Trigger Pickoff

The Trigger Pickoff circuit consists of an amplifier stage and an output cathode follower. The amplifier tubes, V1054 and V1064, monitor the vertical signal from the two grid lines, amplify and invert the signals, and combine them to provide the output signal. The single-ended output is coupled through V1223A to the interconnecting wiring of the oscilloscope for application to the Time-Base Trigger circuits where it can be used to trigger the display.

TIME-BASE TRIGGER

The basic function of the Time-Base Trigger circuit is to provide constant-amplitude negative spikes that are time-related to the input signal for starting each horizontal sweep at the proper time to present a stable display.

The Type 21A and the Type 22A have similar Time-Base Trigger circuits which operate on input signals up to 30 mc. Each of the circuits, as shown in the block diagram (Fig. 4-3), consists essentially of a vacuum-tube comparator, an emitter-coupled transistor current amplifier, a pulse generator, a countdown circuit and an output pulse amplifier. Refer to the Time-Base Trigger schematic diagram in the back of this manual during the following description.

Trigger Input

The SOURCE switch, SW8, at the input to the circuit provides selection of the trigger signal from one of six possible sources: either of the Vertical Amplifier trigger pickoff circuits; either of the vertical plug-in units; the line frequency, or an external signal applied through the trigger INPUT connector. Use of the plug-in units for triggering sources is limited to operation with multi-trace plug-in units with internal trigger pickoff circuits. The line-frequency signal is taken from the 6.3 volt regulated filament supply and filtered by R5 and C5 to remove some of the rms regulator distortion.

The TRIG DC LEVEL controls, R3 and R8, set the dc levels of the inputs from the Vertical Amplifier at zero volts for dc-coupling of the internal signals. The attenuators associated with the DC TRIG LEVEL controls provide compensation for high-frequency triggering signals. The COUPLING switch, SW10, provides either ac- or dc-coupling of the trigger signal, and the trigger SOURCE switch, SW22, permits triggering to be done on either the positive-going or the negative-going slope of the selected signal.

Comparator and Difference Amplifier

The trigger comparator circuit consists of a cathode-coupled vacuum tube pair, V24A and V24B. The input triggering signal is applied to one of the grids and compared to a dc voltage on the other grid. The comparison voltage is provided by the trigger LEVEL and VERNIER controls, R17 and R21. The LEVEL control can vary the comparison voltage by about ±10 volts, and the VERNIER control has a range of about ±1 volt. When both of the controls are centered, the voltage is approximately zero.

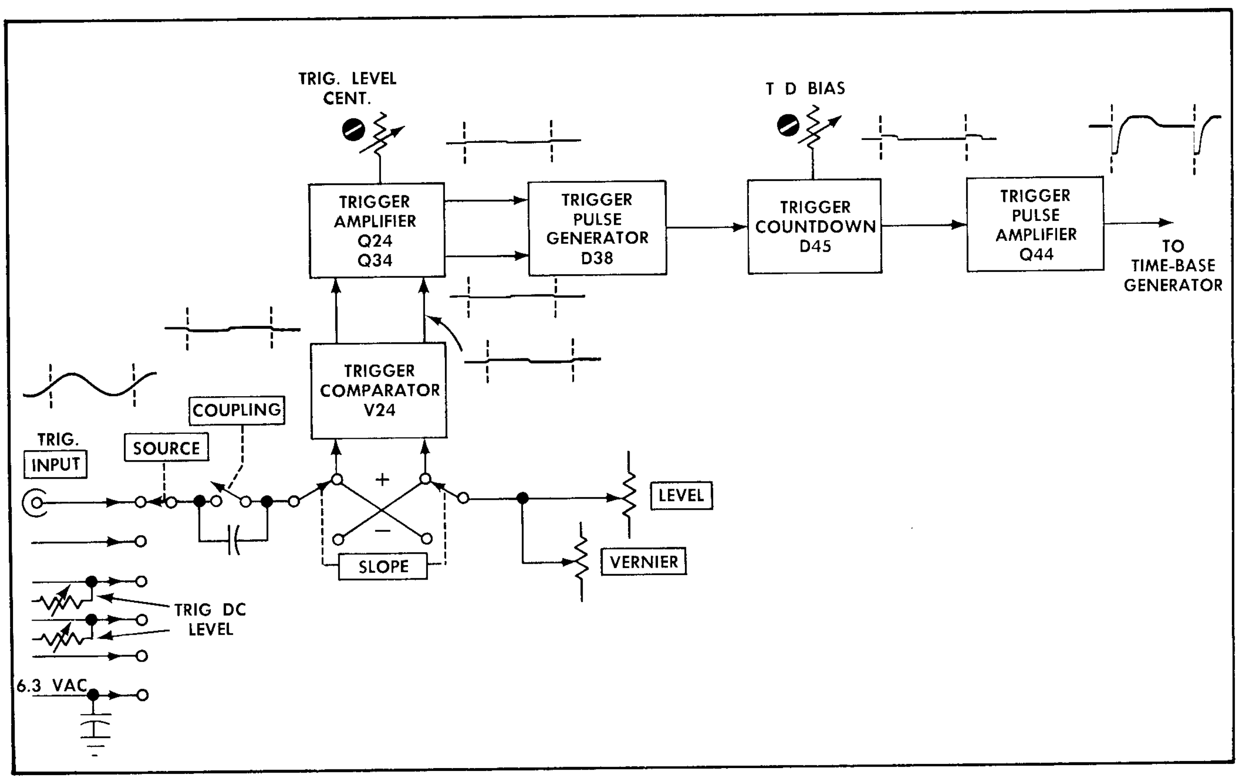

Fig. 4-3. Time-Base Trigger block diagram.

To illustrate the operation of the circuit, assume that the SLOPE switch, SW22, is set to + and the trigger level voltage is set slightly positive. The comparison voltage from the trigger level circuit is then connected to the grid of V24B and the triggering signal is applied to the grid of V24A. V24B will be conducting more heavily than V24A, D24 will be conducting, D25 will be reverse biased and current through Q24 will be greater than that through Q34. When the level of the input triggering signal becomes more positive than the comparison voltage, current through V24A becomes greater than that through V24B. The resulting current and voltage change in the plate circuits of V24A and V24B is applied to the transistor pair, Q24 and Q34. As D24 becomes reverse-biased and D25 begins to conduct, the voltage amplitude of the push-pull signal applied to Q24 and Q34 is limited to the sum of the bias voltages of D24 and D25. Thus the circuit is able to amplify and operate on small triggering signals, but large signals are clipped so they will not overdrive the circuit.

The signal applied to the base circuits of the transistor pair causes current to increase through Q34 and to decrease through Q24. The push-pull current pulse existing between the collectors of the transistor pair is sent through tunnel diode D38, causing it to switch rapidly to its high voltage state as soon as the current reaches approximately 5 ma.

If the SLOPE switch had been set at — and the triggering level voltage set slightly negative, a push-pull current pulse would have been sent through D38 in exactly the same manner. In that case, however, the switching pulse would have occurred on the negative slope of the input signal, as the trigger source voltage on the grid of V24B became more negative than the comparison voltage at the grid of V24A. The TRIG LEVEL CENT control, R26, balances the base voltages on Q24 and Q34 so that their bias currents are equal.

Pulse Generator and Amplifier

Bias current for tunnel diode D38 is supplied primarily through D45, R41 and R38, setting both D38 and D45 near their switching levels (see Fig. 4-4). This current is adjusted with the TD BIAS control, R44, during calibration. Resistor R36 sets the lower switching level of D38.

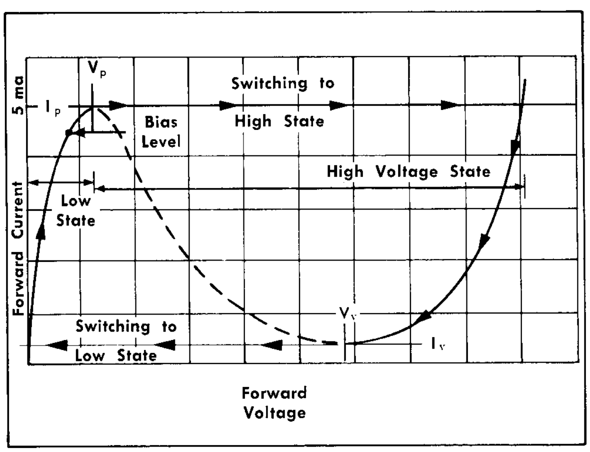

Fig. 4-4. Characteristic curve for tunnel diodes D38 and D45.

When diode D38 is switched to its high voltage state by the current pulse from the transistor pair, the resulting voltage pulse is differentiated by C38, C40, R40 and the impedance of T40. The small pulse is then applied through D40 to the countdown tunnel diode, D45, switching it to its high state. The output amplifier-inverter, Q44, is quiescently biased to conduct slightly. As D45 switches to its high state, the positive-going pulse applied to the base of Q44 causes the transistor to saturate. The resulting fast negative-going pulse at the collector is the output trigger pulse to be used by the Time-Base Generator circuit.

Trigger Countdown

The input comparator and amplifier stages of the Time-Base Trigger circuit, as well as D38 and D40, can follow changes in the input trigger signal to well above 30 mc. Thus, the frequency of the constant-amplitude pulses applied to D45 can be as high as 30 mc. The maximum repetition rate of the Time-Base Generator circuit is about 150 kc, and it cannot "count down" well from high frequencies. Therefore countdown of the trigger pulses is provided by D45 to limit the repetition rate of trigger pulses to the Time-Base Generator circuit to less than 70 kc.

Countdown is accomplished by making the cycle time of D45, from the instant of triggering to the next instant of triggerability, about 14 μsec. When D45 is triggered by a pulse from D38, it switches to its high voltage state, but this is an unstable state so the voltage and current immediately begin to decrease along the tunnel diode curve at a rate determined by the L/R time constant of L42 and the resistance of the circuit. D45 switches back to its low voltage state when it reaches the valley current, then recovers to its bias point at the L/R time constant of the circuit at that time. Since the total cycle time is about 14 μsec, the maximum repetition rate of the countdown circuit is about 70 kc.

Reset

When the input triggering signal at the comparator drops somewhat below the comparison voltage, D38 resets to its initial state. The negative voltage pulse through T40 is blocked by D40 and does not reach the countdown circuit. Thus the output trigger pulse is a fast 10-volt negative step as Q44 saturates, followed by a slow positive rise as the output is differentiated and Q44 returns to its initial bias conditions.

TIME-BASE GENERATORS

The Time-Base Generator circuits in the Type 21A and the Type 22A are essentially identical except for portions related to the delayed sweep. Fig. 4-5 is a block diagram of the Time-Base Generator showing the basic circuits and differences between the two units. The following circuit description applies to both generators. Operation of the delayed sweep circuitry is described later in this section.

Trigger signals received from the Time-Base Trigger circuit are applied to the auto baseline multivibrator and through a differentiating circuit to the sweep-gating multivibrator. Whenever the Time-Base circuit operates, whether triggered or free running, it produces four output signals:

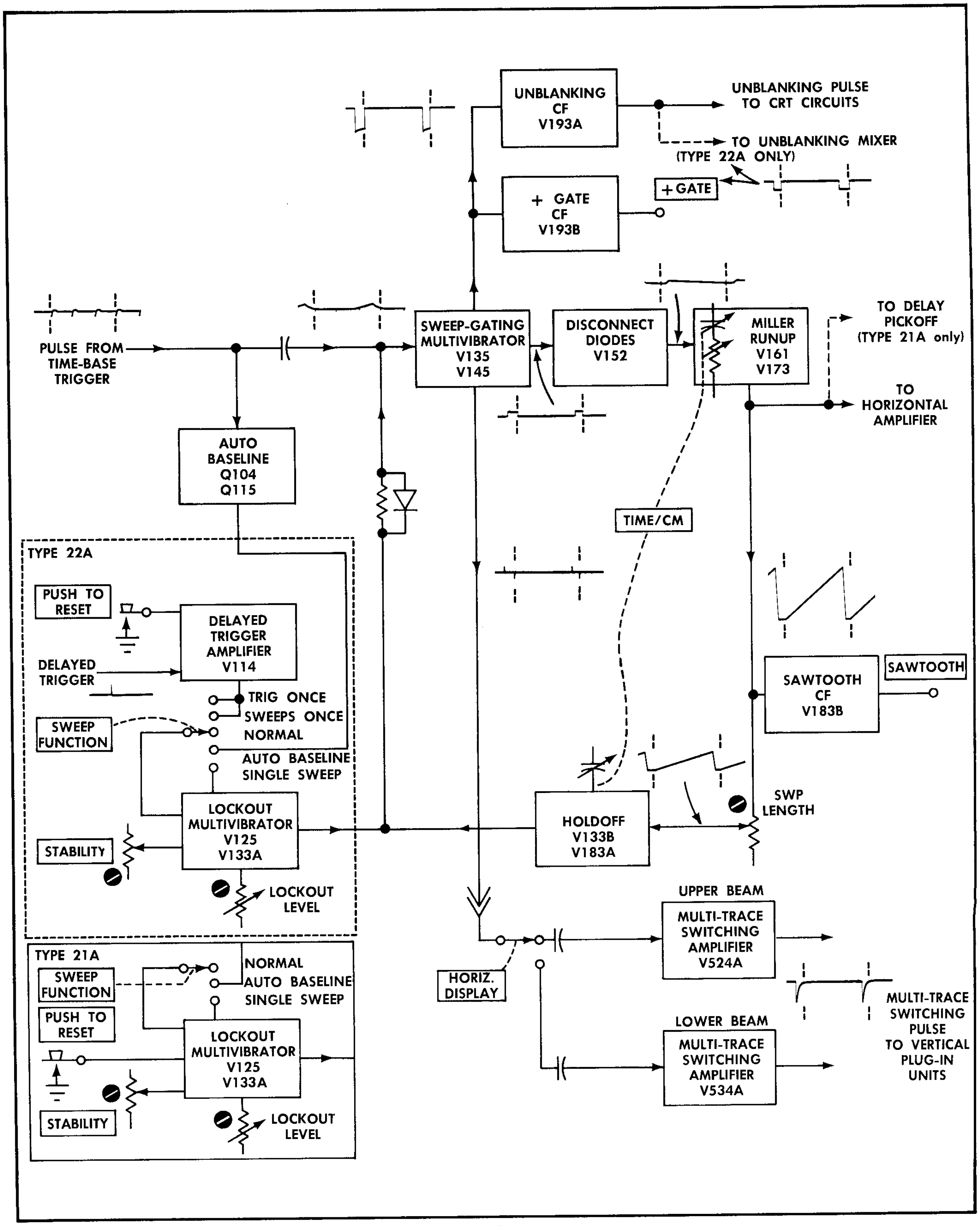

Fig. 4-5. Time-Base Generator block diagram showing differences between the Type 21A and the Type 22A.

1. A 150-volt positive-going sweep sawtooth waveform that can be coupled through the HORIZ. DISPLAY switches to either or both of the Horizontal Amplifiers. The sawtooth output is coupled to the SAWTOOTH connector through an output cathode follower, and the Time Base A sawtooth is also connected to the Delay Pickoff circuit.

2. A positive-going 65-volt unblanking waveform, with the same duration as the sawtooth rise, coupled through the HORIZ. DISPLAY switches to floating high-voltage negative supplies in either or both sides of the crt circuit. The unblanking waveform unblanks the crt beam(s) being deflected by the Time-Base Unit during the sweep.

3. A positive 25-volt +gate waveform with the same duration as the sawtooth rise, available at the front-panel +GATE connector for external use.

4. A negative-going 12-volt multi-trace sync pulse with the same duration as the sawtooth rise, coupled through the HORIZ. DISPLAY switches to either or both of the vertical plug-in units. The trailing edge of the pulse causes a multi-trace plug-in unit to switch channels when operated in the alternate mode.

Each cycle of events is either started by a trigger pulse from the Time-Base Trigger circuit, or is started by the end of the previous cycle when the circuit is set for free-run operation. Triggered operation is used for most applications. The Time-Base Generator can also be disabled so that the circuit will not operate. The desired mode of operation is obtained through the appropriate setting of the SWEEP FUNCTION switch and the trigger LEVEL and VERNIER controls.

The auto baseline circuit provides free-run operation of the sweep in the absence of trigger pulses, and the lockout multivibrator provides single sweep operation. The sweep-gating multivibrator is a two-state electronic switch that turns the disconnect diodes on and off. When the diodes are on, the output of the Time-Base Generator is clamped slightly below ground. When the diodes are cut off, the Miller runup circuit is allowed to produce a sweep sawtooth signal. A portion of the sawtooth waveform is fed back to the sweep-gating multivibrator through the hold off circuit, forming the holdoff waveform. When the rise of the holdoff waveform reaches a preset amplitude, the sweep-gating multivibrator resets, switching the disconnect diodes on. The Miller runup circuit then resets, forming the retrace or falling portion of the sawtooth. The retrace portion of the feedback sawtooth sample is delayed by the holdoff circuit, preventing the generator from beginning the next cycle of operation until the circuits have stabilized.

The dc level at the input of the sweep-gating multivibrator is controlled by the lockout multivibrator, the STABILITY control, the auto baseline circuit and the holdoff waveform. In normal triggered operation, one half of the lockout multivibrator serves as a cathode follower to hold the input voltage at the "triggerable" level.

In the following detailed circuit description, refer to the Type 21A Time-Base Generator schematic diagram in the back of this manual. Unless otherwise stated, the SWEEP FUNCTION switch is set to NORMAL and the trigger LEVEL and VERNIER controls are set for triggered operation.

Quiescent Conditions

In the quiescent state with the generator in a triggerable condition but no sweep being generated, the circuit conditions are as follows:

Sweep Gating Multivibrator—V135A is conducting and V145 is cut off. The STABILITY control, operating through cathode follower V125, sets the grid voltage of V135A at about —50 volts. The plate voltage of V135A, applied through cathode follower V135B sets the grid of V145 about 5 volts more negative than the grid of V135A, so V135A draws all the current available from the common cathode circuit. The cathode voltage of V135B sets the voltage at the grids of V193A and V193B so that V193A is conducting and V193B is cut off. Thus the blanking voltage to the crt from the cathode of V193A is at about —45 volts, and the +GATE output at the cathode of V193B is held at ground. With V145 cut off, its plate voltage of about —3 volts keeps the disconnect diodes turned on.

Disconnect Diodes — V152A and V152B are conducting. V152A clamps the sawtooth output at about —3.5 volts at the cathode of V173, to provide a stable starting voltage for the sawtooth. V152B clamps the grid of V161 at about —2.5 volts.

Miller Runup Circuit—V161 is conducting heavily with its grid held at about —2.5 volts and its plate voltage at about +40 volts. V173 is cut off with a voltage of about —12 volts on its grid, set by the plate voltage of V161 and the divider, B167 and R167.

Holdoff Circuit—V183A is conducting and V133B is cut off. Voltage applied to V183A through the SWP LENGTH control sets the voltage at its grid at about —95 volts and its cathode at about —85 volts. This voltage, which is connected to the grid of V133B, is about 35 volts more negative than the —50 volts on the cathode of V133B set by the stability control circuit, so the tube is cut off.

Lockout Multivibrator—V125 is conducting and V133A is cut off. The circuit is essentially inoperative, though V125 is serving as a cathode follower for the stability voltage.

Auto Baseline Circuit—V115A and Q104 are conducting and V115B is cut off. With the grid of V115A held at about +18 volts (with SWEEP FUNCTION at NORMAL), negative trigger pulses applied through D108 cannot cause the circuit to operate.

Cycle of Operation

a. Gating

When the negative-going pulse is received from the Time-Base Trigger circuit at the grid of V135A, the sweep-gating multivibrator switches states. The switching action begins as the trigger pulse at the plate of V135A is applied to the grid of V145 through cathode follower V135B, starting conduction of current through V145 and decreasing current from the common cathode through V135A. This regenerative action quickly switches the state of the multivibrator so that V135A is cut off and V145 is conducting heavily. The positive-going portion of the trigger signal is clipped by diode D132 and has no effect on the sweep-gating multivibrator.

