CATHODE-RAY OSCILLOSCOPE
TYPE 543

INSTRUCTION
MANUAL

TEKTRONIX, INC.

MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

Sunset Highway and Barnes Road • P. O. Box 831 • Portland 7, Oregon, U. S. A.

Phone: CYpress 2-2611 • Cables: Tektronix

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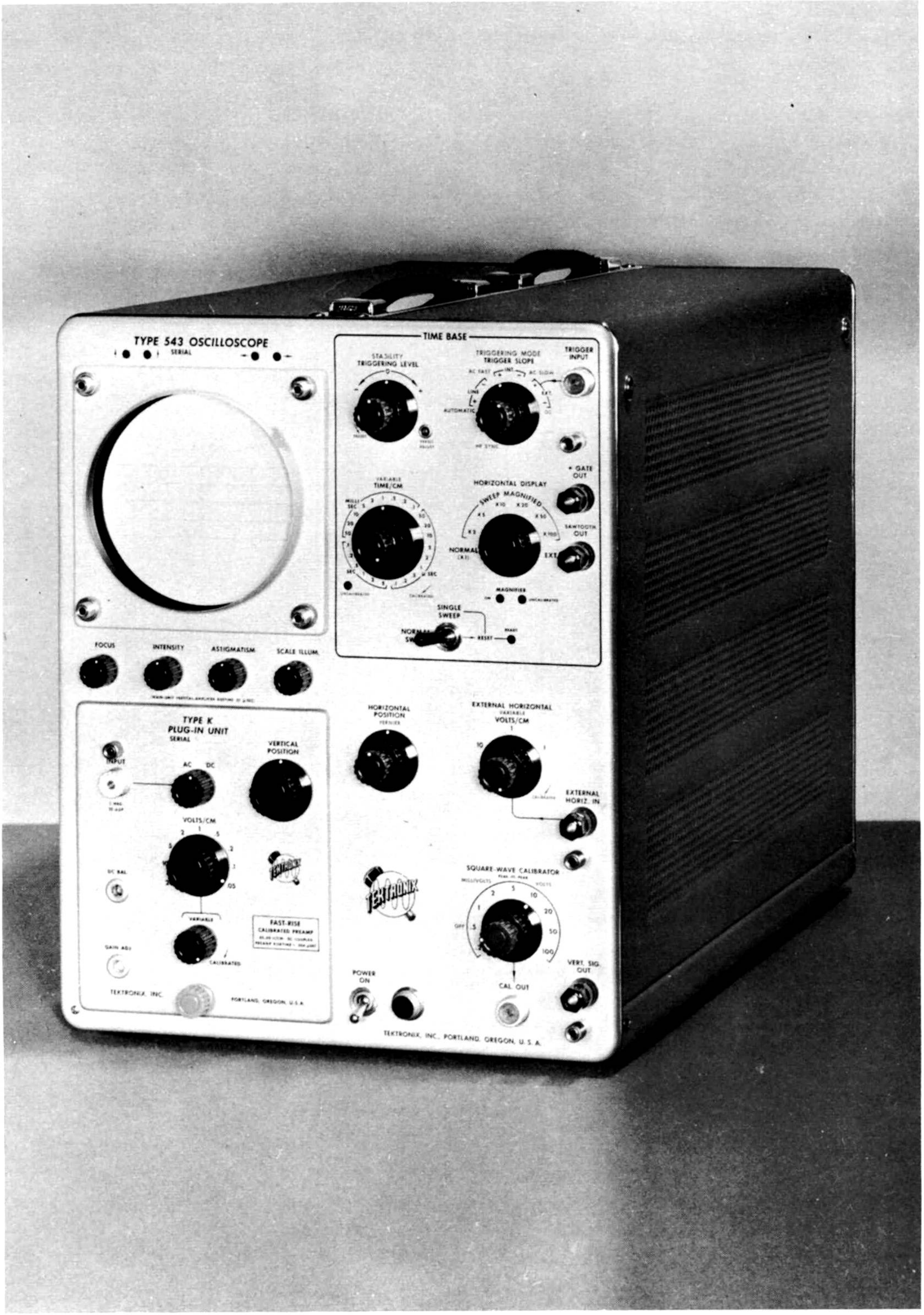
TYPE 543 SERIAL NUMBER 1244



A The Type 543 Oscilloscope (with Type K Plug-In Unit).

SECTION 1

SPECIFICATIONS

The Type 543 Oscilloscope is a laboratory-type instrument well suited to oscilloscope applications involving fast-rise pulses and transients. Plug-in preamplifiers are used in the vertical-deflection system, permitting the instrument to be used in many specialized applications.

VERTICAL-DEFLECTION SYSTEM

TABLE 1-1

Characteristics of Plug-In and Type 543 Combinations.

PLUG-IN	DEFLECTION FACTOR (Calibrated)	PASS BAND	RISETIME	*INPUT CHARACTERISTICS
Type A	0.05 v/cm to 20 v/cm	dc to 20 mc	0.018 μsec	47 $\mu\mu$f, 1 meg
Type B	0.05 v/cm to 20 v/cm 5 mv/cm to 0.05 v/cm	dc to 20 mc 5 cps to 12 mc	0.018 μsec 0.03 μsec	47 $\mu\mu$f, 1 meg 47 $\mu\mu$f, 1 meg
Type CA	0.05 v/cm to 20 v/cm	dc to 24 mc	0.015 μsec	20 $\mu\mu$f, 1 meg
Type D	1 mv/cm to 50 v/cm	dc to 350 kc at 1 mv/cm, increasing to 2 mc at 50 v/cm		47 $\mu\mu$f, 1 meg
Type E	50 μv/cm to 10 mv/cm	0.06 cps to 30 kc at full gain, increasing to 60 kc at 0.5 v/cm		47 $\mu\mu$f, 1 meg
Type G	0.05 v/cm to 20 v/cm	dc to 20 mc	0.018 μsec	47 $\mu\mu$f, 1 meg
Type H	0.005 v/cm to 20 v/cm	dc to 15 mc	0.023 μsec	47 $\mu\mu$f, 1 meg
Type K	0.05 v/cm to 20 v/cm	dc to 30 mc	0.012 μsec	20 $\mu\mu$f, 1 meg
Type L	0.05 v/cm to 20 v/cm 0.005 v/cm to 2 v/cm	dc to 30 mc 3 cps to 24 mc	 0.015 μsec	20 $\mu\mu$f, 1 meg 20 $\mu\mu$f, 1 meg

*Characteristics at the input connector to the plug-in. The Type P410 probes furnished with the Type 543 will reduce the 47-$\mu\mu$f input capacitances to 11 $\mu\mu$f and the 20-$\mu\mu$f input capacitances to 8 $\mu\mu$f. The input resistance in all cases is increased to 10 megohms when a Type P410 probe is used.

Oscilloscope Amplifier

Risetime—0.01 μsec.

Linear Deflection 4 cm.

DC coupled.

Delay Line

Balanced Network,

Signal Delay 0.2 μsec.

HORIZONTAL-DEFLECTION SYSTEM

Sweep Rates

Twenty-four calibrated sweep rates from 0.1 μsec/cm to 5 sec/cm. Accuracy typically within 1% of full scale; in all cases within 3% of full scale.

Continuously variable sweep rates are available from 0.1 μsec/cm to 12 sec/cm.

Magnifier

Six degrees of sweep magnification are provided: 2, 5, 10, 20, 50 and 100 times.

Accuracy within 5% when the magnified sweep speed does not exceed the maximum calibrated rate of 0.02 μsec/cm.

Unblanking

DC coupled.

Triggering Signal Requirements

Internal—2 mm of vertical deflection.

External—2 v to 50 v, peak-to-peak.

Frequency range—dc to 5 mc.

Synchronizing Signal Requirements

Internal—2 cm of vertical deflection.

External—2 v to 50 v, peak-to-peak.

Frequency range—5 mc to 30 mc.

External Horizontal Signal Input

Deflection factor—calibrated ranges of 0.1 v, 1 v, and 10 v/cm.

Continuously variable from 0.1 v to approximately 100 v/cm.

Frequency range—dc to 500 kc in the calibrated positions.

Input impedance—approximately 45 μμf paralleled by 1 megohm.

OTHER CHARACTERISTICS

Cathode-Ray Tube

Type T543 P2—P1, P7, P11 phosphors optional.

Accelerating potential—10,000 volts.

Vertical deflection factor—nominal 7 v/cm.

Horizontal deflection factor—nominal 30 v/cm.

Voltage Calibrator

Square-wave output at approximately 1 kc.

Eighteen fixed voltages from .2 millivolts to 100 volts, peak-to-peak.

Accuracy—3%.

Output Waveforms

Positive gate of same duration as sweep, 30 volts.

Positive-going sweep sawtooth, 150 volts.

A sample of the vertical amplifier signal with a limited passband, 20 cps to 4.5 mc.

Beam-Position Indicators

Indicator lamps to show which way the beam is off the screen if it cannot be seen.

Power Requirements

Line voltage—105 v to 125 v, or 210 v to 250 v, 50-60 cycles.

Power—530 watts at 117 v line voltage with a Type CA Plug-In Preamplifier installed.

Mechanical Specifications

Ventilation—filtered, forced air.

Oscilloscope Amplifier

Risetime—0.01 μsec.

Linear Deflection 4 cm.

DC coupled.

Delay Line

Balanced Network,

Signal Delay 0.2 μsec.

HORIZONTAL-DEFLECTION SYSTEM

Sweep Rates

Twenty-four calibrated sweep rates from 0.1 μsec/cm to 5 sec/cm. Accuracy typically within 1% of full scale; in all cases within 3% of full scale.

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Continuously variable from 0.1 v to approximately 100 v/cm.

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Vertical deflection factor—nominal 7 v/cm.

Horizontal deflection factor—nominal 30 v/cm.

Voltage Calibrator

Square-wave output at approximately 1 kc.

Eighteen fixed voltages from .2 millivolts to 100 volts, peak-to-peak.

Accuracy—3%.

Output Waveforms

Positive gate of same duration as sweep, 30 volts.

Positive-going sweep sawtooth, 150 volts.

A sample of the vertical amplifier signal with a limited passband, 20 cps to 4.5 mc.

Beam-Position Indicators

Indicator lamps to show which way the beam is off the screen if it cannot be seen.

Power Requirements

Line voltage—105 v to 125 v, or 210 v to 250 v, 50-60 cycles.

Power—530 watts at 117 v line voltage with a Type CA Plug-In Preamplifier installed.

Mechanical Specifications

Ventilation—filtered, forced air.

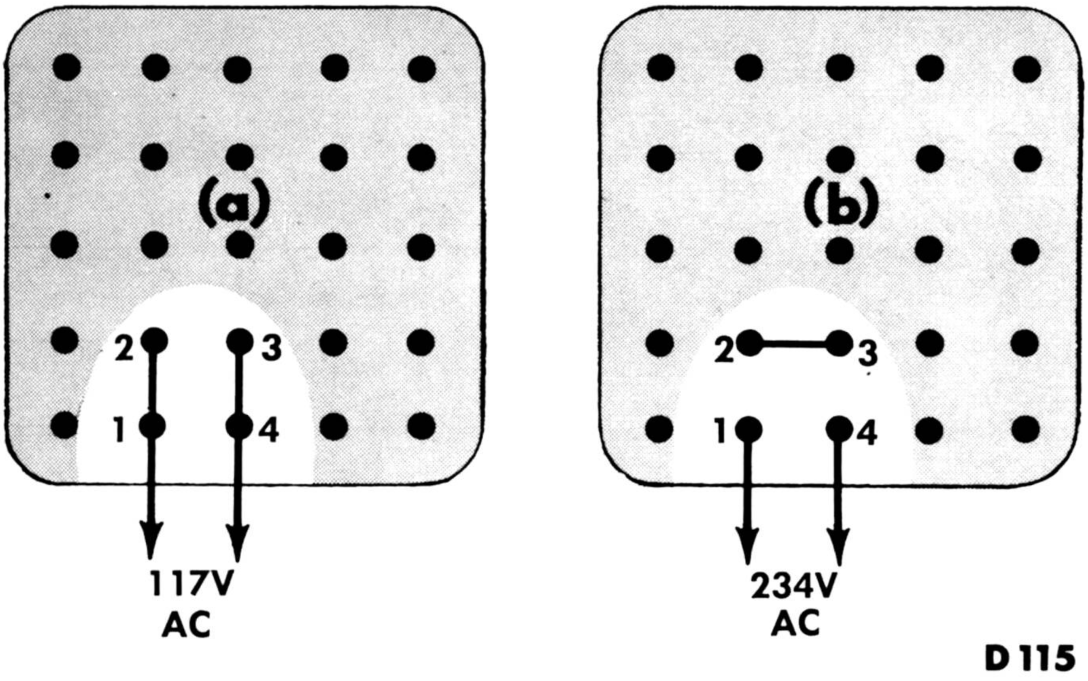


Fig. 2-1. Converting the power transformer from 105-125 volt operation to 210-250 volt operation.

