INSTRUCTION MANUAL

Serial Number ____________

TYPE 564B
MOD 121N
OSCILLOSCOPE

Tektronix, Inc.
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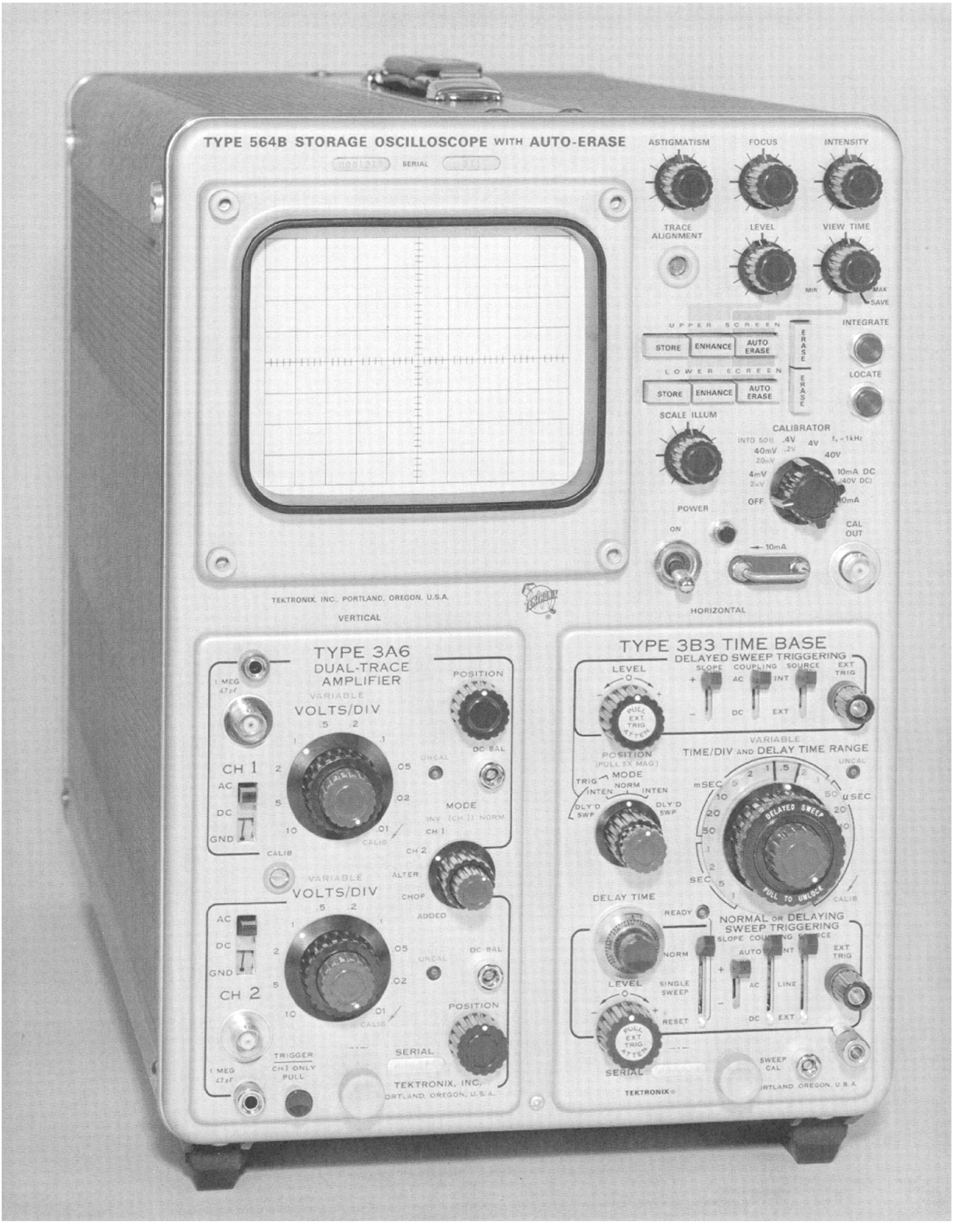

TYPE 564B STORAGE OSCILLOSCOPE WITH AUTO-ERASE
SERIAL
ASTIGMATISM
FOCUS
INTENSITY
TRACE ALIGNMENT
LEVEL
VIEW TIME
MIN
MAX
SAVE
UPPER SCREEN
STORE
ENHANCE
AUTO ERASE
ERASE
INTEGRATE
LOWER SCREEN
STORE
ENHANCE
AUTO ERASE
ERASE
LOCATE
SCALE ILLUM
CALIBRATOR
40mV
4V
40V
4mV
10mA DC
(40V DC)
OFF
10mA
POWER
CAL OUT
ON
10mA
TEKTRONIX, INC. PORTLAND, OREGON, U.S.A.
VERTICAL
HORIZONTAL
TYPE 3A6
DUAL-TRACE AMPLIFIER
VARIABLE
VOLTS/DIV
POSITION
1 MEG 47pF
CH 1
AC
DC
GND
UNCAL
DC BAL
MODE
CH 1
CALIB
CH 2
ALTER
CHOP
ADDED
VARIABLE
VOLTS/DIV
AC
DC
GND
UNCAL
DC BAL
CH 2
POSITION
SERIAL
TRIGGER
CH1 ONLY
PULL
1 MEG 47pF
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.
TYPE 3B3 TIME BASE
DELAYED SWEEP TRIGGERING
LEVEL
SLOPE
COUPLING
SOURCE
EXT TRIG
AC
INT
DC
EXT
PULL EXT TRIG ATTEN
POSITION
(PULL 5X MAG)
VARIABLE
TIME/DIV AND DELAY TIME RANGE
UNCAL
MODE
TRIG
NORM
INTEN
INTEN
DLY'D SWP
DLY'D SWP
mSEC
μSEC
SEC
DELAYED SWEEP
PULL TO UNLOCK
CALIB
DELAY TIME
READY
NORMAL OR DELAYING
SWEEP TRIGGERING
NORM
SINGLE SWEEP
RESET
AUTO
AC
LINE
DC
EXT
EXT TRIG
LEVEL
PULL EXT TRIG ATTEN
SERIAL
SWEEP CAL
TEKTRONIX

SECTION 1
TYPE 564B MOD 121N SPECIFICATION

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

Introduction

The Type 564B Storage Oscilloscope with Auto Erase is designed to store cathode-ray tube displays for viewing or photographing up to an hour after application of the input signal. In addition, the instrument can be operated as a conventional oscilloscope. The Type 564B is compatible with Tektronix 2-Series and 3-Series plug-in units (see following table and Section 2 for exceptions); thus, it can be used in a variety of applications including differential, multi-trace, wide-band, delayed sweep, sampling and spectrum analysis.

The cathode-ray tube used in the Type 564B is a direct view, bistable storage tube having an 8 X 10 centimeter display area, divided into two 4 X 10 cm storage screens. The storage screens are independently controlled for split screen applications. An additional area which does not store is provided to the left of the targets to function as a locate zone in the single-sweep store mode.

This instrument will perform to the specifications listed in this section in a laboratory environment with an ambient temperature range between 0° C and +50° C, except as indicated. Warmup time for rated accuracies is 5 minutes (certain plug-ins may require additional warmup time). The Performance Check instructions outlined in Section 5 of this manual provide a convenient method of checking the performance of this instrument.

ELECTRICAL CHARACTERISTICS

CRT

Characteristic	Performance
Plug-in compatibility	2- and 3-Series plug-ins, except the 3S6, 3T6; 3B5 (horizontal only)
CRT Type	Electrostatic deflection
Graticule Area	8 x 10 cm
Phosphor	Storage (similar to P1)
Typical CRT Accelerating Voltage	3.5 kV

STORAGE DISPLAY

	T5641-200	T5641-201
Writing Speed Basic (Initial)	At least 25 cm/ms	At least 100 cm/ms
Enhanced	At least 250 cm/ms	At least 500 cm/ms
Luminance Initial	At least 6 fL	At least 2 fL
Contrast Ratio Initial	2:1	2:1
Storage Time (Recommended)	One hour or less	
Erase Time	250 ms or less	
Locate	Displaces dot to preview area (left of graticule) and at the vertical position of the next sweep when sweep start is positioned to first graticule line	
AUTO ERASE Mode Viewtime	1 s or less to at least 12 s	

EXTERNAL OUTPUTS

Calibrator Output Voltage Into High Impedance (1 MΩ or greater)	+4 mV, +40 mV, +0.4 V, +4 V, +40 V (ground to peak) square wave and 40 VDC; (within 1½%, +20°C to +30°C; within 2%, 0°C to +50°C)
Into 50.0 Ω	+2 mV, +20 mV, +0.2 V (ground to peak) square wave; (within 1½%, +20°C to +30°C; within 2%, 0°C to +50°C)
Current Loop	10 mA DC or 10 mA (P-P) square wave (within 1½%, +20°C to +30°C; within 2%, 0°C to +50°C)
Frequency	1 kHz, within 1%
Duty Factor	48% to 52%
Risetime and Falltime	1 μs or less at all voltages with load capacitance of 100 pF or less, except 40 V. 2.5 μs or less at 40 V with load capacitance of 100 pF or less

EXTERNAL INPUTS

CRT Cathode (AC Coupled) Low —3 dB Frequency	1.8 kHz or less
Z Axis Modulation	10 V or less (P-P) gives useful intensity variation
Maximum Input Voltage	150 V
Remote (Storage) Control Input Half Screen Erase Pulse Initiated Erase	Negative pulse of 5 V to 100 V. Rate of change at least 0.1 V/μs
Impedance Change Initiated Erase	From at least 1 MΩ to 50 kΩ or less in 10 μs or less
Save	To actuate: 100 Ω or less to ground
Shorted ERASE PULSE OUTPUT	Viewtime cycle freeruns (5 kΩ or less to ground)

POWER SUPPLY

Characteric	Performance	
Line Voltage Ranges	115 VAC	230 VAC
Low	90 V to 110 V	180 V to 220 V
Medium	104 V to 126 V	208 V to 252 V
High	112 V to 136 V	224 V to 272 V
Line Frequency Range	48 to 440 Hz	
Maximum Power Consumption at 115 V, 60 Hz	196 W, 2.16 A	

ENVIRONMENTAL CHARACTERISTICS

Characteristic	Performance
Temperature Non-operating Operating	 —40°C to +65°C 0°C to +50°C
Altitude Non-operating Operating	 To 50,000 feet To 15,000 feet
Transportation	18-inch package drop. Qualified under the National Safe Transit Committee test procedure 1A.

PHYSICAL

Finish	Blue vinyl painted rear panel and sides. Anodized aluminum front panel.
Dimensions Height Width Length	 ≃14¾ inches ≃9¾ inches ≃21½ inches

Accessories

Standard accessories supplied with the Type 564B are listed on the last pullout page of the Mechanical Parts List illustrations. For optional accessories available for use with this instrument, see the current Tektronix, Inc, catalog.

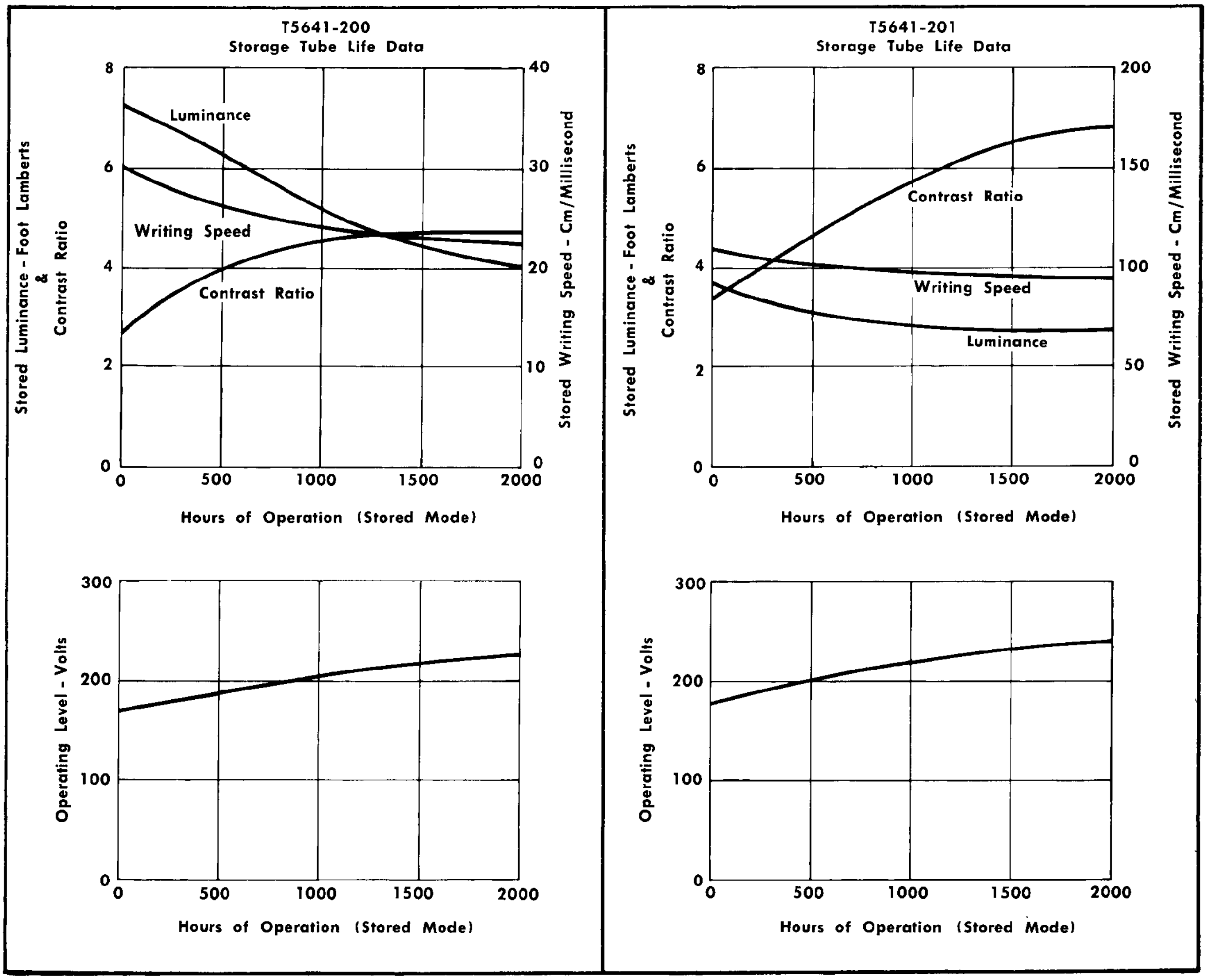


Fig. 1-2. Life data graphs of T5641-200 and T5641-201 storage tubes.

SECTION 3
CIRCUIT DESCRIPTION

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

Introduction

This section of the manual contains a description of the circuitry used in the Type 564B Storage Oscilloscope with Auto Erase. Each circuit is described in detail using a detailed block diagram to show the interconnections between the stages in each major circuit, and the relationship of the front-panel controls to the individual stages. Complete schematic diagrams are located at the back of this manual.

LOW-VOLTAGE POWER SUPPLY

General

The Low-Voltage Power Supply circuit provides the operating power for this instrument from four regulated supplies. Electronic regulation is used to provide stable, low-ripple output voltages. Each regulated supply contains a short-protection circuit to prevent instrument damage if a supply is inadvertently shorted to ground or to another supply. The voltage input stage includes the Voltage Selector Assembly which allows selection of the nominal operating voltage and regulating range for the instrument. Fig. 3-1 shows a detailed block diagram of the Low-Voltage Power Supply.

Power Input

Power is applied to the primary of transformer T1 through fuse F1, POWER switch SW1, thermal cutout TK1, Voltage Selector switch SW2 and Range Selector switch SW3. SW2 connects the split primaries of T1 in parallel for 115-volt nominal operation, or in series for 230-volt nominal operation. SW3 allows three ranges of regulation by changing the taps on the primary windings to fit different line requirements. A second fuse, F2, is connected into the circuit when SW2 is set to the 230 V position to provide the correct protection for 230-volt operation.

Thermal cutout TK1 provides thermal protection by interrupting the power if the instrument overheats. When the temperature returns to a safe level, TK1 automatically closes to re-apply the power.

—100-Volt Supply

The —100-Volt Supply provides the reference voltage for the remaining supplies. The output from the secondary of T1 is rectified by bridge rectifier D8A-D. This voltage is filtered by C9, then applied to the —100-Volt Series Regulator stage to provide a stable output voltage. The Series Regulator can be compared to a variable resistance which is changed to stabilize the output voltage. The conductance of the Series Regulator stage is controlled by the Error Amplifier to provide the correct regulated output voltage.

The Error Amplifier consists of Q12 and Q14, connected comparator. The output at the collector of Q14 indicates that voltage variations have occurred at the base of Q14 relative to the fixed voltage at the base of Q12. Zener diode D10 maintains a fixed 9-volt drop, setting the base of Q12 at about —9 volts. The base level of Q14 is determined by the voltage divider network R18-R19-R20-R21-R23. R23, the —100 Volts adjustment, allows the operating point of the Error Amplifier to be adjusted to set the output voltage of the supply at —100 volts. R13 is the emitter resistor for both comparator transistors and the current through it divides between Q12 and Q14. The output current of the Error Amplifier stage controls the conduction of the Series Regulator stage. This is accomplished as follows: Assume that the output voltage increases (becomes more negative) because of a change in load or an increase in line voltage. This negative-going voltage change at the output is applied to the base of Q14, reducing the conduction of Q14. As current through Q14 is reduced, Q24 base current increases. This results in increased Q24 collector current, increasing the voltage drop across R25 and R26 and pulling the base of Q28 negative. The emitter of Q28 follows the base, hence the base of Q32 is also pulled negative. Reduced current through Series Regulator Q32 decreases current through the load, causing the output voltage to decrease (become less negative) to its correct level. These changes occur rapidly, and the effect is to maintain unchanged output voltage. In a similar manner, the Series Regulator and Error Amplifier stages compensate for output changes due to ripple. As will be seen in subsequent paragraphs, R33 determines the limit current for the Series Regulator stage, and thus for the load. Transients beyond the frequency range of the regulator are filtered by C31 to prevent their appearance on the output voltage.

When the power switch is activated, diode D25 provides a base current path for Q28, allowing the —100-Volt Supply to turn on first, since all the other supplies are dependent upon its output. As the —100-Volt Supply output builds up to its correct level, D25 is reverse biased and remains off during normal operation of the instrument.