When V135A cuts off, the voltage at the cathode of V135B rises sharply. This voltage step is coupled to the unblanking and +gate cathode followers, V193A and V193B, causing them to unblank the crt beam and start the +gate output pulse.

With V145 now in conduction, its plate voltage has dropped to a new level of about —6 volts. This negative voltage step lowers the voltage on the plates of the disconnect diodes to a value more negative than their cathodes, and causes the tubes to cut off.

b. Runup

Current through the timing resistor, R160, that had been conducted by V152B, is now diverted and begins to charge the timing capacitor, C160, toward —150 volts. The initial negative change in voltage at the grid of the Miller tube, V161, is amplified by a factor of about 200 and appears as a positive-going voltage at the plate of the tube. This amplified change is coupled back through the dc voltage-dropping bulb, B167, and cathode follower V173 to the output side of the timing capacitor, tending to oppose any change at the grid side of the capacitor. The feedback action continues throughout the sawtooth rise, limiting the total swing at the grid to less than 1 volt. With the grid of V161 held at a nearly constant voltage level, the voltage across the timing resistor remains essentially unchanged. Current through the resistor is therefore constant and the timing capacitor charges linearly. The resulting voltage change at the cathodes of V173 is a linear 150-volt sawtooth that is capable of driving the Horizontal Amplifier. The rate of rise of the sawtooth is determined by the RC time constant of the particular timing resistor and timing capacitor combination selected with the TIME/CM switch, SW160. The fast sweep rates are also accurately calibrated with variable capacitors.

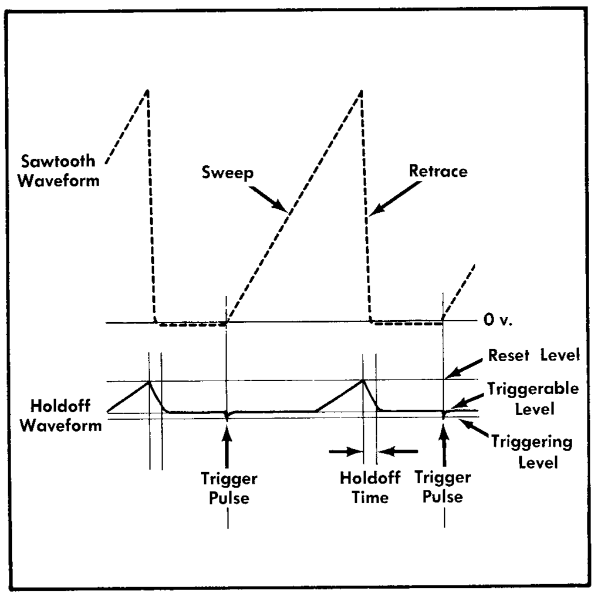

Fig. 4-6. Cycle of events at grid of V135A, related to output sawtooth waveform.

An attenuated portion of the positive-going voltage sawtooth waveform is also fed back to the grid of V183A in the holdoff circuit. The amount of attenuation of the waveform is set by the SWP LENGTH control, R176.

As the voltage rises at the grid of V183A, the cathode follows the grid voltage, causing the holdoff capacitor to charge through R181. The cathode voltage is also coupled to the grid of V133B. When the grid of V133B becomes slightly more positive than the —50 volts set at the cathode by the stability circuit, V133B begins to conduct. Since V125 is cathode-coupled to V133B, V125 cuts off as V133B starts to conduct, and the attenuated sawtooth above the stability level is coupled through V133B to the grid of V135A at the input to the sweep-gating multivibrator. Figure 4-6 relates the cycle of events at the grid of V135A to the output sawtooth waveform.

c. Reset

The holdoff waveform rises until it reaches the reset level, which is slightly more positive than the common cathode voltage set by the grid of V145. V135A then begins to conduct, diverting current from V145 and causing the multivibrator to switch back to its original state.

The negative-going voltage step at the cathode of V135B as the multivibrator switches is coupled through V193A and V193B to end the +gate pulse and blank the crt for retrace. The positive-going voltage at the screen grid of V145 is connected through the appropriate multi-trace switching amplifier, V524A or V534A, to the vertical plug-in unit for alternate-trace switching during retrace.

As V145 cuts off, its plate rises to about —3 volts again, bringing V152B into conduction. The voltage at the grid of V161 rises rapidly and the plate voltage drops. The grid and cathode voltages on V173 follow the plate of V161 to form the falling portion, or retrace, of the sawtooth waveform. When the cathodes of V173 reach about —3.5 volts, V152A conducts, stopping the voltage fall and clamping the output voltage at that level.

The portion of the sawtooth waveform coupled back to the holdoff circuit is applied to the grid of V183A, reducing current through the tube. The holdoff capacitor, which had been charging during the sweep, now discharges through R181. The voltage fall is thus retarded at the grid of V133B and hence at its cathode. When the grid voltage of V133B reaches the level set by the stability circuit, V125 conducts and V133B cuts off. The voltage at the grid of V135A is then set again at the triggerable level and the Time-Base Generator is ready to repeat the cycle of the sawtooth waveform.

The holdoff time at each sweep rate is set for the required recovery time of the runup circuit by the holdoff capacitor selected with the TIME/CM switch (see the Timing Switch schematic diagram). The stability voltage, applied to the grid of V135A through cathode follower V125 is set with the STABILITY control, R111, so that with the SWEEP FUNCTION switch set at NORMAL, the minimum voltage at the grid of V135A will be at the "triggerable" level, about 2 volts above the level required to cut off V135A and switch the multivibrator. An incoming trigger from the Time-Base Trigger circuit will then drive the grid below the switching level, causing the multivibrator to switch and start a cycle of the sawtooth waveform.

Multi-Trace Sync

Pulses from the sweep-gating multivibrators are applied to the vertical plug-in units to switch between channels when using a multi-trace vertical plug-in unit in the alternate mode. Channel switching is accomplished while the crt beam is blanked during retrace of the sweep.

The waveform from the screen grid of V145 in the sweep-gating multivibrator of either time-base unit may be connected through the HORIZ. DISPLAY switches to the grids of either or both of the multi-trace switching amplifiers, V524A and V534A, shown on the Horizontal Display Switching schematic diagram. The waveform is differentiated by the network at the grid of each tube. Since both the cathode and plate voltages are supplied by the vertical plug-in unit, the operation of V524A or V534A depends on the multi-trace unit being used. In general, the tube is conducting when the plug-in unit is in alternate mode and inoperative in all other modes. When V524A (or V534A) is conducting, the multi-trace sync pulse from the sweep-gating multivibrator is applied to the plug-in unit, either as an amplified negative-going pulse taken from the plate, or as a small positive-going pulse taken from the cathode with the tube connected as a cathode follower.

Auto Baseline

The auto baseline circuit in each of the time-base units is designed to produce a free-running trace on the crt screen when no trigger pulses are being applied to the Time-Base Generator. The operation of the auto baseline circuit in the Type 22A is identical to that of the one in the Type 21A; however, the circuit numbers of many of the components are not the same in the two units. Refer to the schematic diagram of the Type 21A Time-Base Generator circuit during the following description.

The circuit is essentially a cathode-coupled monostable multivibrator, V115A and V115B, which turns transistor Q104 on and off to control the stability voltage at the grid of V125. When the SWEEP FUNCTION switch is set at any position except AUTO BASELINE, the positive voltage applied to the grid of V115A causes V115A to conduct and keeps V115B cut off. Current from the plate circuit of V115A biases Q104 into saturation, setting its collector at +100 volts. This voltage is then applied to the stability circuit through R115. The STABILITY control is set during calibration to place the grid of V125 at about —50 volts while Q104 is in saturation.

When the SWEEP FUNCTION switch is in AUTO BASELINE and no trigger pulses are being applied to the Time-Base Generator circuit, the voltage on the grid of V115A is reduced to a level about 8 volts more negative than the grid of V115B. Thus V115B is conducting, V115A is cut off, and the voltage at the plate of V115A is positive enough to reverse bias the base-emitter junction of Q104, cutting off the transistor. The voltage at the collector of Q104 is about +80 volts with the transistor turned off, or about 20 volts more negative than when Q104 is saturated. The stability voltage at the grid of V125 is proportionally more negative, and the lower limit of the holdoff waveform is allowed to drop below the triggering level of the sweep-gating multivibrator. With the holdoff waveform set at this level, the reset portion of each cycle of the holdoff waveform triggers a new sweep, causing the Time-Base Generator circuit to free run (see Fig. 4-7).

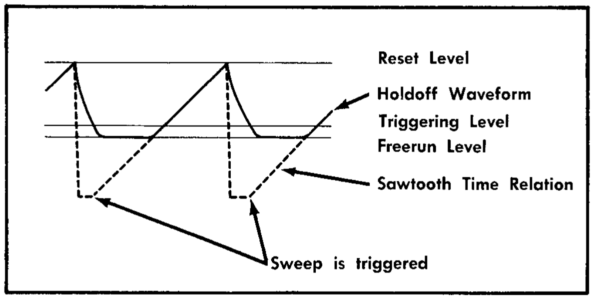

Fig. 4-7. Holdoff waveform at grid of V135A with Time-Base Generator set for free-run operation. SWEEP FUNCTION switch is at AUTO BASELINE and LEVEL control is fully clockwise.

The voltage at the grid of V115B is normally set at about +12 volts by current through R107 and D108, and through R49 and Q44 in the Time-Base Trigger circuit. When the SWEEP FUNCTION switch is in any position except AUTO BASELINE, negative trigger pulses applied through D108 only tend to hold V115B in cutoff. However, when the SWEEP FUNCTION switch is set to AUTO BASELINE V115B is turned on and negative pulses applied through D108 cut off V115B. As V115A turns on, the resulting negative-going voltage at the plate of 115A is coupled back to the grid of V115B through C108 and drives V115B farther into cutoff. Following the trigger pulse, the voltage at the cathode of D108 returns immediately to about +12 volts. Therefore, as soon as the regenerative action of the multivibrator has ended, the grid of V115B also attempts to return to that voltage. The return to +12 volts is relatively slow, however, since D108 is now reverse biased, and C108 has to discharge through R107. As soon as the grid of V115B becomes more positive than the grid of V115A, the multivibrator reverts to its previous state, with V115B conducting and V115A cut off. The time constant of this monostable multivibrator is designed for a reset time of about 80 msec.

When the trigger pulse was applied and the multivibrator switched, the negative-going voltage at the plate of V115A started to charge C105 and also forward biased Q104, causing the transistor to saturate. The momentary charge on C105 stretches the pulse at the base of Q104, and the transistor is held in saturation for the duration of the stretched pulse. The resulting positive voltage applied to the grid of V125 raises the holdoff voltage from a free-running condition to a triggerable condition. As the stretched pulse on the base of Q104 ends, the transistor cuts off and the stability level again drops to a free-run condition, triggering the Time-Base Generator.

If trigger pulses are received at a rate faster than about 20 cycles per second, the voltage level on C105 and at the base of Q104 is held far enough negative to keep the transistor saturated. Thus, at this triggering rate, the stability voltage is held positive and the lower limit of the holdoff waveform is held at the triggerable level. Triggering then occurs exactly the same as it would with the SWEEP FUNCTION switch at NORMAL.

Lockout Multivibrator

The lockout multivibrator circuit is designed to hold off the sweep of the crt beam under certain conditions by locking out operation of the Time-Base Generator circuit. This action permits observation of a single sweep of the crt beam, and also provides for delayed operation of the sweep in the Type 22A as described below under Delayed Sweep. Refer to the Type 21A schematic diagram during the following description.

With the SWEEP FUNCTION switch, SW128, set at NORMAL or AUTO BASELINE, the plate of V133A is disconnected from the positive supply; therefore, the tube is cut off and V125 is allowed to conduct. Under these conditions, V125 acts merely as a cathode follower between the stability voltage on its grid and the holdoff waveform on its cathode.

When the SWEEP FUNCTION switch is set to SINGLE SWEEP, the plate of V133A is connected to the +100 volt supply through R128. With power applied to both tubes, the circuit operates as a cathode-coupled bistable multivibrator. The voltage level on the grid of V133A is then set with the LOCKOUT LEVEL control, R125, so that when V133A is conducting, the minimum voltage of the holdoff waveform is at the "lockout" level, far enough positive that incoming trigger pulses cannot switch the sweep-gating multivibrator. The sweep is then disabled until the cathode voltage is allowed to drop.

To produce a single sweep of the crt beam, the front-panel PUSH TO RESET switch, SW101, is pressed. C102, which had been charged to +100 volts through R101, discharges to ground, applying a fast negative-going pulse through C123 to the grid of V133A. The pulse cuts off V133A, allowing V125 to turn on, and the negative-going voltage at the plate of V125, applied through C123, forces V133A farther into cutoff. With V125 then controlling the cathode, the voltage drops to the stability level on the grid of V125, which puts the sweep-gating multivibrator into a triggerable state. With V133A cut off, its plate voltage attempts to go to +100 volts and the READY neon bulb lights, indicating that the Time-Base Generator is ready to produce a single sweep. The next trigger pulse that arrives at the sweep-gating multivibrator switches it, starting a cycle of the sweep waveform (see Fig. 4-8).

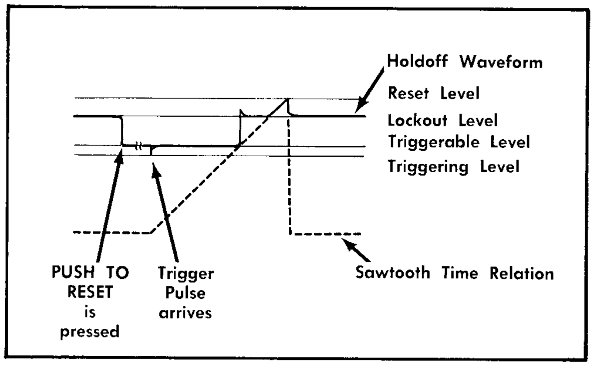

Fig. 4-8. Single sweep holdoff waveform, with SWEEP FUNCTION switch set at SINGLE SWEEP.

When the rising portion of the holdoff waveform at the cathode of V125 reaches the stability voltage on its grid, V125 cuts off and the multivibrator resets for single sweep operation. V133A turns on, the READY neon turns off as the plate voltage drops, and the cathode of V133A sets the voltage at the grid of V135A at the lockout level. As the sawtooth portion of the holdoff waveform rises above the lockout level, V133B takes control of the common cathode and cuts off V133A. The holdoff waveform rises to the reset level, then begins its retrace. When the waveform reaches the lockout level, V133A begins to conduct again and holds the voltage at the grid of V135A at that level. The sweep-gating multivibrator is thus locked out until the PUSH TO RESET button is pressed once more.

Delayed Sweep

A delayed trigger amplifier circuit in the Type 22A Time-Base Unit allows the delayed trigger from Time Base A (Type 21A) to be used in one of two modes to operate the lockout multivibrator in the Type 22A. In one mode the sweep becomes triggerable after receiving a delayed trigger pulse, and in the other mode, the sweep is triggered by the lockout circuit as soon as a delayed trigger arrives.

The lockout multivibrator in the Type 22A operates in exactly the same manner as the one in the Type 21A when the SWEEP FUNCTION switch is in the NORMAL, AUTO BASELINE and SINGLE SWEEP positions. However, the pulse from the PUSH TO RESET switch is applied through V114, rather than being connected directly.

When the SWEEP FUNCTION switch, SW120, is set to TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG, V133A is conducting and the multivibrator is set for single sweep operation, with the cathode voltage on V133A locking out the sweep. When the Time Base A sweep has run to a certain level, set by the DELAYED TRIGGER 1-10 MULTIPLIER control, a delayed trigger pulse is applied to the grid of V114 in the Type 22A (Time Base B). The pulse is amplified by V114 and applied as a negative pulse to the grid of V133A. This pulse cuts off V133A, allowing V125 to set the cathode voltage at the triggerable level. The Type 22A will not sweep, however, until it receives a trigger pulse from its Time-Base Trigger circuit (see Fig. 4-9).

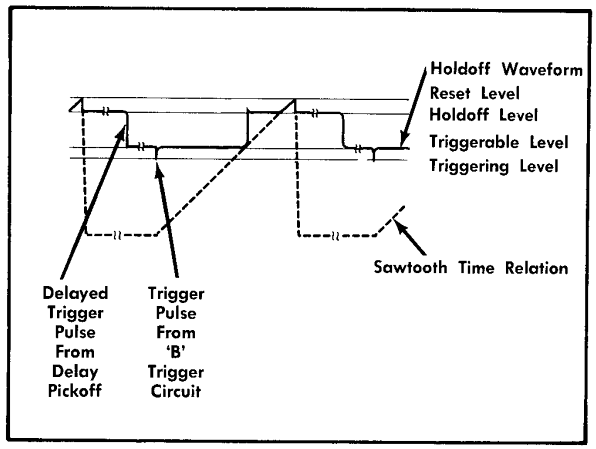

Fig. 4-9. Delayed sweep holdoff waveform with Type 22A SWEEP FUNCTION switch set at TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG.

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After the sweep has been triggered and starts to rise, the holdoff waveform resets the lockout multivibrator and the minimum level of the holdoff waveform is again set at the lockout level after retrace. The next sweep is then held off until another delayed trigger pulse is received during the next cycle of the Time Base A generator circuit, setting the sweep-gating multivibrator in the Type 22A into a triggerable condition again.

When the SWEEP FUNCTION switch is set to SWEEPS ONCE FOR EACH 'A' DLY'D TRIG, the lockout multivibrator switches the sweep-gating multivibrator, causing the Type 22A to produce one cycle of its output sawtooth as soon as it receives a delayed trigger pulse from Time Base A. All conditions are the same in this mode as in the triggerable delayed mode, except that the voltage on the grid of V125 is set at about —60 volts. This sets the lockout multivibrator into a monostable configuration. Incoming delayed trigger pulses are again applied by way of V114 to the grid of V133A, cutting that tube off and allowing V125 to conduct. The cathode drops to the voltage set by the grid of V125, which is now set below the triggering level of the sweep-gating multivibrator. This voltage step triggers the sweep-gating multivibrator, immediately starting the sweep of the Time-Base Generator (see Fig. 4-10). As soon as the regenerative action of the lockout multivibrator has ended, the grid of V133A returns to the level set by the LOCKOUT LEVEL control, setting the grid at the lockout level as before. V133A turns on, raising the cathode back to the lockout level. The sweep continues, then retrace occurs and the input grid of the sweep-gating multivibrator is held at the lockout level until another delayed trigger is received from Time Base A. Each time another delayed trigger pulse arrives, the lockout multivibrator will trigger the sweep, without waiting for a trigger from the Time-Base Trigger circuit.

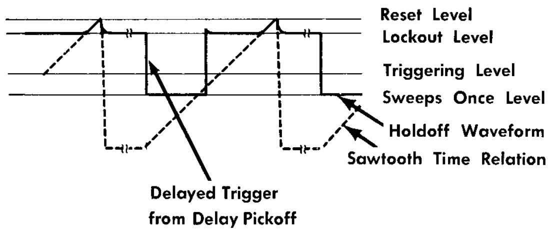

Fig. 4-10. Delayed sweep holdoff waveform with Type 22A SWEEP FUNCTION switch set at SWEEPS ONCE FOR EACH 'A' DLY'D TRIG.

DELAY PICKOFF

The Delay Pickoff circuit generates a positive-going differentiated pulse at a predetermined time during each sweep produced by Time Base A (Type 21A). The pulse is always available at the front-panel DELAYED TRIG OUT connector and is also applied internally to the delayed trigger amplifier in Time Base B (Type 22A) for use in the delayed sweep modes. Refer to the block diagram, Fig. 4-11, and to the Delay Pickoff schematic diagram during the following discussion.

Before the input sawtooth waveform has started its rise, V568A, V564 and V585B are conducting and V554 and V585A are cut off. V568B is conducting, but is biased near cutoff with the output voltage held near ground level.