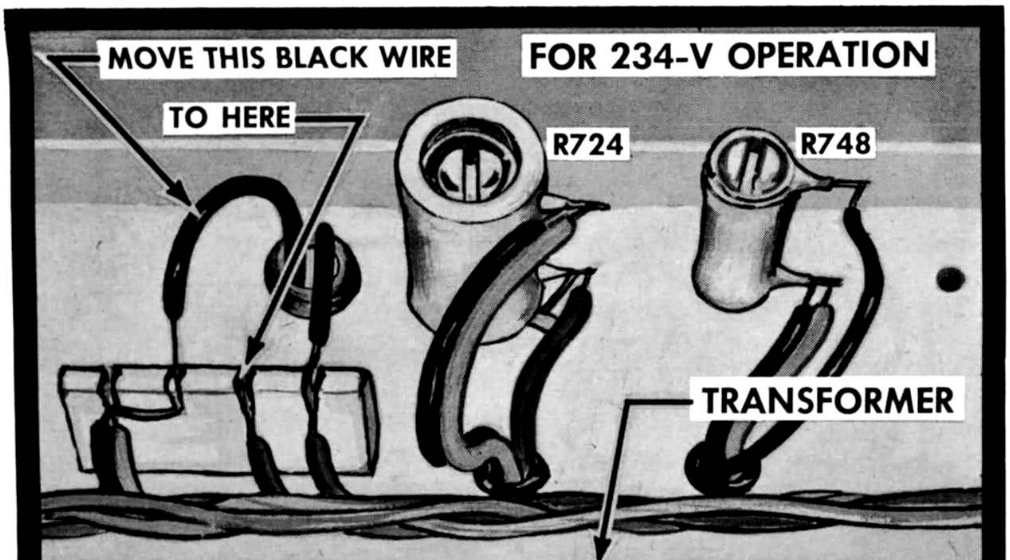


Fig. 2-2. Converting the fan motor from 105-125 volt operation to 210-225 volt operation.

EXPORT POWER TRANSFORMER

Transformer Primary

The instrument for which this manual was prepared is equipped with a special transformer. The transformer has eight primary terminals making possible six different input connections. The six primary connections are shown in Fig. 1.

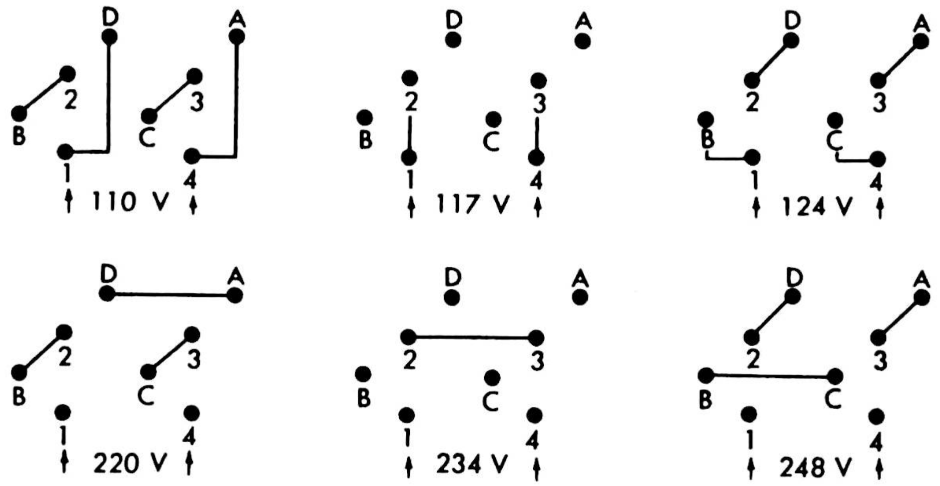


Fig. 1. The power transformer has two extra windings permitting nominal primary voltages of 110, 117, 124, 220, 234, 248 volt, 50 or 60 cycle operation.

TEK NUMBER 120—087

SECTION 4

CIRCUIT DESCRIPTION

BLOCK DIAGRAM

General

The Block Diagram shows interconnections of the functional parts of the oscilloscope, except the low-voltage power supply. Functions of the switches are shown instead of their actual connections.

Plug-In Preamplifiers

In the upper left of the Block Diagram is shown the vertical-deflection system. The block labeled "Plug-Ins" represents one of the plug-in preamplifiers available. Connections for power in and signal out are made through a multiple-contact mating plug and socket. Output from these units is push-pull at low impedance.

Main-Unit Amplifier

The main-unit Vertical Amplifier amplifies the signal and drives the delay line which terminates in the vertical deflection plates. The trigger pick-off circuits obtain a sample of the vertical signal for triggering the sweep.

Delay Line

The balanced, 50-section delay line adds 0.2 microsecond of delay to the signal so the sweep circuits will have time to get the cathode-ray spot unblanked and sweeping before the signal reaches the vertical-deflection plates.

Trigger Cathode Followers

The trigger signal from the main-unit amplifier passes through two cathode followers. The first applies the signal at low impedance to the trigger amplifier and the second connects to the front-panel VERT. SIG. OUT binding post.

Time-Base Trigger Circuit

The trigger circuits convert the triggering signal into sharp negative triggers for triggering the sweep-gating multivibrator. Triggers may be produced on either the rise or fall of the triggering signal at a level determined by a triggering-level control.

Sweep-Gating Multivibrator

The multivibrator turns on the sweep generator through the on-off diodes, and generates the crt unblanking pulse when it is switched from its quiescent state. The sharp negative-going trigger signal from the trigger circuit trips the multivibrator, which thereafter stays in the second state until the sweep generator reverts it to its quiescent state.

Miller Runup Circuit

The sweep generator is a Miller integrator that produces a positive-going sawtooth about 150 volts peak-to-peak. The sweep generator turns itself off when it reaches a prescribed level determined by the sweep-length control, by transmitting a signal through the trigger-holdoff circuits to the sweep gating multivibrator.

Holdoff Circuit

The trigger-holdoff circuit transmits the sweep turn-off signal to the multivibrator and briefly holds off subsequent trigger signals from starting the sweep again until all parts of the circuit have reached their quiescent states.

Sweep Lockout Circuit

The sweep lockout circuit permits the sweep-gating multivibrator to turn on the sweep generator for one sweep when the next trigger pulse arrives; subsequent trigger pulses are locked out . . . prevented from starting a sweep . . . until the circuit is reset.

Horizontal Amplifier

The horizontal amplifier converts the sawtooth output of the sweep generator into push-pull output at low impedance at the level required to sweep the beam across the crt screen. The amplifier gain can be increased up to 100 times for sweep magnification. The horizontal-positioning control operates in this circuit.

Unblanking

The sweep-gating multivibrator generates a positive-going unblanking pulse at the same time it turns on the sweep generator. The positive pulse is transmitted by means of two cathode followers through a floating high-negative-voltage supply to the control grid of the crt.

External Horizontal Amplifier

The external horizontal amplifier provides a means of using external sweep voltage. It includes a fixed attenuator and a variable control. Choice of internal or external sweep can be made by means of a horizontal display switch. The sweep-magnifier circuits cannot be used with external sweeps.

Calibrator

The calibrator has no internal connection to the vertical-amplifier system. It consists of a symmetrical multivibrator with a cathode-follower output tube whose cathode resistor is a precision voltage divider.

VERTICAL DEFLECTION SYSTEM

General

The dc-coupled, push-pull, main Vertical Amplifier provides the necessary gain to drive the Delay Line and the vertical deflection plates of the crt. The main units of the Vertical Amplifier are the Input Amplifier stage V1014 and V1024, the cathode follower stages V1033 and V1043, and the 6-section Distributed Amplifier output stage. Other circuits of importance are the Trigger Pickoff Amplifier V1054 and V1064, the Trigger Pickoff C.F. V1223B, the Vert. Sig. Out C.F. V1223A, and the Indicator Amplifiers and Lamps, V1084A and B1083, and V1084B and B1087, respectively.

Input Circuit

The signal input from the plug-in unit is coupled through terminals 1 and 3 of the interconnecting plug to the grids of the Input Amplifier stage. R1027 varies the cathode degeneration, and thus sets the gain of the stage to agree with the Preamplifier's front-panel calibration when the VARIABLE knob is in the CALIBRATED position.

The Input Amplifier is coupled to the Distributed Amplifier by the cathode followers V1033 and V1043. The cathode followers isolate the Distributed Amplifier from the Input Amplifier, and provide the necessary low-impedance drive for the Distributed Amplifier's grid line.

High-frequency compensation for the Input Amplifier is provided by the variable peaking coils L1014 and L1024. Variable inductors L1036 and L1046 provide additional peaking at the very high frequencies.

Output Stage

The output stage is a 6-section Distributed Amplifier. The tapped inductors in the transmission line, between each grid and between each plate, isolate each section from the capacitance of the adjacent sections.

The input signal for each tube is obtained from the grid line, which is driven by the cathode followers V1033 and V1043. The amplified signal at each plate, fed to the plate line, becomes an integral part of the wave traveling down the line toward the deflection plates.

The vertical signal is delayed 0.2 microsecond between the input to the grid line and the vertical deflection plates. This delay insures that the very "front" of fast vertical signals can be observed. About 0.015 microsecond of the total delay time occurs in the Distributed Amplifier; the remaining 0.185 microsecond occurs in the Delay Line.

The tapped inductors between each section of the Distributed Amplifier provide about 0.003 microsecond of delay. By making the delay time in the grid and plate lines equal, the signal arriving at each plate, through the electron stream of the tube, will be synchronous with the signal moving down the plate line from the preceding sections.

DC Shift Compensation

DC shift in the amplifier—a condition whereby the dc and very low-frequency transconductance is less than at mid-frequencies—is compensated for in two ways. R1090 and C1093B, in plate line L1104, and R1095 and C1093D in plate line L1114, form a low-frequency boost network; the time constant of this network is such that the termination resistance of the line is increased in the range from very low frequencies to dc. A longer time constant, for extremely low-frequency and dc compensation, is provided by R1092, R1094 and C1093A in one plate line, and by R1097, R1099 and C1093C in the other, which provide a small amount of positive feedback from the plate lines to the plate circuits of the Input Amplifier. A variable resistor R1091, the DC SHIFT control, is connected between the two networks to adjust for the proper amount of compensation.

Beam-Positioning Indicators

The beam-position indicators B1083 and B1087, located on the front panel above the crt, indicate the relative vertical position of the trace with respect to the center of the graticule. When the beam is centered vertically, the potential across either neon is insufficient to light it. As the beam is positioned up or down the screen, however, the current through the Indicator Amplifiers, and hence the voltage across the neons, will change. The voltage across one neon will increase, causing it to light, and the voltage across the other will decrease, causing it to remain extinguished. The neon that lights will indicate the direction in which the beam has been moved.

Trigger Pickoff

When internal triggering of the Time Base Generator is desired (black TRIGGER SLOPE knob in either the + or —INT. position), a "sample" of the vertical signal is used to develop the triggering pulse. This "sample" is obtained from the trigger pickoff circuit consisting of the Trigger Pickoff Amplifier V1054 and V1064, and Trigger Pickoff C.F. V1223B.

This "sample" of the vertical signal is also ac-coupled, through V1223A and C1228, to a front-panel binding post labeled VERT. SIG. OUT.

Delay Line

The output signal from the Vertical Amplifier is coupled through the balanced Delay Line to the vertical deflection plates of the crt. The function of the Delay Line is to retard the arrival of the waveform at the deflection plates until the crt has been unblanked and the horizontal sweep started. This delay, as mentioned previously, insures that the very "front" of fast vertical signals can be observed. The line is adjusted, by means of the variable capacitors connected across the line, for optimum transient response.

The entire Delay Line, which includes the plate line in the Distributed Amplifier, is reverse-terminated in its characteristic impedance. The Termination Network, shown on the Vertical Amplifier diagram, is designed to dissipate both the dc and signal energy in the line by presenting a constant resistance over the frequency range of the amplifier. The terminating resistors R1071 and R1073 are specially made, wirewound, noninductive, distributed resistors. The 600 ohms total resistance in each is "tapered", or distributed, in steps. The largest segment of the terminating resistance appears nearest the line; the smallest segment appears at the opposite end. Each step of the resistance is then tuned, by means of the variable capacitors, so that the network will present an optimum load to the line.

HORIZONTAL-DEFLECTION SYSTEM

TIME-BASE TRIGGER

Trigger Slope

The function of the Time-Base Trigger circuitry is to develop a negative-going triggering pulse to trigger the Time Base Generator in the proper time sequence. The signal from which the negative-going triggering pulse is produced may emanate from one of three sources, as determined by the setting of the TRIGGER SLOPE switch SW10A. When the switch is in the + or —EXT. position, an external signal is employed in the development of the triggering pulse. When the switch is in the + or—INT. position, the vertical signal itself is used to develop the triggering pulse. In the + or —LINE position of the switch, a voltage at the power line frequency is used to develop the triggering pulse.

In addition to selecting the source of the triggering voltage, the TRIGGER SLOPE switch also arranges the input circuit of the Trigger-Input Amplifier so that a negative-going pulse is always produced at the plate of V45B regardless of whether the switch is in the + or — position of the EXT., INT. or LINE setting.

Trigger-Input Amplifier

The Trigger-Input Amplifier V24 is a polarity-inverting, cathode-coupled amplifier. The output is always taken from the plate of V24B, but the grid of either stage may be connected to the input signal source. When the TRIGGER SLOPE switch is in the — position (EXT., INT. or LINE range), the grid of V24A is connected to the input source. The grid of V24B is connected to a dc bias source, adjustable by means of the TRIGGERING LEVEL control. This bias voltage establishes the quiescent voltage at the plate of V24B. When the TRIGGER SLOPE switch is in the +position (for any of the three ranges) the grid of V24B is connected to the signal input and the grid of V24A is connected to the bias source.

The voltage at the grid of V24A and the voltage at the plate of V24B are in phase with each other. Therefore, when the switch is in any of the — positions (the signal applied to the grid of V24A), the voltage at the plate of V24B is in phase with the input signal voltage. By this arrangement V24A acts as a cathode follower, having a gain of approximately unity, and the signal voltage developed across the cathode resistor becomes the signal input to V24B.