The Short-Protection Amplifier stage, Q30, protects the —100-Volt Supply if the output is shorted, and also serves to limit the current demanded from the Series Regulator under excessive load. During normal operation, divider R30-R31 sets the base of Q30 to a point below the turn on level of the transistor. When excess current is demanded from Series Regulator Q32 due to an overload or short circuit, the additional current through R33 raises the emitter of Q32 more positive. This produces a corresponding change at the base of Q32, which is connected through R30 to the base of Q30. This positive-going change biases Q30 into conduction. As a result, less current is available to Q28, to Q32 and to the load, thus causing the supply to lose regulation. R31 senses

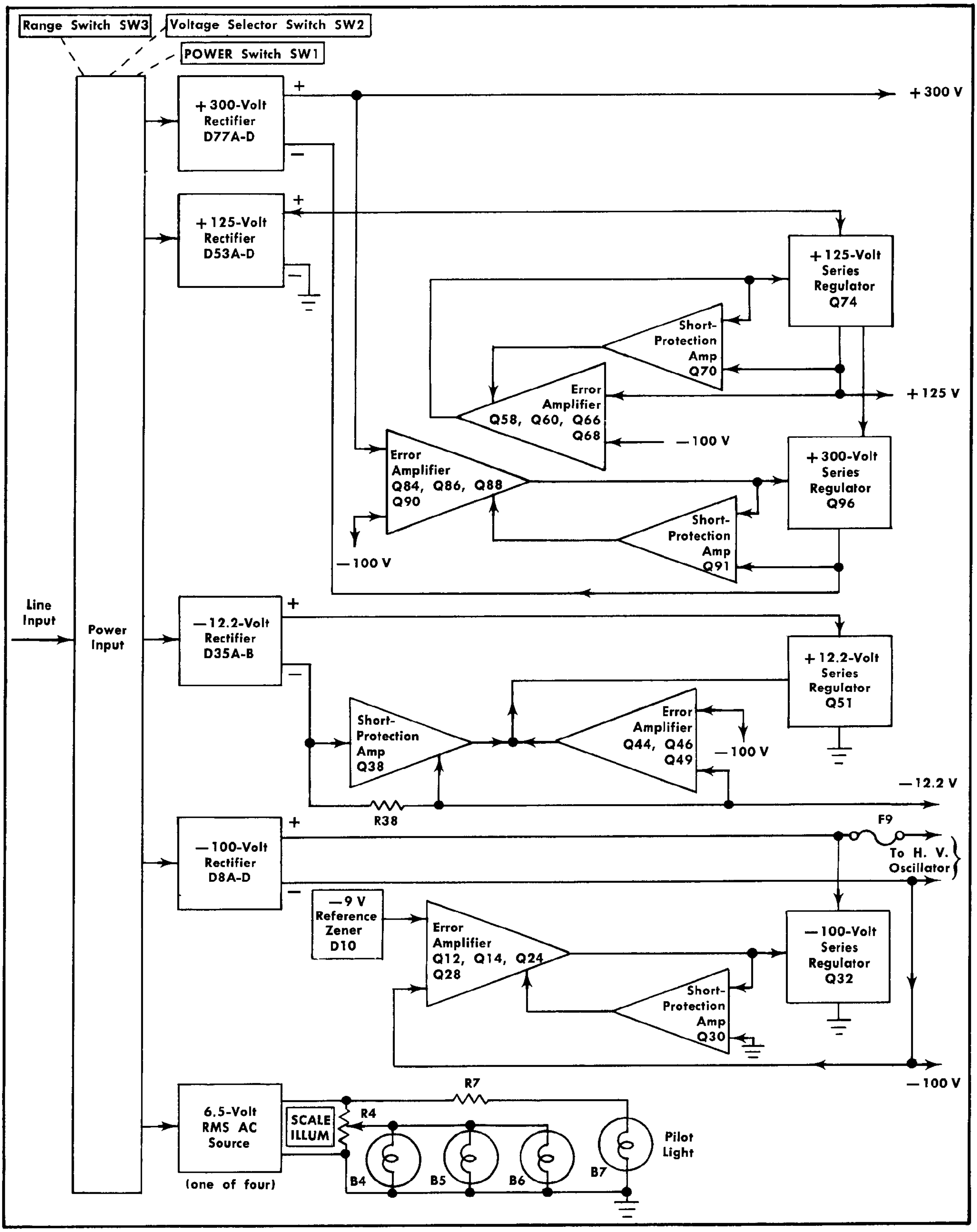


Fig. 3-1. Power Supply detailed block diagram.

the decrease in load voltage and adds to increasing base current of Q30. As the collector of Q30 goes negative, conduction of Q28 and Q32 is further decreased. Thus the output current is decreased and remains low until the excessive load is removed. D19, together with divider R18-R19-R20, provides protection to the —12.2-Volt Supply, in the event the —100-Volt Supply is shorted to the —12.2-Volt Supply. This is accomplished by causing the —100-Volt Supply to lose regulation, and therefore lose reference voltage for the —12.2-Volt Supply. D31 protects the —100-Volt Supply from damaging polarity reversal if it is shorted to either the +125-Volt Supply or the +300-Volt Supply.

—12.2-Volt Supply

Rectified voltage for operation of the —12.2-Volt Supply is provided by D35A-B, filtered by C36 and applied to the —12.2-Volt Supply Series Regulator stage. Reference voltage for this supply is provided by voltage divider R42-R43 between the regulated —100-Volt Supply and ground. If the —12.2-volt output changes, a sample of the change appears at the base of Q46 as an error signal. Regulation of the output voltage is controlled by Error Amplifier Q44-Q46-Q49 and Series Regulator Q51 in a manner similar to that described for the —100-Volt Supply. Transients beyond the frequency range of the regulator are filtered by C47.

Short protection is provided by Q38 and R38. For normal operation, the emitter-base voltage of Q38 is not enough to bias it into conduction. However, when the output is shorted, the high current demanded from the —12.2-Volt Supply is drawn through R38, producing a voltage drop sufficient to forward bias Q38. Q38 collector current then produces an increased voltage drop across R40, reducing the conduction of both Q49 and Q51 to limit the output current. R39 protects Q38 from sudden current surges by limiting the base current. D47 protects the —12.2-Volt Supply from damage if it is shorted to either the +125-Volt Supply or the +300-Volt Supply.

+125-Volt Supply

Rectified voltage for operation of the +125-Volt Supply is provided by D53A-D, filtered by C54 and applied to the +125-Volt Supply Series Regulator stage. The +125-volt output is summed with the —100-volt reference through divider R62-R63, and the summation is applied through R61 to the base of Q60 and compared to the grounded base of Q58. If the +125-volt output changes, a sample of the change appears at the base of Q60 as an error signal. Regulation of the output voltage is controlled by Error Amplifier Q58-Q60-Q66-Q68 and Series Regulator Q74 in a manner similar to that described for the —100-Volt Supply. Transients beyond the frequency range of the regulator are filtered by C97B-C to prevent their appearance on the output voltage.

Short protection for this supply is provided by the Short-Protection amplifier stage Q70, which functions in a manner similar to that described for Q30 in the —100-Volt Supply. D62 protects the Error Amplifier from damage if the output of the +125-Volt Supply collapses or goes negative, causing C62 to rapidly discharge and reverse bias Q60. Diode D75 protects electrolytic capacitor C97B-C and the transistors in the circuit from damaging polarity reversals in the event the +300-volt output is shorted to ground or to one of the negative supplies. D76 causes the +125-Volt Supply to go into current limiting when the +300-Volt Supply is shorted to ground or to one of the negative supplies.

+300-Volt Supply

Rectified voltage for operation of the +300-Volt Supply is provided by D77A-D, filtered by C78 and applied from the negative side of the rectifier to the +300-Volt Supply Series Regulator stage. The +300-volt output is summed with the —100-volt reference through divider R80-R81, and the summation is applied through R83 to base of Q84 and compared to the grounded base of Q86. If the +300-volt output changes, a sample of the change appears at the base of Q84 as an error signal. Regulation of the output voltage is controlled by Error Amplifier Q84-Q86-Q88-Q90 and Series Regulator Q96 in a manner similar to that described for the —100-Volt Supply. Transients beyond the frequency range of the regulator are filtered by C97A. The load current through Series Regulator Q96 also passes through the +125-Volt Supply Series Regulator, Q74; however, this does not affect the limit current of the +125-Volt Supply.

Shorting protection for this supply is provided by the Short-Protection Amplifier stage, Q91, which functions in a manner similar to that described for Q30 in the —100-Volt Supply. D80 protects the Error Amplifier from damage if the output of the +300-Volt Supply collapses or goes negative, and D95 protects the transistors in the circuit from damaging polarity reversals in the event the +125-Volt Supply is shorted to ground or to one of the negative supplies.

6.5-Volt RMS AC Source

The four 6.5-volt RMS secondary windings of T1 provide power for the CRT heater, the plug-in heaters via J11 and J21, the pilot light, B7, and the scale illumination lights, B4, B5, and B6. Current through the scale illumination lights is controlled by the SCALE ILLUM control, R4, to change the brightness of the graticule lines.

DEFLECTION CIRCUITS

Push-pull horizontal and vertical signals for deflecting the writing-gun beam are received through pins 17 and 21 of each plug-in connector (J11 and J21) and applied to the respective deflection plates of the CRT. The effective deflection circuit capacitance encountered by each of these signals at the plug-in connector affects the bandwidth and phase shift of the plug-in unit. Compensating capacitors C102 and C109 (shown on the Plug-In Connectors diagram) are factory adjusted to set the effective capacitance at a standard value of 14.3 picofarads to ensure plug-in compatibility.

When the sweep start is positioned to the left edge of the graticule and the LOCATE button is pushed (see CRT Circuit), the writing-gun beam is deflected to the preview area at the left side of the CRT screen, permitting the beam to be located without altering a stored display. This is accomplished by applying a positive voltage via R105 and D105 to the left-hand horizontal deflection plate.

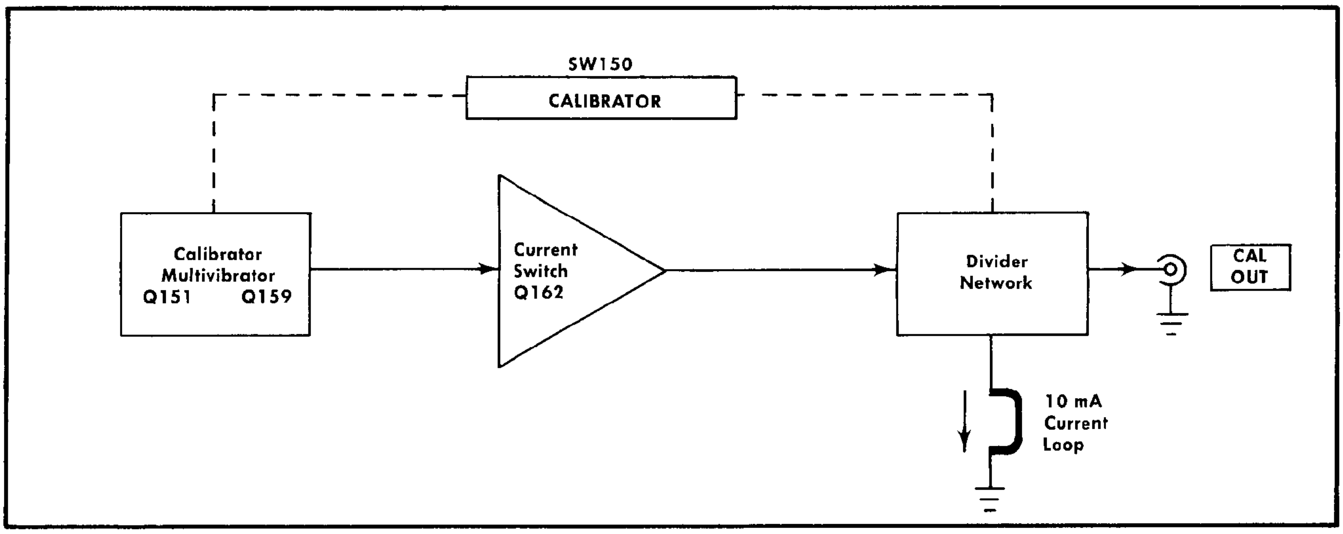


Fig. 3-2. 1 kHz calibrator detailed block diagram.

The push-pull horizontal signal (sweep sawtooth) is also applied to the End of Sweep Detector in the Auto Erase Circuit.

1 kHz Calibrator

General

The 1 kHz Calibrator circuit produces a square-wave output with accurate amplitude and frequency. This output is available as a square-wave voltage at the CAL OUT connector or as a square-wave current through the 10 mA probe current loop. An accurate +40 volts DC level is also available. The CALIBRATOR switch selects the attenuation of the output signal to provide square-wave voltage outputs between 40 volts and 4 millivolts (between 0.2 volts and 2 millivolts into 50 ohms) peak to peak. Fig. 3-2 shows a detailed block diagram of the 1 kHz Calibrator circuit.

Calibrator Multivibrator

The Calibrator Multivibrator is composed of Q151 and Q159, and is a free-running emitter-coupled multivibrator[1]. The circuit operates in a symmetrical manner and the output is an accurate one-kilohertz square wave. Only an approximate 9-volt change is exhibited at the emitters of Q151 and Q159, so that an essentially constant current of about 0.8 mA is maintained through resistors R150 and R158.

Refer to the waveforms shown in Fig. 3-3 for this discussion. With the CALIBRATOR switch, SW150, in all positions except 10 mA DC and OFF, the emitters of Q151 and Q159 are returned to the +125-volt supply through D151-R150 and D159-R158. Assume that the multivibrator has just switched states; Q151 is off and Q159 is on. This is T_O in Fig. 3-3. The base potential of Q159 is set to about —11.0 volts by voltage divider R153-R154-R156 to ensure that Q159 will not saturate. The voltage at the anode of D159 is about —9.8 volts because of the voltage drop across two forward-biased junctions. Capacitor C157 had about a 2-volt charge as switching occurred; thus, the voltage at the anode of D151 is about —7.8 volts, cutting off Q151. C157 begins to charge toward the +125-volt supply via R150. Total current through Q159 is about 1.6 mA; 0.8 mA through R158 and 0.8 mA through C157 and R150.

After about 0.5 milliseconds (corresponding with T_1 in Fig. 3-3), C157 has charged to the turn-on level of Q151 and D151. At this point, the capacitor has a charge of about 11 volts and the potential at the anode of D151 is about +1.2 volts. The capacitor charging current through Q159 ceases as Q151 and D151 begin to conduct. As the collector of Q151 (hence the base of Q159) rises, Q159 and D159 are switched off and C157 begins to discharge through R158. The C157-R158 current sums with the R150 current through Q151, producing an approximate 9-volt positive-going step at the base of Q159.

C157 continues to discharge, and after 0.5 milliseconds (T_2 in Fig. 3-3), the voltage at the anode of D159 has risen to forward bias Q159 and D159. As Q159 begins to conduct, the anode of D159 is clamped at about —0.8 volts and discharge action of C157 is halted. The current through Q151 decreases, causing its collector to introduce a negative-going step which is connected through the Q159 base-emitter junction and D159 to C157. Because C157 cannot obtain an instantaneous charge, the anode of D151 is pulled negative to reverse bias D151 and Q151. Q151 turns off, and its collector falls rapidly to about —11.0 volts, resulting in an approximate 9-volt negative-going step applied through Q159 and D159 to C157. The anode of D151 is pulled down to about —7.8 volts, completing the cycle.

The Calibrator Multivibrator circuit has been designed to repeat the preceding sequence at an accurate one-kilohertz frequency. However, since a tolerance range of the passive components does exist, the frequency can be adjusted by varying the amplitude slightly across C157 during the charge-discharge cycle. This is accomplished by adjustment of R154, Frequency, which determines the potential on D159 anode at the instant the diode turns on. For example, with

[1]Jacob Millman and Herbert Taub, "Pulse, Digital, and Switching Waveforms," McGraw-Hill, New York, 1965, pp. 445-451.

greater amplitude, longer charge and discharge times are required, thus lowering the frequency.

Output Stage

The output stage consists of the Current Switch, Q162, and the Divider Network. During the half cycle that Q159 is conducting, current is injected into the base of Q162. Q162 saturates and its collector drops to about —12 volts, reverse biasing D168. With D168 off, there is no current through R170 and R171, and the output level at the cathode of D168 drops to zero volts.

When Q159 turns off, Q162 turns off and D161 turns on to protect the Q162 base-emitter junction from reverse-bias breakdown. D164 and D168 turn on, and the output of the circuit (at D168 cathode) is dependent upon voltage divider R166-R167-R170-R171 between +125 volts and ground. This output level is set to exactly +40 volts by adjustment of R166, Amplitude. When this adjustment is made, the current through the divider is an accurate 10 mA which is available at the current probe loop in the 10 mA positions of the CALIBRATOR switch.

The signal voltage available at the CAL OUT connector is determined by the divider network (made up of precision resistors) and the setting of the CALIBRATOR switch. In the 10 mA DC (40 VDC) position, the Calibrator Multivibrator is inoperative so that a 40-volt DC output level is produced. R173 is placed in series with the R166-R167-R170-R171 resistance to obtain an effective resistance of 450 ohms with 4 volts applied, as seen by the CAL OUT connector in the 4 V position of the switch. This effective resistance becomes part of the output voltage divider in the positions of 0.4 V and below (these positions have an accurate 50-ohm output resistance, which when terminated by 50 ohms can further divide the outputs by two, providing outputs of 0.2 V, 20 mV and 2 mV). In the 10 mA position, the CAL OUT connector is grounded.

R183, which is about ten times the resistance of the braid of a 42-inch coaxial cable, cancels any ground loop current that may exist between the CAL OUT connector and some other instrument chassis.

