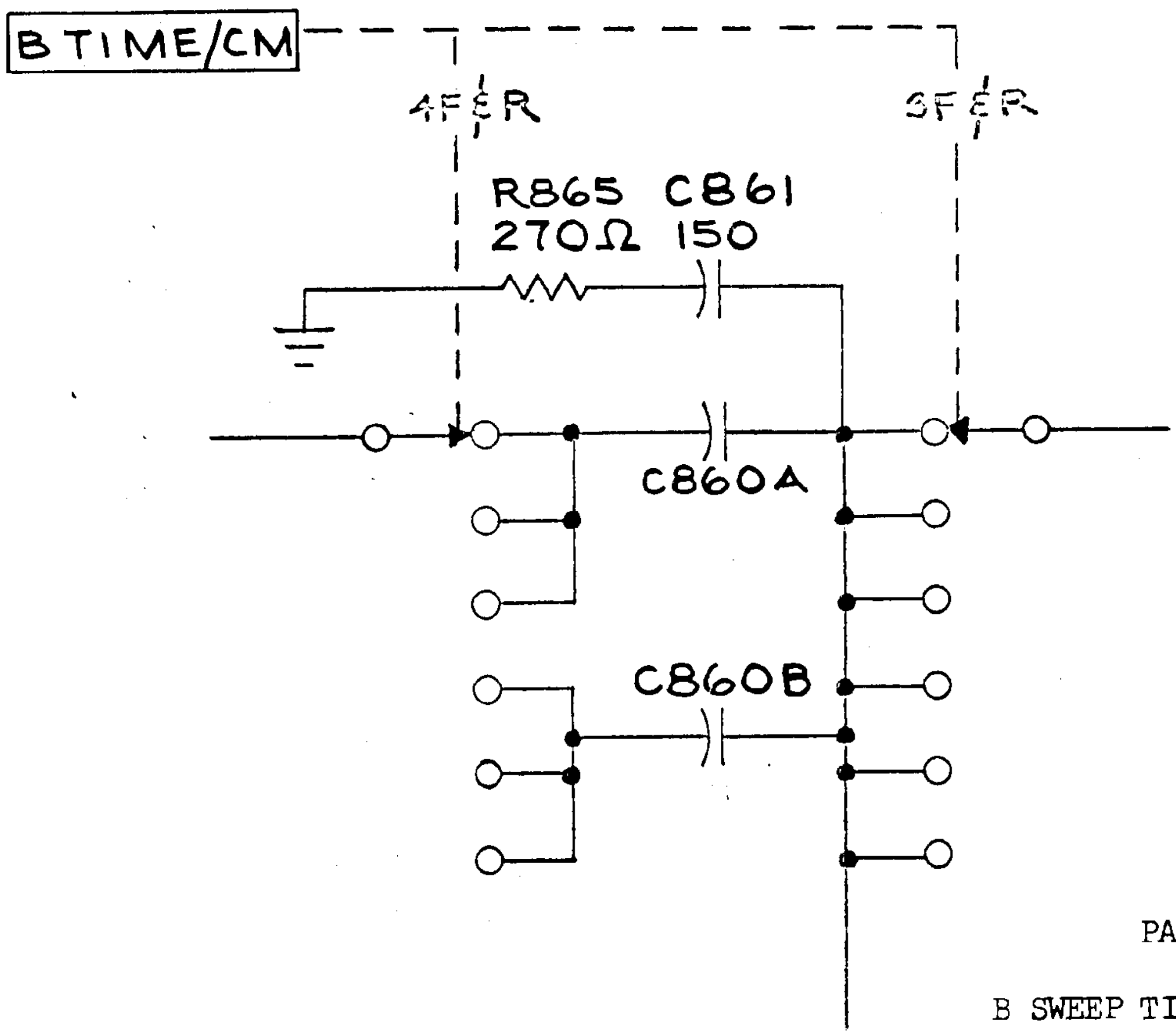
ADD:

C661	281-0524-00	150 pF	Cer	500 V	
C861	281-0524-00	150 pF	Cer	500 V	
R665	315-0271-00	270 Ω	1/4 W		5%
R674	315-0272-00	2.7 k	1/4 W		5%
R865	315-0271-00	270 Ω	1/4 W		5%
R874	315-0272-00	2.7 k	1/4 W		5%