When the switch is moved to any of the + positions, the grid of V24B is connected to the input signal source. With this configuration, the signal at the plate of V24B will be 180 degrees out of phase with the input signal. Thus, depending on the setting of the switch (+ or —), the plate-signal swing of V24B may be in phase, or 180 degrees out of phase, with the input signal.

Trigger Multivibrator

A Schmitt Trigger circuit V45 is used as the Trigger Multivibrator. In the quiescent state, i.e., ready to receive a signal, V45A is conducting and its plate is down. This holds the grid of V45B below cutoff, since the two circuits are dc-coupled. With V45B cutoff its plate voltage is up; hence no output is being developed.

A negative-going signal is required at the grid of V45A to drive the multivibrator into its other state in which a triggering pulse can be produced. However, the signal coupled to the grid of V45A is a component of the vertical input signal, and therefore contains both negative- and positive-going voltages.

The negative-going portion will drive the grid of V45A in the negative direction, and the cathodes of both tubes will follow the grid down. At the same time the plate voltage of V45A starts rising, which causes the grid voltage at V45B to rise. With the grid of V45B going up and its cathode going down, V45B starts conducting. The cathodes will now follow the grid of V45B; hence the cathode voltages start going up. With the grid of V45A down and its cathode up, this tube cuts off. As V45B conducts its plate voltage drops, creating a negative step at the output. This transition occurs very rapidly, regardless of how slowly the grid signal of V45A falls.

When the signal at the grid of V45A starts in the positive direction, just the opposite will occur. That is, V45A will start conducting again, V45B will be cutoff, and the circuit will revert to its original state with the plate voltage of V45B up. This completes the negative step-voltage output from the Schmitt Trigger circuit.

The operation of the Schmitt Trigger circuit is exactly the same for + or — positions of the TRIGGER SLOPE knob. However, since there is a reversal in signal polarity—between these two settings—at the output of the Trigger-Input Amplifier, triggering will occur at different points with respect to the signal being observed. For example, when the switch is in the + position, triggering will occur during the positive slope of the waveform being observed. That is, the start of the trace will occur when the waveform is going in the positive direction. Conversely, when the switch is in the — position the trace will start when the waveform is going in the negative direction.

Trigger Sensitivity

The hysterisis of the Trigger Multivibrator is determined by the setting of the TRIGGER SENSITIVITY control R37. Increasing the resistance of R37 reduces the loop gain and decreases the hysterisis. The lower the hysterisis the greater the sensitivity of the circuit. Increasing the resistance of R37 therefore increases the trigger sensitivity.

The TRIGGERING LEVEL CENTERING control R39 is adjusted to set the dc quiescent condition of the Multivibrator about the same as that of the Trigger Amplifier.

Triggering Mode

The TRIGGERING MODE switch SW10B selects the type or mode of triggering. In the DC position the triggering signal is dc-coupled to the Trigger Input stage, which in turn is dc-coupled to the Trigger Multivibrator circuit.

In the AC SLOW and AC FAST modes, capacitor C10 removes the dc component of the triggering signal; the Trigger Input stage is still dc-coupled to the Multivibrator, however. The AC FAST mode contains a high-pass filter C11-R13 to remove any low-frequency components from the triggering signal and allow fast recovery of the trigger circuits in the presence of dc level changes.

In the AUTOMATIC mode the Schmitt circuit is converted from a bistable multivibrator to a recurrent configuration. This is accomplished by coupling the grid circuit of V45B to the grid circuit of V45A via R41. In addition, the dc coupling between the Trigger Input stage and the Multivibrator is removed in this mode of triggering.

The addition of R41 to the circuit causes the Multivibrator to free-run in the absence of a triggering signal. For example, assume the grid of V45A is just being driven into cutoff. The voltage at its plate starts to rise, carrying with it the voltage at the grid of V45B. Since the two grids are dc coupled through R41 and R33, this action will pull the grid of V45A back up. The time constant of the r-c network R41, R33 and C32 is such that it takes about .01 second for the grid voltage of V45A to rise exponentially from its starting point below cutoff to a value where plate current can flow.

As V45A starts to conduct its plate voltage drops, which in turn lowers the grid voltage of V45B. The voltage at the grid of V45A then starts dropping exponentially toward cutoff. When this tube cuts off, the circuit has completed one cycle of its approximately 50-cycle rectangular waveform.

The hysterisis of the circuit (the range of voltage at the grid of V45A between V45A cutoff and V45B cutoff) is about 6 volts when triggering in the AUTOMATIC mode. This is increased from about 0.25 volt, for the DC, AC SLOW and AC FAST modes, by the addition of R41 and R46 to the circuit. Since the grid of V45A is never more than 6 volts from cutoff, a triggering signal with a peak-to-peak amplitude of 6 volts can drive the grid to cutoff at any time and produce a trigger output. Smaller signals can also produce a trigger output, but only if they occur at a time when the sum of the signal voltage and the triangular grid voltage is sufficient to drive the grid of V45A to cutoff. However, the duty cycle of operation is somewhat reduced when smaller triggering signals are being received.

With the circuit configuration just described, the horizontal sweep can be triggered with repetitive signals, over a wide range of frequencies, without readjustment. When not receiving triggers, the sweep continues at approximately a 50-cycle rate. Thus, in the absence of any vertical signal, the sweep generates a base line which indicates that the oscilloscope is adjusted to display any signal that might be connected to the vertical deflection system.

With the TRIGGER SLOPE switch in the HF SYNC position, the Trigger circuits are bypassed and the input "triggering" signal is applied directly to the Time Base Generator. This signal now acts as a synchronizing voltage, superimposed on the holdoff waveform (to be discussed in the section that follows). This synchronizes the Time-Base Generator at a sub-multiple of the triggering-signal frequency. This mode is useful for input signals in the range from 5 mc to 30 mc.

TIME-BASE GENERATOR

The Trigger circuit produces a negative-going waveform which is coupled to the Time-Base Generator. This waveform is differentiated in the grid circuit of V135A to produce a sharp negative-going triggering pulse to trigger the Time-Base Generator in the proper time sequence. Positive-going pulses are also produced in the differentiation process, but they are not used in the operation of the Time-Base Generator.

The Time-Base Generator consists of three main circuits: a Sweep-Gating Multivibrator, a Miller Runup Circuit, and a Hold-Off Circuit. The Sweep-Gating Multivibrator consists of V135A, V146 and the cathode follower V135B. The essential components in the Miller Runup circuit are the Miller Tube V161, the Runup C.F. V173, the On-Off Diodes V152, the Timing Capacitor C160 and the Timing Resisior R160. The Hold-Off Circuit consists of the Hold-Off C.F.'s V183A-V133B, the Hold-Off Capacitor C180 and the Hold-Off Resistors R181-R180.

Sweep-Gating Multivibrator

The Sweep-Gating Multivibrator operates as a bistable circuit. In the quiescent state V135A is conducting and its plate is down. This cuts off V146 through V135B and the divider R141-R143, and the common cathode resistor R144. With V146 cutoff, its plate is clamped about 3 volts below ground by the conduction of diodes V152 (A & B) through R147 and R148. Conduction of the lower diode V152A through the Timing Resistor R160 then clamps the grid of the Miller tube at about —3.5 volts.

Miller Runup Circuit

The quiescent state of the Miller circuit is determined by a dc network between plate and grid. This network consists of the neon glow tube B167, the Runup CF V173 and the On-Off Diodes V152. The purpose of this network is to establish a voltage at the plate of the Miller tube of such a value that the tube will operate above the knee, and thus over the linear region, of its characteristic curve. This quiescent plate voltage is about +43 volts.

Sweep Generation

If the STABILITY and TRIGGERING LEVEL controls are now adjusted for triggered operation, a negative trigger will drive the grid of V135A below cutoff and force the Sweep-Gating Multivibrator into its other state in which V146 is the conducting tube. As V146 conducts its plate drops, cutting off the On-Off Diodes V152. Any spiking that many occur during this transistion is attenuated by the C150-R150 network.

With V152 cutoff the grid of the Miller tube and the cathode of the Runup C.F. are free to seek their own voltages. The grid of the Miller tube then starts to drop, since it is connected to the —150-volt bus through the Timing Resistor R160. The plate of the Miller tube starts to rise, carrying with it the grid and cathode of V173. This raises the voltage at the top of the Timing Capacitor C160, which in turn pulls up the grid of the Miller tube and prevents it from dropping. The gain of the Miller tube, as a Class A amplifier, is so high that the voltage coupled back through C160 keeps the grid constant within a fraction of a volt.

The Timing Capacitor then starts charging with current from the —150-volt bus. This charging current flows through the Timing Resistor R160. Since the voltage at the grid of the Miller tube remains essentially constant the voltage drop across the Timing Resistor remains essentially constant. This provides a constant source of currrent for charging C160. By this action C160 charges linearly, and the voltage at the cathode of V173 rises linearly. Any departure from a linear rise in voltage at this point will produce a change in the voltage at the grid of the Miller tube in a direction to correct for the error.

Timing Switch

The linear rise in voltage at the cathode of V173 is used as the sweep time-base. Timing Capacitor C160 and Timing Resistor R160 are selected by the TIME/CM switch SW160. R160 determines the current that charges C160. By means of the TIME/CM switch 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). For high-speed sweeps bootstrap capacitor C165 helps supply current to charge the stray capacitance at the plate of the Miller tube; this permits the plate voltage to rise at the required rate.

If uncalibrated sweep rates are desired, the VARIABLE TIME/CM (red knob) control may be turned away from the CALIBRATED position. (See Timing Switch diagram.) This control, R160Y, varies the sweep rate over a $2\frac{1}{2}$ to 1 range. Switch 160F is ganged with the VARIABLE control in such a way that the UNCALIBRATED light comes on when the control is turned away from the CALIBRATED position.

Sweep Length

As explained previously, the sweep rate (the rate at which the spot moves across the face of the crt) is determined by the timing circuit C160 and R160. The length of the sweep (the distance the spot moves across the face of the crt), however, is determined by the setting of the SWP. LENGTH control R176. As the sweep voltage rises linearly at the cathode of V173 there will be a linear rise in voltage at the arm of the SWP. LENGTH control R176. This will increase the voltage at the grid and cathode of V183A and at the grid and cathode of V133B. As the voltage at the cathode of V133B rises, the voltage at the grid of V135A will rise. When the voltage at this point is sufficient to bring V135A out of cutoff, the multivibrator circuit will rapidly revert to its original state with V135A conducting and V146 cutoff. The voltage at the plate of V146 rises, carrying with it the voltage at the diode plate V152A. The diode then conducts and provides a discharge path for C160 through R147 and R148 and through the resistance the cathode circuit of V173. The plate voltage of the Miller Tube now falls linearily, under feedback conditions essenially the same as when it generated the sweep portion of the the waveform except for a reversal of direction. The resistance through which C160 discharges is much less than that of the Timing Resistor (through which it charges). The capacitor current for this period will therefore be much larger than during the sweep portion, and the plate of the Miller Tube will return rapidly to its quiescent voltage. This produces the retrace portion of the sweep sawtooth during which time the crt beam returns rapidly to its starting point.

Hold-Off

The Hold-off Circuit prevents the Time-Base Generator from being triggered during the retrace interval. That is, the hold-off allows a finite time for the Time-Base circuits to regain a state of equilibrium after the completion of a sweep.

During the trace portion of the sweep sawtooth the Hold-Off Capacitor C180 charges through V183A, as a result of the rise in voltage at the cathode of V183A. At the same time the grid of V135A is being pulled up, through V133B, until V135A comes out of cutoff and starts conducting. As mentioned previously, this is the action that initiates the retrace. At the start of the retrace interval C180 starts discharging through the Hold-Off Resistor R181. The time constant of this circuit is long enough, however, so that during the retrace interval (and for a short period of time after the completion of the retrace) C180 holds the grid of V135A high enough so that it cannot be triggered. However, when C180 discharges to the point the V133B is cut off, it loses control over the grid ofV135A and this grid returns to the level established by the STABILITY control. The hold-off time required is determined by the size of the Timing Capacitor. For this reason the TIME/CM switch changes the time constant of the Hold-Off Circuit simultaneously with the change of Timing Capacitors. (In the μSEC positions of the TIME/CM switch R181 is shunted by either R180A or R180B, shown on the Timing Switch diagram.)

Stability

The operational mode of the Time-Base Generator is determined by the setting of the STABILITY control R110. By means of this control the sweep can be turned off, adjusted for triggered operation, or adjusted for free-running operation. The STABILITY control, through cathode follower V125, regulates the grid level of V135A. (V133A is inoperative for NORMAL SWEEP operation.)

For triggered operation, the STABILITY control is adjusted so that the grid of V135A is just high enough to prevent the Sweep-Gating Multivibrator from free-running. Adjusted in this manner a sweep can only be produced when an incoming negative trigger pulse drives the grid of V135A below cutoff.

Moving the arm of the STABILITY control toward ground (ccw rotation), but not so far as to actuate the PRESET switch, will raise the grid level of V135A and prevent the Sweep-Gating Multivibrator from being triggered. This action turns off the sweep. Moving the arm toward —150 volts drops the grid of V135A to the point that the discharge of the Hold-Off Capacitor C180 can switch the multi. Adjusted in the manner, the Sweep-Gating Multivibrator will free-run and produce a recurrent sweep.