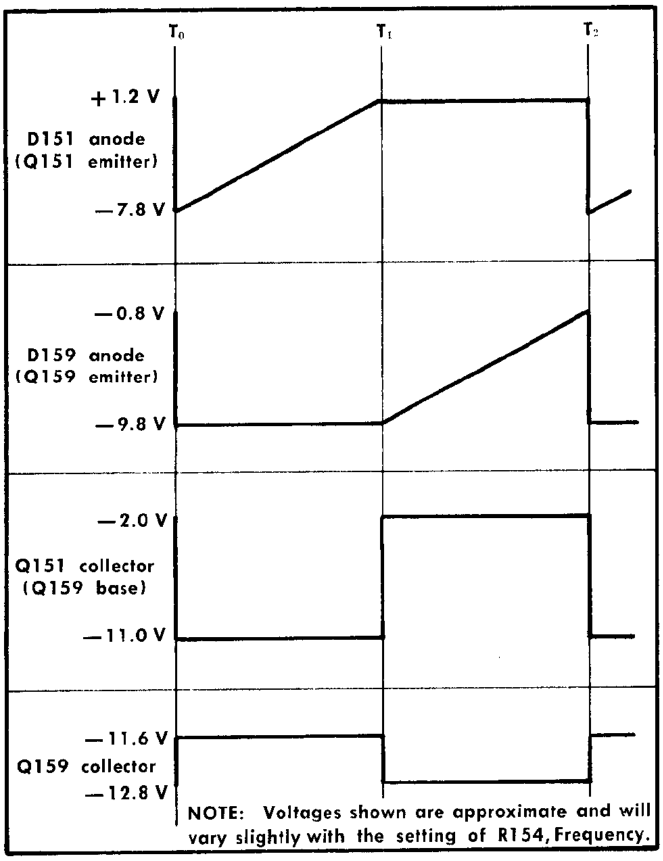


Fig. 3-3. Calibrator multivibrator waveforms.

CRT CIRCUIT

General

The CRT Circuit provides the high voltage and control circuits necessary for operation of the cathode-ray tube (CRT). Fig. 3-4 shows a detailed block diagram of the CRT Circuit.

High Voltage Oscillator

Q219 and its associated circuitry comprise a class C oscillator[2] to provide the drive for the high-voltage transformer, T220. When the instrument is turned on, conduction of Q214 provides a base current path for Q219. The collector current of Q219 increases and a voltage is developed across the collector winding of T220. This produces a corresponding voltage increase in the feedback winding of T220 which is connected to the base of Q219, causing it to conduct harder. While Q219 is conducting, C217 charges negatively to the peak-to-peak voltage of the feedback winding. Eventually the rate of collector current increase in Q219 becomes less than that required to maintain the voltage across the collector winding, and the voltage drops. This turns off Q219 by way of feedback voltage to the base. During the interval that Q219 is not conducting, the negative charge on C217 is partially removed through Q214. Q219 remains off until the feedback voltage on the base is near the peak positive value again. The cycle repeats at a frequency of 40 to 50 kilohertz. The amplitude of sustained oscillation depends upon the average current delivered to the base of Q219, and finally, the average Q219 collector current.

High Voltage Regulator

Feedback from the secondary of T220 and +125 volts is summed through the voltage divider network consisting of R200, R201, R206, R208 and R233 through R238, and the difference is applied to the gate of Field-Effect Transistor Q211. This sample of the output voltage is compared to the regulated —12.2-volt level at the source of Q211. It is then inverted and amplified by Q211 and applied to the base of Q214. Amplitude of the oscillations at the collector of Q219 is determined by the average collector current of Q214.

Regulation is accomplished as follows: If the output voltage at the —3300 V test point starts to go positive (become

[2]Lloyd P. Hunter (ed.), "Handbook of Semiconductor Electronics," second edition, McGraw-Hill, New York, 1962, pp. 14-19—14-21.

less negative), a sample of this positive-going voltage is applied to the gate of Q211. Conduction of Q211 is increased, and as its drain goes negative because of the voltage dropped across R211, the base current of Q214 is increased. An increase in conduction of Q214 increases the average collector current, which is applied through the feedback winding of T220 to the base of Q219. Q219 conducts harder, increasing the collector current to produce a larger induced voltage in the secondary of T220. This increased voltage appears as more negative voltage at the —3300 V test point to correct the original positive-going change. By sampling the output from the cathode supply in this manner, the total output of the high-voltage supply is held constant.

Output voltage level of the high-voltage supply is controlled by the High Voltage Adjustment, R206, in the gate circuit of Q211. This adjustment sets the effective divider ratio, which in turn determines the voltage necessary to satisfy the quiescent condition of Q214 and Q219 in the manner described for a change in output voltage. Neon bulb B209 and diode D212 protect the FET, Q211, from damage due to excessive voltage.

The INTEGRATE switch, SW480, grounds R203 in the gate circuit of Q211, which causes a slight shift in the high voltage to correct for the deflection sensitivity changes that occur when the flood gun cathodes are turned off.

High Voltage Rectifiers and Output

The high-voltage transformer, T220, has two output windings. These windings provide the negative CRT cathode potential and the CRT control grid bias.

The accelerating potential for the CRT cathode is supplied by the half-wave rectifier D221 and held constant by the High-Voltage Regulator stage in the primary of T220. The output level is adjustable to about —3300 volts on the cathode by the High Voltage adjustment mentioned previously. (The 6.5-volt writing gun heater is also elevated to the cathode potential through R246.)

Half-wave rectifier D260 provides a negative voltage for the control grid. The voltage applied to the control grid is determined by the setting of the INTENSITY control (to be discussed in the next paragraph), the CRT Grid Bias control (R269) and any intensification signals received from the time-base plug-in unit (delayed sweep and sampling units only). Reference to ground for this supply is set by the conduction of D272.

Beam current is controlled by R225, INTENSITY. As the control is rotated clockwise, the wiper arm moves toward —100 volts. This more negative DC reference voltage is applied to the secondary winding controlling the CRT cathode, reducing the voltage demanded of the winding to maintain —3300 volts at the —3300 V test point. This is accomplished by the regulator circuit. The voltage across the grid winding is also reduced, which results in a more positive voltage applied to the CRT control grid, thus increasing beam current. Beam current is reduced in a like manner by rotating R225 counterclockwise.

Neon bulbs B277, B278 and B279 provide protection to the CRT if the voltage difference between the control grid and the cathode exceeds about 135 volts.

CRT Control Circuits

In addition to the INTENSITY control discussed previously, the FOCUS and ASTIGMATISM controls have been incorporated for arriving at the optimum CRT display. FOCUS control R237 provides the correct voltage for the second anode in the CRT. Proper voltage for the third anode is obtained by adjusting ASTIGMATISM control R257. In order to obtain optimum spot size and shape, both the FOCUS and ASTIGMATISM controls are adjusted to provide the proper electrostatic lens configuration in the CRT.

The TRACE ALIGNMENT control, R259, permits adjustment of the DC current through beam-rotation coil L259 to align the display with the horizontal graticule lines.

When the LOCATE button, SW225, is pushed, a dot (or line, if varying vertical deflection is present) will appear to the left of the screen at the display level of the trace, provided that the sweep start is at the left edge of the graticule. This is accomplished by applying a positive deflection voltage to the left horizontal deflection plate and unblanking the CRT writing beam. At the same time, the INTENSITY control is removed from the circuit and the cathode supply is referred to the voltage set by the divider R227-R228. Locate intensity is therefore a fixed value, determined by the setting of the CRT Grid Bias control (R269), and is independent of the INTENSITY setting.

Blanking

The writing-gun beam is blanked by a special set of deflection plates in the CRT. One of the plates (pin 7) is connected directly to the +125-volt supply through R243, SW225 (LOCATE switch) and R242. The second plate (pin 5) is connected through plug-in connector J21 to the horizontal plug-in unit. When there is no sweep, a quiescent voltage is applied from the horizontal unit to create a difference of potential between the two plates. This voltage can be either positive or negative with respect to the +125 volts on the other plate. The potential difference created is sufficient to deflect the writing-gun beam so that it is absorbed in the deflection structure and does not reach the screen.

The writing-gun beam is unblanked whenever the two deflection plate voltages become equal. For example, if a sweep occurs, if the LOCATE button is pressed, or if the horizontal plug-in unit is removed, the voltages are made equal and the beam is allowed to pass through to the CRT screen. Sweep unblanking is produced by either a positive or negative gate pulse (depending on the quiescent level) applied to pin 5, equaling the +125 volts normally present at pin 7. Beam unblanking when the LOCATE button is pressed is accomplished by disconnecting pin 7 from the +125-volt supply, allowing the two plates to become equalized through R244. In a like manner, when the horizontal plug-in unit is removed, the two deflection plates are equalized through R244 at +125 volts.

Intensity Modulation

The intensity of the writing-beam display may be modulated by applying signals to either the grid or the cathode of the writing gun.

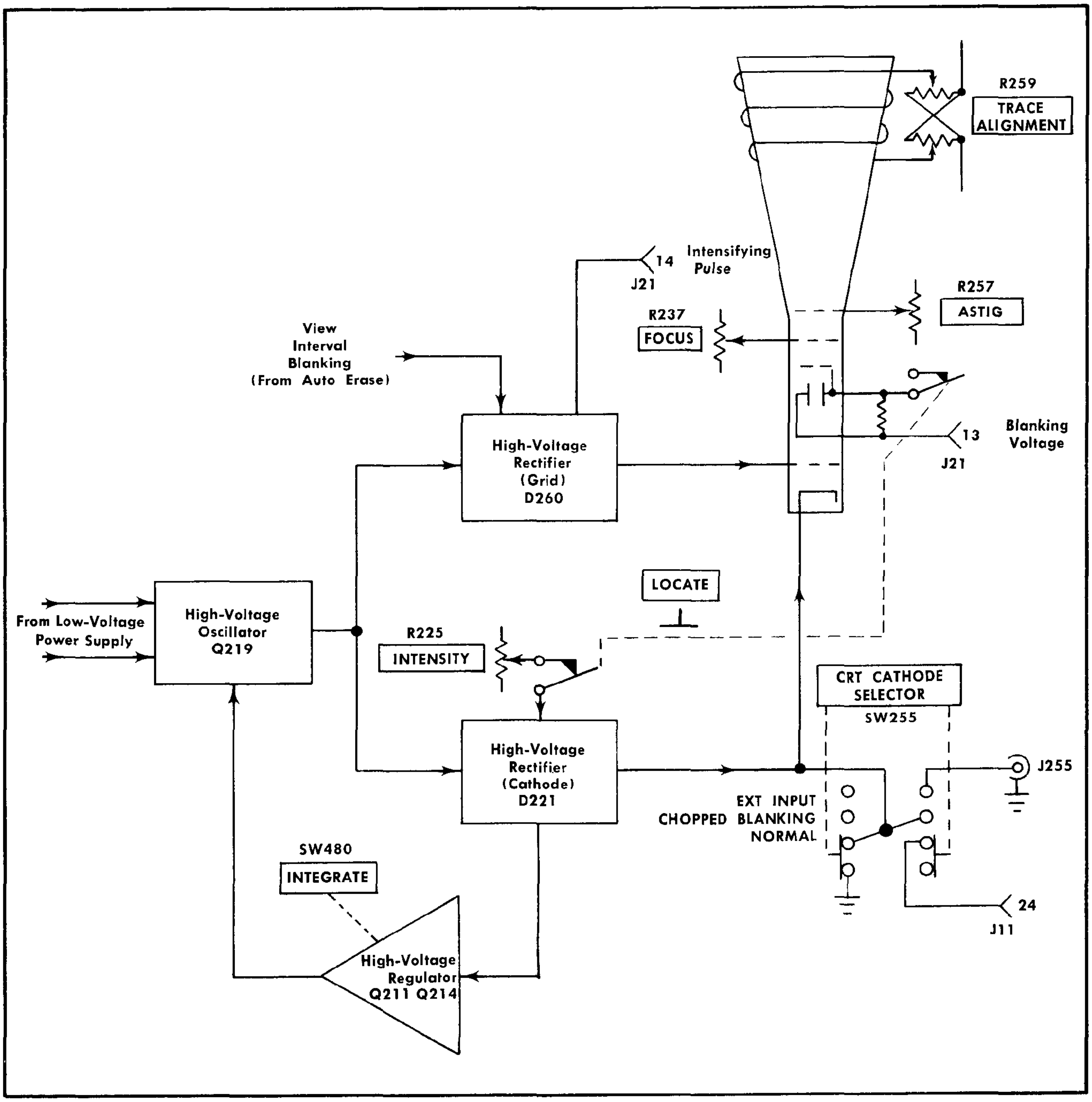


Fig. 3-4. CRT Circuit detailed block diagram.

Intensifying signals from a delayed sweep time-base plug-in unit are applied to the grid supply via pin 14 of the horizontal plug-in interconnecting socket, J21. These signals brighten the delayed-sweep portion of the delaying-sweep display. When the time-base unit is set to Intensified, the writing-gun grid supply is referred to a negative voltage in the intensifying circuit through D275, reducing the overall display intensity. At this time, D272 is reverse biased by the negative voltage at the juncture of the two diodes. Intensification results when the positive-going pulse from the time-base unit reverse biases D275 and the grid supply is referred to ground through D272 (as for normal operation). The positive-going pulse is then coupled through R275 and C275 to the CRT control grid. Thus, the brightened portion of the display is the same intensity as a normal display, and the background trace is dimmed.

External modulating signals may also be applied to the writing gun by way of the cathode, through the rear-panel EXT INPUT connector, J255, and the CRT CATHODE SELECTOR, SW255. With the INTENSITY control adjusted properly, a positive or negative pulse between 3 and 50 volts in am-

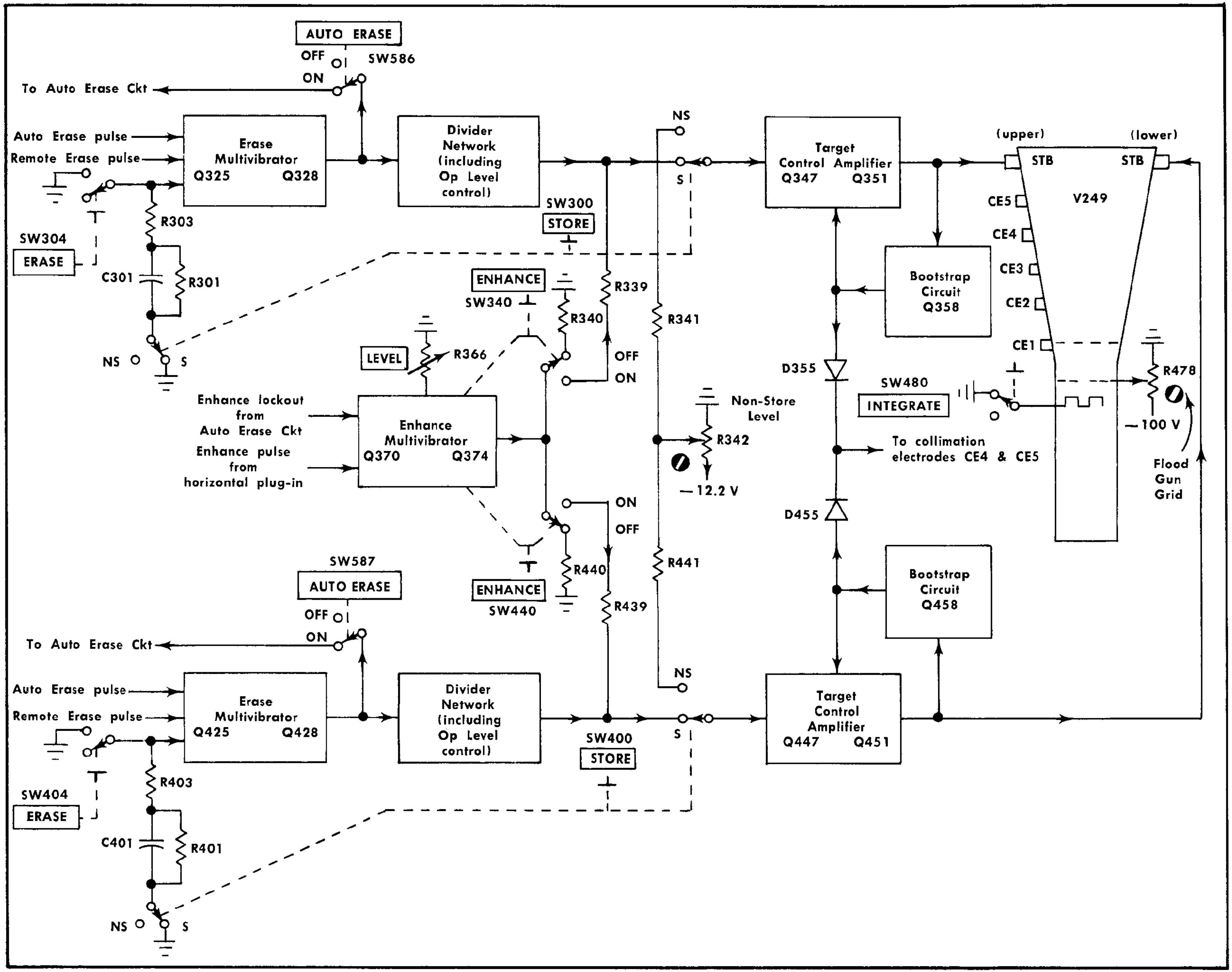


Fig. 3-5. Storage Circuit detailed block diagram.

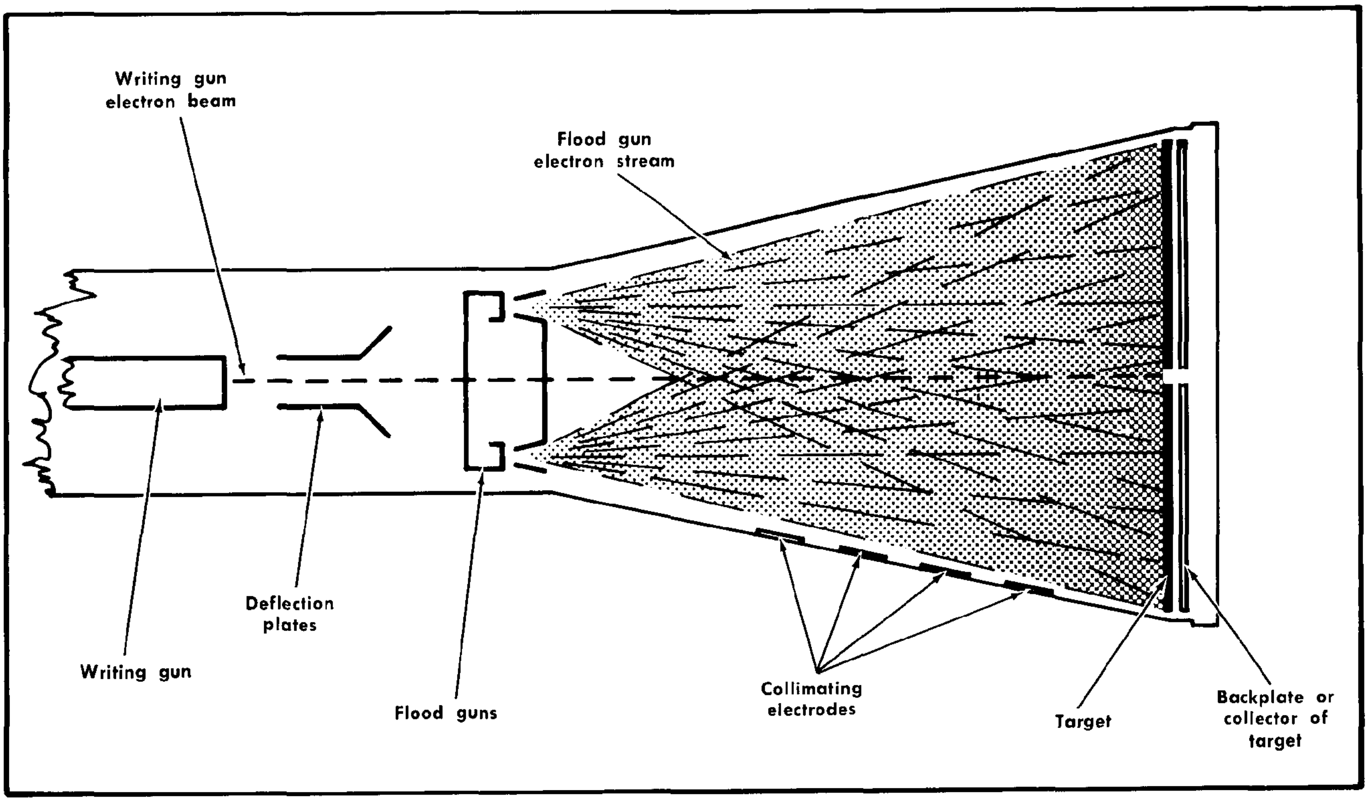


Fig. 3-6. Pictorial diagram of storage tube Type T5641.

amplitude will produce dimming or intensification of the writing beam.