Difference Amplifier

A sawtooth waveform from Time Base A is applied to the input of the Delay Pickoff difference amplifier, V554 and V564. This circuit is a comparator that compares the voltage level of the input sawtooth waveform against a voltage determined by the DELAYED TRIGGER 1-10 MULTIPLIER control. As the input sawtooth level exceeds the comparison voltage, the comparator produces an output waveform that is then applied to the delayed trigger multivibrator.

Quiescently, the common cathode voltage of the difference amplifier is set by the voltage on the grid of V564. This comparison voltage is adjusted by means of R573, the DELAYED TRIGGER 1-10 MULTIPLIER control. Total current through V554 and V564 is held constant by V568A, the constant-current tube. When the input sawtooth voltage reaches the level of the comparison voltage, the grid of V554 begins to control the voltage on the common cathodes, turning this tube on. As V554 turns on, the decreased current through V564 causes its plate voltage to start positive. As the sawtooth continues positive, the plate quickly reaches the switching level of the bistable delayed trigger multivibrator.

Because the input sawtooth waveform is the linear waveform from Time Base A, the time interval between the start of the Time Base A sweep and the instant of comparison is proportional to the voltage applied from the DELAYED TRIGGER 1-10 MULTIPLIER control. This control is accurately calibrated so that its readings correspond to the horizontal displacement of the Time Base A crt beam on the screen at the time of comparison.

Constant Current Tube

V568A is a constant-current source for the difference amplifier. The voltage divider, R565 and R566, set the grid of V568A at about —50 volts. This stable grid voltage and the high resistance in the cathode force a constant current of 5 ma to flow through the tube. The two tubes of the difference amplifier share the current from V568A.

With current held constant through the conducting tube of the difference amplifier, regardless of the voltage levels being compared, the output signal of the difference amplifier will be uniform over the entire range of the 150-volt sawtooth waveform applied at the input grid.

Delayed Trigger Multivibrator

The delayed trigger multivibrator, V585A and V585B, produces a gate output that has a fast rise independent of the rate of rise of the input sawtooth.

When the voltage at the plate of V564 reaches the cathode voltage of the delayed trigger multivibrator, V585A begins to conduct. V585B cuts off as the multivibrator switches to its second bistable state. The resulting positive step at the plate of V585B is applied through a differentiating network to the grid of the delayed trigger output tube, V568B.

As the retrace portion of the input waveform occurs, the difference amplifier is switched back to its original state and the delayed trigger multivibrator is also switched back to the quiescent state. When it switches, the negative step at the plate of V585B is applied to the differentiating network.

Delayed Trigger C F

The positive-going portion of the differentiated waveform from the multivibrator applied to the grid of cathode follower tube, V568B, causes the tube to conduct more heavily. The 5-volt pulse appearing across R598 is thus obtained at low impedance at the cathode of the tube. This delayed trigger pulse is coupled to the DELAYED TRIG OUT connector on the front panel, and through the oscilloscope to the Time-Base Trigger circuit of Time Base B.

When the delayed trigger multivibrator resets and the negative pulse is applied to the grid of V568B, the tube is driven into cutoff and the output remains at ground. Thus the output waveform consists of only positive spikes.

The time delay between the start of the Time Base A sawtooth and the occurrence of the delayed trigger pulse is the delay time determined by the Time Base A TIME/CM switch and the 1-10 MULTIPLIER control. The Time Base A sweep will have moved across the crt screen the number of centimeters indicated by the MULTIPLIER dial.

HORIZONTAL AMPLIFIERS

The Horizontal Amplifier circuits for the Upper Beam and the Lower Beam are essentially identical. The following description applies to both circuits, but the circuit reference numbers refer to the Upper Beam amplifier. Fig. 4-12 is a block diagram of the Upper Beam Horizontal Amplifier.

The input signal is selected with the appropriate HORIZ. DISPLAY switch from one of three sources: Time Base A sawtooth; Time Base B sawtooth, or the External Horizontal Amplifier for that beam. The input waveform is applied through an input cathode follower and a driver cathode follower to a cathode-coupled paraphase output amplifier. This amplifier provides a push-pull output to the horizontal deflection plates through a pair of output cathode followers.

Input Circuit

The input horizontal deflection voltage signal is applied through a frequency compensated voltage divider to the grid circuit of the input tube, V343A. Frequency compensation of the divider is adjusted with C330 during calibration. The two front-panel HORIZ. POSITION controls in the circuit provide horizontal positioning of the display by setting the dc level of the input signal. The two controls are operated by the same front-panel knob and are coupled by a "backlash" coupling that operates both the coarse adjustment, R333, and the fine adjustment, R336, simultaneously. Fine adjustment of the horizontal position is provided by R336 operating alone in a 60° arc permitted by the backlash coupling.

Driver and Output Stages

When the HORIZ. DISPLAY switch is in either of the X.2 positions or in one of the EXT. ATTEN positions, the signal from the input cathode follower is applied directly to the driver cathode follower in the left-hand deflection portion of the circuit. When the switch is in one of the X1 positions, the time-base signals are applied to the driver cathode follower through a compensated attenuator and are attenuated by a factor of 5. The attenuation is adjusted with the SWP CAL control, R351.

Gain of the Horizontal Amplifier is determined by the fixed feedback from the output of the amplifier through R355 and C355 to the input of the driver cathode follower, and by

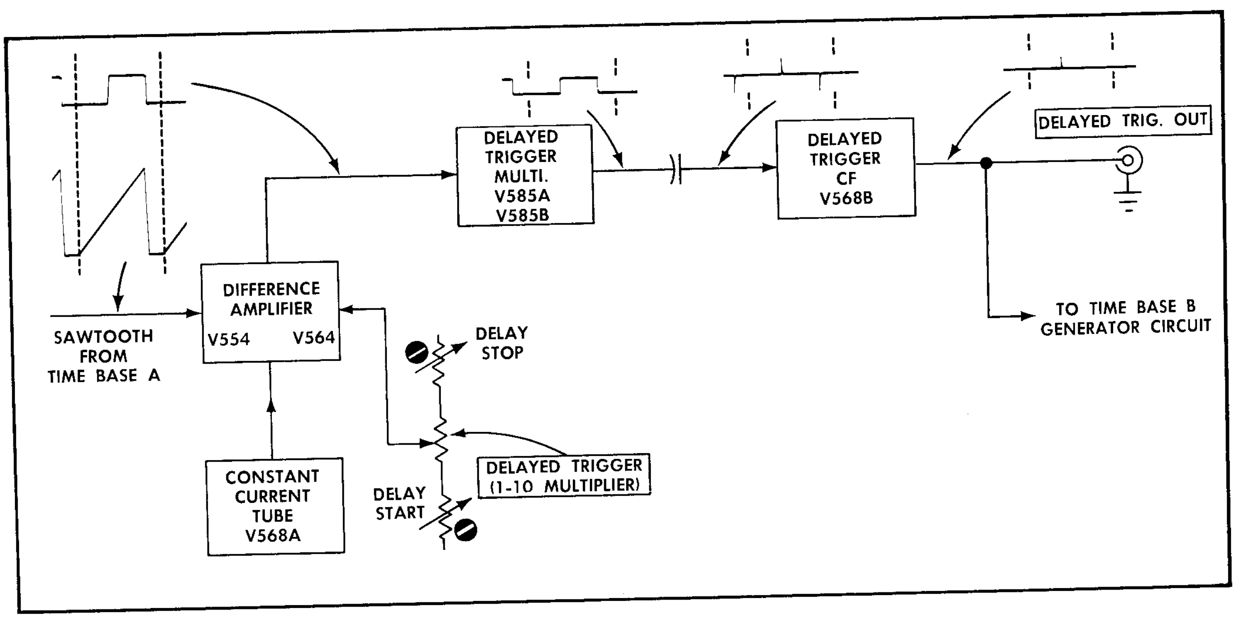

Fig. 4-11. Delay Pickoff block diagram.

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b. Upper Beam Intensity Modulation

Set the Upper Beam INTENSITY control to present a dim display. Connect two 18-inch jumper leads together and apply the calibrator signal to the Upper Beam CRT CATHODE connector. There should be appreciable difference in intensity between the top and bottom of the waveform. Set the AMPLITUDE CALIBRATOR switch to 20 VOLTS, and re-adjust the INTENSITY control so the brightest portion of the waveform is at normal intensity. The top portion of the calibrator signal should now be completely blanked. Remove the jumper leads.

c. Lower Beam Compression

Move the coax with the calibrator signal to the INPUT of the Lower Beam plug-in unit. Set the AMPLITUDE CALIBRATOR switch to 10 VOLTS. Adjust the gain of the Type K (Lower Beam) unit for 1 cm of deflection at the lower center-line. Check the Lower Beam for compression or expansion as described for the Upper Beam.

d. Lower Beam Intensity Modulation

Set the Lower Beam INTENSITY control for a dim display. Connect the calibrator signal to the Lower Beam CRT CATHODE connector and check the intensity modulation of the Lower Beam by the procedure described for the Upper Beam.

Remove the jumper leads and replace the ground straps between the rear-panel connectors.

TRIGGER ADJUSTMENTS

The time-base triggering adjustments that follow must be made in the indicated sequence. The time-base units must be extended at this time if this has not been done previously (see "Preliminary" step).

11. Adjust Tunnel Diode Bias

Set front-panel controls as follows:

Lower Beam	
HORIZ. DISPLAY	TIME BASE A X1
Time Base A and Time Base B	
SOURCE	LOWER BEAM
TIME/CM	.5 mSEC
SWEEP MODE	NORMAL
LEVEL	Centered
VERNIER	Centered
Type K (Lower Beam)	
AC-DC	DC
VOLTS/CM	1
VARIABLE	CALIBRATED

Set the AMPLITUDE CALIBRATOR switch to 1 VOLT. With the calibrator signal applied to the INPUT connector of the Type K plug-in unit, center the Lower Beam waveform on the lower horizontal centerline.

a. Time Base A (Type 21A)

Turn the Time Base A TD BIAS control (R44) fully counter-clockwise (see Fig. 6-8 for location of control), then turn it slowly clockwise until a stable display appears. Note the position of the TD BIAS control. Continue turning the control clockwise until the display free runs. Again note the position of the control. Set the TD BIAS control midway between the two positions just determined.

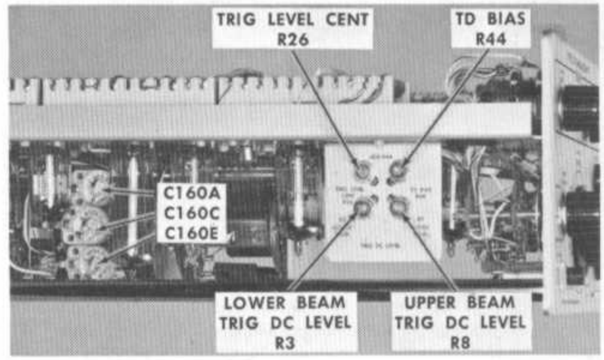

Fig. 6-8. Left side view of Type 21A with Time Base A trigger and timing adjustments.

b. Time Base B (Type 22A)

Set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X1. Adjust the Time Base B TD BIAS control (R44) in the manner just described for Time Base A. See Fig. 6-9 for the location of the TD BIAS control in Time Base B.

Remove the coax cable and connectors after completing this step.

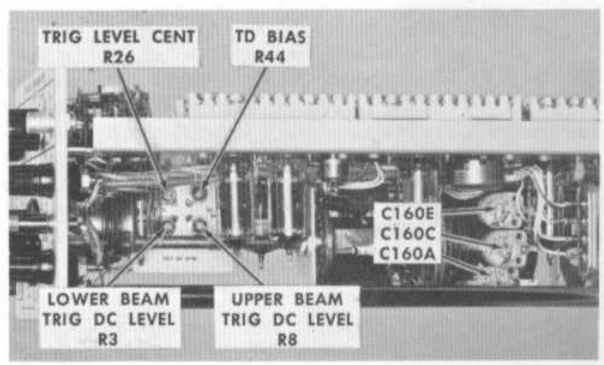

Fig. 6-9. Right side view of Type 22A with Time Base B trigger and timing adjustments.

12. Check HF Triggering

Reset the following controls:

Lower Beam	
HORIZ. DISPLAY	TIME BASE A X.2
Time Base A and Time Base B	
TIME/CM	.1 μSEC

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Time Base A SOURCE	LOWER BEAM
Time Base B SOURCE	UPPER BEAM

Set the Type 190B Signal Generator for an output frequency of 30 mc and an output amplitude of about 2.5 volts.

a. Time Base A

Connect the sine-wave signal to the INPUT connector of the Type K (Lower Beam). If necessary, trigger the display with the Time Base A VERNIER control. Adjust the output amplitude of the signal generator to produce 1 cm of deflection on the crt screen. A stable waveform should be displayed.

Set the Time Base A SOURCE switch to UPPER BEAM. The display should not trigger well at any position of the VERNIER control.

b. Time Base B

Set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X.2. Set the Time Base B SOURCE switch to LOWER BEAM. A stable waveform should be displayed. If necessary, trigger the display with the Time Base B VERNIER control.

Set the Time Base B SOURCE switch to UPPER BEAM. The display should not trigger well at any position of the VERNIER control.

Remove the input signal.

13. Adjust Stability

Reset the following controls:

Upper Beam and Lower Beam	
HORIZ. DISPLAY	TIME BASE A X1
Time Base A and Time Base B	
SOURCE	LOWER BEAM
TIME/CM	.5 mSEC
Upper Beam Vertical Plug-In	
Deflection Factor	5 v/cm (cal.)
Input Coupling	DC

Install the 10X probe on the INPUT connector of the Upper Beam vertical plug-in unit. Connect the coax from the CAL. OUT connector to the INPUT of the Type K (Lower Beam). Set the AMPLITUDE CALIBRATOR switch to 1 VOLT.

a. Time Base A

Connect the probe tip to the center terminal of R111 (STABILITY) in the Time Base A plug-in unit. Trigger the display with the LEVEL and VERNIER controls. Increase the Upper Beam intensity to present a free-running trace of normal intensity.

Turn the Time Base A STABILITY control fully counterclockwise, then turn it slowly clockwise until the traces of the two beams just appear on the screen. With the Upper Beam Vertical Position control, position the Upper Beam trace on the topmost graticule line. Now turn the LEVEL control fully clockwise. The traces will disappear. Continue turning the STABILITY control clockwise until the traces again appear, with the Lower Beam display free running. Note the vertical position of the Upper Beam trace. Now center the LEVEL control and adjust the STABILITY control to position the Upper Beam trace midway between the topmost graticule line and the point where the Lower Beam trace began to free run.

b. Time Base B (Type 22A)

Move the probe tip to the center terminal of the Time Base B STABILITY control. Set both HORIZ. DISPLAY switches to TIME BASE B X1, then adjust the Time Base B STABILITY control by the procedure just described for Time Base A.

Disconnect the probe tip from the STABILITY control after completing this step.

14. Adjust Lockout Level

Reset the following controls:

Upper Beam	
INTENSITY	Counterclockwise
Lower Beam	
HORIZ. DISPLAY	TIME BASE A X1
Type K (Lower Beam)	
VOLTS/CM	1

a. Time Base A

With the coax cable connected from the CAL. OUT to the INPUT connector on the Type K, adjust the Time Base A LEVEL and VERNIER controls to trigger the square-wave display. Then disconnect the coax cable from the INPUT of the Type K Plug-In.

Set the Time Base A SWEEP FUNCTION switch to SINGLE SWEEP. Connect the dc voltmeter between ground and pin 2 of V125 in the Time Base A plug-in unit (see Fig. 6-10).

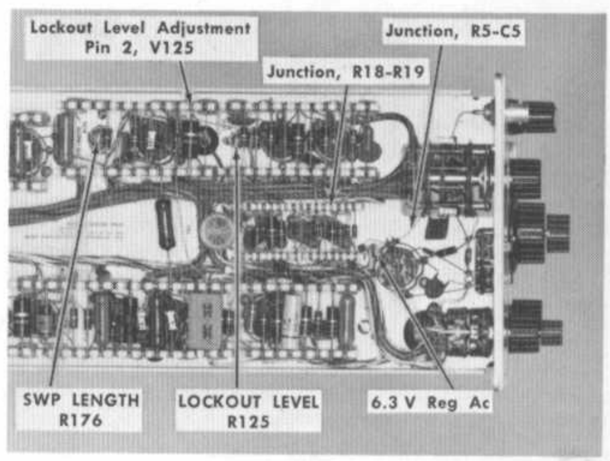

Fig. 6-10. Top view of Time Base Unit showing test points and sweep adjustments.

Press the PUSH TO RESET button. The READY lamp inside the button should light and remain on. Note the voltage on the meter. Now, again connect the calibrator signal to the INPUT connector on the Type K. Following a single sweep of the trace, the meter should read 10 volts below the previous reading. If it does not, adjust the Time Base A LOCKOUT LEVEL control, R125, so the voltage on pin 2 will be just 10 volts below the first reading. Disconnect the meter leads.

Press the PUSH TO RESET button. One triggered sweep should now occur each time the button is pressed.

b. Time Base B

Set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X1. Adjust the Time Base B LEVEL and VERNIER controls for a triggered display of the calibrator waveform, then disconnect the coax cable from the INPUT connector.

Set the Time Base B SWEEP FUNCTION switch to SINGLE SWEEP. Connect the dc voltmeter between ground and pin 2 of V125 in the Time Base B plug-in unit and check the Time Base B LOCKOUT LEVEL adjustment and single sweep operation by the procedure just described for Time Base A.

Remove the coax from the input of the Type K.

15. Adjust Trigger Centering and Level

Reset the following controls:

Time Base A and Time Base B

SOURCE	UPPER BEAM
COUPLING	DC
SWEEP FUNCTION	NORMAL
TIME/CM	5 mSEC

Upper Beam and Lower Beam

HORIZ. DISPLAY	TIME BASE A X1

Vertical Plug-In Units

Deflection Factor	.5 v/cm (cal.)
Input Coupling	DC

a. Time Base A

In the Time Base A plug-in unit, connect a shorting strap from ground to the junction of R18 and R19 (see Fig. 6-10). With the 10X probe installed on the INPUT connector of the Upper Beam vertical plug-in unit, connect the tip of the probe to the junction of R5 and C5 in Time Base A. Set the INTENSITY controls to display the two traces on the screen. Center the Upper Beam display on the upper horizontal centerline.

In the Time Base A plug-in unit adjust R26, the TRIG LEVEL CENT control, so the waveform starts at the same dc level while the SLOPE switch is moved from + to —. Leave the SLOPE switch in the + position.

Adjust R8, the UPPER BEAM TRIG DC LEVEL control in Time Base A so the waveform starts positive at the centerline with the SLOPE switch in the + position and starts negative at the centerline with the SLOPE switch in the — position.

Remove the probe from the INPUT of the Upper Beam vertical plug-in unit and connect it to the INPUT of the Type K (Lower Beam). Set the Time Base A SOURCE switch to LOWER BEAM. Center the Lower Beam display on the lower horizontal centerline. In the Time Base A plug-in unit, adjust R3, the LOWER BEAM TRIG DC LEVEL control so the waveform starts at the centerline with the SLOPE switch in either the + or — position.

b. Time Base B

Move the shorting strap from Time Base A to the junction of R18 and R19 in Time Base B. Remove the probe from the INPUT of the Type K and install it on the INPUT of the Upper Beam vertical plug-in unit. The probe tip can be left connected to the Time Base A plug-in unit or moved to the junction of R5 and C5 in the Time Base B plug-in unit. Set both HORIZ. DISPLAY switches to TIME BASE B X1.

Center the Upper Beam display on the upper centerline. Now use the procedure just described for Time Base A to adjust R26 (TRIG LEVEL CENT), R8 (UPPER BEAM TRIG DC LEVEL) and R3 (LOWER BEAM TRIG DC LEVEL) in the Time Base B plug-in unit.

At the end of this step remove the shorting strap and the probe.

TIMING AND HORIZONTAL ADJUSTMENTS

For steps 16 through 20 leave both Time Base units extended from the Indicator Unit.

Install a coaxial tee connector on the INPUT of the Upper Beam vertical plug-in unit. Connect a coax cable from one end of the tee to the INPUT of the Type K (Lower Beam) unit. These connections will remain throughout the timing adjustments.

Set front-panel controls as follows:

Upper Beam and Lower Beam

HORIZ. DISPLAY	TIME BASE A X.2

Time Base A and Time Base B

SWEEP FUNCTION	NORMAL
SOURCE	UPPER BEAM
TIME/CM	1 mSEC
SLOPE	+
COUPLING	AC
LEVEL	Clockwise
VERNIER	Centered

Vertical Plug-In Units

Deflection Factor	5 v/cm (cal.)
Input Coupling	AC

16. Adjust Magnifier Gain

Set the Type 180A Time-Mark Generator for an output of 100 microsecond markers and connect the output to the tee connector on the Upper Beam plug-in unit. Adjust the Time Base A LEVEL control to trigger the display.

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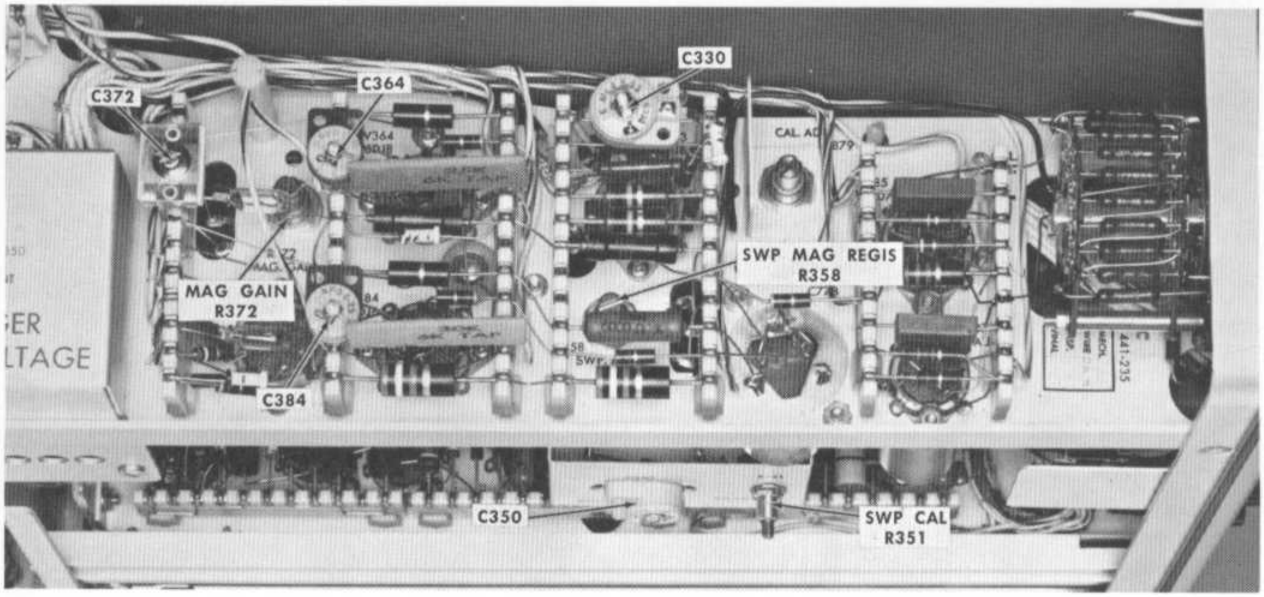

Fig. 6-11. Upper Beam Horizontal Amplifier circuit.

Check the Upper Beam display for exactly 2 time marks per cm between the 1 cm and 9 cm graticule lines. Adjust R372, the Upper Beam MAG GAIN control if necessary to obtain the proper display. The location of this control is shown in Fig. 6-11.

Check the Lower Beam display for exactly 2 time marks per cm between the 1 cm and 9 cm graticule lines. Adjust R472, the Lower Beam MAG GAIN control if necessary to obtain the proper display. See Fig. 6-12 for the location of R472.

17. Adjust Sweep Calibration

Set the time-mark generator for an output of 1 millisecond markers. Set the HORIZ. DISPLAY switches of both beams to TIME BASE A X1.

Check the Upper Beam display for exactly 1 time mark per cm between the 1 cm and 9 cm graticule lines, and adjust R351, the Upper Beam SWP CAL control, if necessary.

Check the Lower Beam display for exactly 1 time mark per cm between the 1 cm and 9 cm graticule lines, and adjust R451, the Lower Beam SWP CAL control, if necessary.

18. Adjust Sweep Magnifier Registration

Set the time-mark generator for 5 millisecond markers. Set the HORIZ. DISPLAY switches of both beams to TIME BASE A X.2, and focus both displays.

With the Upper Beam HORIZ. POSITION control, position the leading edge of the middle marker in the Upper Beam display on the vertical centerline of the graticule. Now set the Upper Beam HORIZ. DISPLAY switch to TIME BASE A X1. The leading edge of the middle marker should remain exactly on the centerline as the switch is moved from the X.2 to the X1 position. If not, adjust R358, the Upper Beam SWP MAG REGIS control.

With the Lower Beam HORIZ. POSITION control, position the leading edge of the middle marker in the Lower Beam display on the vertical centerline. Now switch the Lower Beam HORIZ. DISPLAY to TIME BASE A X1. The leading edge of the middle marker should remain on the vertical centerline. If not, adjust R458, the Lower Beam SWP MAG REGIS control.

19. Adjust Sweep Length

With the time-mark signal still applied to the INPUT connectors, set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X1. Adjust the Time Base B LEVEL control for a stable display of the Lower Beam waveform.

a. Time Base A

Set the time-mark generator for 500 microsecond markers. In the Time Base A plug-in unit, adjust R176, the SWP LENGTH control, to display 10.5 cm of horizontal deflection (22 markers) of the Upper Beam display.

b. Time Base B

In Time Base B, adjust R176, the SWP LENGTH control, to display 10.5 cm of horizontal deflection (22 markers) of the Lower Beam display.

20. Check Variable Control

The VARIABLE control (R160Y) requires at least a 2.5-to-1 range to provide continuously variable sweep rates (uncalibrated) between the steps of the TIME/CM switch.

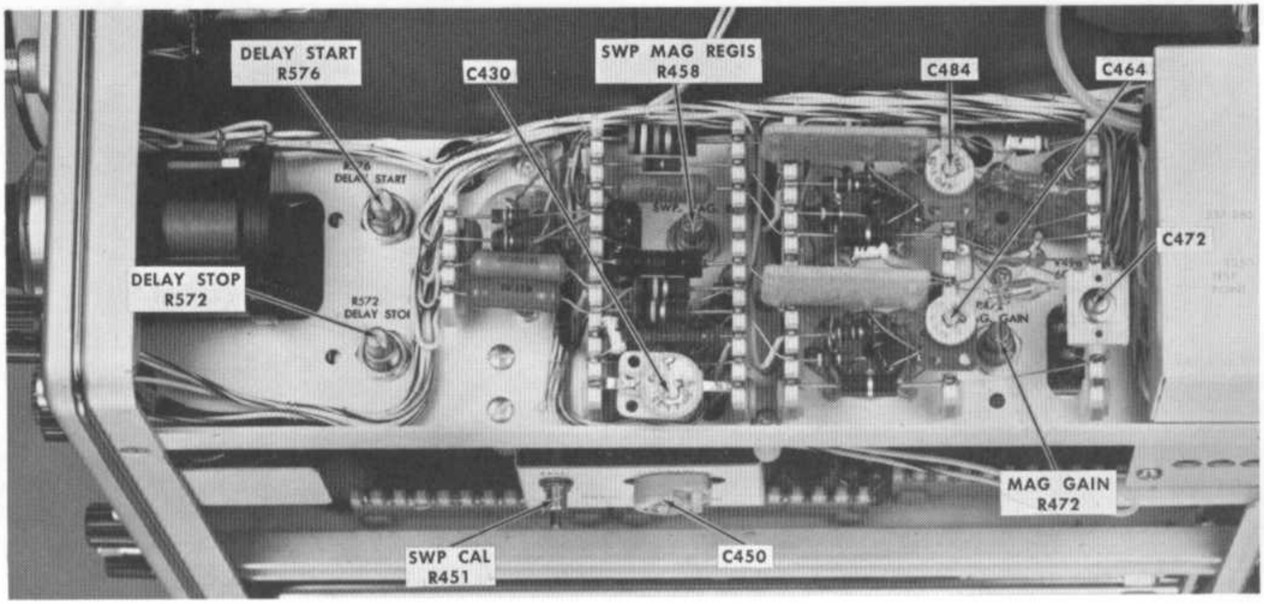

Fig. 6-12. Lower Beam Horizontal Amplifier circuit.

a. Time Base A

With the input signal connected as in step 19, set the time-mark generator for 5 millisecond markers. There should now be 1 marker displayed every 5 cm. Turn the Time Base A VARIABLE control fully counterclockwise. The markers in the Upper Beam display should now be less than 2 cm apart.

Check to see that the UNCALIBRATED neon lamp is on when the VARIABLE control is in any position except CALIBRATED.

b. Time Base B

Turn the Time Base B VARIABLE control fully counterclockwise. The markers in the Lower Beam display should now be less than 2 cm apart.

Check to see that the UNCALIBRATED neon lamp is on when the VARIABLE control is in any position except CALIBRATED.

IMPORTANT

For the remainder of the timing procedure (steps 21 through 27) the time-base units must be installed in the Indicator Unit and the side panels of the Indicator Unit must be inplace. Turn off the power while removing the extensions, then allow a few minutes for warm up after applying power.

During the timing procedure, if an adjustment is required, remove the appropriate side panel temporarily to make the adjustment, then recheck the control setting with the side panel in place.

21. Check Sweep Rates

Front-panel controls should be set as follows:

Upper Beam and Lower Beam

HORIZ. DISPLAY	TIME BASE A X1

Time Base A and Time Base B

SOURCE	LOWER BEAM
SLOPE	+
COUPLING	AC
LEVEL	Centered
VERNIER	Centered
SWEEP FUNCTION	NORMAL
TIME/CM	.1 mSEC
VARIABLE	CALIBRATED

Vertical Plug-In Units

Deflection Factor	5 v/cm (cal.)
Input Coupling	AC

a. Time Base A

With the time-mark signal applied to both vertical INPUT connectors as in the previous steps, set the generator for 100 microsecond markers. Check the Time Base A sweep rates by applying the time marks listed in Table 6-2 and checking for the indicated displays between the 1 cm and 9 cm graticule lines. All positions of the TIME/CM switch must provide sweep rates within 3% accuracy (0.24 cm) over the center 8 cm of the screen. Typical accuracy is within 1%. (Remember that the time-mark generator may introduce ±1% error.)

b. Time Base B

Set the HORIZ. DISPLAY switches of both beams to TIME BASE B X1. Check the Time Base B sweep rates according to Table 6-2. All positions of the TIME/CM switch must provide sweep rates within 3% accuracy between the 1 cm and 9 cm graticule lines. Typical accuracy is within 1%.

TABLE 6-2

Sweep Rate Check

TIME/CM Switch	Time-Mark Generator	Observe
.1 msec	100 μsec	1 mark/cm
.2 msec	100 μsec	2 marks/cm
.5 msec	500 μsec	1 mark/cm
1 msec	1 msec	1 mark/cm
2 msec	1 msec	2 marks/cm
5 msec	5 msec	1 mark/cm
10 msec	10 msec	1 mark/cm
20 msec	10 msec	2 marks/cm
50 msec	50 msec	1 mark/cm
.1 sec	100 msec	1 mark/cm
.2 sec	100 msec	2 marks/cm
.5 sec	500 msec	1 mark/cm
1 sec	1 sec	1 mark/cm
2 sec	1 sec	2 marks/cm
5 sec	5 sec	1 mark/cm

22. Adjust Sweep Range Registration

Reset the following controls:

Upper Beam and Lower Beam

HORIZ. DISPLAY — TIME BASE B X.2

Time Base B

TIME/CM — .1 mSEC

Vertical Plug-In Units

Deflection Factor — 2 v/cm (cal.)

Set the time-mark generator for 1 microsecond time marks. With the two HORIZ. POSITION controls, position the first time marker of each display near the center of the graticule.

a. Upper Beam

Switch the Time Base B TIME/CM switch to 50 μSEC, then back to .1 mSEC. There should be no horizontal movement of the first marker. Adjust C330 (see Fig. 6-11) if necessary, so the leading edge of the first marker in the Upper Beam display remains stationary as the TIME/CM switch is moved between the .1 mSEC and 50 μSEC positions. Remove the adjustment tool from the capacitor while checking the registration.

b. Lower Beam

Adjust C430 (Fig. 6-12) if necessary, so the first marker in the Lower Beam display remains stationary as the TIME/CM switch is moved between the .1 mSEC and 50 μSEC positions. Remove the adjustment tool while checking the registration.

23. Adjust HF Sweep Rates

Reset the following controls:

Upper Beam and Lower Beam

HORIZ. DISPLAY — TIME BASE B X1

Time Base B

SOURCE — EXT.

TIME/CM — .5 μSEC

a. Time Base B HF Range

Connect a cable from the trigger output of the time-mark generator to the external trigger INPUT on the Time Base B plug-in unit. (The time-mark signal should still be connected to the two vertical input connectors.) Set the time-mark generator for a 10 microsecond trigger output and a 1 microsecond marker output. Trigger the sweep with the Time Base B LEVEL control and check for a display of 1 mark every 2 cm between the 1 cm and 9 cm graticule lines. If not correct, adjust C160A in the Time Base B unit (see Fig. 6-9).

b. Horizontal Amplifiers

Set the Time Base B TIME/CM switch to .1 μSEC and set the time-mark generator for a 10 mc sine-wave marker output. Check the display for linearity of the sweep and for 1 cycle/cm between the 1 cm and 9 cm graticule lines. Adjust the capacitors indicated below, if necessary.

Observe	Adjust	Location
Linearity 1 cycle/cm	C372 C350	Upper Beam Horiz. Amp (Fig. 6-11)
Linearity 1 cycle/cm	C472 C450	Lower Beam Horiz. Amp (Fig. 6-12)

Set both HORIZ. DISPLAY switches to TIME BASE B X.2. Reset the marker signal for 50 mc sine-waves and adjust the deflection factor of the vertical input plug-ins for about 2 cm of deflection. Check the displays for 1 cycle/cm between the 1 cm and 9 cm graticule lines. Adjust the timing capacitors indicated below if the sweep rates are not correct.

Observe	Adjust	Location
1 cycle/cm	C364 and C384	Upper Beam Horiz. Amp
1 cycle/cm	C464 and C484	Lower Beam Horiz. Amp

c. Time Base B Intermediate Ranges

Reset both HORIZ. DISPLAY switches to TIME BASE B X1. Set the external trigger rate to 100 microseconds. With the Time Base B TIME/CM switch and the marker signal set as indicated in the table below, check the sweep rates between the 1 cm and 9 cm graticule lines. Adjust the Time Base B timing capacitors if necessary. Each capacitor should be set for the optimum accuracy of the three sweep rates affected by the adjustment.

Time Base B TIME/CM	Time-Mark Generator	Observe	Adjust
1 μSEC	1 μsec markers	1 mark/cm	
2 μSEC	1 μsec markers	2 marks/cm	C160C
5 μSEC	5 μsec markers	1 mark/cm	
10 μSEC	10 μsec markers	1 mark/cm	
20 μSEC	10 μsec markers	2 marks/cm	C160E
50 μSEC	50 μsec markers	1 mark/cm	

If adjustments were required, it will be necessary to recheck this entire step because of the interaction of the controls.

Remove the external trigger signal from the trigger INPUT connector at the end of this step.

24. Adjust Delay Start and Stop

Reset the following controls:

Upper Beam

HORIZ. DISPLAY	TIME BASE A X1

Time Base A

SOURCE	UPPER BEAM
LEVEL	Centered
TIME/CM	1 mSEC

Time Base B

SOURCE	UPPER BEAM
SWEEP FUNCTION	SWEEPS ONCE FOR EACH 'A' DLY'D TRIG
LEVEL	Clockwise
TIME/CM	10 μSEC

Vertical Plug-In Units

Deflection Factor	5 v/cm (cal.)

Set the time-mark generator for 1 millisecond markers and trigger the displays with the Time Base A LEVEL control. Adjust both beams for normal intensity with a brightened portion visible on the Upper Beam trace.

Position both beams on their respective centerlines and set the DELAYED TRIGGER 1-10 MULTIPLIER to 1.00. The brightened portion of the Upper Beam display should be on the second time marker (1 cm from the left edge) and the leading edge of the magnified marker in the Lower Beam display should be at the left edge of the graticule (see Fig. 6-13). If the display is not correct, adjust R576, the DELAY START control.

Now turn the DELAYED TRIGGER 1-10 MULTIPLIER to 9.00. The brightened portion should be on the tenth time marker (1 cm from the right edge), and the leading edge of the magnified marker in the lower display should be at the left edge of the graticule as in the previous display. Adjust R572, the DELAY STOP control if the display is not correct.

The DELAY START and DELAY STOP adjustments interact with each other, therefore readjustment may be required. Recheck the settings of both controls if the DELAY STOP control required adjustment.

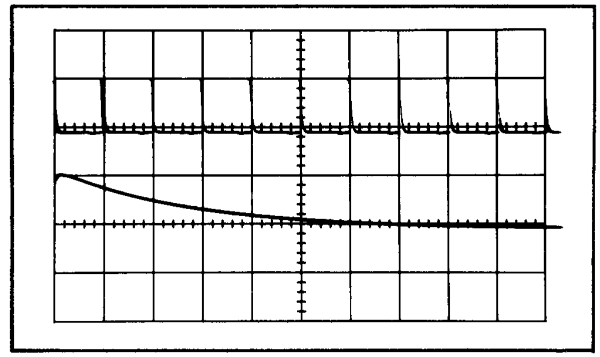

Fig. 6-13. Crt display with the DELAY START control correctly adjusted.

The brightened portion of the display should move smoothly across the screen as the 1-10 MULTIPLIER dial is turned.

25. Check Delayed Trigger

Leave connections and controls as they were at the end of the preceding step. Set the time-mark generator for 1 millisecond and 100 microsecond markers. Now set the Time Base B SWEEP FUNCTION switch to TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG. Trigger the Upper Beam display on the tall markers with the Time Base A LEVEL control, and trigger the Lower Beam display on the shorter markers with the Time Base B LEVEL control. Turn the 1-10 MULTIPLIER dial slowly and observe the motion of the brightened portion of the trace. It should jump from marker to marker, rather than moving smoothly along the display.

Return the SWEEP FUNCTION switch to SWEEPS ONCE FOR EACH 'A' DLY'D TRIG.

26. Adjust 'A' Intermediate Sweep Rates

Because the Time Base A intermediate sweep rates are used in conjunction with Time Base B for Delayed Sweep operation, these sweep rates are adjusted with respect to Time Base B.

Reset the Time Base A TIME/CM switch to 10 μSEC and the Time Base B TIME/CM switch to .5μSEC. With the marker signal connected to both vertical inputs as before, set the time-mark generator for 10 microsecond markers. Trigger the displays with the Time Base A LEVEL control.

Set the DELAYED TRIGGER 1-10 MULTIPLIER so the brightened portion of the Upper Beam display is on the second marker again and the leading edge of the marker in the Lower Beam display is at the left edge of the graticule. Note the setting of the 1-10 MULTIPLIER dial, add 8.00 to the reading, and reset the dial to the number determined by this addition. The brightened portion in the upper display should now be on the tenth marker and the leading edge of the marker in the lower display should be at the left edge of the graticule. If not, adjust C160E in the Time Base A plug-in unit.

With the TIME/CM switches and the time-mark generator set as indicated below, note the 1-10 MULTIPLIER dial readings with the brightened portion of the trace on the markers at the 1 cm and 9 cm graticule lines. The difference (delay time) between the two readings should be within 3% of 8.00 (i.e. 7.76 to 8.24). It may be advisable to readjust C160E slightly for optimum delay time accuracy of the three sweep rates affected.

Time-Mark Generator	Time Base A TIME/CM	Time Base B TIME/CM
10 μsec markers	20 μSEC	.5 μSEC
50 μsec markers	50 μSEC	.5 μSEC

Set the Time Base A TIME/CM switch to 1 μSEC and the Time Base B TIME/CM switch to .1 μSEC. Set the time-mark generator for 1 microsecond markers and turn the 1-10 MULTIPLIER dial to position the brightened portion on the second marker as before. Read the 1-10 MULTIPLIER dial, add 8.00 and reset the dial to the resultant number. The brightened portion of the Upper Beam display should now be on the tenth marker. If the leading edge of the magnified marker is not at the left edge of the graticule, adjust C160C in the Time Base A plug-in unit.

With the TIME/CM switches and the time-mark generator set as indicated below, note the 1-10 MULTIPLIER readings at the markers on the 1 cm and 9 cm graticule lines. Check the delay time for accuracy within 3%. C160C may be slightly readjusted to provide optimum delay accuracy for the three sweep rates.

Time-Mark Generator	Time Base A TIME/CM	Time Base B TIME/CM
1 μsec markers	2 μSEC	.1 μSEC
5 μsec markers	5 μSEC	.1 μSEC

27. Adjust 'A' HF Sweep Rates

Reset the following controls:

Lower Beam	
HORIZ. DISPLAY	TIME BASE A X1
Time Base A	
SOURCE	EXT.
Time Base B	
SWEEP FUNCTION	NORMAL

Connect a coax from the trigger output of the time-mark generator to the external trigger INPUT on the Time Base A plug-in unit and set the generator for 10-microsecond trigger pulses. With the Time Base A TIME/CM switch and the marker signal set as indicated below, check the sweep rates between the 1 cm and 9 cm graticule lines. Adjust C160A in the Time Base A unit if the sweep rates are not correct. The capacitor should be set for optimum accuracy of the three rates affected by the adjustment.

Time Base A TIME/CM	Time-Mark Generator	Observe
.1 μSEC	10 mc sine waves	1 cycle/cm
.2 μSEC	5 mc sine waves	1 cycle/cm
.5 μSEC	1 μsec markers	1 marker/2 cm

Remove all input cables, connectors and adapters after completion of this step.

28. Adjust Ext. Horiz. DC Balance

Controls should be set as follows:

Upper Beam and Lower Beam	
INTENSITY	Counterclockwise
HORIZ. DISPLAY	EXT. ATTEN X1
Time Base A and Time Base B	
SWEEP FUNCTION	NORMAL
LEVEL	Clockwise
TIME/CM	.5 mSEC
SLOPE	+
COUPLING	AC
SOURCE	EXT.
Vertical Plug-In Units	
Deflection Factor	20 v/cm (cal.)
Input Coupling	AC

Center the two beams on the crt screen with the HORIZ. POSITION controls and adjust the INTENSITY controls to produce spots of normal brightness.

a. Upper Beam

Rotate the rear-panel Upper Beam EXT. HORIZ. GAIN control and observe the Upper Beam spot on the screen. If the spot moves horizontally, adjust R326, the Upper Beam EXT HORIZ AMP DC BAL control (Fig. 6-14) so there is no horizontal movement as the control is turned.

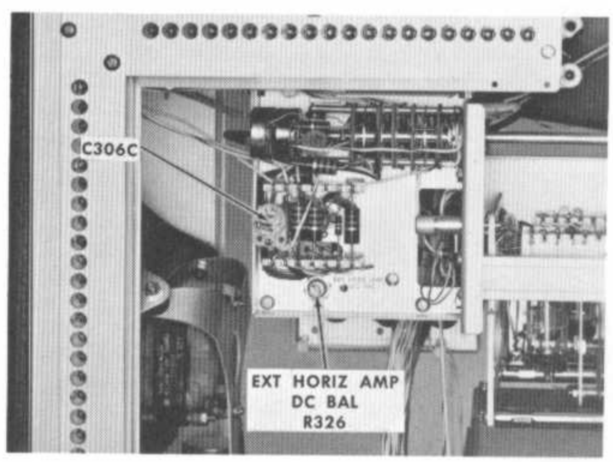

Fig. 6-14. Upper Beam External Horizontal Amplifier Circuit.

b. Lower Beam

Rotate the rear-panel Lower Beam EXT. HORIZ. GAIN control. If the spot moves horizontally on the crt screen, adjust R436, the Lower Beam EXT HORIZ AMP DC BAL control (Fig. 6-15) for no horizontal movement.

Leave both EXT. HORIZ. GAIN controls turned fully clockwise (as viewed from the rear of the instrument).

29. Check Ext. Horiz. Gain and Adjust Compensation

Install a BNC tee connector on the CAL. OUT and connect a binding-post adapter to one arm of the tee. Connect a coax cable from the other arm of the tee to the Time Base A external trigger INPUT connector.

a. Upper Beam

Set the AMPLITUDE CALIBRATOR switch to .2 VOLTS.

Connect two 18-inch jumper leads together and apply the Amplitude Calibrator signal from the binding-post adapter to the Upper Beam EXT. HORIZ. INPUT connector on the rear panel. Connect a short jumper lead from the Time Base A SAWTOOTH connector to the INPUT connector of the Upper Beam vertical plug-in. (A binding-post adapter or BNC-to-UHF adapter will be required if the input has a BNC type connector.) Position the Lower Beam spot off the crt screen. With front-panel controls set as in step 28, trigger the vertical square-wave display with the Time Base A LEVEL and VERNIER controls. At least 1 cm of horizontal deflection must be displayed with the EXT. HORIZ. GAIN control fully clockwise.

Switch the AMPLITUDE CALIBRATOR to 2 VOLTS. Position the baseline on the left edge of the graticule and adjust the Upper Beam EXT. HORIZ. GAIN control to display exactly 10 cm of horizontal deflection. Now set the Upper Beam HORIZ. DISPLAY switch to EXT. ATTEN X10. Center the display. Check for 1 cm of horizontal deflection ($\pm 3\%$).

Return the Upper Beam HORIZ. DISPLAY switch to EXT. ATTEN X1 and set the AMPLITUDE CALIBRATOR switch to .5 VOLTS. Note the waveshape of the square-wave display. Switch the AMPLITUDE CALIBRATOR to 5 VOLTS and the Upper Beam HORIZ. DISPLAY to EXT. ATTEN X10. Adjust C306C (Fig. 6-14) so the waveshape is the same as that observed at the X1 position.

Turn the Upper Beam INTENSITY control fully counterclockwise.

b. Lower Beam

Center the Lower Beam spot on the crt screen. Move the jumper lead with the calibrator signal to the Lower Beam rear-panel EXT. HORIZ. INPUT connector, and move the jumper with the Time Base A sawtooth waveform to the INPUT of the Type K (Lower Beam) unit. Set the AMPLITUDE CALIBRATOR switch to .2 VOLTS and trigger the vertical square-wave display. There must be at least 1 cm of horizontal deflection with the EXT. HORIZ. GAIN control turned fully clockwise.

Switch the AMPLITUDE CALIBRATOR to 2 VOLTS. Check the Lower Beam external horizontal attenuator accuracy and adjust the external horizontal input compensation by the procedure just described for the Upper Beam. Adjust C406C (Fig. 6-15) with the Lower Beam HORIZ. DISPLAY switch in the EXT. AATEN X10 position.

At the end of this step, turn the Lower Beam INTENSITY control fully counterclockwise and remove all jumpers, cables and connectors.

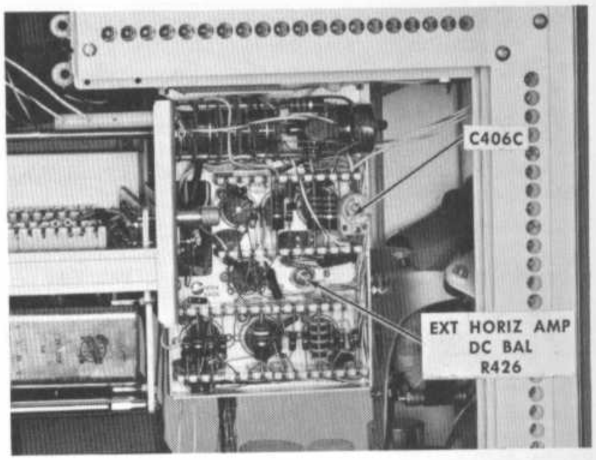

Fig. 6-15. Adjustments in Lower Beam External Horizontal Amplifier circuit.

30. Check Ext. Horiz. Passband

Reset the following controls:

Upper and Lower Beam	
HORIZ. DISPLAY	EXT. ATTEN X1
EXT. HORIZ. GAIN	Clockwise

Set the Type 190B Constant Amplitude Signal Generator for a 50 kc output. Connect a 50-ohm termination to the attenuator head of the signal generator.

a. Upper Beam

Connect the terminated sine-wave signal to the rear-panel Upper Beam EXT. HORIZ. INPUT connector. Increase the Upper Beam intensity to normal and adjust the output amplitude of the signal generator to produce 4 cm of horizontal deflection on the crt screen. Set the frequency of the signal generator to 350 kc, then increase the output frequency until the deflection is 2.8 cm. The frequency should be at least 350 kc.

b. Lower Beam

Move the terminated signal to the Lower Beam EXT. HORIZ. INPUT connector. Set the signal generator for a 50 kc output signal. Check the passband of the Lower Beam External Horizontal Amplifier in the manner described for the Upper Beam.

Remove the signal from the EXT. HORIZ. INPUT.

VERTICAL AMPLIFIER ADJUSTMENTS

The adjustments for both vertical amplifiers are identical and are done in the same manner. Either Time Base unit may be used for the adjustments. In the following procedure, Time Base A is used to produce the Upper Beam sweep and Time Base B is used for the Lower Beam.

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Bulbs

Ckt. No.	Tektronix Part No.	Description		S/N Range
B129	260-518	Part of SW101	READY	
B160W	Use 150-027	Neon, NE-23	UNCALIBRATED	101-11409
B160W	150-0030-00	Neon, NE-2V	UNCALIBRATED	11410-up
B167	Use 150-027	Neon, NE-23		
B170	Use 150-027	Neon, NE-23		

Capactiors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3 V — 50 V = —10%, +250%
51 V — 350 V = —10%, +100%
351 V — 450 V = —10%, + 50%

Ckt. No.	Tektronix Part No.	Description				
C1	281-593	3.9 pf	Cer		500 v	10%
C5	283-026	.2 μf	Disc Type		25 v	
C6	281-593	3.9 pf	Cer		500 v	10%
C10	283-000	.001 μf	Disc Type		500 v	
C15	283-000	.001 μf	Disc Type		500 v	
C20	283-003	.01 μf	Disc Type		150 v	
C37	283-002	.01 μf	Disc Type		500 v	
C38	283-076	27 pf	Disc Type		500 v	
C40	283-076	27 pf	Disc Type		500 v	
C48	283-003	.01 μf	Disc Type		150 v	
C101	283-001	.005 μf	Disc Type		500 v	
C102	281-525	470 pf	Cer		500 v	
C105	290-121	2 μf	EMT		25 v	
C108	285-572	.1 μf	PTM		200 v	
C112	283-001	.005 μf	Disc Type		500 v	
C119	283-001	.005 μf	Disc Type		500 v	
C123	281-504	10 pf	Cer		500 v	10%
C129	283-001	.005 μf	Disc Type		500 v	
C131	281-549	68 pf	Cer		500 v	10%
C134	281-501	47 pf	Cer		500 v	±1 pf
C138	283-002	.01 μf	Disc Type		500 v	
C141	281-503	8 pf	Cer		500 v	±0.5 pf
C150	281-528	82 pf	Cer		500 v	10%
C160A	281-007	3-12 pf	Cer	Var		
C160B	283-534	82 pf	Mica		500 v	5%
C160C	281-010	4.5-25 pf	Cer	Var		
C160D	283-534	82 pf	Mica		500 v	5%
C160E	281-010	4.5-25 pf	Cer	Var		
C160F	*291-008	.001 μf				½%

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
C160G, C160H, C160J	*291-007	.01 μf, .1 μf, 1 μf	Timing Series		½%	
C165	281-528	82 pf	Cer	500 v	10%	
C167	283-000	.001 μf	Disc Type	500 v		
C174	281-513	27 pf	Cer	500 v		
C180A	283-536	220 pf	Mica	500 v	10%	
C180B	285-543	.0022 μf	MT	400 v		
C180C	285-515	.022 μf	MT	400 v		
C180D	285-526	.1 μf	MT	400 v		
C180E	285-526	.1 μf	MT	400 v		
C181	281-517	39 pf	Cer	500 v	10%	
C186	283-000	.001 μf	Disc Type	500 v		
C191	281-550	120 pf	Cer	500 v	10%	
C193	283-006	.02 μf	Disc Type	600 v		
C195	281-509	15 pf	Cer	500 v	10%	
C198	283-001	.005 μf	Disc Type	500 v		

Diodes

Ckt. No.	Tektronix Part No.	Description		
D24	152-141	Silicon	1N3605	
D25	152-141	Silicon	1N3605	
D38	*152-125	Tunnel	Selected TD3A	4.7 MA
D40	152-081	Tunnel	TD2	
D45	*152-125	Tunnel	Selected TD3A	4.7 MA
D108	*152-061	Silicon	Tek Spec	
D132	152-008	Germanium		
D134	*152-061	Silicon	Tek Spec	

Inductors

Ckt. No.	Tektronix Part No.	Description
L24	276-507	Core, Ferramic Suppressor
L25	276-507	Core, Ferramic Suppressor
T40	*120-329	Toroid 15T Bilfilar
L42	use *120-337	Toroid single winding
LR149	*108-173	1.59 mh

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description			
R1	301-105	1 meg	½ w		5%
R2	301-434	430 k	½ w		5%
R3	311-110	100 k		Var	TRIG. DC LEVEL (Lower Beam)
R5	316-103	10 k	¼ w		
R6	301-105	1 meg	¼ w		5%

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
R7	301-434	430 k	½ w			5%
R8	311-110	100 k		Var		TRIG. DC LEVEL (Upper Beam)
R12	302-105	1 meg	½ w			
R15	316-474	470 k	¼ w			
R16	316-474	470 k	¼ w			
R17 } R21 }	311-414	2 x 100 k		Var		TRIGGER LEVEL VERNIER
R18	316-563	56 k	¼ w			
R19	302-475	4.7 meg	½ w			
R20	316-185	1.8 meg	¼ w			
R22	316-470	47 Ω	¼ w			
R23	316-470	47 Ω	¼ w			
R26	311-328	1 k		Var		TRIG. LEVEL CENT.
R28	308-108	15 k	5 w		WW	5%
R30	308-212	10 k	3 w		WW	5%
R32	316-471	470 Ω	¼ w			
R33	316-471	470 Ω	¼ w			
R34	316-471	470 Ω	¼ w			
R35	316-471	470 Ω	¼ w			
R36	317-101	100 Ω	1/10 w			5%
R37	302-101	100 Ω	½ w			
R38	304-333	33 k	1 w			
R40	317-101	100 Ω	1/10 w			5%
R41	302-273	27 k	½ w			
R42	316-470	47 Ω	¼ w			
R43	304-223	22 k	1 w			
R44	311-110	100 k		Var		TD BIAS
R45	316-101	100 Ω	¼ w			
R47	304-273	27 k	1 w			
R48	302-154	150 k	½ w			
R49	316-562	5.6 k	¼ w			
R100	use 302-393	39 k	½ w			
R101	302-475	4.7 meg	½ w			
R102	302-222	2.2 k	½ w			
R103	302-105	1 meg	½ w			
R104	302-103	10 k	½ w			
R105	302-103	10 k	½ w			
R106	302-153	15 k	½ w			
R107	302-825	8.2 meg	½ w			
R108	316-470	47 Ω	¼ w			
R109	302-334	330 k	½ w			
R110	302-183	18 k	½ w			
R111	311-026	100 k		Var		STABILITY
R112	302-104	100 k	½ w			
R113	304-473	47 k	1 w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R114	302-474	470 k	½ w				
R115	302-274	270 k	½ w				
R116	301-184	180 k	½ w			5%	
R119	302-470	47 Ω	½ w				
R121	302-472	4.7 k	½ w				
R122	302-183	18 k	½ w				
R123	302-274	270 k	½ w				
R124	302-474	470 k	½ w				
R125	311-329	50 k		Var		LOCKOUT LEVEL ADJ.	
R126	Use 302-473	47 k	½ w				
R127	302-470	47 Ω	½ w				
R128	302-123	12 k	½ w				
R129	302-103	10 k	½ w				
R130	306-223	22 k	2 w				
R131	302-102	1 k	½ w				
R132	302-470	47 Ω	½ w				
R134	*310-555	6 k/3 k	3 w		WW		
R137	302-470	47 Ω	½ w				
R138	302-101	100 Ω	½ w				
R139	302-104	100 k	½ w				
R140	308-206	7.5 k	5 w		WW	5%	
R141	310-070	33 k	1 w		Prec	1%	
R143	310-072	30 k	1 w		Prec	1%	
R144	308-053	8 k	5 w		WW	5%	
R146	302-470	47 Ω	½ w				
R147	302-102	1 k	½ w				
R148	302-393	39 k	½ w				
R150	302-271	270 Ω	½ w				
R160A	309-045	100 k	½ w		Prec	1%	
R160B	309-051	200 k	½ w		Prec	1%	
R160C	309-003	500 k	½ w		Prec	1%	
R160D	309-359	1 meg	½ w		Prec	¼%	
R160E	309-023	2 meg	½ w		Prec	1%	
R160F	309-087	5 meg	½ w		Prec	1%	
R160G	310-107	10 meg	½ w		Prec	1%	
R160H	310-107	10 meg	½ w		Prec	1%	
R160J	310-505	30 meg	2 w		Prec	1%	
R160W	302-104	100 k	½ w				
R160X	302-103	10 k	½ w				
R160Y†	311-108	20 k		Var	WW	VARIABLE	
R162	304-682	6.8 k	1 w				
R163	304-123	12 k	1 w				
R164	306-223	22 k	2 w				
R165	306-223	22 k	2 w				
R166	306-223	22 k	2 w				

†Concentric with SW160Y. Furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R167	302-155	1.5 meg	½ w				
R168	302-473	47 k	½ w				
R170	302-470	47 Ω	½ w				
R172	302-470	47 Ω	½ w				
R174	308-053	8 k	5 w		WW	5%	
R175	302-470	47 Ω	½ w				
R176	311-008	2 k		Var		SWP. LENGTH	
R178	308-066	4.5 k	5 w		WW	5%	
R180A	302-474	470 k	½ w				
R180B	302-475	4.7 meg	½ w				
R181	302-475	4.7 meg	½ w				
R183	302-470	47 Ω	½ w				
R186	302-104	100 k	½ w				
R188	304-104	100 k	1 w				
R190	302-225	2.2 meg	½ w				
R191	302-104	100 k	½ w				
R192	302-470	47 Ω	½ w				
R193	302-101	100 Ω	½ w				
R194	306-683	68 k	2 w				
R195	302-473	47 k	½ w				
R196	301-114	110 k	½ w			5%	
R197	302-470	47 Ω	½ w				
R198	302-470	47 Ω	½ w				
R199	304-472	4.7 k	1 w				

Switches

	Unwired	Wired		
SW8	260-558	*262-578	Rotary	SOURCE
SW10	260-145		Slide	COUPLING
SW22	260-212		Slide	SLOPE
SW101	260-518		Push w/Neon Bulb	RESET
SW128	260-557	*262-574	Rotary	SWEEP FUNCTION
SW160	260-275	*262-575	Rotary	TIME/CM
SW160Y†	311-108			

Transistors

Q24	151-120	2N2475	
Q34	151-120	2N2475	
Q44	*151-108	Tek Spec.	
Q104	151-055	2N398A	7001-7499
	151-071	2N1305	7500 up

†Concentric with R160Y. Furnished as a unit.

Electron Tubes

Ckt. No.	Tektronix Part No.		Description	S/N Range
V24	154-187	6DJ8		
V115	154-187	6DJ8		
V125	154-022	6AU6		
V133	154-187	6DJ8		
V135	154-187	6DJ8		
V145	154-047	12BY7		
V152	*157-075	12AL5	checked	
V161	154-040	12AU6		
V173	154-187	6DJ8		
V183	154-187	6DJ8		
V193	154-187	6DJ8		

Ⓐ1

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Bulbs

Ckt. No.	Tektronix Part No.	Description		S/N Range
B129	260-518	Part of SW101	READY	
B160W	Use 150-027	Neon, NE-23	UNCALIBRATED	101-11409
B160W	150-0030-00	Neon, NE-2V	UNCALIBRATED	11410-up
B167	Use 150-027	Neon, NE-23		
B170	Use 150-027	Neon, NE-23		

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3 V — 50 V = —10%, +250%

51 V — 350 V = —10%, +100%

351 V — 450 V = —10%, + 50%

Ckt. No.	Tektronix Part No.	Description					
C1	281-593	3.9 pf	Cer		500 v	10%	
C5	283-026	.2 μf	Disc Type		25 v		
C6	281-593	3.9 pf	Cer		500 v	10%	
C10	283-000	.001 μf	Disc Type		500 v		
C15	283-000	.001 μf	Disc Type		500 v		
C20	283-003	.01 μf	Disc Type		150 v		
C37	283-002	.01 μf	Disc Type		500 v		
C38	283-076	27 pf	Disc Type		500 v		
C40	283-076	27 pf	Disc Type		500 v		
C48	283-003	.01 μf	Disc Type		150 v		
C101	283-000	.001 μf	Disc Type		500 v		
C102	281-511	22 pf	Cer		500 v	10%	
C106	283-000	.001 μf	Disc Type		500 v		
C109	283-001	.005 μf	Disc Type		500 v		
C110	290-121	2 μf	EMT		25 v		
C112	285-572	.1 μf	PTM		200 v		
C117	283-001	.005 μf	Disc Type		500 v		
C119	283-001	.005 μf	Disc Type		500 v		
C123	281-504	10 pf	Cer		500 v	10%	
C129	283-001	.005 μf	Disc Type		500 v		
C131	281-549	68 pf	Cer		500 v	10%	
C134	281-501	4.7 pf	Cer		500 v	±1 pf	
C138	283-002	.01 μf	Disc Type		500 v		
C141	281-503	8 pf	Cer		500 v	±0.5 pf	
C150	281-528	82 pf	Cer		500 v	10%	
C160A	281-007	3-12 pf	Cer	Var			
C160B	283-534	82 pf	Mica		500 v	5%	
C160B	281-010	4.5-25 pf	Cer	Var			
C160D	283-534	82 pf	Mica		500 v	5%	
C160E	281-010	4.5-25 pf	Cer	Var			

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
C160F	*291-008	.001 μf			½%	
C160G	*291-007	.01 μf	Timing Series		½%	
C160H	*291-007	.1 μf	Timing Series		½%	
C160J	*291-007	1 μf	Timing Series		½%	
C165	281-528	82 pf	Cer	500 v	10%	
C167	283-000	.001 μf	Disc Type	500 v		
C174	281-513	27 pf	Cer	500 v		
C180A	283-536	220 pf	Mica	500 v	10%	
C180B	285-543	.0022 μf	MT	400 v		
C180C	285-515	.022 μf	MT	400 v		
C180D	285-526	.1 μf	MT	400 v		
C180E	285-526	.1 μf	MT	400 v		
C181	281-517	39 pf	Cer	500 v	10%	
C186	283-000	.001 μf	Disc Type	500 v		
C191	281-550	120 pf	Cer	500 v	10%	
C193	283-006	.02 μf	Disc Type	600 v		
C195	281-509	15 pf	Cer	500 v	10%	
C198	283-001	.005 μf	Disc Type	500 v		

Diodes

Ckt. No.	Tektronix Part No.	Description	
D24	152-141	Silicon	1N3605
D25	152-141	Silicon	1N3605
D38	*152-125	Tunnel	Selected TD3A 4.7 MA
D40	Use 152-081	Tunnel	TD2
D45	*152-125	Tunnel	Selected TD3A 4.7 MA
D122	152-008	Germanium	
D132	152-008	Germanium	
D134	152-061	Silicon	Tek Spec
D135	152-061	Silicon	Tek Spec

Inductors

Ckt. No.	Tektronix Part No.	Description
L24	276-507	Core, Ferramic Suppressor
L25	276-507	Core, Ferramic Suppressor
T40	*120-329	Toroid 15T Bifilar
L42	use *120-337	Toroid single winding
LR149	*108-173	1.59 mh

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description				
R1	301-105	1 meg	½ w		5%	
R2	301-434	430 k	½ w		5%	
R3	311-110	100 k		Var	TRIG. DC LEVEL (Lower Beam)	
R5	316-103	10 k	¼ w			
R6	301-105	1 meg	½ w		5%	

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R7	301-434	430 k	½ w			5%	
R8	311-110	100 k		Var		TRIG. DC LEVEL (Upper Beam)	
R12	302-105	1 meg	½ w				
R15	316-474	470 k	¼ w				
R16	316-474	470 k	¼ w				
R17 } R21 }	311-414	2 x 100 k		Var		TRIGGER LEVEL VERNIER	
R18	316-563	56 k	¼ w				
R19	302-475	4.7 meg	½ w				
R20	316-185	1.8 meg	¼ w				
R22	316-470	47 Ω	¼ w				
R23	316-470	47 Ω	¼ w				
R26	311-328	1 k		Var		TRIG. LEVEL CENT.	
R28	308-108	15 k	5 w		WW	5%	
R30	308-212	10 k	3 w		WW	5%	
R32	316-471	470 Ω	¼ w				
R33	316-471	470 Ω	¼ w				
R34	316-471	470 Ω	¼ w				
R35	316-471	470 Ω	¼ w				
R36	317-101	100 Ω	1/10 w			5%	
R37	302-101	100 Ω	½ w				
R38	304-333	33 k	1 w				
R40	317-101	100 Ω	1/10 w			5%	
R41	302-273	27 k	½ w				
R42	316-470	47 Ω	¼ w				
R43	304-223	22 k	1 w				
R44	311-110	100 k		Var		TD BIAS	
R45	316-101	100 Ω	¼ w				
R47	304-273	27 k	1 w				
R48	302-154	150 k	½ w				
R49	316-562	5.6 k	¼ w				
R98	316-101	100 Ω	¼ w				
R99	316-680	68 Ω	¼ w				
R100	use 302-393	39 k	½ w				
R101	302-226	22 meg	½ w				
R102	302-223	22 k	½ w				
R103	302-102	1 k	½ w				
R104	302-105	1 meg	½ w				
R105	302-394	390 k	½ w				
R106	302-105	1 meg	½ w				
R107	302-470	47 Ω	½ w				
R108	302-103	10 k	½ w				
R109	302-224	220 k	½ w				
R110	302-103	10 k	½ w				
R111	311-026	100 k		Var		STABILITY	

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R112	302-153	15 k	½ w			
R113	302-334	330 k	½ w			
R114	302-474	470 k	½ w			
R115	302-274	270 k	½ w			
R116	301-184	180 k	½ w		5%	
R117	302-183	18 k	½ w			
R118	302-684	680 k	½ w			
R119	302-470	47 Ω	½ w			
R120	302-104	100 k	½ w			
R122	304-683	68 k	1 w			
R123	302-274	270 k	½ w			
R124	302-474	470 k	½ w			
R125	311-329	50 k		Var	LOCKOUT LEVEL	
R126	Use 302-473	47 k	½ w			
R127	302-470	47 Ω	½ w			
R128	302-123	12 k	½ w			
R129	302-103	10 k	½ w			
R130	306-223	22 k	2 w			
R131	302-102	1 k	½ w			
R132	302-470	47 Ω	½ w			
R133	304-473	47 k	1 w			
R134	*310-555	6 k/3 k	3 w	WW		
R135	316-470	47 Ω	¼ w			
R136	302-825	8.2 meg	½ w			
R137	302-470	47 Ω	½ w			
R138	302-101	100 Ω	½ w			
R139	302-104	100 k	½ w			
R140	308-206	7.5 k	5 w	WW	5%	
R141	310-070	33 k	1 w	Prec	1%	
R143	310-072	30 k	1 w	Prec	1%	
R144	308-053	8 k	5 w	WW	5%	
R146	302-470	47 Ω	½ w			
R147	302-102	1 k	½ w			
R148	302-393	39 k	½ w			
R150	302-271	270 Ω	½ w			
R160A	309-045	100 k	½ w	Prec	1%	
R160B	309-051	200 k	½ w	Prec	1%	
R160C	309-003	500 k	½ w	Prec	1%	
R160D	309-359	1 meg	½ w	Prec	¼%	
R160E	309-023	2 meg	½ w	Prec	1%	
R160F	309-087	5 meg	½ w	Prec	1%	
R160G	310-107	10 meg	1 w	Prec	1%	
R160H	310-107	10 meg	1 w	Prec	1%	
R160J	310-505	30 meg	2 w	Prec	1%	
R160W	302-104	100 k	½ w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R160X	302-103	10 k	½ w				
R160Y†	311-108	20 k		Var	WW	VARIABLE	
R162	304-682	6.8 k	1 w				
R163	304-123	12 k	1 w				
R164	306-223	22 k	2 w				
R165	306-223	22 k	2 w				
R166	306-223	22 k	2 w				
R167	302-155	1.5 meg	½ w				
R168	302-473	47 k	½ w				
R170	302-470	47 Ω	½ w				
R172	302-470	47 Ω	½ w				
R174	308-053	8 k	5 w		WW	5%	
R175	302-470	47 Ω	½ w				
R176	311-008	2 k		Var		SWP. LENGTH	
R178	308-066	4.5 k	5 w		WW	5%	
R180A	302-474	470 k	½ w				
R180B	302-475	4.7 meg	½ w				
R181	302-475	4.7 meg	½ w				
R183	302-470	47 Ω	½ w				
R186	302-104	100 k	½ w				
R188	304-104	100 k	1 w				
R190	302-225	2.2 meg	½ w				
R191	302-104	100 k	½ w				
R192	302-470	47 Ω	½ w				
R193	302-101	100 Ω	½ w				
R194	306-683	68 k	2 w				
R195	302-473	47 k	½ w				
R196	301-114	100 k	½ w			5%	
R197	302-470	47 Ω	½ w				
R198	302-470	47 Ω	½ w				
R199	304-472	4.7 k	1 w				

Switches

	Unwired	Wired		
SW8	260-558	*262-578	Rotary	SOURCE
SW10	260-145		Slide	COUPLING
SW22	260-212		Slide	SLOPE
SW101	260-518		Push w/Neon Bulb	RESET
SW120	260-556	use*262-628	Rotary	SWEEP FUNCTION
SW160	260-275	*262-577	Rotary	TIME/CM
SW160Y††	311-108			

†Concentric with SW160Y. Furnished as a unit.

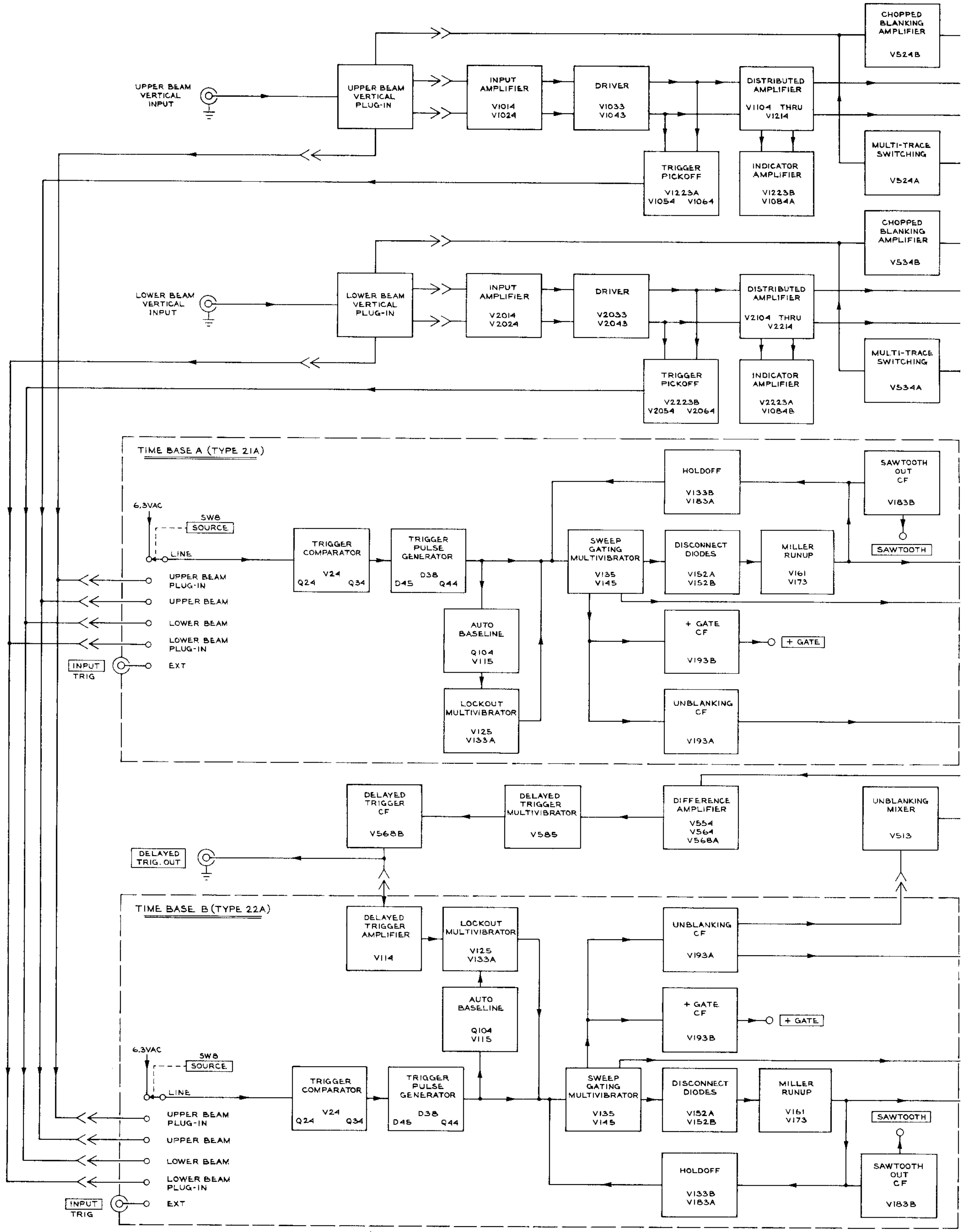
††Concentric with R160Y. Furnished as a unit.

Transistors

Ckt. No.	Tektronix Part No.	Description		S/N Range
Q24	151-120	2N2475		
Q34	151-120	2N2475		
Q44	*151-108	Tek Spec.		
Q104	151-055	2N398A		7001-7499
	151-071	2N1305		7500 up

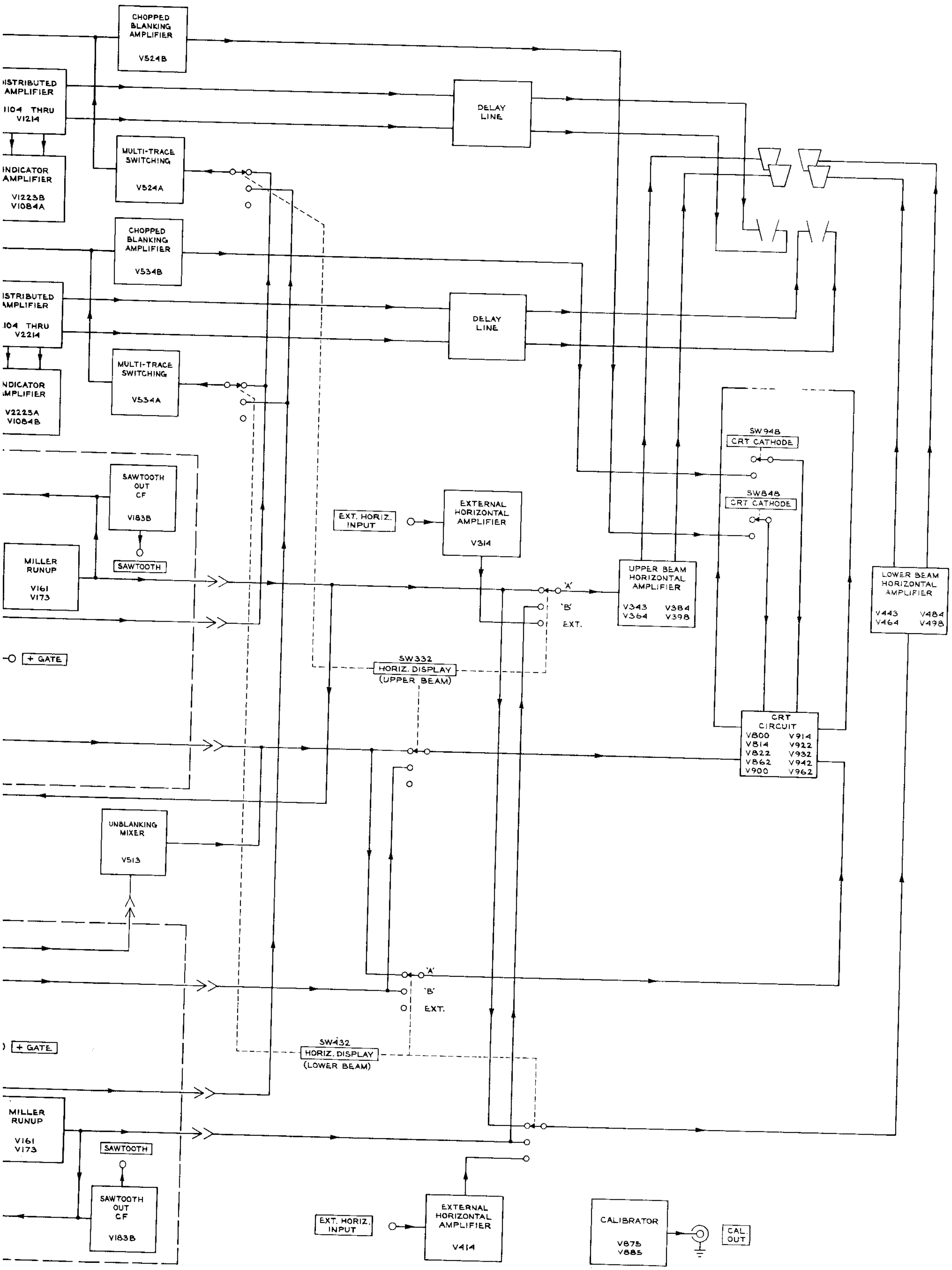
Electron Tubes

Ckt. No.	Tektronix Part No.	Description		S/N Range
V24	154-187	6DJ8		
V114	154-022	6AU6		
V115	154-187	6DJ8		
V125	154-022	6AU6		
V133	154-187	6DJ8		
V135	154-187	6DJ8		
V145	154-047	12BY7		
V152	*157-075	12AL5	checked	
V161	154-040	12AU6		
V173	154-187	6DJ8		
V183	154-187	6DJ8		
V193	154-187	6DJ8		



TYPE 555 OSCILLOSCOPE

AA



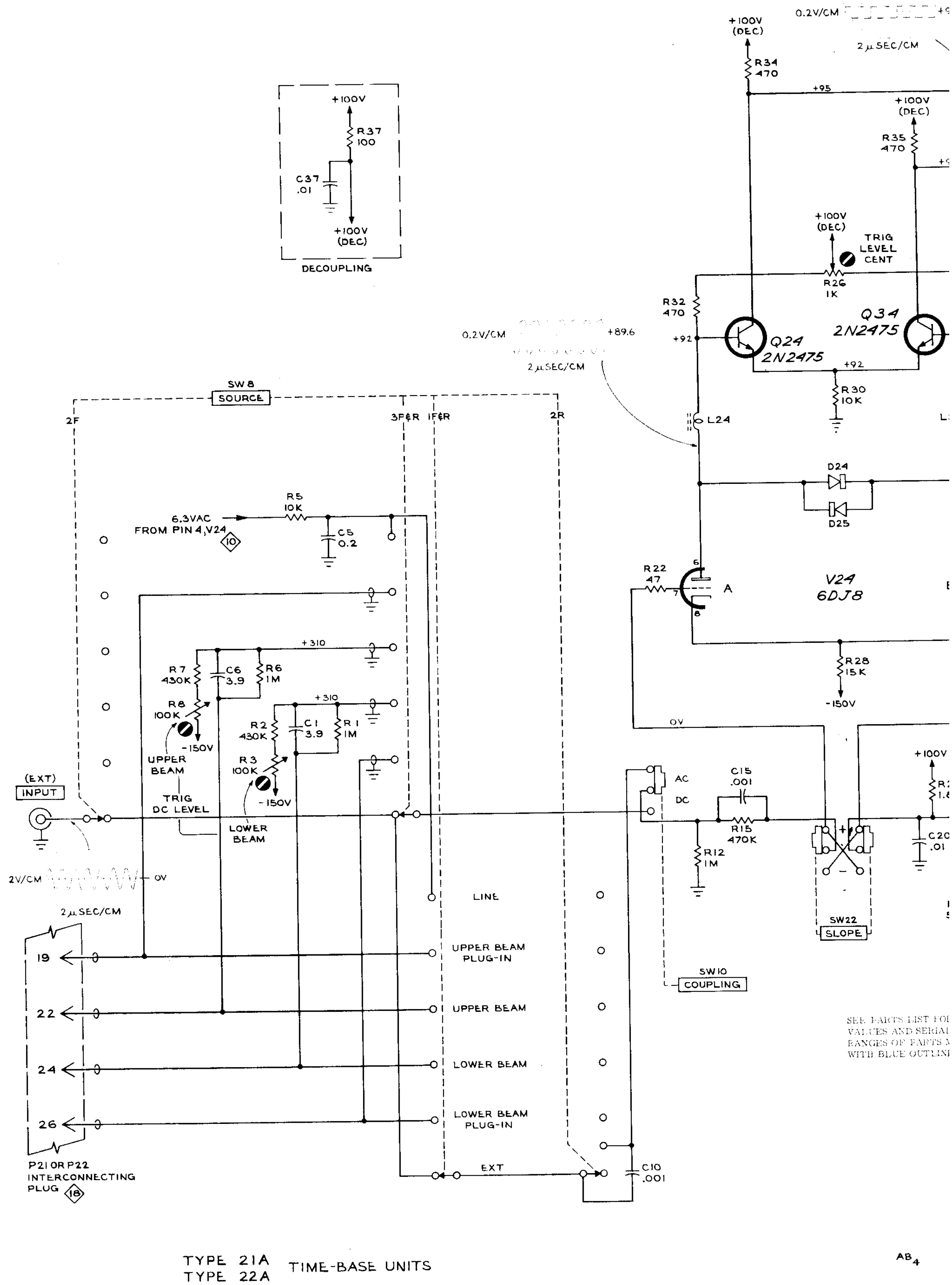
AA

CMD 664

BLOCK DIAGRAM
S/N 7000-UP

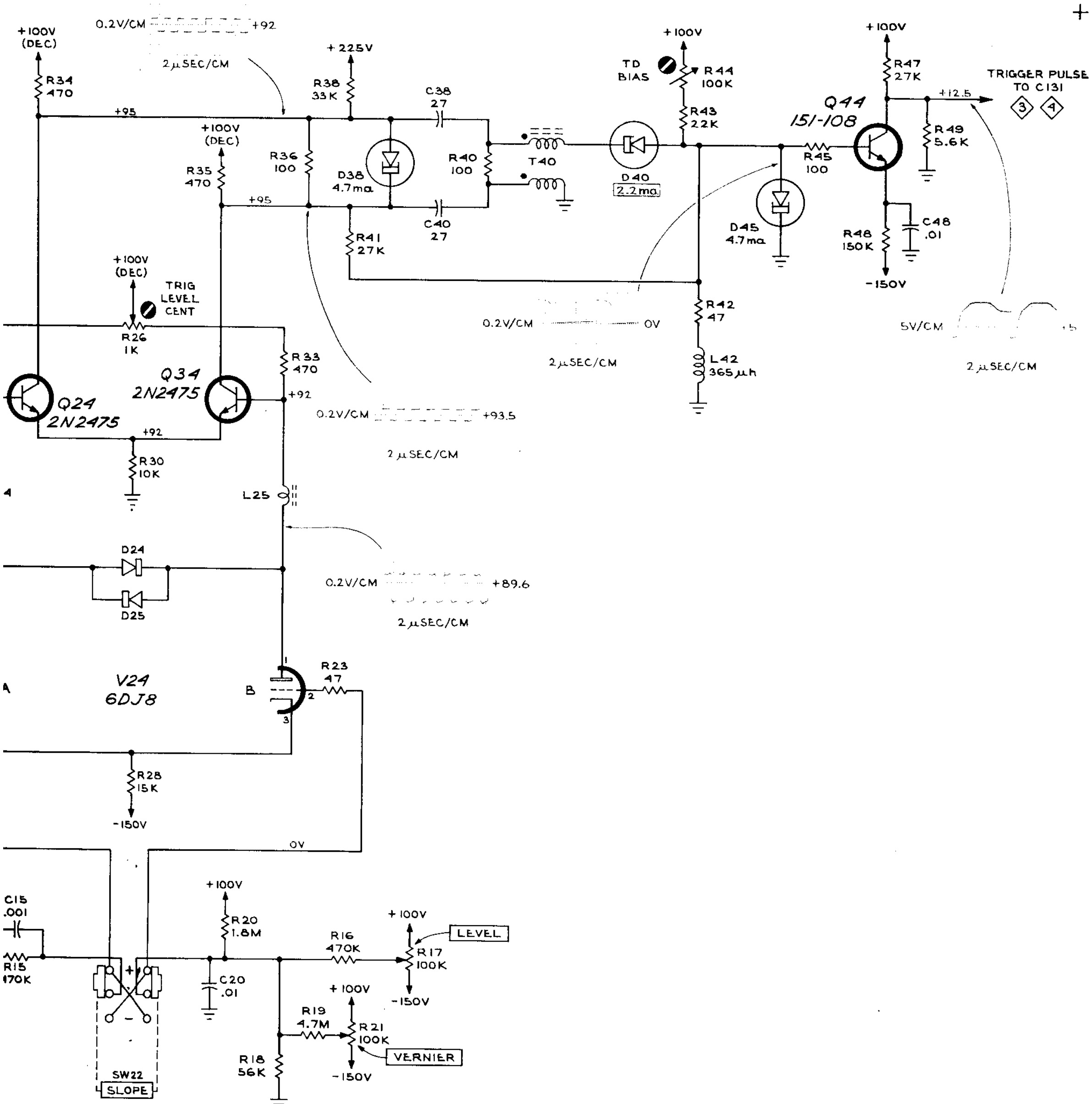
2 TIME-BASE TRIGGER

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:	
Input Signal	5-volt 350-kc Sine Wave
LEVEL Control	Centered
Also see IMPORTANT note on Block Diagram.	



TYPE 21A
TYPE 22A
TIME-BASE UNITS

AB4



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

REFERENCE DRAWINGS

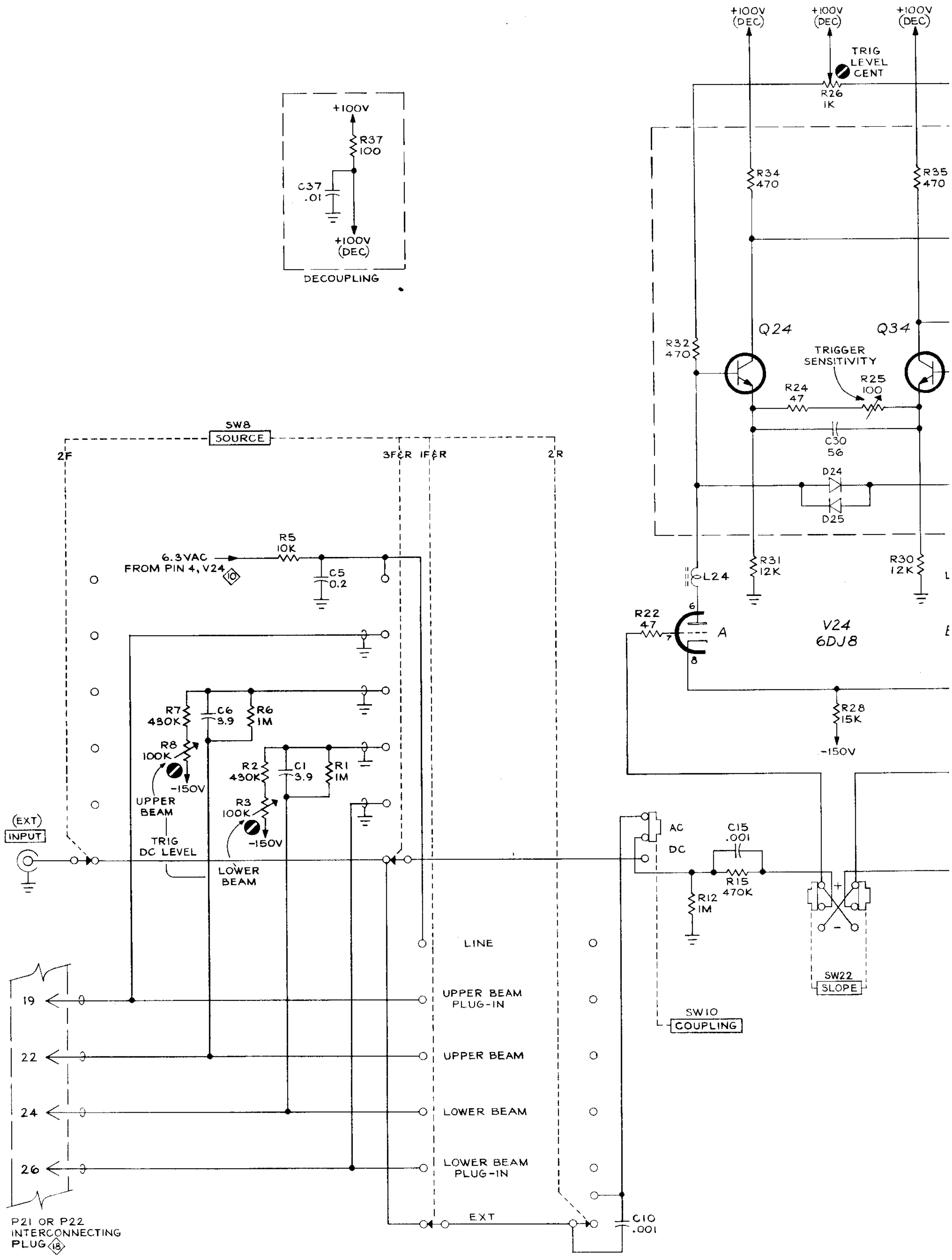
- ③ 21A TIME-BASE GENERATOR
- ④ 22A TIME-BASE GENERATOR
- ⑩ HEATER WIRING DIAGRAM
- ⑱ TIME BASE INTERCONNECTING SOCKETS

AB4

CMD 265

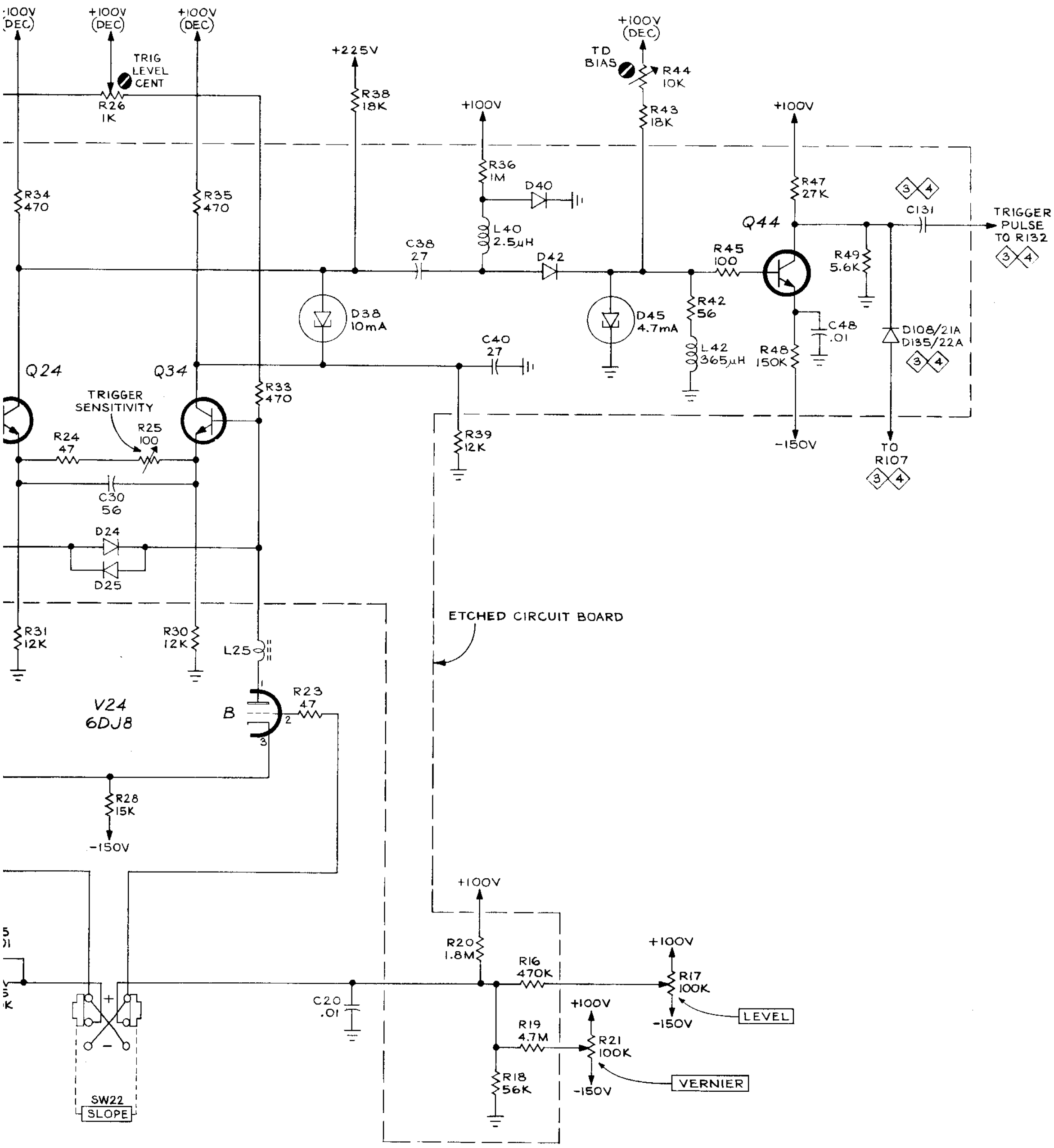
TIME-BASE TRIGGER ②

S/N 7000-10999



TYPE 21A
TYPE 22A
TIME-BASE UNITS

AC



REFERENCE DIAGRAMS

⟨3⟩ 21A TIME-BASE GENERATOR
⟨4⟩ 22A TIME-BASE GENERATOR
⟨10⟩ HEATER WIRING DIAGRAM
⟨18⟩ TIME BASE INTERCONNECTING SOCKETS

SEE PARTS LIST FOR
SEMICONDUCTOR TYPES

GTN
166

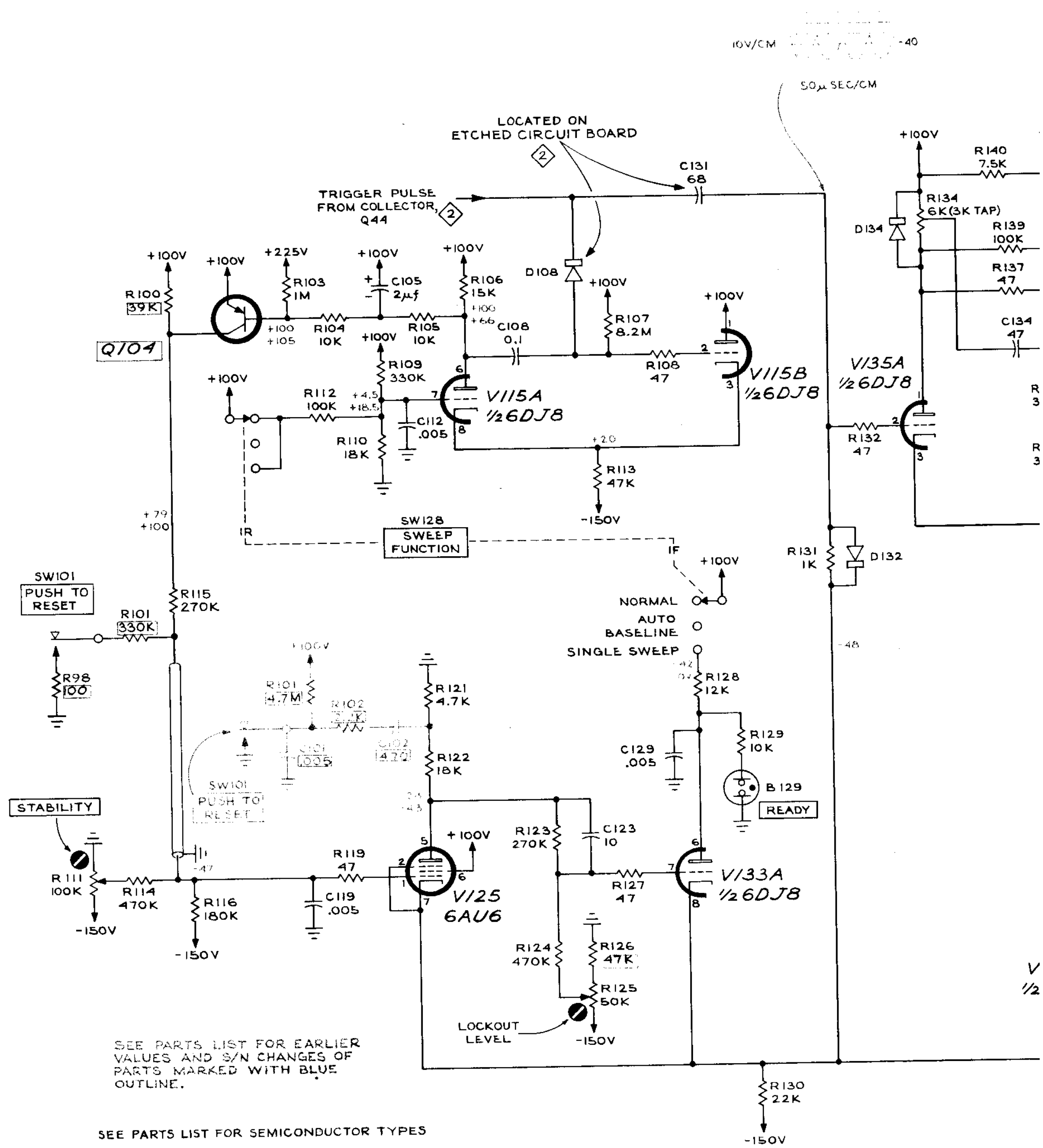
AC

TIME-BASE TRIGGER ⟨2⟩

S/N 11000-UP

3 TIME-BASE GEN. TYPE 21A

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:			
		Voltage Readings	
	Waveforms	Upper	Lower
SWEEP FUNCTION	AUTO BASELINE	AUTO BASELINE	NORMAL
Also see IMPORTANT note on Block Diagram.			

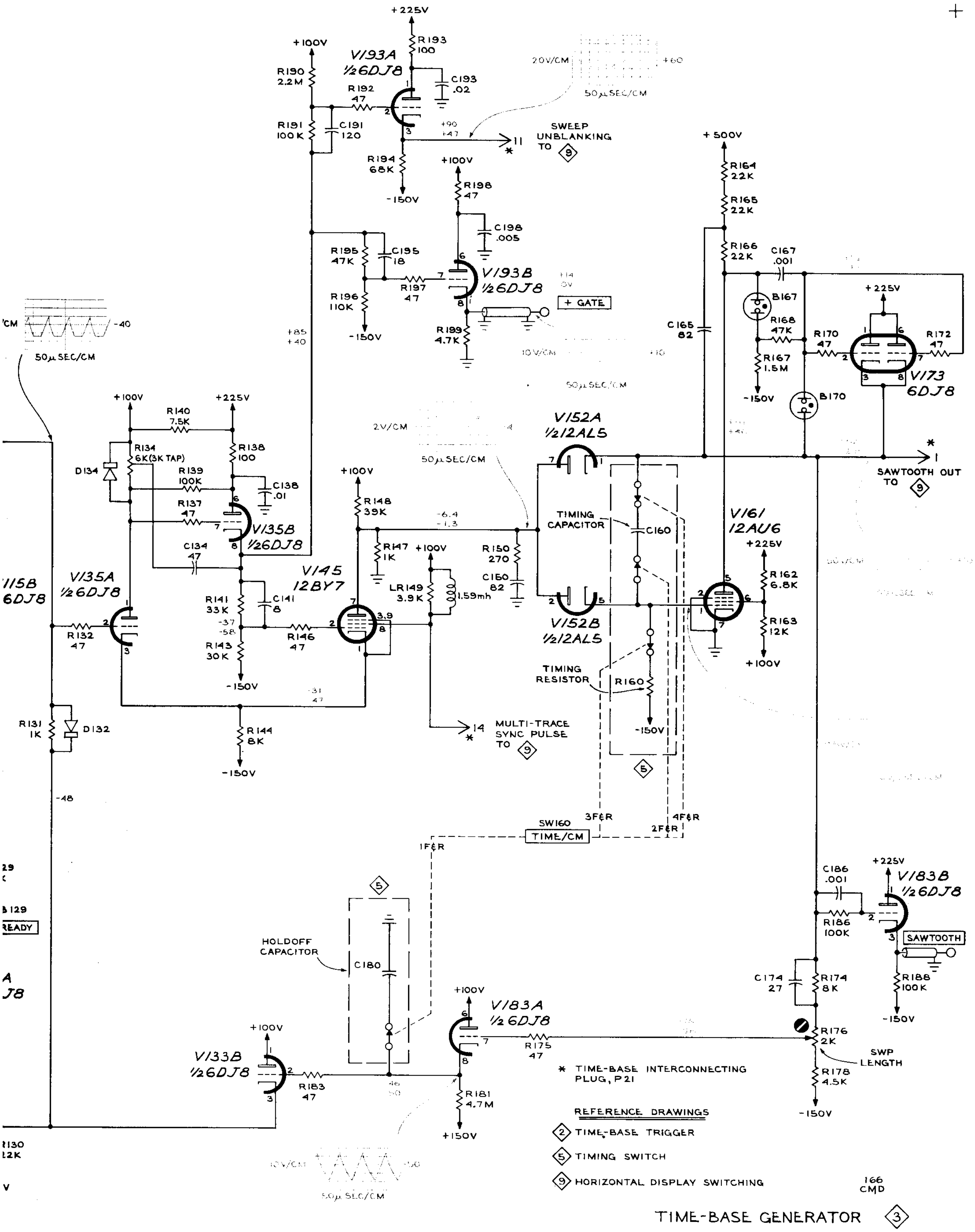


SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE 21A TIME-BASE UNIT

AC

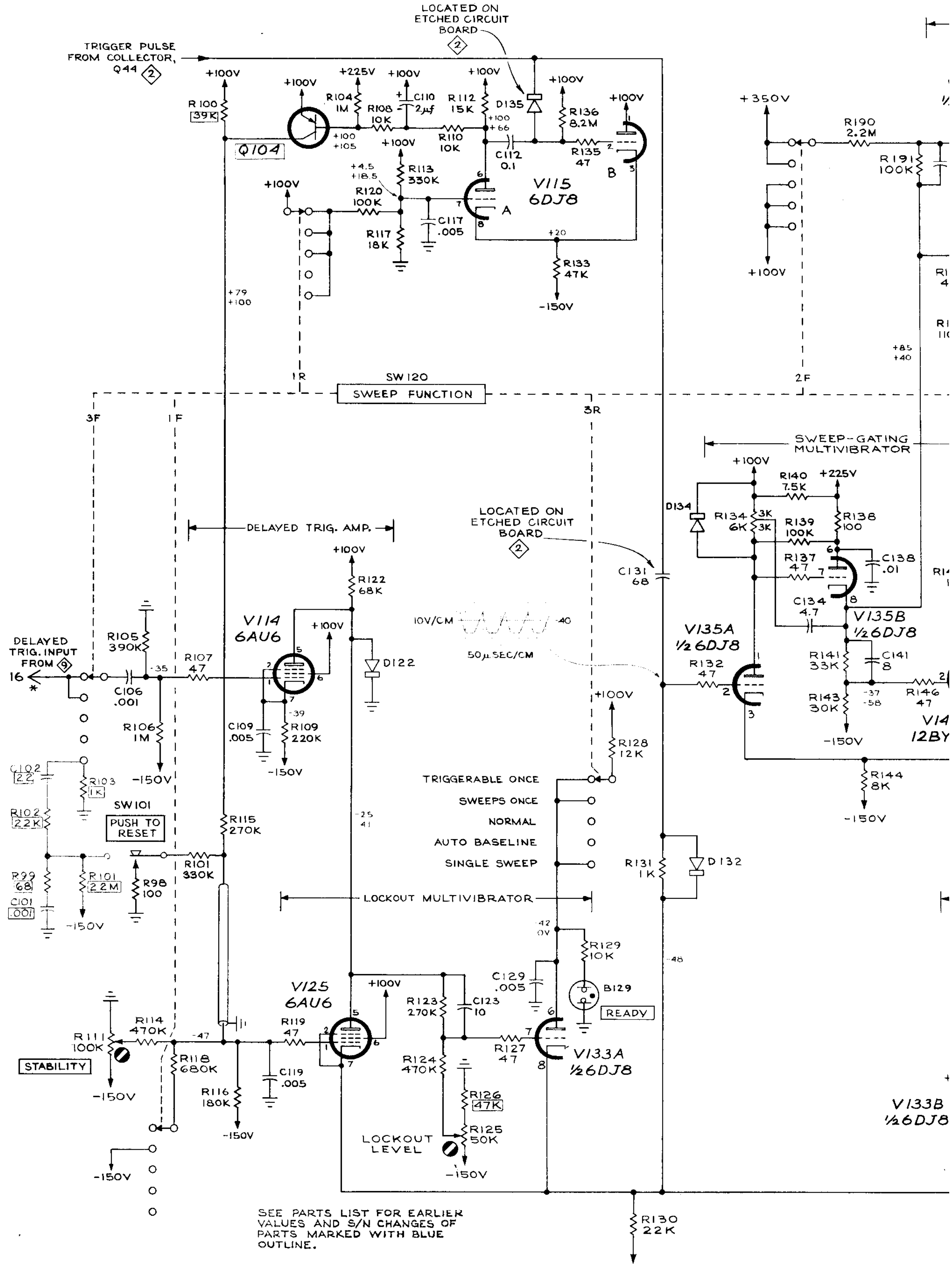


TIME-BASE GENERATOR 3

S/N 7000-UP

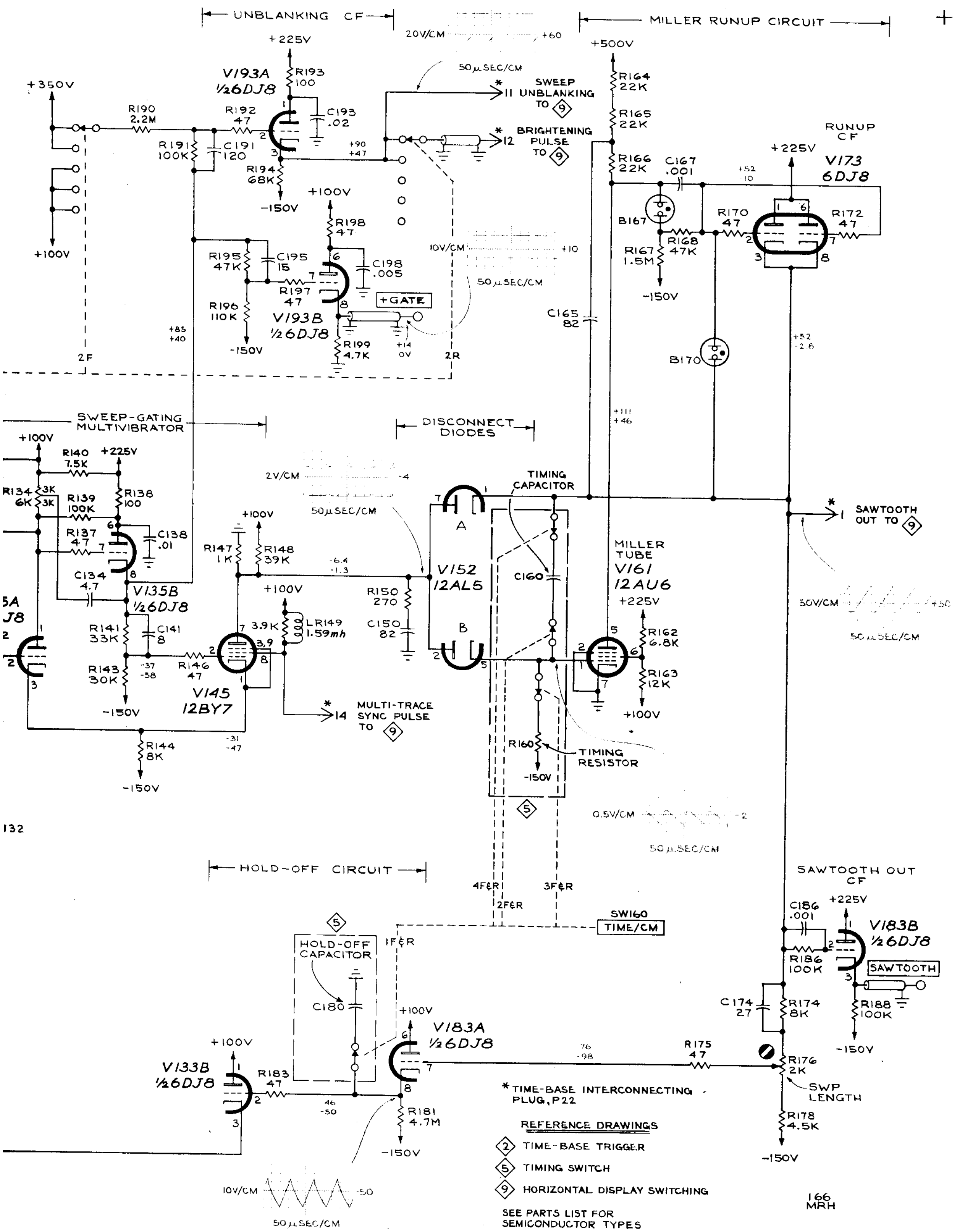
4 TIME-BASE GEN. TYPE 22A

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:			
	Waveforms	Voltage Readings	
		Upper	Lower
SWEEP FUNCTION	AUTO BASELINE	AUTO BASELINE	NORMAL
Also see IMPORTANT note on Block Diagram.			

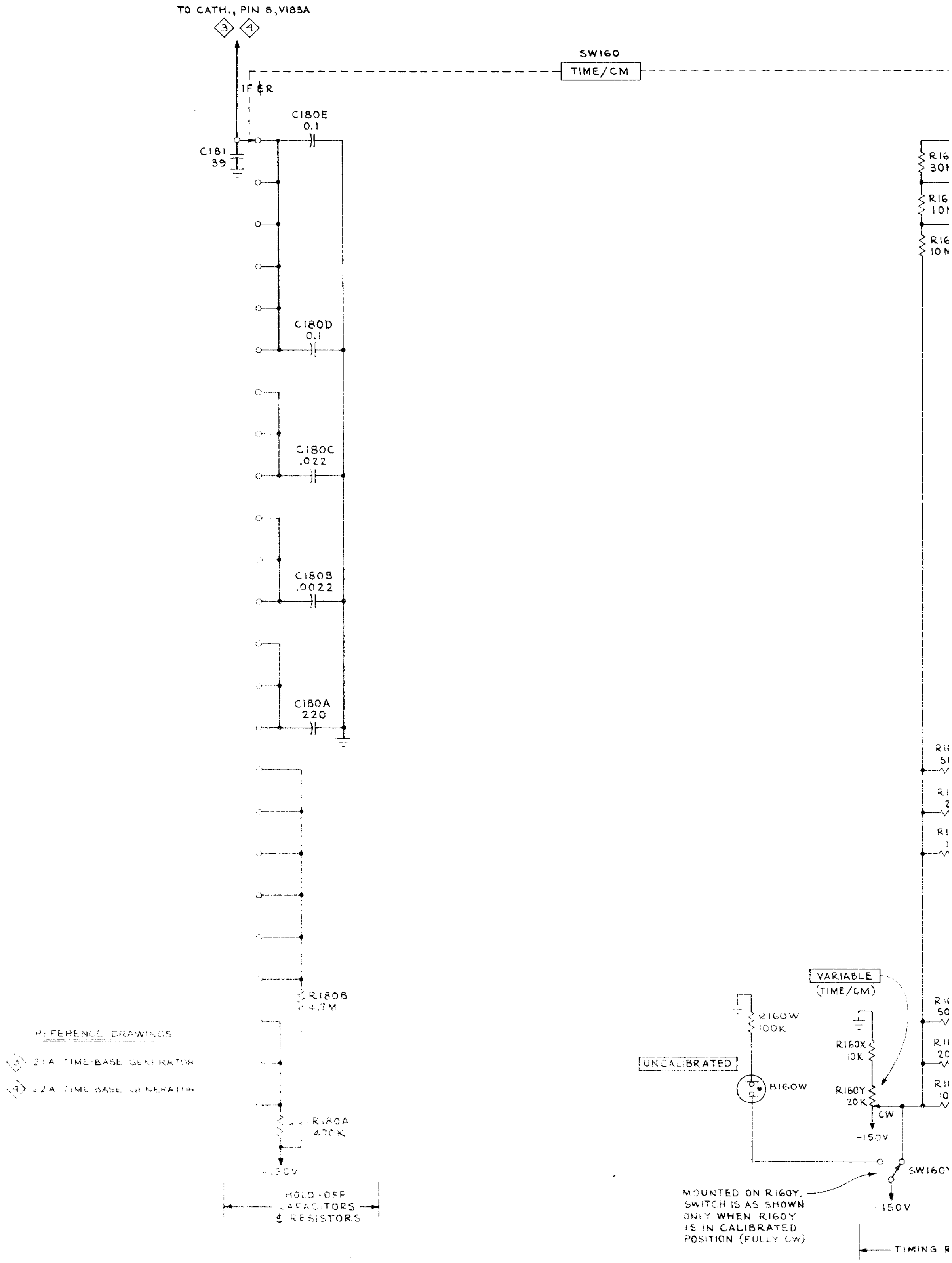


TYPE 22A TIME-BASE UNIT

AC

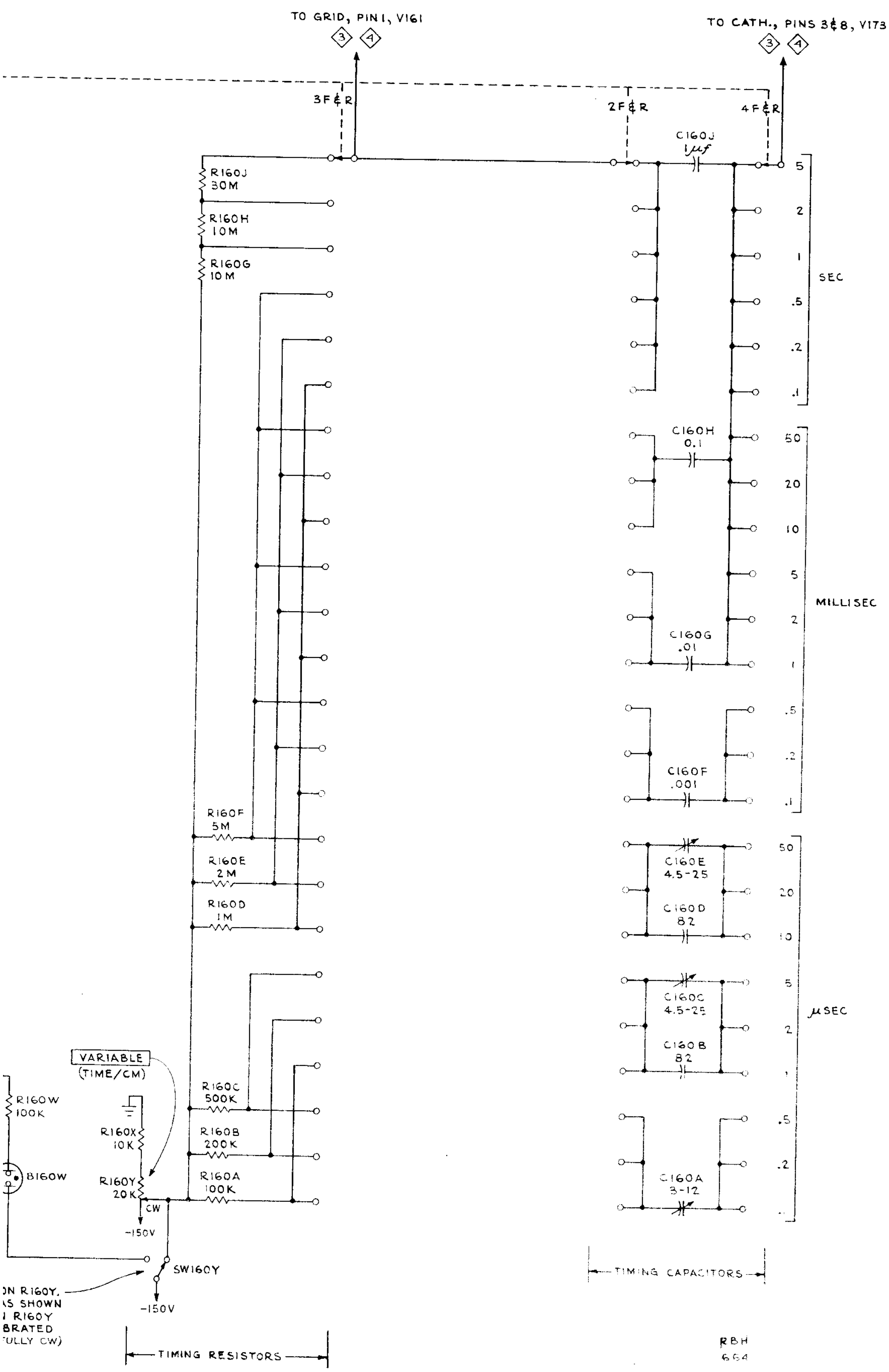


TIME-BASE GENERATOR 4
S/N 7000-UP



TYPE 21A
TYPE 22A
TIME-BASE UNITS

AA



TIMING SWITCH ⑤
S/N 7000-UP