When the STABILITY control is turned full ccw to the PRESET position, R110 is switched out of the circuit and R111 is switched in. This control, a front-panel screwdriver adjustment labeled PRESET ADJUST, provides a fixed dc voltage for the grid of V135A. When properly adjusted, PRESET operation can be used for most triggering applications. Where triggering may be difficult, however, the manual STABILITY control R110 should be used.

Single Sweep Operation

When the NORMAL SWEEP-SINGLE SWEEP switch is in the SINGLE SWEEP position, plate voltage is applied to V133A and this tube operates in conjunction with V125 as a bistable multivibrator.

In the first stable state that exists after the completion of a sweep, V125 is cut off and V133A is conducting. In this state the divider between the plate of V125 and the grid of V133A sets the cathode voltage of the Lockout Multivibrator and consequently the grid voltage of V135A. The LOCKOUT LEVEL ADJ. R125 is adjusted to set the grid of V35A high enough so that the Sweep-Gating Multivibrator cannot be triggered; this "locks out" the sweep.

Depressing the RESET switch grounds C121 through R117. The resulting positive pulse at the grid of V125 forces the Lockout Multivibrator into its other stable state with V125 conducting and V133A cut off. With V133A cut off its plate voltage rises and ignites the READY light. With V125 conducting the STABILITY control regains control over the grid level of V135A.

Depending on the adjustment of the STABILITY control, a sweep can now be produced in one of two ways. If the STABILITY control is turned full right (cw) the grid of V135A will be pulled down and cause the Sweep-Gating Multivibrator to switch to its other state and initiate a sweep. If the STABILITY control is adjusted for triggered operation, the sweep will be initiated by the first negative trigger pulse to arrive at the grid of V135A.

As the sweep begins, the rising sawtooth voltage pulls up the cathode of V133B by the hold-off action previously described. As the cathodes of the Lockout Multivibrator follow the cathode of V133B up, V125 cuts off and V133A conducts. As the cathodes continue to rise, following the rise in the sawtooth sweep voltage, V133A cuts off again. Both tubes are then held cutoff for the remainder of the sweep and the READY light stays on. When the grid of V135A rises to the point that the Sweep-Gating Multivibrator is reverted, the sweep is terminated.

As the Hold-Off Capacitor C180 discharges, the cathodes of the Lockout Multivibrator start to fall. The grid level of V133A is such that this tube comes out of cutoff first; thus, V133A conducts and V125 remains in cutoff. As V133A conducts its plate drops, extinguishing the READY light. A new sweep cannot be initiated until the RESET switch is depressed again.

Unblanking

The positive rectangular pulse at the cathode of V135B, in the Sweep-Gating Multivibrator circuit, is coupled through a cathode follower V183B (shown on the CRT circuit diagram) to the grid supply for the crt. This pulse, whose start and duration are coincident with the rising portion of the sawtooth sweep waveform, pulls up the grid of the crt. This unblanks the crt during the trace portion of the sweep and permits the trace to be observed.

Output Waveforms

The positive pulse coupled to the crt circuit for unblanking is also coupled through a cathode follower V193B to a front-panel binding post labeled + GATE OUT. This positive gate waveform starts at ground and rises to + 30 volts.

The sweep sawtooth voltage at the cathode of V173 is coupled through a cathode follower V193A to a front-panel binding post labeled SAWTOOTH OUT. This waveform, which starts at about ground, provides a 150-volt linear rise in voltage.

Dual Trace Sync and Blanking

Synchronizing pulses for dual-trace plug-in preamplifiers are supplied by V154A. When multi tube V146 cuts off a sharply differentiated positive pulse is developed at its screen. This pulse, coupled to the grid of V154A, produces a negative trigger at the plate of V154A. This trigger then switches the multivibrator in the dual-trace unit employed for alternate sweeps.

When the dual-trace multi is connected for free-running operation to produce chopped sweeps, a negative pulse is coupled from the multi to the grid of V154B. The resultant positive pulse at the plate of V154B is coupled to the cathode of the crt to blank out the beam during switching. Refer to the manual for the dual-trace unit for a detailed description of the switching multi.

HORIZONTAL AMPLIFIER

The dc-coupled Horizontal Amplifier consists of a cathode-follower input stage, two stages of push-pull amplification and a cathode-follower output stage. The gain of Input Amplifier V354-V364 is controlled by negative feedback from the cathodes of the Output C.F. stage V374B-V384B. The amount of negative feedback applied to the Input Amplifier, and hence the gain of the stage, is determined by the setting of the HORIZONTAL DISPLAY switch. As the magnification factor is increased the gain is increased by decreasing the feedback.

Input Circuit

The positive-going sweep sawtooth voltage produced by the Time-Base Generator circuit is coupled through a frequency-compensated voltage divider to the grid of the Input C.F. V343. The attenuation of the divider can be altered slightly by the adjustment of R342 (labeled X10 CAL. on the circuit diagram). The small time-constant network C339-R339 improves the start of the waveform at the faster sweep speeds. The two positioning controls HORIZONTAL POSITION R340 and VERNIER R346 affect the beam positioning by altering the dc level at the grid of V343. The voltage and resistance values in the positioning circuits are such that the VERNIER can move the spot about 1 centimeter while the HORIZONTAL POSITIONING control can move the spot about 10 centimeters when the HORIZONTAL DISPLAY switch is in the NORMAL position. Because of their low impedance, an adjustment of the positioning controls does not alter the attenuation of the divider network.

Input Amplifier

The Input Amplifier V354-V364 is a cathode-coupled phase inverter; the positive-going sawtooth at the grid of V364 is converted to a push-pull sawtooth in the plate circuit.

The impedance network connected between the two cathode circuits plays an important role in determining the amount of negative feedback applied to the Input Amplifier. Two of the components in this network, R361 and C361, have their value selected by the HORIZONTAL DISPLAY switch. The negative feedback, which comes from the cathodes of the Output C.F. stage, is applied through a frequency-compensated divider consisting of R387-C387 on one side and R388-C388 on the other, and the impedance connected between the cathodes of the Input Amplifier. The smaller the impedance connected between the two cathodes the greater the drop across the series components and the less the amount of feedback applied to the Input Amplifier. Details of the R361-C361 network are shown in the switch layout in the upper left corner of the Horizontal Amplifier diagram. In the X100 SWEEP MAGNIFIED position of the HORIZONTAL DISPLAY switch R361 and C361 are replaced with a bare bus wire; this decreases the negative feedback and increases the gain of the stage 100 times over that of the NORMAL (X1) position of the switch. The X100 CAL. control R356 is adjusted to calibrate the maximum gain of the stage; the minimum gain (HORIZONTAL DISPLAY switch in the NORMAL (X1) position) is adjusted with the X1 CAL. control R368.

For dc and extremely low frequencies, a small amount of positive feedback is coupled from the cathode of V374B to the grid of V354. The D.C. SHIFT control R365 is adjusted so that the time constant of the feedback network is equal to the time constant of the slump distortion in the tubes.

The SWP/MAG. REGIS control R359 is adjusted to preserve the dc balance of the amplifier as the degeneration networks in the cathode circuit of the Input Amplifier are changed. This will ensure that the portion of the trace in the exact center of the crt, when the HORIZONTAL DISPLAY switch is in the NORMAL position, will be expanded symmetrically about the center when the switch is moved to any of the SWEEP MAGNIFIED positions.

Two MAGNIFIER neon glow lamps are located on the front panel immediately below the HORIZONTAL DISPLAY switch; circuitry for the lamps is shown in the switch-detail section of the Horizontal Amplifier diagram. The MAGNIFIER ON lamp glows whenever the HORIZONTAL DISPLAY switch is in any of the SWEEP MAGNIFIED positions. The MAGNIFIER UNCALIBRATED lamp is connected to glow whenever the sweep speed exceeds the maximum calibrated rate of .02 μsec/cm. This lamp will not glow so long as the setting of the TIME/CM switch, divided by the magnification factor, is not less than .02 μsec.

Output Stage

The Output Amplifier stage V374A-V384A operates as a conventional push-pull, plate-loaded amplifier. The cathode followers V374B-V384B provide a high-impedance, low-capacitance load to help maintain the gain of the stage constant over the sweep range of the instrument. The cathode followers also provide the necessary low-impedance output to drive the capacitance of the horizontal deflection plates. Bootstrap capacitors C378 and C382 improve the response at the faster sweep rates by supplying additional current from the Output C.F. stage to charge and discharge the stray capacitance in the plate circuit of the Output Amplifier.

Capacitance Driver

At the faster sweep rates the current through the Output C.F. tubes is too small to discharge the capacitance of the horizontal deflection plates and its associated wiring at the required rate. Additional current for this purpose is provided by the gated pentode V394 connected in the cathode-return circuit of V374B. This permits the cathode of V374B, the negative-sawtooth cathode follower, to run down at the required rate. A similar current boost is not required for V384B since this tube is the positive-sawtooth cathode follower and the cathode runs down during the retrace.

Because the plate current of a pentode is fairly constant over a large range of plate voltage, the cathode current of V374B will remain nearly constant even though its cathode falls about 150 volts during the trace portion of the negative sweep waveform.

The additional current required for faster sweep rates is obtained by applying a positive flat-topped pulse to the grid of the pentode V394 during the period of the sweep. This pulse is derived by differentiating the positive-going sawtooth, available at the cathode of V384B, in C394 and the resistance in the grid circuit of V394. The amplitude of this pulse is proportional to the slope of the sawtooth, and thus proportional to the sweep speed.

External Sweep

A front-panel binding post labeled EXTERNAL HORIZ. IN couples an externally-derived signal to the Horizontal Amplifier circuit when the HORIZONTAL DISPLAY switch is in the EXT. position. A preamplifier stage V324 is also connected into the circuit. The setting of the EXTERNAL HORIZONTAL VOLTS/CM switch determines whether the signal is directly coupled to the grid circuit of V324A, or whether one of two frequency-compensated attenuators is connected in the signal path. For all positions of this switch the input impedance is 1 megohm shunted by approximately 45 $\mu\mu$f.

The External-Horizontal Preamplifier V324 operates as a cathode-coupled amplifier. . . V324A is the cathode-follower and V324B is the grounded-grid stage. The VARIABLE control R325 provides a means for adjusting the gain over a 10 to 1 range. The EXT. HORIZ. AMP. DC. BAL. control R334 adjusts the dc level of V324B so that its cathode will be at the same voltage as the cathode of V324A when no signal is applied to the grid of V324A. With the cathodes at the same voltage there will be no current through the VARIABLE control R325. By this arrangement an adjustment of the VARIABLE gain control will not change the dc level at the plate of V324B and will therefore not affect the positioning of the beam.

The gain of the Horizontal Amplifier, when connected for external operation, is calibrated by means of the EXT. HORIZ. AMP. CAL. control R361M, shown in the Switch Details section of the circuit diagram. This control is adjusted so that the horizontal deflection will agree with the setting of the EXTERNAL HORIZONTAL VOLTS/CM switch when the VARIABLE control is turned full right to the CALIBRATED position.

LOW-VOLTAGE POWER SUPPLY

Plate and filament power for the tubes in the Type 543 is furnished by a single power transformer T700. The primary has two equal windings which may be connected in parallel for 117-volt operation, or in series for 234-volt operation. The power supply will maintain regulation over line voltage ranges of 105 to 125 volts, or 210 to 250 volts, rms, 50-60 cycles. Bridge rectifiers are employed for the five separate, full-wave, power supplies. The five supplies furnish regulated output voltages of —150, +100, +225, +350 and +500 volts.

—150-Volt Supply

Reference voltage for the —150-volt supply is furnished by a gas diode voltage-reference tube V710. This tube, which has a constant voltage drop, establishes a fixed potential of about —87 volts at the grid of V712A, one-half of a difference amplifier. The grid voltage for the other half of the difference amplifier, V712B, is obtained from a divider consisting of R715, R716 and R718. The —150 ADJ. control R716 determines the percentage of total voltage that appears at the grid of V712B and thus determines the total voltage across the divider. This control is adjusted so that the output voltage is exactly —150 volts.

If line-voltage or load fluctuations tend to change the output voltage, an error signal exists between the two grids of the difference amplifier. The error signal is amplified in V712B and V700 and applied to the grids of the series tubes V725, V726 and V727. The resulting change in voltage at the plates of the series tubes, which will be in a direction to compensate for any change in output voltage, is coupled through the rectifiers to the output to keep this voltage constant. Capacitors C707 and C717 improve the ac gain of the feedback loop to increase the response of the regulator circuit to sudden changes in output voltage.

A small amount of unregulated bus ripple is coupled to the screen of V700 through R728. The phase of the amplified ripple voltage at the plate of V700 is such as to cancel most of the ripple on the —150-volt bus.

+100-Volt Supply

The +100-volt supply is regulated by comparing to ground (the cathode of V742) the voltage of a point near ground potential obtained from the divider R750-R751 connected between the +100-volt bus and the regulated —150-volt supply. Any error voltage that exists is amplified and inverted in polarity by V742 and coupled through the cathode follower V748B to the output to prevent the output voltage from changing. Capacitor C750 improves the ac gain of this circuit.

A small sample of the unregulated bus ripple appears at the screen of V742 through R744. This produces a ripple component at the grid of the cathode follower V748B that is opposite in polarity to the ripple at the plate; this tends to cancel the ripple at the cathode and hence on the +100-volt bus. This same circuit also improves the regulation in the presence of line-voltage variations.

+225-Volt Supply

Rectified voltage from terminals 7 and 14 of the power transformer is added to the voltage supplying the +100-volt regulator to furnish power for the +225-volt regulator. This supply is regulated by comparing to ground (the grid of V765A) the voltage of a point near ground obtained from the divider R772-R771 connected between the +225-volt bus and the regulated —150-volt supply. Any error voltage that exists between the grids of the difference amplifier (V765) is amplified in both V765 and V757, and coupled through the cathode follower V748A to the +225-volt bus. The change in voltage at the cathode of V748A, due to the regulator action, will be opposite in polarity to the original error signal and will thus tend to keep the output constant. This supply also furnishes an unregulated output of about +340 volts for the oscillator in the crt high-voltage supply. It is unnecessary to regulate this voltage as the crt supply has its own regulator circuits.

+350-Volt Supply

Rectified voltage from terminals 5 and 10 of T700 is added to voltage supplying the +225-volt regulator to furnish power for the +350-volt regulator. This supply is regulated by comparing to ground the voltage of a point near ground obtained from the divider R787-R788 connected between the +350-volt bus and the regulated —150-volt supply. The operation of the regulator circuit is the same as that described for the +100-volt supply.

+500-Volt Supply

Rectified voltage from terminals 20 and 21 of T700 is added to the regulated side of the +350-volt supply to furnish power for the +500-volt regulator. This supply is regulated by comparing to the regulated +350-volts the voltage of a point near +350 obtained from the divider R797-R798 connected between the +500-volt bus and the regulated —150-volt supply. The regulator action of this circuit is the same as that described for the +100-volt supply.

Time-Delay

A time-delay relay K700 delays the application of dc voltages to the amplifier tubes in the instrument for about 25 seconds. This delay is to allow the tube heaters time to bring the cathodes up to emission temperature before operating potentials are applied.

Cathode Ray Tube Control Circuits

The INTENSITY control R831 varies the voltage at the grid of the crt to control the beam current. The FOCUS control R852 varies the voltage at the focusing ring to focus the trace. The ASTIGMATISM control R860 varies the voltage at the astigmatism anode to focus the spot in both dimensions simultaneously. The GEOM. ADJ. R842 varies the field the beam encounters as it emerges from the deflection system to control the linearity at the extremes of deflection.

The CRT CATHODE SELECTOR switch SW800 connects the cathode of the crt through C857 to either a rear-panel binding post labeled EXTERNAL CRT CATHODE or to the plate of V154B in the Time-Base Generator circuit. When in the DUAL-TRACE CHOPPED BLANKING position, the cathode of the crt is connected to receive positive pulses from the Time-Base Generator circuit to blank the crt during switching while operating a dual-trace plug-in unit in the chopped mode.

When SW800 is in the EXTERNAL CRT CATHODE position, the cathode circuit of the crt is connected to the binding post mentioned previously. A bare bus bar normally connects the binding post to ground. When intensity modulation of the beam is desired, the bus bar can be removed so that the modulating signal can be coupled to the crt cathode.

High-Voltage Supply

A single 60-kc Hartley oscillator furnishes power for the three power supplies that provide accelerating potentials for the crt. The main components in the Oscillator circuit are the pentode V800 and the primary of T801 tuned by C806.

A half-wave rectifier V820 provides —1350 volts for the crt cathode. A half-wave voltage-tripler circuit, V821, V822 and V823, provides +8650 volts for the post-anode accelerator. This provides a total accelerating voltage of 10,000 volts. Both supplies are tied to the +100-volt regulated supply through the decoupling filter R800-C800.

A floating half-wave rectifier V824 furnishes bias voltage (about —1450 volts) for the crt grid. This floating grid supply, independent of the cathode supply, is required in order to provide dc-coupled unblanking to the crt grid. All three supplies employ capacitor-input filters.

The —1350-volt cathode supply is regulated by comparing to the —150-volt regulated supply (the cathode of V814B) a voltage near —150 volts obtained from a tap on the divider connected between the decoupled +100-volt bus and the —1350-volt bus. The total resistance of the divider, and hence the voltage across the divider, is determined by the setting of R811 labeled HV ADJ. When this control is properly adjusted, the voltage at the HV ADJ. TEST POINT will be exactly —1350 volts.

If variations in loading should tend to change the voltage on the —1350-volt bus, an error signal will exist between the grid and cathode of V814B. The error signal will be amplified by V814B and V814A; the output of V814A varies the screen voltage of the oscillator tube V800, thereby controlling its output.

The +8650-volt supply and the negative bias supply are regulated indirectly, as the output voltage of all three supplies is proportional to the output of the Oscillator circuit.

Unblanking

As mentioned previously, dc-coupled unblanking is accomplished by employing separate power supplies for the grid and cathode of the crt. The unblanking pulses from the Time-Base Generator are transmitted to the crt grid through the cathode follower V183B and the floating grid supply.

At the faster sweep rates the stray capacitance in the circuit makes it difficult to pull up the floating supply fast enough to unblank the crt in the required time. To overcome this, an isolation network composed of C834, R834 and R835 is employed. By this arrangement the fast leading edge of the unblanking pulse is coupled through C834 to the grid of the crt. For short-duration unblanking pulses, at the faster sweep rates, the power supply itself is not appreciably moved.

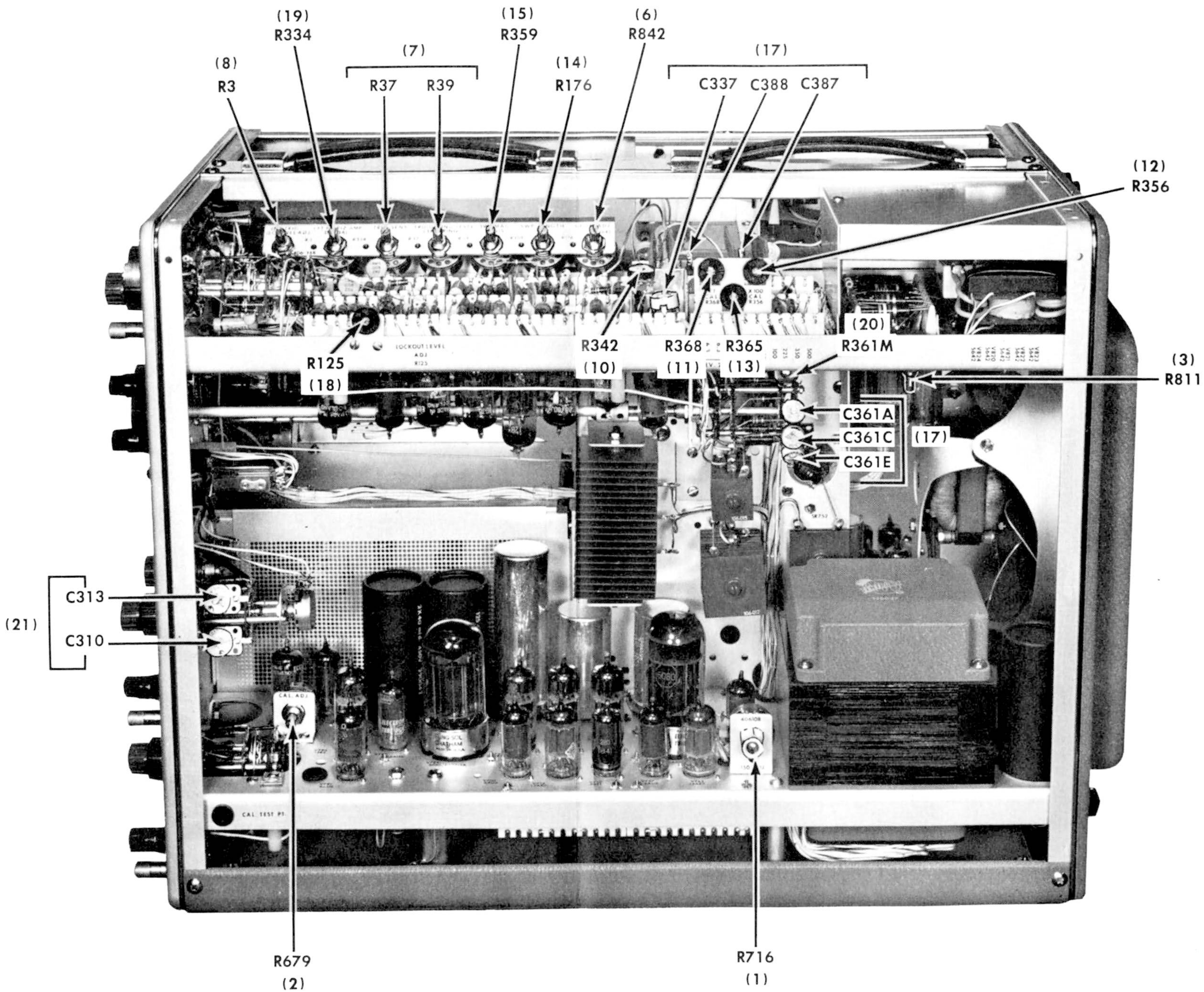
The longer unblanking pulses, at the slower sweep rates, charges the stray capacitance in the circuit through R834. This pulls up the floating supply and holds the grid at the unblanked potential for the duration of the blanking pulse.

CALIBRATOR

The Calibrator is a square-wave generator whose approximately 1-kc output is available at a front-panel connector labeled CAL. OUT. It consists of a multivibrator V670 connected so as to switch the cathode follower V246A between two operating states . . . cutoff and conduction.

During the negative portion of the Multivibrator waveform the grid of V246A is driven well below cutoff and its cathode rests at ground potential. During the positive portion of the waveform V670A is cutoff and its plate rests slightly below +100 volts. The voltage at the plate of V670A, when this tube is cutoff, is determined by the setting of the CAL. ADJ. control R679, part of a divider connected between +100 volts and ground.

Cathode - follower V246A has a precision, tapped divider for its cathode resistor. When the CAL. ADJ. control is properly adjusted, the cathode of V246A is at +100 volts when V670A is cutoff. By means of the tapped divider R683 through R691 and a second 1000/1 divider R694-R695, output voltages from .2 millivolts to 100 volts, in steps, are available. C682, connected between the cathode of V246A and ground, corrects the output waveform for a slight overshoot.



(19)
R334
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R359
(6)
R842
(7)
R37
R39
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C337
C388
C387
(8)
R3
(14)
R176
(12)
R356
R125
(18)
R342
(10)
R368
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R365
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R361M
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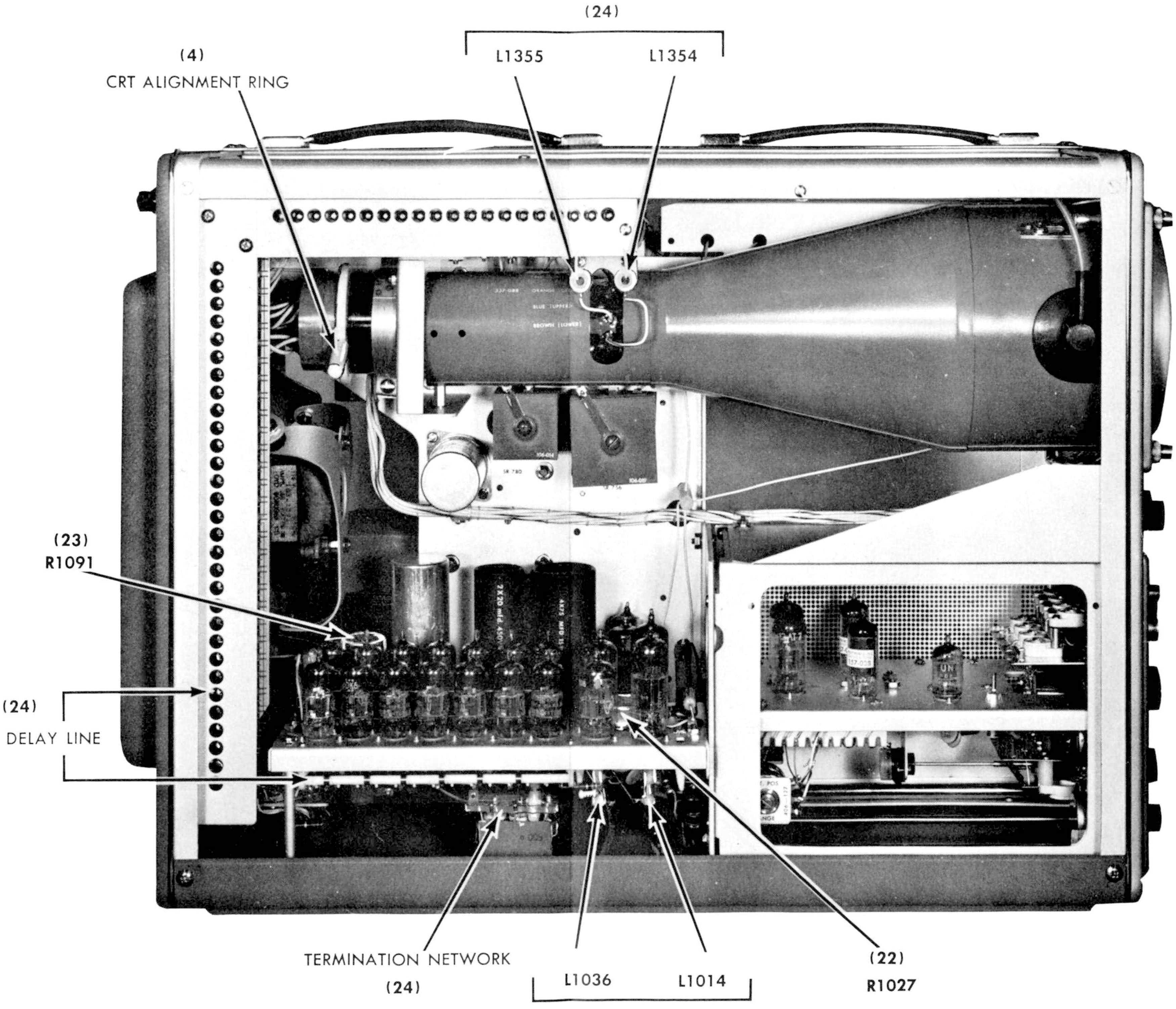
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L1355
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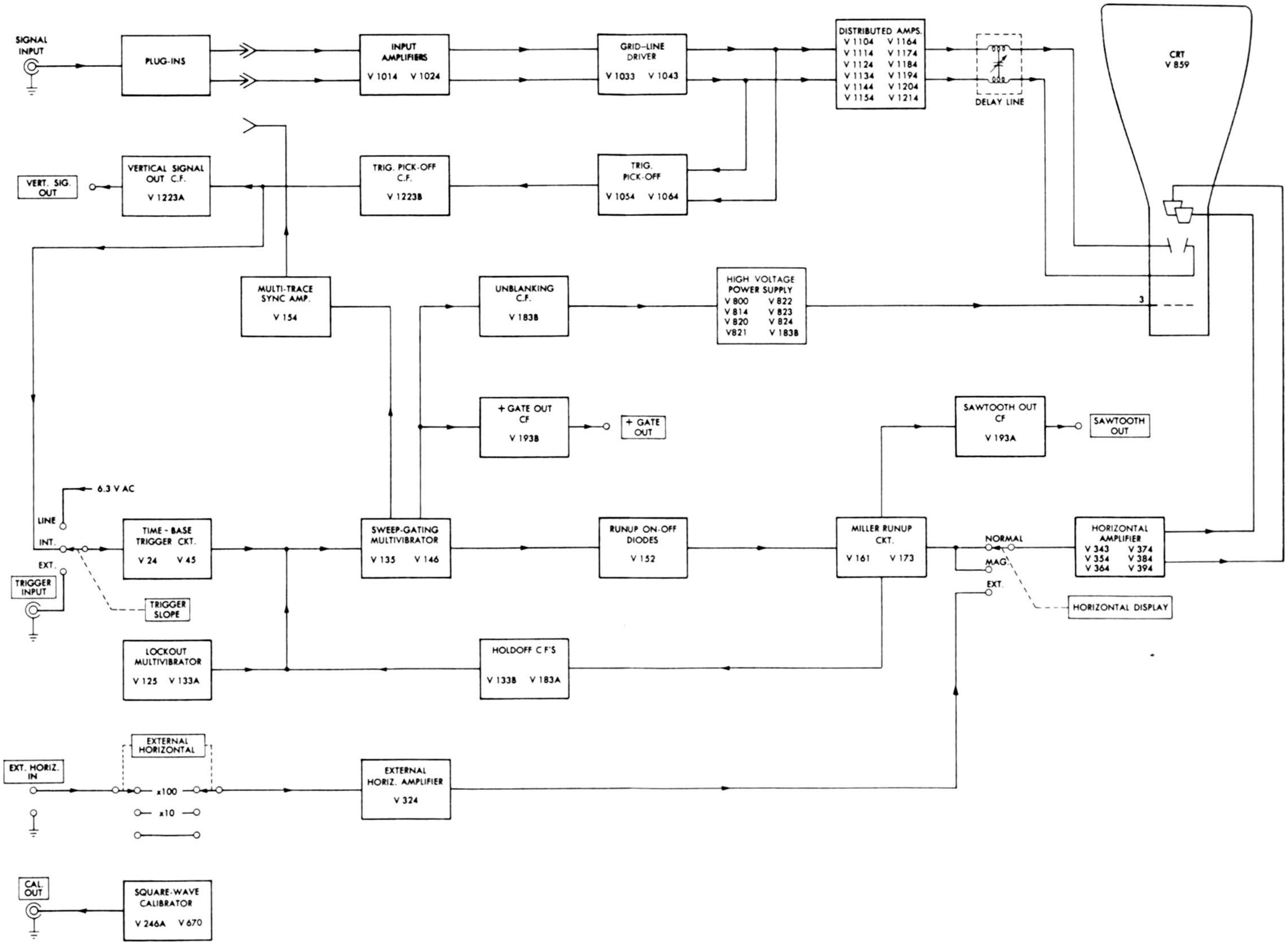
R1027



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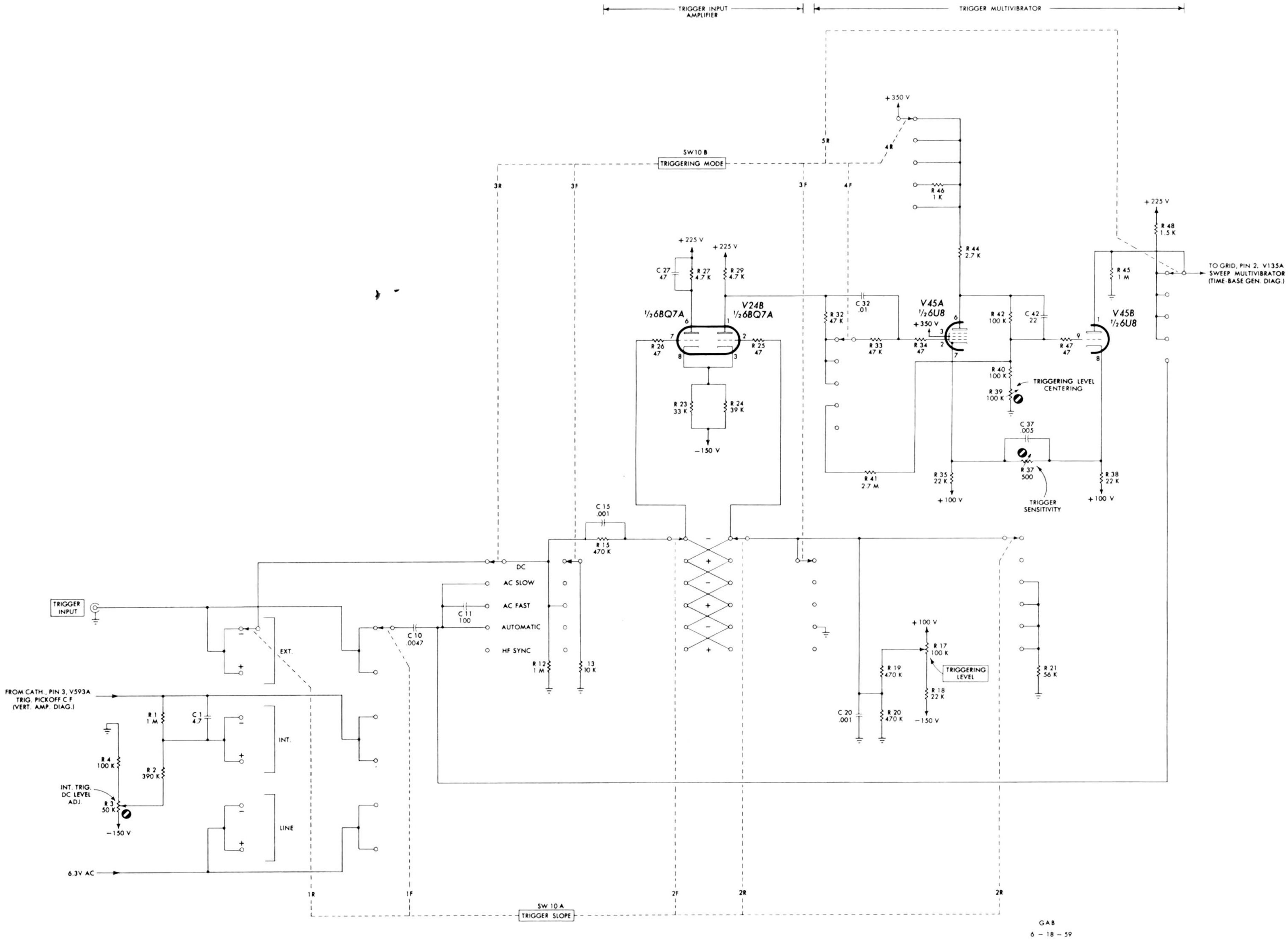
TYPE 543 OSCILLOSCOPE

A

BLOCK DIAGRAM



TYPE 543 OSCILLOSCOPE

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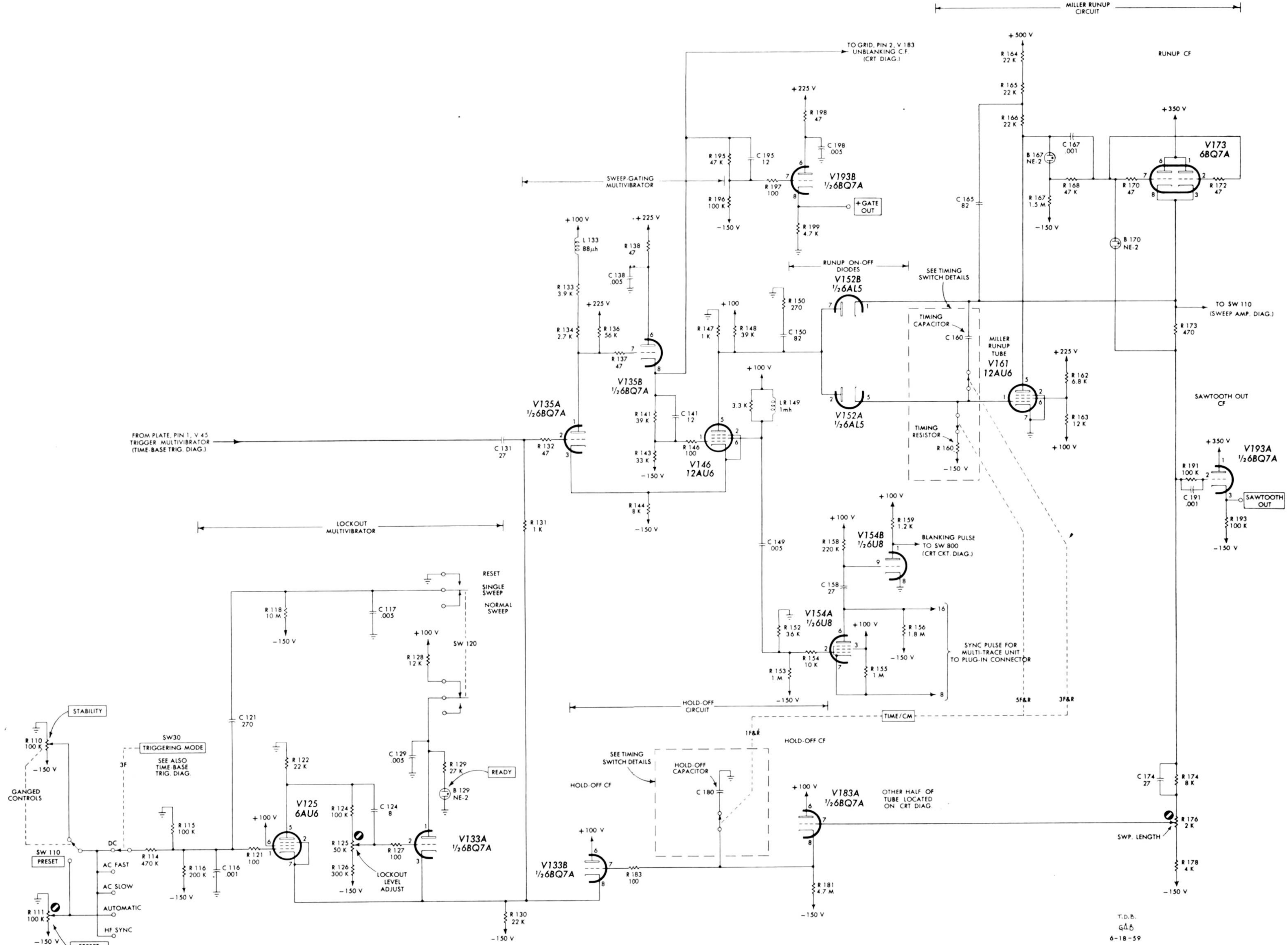
TIME-BASE TRIGGER



TYPE 543 OSCILLOSCOPE

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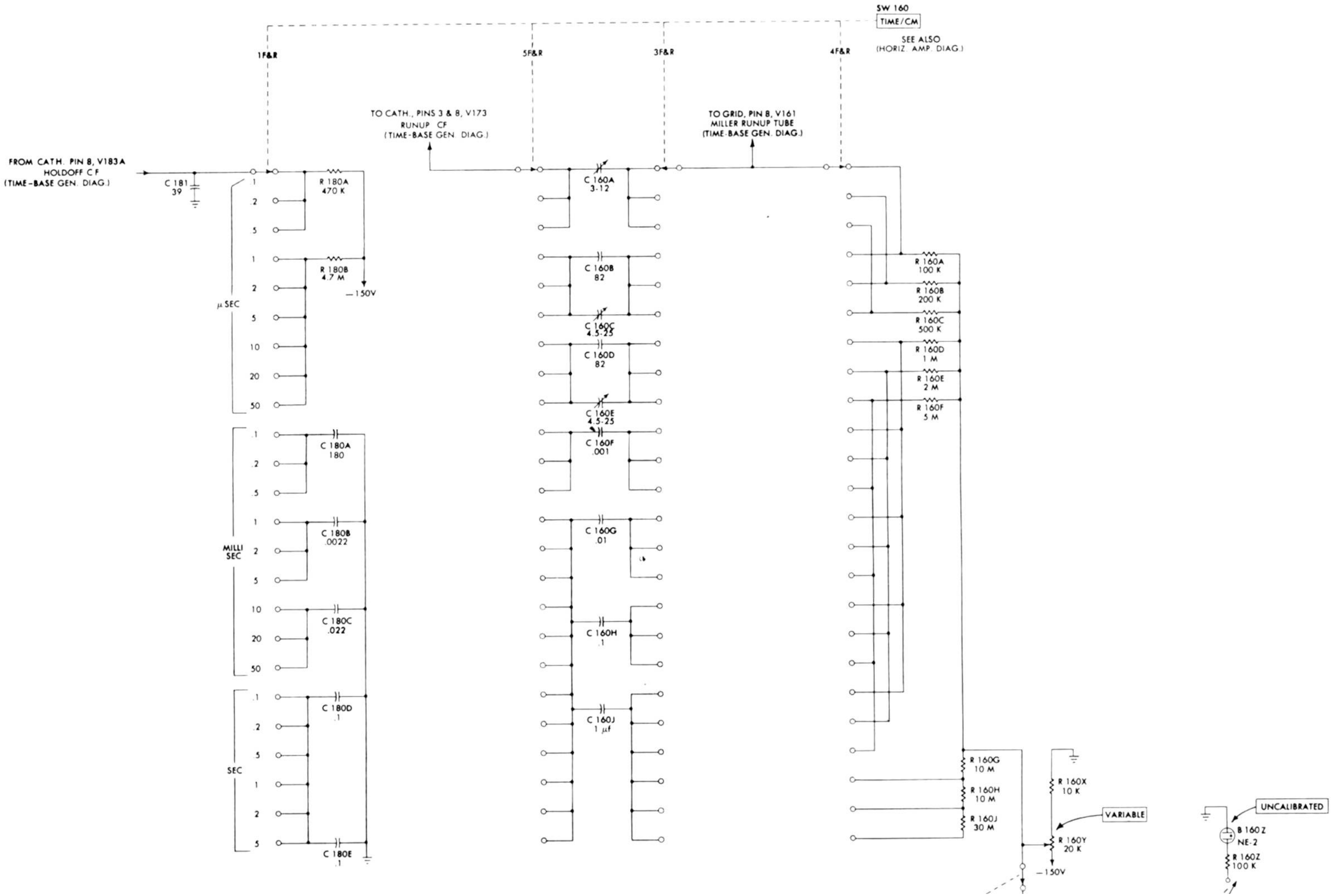
TIME-BASE GENERATOR



SW 160
TIME/CM
SEE ALSO
(HORIZ. AMP. DIAG.)
1F&R
5F&R
3F&R
4F&R
TO CATH., PINS 3 & 8, V173
RUNUP CF
(TIME-BASE GEN. DIAG.)
TO GRID, PIN 8, V161
MILLER RUNUP TUBE
(TIME-BASE GEN. DIAG.)
FROM CATH. PIN 8, V183A
HOLDOFF C F
(TIME-BASE GEN. DIAG.)
C 181
39
R 180A
470 K
R 180B
4.7 M
−150V
μ SEC
MILLI SEC
SEC
C 180A
180
C 180B
.0022
C 180C
.022
C 180D
.1
C 180E
.1
C 160A
3-12
C 160B
82
C 160C
4.5-25
C 160D
82
C 160E
4.5-25
C 160F
.001
C 160G
.01
C 160H
.1
C 160J
1 μf
R 160A
100 K
R 160B
200 K
R 160C
500 K
R 160D
1 M
R 160E
2 M
R 160F
5 M
R 160G
10 M
R 160H
10 M
R 160J
30 M
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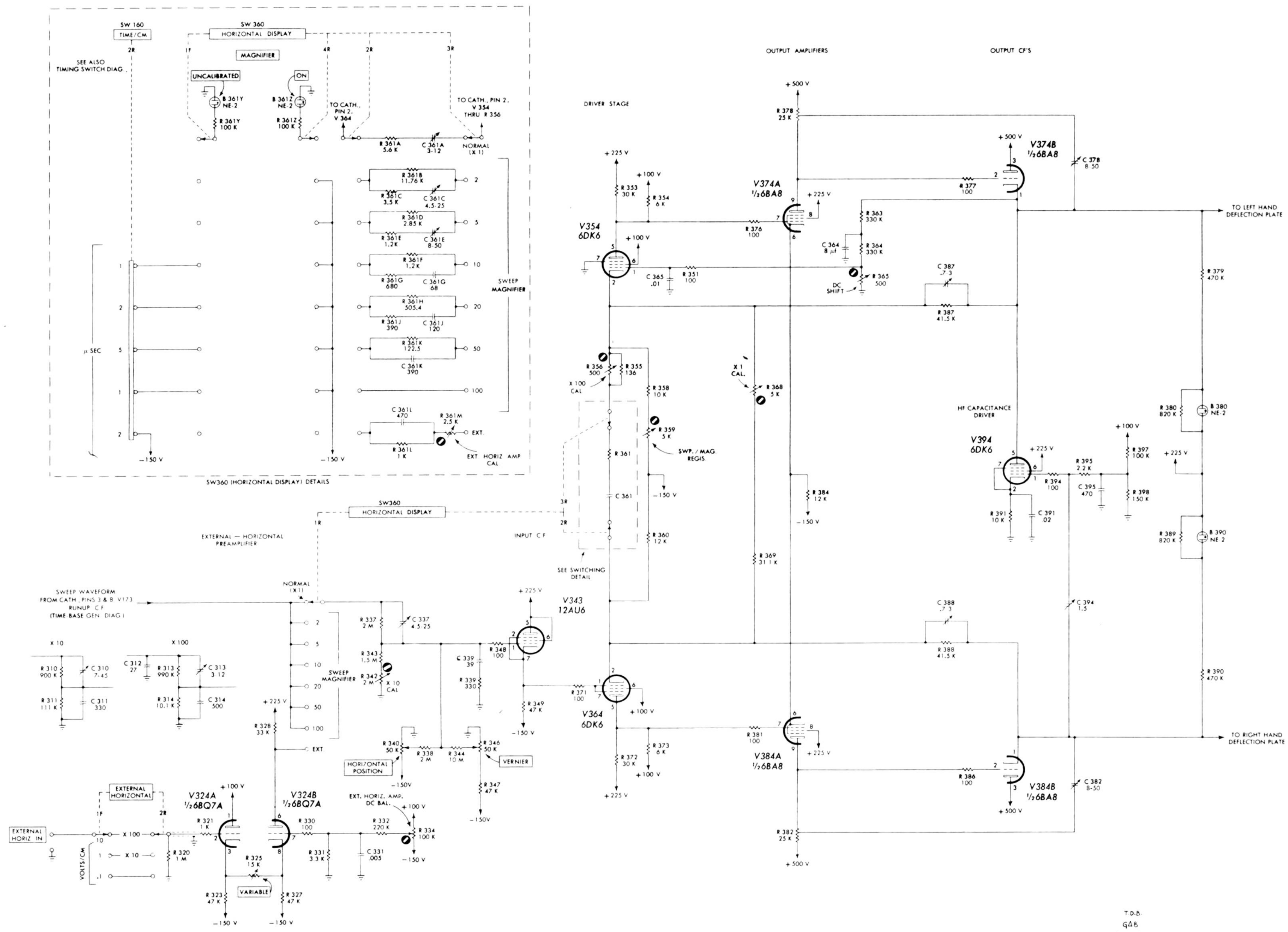
UNCALIBRATED
B 160 Z
NE-2
R 160Z
100 K

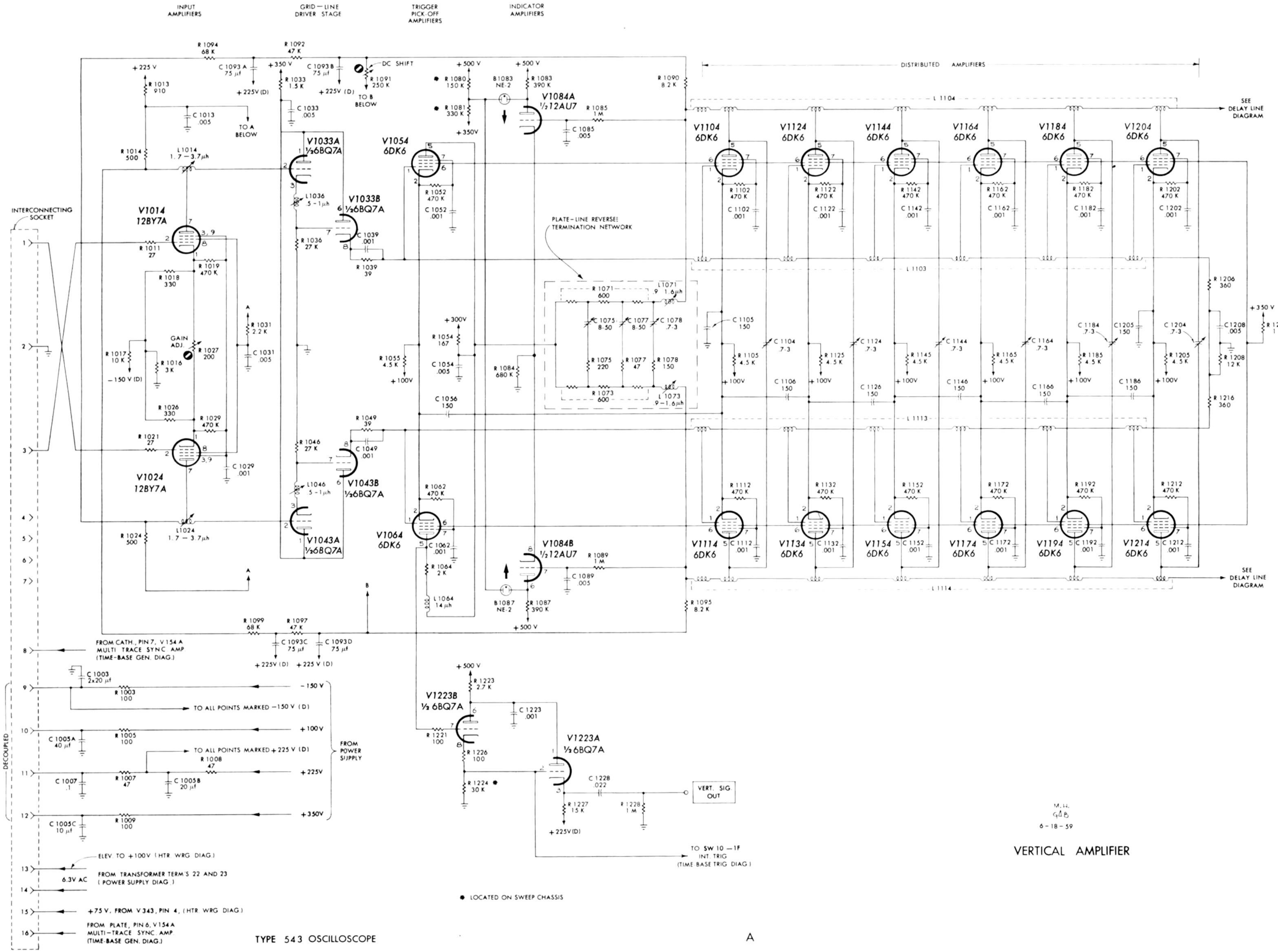


T.D.B
648
6-18-59

TYPE 543 OSCILLOSCOPE

A

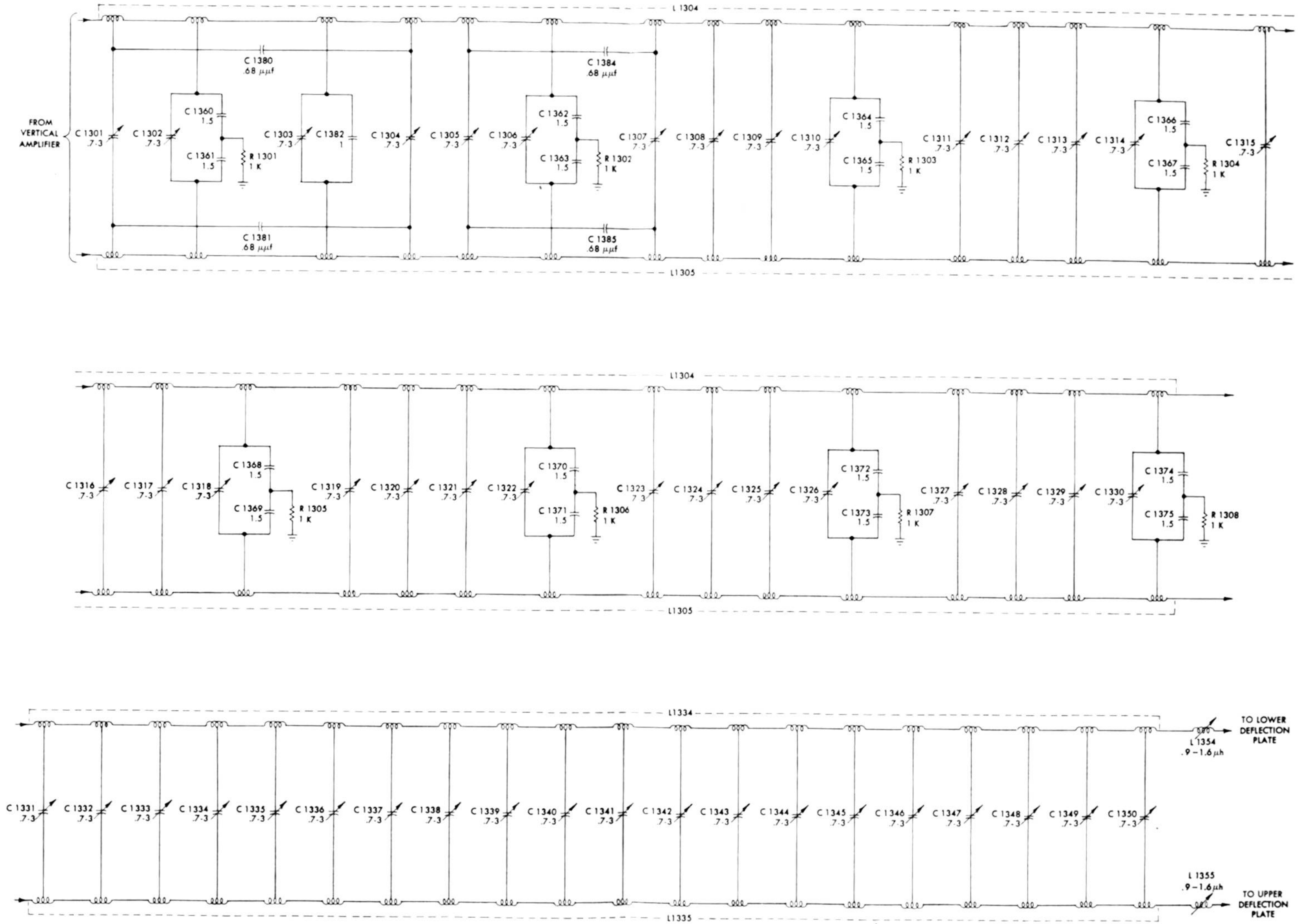
HORIZONTAL AMPLIFIER



VERTICAL AMPLIFIER

TYPE 543 OSCILLOSCOPE

A

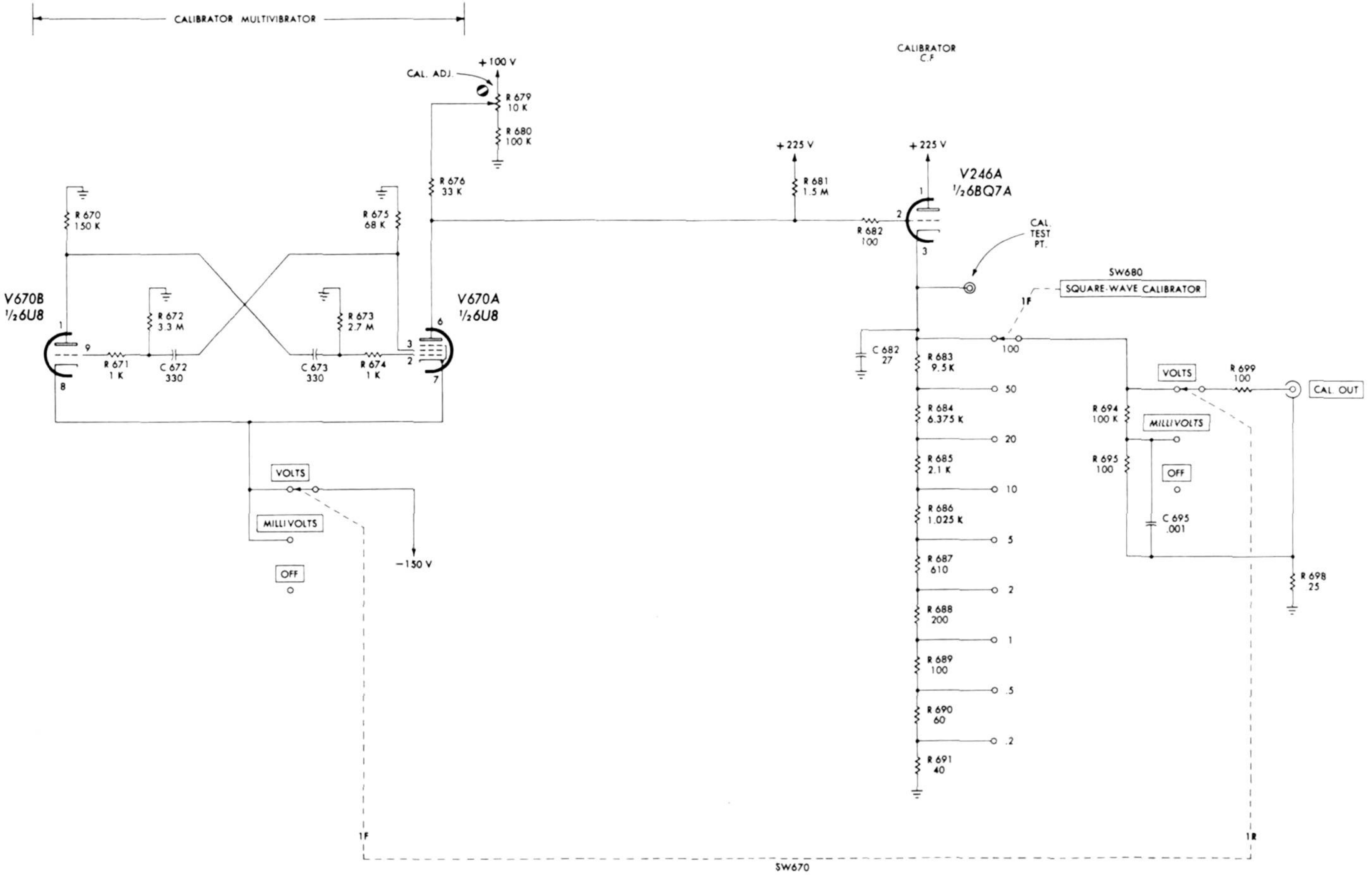


GΔB
6-18-59

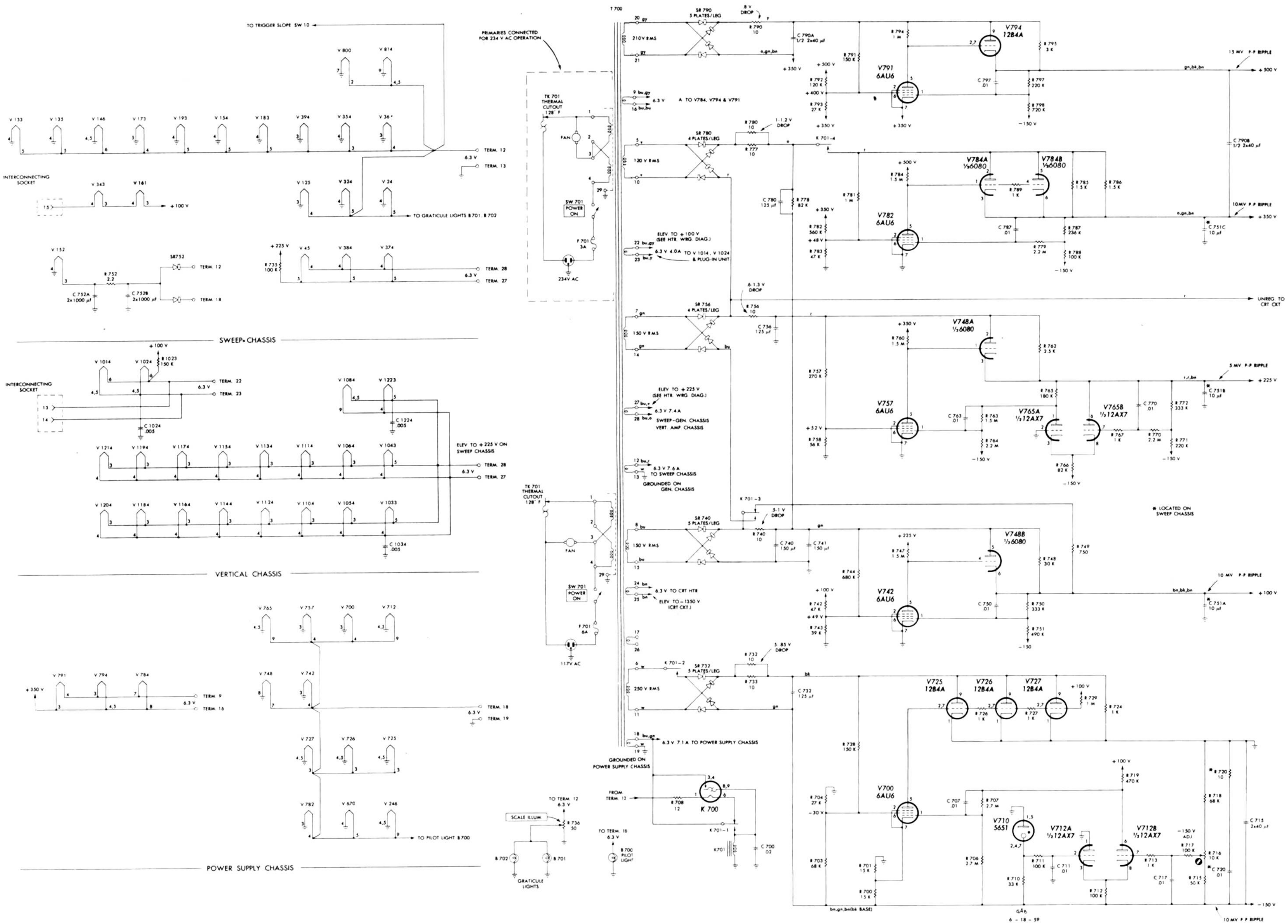
TYPE 543 OSCILLOSCOPE

A

DELAY LINE NETWORK



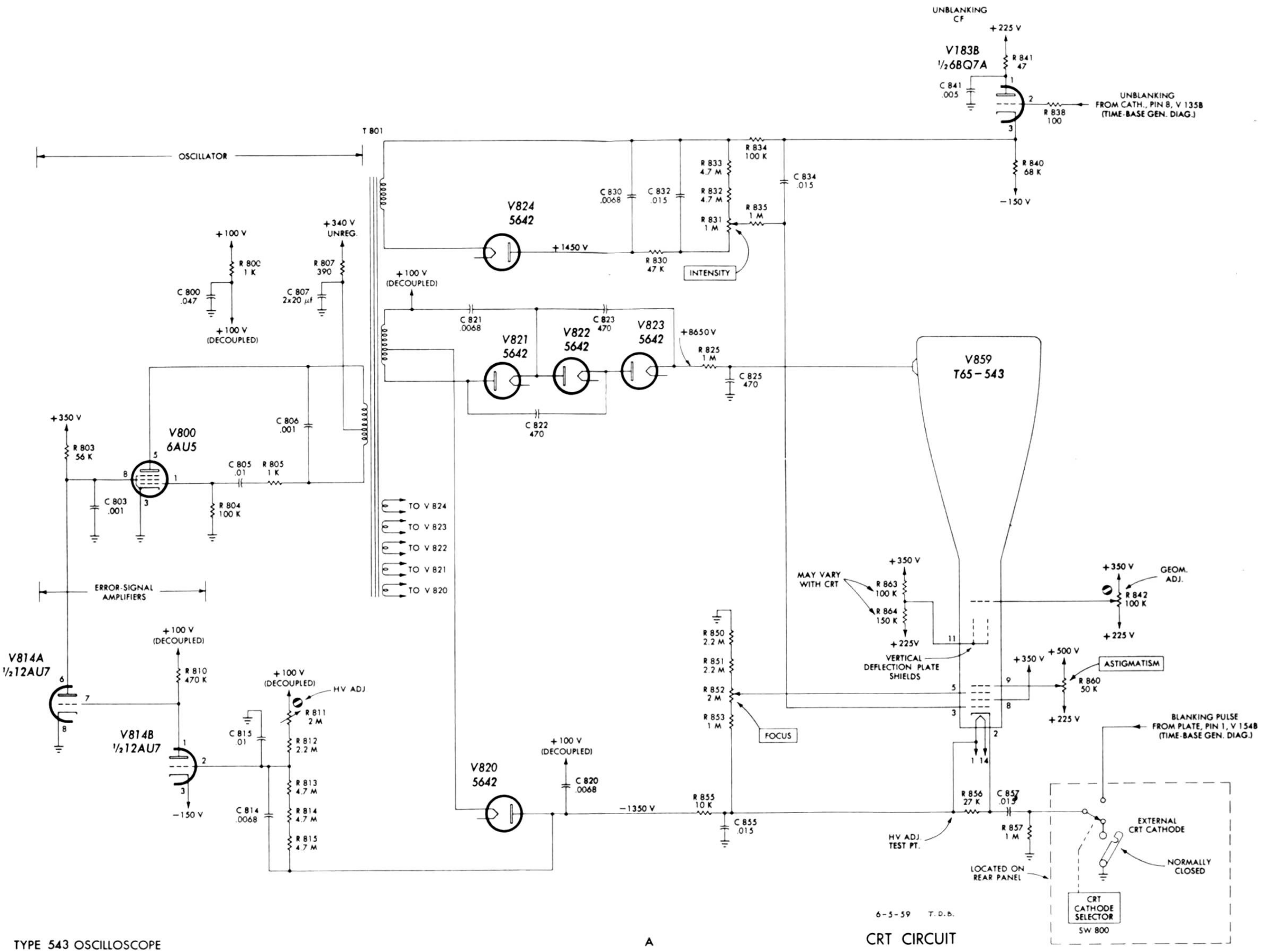
T.D.B.
G4B
6-18-59



TYPE 543 OSCILLOSCOPE

A

LV POWER SUPPLY



TYPE 543 OSCILLOSCOPE

A

CRT CIRCUIT