When a multi-channel vertical plug-in amplifier that provides dual-trace chopped blanking pulses is used, the blanking pulses are applied via the interconnecting socket J11 and the CRT CATHODE SELECTOR to the CRT cathode circuit. These pulses are approximately 5 volts in amplitude, in amplitude, and at normal intensity levels are sufficient to cut off the CRT writing beam during the time the amplifier channels in the vertical plug-in unit are being switched.

When the automatic erase feature is used, a —100-volt pulse is applied from the Auto Erase Circuit to the writing-gun control grid to blank the CRT during the "view time" (see the Auto Erase Circuit description).

STORAGE CIRCUIT

General

The Storage Circuit provides the voltage levels necessary to operate the flood guns, collimation electrodes and target backplates. The storage cathode-ray tube has two targets for split-screen operation; therefore, two identical erase generators are provided, each consisting of an Erase Multivibrator and a Target Control Amplifier. These circuits produce an erase waveform to erase written information. Additional circuitry includes the Enhance Generator, which permits very fast single sweeps to be stored, and the INTEGRATE switch, which permits a stored image of a number of repetitive sweeps, each of which would be too fast to store alone as a single sweep event. Fig. 3-5 shows a detailed block diagram of the Storage Circuit.

Storage Tube Basic Operating Principles

The Tektronix T5641 CRT used in the Type 564B is a direct-view storage cathode ray tube with a split screen viewing area that permits each half to be individually operated for stored displays. The storage target stores electrical charges on an insulated surface by using the secondary emission properties of the surface. The stored charge is then used to control the flow of electrons to a phosphor screen to give the visual output that corresponds to the location of the stored charge.

The storage cathode ray tube contains special storage elements in addition to the conventional writing gun elements. The operating mode of the tube depends primarily on the voltages applied to these storage electrodes. With one condition of applied potentials, the storage screen or target backplate operates in the ready-to-write state; then, when it is bombarded with high energy writing beam current, the bombarded portion shifts to the stored mode to store a written display. With a different set of applied voltages, the screen (target) operates in the conventional mode, similar to conventional cathode ray tube.

The storage screens contain a special coated surface which continues to emit light when bombarded by the flood gun electrons, provided the surface has been written by the writing gun beam and shifted to the stored state. The two targets are electrically isolated from each other, which al-

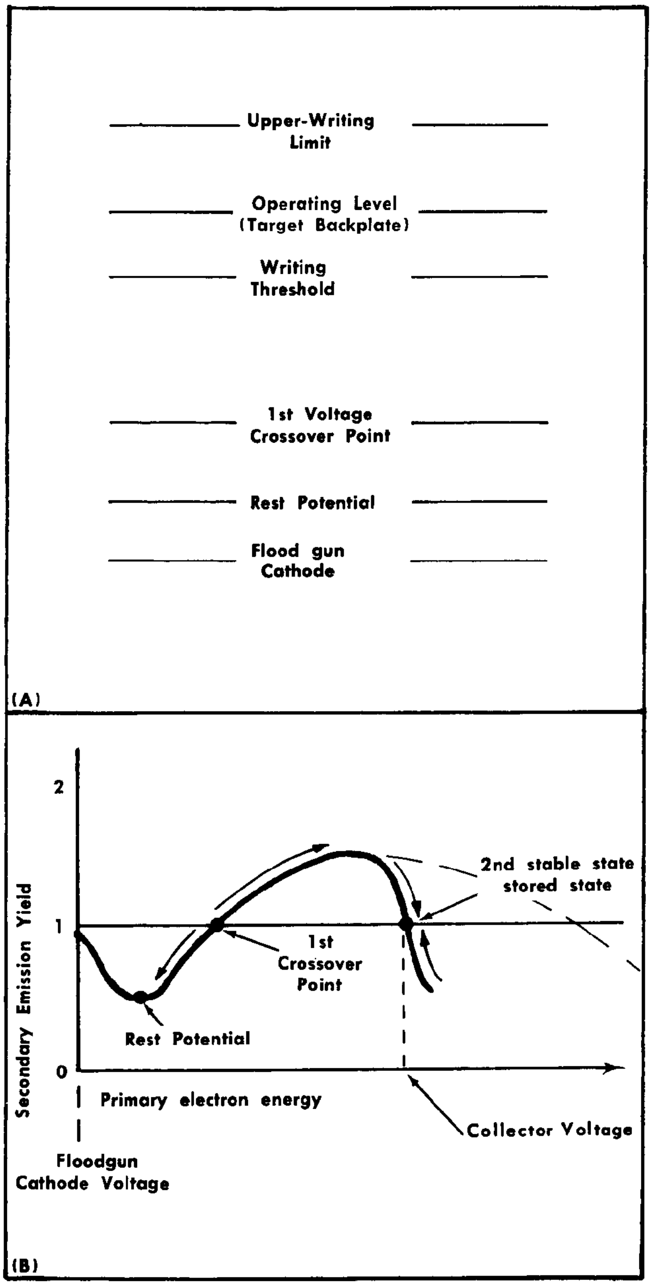


Fig. 3-7. (A) Relative scale of characteristic storage-tube operating potentials; (B) secondary emission curve for insulator showing charging direction.

lows simultaneous presentations of stored information on one half and non-store (conventional) information on the other half of the viewing area.

Fig. 3-6 illustrates the basic construction of the T5641 storage tube. The flood guns are low-energy electron guns which direct a large area flow (or cones) of electrons toward the entire screen. The collimation electrodes shape the flood spray for uniform coverage of the storage targets. The operating level of the tube is the potential difference between the target backplates and the flood gun cathodes. The collimation electrodes have no effect on the bombarding energy of the flood gun electrons.

In the store mode ready-to-write state, the insulator surface of the target tends to charge down to a potential lower than the backplate potential, and toward the potential of the flood gun cathode. This is due to flood gun current from the insulator surface. The potential to which the target charges is callled its rest potential. This potential is such that the flood gun electron landing energy is not enough to illuminate the phosphor in the target. The target is now ready to write. See Fig. 3-7.

In the writing process, the target is scanned by the writing gun electrons. These high energy electrons increase the target secondary emission over the area they scan, so that the ratio of secondary current to primary current becomes greater than one. (This is shown in Fig. 3-7B as the first crossover point.) When this ratio exceeds one, that part of the bombarded surface shifts to a new stable state. Writing has been accomplished and this segment of the target is now stored.

In the written state, the potential difference between the flood gun cathode and target becomes greater and the flood gun electrons now have a landing energy that is sufficient to provide a visual display. This visual display will continue as long as the flood gun beam covers the target.

At high sweep rates, the writing beam current is not adequate to bring the portion of the target scanned above the crossover point; therefore, the flood gun electrons when landing on the bombarded area will remove the charge developed by the writing gun electrons, and the target will discharge to its initial ready-to-write state without being written. Thus, complete writing is a function of writing beam current density.

When the stored display is no longer desired, the information is erased by a waveform as illustrated in Fig 3-8. A positive-going pulse is first applied to raise the backplate voltage above the writing threshold and write the entire target area with flood gun electrons. Next, the backplate voltage is pulled well below the rest potential, then as the backplate voltage is gradually returned, the target is charged to the rest potential and the target is now in the ready-to-write state.

For a comprehensive study of storage tube operating principles, a Tektronix Circuit Concepts paperback book entitled "Storage Cathode-Ray Tubes and Circuits" is available through your local Tektronix, Inc., Field Office or representative. Tektronix Stock No. 062-0861-00.

Flood Guns and Collimation Electrodes

Two low-energy electron guns, or flood guns, are used in the Type 564B. The cathodes are grounded and the Flood Gun Bias control, R478, is adjusted to set the bias at approximately —50 volts.

The collimation electrodes serve as an electrostatic lens to distribute the flood gun electrons uniformly over the storage target, and they have no effect on the landing energy of the electrons. CE1, CE2 and CE3 cause the flood electrons to converge, while CE4 and CE5 provide fine adjustment of the flood electron trajectories to cover the extreme rim of the targets and optimize uniformity of the target coverage. Zener diode D473 maintains a 50-volt drop to establish the +250-volt level applied to CE2, while the setting of R475, Geometry, establishes the level applied to CE1

(Flood Gun Anode). Potentiometer R470 (Collimation #1) provides a means of varying the DC levels applied to CE3 to obtain the correct electrostatic lens configuration. Voltage levels for CE4 and CE5 are established by divider network R462-R463-R465-R467. R462 (Collimation #2) is adjusted to achieve uniform luminance. The Target Control Amplifiers control CE4 and CE5 during the erase pulse so that correct collimation is maintained when the operating level of the tube is changed.

Target Control Amplifiers

The Target Control Amplifiers are incorporated to maintain a high degree of control of the upper and lower storage target backplate voltages. These are emitter-follower operational amplifiers, consisting of Q347 and Q351 for the upper target backplate, and Q447 and Q451 for the lower target backplate. The amount of output accuracy is limited primarily only by the tolerances in the values of the passive elements used in the input and feedback networks. A bootstrapping circuit is provided for each Target Control Amplifier to maintain transistor operating voltage during the positive-going portion of the erase waveform (fade positive) and to provide correct collimation at the same time. The bootstrapping circuits will be described in full detail in the Erase Generator discussion.

A separate STORE switch is provided for each Target Control Amplifier, SW300 (upper) and SW400 (lower), allowing the target backplates to be operated individually. In the STORE mode, when the STORE switches are pushed in and the CRT is shifted to the ready-to-write state, the backplate voltages are adjusted individually by the Op Level controls, R332 and R342. These controls set the value of current to the operational amplifier null points (Q347 and Q447 bases). In the non-store, or conventional mode, the backplate voltages are established by adjustment of R342, Non-Store Level.

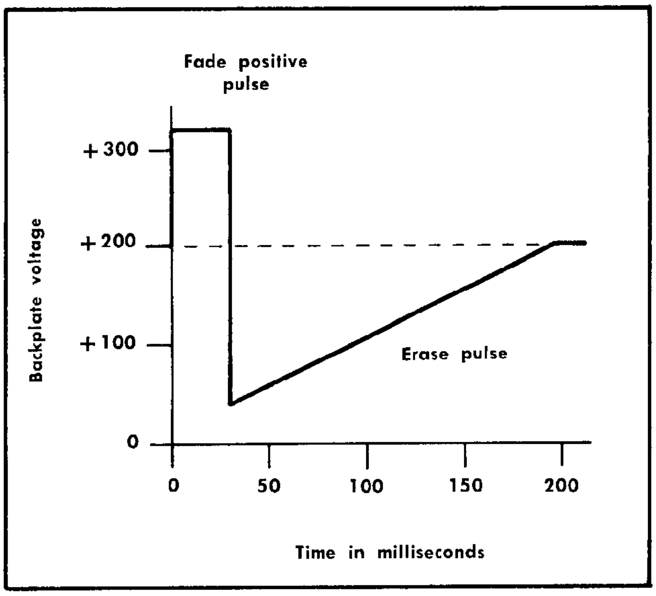


Fig. 3-8. Typical erase cycle waveform.

Erase Generator

NOTE

The following description applies to both erase generators, however, the circuit numbers used are those of the upper circuit.

In order to erase the stored display, a fade-positive pulse is first applied to the storage target backplate. This increases the potential difference between the flood gun cathodes and target backplate, raising the operating level above the upper writing limit and writing the entire target area with flood gun electrons. Next, the backplate voltage is pulled negative, well below the retention threshold. Then as the backplate voltage is gradually returned, the target is charged to the rest potential and returned to the ready-to-write state. The following paragraphs describe how the erase waveform is generated.

The Erase Multivibrator is composed of Q325, Q328 and their associated circuit components. This is a monostable multivibrator, with Q325 quiescently saturated and Q328 cut off. The collector potential of Q328 is set slightly above ground by the conduction of D329. Capacitor C323 is charged to the voltage difference between the R321-R322 juncture (about —9 volts) and the Q328 collector.

When the ERASE button is pushed, the contacts of SW304 are closed, grounding R305. This produces a negative-going step which turns Q325 off and Q328 on. The collector of Q328 snaps down to about —12 volts as the transistor saturates, drawing current through R338 and R353, causing the operational amplifier system to pivot about its imaginary fulcrum and pulling the target backplate positive. Thus the operating level is increased and the entire target area is written.

When Q328 turns on, the negative-going step produced at its collector is also coupled through C323, turning D322 off and ensuring cutoff of Q325. C323 begins to discharge through R321 and after an RC-controlled time of about 30 milliseconds, current through R321 has diminished sufficiently to allow the voltage at the anode of D322 to rise above the turn-on level. The base of Q325 is also raised to the turn-on level, and the multivibrator is switched back to its quiescent state.

While Q328 is conducting, the charge on C330 is removed. When Q328 turns off, its collector rises rapidly and is clamped slightly above ground by D329. This produces a positive-going step which is coupled through C330, reverse biasing D330. Once again, the operational amplifier system pivots about its imaginary fulcrum, pulling the target backplate negative, well below the rest potential. As C330 charges, the voltage at the R331-R332 juncture decays from zero volts to —12.8 volts at an RC-controlled rate until D330 turns on and clamps it. This negative-going sawtooth voltage is applied to the operational amplifier, which produces a positive-going sawtooth to raise the backplate to the ready-to-write state. In addition to setting the quiescent operating level of the CRT, R332 proportionately sets the amplitude of the sawtooth portion of the erase waveform. R334 and R335 then determine not only the minimum DC operating level of the CRT, but also the minimum value of the sawtooth applied to the backplate by the combined effective resistance seen at their juncture.

When the CRT is shifted from the conventional mode to the store mode, pushing the STORE button grounds C301, producing a negative trigger to switch the Erase Multivibrator and prepare the target for storage by applying an erase waveform. Remote erase function is provided through J950. A switch closure to ground or application of a negative-going pulse causes differentiating network C317-R318 to produce a negative-going trigger, which is applied through D318 to the Erase Multivibrator.

When the Auto Erase feature is used, the switching pulse from the View Time Multivibrator is applied through R310 to the input of the Erase Multivibrator. The negative-going step produced at the collector of Q328 when the Erase Multivibrator is switched to its unstable state is applied to the Erase Detector. The action of the Auto Erase Circuit is described in full detail later in this section.

Maintaining operating voltage for Q347 and Q351 during the fade positive portion of the erase waveform, when Q351 emitter is pulled positive, is accomplished by bootstrapping. The voltage drop across Zener diode D356 sets the base of Q358 150 volts below the emitter of Q351. This voltage drop is kept constant under dynamic conditions by the essentially constant current established through R357, which is clamped by the Q358 forward bias voltage (V_{be}) when the emitter of Q351 is suddenly stepped positive by the erase waveform, the base of Q358 is stepped positive by the same amplitude. Q358 emitter follows the base, and the positive-going step is coupled through C355 to raise the collector of Q351 positive by essentially the same amplitude as that at its emitter, thus maintaining a fairly constant collector-to-emitter voltage. This action reverse biases D350, disconnecting the +300-volt supply.

The positive-going pulse at Q351 collector is also connected through D355 and C462 to collimation electrodes CE4 and CE5 to provide correct collimation. When the fade positive pulse is terminated and the emitter of Q351 is pulled negative, D357 turns off, disconnecting the bootstrap circuit and allowing the collector of Q351 to return to its +300-volt level.

Enhance Generator

Writing speed is primarily a function of the writing gun beam current density and physical properties of the storage tube. At very fast sweep speeds, the writing beam does not charge the scanned portions of the target sufficiently to shift them to the stored state, and the flood gun electrons discharge the small deposited charge back down to the rest potential before the next sweep.

Writing beyond the normal writing speed of the CRT is attained through the process of enhancement or integration. First to be discussed will be enhancement.

The enhance generator produces an approximate one-millisecond negative-going pulse which is applied to the operational amplifier summing point, resulting in a positive-going pulse to the target backplate. This conditions the target so that less writing gun current is required to shift the scanned section to the stored state.

Q370, Q374 and their associated circuitry form a monostable multivibrator. Operation of this circuit is similar to that described for the Erase Multivibrator. When either ENHANCE switch (SW340 or SW440) is pushed in, Q370 has a conduction path to ground through R370. Saturation voltage at Q370 collector holds Q374 cut off. The negative-going portion of the multi-trace sync pulse from the time-base plug-in unit is coupled through C361 to switch the Enhance Multivibrator. Q370 turns off and Q374 turns on. The collector of Q374 snaps down to about —12 volts, producing a negative-going step which turns off D368. The length of time that the multivibrator remains in this state (and thus the pulse width) is determined by the setting of R366, LEVEL, and the values of R367 and C367. The amplitude of the pulse which is applied to the operational amplifier summing point is determined by R373, Enhance (amplitude).

When the Auto Erase feature is used, the Enhance Multivibrator is prevented from switching during the "view time". This is accomplished by essentially grounding R364, which holds D365 reverse biased.

Integrate

The second fast writing technique to be discussed is integration. In this mode of operation, the flood gun beam is interrupted momentarily, allowing the writing gun beam to sum small amounts of charge for successive sweeps so that when the flood electrons are again turned on, the scanned target area shifts to the stored state. This is accomplished by pressing SW480, INTEGRATE, which disconnects the flood gun cathodes from ground. This also connects a resistor into the divider network in the High Voltage Regulator circuit to shift the high voltage slightly, correcting for the deflection sensitivity changes that occur when the flood guns are turned off. Releasing the INTEGRATE switch, then, allows the display to shift to the stored state.

AUTO ERASE CIRCUIT

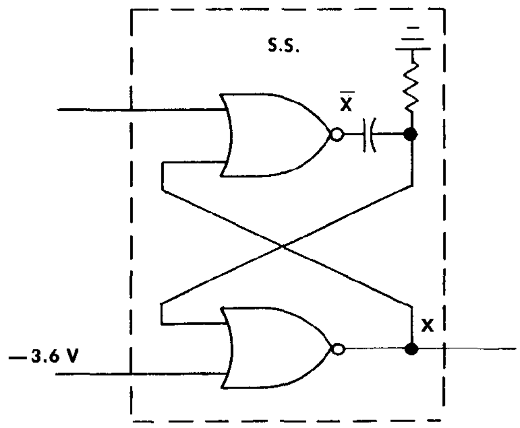
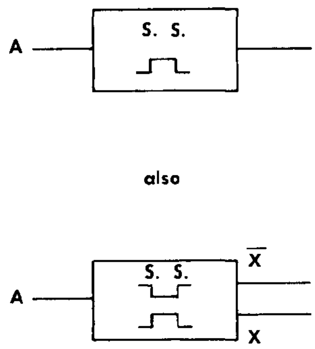
General

The Auto ERASE Circuit provides a negative-going pulse to trigger the Erase Generator from less than one second to several seconds after a sweep is stored. While a display is stored, the CRT is blanked and the Enhance Generator is locked out to prevent altering the display. The circuit is comprised primarily of an End of Sweep Detector, a Start of Erase Detector, a logic circuit, and a View Time Multivibrator. Other features of this circuit include periodic erase operation (provided by free running the View Time Multivibrator), and a mode of operation in which the erase pulse is utilized to trigger the sweep. The latter will be discussed under Erase-Triggered Sweep.

Logic

Logic symbols and terminology used in this circuit description are approved by the American Standards Association, document ASA Y32.14 - 1962 and Military Standard 806C - 1965. In this discussion, the high voltage level corresponds to about zero volts and the low voltage level corresponds to about —3.6 volts. Following a brief description of the two-state devices used in this sytem, the circuit action will be discussed.

Single Shot. Fig. 3-9A. This device is activated by the transition of the input signal to the high state. The normal,

<table>
<tr><th>Circuit Diagram</th><th>Symbol</th><th>Truth Table</th></tr>
<tr><td>
(A) Single Shot</td><td></td><td>A | X | X̄
L→H | L→H→L | H→L→H
H→L | No change

A | X | X̄
L→H | L→H→L | H→L
H→L | No change | L→H

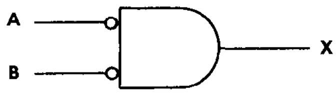
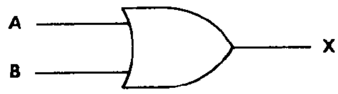
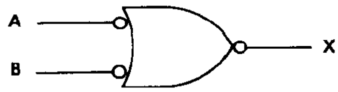
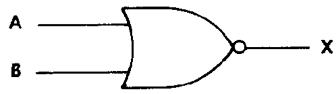
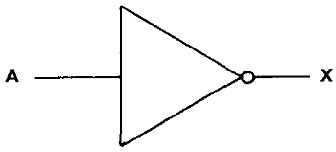
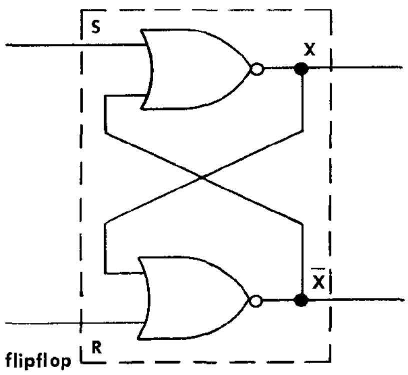
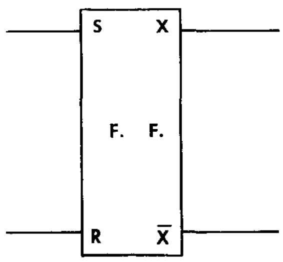
Table 1 is true when the input pulse duration is shorter than the characteristic time of the device; Table 2, vice versa.</td></tr>
<tr><td>(B) —NAND gate</td><td></td><td>A B | X
H H | L
H L | L
L H | L
L L | H</td></tr>
<tr><td>(C) +OR gate</td><td></td><td>A B | X
H H | H
H L | H
L H | H
L L | L</td></tr>
<tr><td>(D) —OR gate</td><td></td><td>A B | X
H H | H
H L | L
L H | L
L L | L</td></tr>
<tr><td>(E) +NOR gate</td><td></td><td>A B | X
H H | L
H L | L
L H | L
L L | H</td></tr>
<tr><td>(F) Inverter</td><td></td><td>A | X
L | H
H | L</td></tr>
<tr><td>
(G) RS flipflop</td><td></td><td>S R | X X̄
L L | No change
H L | L H
L H | H L
H H | Undefined</td></tr>
</table>

Fig. 3-9. Logic symbols and truth tables for the two-state devices used in the Auto Erase Circuit.

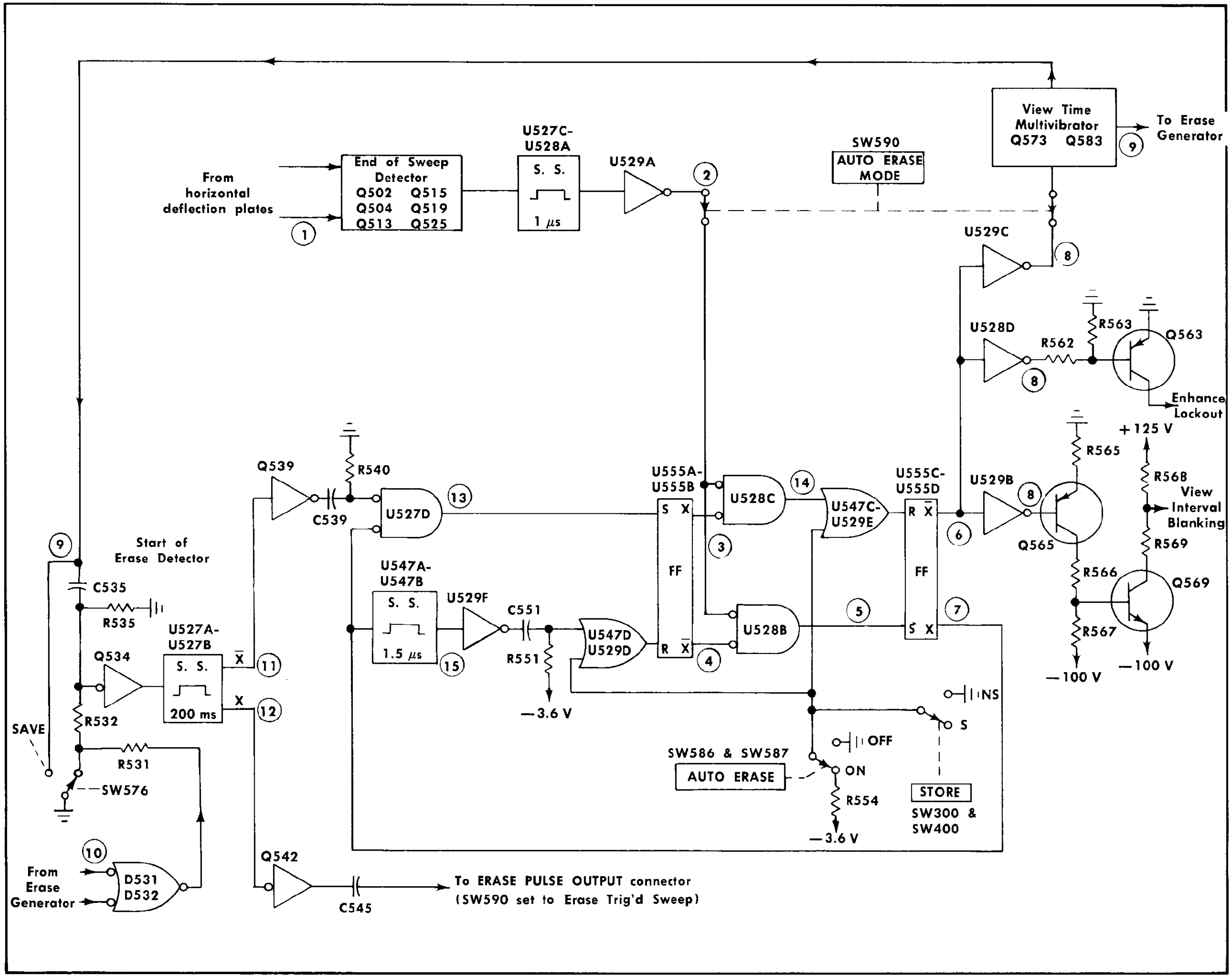


Fig. 3-10. Auto Erase Circuit basic block diagram.

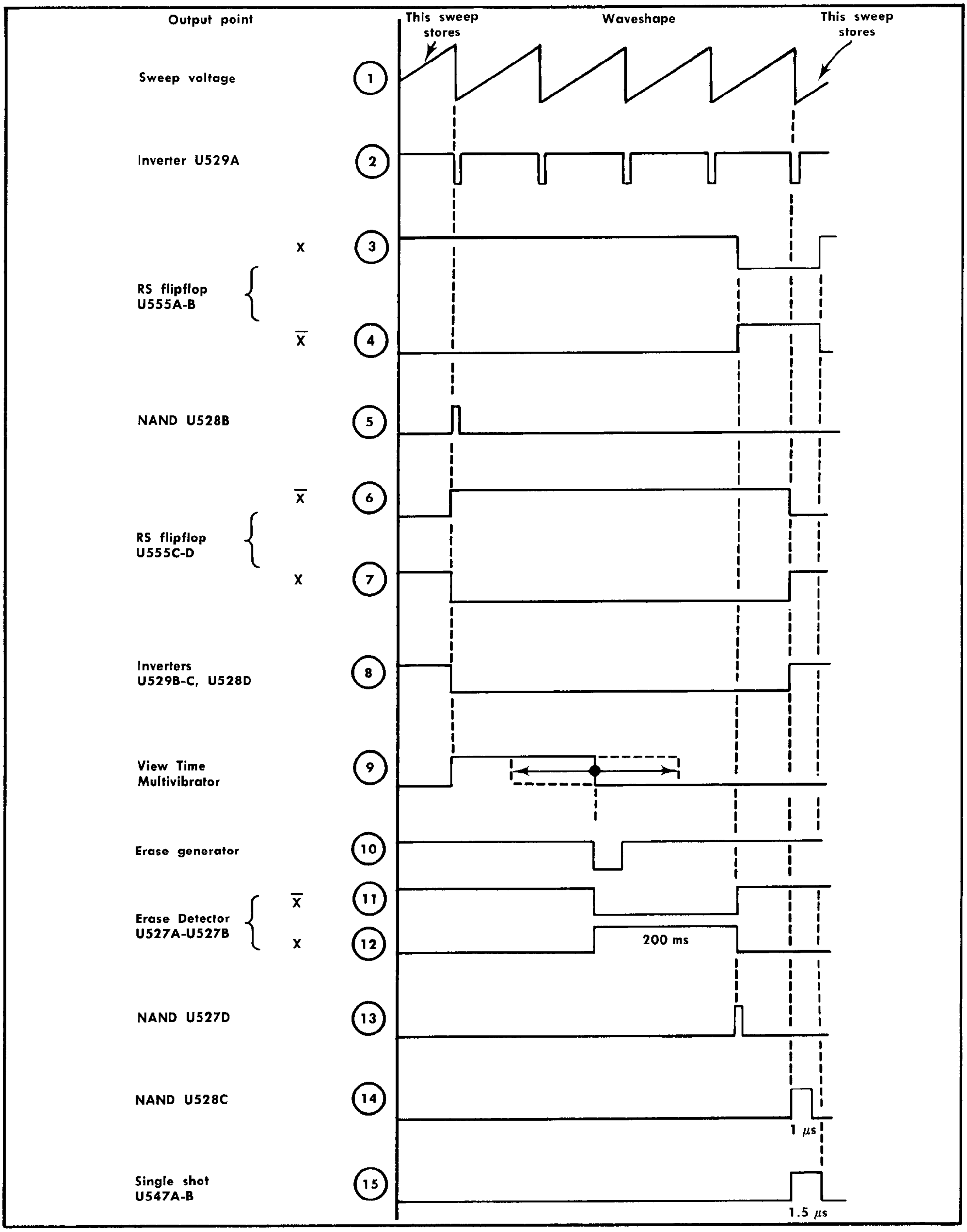


Fig. 3-11. Auto Erase Circuit timing diagram.

or inactive state of the single shot at its X output is the low state. When activated, it changes to the high state, remains there for the characteristic time of the device, and returns to the low state. If the $\overline{X}$ output is used, its state is controlled by either the input pulse at A, or by feedback from the X output, whichever is the longer duration of time. In this application, with the input pulse at A $\approx$ 30 milliseconds or less, and the characteristic time of the device $\approx$ 200 milliseconds, the $\overline{X}$ output is opposite that of the X output. See the accompanying truth table.

NAND gate. Fig. 3-9B. This device has two inputs. The activated output level is of opposite state in comparison to both inputs. In this circuit, the output will be high only when both inputs are low. Any other combination of input levels will produce a low at the output.

+OR gate. Fig. 3-9C. This device delivers an activated output whenever either one of its two inputs is at the same logic level as its output. In this circuit, a high level at either or both inputs will produce a high level at its output.

—OR gate. Fig. 3-9D. This device functions the same as the +OR gate described in the preceding paragraph; however, a low level is required at either input in order to produce a low level activated output.

+NOR gate. Fig. 3-9E. With this device, the activated output requires the existence of its logical opposite on any one or more inputs. In this circuit, a high level at either or both inputs will produce a low level at its output.

Inverter. Fig. 3-9F. This device is used to attain the opposite state. The output will be high when the input is low, and vice versa.

RS flipflop. Fig. 3-9G. This is a bistable device which, when triggered, will change its output levels from one stable state to the other stable state. The RF flipflop has two inputs, labeled SET and RESET, and two outputs, $\overline{X}$ and X. The application of a high to both inputs will cause the flipflop to revert to an undefined state. The application of a high to the RESET input will cause the flipflop to exhibit a high at its X output and a low at its $\overline{X}$ output (this is the reset condition). If a high is then applied to the SET input, the flipflop will change to a low at the X output and a high at the $\overline{X}$ output (this is the set condition). Reversion of either input to the low state will not alter the state of the outputs. With proper input conditions, the outputs will always be the complement of one another.

For additional information and internal wiring of these integrated circuits, refer to the manufacturer's specifications.

Basic Logic Diagram

The basic logic diagram of the Auto Erase Circuit is shown in Fig. 3-10. Fig. 3-11 is a timing diagram to be used in conjunction with Fig. 3-10, showing the waveshape relationship of points keyed on the basic logic diagram. It is understood that either or both of the upper and lower STORE and AUTO ERASE switches are on (pushed in).

Assume that the Auto Erase Circuit is reset and the storage target is ready to write. The input signal to the vertical amplifier unit triggers the sweep circuits and as the sweep runs, a new display is written and stored on the CRT screen. The sweep sawtooth is applied to the horizontal deflection plates and also to the End of Sweep Detector (point 1)[3], which senses the sweep termination and produces a positive trigger pulse at a time corresponding to the time that the sweep ends. This trigger pulse is applied to the single shot, U527C-U528A. The output of the single shot goes to the high state, applying a high to inverter U529A. The output of U529A (2) goes low, applying a low level to NAND gates U528B and WU528C. The other input to U528C is connected to the X output of RS flipflop U555A-B (3), which is high because the flipflop is in the reset condition, so the output of U528C (14) remains unchanged. The other input to U528B, however, is connected to the $\overline{X}$ output of U555A-B (4), so with both inputs low, the output of U528B (5) goes high. This high is applied to the SET input of RS flipflop U555C-D, producing a high at its $\overline{X}$ output (6) and a low at its X output (7). The RS flipflop remains set, even after the single shot reverts to its inactive state and causes the SET input to go low.

When the $\overline{X}$ output of U555C-D (6) goes high, the outputs of inverters U528D, U529B and U529C (8) go low simultaneously. The low from U529C is connected through SW590 to switch the View Time Multivibrator to its unstable state. The low from U528D causes Q563 to saturate, which provides a conduction path for D363 in the Enhance generator, locking out triggering information that would switch the enhance multivibrator. The low from U529B turns on Q565, raising the base level of Q569. Q569 saturates, applying about —100 volts to the CRT writing gun grid to cut the CRT off.

When the View Time Multivibrator reverts to its stable state (9), the erase cycle waveform is initiated in the erase generator (10). Also, the negative-going transition produced at the collector of Q583 is differentiated by C535-R532-R535 and applied to the Start of Erase Detector, which consists of NOR gate Q534 and single shot U527A-B. (In all positions of the VIEWTIME control except the full clockwise SAVE position, the juncture of R531-R532 is grounded through SW576.) At a time corresponding to the time that erasure of the storage target is completed (about 200 milliseconds after the Erase Multivibrator is triggered by the View Time Multivibrator output), the single shot reverts to its inactive state. The X output of U527A-B (12) goes low, but is not used at this time; however, the $\overline{X}$ output (11) goes high, applying a high level to the input of inverted Q539. The output of Q539 goes low, which when differentiated by C539-R540 appears as a negative-going pulse applied to the input of NAND gate U527D. Since the other input to U527D is held low by the X output of U555C-D (7), the output of U527D (13) is a short-duration positive-going pulse. This pulse is applied to the SET input of RS flipflop U555A-B, causing the outputs to switch from one stable state to the other. The high output (4) is now applied to NAND gate U528B and the low (3) to NAND gate U528C. U555A-B remains set after the SET input goes low.

The logic circuit is reset by the termination of the next sweep. This is so that the CRT does not become unblanked in the middle of a sweep, permitting only the latter portion of the display to be stored. The End of Sweep Detector senses the sweep termination (1) and triggers single shot U527C-U528A, which results in a momentary low (2) applied simultaneously to NAND gates U528B and U528C, as previously discussed. U528C now has two low inputs, so its

[3]**Text is keyed to points and waveforms given in Figs. 3-10 and 3-11.**

output goes high (14). The output of OR gate U547C-U529E goes high, which is applied to the RESET input of RS flipflop U555C-D. This resets U555C-D; that is the $\overline{X}$ output (6) goes low and the X output (7) goes high. The $\overline{X}$ output is applied to inverter U528D to remove the enhance lockout and to inverter U529B to enable CRT unblanking. The X output of U555C-D is applied to single shot U547A-B. this produces a high at its output (15), which is applied to inverter U529F. The output of U529F goes low, but the negative-going transition produced at the output of U529F when the single shot is activated is not used. However, when the single shot reverts to its inactive state, the positive-going transition produced at the output of U529F is differentiated by C551-R551 and appears as a positive-going pulse applied to the input of OR gate U547D-U529D. The output of U529D appears as a positive-going pulse applied to the RESET input of RS flipflop U555A-B. This causes U555A-B to reset, completing the cycle. The characteristic time of single shot U547A-B (15) is longer than that of U527C-U528A (2), so that U527C-U528A reverts to its inactive state, removing the low applied to NAND gates U528B and U528C before U555A-B can be reset.

When both AUTO ERASE switches (SW586 and SW587) are cut off, or if the oscilloscope is operated in the conventional mode (neither STORE switch pushed in), the two RS flipflops are locked in the reset condition in which a low is exhibited at the $\overline{X}$ output and a high at the X output, rendering the output circuits insensitive to any pulses produced by detector circuits. This is accomplished by holding the inputs of OR gates U547C-U529E and U547D-U529D in the high state, and thus holding the two RS flipflops reset.

The —3.6 volts for the logic circuit is established by emitter follower Q598, the base of which is set by voltage divider R594-R595 between ground and the —12.2-volt supply.

End of Sweep Detector

The End of Sweep Detector consists of transistors Q502, Q504, Q513, Q515, Q519 and Q525, tunnel diode D521, and their associated circuit components. A positive-going output pulse is produced when D521 is switched to its low state. The means by which this is accomplsiehd is discussed in subsequent paragraphs.

The push-pull sweep sawtooth signal that is applied to the horizontal deflection plates is also applied to the bases of amplifiers Q502 and Q513 through attenuating resistors (R500-R505 and R510-R512). R500 and R510 are of sufficient value to minimize loading of the deflection plates. The emitters of Q502 and Q513 are longtailed respectively through R507 and R508 to the +125-volt supply. As the sweep progresses to the right across the CRT, Q502 receives the negative-going portion of the signal and Q513 receives the positive-going portion. A significant portion of the Q513 emitter current is diverted to the Q502 emitter via C506 and R506. A positive-going sawtooth signal is developed at the collector of Q502 and applied to Q504 base, and a negative-going signal is developed at the collector of Q513 and applied to Q515 base. Q519 is saturated so that its base-emitter junction acts as a diode between Q504 emitter and capacitor C516. As Q504 emitter goes positive and Q515 emitter goes negative, an increasing charge is placed on C516. R518 limits the current to a safe level at the fastest sweep rate. Tunnel diode D521 is quiescently held in the high state by the Q504-Q519 current.

When the sweep terminates and retrace starts, Q504 emitter goes negative and Q515 emitter goes positive. C516 begins to discharge through R515 and R517. Since the capacitor voltage decays much more slowly than the rate of voltage change at the Q504 and Q515 emitters, Q519 and Q504 are turned off. When Q519 turns off, D521 switches to its low state and Q525 turns off. The voltage at the R524-R525 juncture goes to zero, producing the high level to activate single shot U527C-U528A.

D521 will return to its high state under either of two conditions; (1) a new sweep begins to restore the charge to C516, turning on Q519, and (2) the C516 charge decays sufficiently to allow R517 to turn on Q519. R521, R522 and R523 provide a voltage offset to effectively raise the D521 high-state voltage to the required turn-on level of Q525.

Diodes D507 and D508 protect C506 from excess voltage if either transistor Q502 or Q513 is removed from the circuit. C514 improves the noise immunity of the circuit. C519 and R519 form a decoupling network for the —12.2 volts applied to the collector of Q515.

View Time Multivibrator

The View Time Multivibrator is composed of Q573 and Q583. This multivibrator produces a negative pulse which initiates an erase cycle waveform, and also resets the logic circuit. The view time, (the length of time after a display is stored until it is erased) can be varied from less than one second to several seconds. If it is desired to save the display for a long time, a switch closure to ground (at maximum clockwise rotation of the VIEWTIME control) prevents the View Time Multivibrator output from reaching the erase generator. While normal operation of the multivibrator is monostable, an astable mode of operation can be attained to produce periodic erase pulses by grounding the ERASE PULSE OUTPUT connector.

Q573 and Q583 are each composite transistors, internally connected in a Darlington configuration. Quiescently Q583 is saturated and Q573 is cut off. Forward bias for Q583 is provided through R576 and R577. The —12-volt potential at the collector of Q583 is applied through R580 to hold Q573 cut off. During normal operation, diodes D590 and D591 have about —33 volts applied to their anodes to keep them reverse biased.

The multivibrator is actuated when the output of inverter U529C goes low upon termination of a sweep. The negative-going transition is differentiated by C571-R571-R573 and appears as a negative trigger at the collector of Q573. Capacitor C575 is charged to the voltage difference between Q573 collector (ground) and Q583 base (—11 volts). Since the charge on C575 cannot be removed instantaneously, the negative trigger also appears at the base of Q583,which turns Q583 off. The collector potential of Q583 rises rapidly, carrying with it the base of Q573. Q573 saturates and its collector is pulled down to about —12 volts, which drives Q583 base negative by an equal amount below its turn-on voltage.

C575 begins to discharge, and as it does, the base voltage of Q583 rises. The rate at which C575 discharges can be varied by adjusting the VIEWTIME control, R576. When the base of Q583 rises to the turn-on level of the transistor, Q583 saturates. The collector of Q583 is rapidly pulled down to about —12 volts, producing a negative-going step. Since the charge on C580 cannot be removed instantaneously, Q573 is driven into cutoff. This negative-going step is coupled through C584, where it is applied to the erase generators via D586, D587 and the contacts of switches SW586 and SW587.

When the ERASE PULSE OUTPUT connector is grounded, D590 becomes forward biased, allowing the multivibrator to free run at a rate that is adjustable with the VIEWTIME control, resulting in a periodic erase pulse. At the same time, a high level is applied via D591 to the logic circuit, holding the RS flipflops reset, which enables CRT unblanking and permits use of the Enhance Generator.

Erase-Triggered Sweep

On slower sweep rates where it may be inconvenient to wait for the Auto Erase circuit to reset before a display can be stored, the Erase-Triggered Sweep mode can be used. In this mode, a new sweep starts upon completion of erasure because the trailing edge of the 200-millisecond pulse from the Start of Erase Detector is used to trigger the time-base plug-in unit.

With the Auto Erase Mode switch, SW590, in the ERASE TRID'D SWEEP position, the output of inverter U529A is connected directly to the input of the View Time Multivibrator and a high is applied to the inputs of U547C and U547D to hold the RS flipflop reset. When the sweep terminates, single shot U527C-528A is actuated, producing a negative pulse at the output of U529A to switch the View Time Multivibrator to its unstable state. After an RC-controlled time determined by the setting of the VIEWTIME control, the multivibrator reverts to its stable state, initiating the erase pulse and activating the Start of Erase Detector. At a time corresponding to the end of the erase cycle ($\approx$ 200 milliseconds), single shot U527A-B reverts to its inactive state. Differentiating network C541-R541 produces a negative trigger which is applied to the base Q542. The result is a postive trigger at the collector of Q542 which is made available via the contacts of SW590 to the ERASE PULSE OUTPUT connector. This pulse can be applied via a coaxial cable to the Ext Trig Input connector of the time-base plug-in unit.

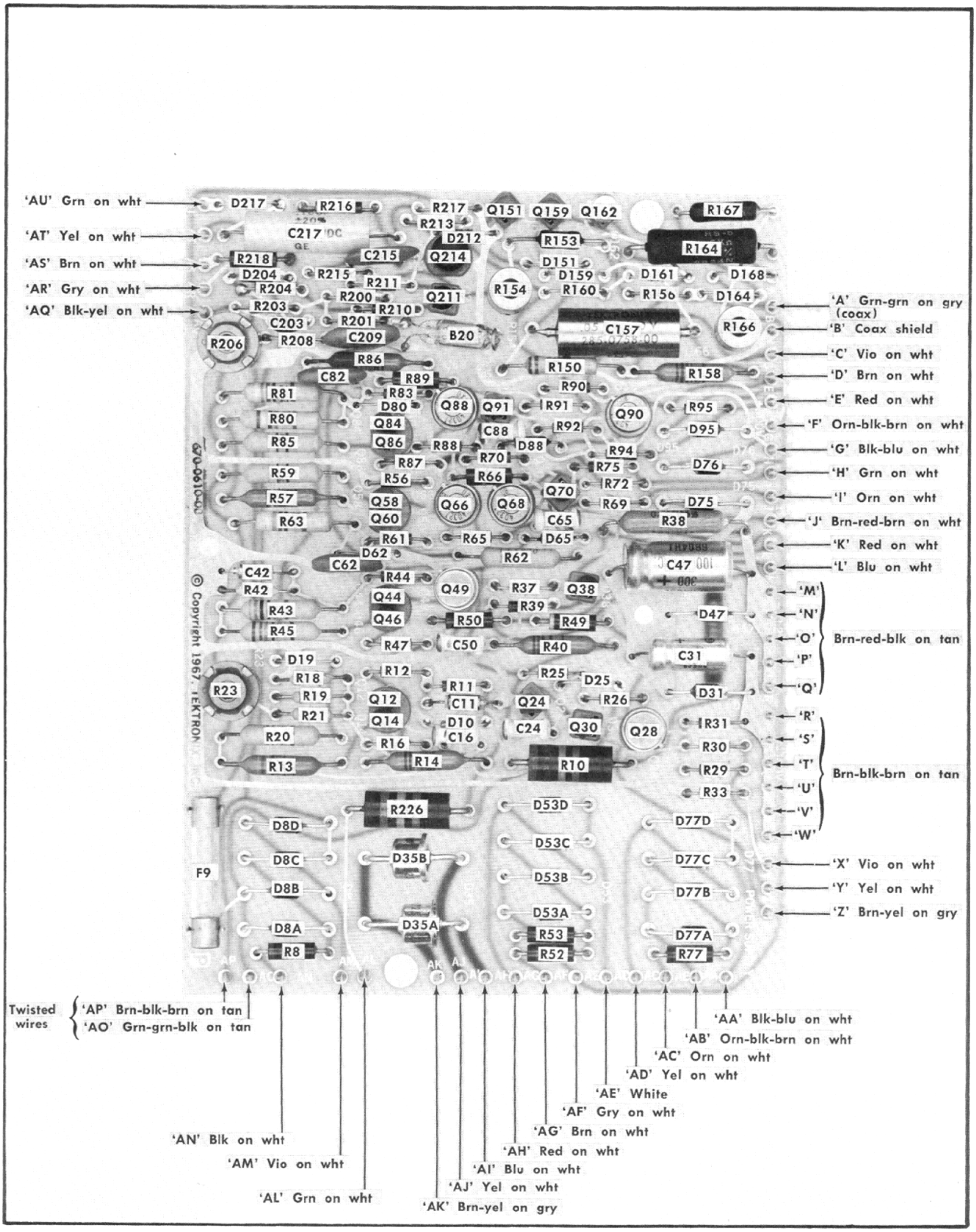


Fig. 4-5. Low Voltage Power Supply and 1 kHz Calibrator circuit board.

Ⓐ

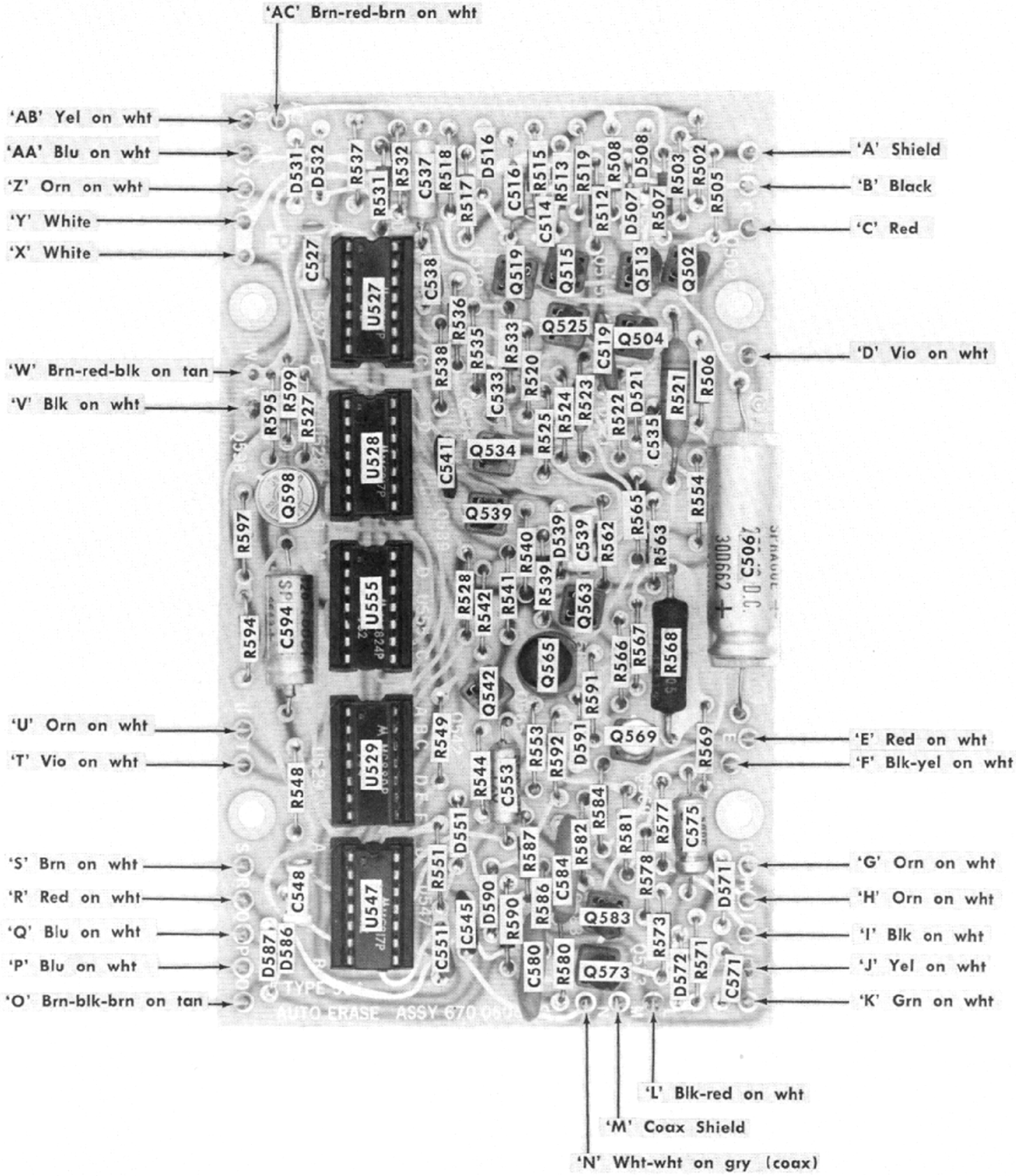
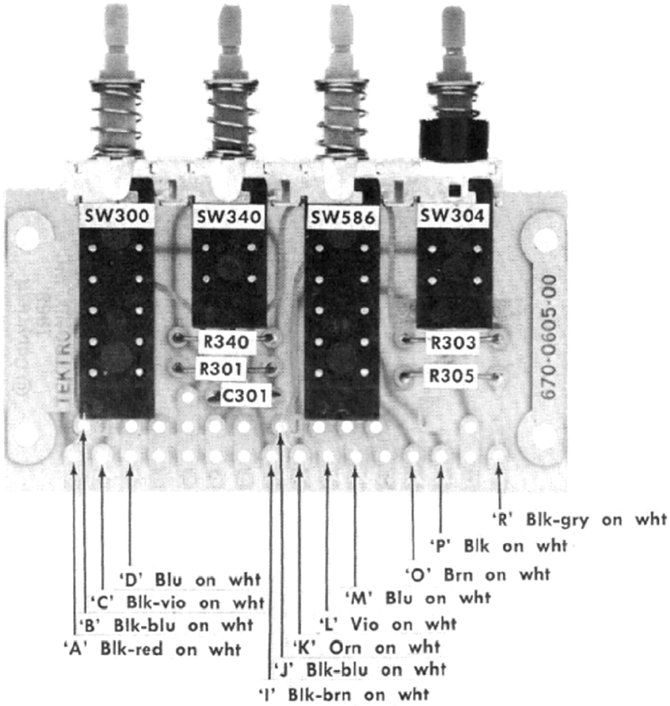


Fig. 4-7. Auto Erase circuit board.

(A)



(B)

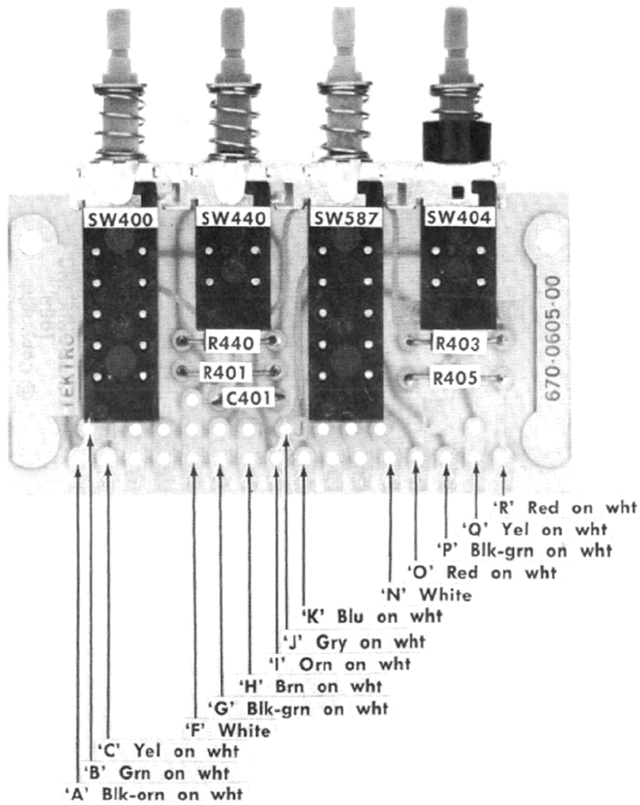


Fig. 4-8. Switch Interface circuit boards; (A) upper and (B) lower.

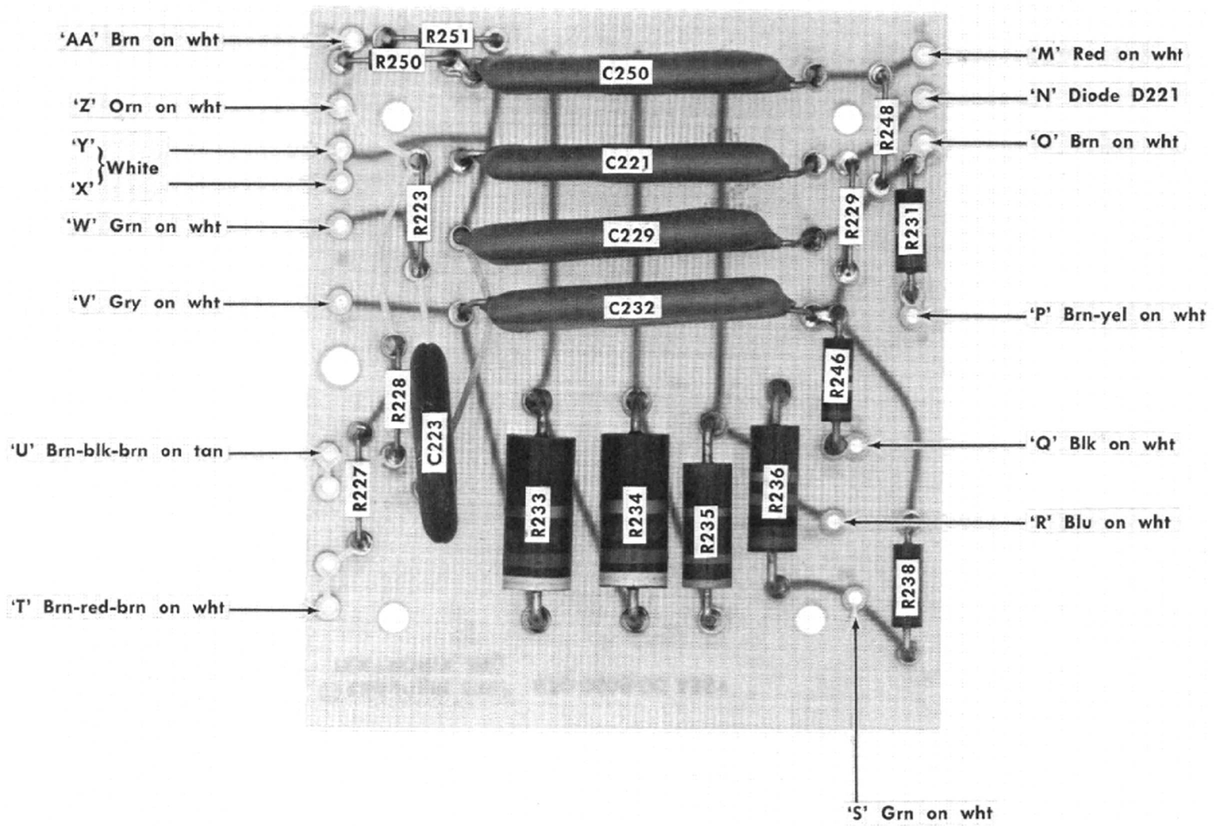


Fig. 4-9. Upper High Voltage circuit board.

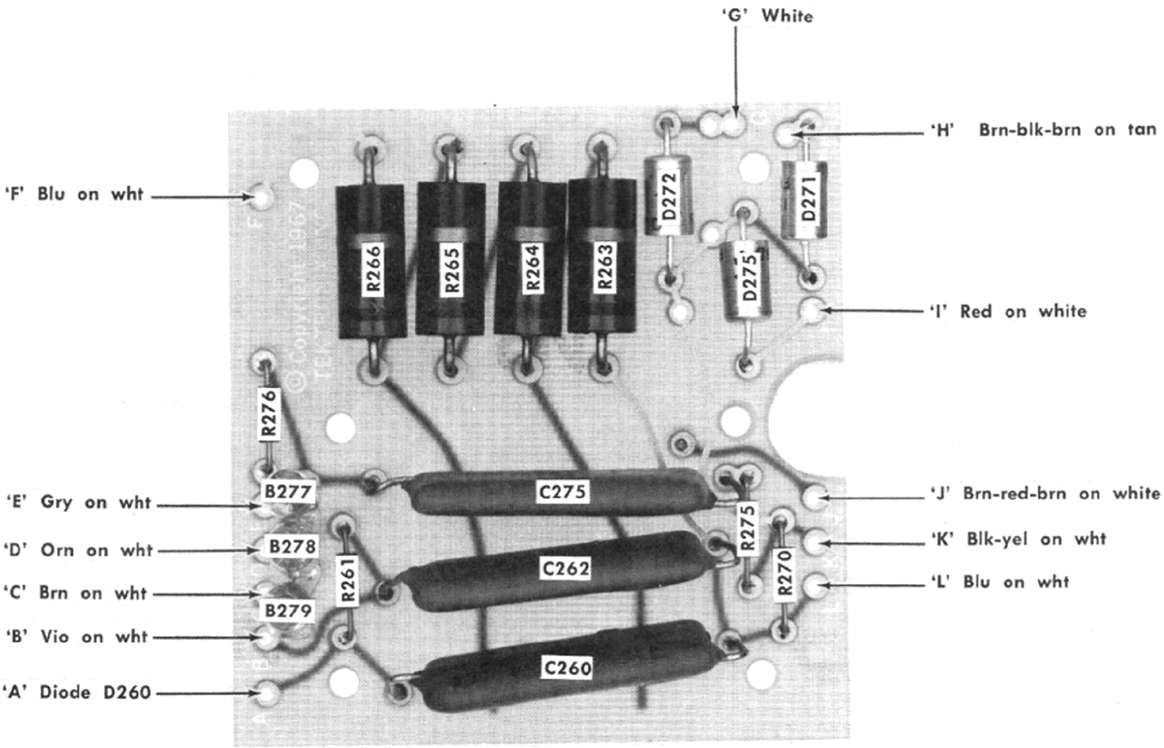
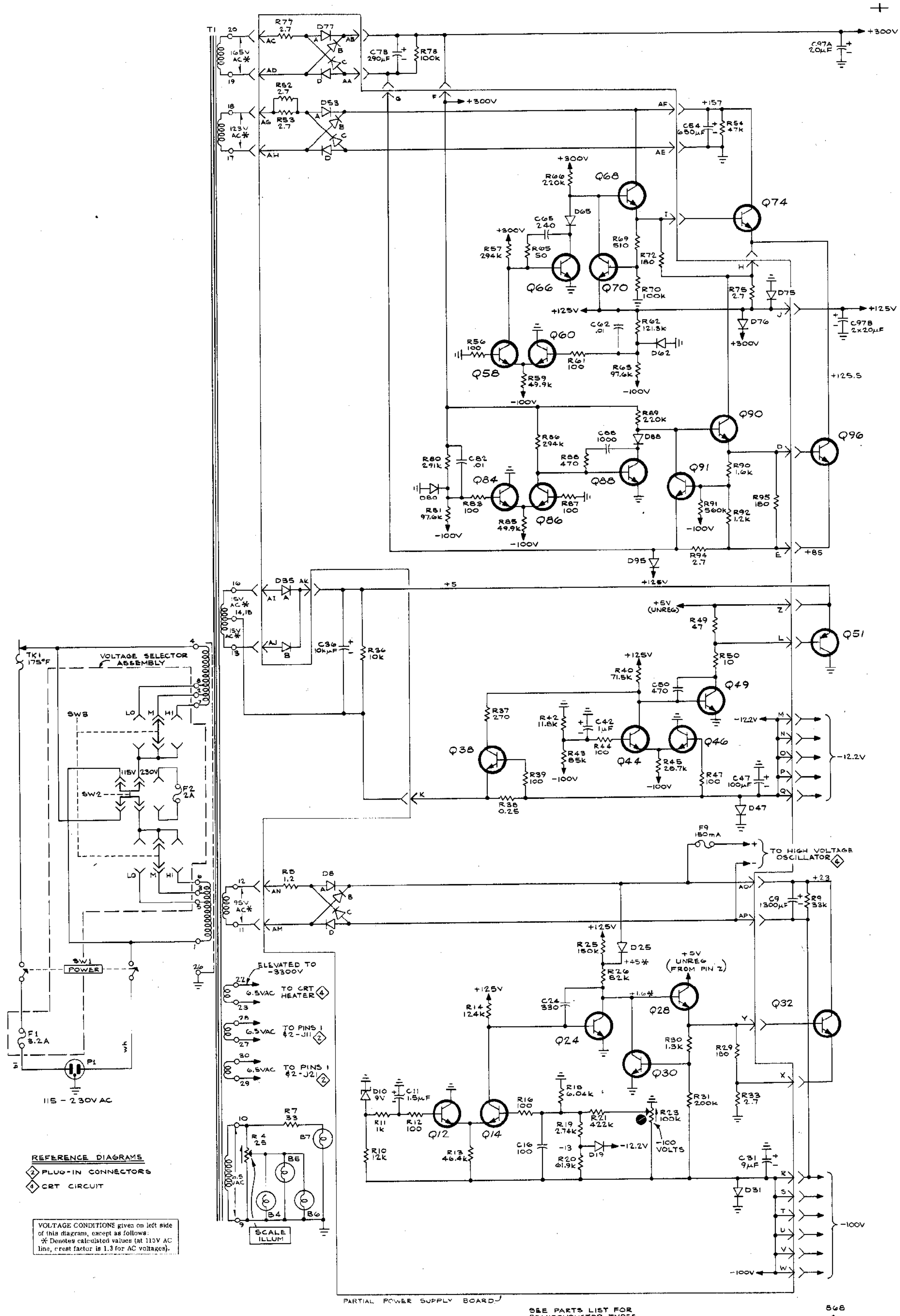


Fig. 4-10. Lower High Voltage circuit board.



REFERENCE DIAGRAMS

2 PLUG-IN CONNECTORS

4 CRT CIRCUIT

VOLTAGE CONDITIONS given on left side of this diagram, except as follows:
* Denotes calculated values (at 115V AC line, crest factor is 1.3 for AC voltages).

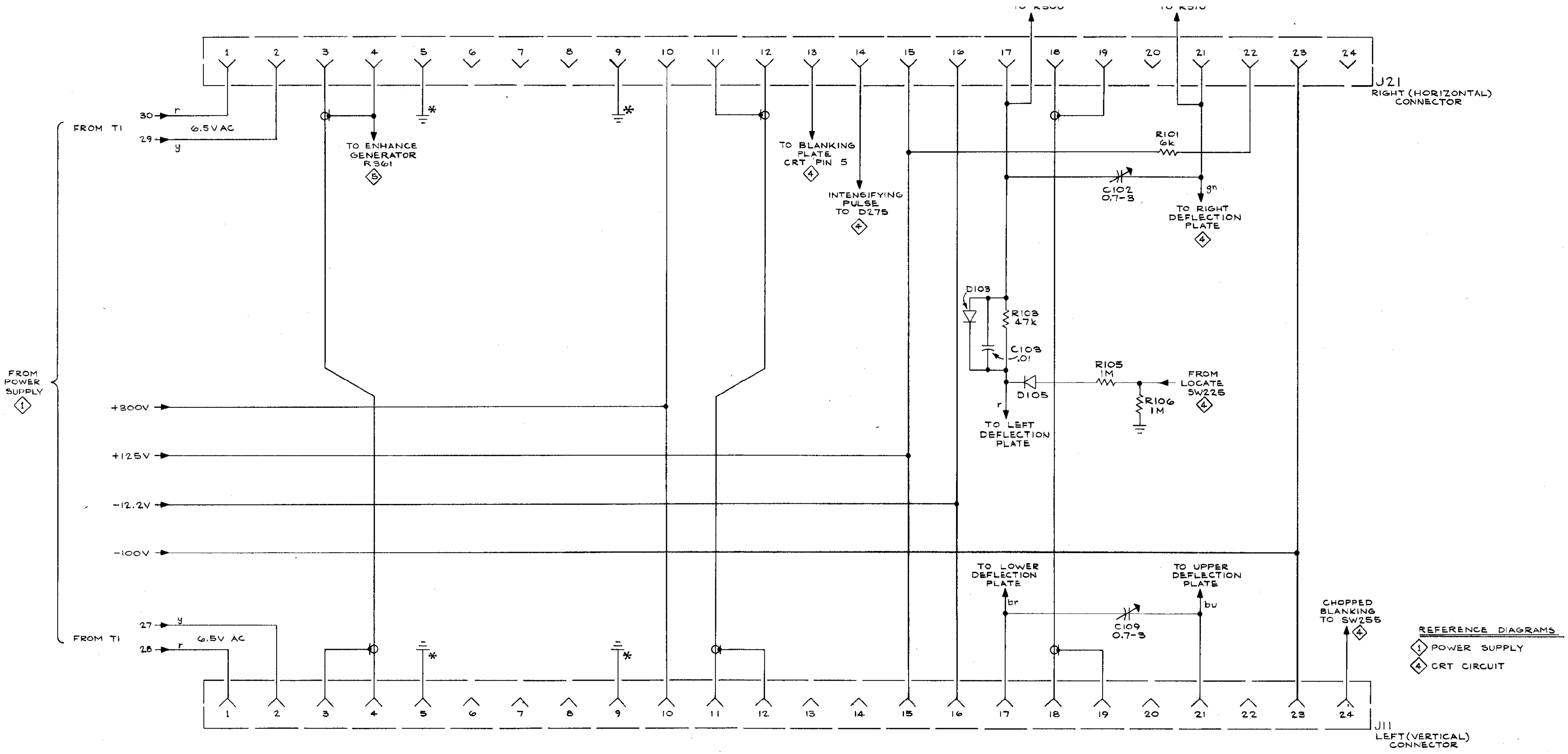
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

868

TYPE 564B-121N

A

POWER SUPPLY 1



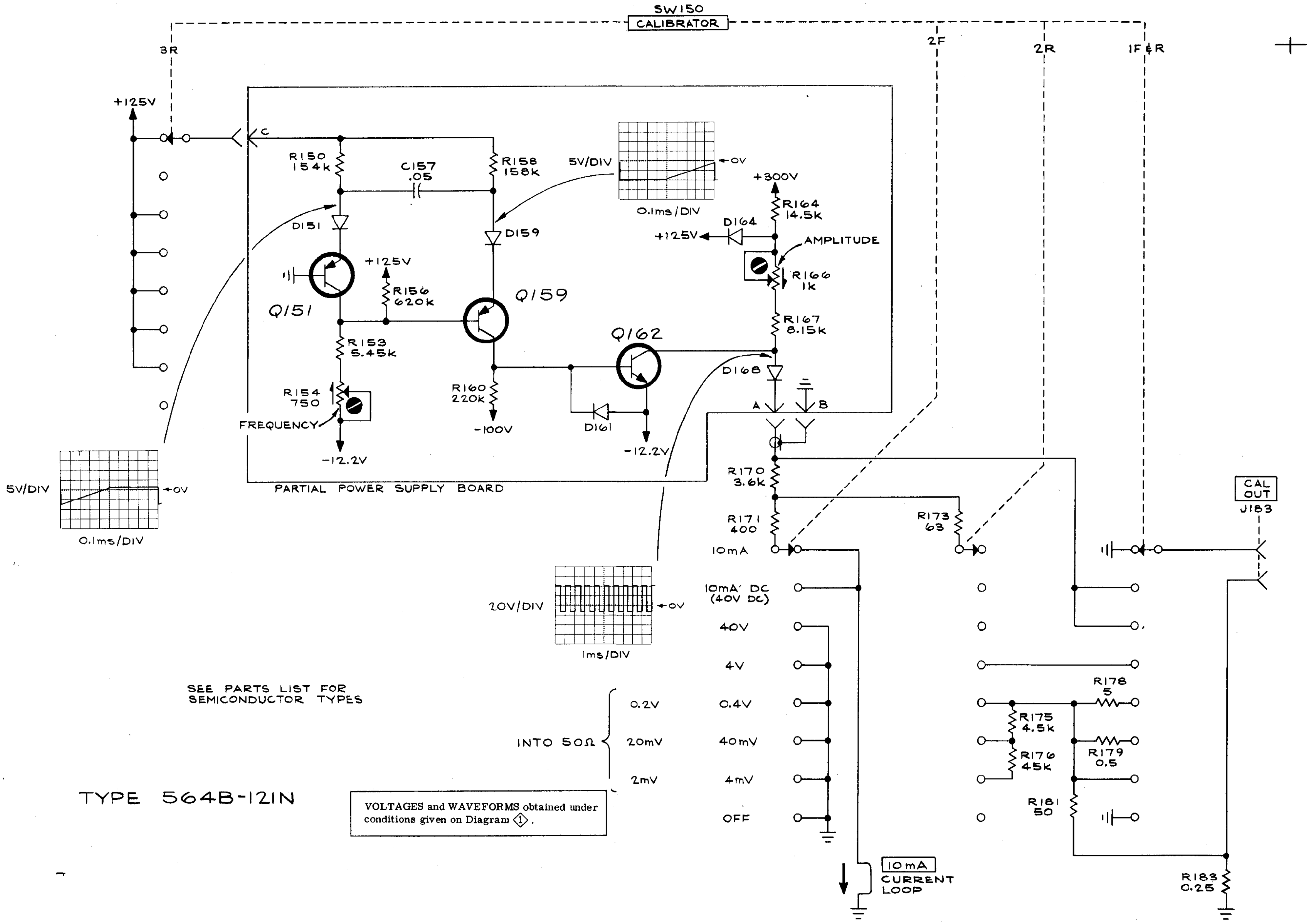
* RETURNED TO COMMON GROUND POINT NEAR C97.

868

PLUG-IN CONNECTORS ②

TYPE 564B-121N

A



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

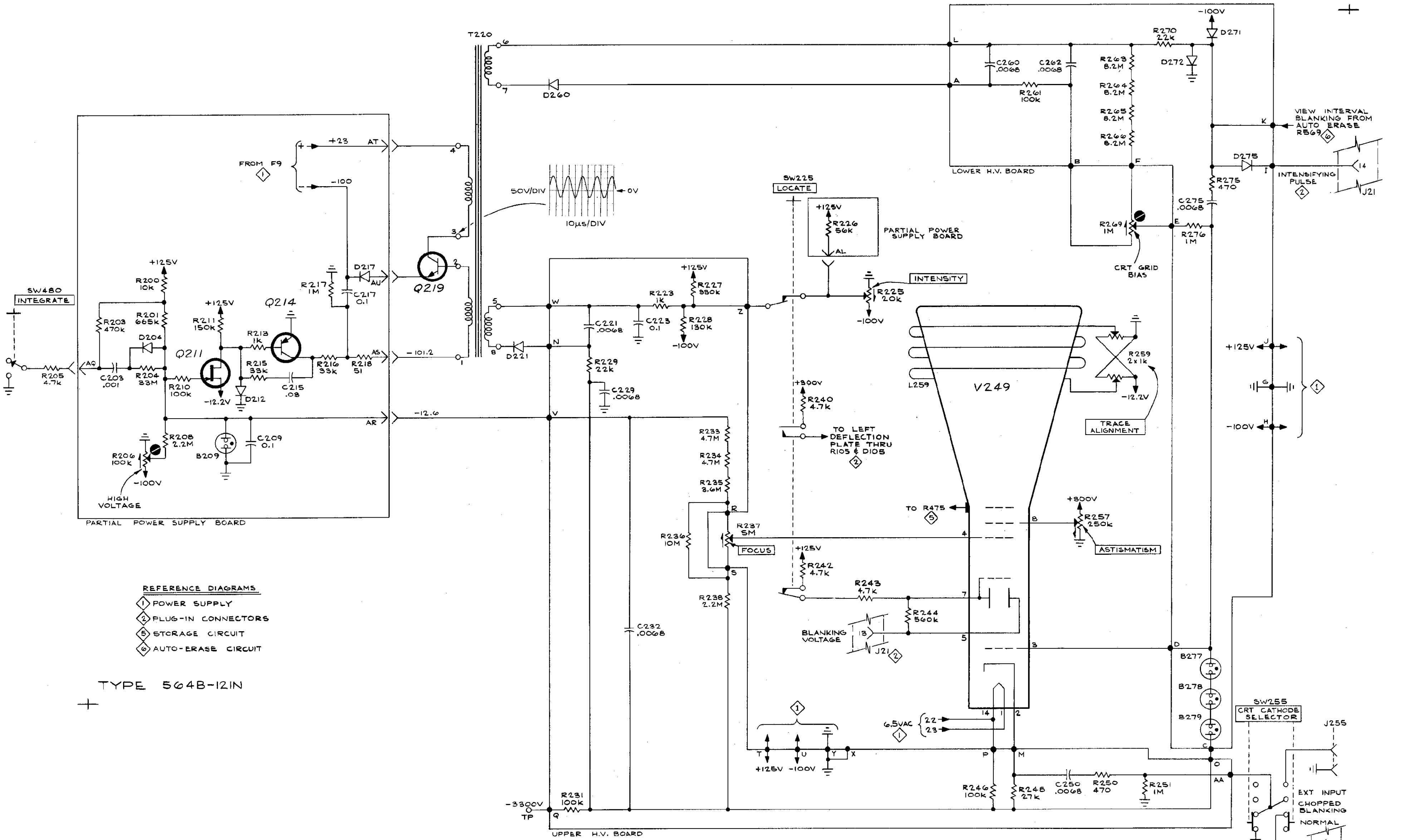
TYPE 564B-121N

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram ①.

868

A

1kHz CALIBRATOR ③



REFERENCE DIAGRAMS

1. POWER SUPPLY
2. PLUG-IN CONNECTORS
5. STORAGE CIRCUIT
6. AUTO-ERASE CIRCUIT

TYPE 564B-12IN

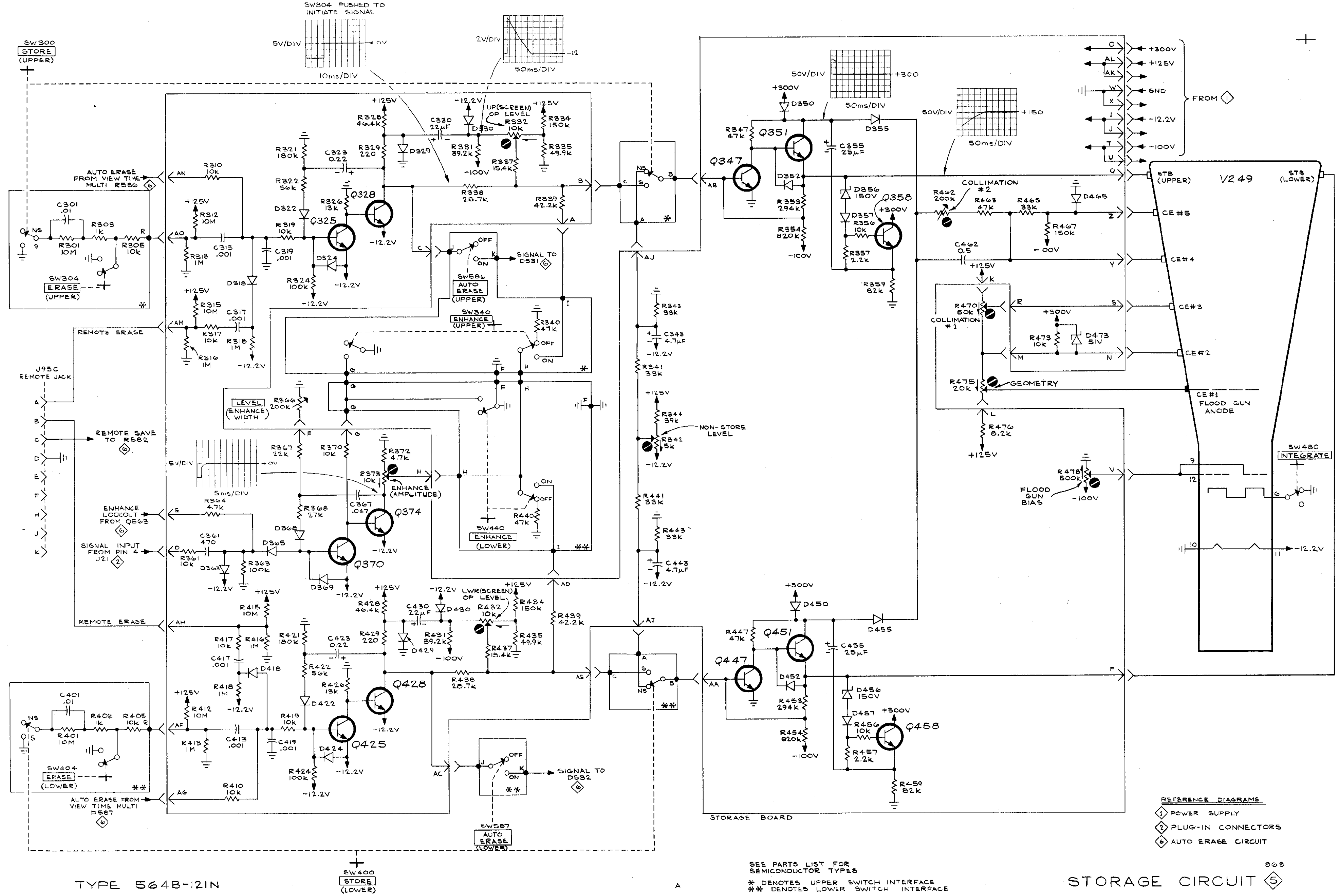
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1.

A

868

CRT CIRCUIT 4



TYPE 564B-121N

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

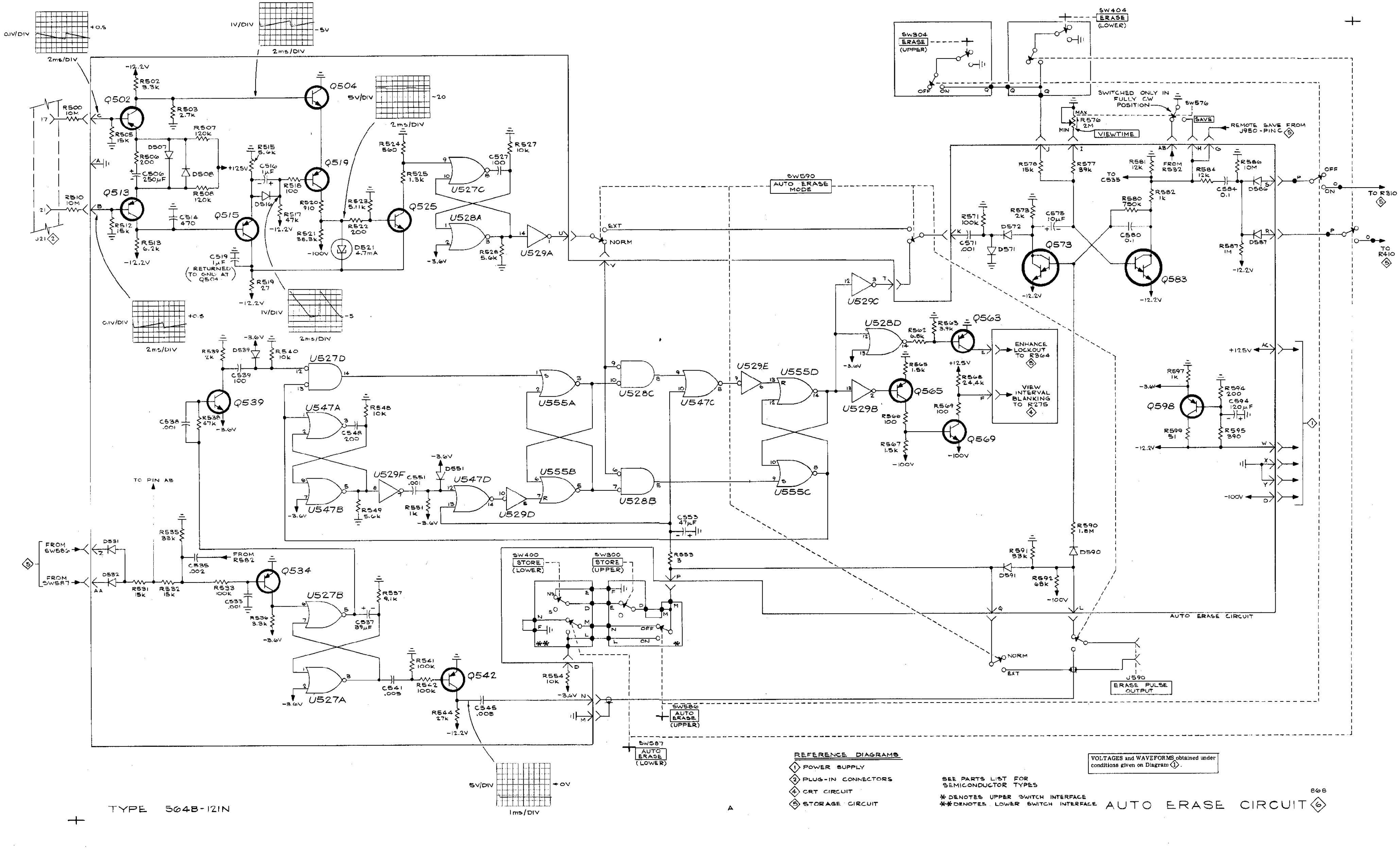
* DENOTES UPPER SWITCH INTERFACE

** DENOTES LOWER SWITCH INTERFACE

868

STORAGE CIRCUIT 5

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1.



REFERENCE DIAGRAMS

1. POWER SUPPLY
2. PLUG-IN CONNECTORS
4. CRT CIRCUIT
5. STORAGE CIRCUIT

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

* DENOTES UPPER SWITCH INTERFACE
** DENOTES LOWER SWITCH INTERFACE

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1.

TYPE 564B-121N

A

868

AUTO ERASE CIRCUIT 6

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.

TYPE 564B-121N TENT SN B060330

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

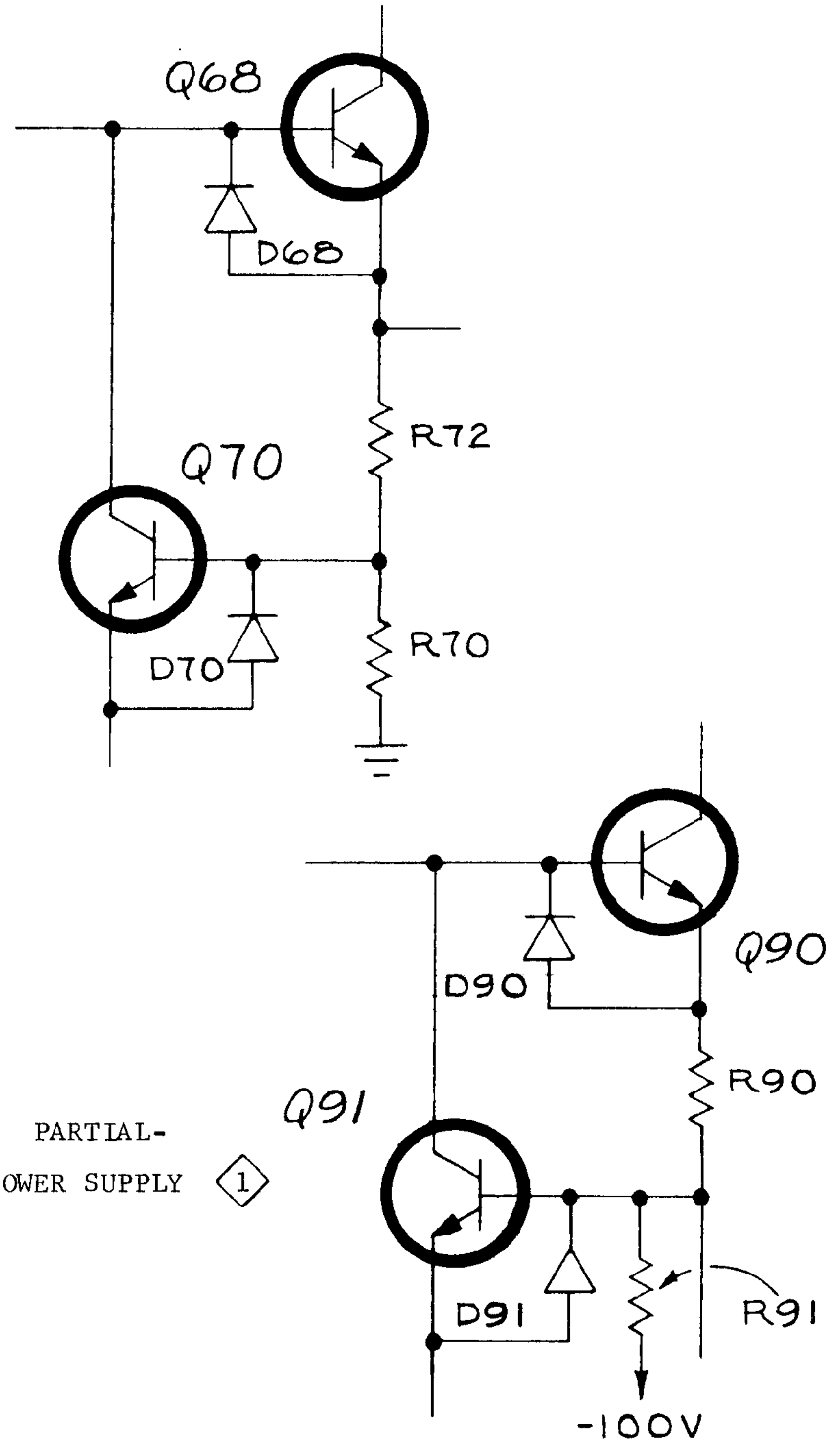
C367	285-0686-00	0.068 μF		PTM	100 V	
R367	315-0203-00	20 kΩ	1/4 W			5%

M14,859/569

ELECTRICAL PARTS LIST AND SCHEMATIC ADDITION

ADD:

D68	152-0107-00	Silicon	Replaceable by 1N647
D70	152-0107-00	Silicon	Replaceable by 1N647
D90	152-0107-00	Silicon	Replaceable by 1N647
D91	152-0107-00	Silicon	Replaceable by 1N647



PARTIAL-
POWER SUPPLY ⟨1⟩

M14,964/569

TYPE 564B-121N TENT SN B060330

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE:

R101	308-0021-00	4.5 kΩ	10 W	WW	5%

M15,019/569

TEXT CORRECTION

Section 5   Performance Check/Calibration

Page 5-2   Short-form procedure

CHANGE: Step 25 to read:

☐ 25. Check Operating Level Range   (Page 5-21)

From $\leq$ +125 volts to $\geq$ + 275 volts.

Page 5-21   Step 25

CHANGE: parts d and k to read:

CHECK--Operating level is +125 volts or less.

CHANGE: parts f and m to read:

CHECK--Operating level...is +275 volts or more.

TEXT CORRECTION

Section 5 Calibration

Page 5-6 Step 6

CHANGE: Step 6 to read as follows:

6. Adjust CRT Grid Bias

a. Set the time-base Normal-Single Sweep switch to Normal and rotate the INTENSITY control clockwise until a trace can bee seen.

b. Position the start of the sweep to the left edge of the graticule and adjust the FOCUS control for a well-defined trace.

c. Rotate the INTENSITY control fully counterclockwise.

d. Set the time-base Normal-Single Sweep switch to Single Sweep and rotate R269, CRT Grid Bias (Fig. 5-4), counterclockwise.

e. Press the LOCATE button and hold it in while performing the next step.

f. ADJUST--R269, CRT Grid Bias, clockwise until a low-intensity spot appears to the left of the sweep start in the locate zone. (It is best to view the CRT trace under low ambient light conditions or by using a viewing hood.)

g. With the LOCATE button still depressed, rotate the INTENSITY control throughout its range and note that it has no effect on the spot brilliance.

h. Rotate the INTENSITY control fully counterclockwise and release the LOCATE button.

Page 5-13 Step 17 A

DELETE: the note after step d, which says to clip a wire jumper around R167 to increase the drive to the Capacitance Normalizer.

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

R201	322-0464-00	665 kΩ	1/4 W	MF	1%

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

D221	152-0408-00	Silicon	10,000 V
D260	152-0408-00	Silicon	10,000 V

TYPE 564B-121N

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

D164	152-0107-00	Silicon	Replaceable by 1N647

M14,754/1268