PARTIAL

A SWEEP GENERATOR



PARTIAL

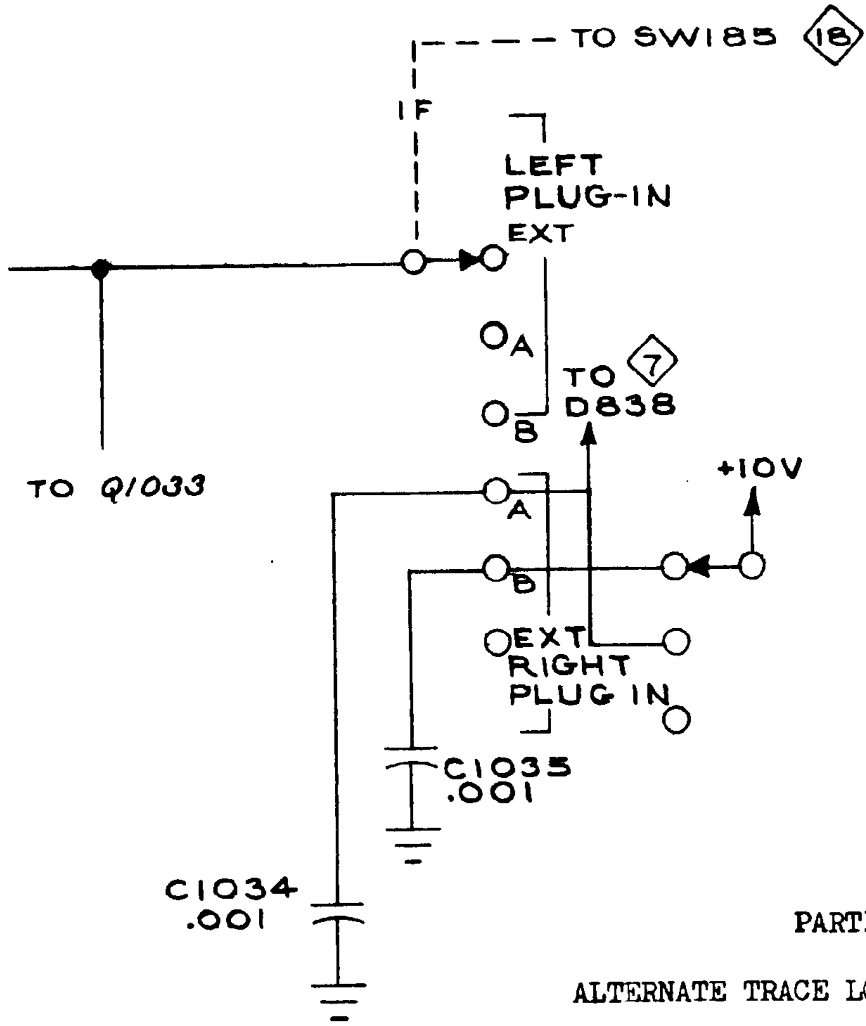
B SWEEP TIMING SWITCH

PARTS LIST CORRECTION

ADD:

C1034	283-0000-00	0.001 µF	Cer	500 V
C1035	283-0000-00	0.001 µF	Cer	500 V
R1101	315-0101-00	100 Ω	1/4 W	5%
R1201	315-0101-00	100 Ω	1/4 W	5%

SCHEMATIC CORRECTION



PARTIAL

ALTERNATE TRACE LOGIC AND BLANKING ⟨10⟩

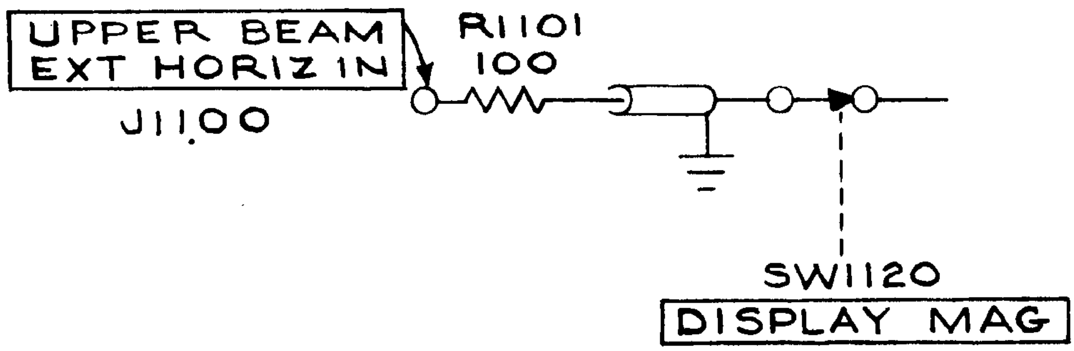
ADD: C1034 and C1035 as shown above:

M13,361/168

SCHEMATIC CORRECTION

UPPER BEAM HORIZONTAL AMPLIFIER ⟨11⟩

ADD: R1101 as shown below:



LOWER BEAM HORIZONTAL AMPLIFIER ⟨12⟩

ADD: R1201 as shown below: